E.T.S. de Ingeniería Industrial,
Informática y de Telecomunicación

Design, dimensioning and construction of the suspension of the IRT19 for the Formula Student season 2019

Máster Universitario en
Ingeniería Industrial

Trabajo Fin de Máster

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Pamplona, 26/06/2019

Universidad Pública de Navarra
Nafarroako Unibertsitate Publikoa

This project was written in the Hochschule Osnabrück during the academic year 2018-2019. It has been done in the facilities of the Ignition racing Team electric in the Hochschule Osnabrück in collaboration in parallel with the work of the other students of the team and with direct contribution of them in the results of the project.

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Abstract:

During the European Project Semester (EPS) a team of interdisciplinary students from different universities carry on a project together. The project took part with the Ignition Racing Team electric, the Formula Student team of the Hochschule Osnabrück. In particular, the work carried out during this Master's Thesis deals with the suspension of the vehicle.

In the first semester the design part took place with the Catia software. The suspension of the year 2017 was taken as a basis and the new requirements of this year were implemented, such as, the new geometry of the suspension, the new sensor of displacement and a system of adjustment of the pushrod. In the second semester the technical drawings were sent to the manufacturer and the commercial parts were bought and the building of the car was accomplished.

In a parallel way, mechanical tests were performed to carbon fibre tubes for the dimensioning of the suspension. Tensile, compression and bending test were carried out to test four different CFK tube diameters. Stress-strain graphs, maximum deformation, strength and stress of the CFK tubes were calculated and compared with the solicitations of the suspension to choose the optimal solution for the suspension of the vehicle.

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1 INTRODUCTION, OBJECTIVE AND SCOPE

The scope of this project is both a team work project and a technical project during one-year period in the Hochschule of Osnabrück.

The first semester was part of the program “European Project Semester” (EPS). This is a program offered in several universities of Europe to develop engineering projects. It is based on a mixture of “Project Related Courses” and project organized/problem-based learning. It is crafted to address the design requirements of the degree and prepare engineering students with all the necessary skills to face the challenges of today’s world economy. The students are divided in interdisciplinary teams formed by 3 to 6 students to develop a common project. Teams are composed by students of different nationalities and different engineering fields to encourage cultural diversity and skills. Projects are done in cooperation with commercial businesses and industries or with research centres.

The general aspects of the EPS are the following:

- Semester lasts at least 15 weeks
- EPS is oriented to a project.
- English is the official language of the project and the courses
- 30 ECTS per semester are offered in total, whereof the project covers min. 20 ECTS, accompanying subjects 5 to 10 ECTS
- Accompanying subjects must support the project subject English and a basic crash course in the local language must be an option
- Subjects include Teambuilding and Project Management
- Project groups are composed multinational, group size 3-6 students, min. 3 nationalities multi disciplinarily desired
- The Main focus in EPS is the team work
- Project supervision focuses on the process as well as the product
- EPS must have continuous assessment including an Interim report and a final report.

Some of the providers of the EPS are the following universities:

- St. Pölten University of Applied Sciences, Austria
- AP University College Antwerp, Belgium
- University of Antwerp, Belgium
- Novia University of Applied Sciences, Finland
- Ecole Nationale d'Ingénieurs de Tarbes, France
- Kiel University of Applied Sciences, Germany
- Hochschule Osnabrück, Germany
- HS Augsburg, Germany
- The Hague University of Applied Sciences, The Netherlands
- Avans University of Applied Sciences, The Netherlands
- Saxion university of applied sciences, The Netherlands
- Oslo Metropolitan University, Norway
- Lodz University of Technology, Poland
- Instituto Superior de Engenharia do Porto, Portugal
- University Politehnica of Bucharest, Romania
- Glasgow Caledonian University, Scotland

- Universitat Politècnica de València, Spain
- Vilanova i la Geltrú School of Engineering, Spain
- Nottingham Trent University, England

In the European Project Semester Mariana Carbajal Curiel (México), Stefano Segneri (Italy), Laura Hernandez Wilches (Colombia) and I joined the “Ignition Racing Team electric” (IRTe) in the Hochschule of Osnabrück to participate in the design of the vehicle for the formula student competition of the season 2018-2019. The IRTe has been working in the Hochschule for 12 seasons with a best ranking in 2015 with 6th position in the events of Barcelona and Hockenheim. The team has also achieved first position in efficiency in 2014. The team is currently composed by 43 people, 19 members with previous experience in the team and 24 new members or “Trainees”. The team has over 60 sponsors from which the main ones are the Hochschüle of Osnabrück, Harting and dSpace. It counts with a budget of over 100.000 € and also with some of the manufacturing capacities of the sponsors.

