UNIVERSITY OF TWENTE.

Internship Report

Project Manager at Schrader T+A Fahrzeugbau

Redesign of production process

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1 General information

- Company: Schrader T+A Fahrzeugbau Ellinghaus
- External supervisor: Paul Hannot
- Beckum Germany
- Period: 05-09-18 till 02-01-18
- University of Twente
- Mechanical Engineering, DPM
- Name of UT supervisor: DR.IR. T.H.J. Vaneker

1.1 Introduction

Being a project manager for 3 months involves quite some challenges. The initial assignment has to be carried out while managing other projects and people at the same time. The main goal of all projects is to achieve higher productivity, more safety and higher employee satisfaction. Schrader T+A Fahrzeugbau is a family business which is in the 3rd generation right now. The business produces trailers for transport of mineral oils and other liquids. In Germany there are 2 facilities, one focused on mineral oil trailers built with aluminum and the other facility focused on other, more specialized trailer build from stainless steel. There used to be a facility in Romania but this facility unfortunately had to be shut down in the period I was doing my internship so I was never able to visit that production facility.
In the report the main topic will be related to the main assignment. Besides the main assignment there were smaller sub assignment. These will be discussed in the appendixes. As these assignments were related to the job of a project manager these were sometimes related sometimes not related to the main assignment.

2 Tankbau

In this chapter the problem will be described. The process of building a trailer consists of a lot of different steps. To describe the problem more than just the process will be explained.
The problem description in short is: The time and effort needed to prepare the welding procedure of welding 2 aluminum cylinders together is not efficient. The process has to be faster and made easier for the employees to use. An automated system is suggested by the company but further research has to be performed.

2.1 current production process

The process of building a tank can be split in multiple procedures. These can be all split in individual tasks but the main process is split into two parts. These parts are the building of the tank and the assembling of the tank. These distinctions are also made in the production halls themselves having a "Tankbau" and a "Aufbau" hall.

1. Tank building

    From plate to cylinder

    Making the back and front

    Joining cylinders

    Making compartment walls

    Building chassis

    Attaching axles

2. Tank Assembling

    Building compartments

    Building tank protection and driving protection

    Pluming

    Wiring and electricals

    Testing and validation of tank

    Painting (external)

    Finalizing assembly

During the internship less knowledge of the tank assembling has been acquired as the problem is mostly related to the building of the tank. Now in more detail the production process of the tank will be described below.

2.2 Tankbau

The tank construction starts with two different types of plate material thickness, where 5 and 7mm aluminum plates will be used. Depending on which part of the trailer a piece of 7mm aluminum is needed on the bottom of the tank, as can be seen in figure 2.1. This is the section where the chassis is welded on. Also in the front of the trailer where the kingpin attachment is located a 7mm plate is used.

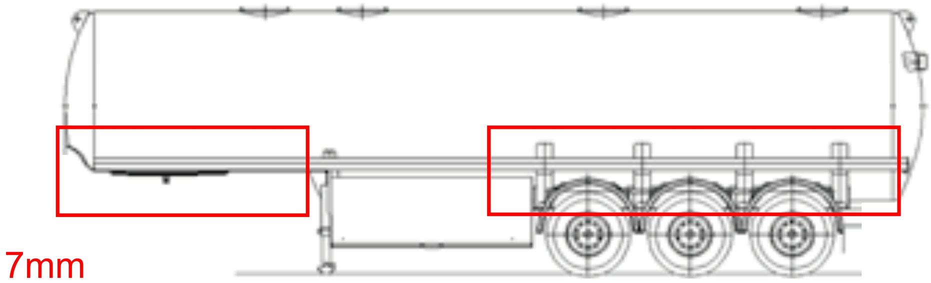


Figure 2.1: Position of 7mm material

To make the cylinders with the thicker material the 5 and 7 mm material are joined together before rolling the plate. The outer diameter from the cylinder remains constant therefore there is 2mm extra material on the inside of the cylinder in the bottom parts. The tubes are welded together using a linear welding machine. To make sure the machine is able to weld the 7mm to the 5mm a milling procedure is used. The sides of the 7mm plate are reduced to an edge having only 5mm. This is achieved with a hand operated Atlas Copco LSV 48 SA066 see figure 2.2 and results in a beveled edge see figure 2.3 and 2.4.

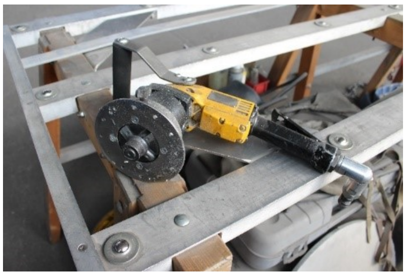


Figure 2.2: Copco LSV 48 SA066

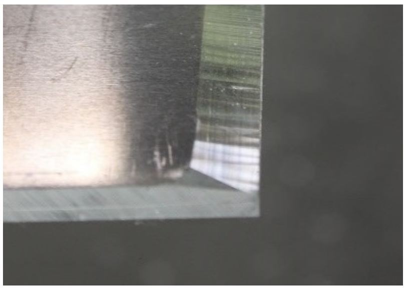


Figure 2.3: Top view bevelled edge

Figure 2.4: Side view bevelled edge

The milling machine simply removes the edge of the 7mm after which the edge is cleaned and welded together using the linear welding machine. After the welding process the plate goes through the plate bending machine. The end is welded together using the same linear TIG welding machine. Figure 2.5 shows the weld of the semi-finished product.

Figure 2.5: Semi finished product of cylinder

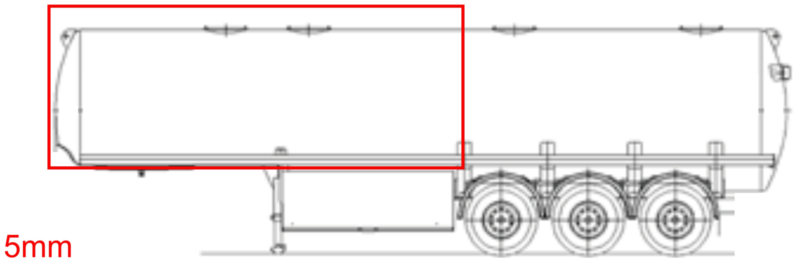


Figure 2.6: Position of full 5mm cylinder

Depending on the length of the trailer the amount of cylinders can be changed. The most sold trailer consist of 4 to 5 cylinders welded together. Figure 2.6 shows the position of full 5mm cylinders. The figure seems contradicting to figure 2.1 but the 7mm part is built up later in the process.

These cylinders all go through a different next step. The front and the end will be welded together using prefabricated end caps. Here is where the process that has to be improved is first needed. To assure the weld is properly sealed and is structurally sound the welding edged will have to be prepared. The edge of the cylinder is worked on using a burr wheel 2.7. The burr wheel removes a little layer on the top of the surface of the aluminum and removes all impurities that are present in the edge. Impurities influence the weld negatively. The burring process is performed in 3 steps as can be seen in figure 2.9.

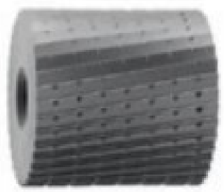


Figure 2.7: Z3 Burr wheel with inner thread

Figure 2.8: Tool used for the process

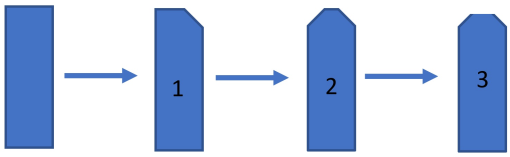


Figure 2.9: Edge preparation process

This welding preparation process is very time consuming and very inefficient. During production some quick methods have been developed depending on which part has to be prepared. Another downside of the procedure is the fact that the cylinders are very heavy. As they have to be machined from the bottom while hanging from the ceiling this creates a very unfriendly working condition working above your reach. This makes the process very tiring. The tools used to perform this process are different kinds of simple hand held air tools adjusted to hold the Z3 burr wheel figure 2.8 or rotary tools fitted with a smaller burr wheel of the same cut. The air tool is relatively heavy especially with the thick compressed air hose attached to it.

When the welding preparation is finished it will have a shiny, scaly look. This can be seen in figure 2.10,2.12 and 2.11. These parts are now ready to be welded together. They get a quick wipe with some alcohol to get rid of any fat particles from the tools or production workers that could have gotten to the edge.

Figure 2.10: Close up of prepared edged

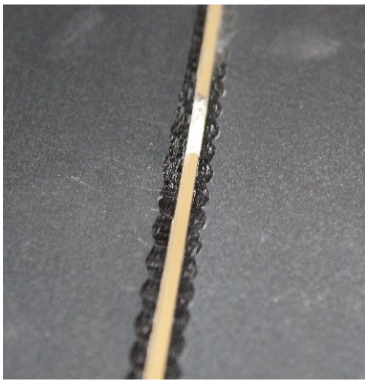


Figure 2.11: two cylinder in position ready to weld

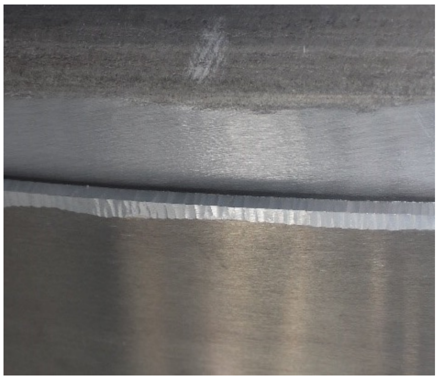


Figure 2.12: End cap and cylinder ready to weld

After the welding preparation of the cylinders the weld that is performed here is a both sided TIG Weld see figure 2.16. The black parts in the figure are the same aluminum material as the blue parts, the black shows how the parts are welded together from both sided.

The next step is to weld the cylinders together. This is done in a vertical position to avoid tension in the weld. First the two cylinders are tack welded together, figure 2.13,2.14), and then finally welded all the way around, figure 2.15 and 2.16. This is done this way to avoid deformation due to the heat of the weld, but mainly because not all welders are allowed to make these welds. There are specific people for welding the structural welds that have the education and certificates to make these welds.

Figure 2.13: Tack welded cylinders

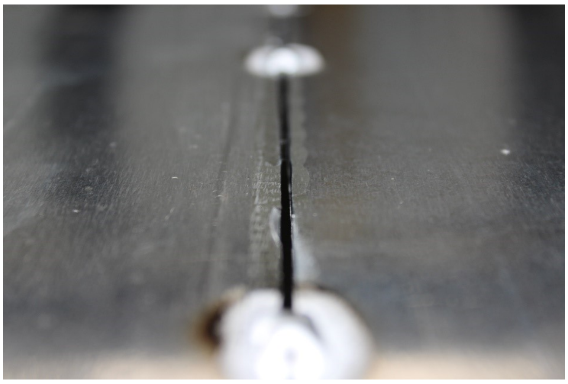


Figure 2.14: Tack weld close up

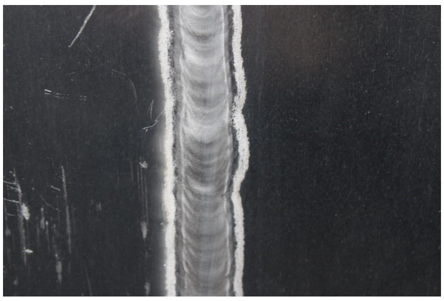


Figure 2.15: Final weld of 2 cylinders joined

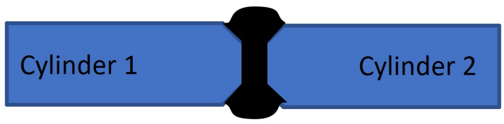


Figure 2.16: Double sided TIG weld

The next step is to press and weld compartment walls. The compartment walls are the same as the end caps. Depending on if the wall will be a division wall or a strengthening wall there will be holes. The strengthening walls are situated inside the compartments and they will minimizing fluid motion. These holes are cut by hand and then pressed to create a bend edge which is structurally stronger. These edges also will also be burred using the same burr tool. Only this is not a preparation for the welding, this is only to deburr the edges.

The burring of the edge is very important for the quality of the weld. This process has to be done right before welding so the least amount of oxidation and other contaminates are present in the edge. To tackle this problem there are a lot of possibilities. To find these possibilities the TRIZ idea generation is used. But first some research on this procedure is done in more detail. Are there existing things in the market. Are there other ways of doing this available right now?

3 Production Process Evaluation

Using TRIZ there are different routes that can be taken. But first he system has to be broken down in systems, subsystems and supersystems. The next step is to find all the interactions these system have with one another and find possible harmful and insufficient interactions. The TechOptimizer program is used to find these interactions.

3.1 System analysis

Systems:

1. Mill/Burr
2. Motor (compressed air/Electric)
3. Handle
4. Air hose/Electricity cable
5. Human
6. Crane control
7. Crane hook
8. Straps

Supersystems:

1. Aluminum cylinder
2. Air
3. Dust
4. Aluminum particles
5. Crane

The diagram generated can be seen in figure 3.1 and all interactions can be seen in tables 3.1 and 3.2.

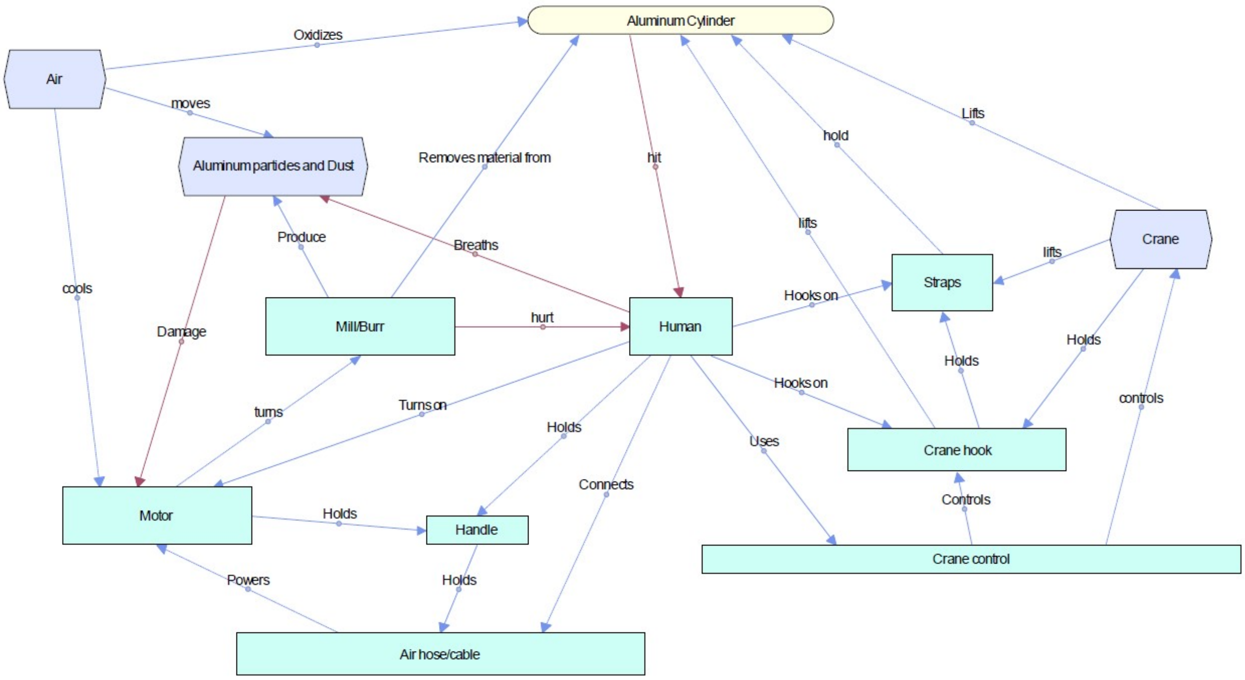


Figure 3.1: TRIZ System analysis

System 1	Problem	Verb	System 2
Air	Excessively	Oxidizes	Aluminum Cylinder
Air	**Insufficiently**	**Cools**	**Motor**
Air	Excessively	Moves	Aluminum particles and Dust
Mill/Burr	**Insufficiently**	**Removes**	**Material from Aluminum Cylinder**
Crane	**Insufficiently**	**Lifts**	**Aluminum Cylinder**
Motor	**Insufficiently**	**Turns**	**Mill/Burr**
Air hose/cable	**Insufficiently**	**Powers**	**Motor**
Human	**Insufficiently**	**Holds**	**Handle**
Human	Insufficiently	Connects	Air hose/cable
Crane control	Insufficiently	Controls	Crane
Crane hook	Insufficiently	Lifts	Aluminum Cylinder
Straps	Insufficiently	Holds	Aluminum Cylinder

Table 3.1: Insufficient or excessive relations

System 1	Verb	System 2
Mill/Burr	**Hurts**	**Human**
Aluminum Cylinder	Hit	Human
Aluminum particles and Dust	**Damage**	**Motor**
Human	Breaths	Aluminum particle and Dust

Table 3.2: Harmfull interactions

The problems in **'bold'** found in the function analysis are either something found to be important and crucial to be taken into account. The others are either unrelated or are not influencing the main desire of remodeling the production process. Now the **'bold'** problems will be ranked see figure 3.2 And 3.3

#	Problem	1	2	3	4	5	6	7	8	Total
1	Air Insufficiently Cools Motor		-	-	-	-	+	-	+	-3
2	Mill/Burr **Insufficiently** Removes Material from Aluminum Cylinder	+		+	0	+	+	+	+	6
3	Crane **Insufficiently** Lifts Aluminum Cylinder	+	-		-	+	+	-	+	1
4	Motor **Insufficiently** Turns Mill/Burr	+	0	+		+	0	-	+	3
5	Air hose/cable **Insufficiently** Powers Motor	+	-	-	-		+	-	+	-1
6	Human **Insufficiently** Holds Handle	-	-	-	0	-		-	+	-4
7	Mill/Burr **Hurt** Human	+	-	+	+	+	+		+	5
8	Aluminum particles and Dust **Damage** Motor	-	-	-	-	-	-	-		-7

Figure 3.2: Problem rating

#	Problem	Total
1	Mill/Burr **Insufficiently** Removes Material from Aluminum Cylinder	6
2	Mill/Burr **Hurt** Human	5
3	Motor **Insufficiently** Turns Mill/Burr	3
4	Crane **Insufficiently** Lifts Aluminum Cylinder	1
5	Air hose/cable **Insufficiently** Powers Motor	-1
6	Air Insufficiently Cools Motor	-3
7	Human **Insufficiently** Holds Handle	-4
8	Aluminum particles and Dust **Damage** Motor	-7

Figure 3.3: Problems ordered to importance

So from this it can be concluded that it is important to remove the right amount of material, without hurting the Human. The first problem has been taken and a RCA+ analysis has been performed.

3.2 Contradiction identification

The following contradictions were found and ordered from top to bottom. The RCA+ analysis can be seen in appendix 8.1. Following the rules of solving problems with RCA+ it has to be solved from top to bottom using for example the 40 principles, see figure 3.4 for the contradictions from the analysis. However some of the contradictions found here are not a problem in the real application because in most cases the cheaper option is not the preferred one, or is not the problem therefore the contradictions left are the **'bold'** faced contradictions in figure 3.4. As anything can be made in this company adaptability is not that big of an issue either.

1	*Mill/Burr gets used up too quickly*	*Poor quality Mill/Burr*	*Cheaper*
2	**Inconsistent use of tool**	**Used by Human**	**Cheaper and flexibility**
3	**Inconsistent use of tool**	**Different users**	**Flexibility**
4	**It is a different Mill**	**Tool is not adaptable**	**Better fit for good Mill**
5	*Mill is hard to replace*	*Homemade tool*	*Doesn't exist on market*
6	**Place of application cannot be reached**	**Tube is too high**	**Cannot be welded vertically**
7	**Low amount of control of tool**	**No guiding on tool**	**More flexible/simpler design**
8	**Low amount of control of tool**	**Little automation in tooling**	**Easier application**

Figure 3.4: Contradiction found using RCA+. The bold contradictions will be used for idea generation

Now using the Altshuller matrix [1] the principles for idea generation are found. See figure 3.5.

1	Accuracy of manufacturing	35	7	13	1	4	Adaptability / Versatility
2	Accuracy of manufacturing	35 2	7 10	13 39	1 18	4	Adaptability / Versatility Productivity
3	Shape / Form	30	32	40	22		Accuracy of manufacturing
4	Shape / Form	17 30	32 32	1 40	28 22		Manufacturability Accuracy of manufacturing
5	Complexity of control	1 28	7 15	28 37	25 7	26 2	Adaptability / Versatility Complexity of a system
6	Complexity of control	28 1	15 7	37 28	7 25	2 26	Complexity of a system Adaptability / Versatility

Figure 3.5: results from using the 2003 Altshuller matrix

Next the 40 inventive principles are used to generated ideas for solving the problem.

3.3 Idea generation

3.3.1 Idea generation 1 for inconsistency of use of tool

35: Parameter or property change

1. Remove the oxide using chemicals.
2. Burn off the oxides with a laser.

7: Nesting

1. Do all 3 edges at the same time.
2. Change the thickness when it arrives at the 7mm.
3. Include a guiding system in the tool.
4. Make a telescopic tool so the whole tube can be done from one side.

13: Other way around

1. Do both side before lifting it up.
2. Do the process on its side so it can be reached easier.
3. Use a swing to turn around the tube quickly.
4. Make the tube rotate and the tool fixed.

5. Make the tube fixed and the tool go around the perimeter.
6. Use of a robotic arm moving the mill and welding straight after.

1: Segmentation

1. Mill the tube with multiple people at the same time in different segments.
2. Use multiple mills to do the same operation at the same time.
3. Use two sets, one for the 5mm part and 1 for the 7mm part.

4: Assymetry

1. Do the 3 different sides on 3 different spots in the process so they do not interact on one another.

2: Taking Away

1. Do the edge preparation before making a tube.

10: Prior action

1. Using a mill as a plate and use a laser after to clean it again.
2. Put the aluminum in a bath while storing it so it will have no oxide when it is used again.

39: Inert environment

1. Do everything in a vacuum chamber.
2. Put the tubes in an inert environment while not used.

18: Vibrations

1. Vibrate the tool left and right to remove the material quicker.
2. Vibrate the tool on it sides to remove the 3 sides in one go.

3.3.2 Idea generation 2 for Place for application cannot be reached properly

17: Another dimension

1. Tilt the tool to do the sides, but do this automatically without needing control of the human.
2. Add stairs to reach the top part.
3. Add a extension arm on the tool to reach the place you want to reach.

32: Color and transparency change

1. Use a Plexiglas shield so one can still look at how the tool is performing.

1: Segmentation

1. Stairs with different levels to be able to do multiple sides with the same stairs.

28: Principe replacement

1. Use lasers to remove oxide
2. Use vibrations to remove oxides
3. Use microwaves to remove oxides
4. Put rim on the outside so the edge weld does not need to be cleaned as thoroughly as before and use a strip that is easier to clean.

30: Thin films and flexible shells

1. Add a special film to the edge which removes the oxides right before welding by burning/exploding locally.
2. Replace the welding by a different joining method which does not need cleaning.

40: Composite structure

1. Build a tank out of composites.

3.3.3 Idea generation 3 for Low amount of control of a tool

15: Dynamization

1. Make the tool more mobile in a controlled way.
2. Have different driving .

37: Expansion effect
1. Make the tube warm to expand and hit the tool while fixing the tool to get a precise material removal.
25: Self service
1. Self oxide layer removing aluminum
2. While moving the tubes use an abrasive/burr floor to transport the tube over which allows material removal while moving the object.
3. Move the object using a burr wheel, so material is removed while the tube is moved.
26: Use of copies and models
1. First try the robot/new method in another program to really test it before using it on the shop floor.

3.4 First Designs

Now taking into account the ideas generated using TRIZ some designs were made. Normally an idea landscape would be used to make sure the proper ideas are chosen. However this step is skipped. This is done because already some ideas were talked about with the colleagues and were said to be ideas to further develop.

3.4.1 Prototype 1

The first design is a magnetic clamp clamping on the edge of the tube. The single mill can be adjusted to the proper angle to do the sides.

3.4.2 Prototype 2

Next there is a similar design. This portable mill is based on some existing tube bevelling machines. However this one does 3 edges at the same time.

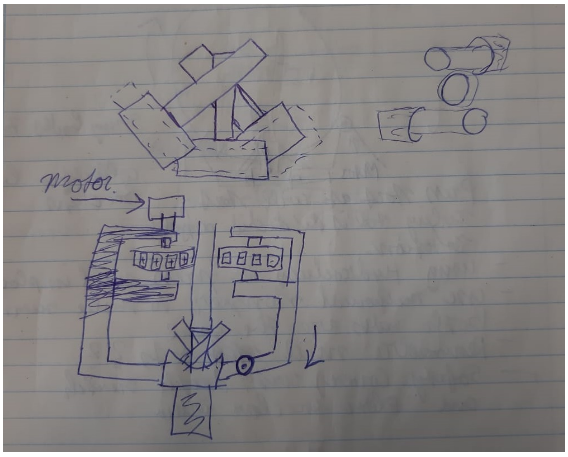


Figure 3.6: Prototype 1 magnetic triple mill

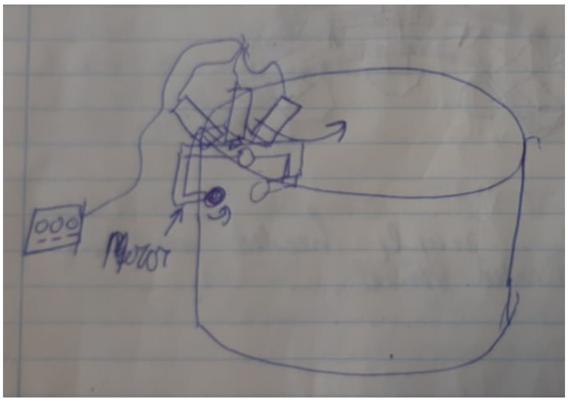


Figure 3.7: Prototype 2 portable triple mill

3.4.3 Prototype 3

Putting the tube on a fixed location makes it a lot easier to machine it. Using the existing rollers for turning a trailer to weld on the bottom a rig can be built to mill it on both ends with 3 mills.

3.4.4 Prototype 4

This is a more local solution simply adapting the current tool to have 3 heads milling 3 sides at the same time. This solution would not be fully automated but will make the process 3 times as fast.

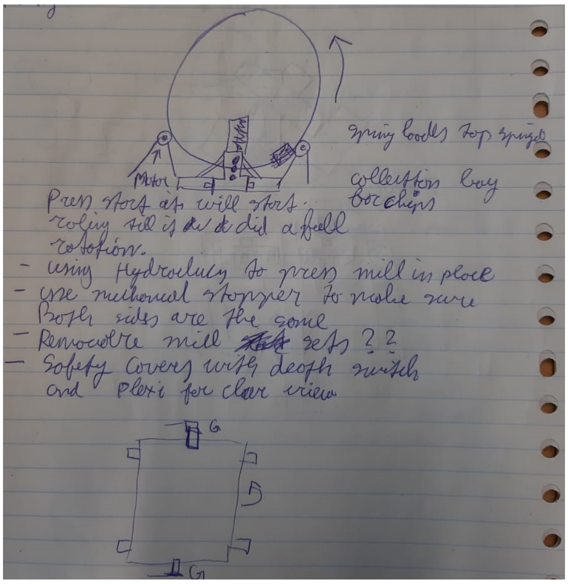


Figure 3.8: Prototype 3 Horizontal double sided triple mill

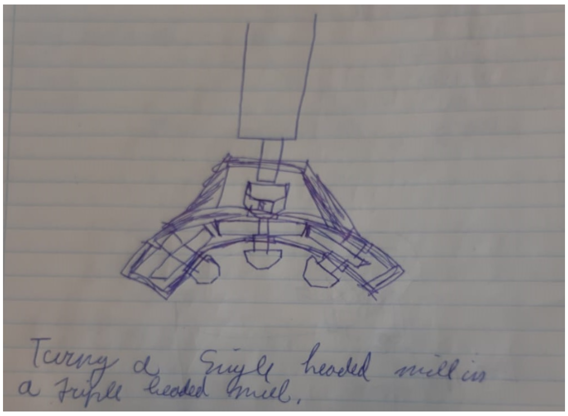


Figure 3.9: Prototype 4 gear box mill

3.4.5 Prototype 5

A robot arm can basically replace a human directly. This would be an expensive solution but it would be able to take over the job and still be flexible.

3.4.6 Prototype 6

In this design the tube will be hung up in the crane. This would allow the tube to be machined from the bottom.

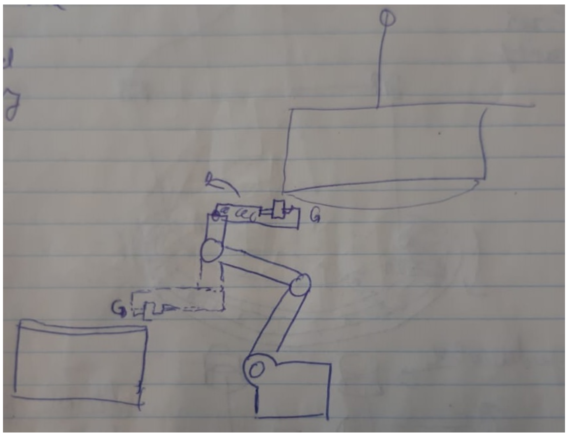


Figure 3.10: Prototype 5 robotic arm replacement

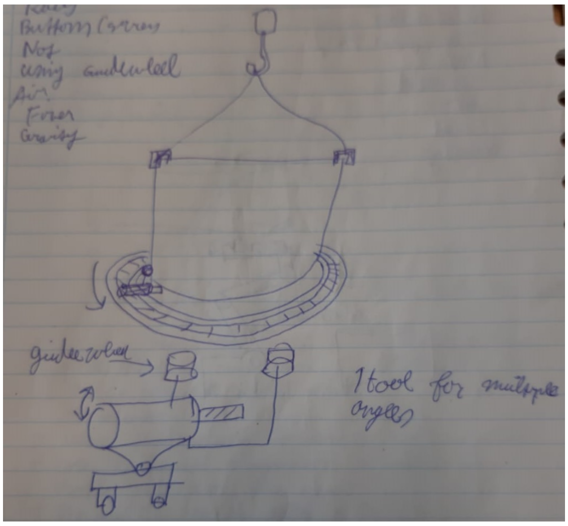


Figure 3.11: Prototype 6 rail way design

3.4.7 Prototype 7

The last prototype design is based on a fixed location again. It is similar to the railway design the different is that the tube rotates and not the mill.

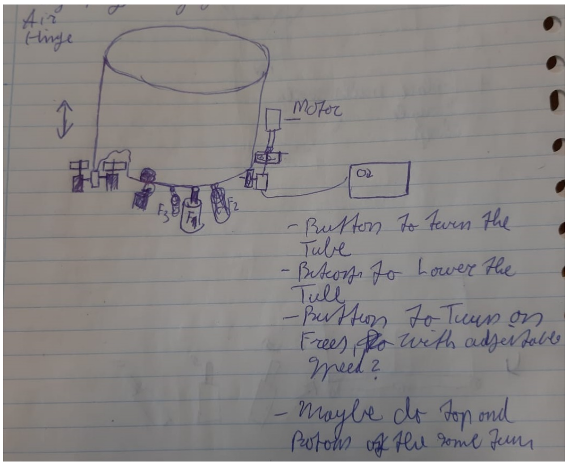


Figure 3.12: Prototype 7 Vertical rolling tube

4 Prototyping

4.1 Prototype 1

Discussing all designs with the production team it was decided to further develop prototype 3 the horizontal double sided triple mill. There were a couple of main reasons why this design is chosen. The main reason is the fact that both sides of the cylinder can be milled in one go. So it would speed up the operation 5 times. There are a couple of things that have to be taken into account.

- The tube should be placed using the crane
- while in operation workers should not be able to get too close to the machine
- Only 1 button should have to be pressed to start the process
- The orientation of the tube should not matter to where the 7mm plate begins or ends.
- Burrs should be easily replaceable when dull

So the designing process started with some initial sketches on how to tackle this machine. With some initial research it was found no existing solution was there. therefore all the parts have to be designed from scratch. The first part to be designed was the end point manipulator with the mill attached to it using a burr.

The idea is to make 1 clamp design and then using 3 different add-ons with different angles of the mill. Figure 4.1 Shows the clamp design. This clamp was designed using some simple design strategies in constraining all direction but only once and avoiding any over-constraints.

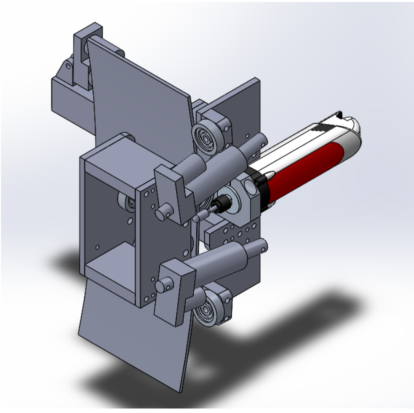


Figure 4.1: Clamp design

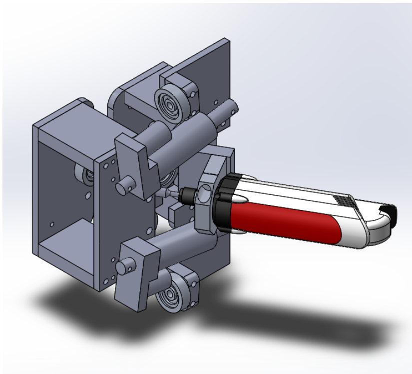


Figure 4.2: Clamp under 60 degree angle inside

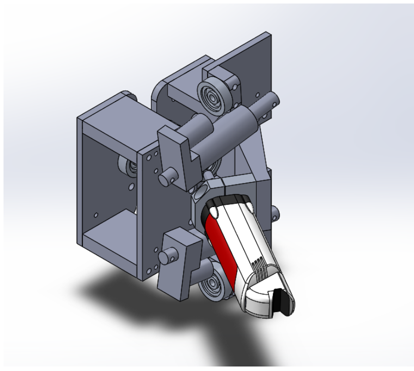


Figure 4.3: Clamp under 60 degree outside

The two bottom wheels are exactly aligned and therefore only take out the rotation around and the linear movement in the perpendicular to the plane of the tube. The pressure needed on the mill will be from the main clamp actuator pulling the clamp over the tube edge. To make sure the mill cannot move 3 wheels are used to align it. The exact same clamp can be used but with a different fixture for the mill under different angles as can be seen in figure 4.2 and 4.3. Putting 3 actuators on a steel frame on both sides of the tube will allow the tube to be machined very easy and quick to prepare it for welding.

4.1.1 Thickness detection

There are 2 different kind of tubes. one only from 5mm and one with a 5mm and 7mm part. The mill on the inside will have to be able to adapt to this change in material thickness in order to mill the side properly. To do so a laser distance sensor is suggested to be used that measures the distance from a fixed point on the inside of the cylinder. The thickness will only change on the inside therefore a single sensor can be used. It should be used to monitor how far the process is and when it is finished. This can be done because the speed of rotating the tube can be controlled and the start position of the tube is known when the machine knows where the begin and end is of the 7mm part.

4.2 Prototype 2

After having developed the prototype in the Solidworks software and showing it now also to the production workers a problem arises. Where having a fixed location would be most efficient, having better results and be better for full automation, in the current production process this would not fit. The workers simply want to have a device they can clamp on, mill 3 edges and take off. This means the first prototype would not be accepted in the production right now.

Now re-evaluating the designed prototypes prototype number 4, the gear box mill would be the best option. This would mean the same mill as now can be used. A little bit of a stronger mill might be needed but the idea is simple. Such a gearbox does not exist yet and one problem here is that the design cannot be static. There has to be a adapting part to the 7mm. It would be preferable if no sensors would be needed to detect the 7mm. Therefore a mill following the shape of the tube would be beneficial.

The previous prototype is left for what it is and a new design has been made. Figure 4.4, 4.5 and 4.6 shows this new design. Due to time limitation actual iterations of this design have never been made. In this design it was chosen to use a belt to connect the two different mills. However these belts have a certain length and putting tension on the belt will be hard. The length of the belt also has a big impact on the the size of the gearbox.

In the design springs are used to put pressure on the mills. The reason this was chosen is because it will allow the gearbox to move with the profile to the 7mm part of the tube without any problems. For the top side a different burr wheel is chosen because this burr wheel will allow the orientation of all mills to stay the same.

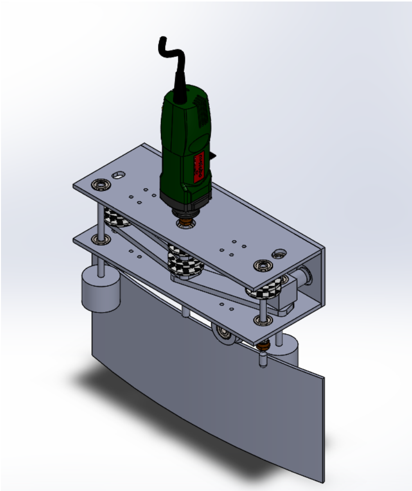


Figure 4.4: Design of the adjustable gearbox with Metabo mill

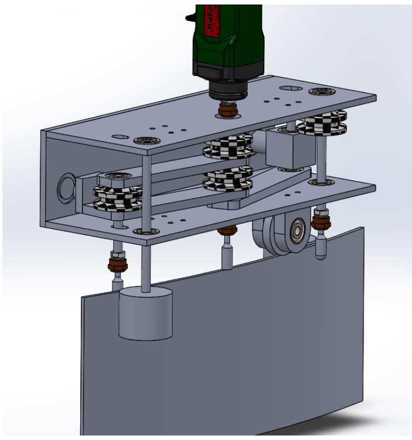


Figure 4.5: Design of adjustable gearbox

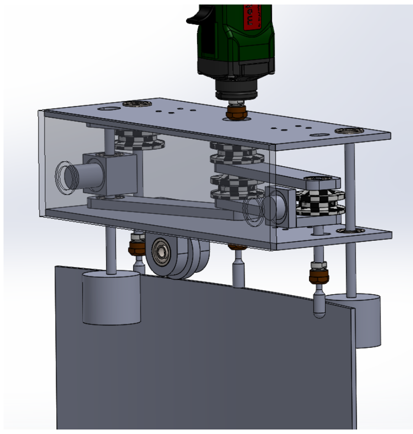


Figure 4.6: Design of adjustable gearbox

A second iteration of this design is needed. There are some size problems and it has to be made more portable. Researching to find an existing gearbox like this resulted in nothing. It is also suggested to test the gearbox with the belt drive. The mill has quite high rotations and needs these to get the wanted result. Having 3 mills connected to this would maybe be too much for one mill like this. A solution with 2 or 3 mills at the same time could also offer a great solution. However this would result in only creating a holder for 3 mills oriented properly with to one another.

5 Discussion

No final design and solution was managed to be constructed during the internship. This is related to some different factors. In the beginning communication was a bit hard, this gave the main assignment quite a set back to begin with. In the beginning period other things were done simply to get to know the people, learn the basics for the language and figure out what is actually being done in the factory. It took quite some time to document all the current processes and learn all the production processes in detail.

During the prototyping it became clear that full automation of this single process was not going to work. Even though this was asked to be done, within the current production of the tank full automation would not fit. Main reasons is the available space, the flexibility needed of the tool (which also has to be used in a different hall) and the needs of the workers that have to be full-filled. This showed that full automation for the tank production would be a better investment then just having one process being automated. When the complete production is automated this would make the use of the space way more efficient. Even though the prototype has not been built a lot is learned about such a project within a production company. There is way less focus on one project and there are rather 5 or 6 projects going on at the same time making a designing project like this slow.

Other project as a project manager definitely took quite some time and made the process slower than wanted. Having to put people to work especially work you have not done before takes time. It is very important to first do a process yourself to find out how it works before you give the task to somebody else. Managing different projects also shows how to put priorities to the different projects. For certain projects there were deadlines which were hard deadlines due to audits that would be planned.

6 Conclusion

It can be concluded that a successful TRIZ-analysis has been performed giving a lot of solutions to the problem. TRIZ was very helpful in defining the problem and finding solutions not only in one single direction. There were quite some difficulties in defining what the company really wanted and mixed opinions were given by production management and production workers. This resulted in two different prototypes in their beginning state not worth being developed and tested. It is suggested to fully automate the production of the tank instead of automating a single process.

The task of a project manager has been successfully completed. The work environment was pleasant and language barriers were resolved. The internship is completed satisfactorily from both the company and the intern. Besides the main project a lot of other smaller projects have been successfully completed as can be read in the chapter 7.

7 Project management

As a project manager at Schrader T+A Fahrzeugbau there was more then just the main assignment. Different projects were running at the same time. Different German interns were doing their own internship with me leading the progress. In these projects also i have gained some practical skills which are also used on the work floor. Besides smaller projects there were 4 main project. The bicycle rack, axle measurement system, Rebuilding of a complete workstation and redesign of an inventory system.

7.1 Bicycle rack

The bicycle rack was the first project under my supervision. The goal was to design and build a bicycle stand with roof. There was some material available to build the stand and this had to be used. First the requirements for the bicycle stand were collected.

7.1.1 Requirements

To start the design of the bicycle rack the following requirements were collected.

1. The stand should be placed against the Tankbau halle
2. It should span 9 meter in width
3. It has to be fixed to the ground
4. It should have lights
5. It should have spots for electric bikes to charge
6. It should able to be moved in pieces
7. It should be protected against all weather

These requirements are taken and some basic research was performed on what typical dimension for a bicycle rack are. Next the designing started. The bicycle stand is split up in 7 different segments. There are 2 back pieces, 2 sides pieces, 2 roof pieces and one centre piece. These part are bolted together so they can be taken apart again if the bicycle stand has to be moved. See figure 7.1 and 7.2 for the bicycle stand design. The position for the bicycle stand to be placed was on a rather large slope. Therefore the feet had to be extended. To allow for variation a special adjustment foot has been designed. This will be placed on every single corner of the bicycle stand see figure 7.3.

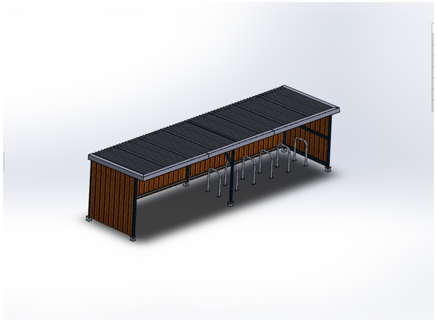


Figure 7.1: Outside view of the bicycle stand design

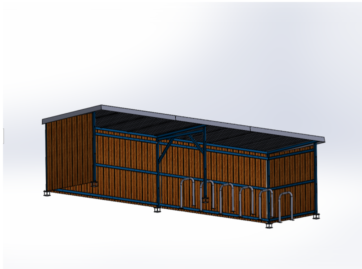


Figure 7.2: outside view of bicycle stand design

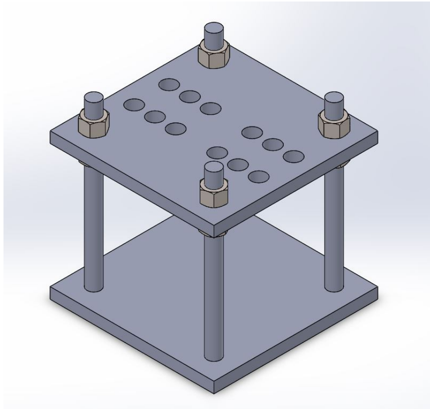


Figure 7.3: Adjustment foot

Using some basic static calculations it was checked if the roof could support a construction worker to go up the roof to fit the roof tiles. As the material used was way stronger then actually needed for this application no problems were found. The next step was ordering the material and planning the building process. For The ordering some drawings had to be made. These drawings can be seen in appendix 8.2

For building the bicycle rack there were 3 other interns that would help building. The build was finished after 3 weeks. The first week there was full time building with 2 persons. The second week there was a 3rd man helping. In the final week some smaller adjustments had to be done to the roof to fully finish the bicycle stand. Besides the team, appointments had to be made with workers within the production area. There were parts that have to be welded on a flat surface within the production hall. All in all about 10 different people worked on this project throughout the whole procedure.

7.1.2 Discussion

The challenge in this building process was mainly related to communication. The language barrier made it in the beginning hard to make clear what had to be done. Besides that the building took way longer then expected. This is because the tools used were not optimal. For the next project a better inventory on the exact production steps has to be made. In the end there were more tools available which simply were unknown to the project manager at that time. Using better equipment would have saved half the time and resulted in better quality parts. There were quite some rough edges on the beams as they were cut with a large angle grinder with a cutting disc.

7.1.3 Conclusion

In the end the bicycle stand has been successfully built. It fits to all requirements and a lot of practice has been done managing a small production team within the company. As project manager there are a lot of things to improve mainly related to planning and making an inventory on the production process. Besides that the working atmosphere during this project was good.

7.2 Rebuilding stage

One of the areas where the main project will be used needed a new working area. The area needed a new stage to work on a higher level as the old one was not sufficient any more. To do so there was an existing stage that had to be cut up in order to make it fit. To make the new stage work some requirements are given. The stage that will be transformed is a stage used during a fair. To safe building a complete new stage spending a lot of money this stage will be transformed using similar materials.

7.2.1 Requirements

For the design of the new stage there are some requirements.

1. The stage should have the proper working height.
2. An easily removable bridge is preferred.
3. The stage should be able to be brought back in its original configuration, this means no part can be cut of the original stage.
4. A similar look is preferred.
5. A design in Solidworks has to be made to copy the build if needed.
6. Aluminum has to be used.

To start of the initial design is evaluated and the parts are collected. The stage consisted out of 2 of the same stages with a staircase on one end and railing on both sides of the walkway. In figure 7.4 the new stage design can be seen. The red parts are the part from the initial configuration and are depicted as simple blocks that cannot be changed. In appendix 8.4 the drawings for the parts can be seen.

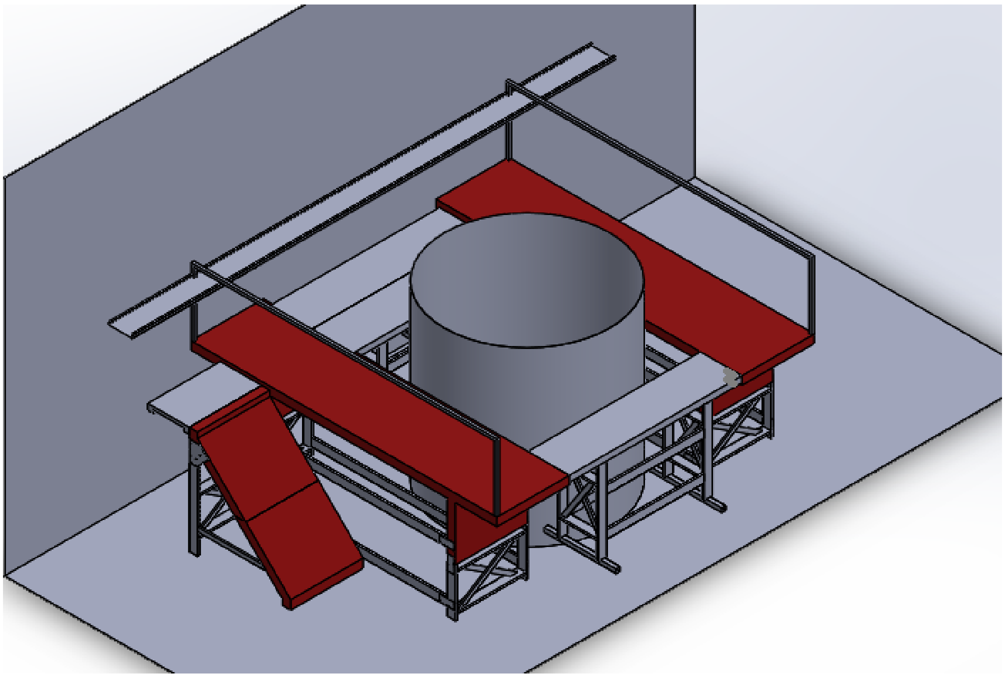


Figure 7.4: Design of the new stage for the production area. Red parts are from the initial configuration.

7.2.2 Discussion

The main problem during this smaller project was the challenge of adapting the stage without destroying the original design. At the start it was thought that the design could be broken down. However after discussion being able to be put back to the original design was more beneficial so the stage could maybe be used in the future for another fair. This change of design took quite some time as everything from the first drawings had to be scrapped. In the end the stage fitted perfectly and the workers were happy with the new precautions.

Besides the new stage there were adjustments to the existing stages that had to be made. Because the stage has to be adjustable due to different lengths of vehicles being worked on there was no guide rail to protect the workers between the stairs and the bridge. This is solved by having a chain in between and a adjustable slide to made sure one cannot slip his foot off the stage and get hurt.

7.3 Inventory sorting system

Another project was sorting the inventory situated outside behind the Aufbau Halle. There are quite some different types and sizes of parts stored here. The goal of this project was to create a structure in the sorting system. Things are stored where there is space. But not on a specific spot. Besides just creating structure the inventory has to be labeled and signs have to be placed. Besides the space behind the Aufbau Halle has to be made bigger. New patches of land will have to be cleared out so everything can be sorted properly.

In discussion with the colleagues from the storage a new way of sorting has been discussed. The main problem was sorting the cabinets that are there. A list of present cabinet was collected and model of the space behind the hall was made. It was decided to sort the cabinets from large width to small width counter clockwise. This because the larger cabinets are used more often. The space designed can be seen in figure 7.5

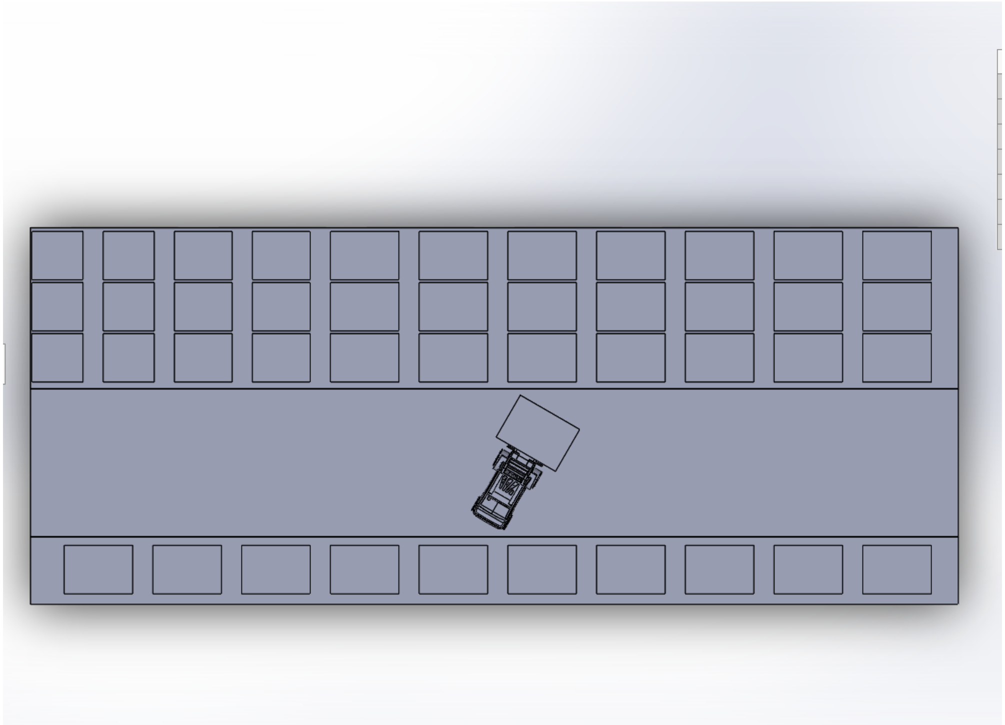


Figure 7.5: available space with sorted cabinets

Important was to keep enough space for the forklift to keep being able to turn in the area with the cabinets. The next step was organizing so the pieces would be put on the spot. This was hard as there was limited time for using the forklift and therefore it took longer then needed.

With a team of 3 people the cabinets were moved away. The area was quickly cleaned and the new cabinets were placed on the spot. After that signs with according information were attached to the wall to indicate which cabinet it is.

This project needed little knowledge but it did provide a lot of insight in sorting parts but also a lot of insight in all the different parts of the trailer. All cabinets for example are used in different configurations. Different requirements for different clients give different cabinets that are needed on a trailer.

7.4 Axle measurement

For Attaching the axles to the trailer they have to make sure the axles are properly aligned. A self fabricated measurement system is used to do this. However this measurement system is quite old and there were some efficiency issues in using the mechanism. It was asked to first document the measurement current measurement system and then find a way to improve the system. It was not asked to come up with a final solution, but mainly think about the current process and see how it can be improved with the colleagues from the production team.

7.4.1 Current measurement system

It is unknown who design the measurement system but it was probably designed a couple of decades ago by the production workers. The idea of the measurement system is very simple. The distance with respect to the towing vehicle has to be equal on both sides of the trailer and it has to be horizontal under the trailer. Otherwise there will be unequal wear on the tires of the trailer and it will influence the driving behaviour of the vehicle. The axles are attached while the trailer is upside down. Depending on the length of the tank a long rod is used to measure out the placement of the axles with respect to the kingpin see figure 7.6. For the kingpin a special attachment has been made to model the position of the towing vehicle that will be attached to the trailer.

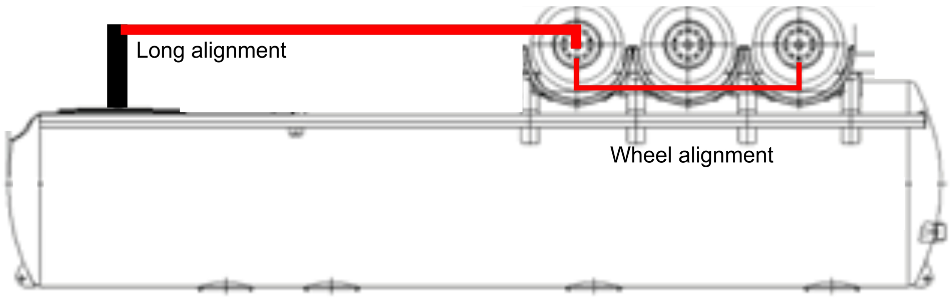


Figure 7.6: Method of aligning the axles of the trailer.

To make sure that the centre of the axles are properly aligned they will also be measured from the centre of the axles. A short measuring stick is used with a standard measurement which is a standard size.

All parts of the measurement system were measured and documented in Solidworks drawings. This is done for future reference but also to finally document the measurement system. The Solidworks drawings can be seen in Appendix **??**

7.4.2 Redesign

To redesign this measurement system providing the right accuracy is key. The current system is old and takes quite a bit of time in using it. But in its simplicity it is very consistent. It will be the same every time with only small influence from environmental effects. The biggest error that can come from human error.

Now for the redesign it would be best to take out the human error. Therefore a fully autonomous measurement system will have to be used. A Laser system was suggested to measure out the distance from the kingpin see figure 7.7. This simple sketch displays a simple mechanism where lasers are used to measure out the distance to all 3 axles. Using light feedback the system can very easily say of all axles are aligned properly. Working out this system would take quite some time and was not asked to be finished during my internship. There are a couple of requirements that have to be met.

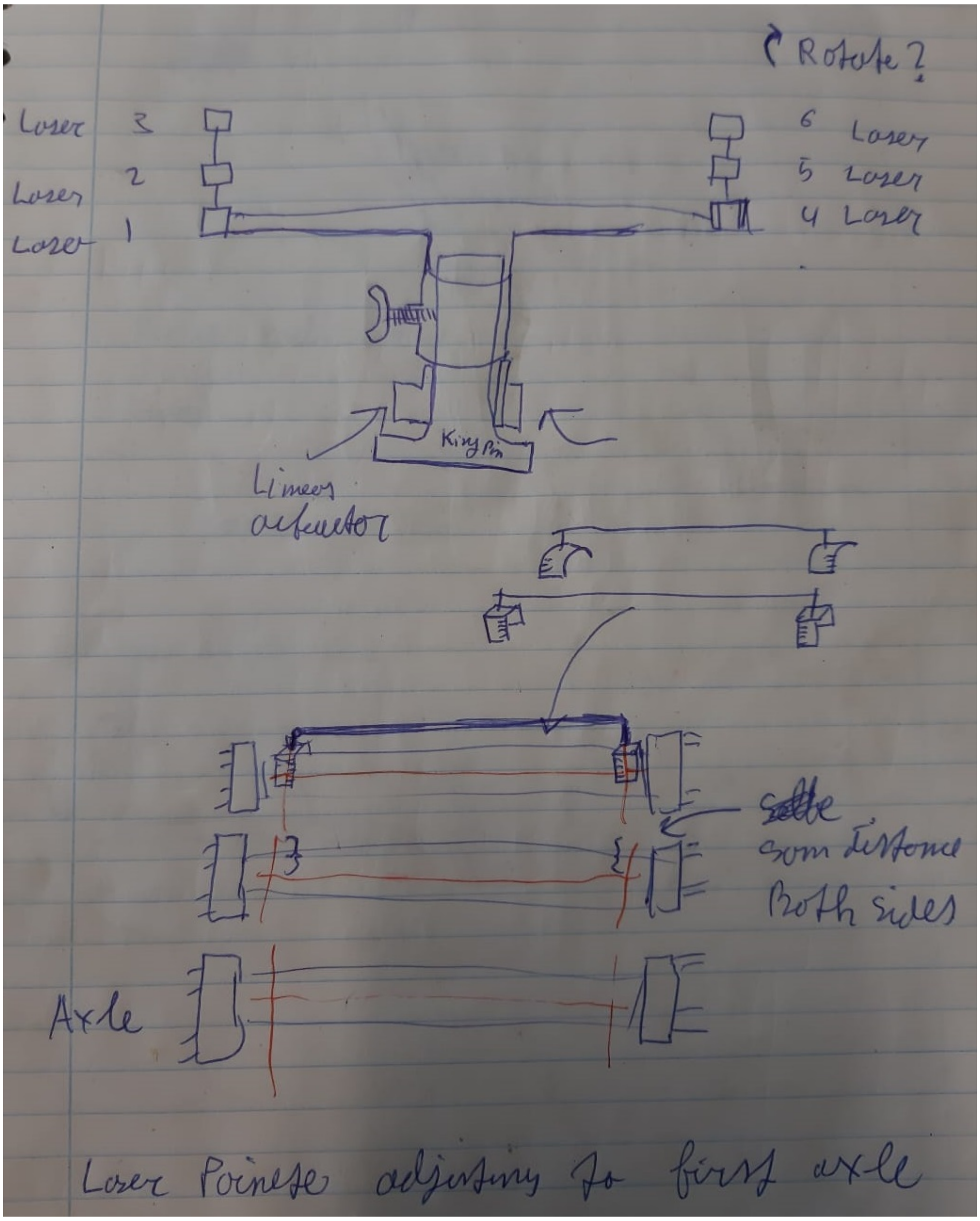


Figure 7.7: Sketch of suggested redesign

For redesign the following points will have to be taken into account.

1. Robust design for production environment
2. Easy donning and doffing
3. Lightweight
4. Stiff design
5. Reference from Kingpin
6. Remotely adjustable

8 Appendix

8.1 Appendix 1: RCA+ analysis

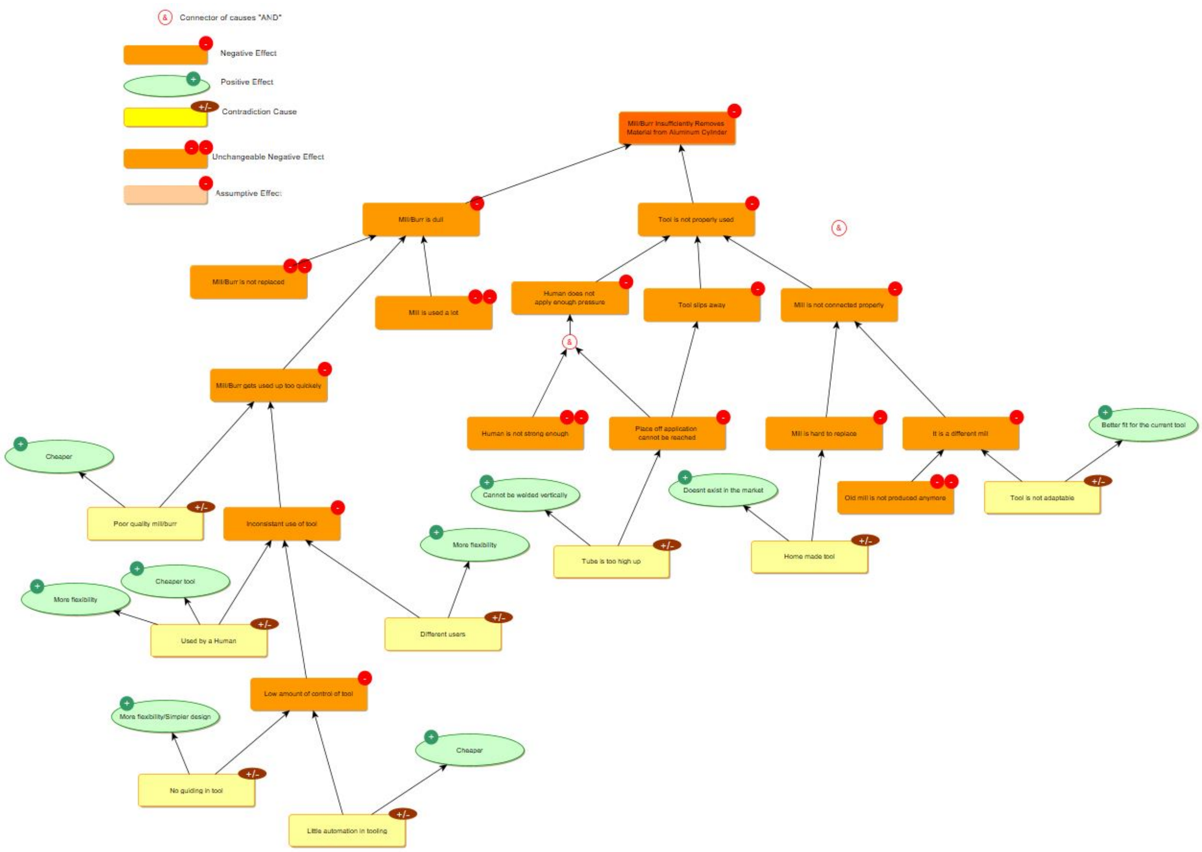
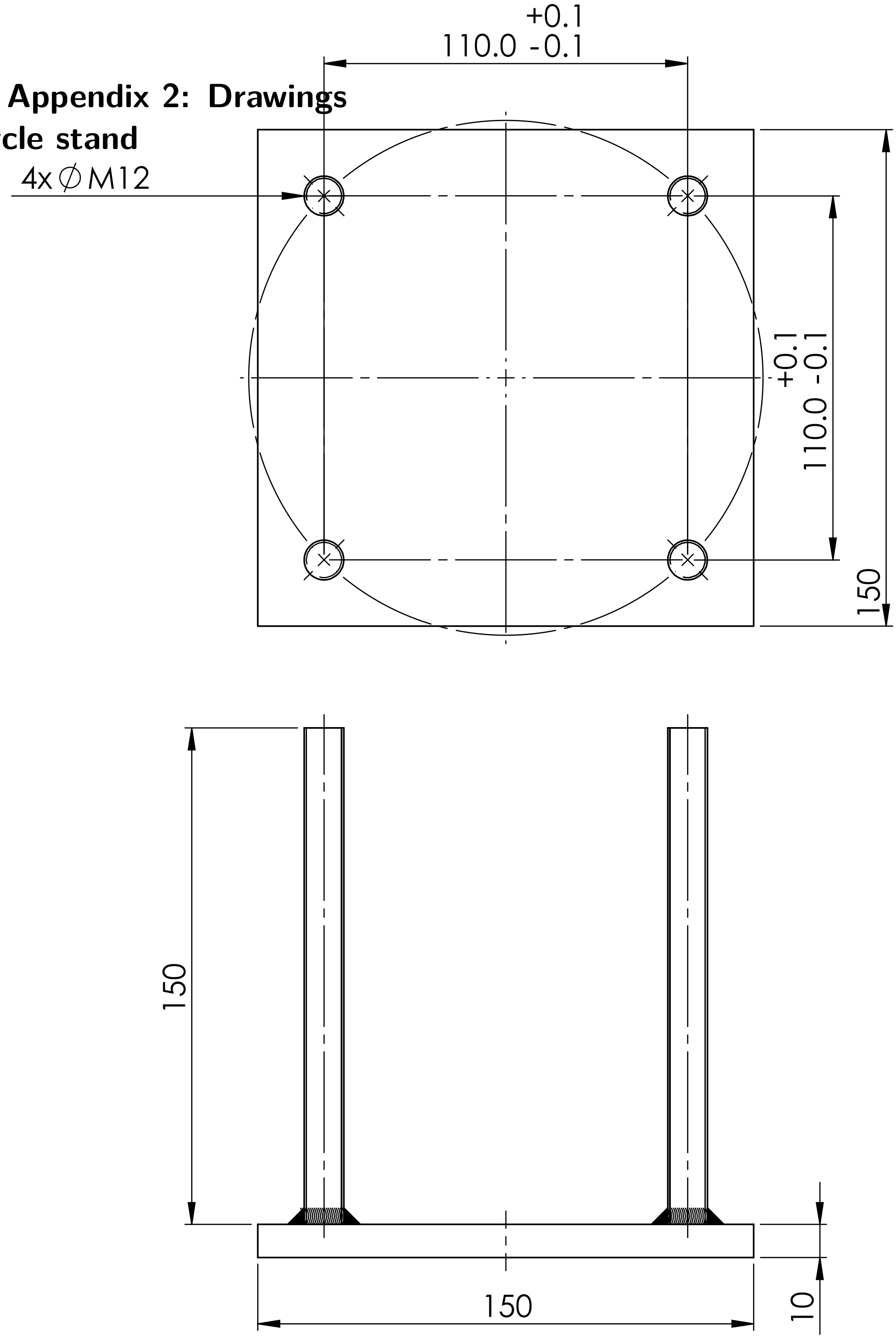


Figure 8.1: RCA+ Analysis

8.2 Appendix 2: Drawings

bicycle stand



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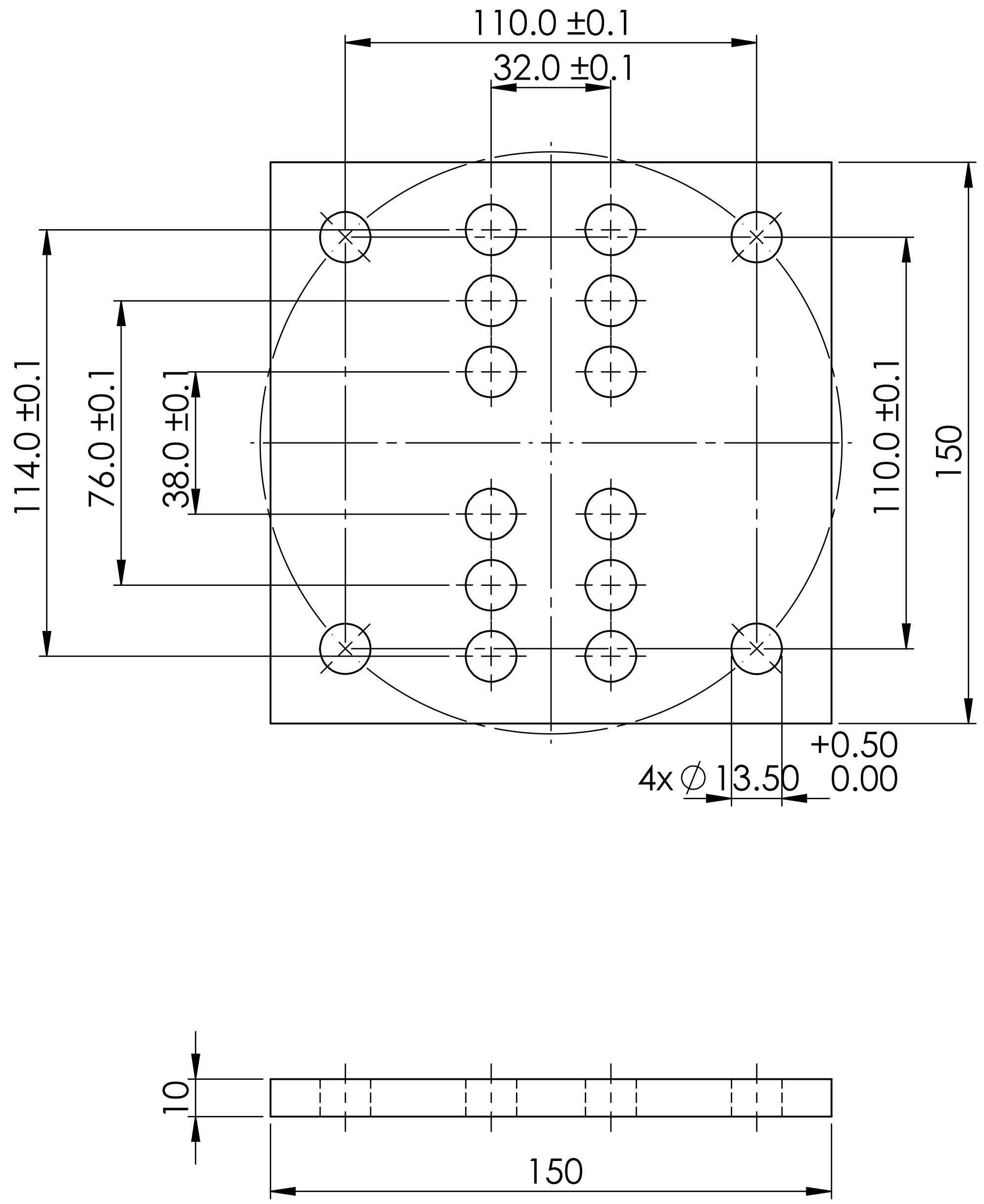

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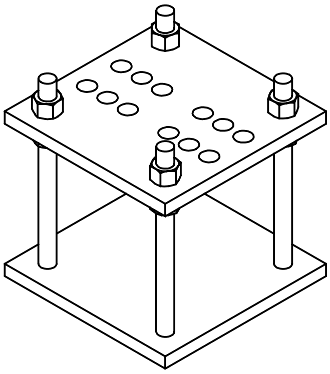

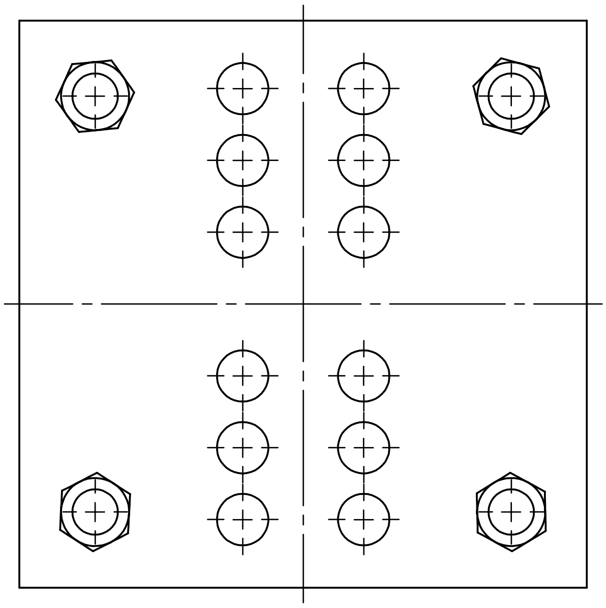

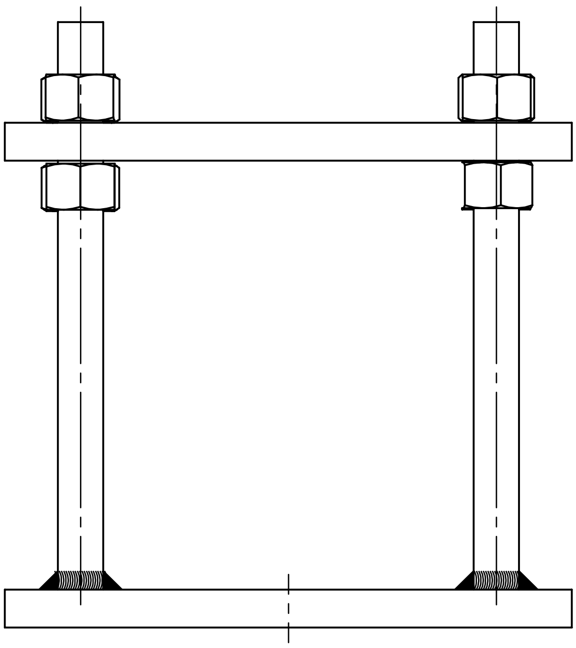

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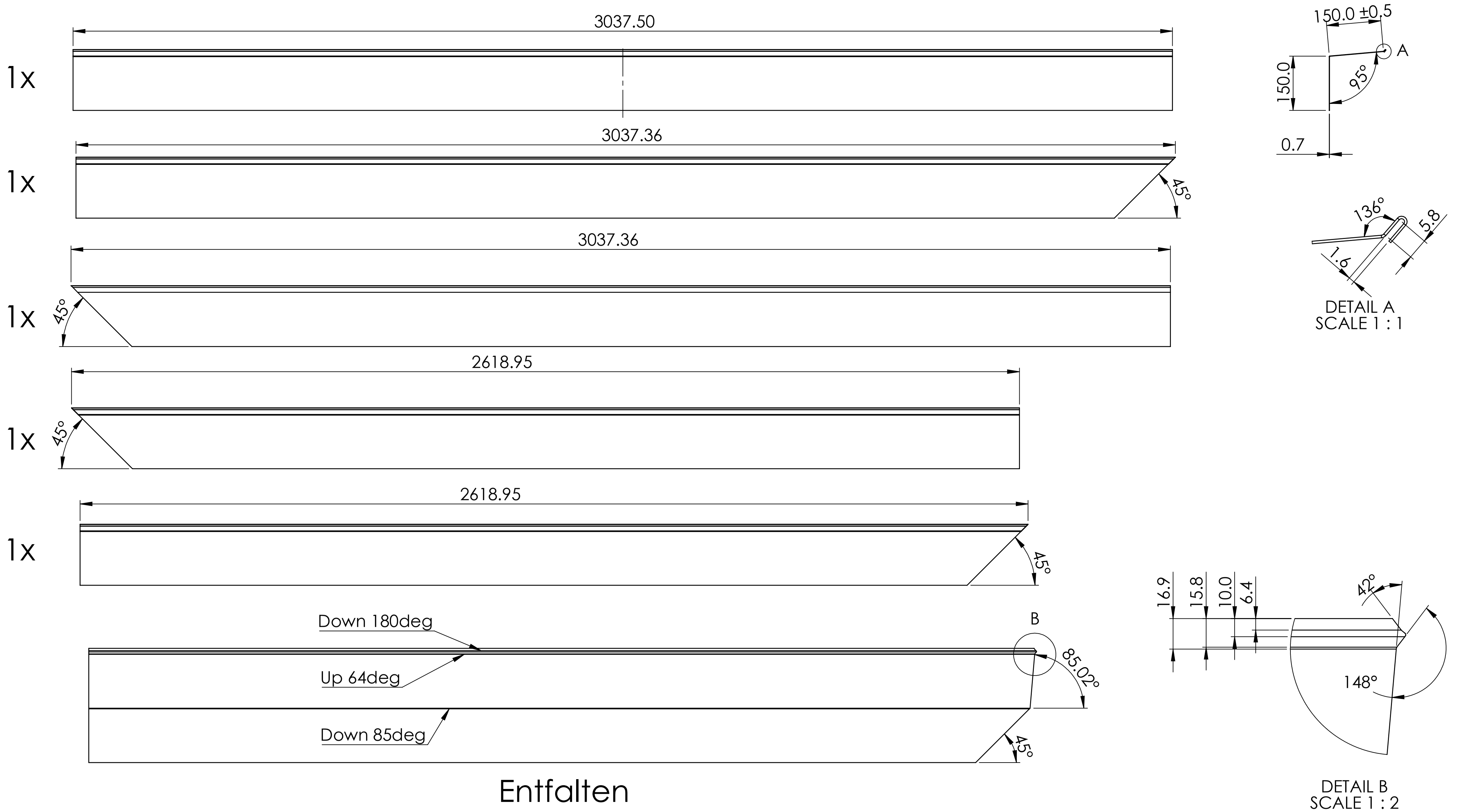

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8.3 Appendix 3: Drawings

Axle aligment

JOST King_pin
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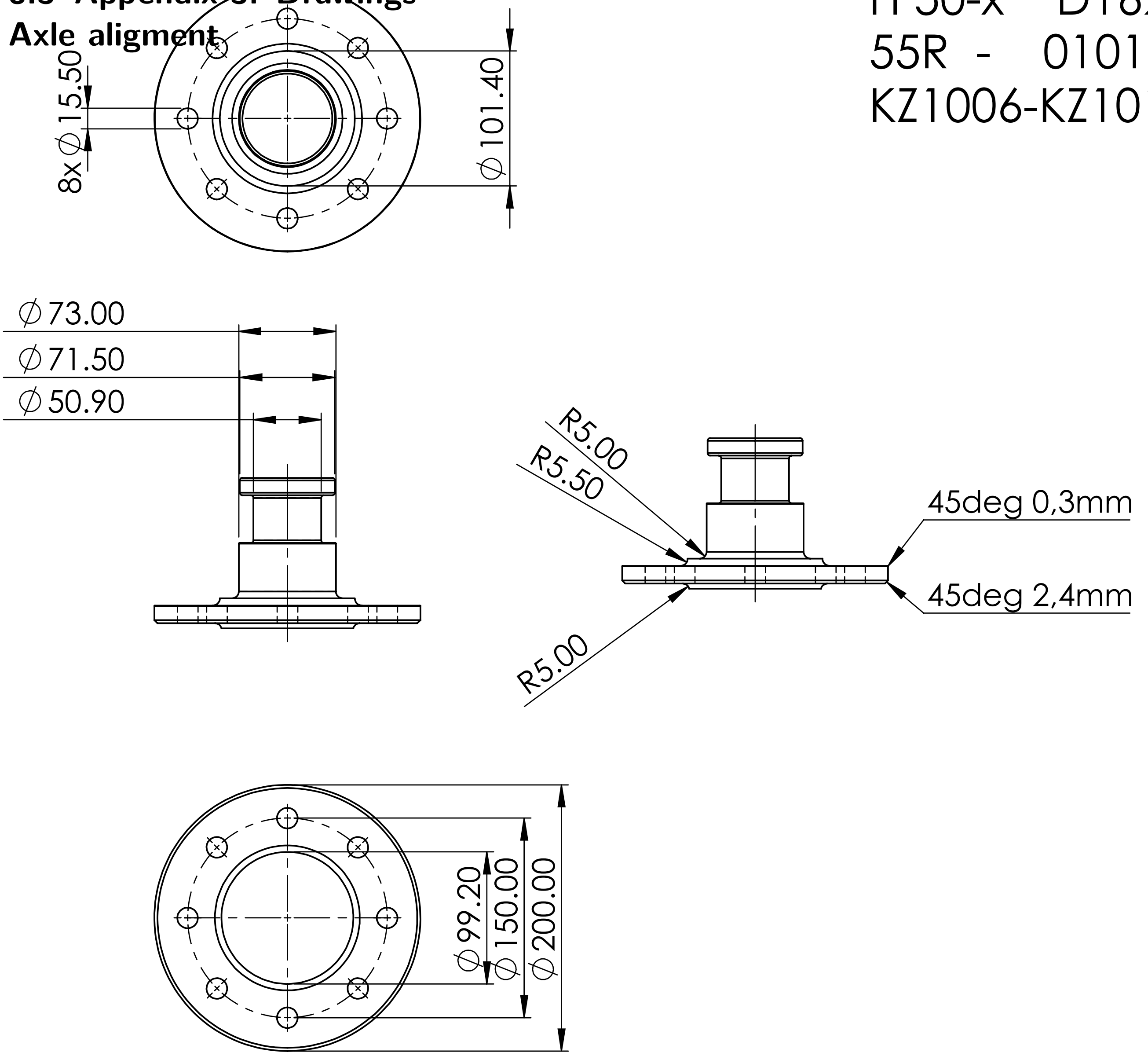
H 50-x D162
55R - 010145
KZ1006-KZ1012



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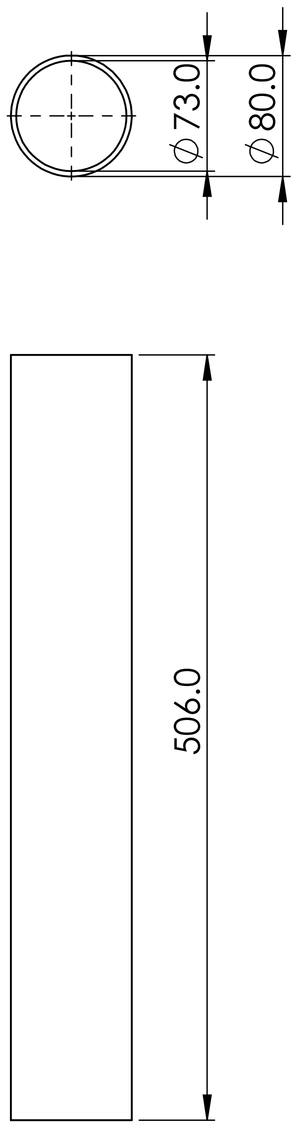

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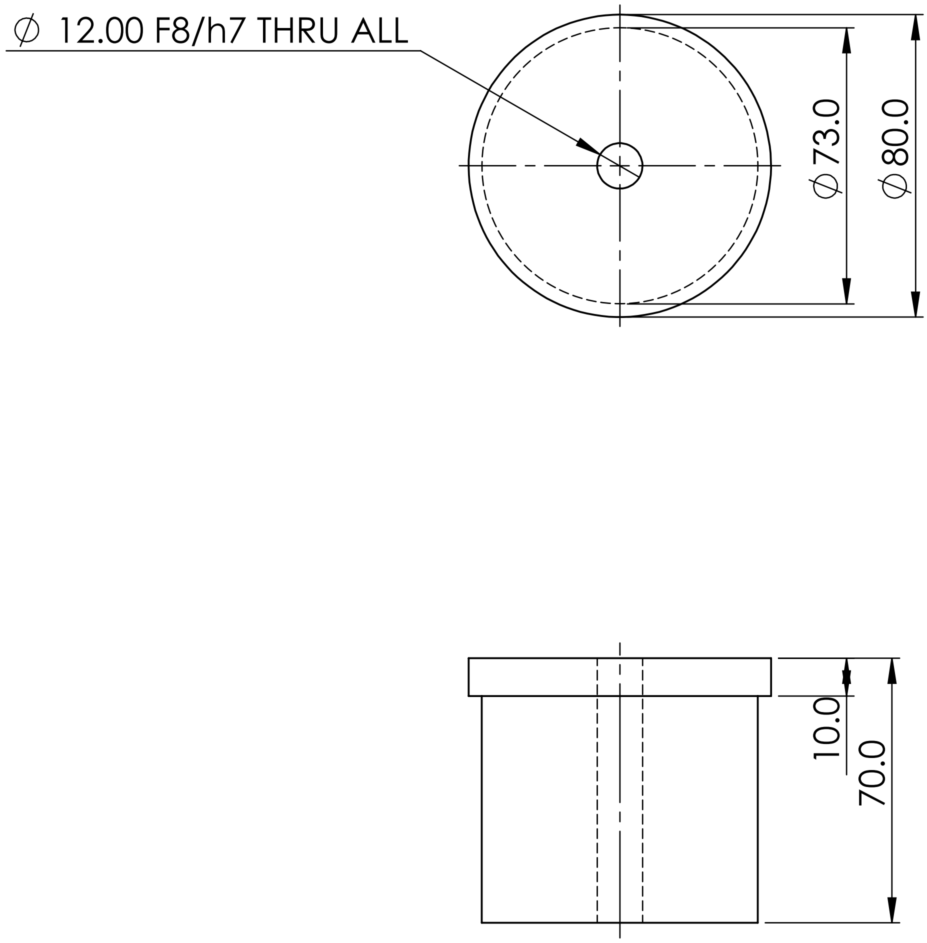

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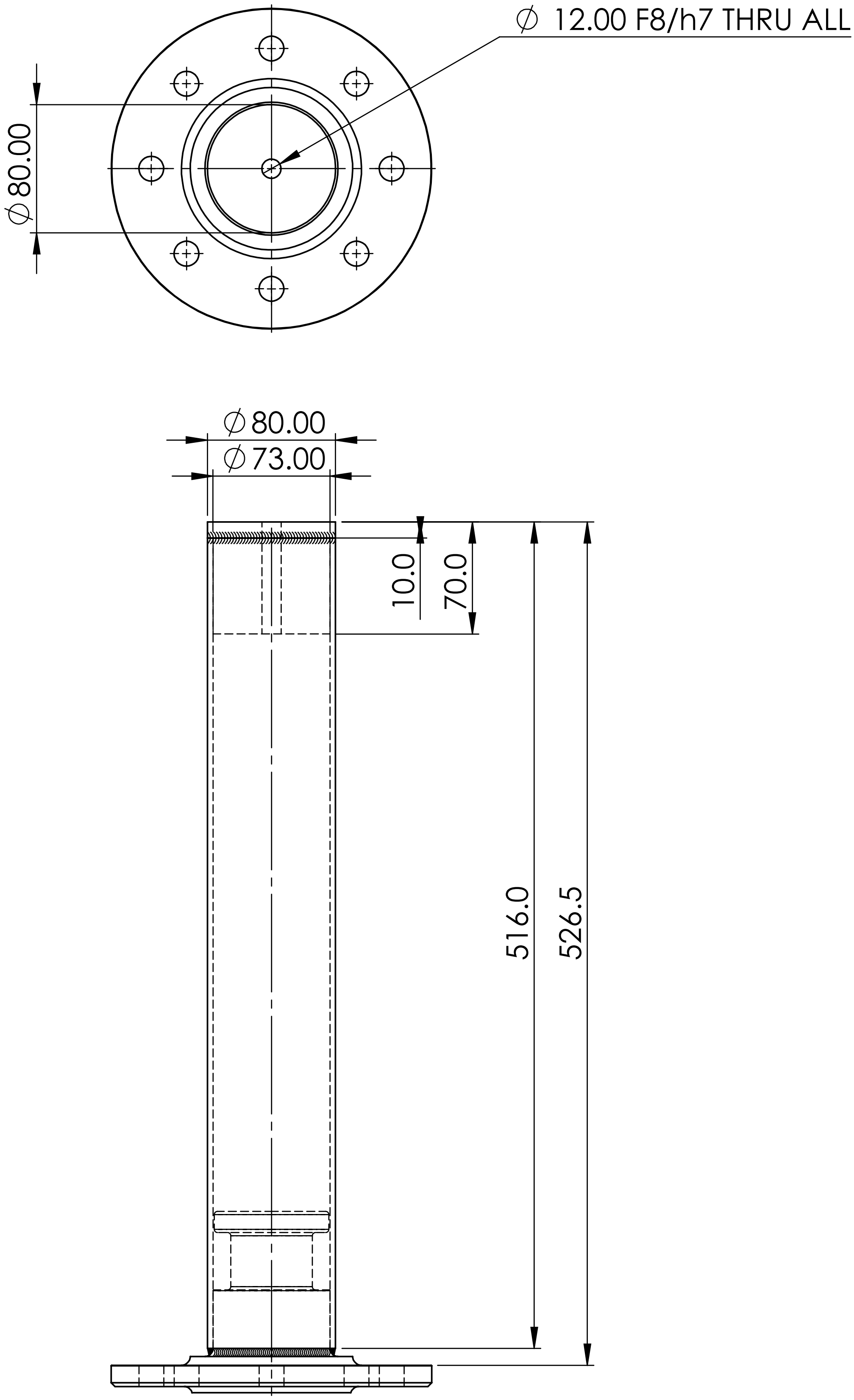

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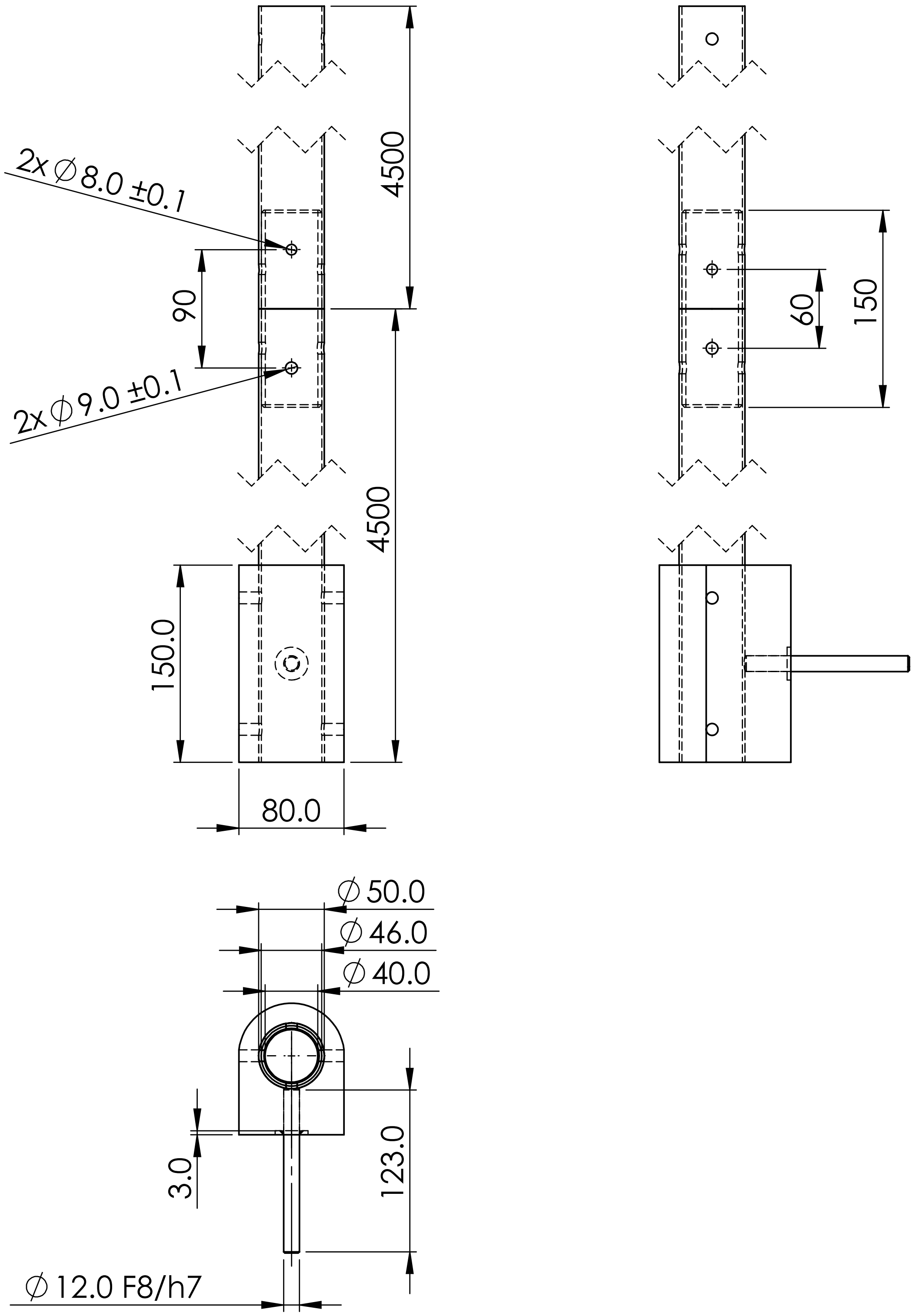
	Datum	Name	Benennung: Montage
Bearb.	28/09/18	Rick Timmer	
Gepr.			
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS		Zeichnungs-Nr.: King_pin_Achsen_ausrichtung.004	A4 Blatt 4 von 4

Index	Änderung	Datum	Name

G:\My Drive\Internship_map_Schrader\Axle)_measurement_device\Lange_achsen_ausrichtung\ Druckdatum: 9/28/2018

Entstanden aus:	Ersatz für:	Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Alu

Maßstab: 1:5

Allgemeintoleranz 0,5mm

Oberflächenangaben

Kom. Nr.

	Datum	Name
Bearb.	09/24/18	Rick Timmer
Gepr.		

Benennung

Montage

SCHRADER FAHRZEUGBAU WERK ELLINGHAUS

Zeichnungs-Nr.

Lange_Achsenausrichtung.004

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Index	Änderung	Datum	Name

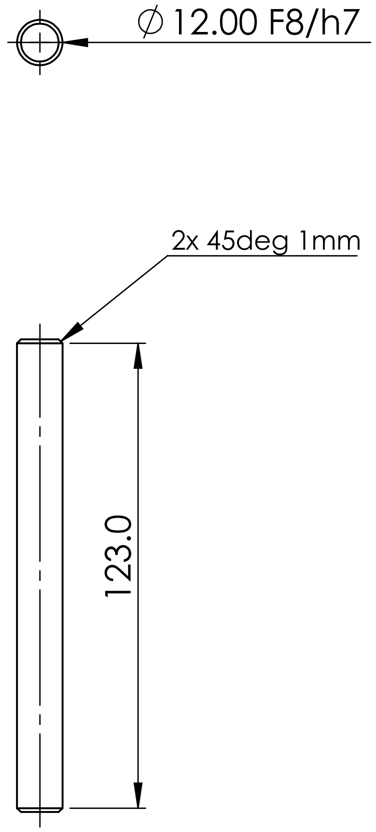
G:\My Drive\Internship_map_Schrader\Axle]_measurement_device\

Druckdatum: 10/8/2018

Entstanden aus:

Ersatz für:

Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug
Alu

Maßstab
1:2

Allgemeintoleranz
0,5mm

Oberflächenangaben

Kom. Nr.

	Datum	Name
Bearb.	09/24/18	Rick Timmer
Gepr.		

Benennung

Pin

Index	Änderung	Datum	Name

SCHRADER
FAHRZEUGBAU
WERK ELLINGHAUS

Zeichnungs-Nr.
Lange_Achsenausrichtung.001

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G:\My Drive\Internship_map_Schrader\Axle)_measurement_device\

Druckdatum: 10/8/2018

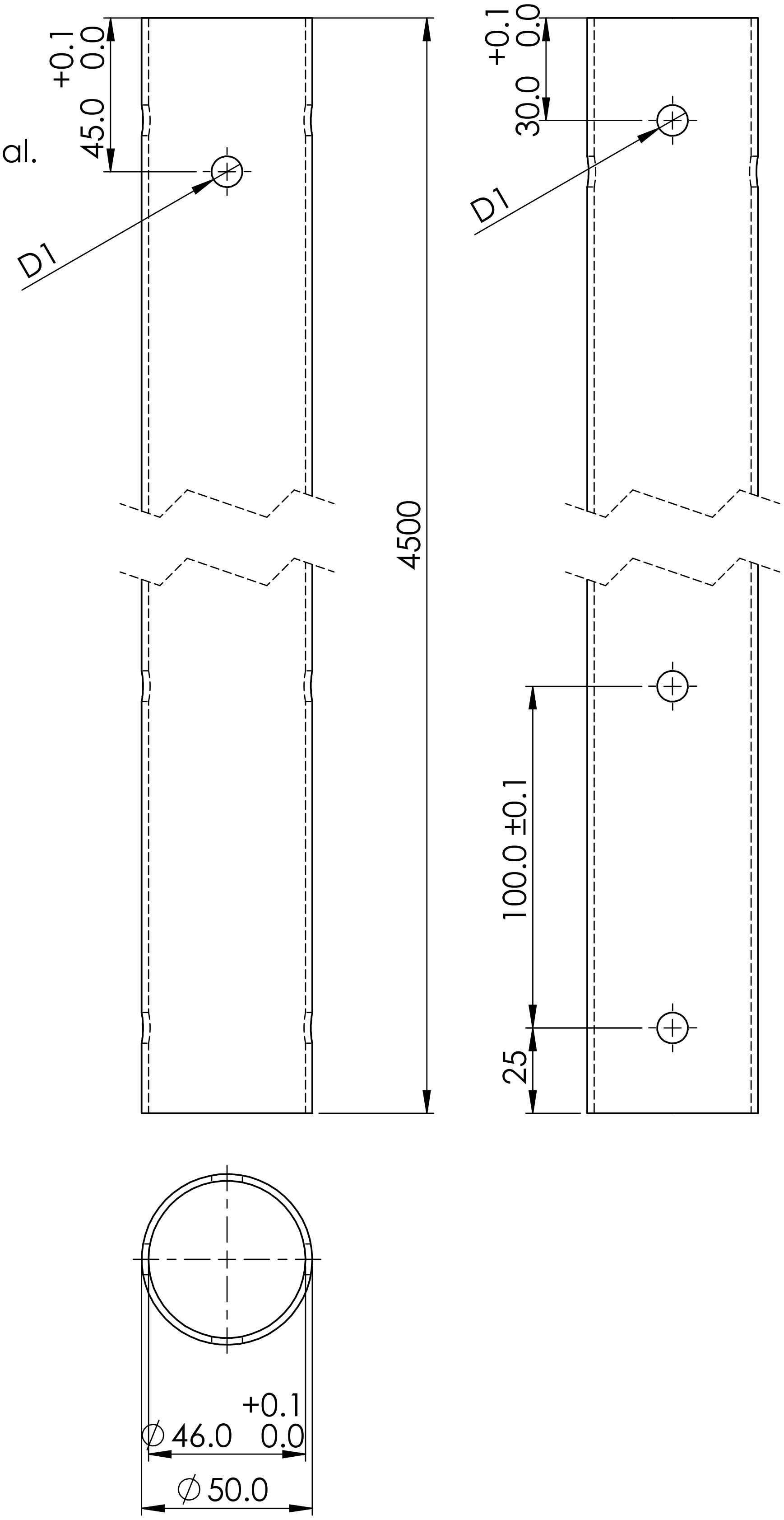
Entstanden aus:

Ersatz für:

Ersetzt durch:

oft	D1
1x	9.0mm
1x	8.0mm

Es gibt 2 Varianten.
Wir brauchen beide einmal.



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Federstahl	Maßstab: 1:2	Allgemeintoleranz 0,5mm	Oberflächenangaben
		Kom. Nr.	
	Datum	Name	Benennung: Rohr
Bearb.	09/24/18	Rick Timmer	
Gepr.			
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS		Zeichnungs-Nr.: Lange_Achsenausrichtung.002	A4, Blatt 3 von 5

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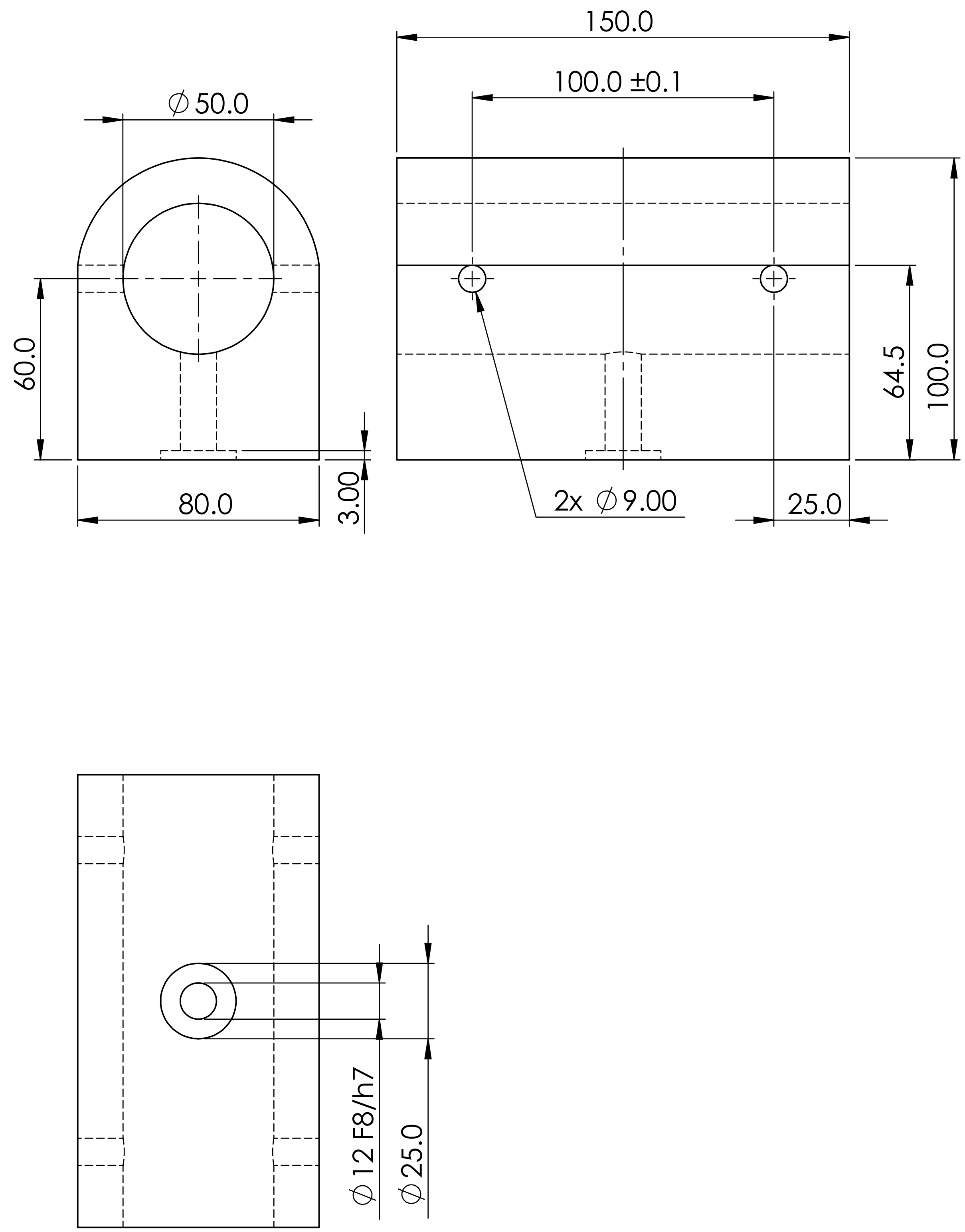
G:\My Drive\Internship_map_Schrader\Axle]_measurement_device\

Druckdatum: 10/8/2018

Entstanden aus: | Ersatz für: | Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

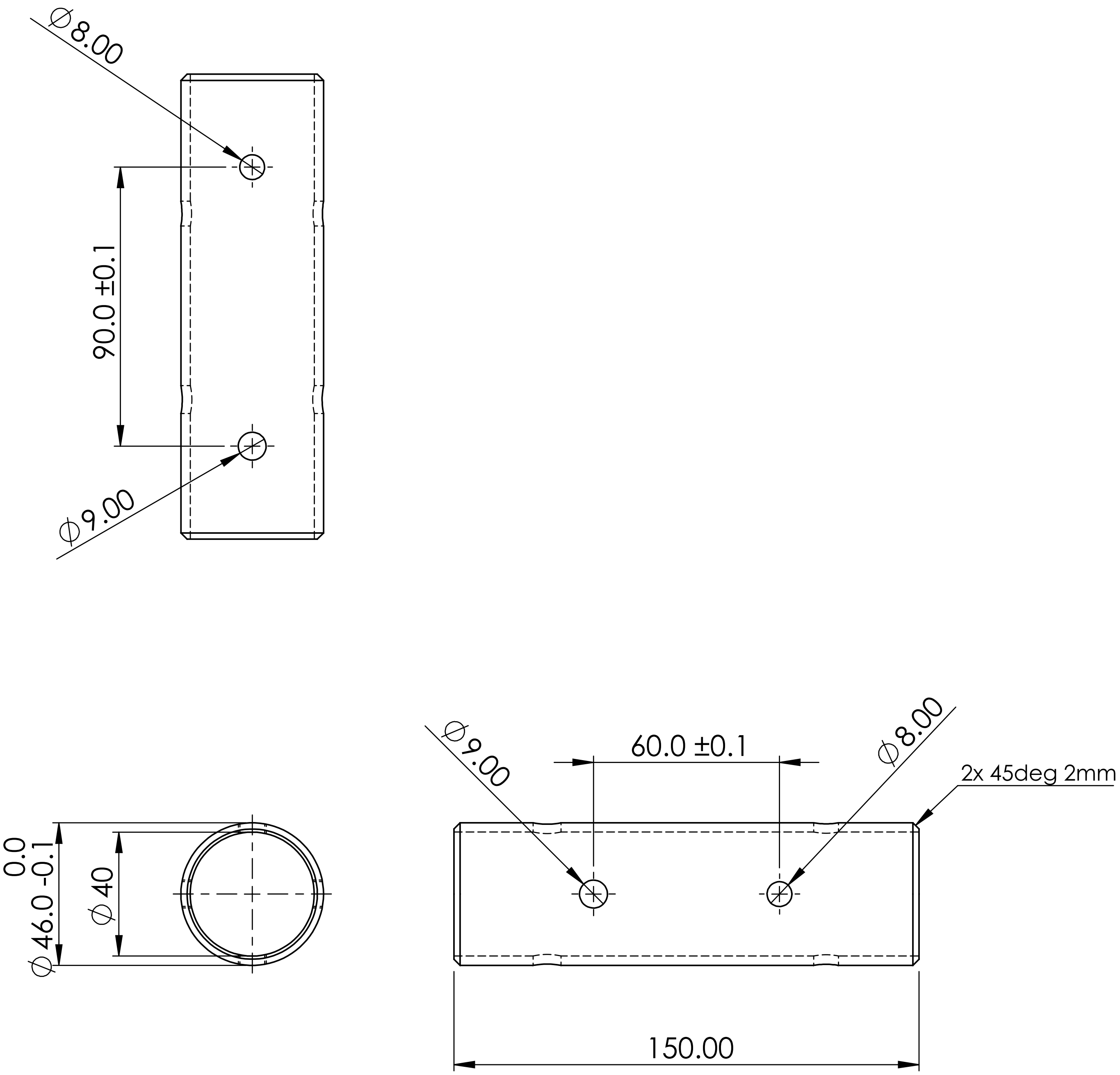
Werkstoff, Halbzeug: Alu	Maßstab: 1:2	Allgemeintoleranz 05,mm	Oberflächenangaben
		Kom. Nr.	
	Datum	Name	Benennung: Pin_holder
Bearb.	28/09/18	Rick Timmer	
Gepr.			

Index	Änderung	Datum	Name

SCHRADER FAHRZEUGBAU WERK ELLINGHAUS

Zeichnungs-Nr.: Lange_Achsenausrichtung.003 — A4 — Blatt 4 von 5

G:\My Drive\Internship_map_Schrader\Axle]_measurement_device\ | Druckdatum: 10/8/2018 | Entstanden aus: | Ersatz für: | Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Alu	Maßstab: 1:2	Allgemeintoleranz 0,5mm	Oberflächenangaben
		Kom. Nr.	
	Datum	Name	Benennung: Rohr_connector
Bearb.	04/10/2018	Rick Timmer	
Gepr.			
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS			Zeichnungs-Nr.: Lange_achsenausrichtung.005
			A4
			Blatt 5 von 5

Index	Änderung	Datum	Name

G:\My Drive\Internship_map_Schrader\Axle)_measurement_device\

Druckdatum: 10/8/2018

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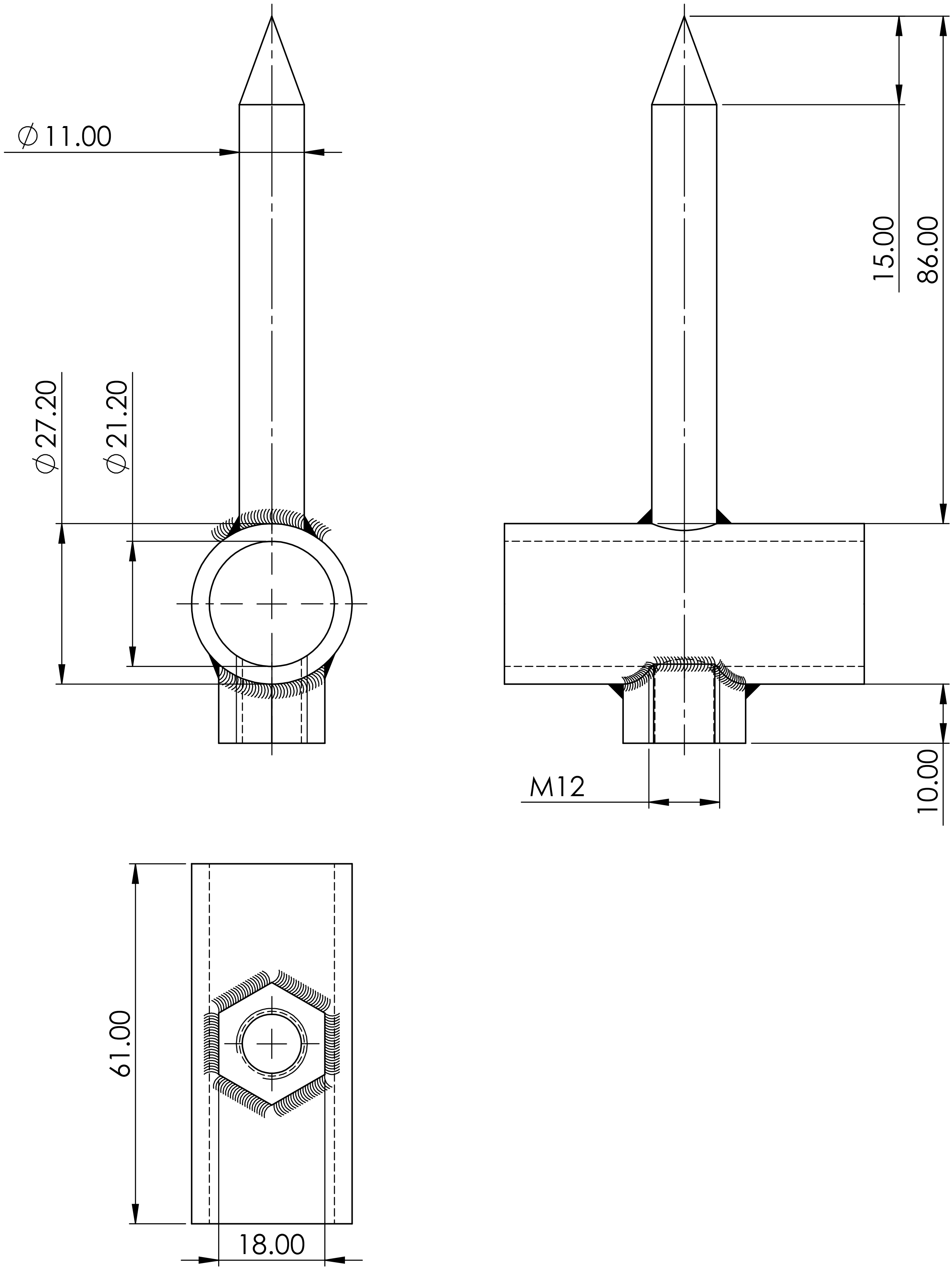

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug
Edelstahl
und Stahl

Maßstab
1:1

Allgemeintoleranz
0,5mm

Oberflächenangaben

Kom. Nr.

	Datum	Name
Bearb.	09/24/18	Rick Timmer
Gepr.		

Benennung
Stell_Pin_4

Index	Änderung	Datum	Name

SCHRADER
FAHRZEUGBAU
WERK ELLINGHAUS

Zeichnungs-Nr.
Kurze_Achsenausrichtung.001

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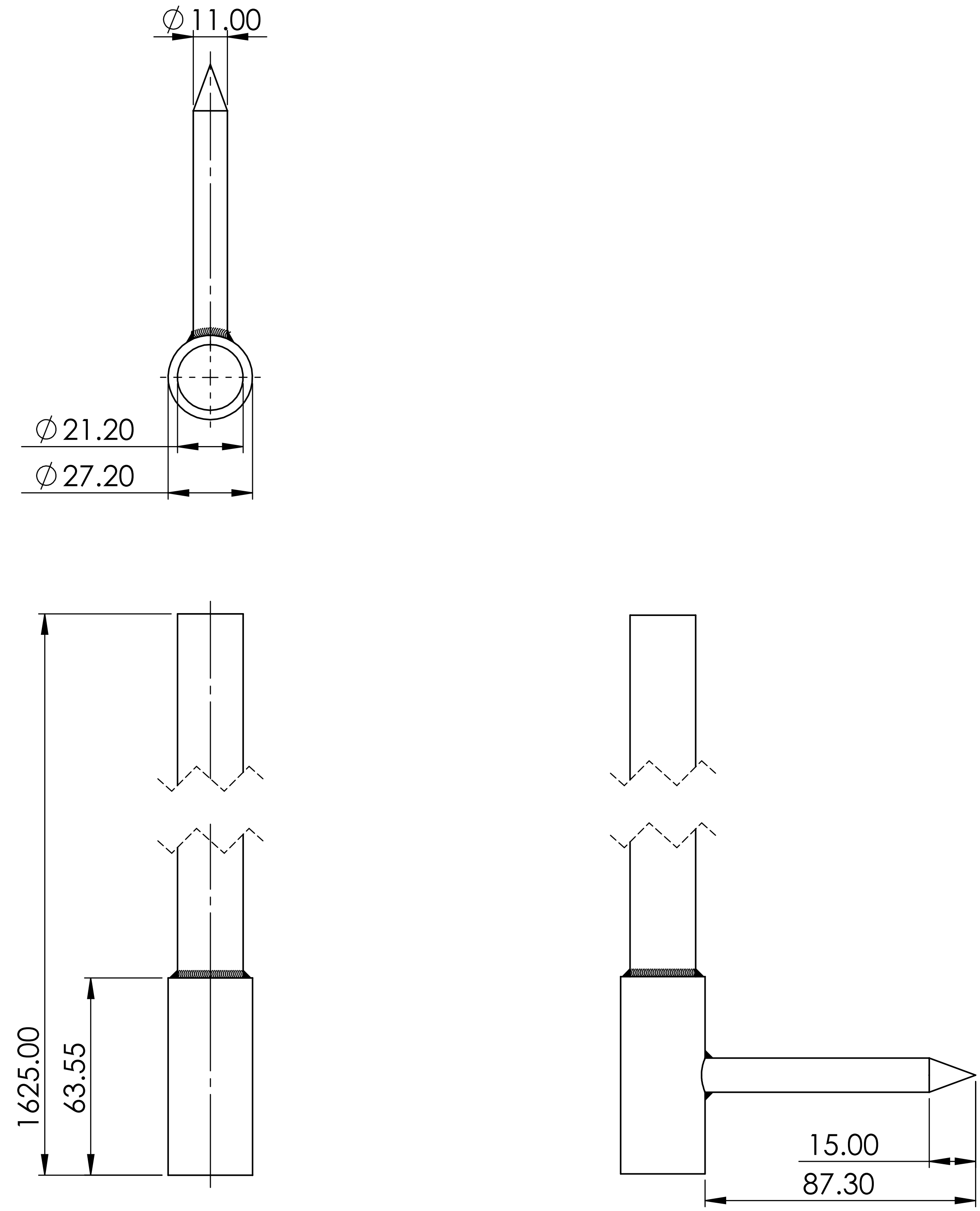
G:\My Drive\Internship_map_Schrader\Axle]_measurement_device\

Druckdatum: 9/26/2018

Entstanden aus:

Ersatz für:

Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug
Edelstahl
und Stahl

Maßstab	Allgemeintoleranz	Oberflächenangaben
1:2	0,5mm	

Kom. Nr.

	Datum	Name
Bearb.	09/24/18	Rick Timmer
Gepr.		

Index	Änderung	Datum	Name

SCHRADER FAHRZEUGBAU
WERK ELLINGHAUS

Benennung
Pin_Stange

Zeichnungs-Nr.
Kurze_AchsenAusrichtung.002

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Blatt 2 von 3

G:\My Drive\Internship_map_Schrader\Axle)_measurement_device\
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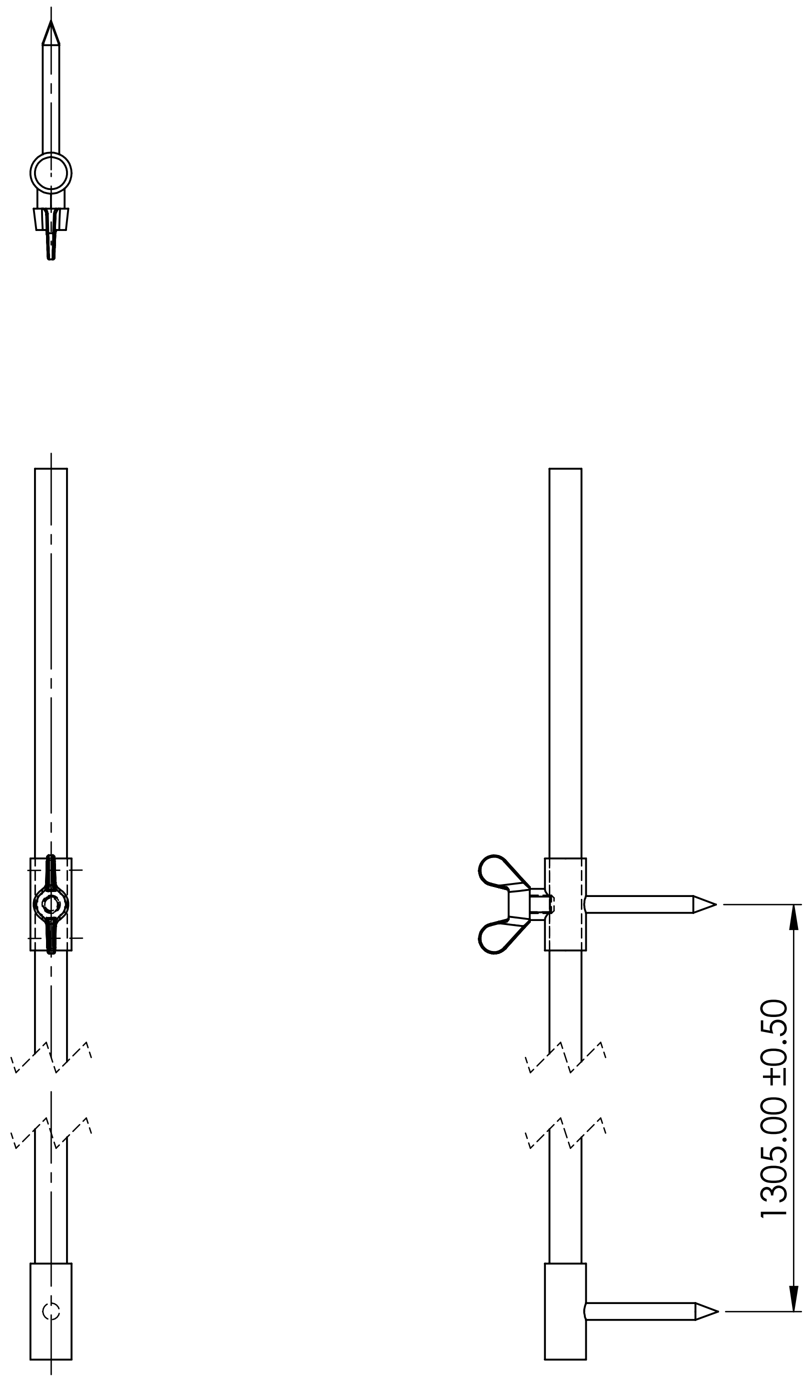
Ersatz für:
Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug	Maßstab	Allgemeintoleranz	Oberflächenangaben
Edelstahl und Stahl	1:5	0,5mm	

Kom. Nr.

	Datum	Name
Bearb.	09/24/18	Rick Timmer
Gepr.		

Index	Änderung	Datum	Name

SCHRADER FAHRZEUGBAU WERK ELLINGHAUS

Benennung

Montage

Zeichnungs-Nr.

Kurze_Achsenausrichtung.003

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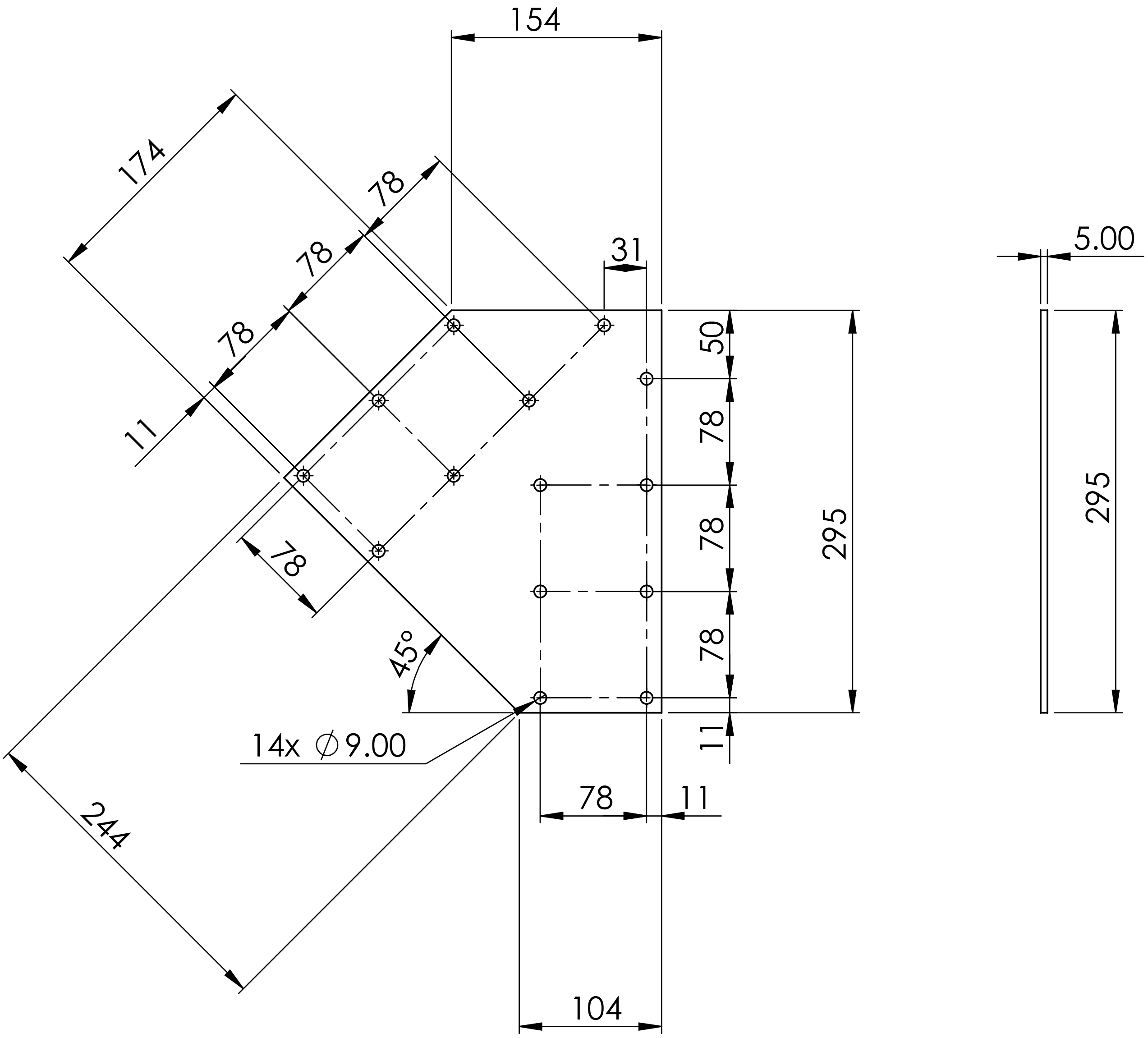
G:\My Drive\Internship_map_Schrader\Axle)_measurement_device\

Druckdatum: 9/26/2018

Entstanden aus:	Ersatz für:	Ersetzt durch:

8.4 Appendix 4: Drawings

Geruste



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug Alu/Verzinkt stahl	Maßstab 1:5	Allgemeintoleranz 0,5mm	Oberflächenangaben
		Kom. Nr.	
	Datum / Name	Benennung	
	Bearb. 16/10/18 Rick Timmer	Treppe_platte	
	Gepr.		
Index / Änderung / Datum / Name	SCHRADER FAHRZEUGBAU WERK ELLINGHAUS	Zeichnungs-Nr. Geruste.001	A4 Blatt 1 von 7
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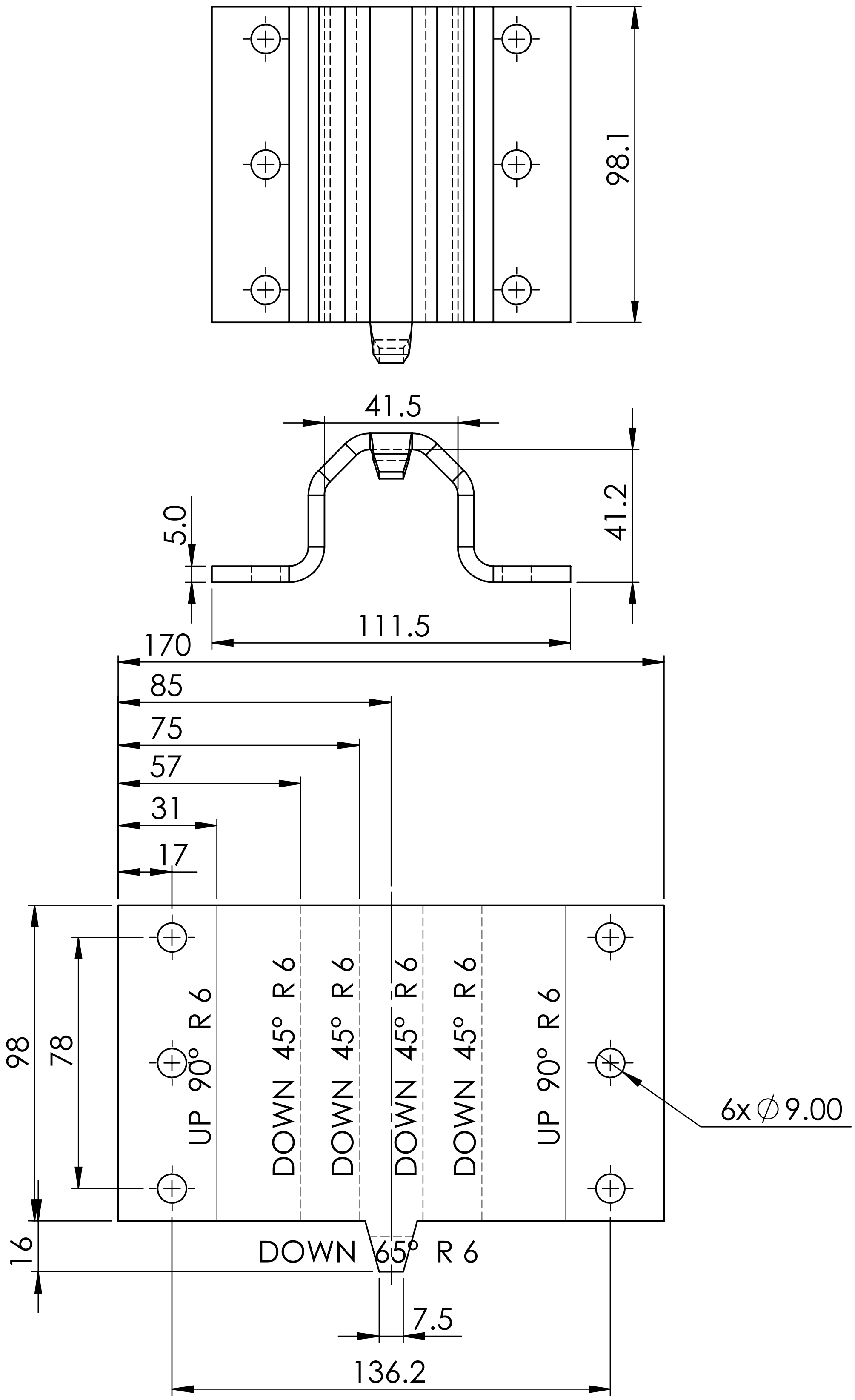

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Stahl/Verzinkt Stahl		Maßstab: 1:2		Allgemeintoleranz 0,5mm	Oberflächenangaben
				Kom. Nr.	
	Datum	Name		Benennung: Halter fur Brücke	
Bearb.	16/10/18	Rick Timmer			
Gepr.					
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS				Zeichnungs-Nr.: Geruste.002	A4 / Blatt 2 von 7

Index	Änderung	Datum	Name

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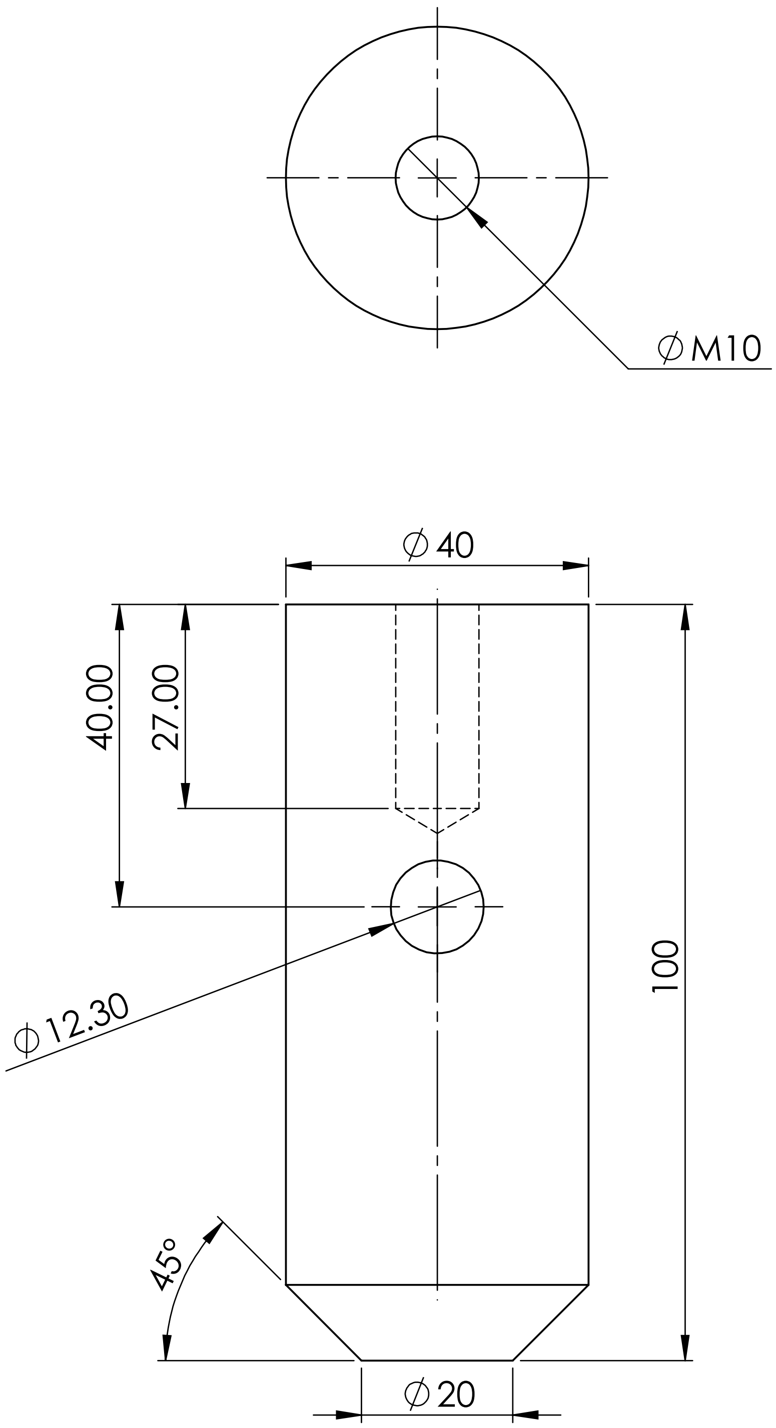

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Stahl/Verzinkt Stahl	Maßstab: 1:1	Allgemeintoleranz 0.5mm	Oberflächenangaben
		Kom. Nr.	
	Datum	Name	Benennung: Connector_pin
Bearb.	16/11/18	Rick Timmer	
Gepr.			
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS		Zeichnungs-Nr.: Geruste.003	A4
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Druckdatum: 10/25/2018

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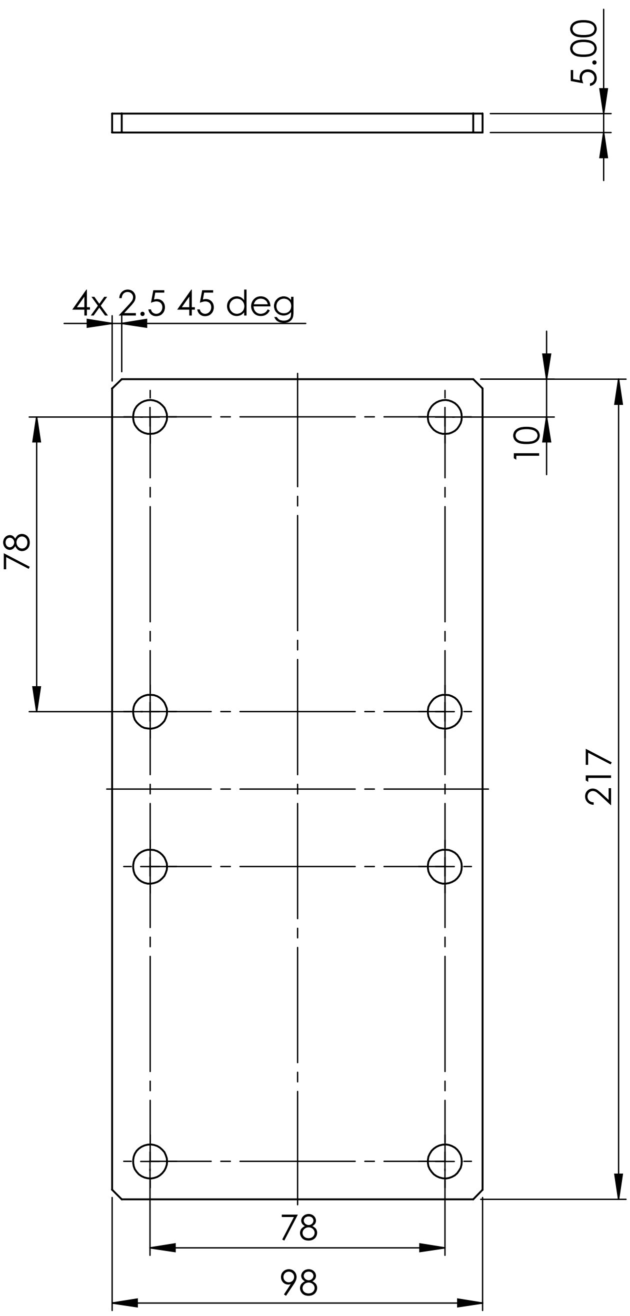

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug
Alu/Verzinkt stahl

Maßstab 1:2

Allgemeintoleranz 0,5mm

Oberflächenangaben

Kom. Nr.

	Datum	Name
Bearb.	16/10/18	Rick Timmer
Gepr.		

Index	Änderung	Datum	Name

SCHRADER FAHRZEUGBAU WERK ELLINGHAUS

Benennung
Main_connecto_platte

Zeichnungs-Nr.
Geruste.004

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Druckdatum: 10/25/2018

Entstanden aus:

Ersatz für:

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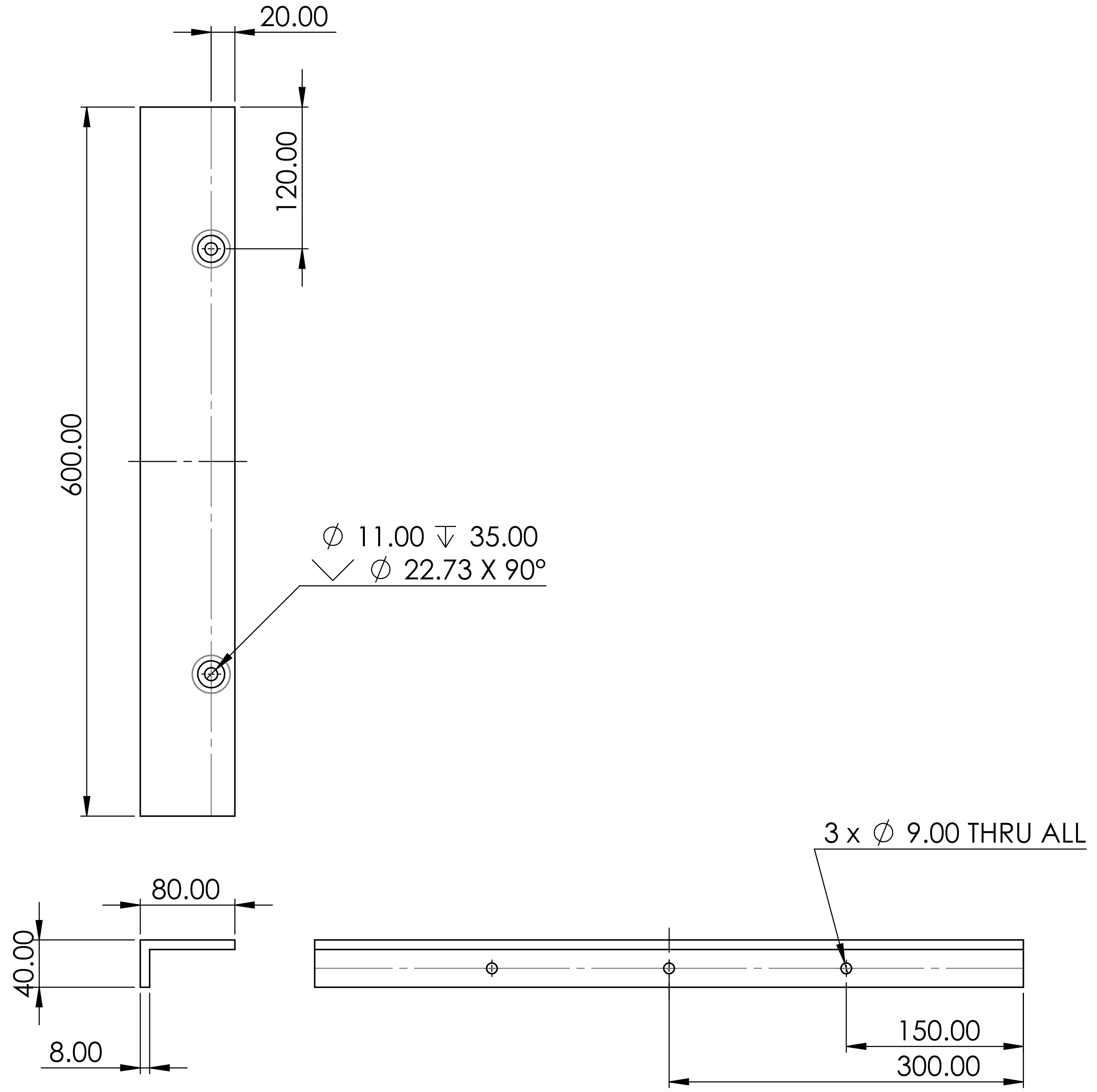

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Alu	Maßstab: 1:5	Allgemeintoleranz 0,5mm	Oberflächenangaben
		Kom. Nr.	

Index	Änderung	Datum	Name

	Datum	Name
Bearb.	17/10/2018	Rick Timmer
Gepr.		

SCHRADER FAHRZEUGBAU WERK ELLINGHAUS

Benennung

Brücke_winkel

Zeichnungs-Nr.

Gerüste.005

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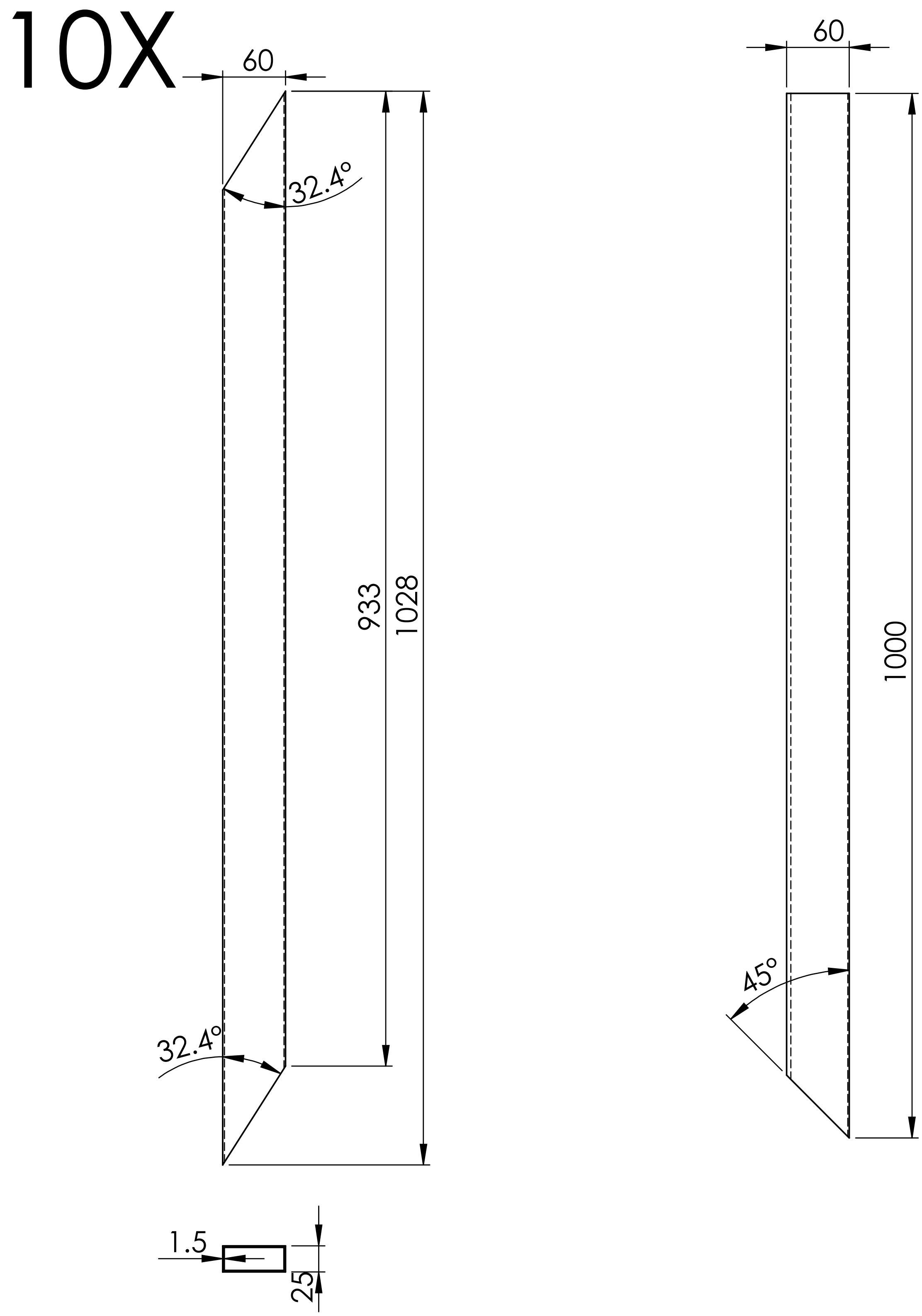
Druckdatum: 10/25/2018

Entstanden aus:	Ersatz für:	Ersetzt durch:



Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug		Maßstab	Allgemeintoleranz	Oberflächenangaben
Alu		1:6	Kom. Nr.	
		Datum / Name	Benennung	
	Bearb.	25/10/2018 / Rick Timmer	Cross_beam	
	Gepr.			
Index / Änderung / Datum / Name	SCHRADER FAHRZEUGBAU WERK ELLINGHAUS		Zeichnungs-Nr.: Gerüste.006	A4 / Blatt 6 von 7
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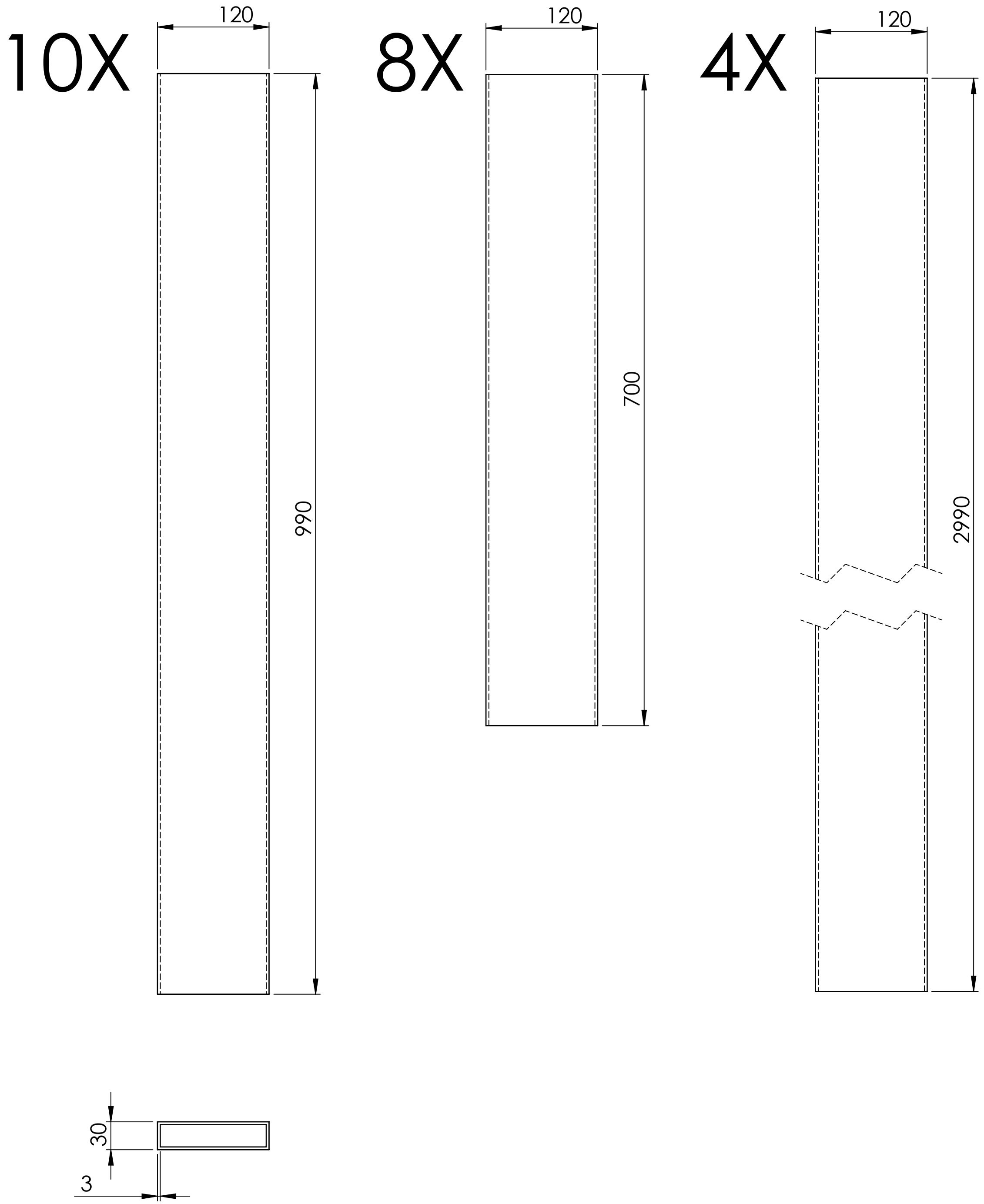

Schutzvermerk nach DIN ISO 16016 beachten

Werkstoff, Halbzeug: Alu	Maßstab: 1:5	Allgemeintoleranz	Oberflächenangaben	
		Kom. Nr.		
	Datum	Name	Benennung: Main_profile	
Bearb.	25/10/2018	Rick Timmer		
Gepr.				
SCHRADER FAHRZEUGBAU WERK ELLINGHAUS			Zeichnungs-Nr.: Gerüste.007	A3, Blatt 7 von 7
Index / Änderung / Datum / Name	Druckdatum: 10/25/2018	Entstanden aus:	Ersatz für:	Ersetzt durch:

G:\My Drive\Internship_map_Schrader\Geruste_rebuild\

Bibliography

[1] Altshuller matrix 2003, 2003. Provided through TRIZ Fundamentals course at University of Twente.