The IRTe at the same time is divided in different sub teams: monocoque, chassis, drive train, electric and electronic department and management. These each team have tasks and responsibilities:

Monocoque

- Construction and production of a brake air duct
- Development and construction of a Drag Reduction System (DRS)
- Manufacturing monocoque
- Development and construction of the front wing
- Development and construction of the rear wing
- Development and construction of the diffuser
- Construction and production of the side box
- Computational comparison between monocoque and tubular frame
- Structure analysis monocoque
- Development and construction of a subfloor

Chassis

- Design, construction and installation of the suspension
- Performing various strength calculations
- Care of the tires and care of the rims
- Design Development and construction of stabilizers

Drive train

- Design, simulation and subsequent assembly of a drive chain
- Design, simulation and subsequent installation of a cooling system
- Development and construction of the homemade gearbox multiplier

Electric

- Design, implementation and support of dynamic control
- Design, implementation and support of static control
- Development, simulation and subsequent installation of a battery management system (BMS)
- Detailed data acquisition of the engines on a test bench
- Development and construction of the battery (mechanical)
- Development and production of a wiring harness
- Design, development and installation of various circuit boards

Management

- Promotional videos
- Graphic Designer
- Treasurer
- Social media expert
- Event management
- Photograph
- 3D modeling

The objective of the EPS project in the Ignition Racing Team was to join the team and work with the german team developing a team project in the design part of the season (first semester). During the first semester only, the developing of the new ideas, the 3D modelling, the technical drawings are completed. In the end of the semester the materials are ordered, the commercial items purchased, and the technical drawings sent to the manufacturers.

The second semester of the year the EPS is already over, however, this is period of the year when actual the building of the car is done.

The design part has also a side part: The dimensioning of the carbon tubes for the suspension. For that purpose, the forces in the carbon tubes and each of the carbon tubes will be calculated. Then some mechanical tests in tensile strength, compression and bending for the carbon tubes will be performed and compare the data collected with the forces to choose the optimal diameter for the suspension.

2 BACKGROUND

2.1 INTRODUCTION

The first task for anyone to join the team is a ''Trainee Project'', a short project of a need that the IRTe team has. Some of these projects have been from a barbecue cart or holders for the computer, to analysis of certain data from the sensor or just research projects of information. In my case some topics where delivered to me for a presentation that was completed the 11/10/18.

2.2 GENERAL VEHICLE DYNAMICS

2.2.1 Definition

The vehicle dynamics is based in the study of a vehicle and how it behaves in movement.

We can divide the study in the three basic situations:

- Longitudinal dynamics: Study of the behaviour of the vehicle in a straight line i.e. during acceleration, braking, straight line stability etc.
- Lateral dynamics: Study of the behaviour of the vehicle taking a turn i.e. taking a turn, during overtaking etc.
- Vertical dynamics: Study of the behaviour of the vehicle in the vertical direction i.e. encountering a speed breaker, or a puddle etc.

2.2.2 Forces

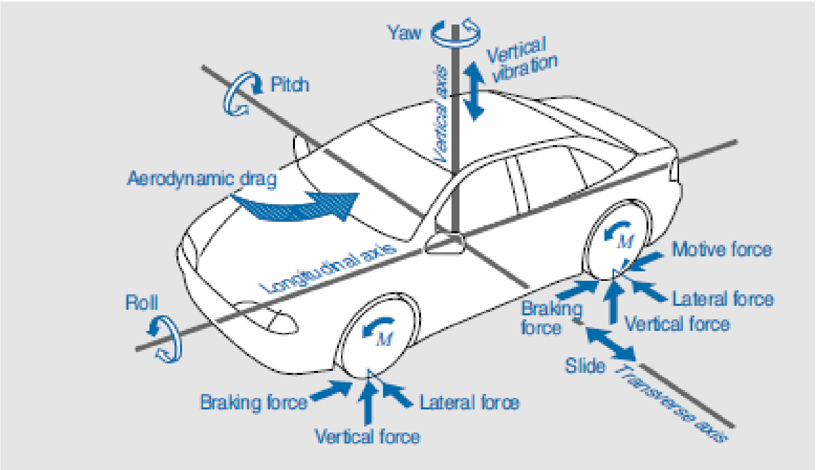
2.2.2.1 Acting point

In addition to the vehicle's weight (resulting from gravitational force), various types of force act upon it regardless of its state of motion.

Some of these are forces which act along the longitudinal axis of the vehicle (e. g. motive force, aerodynamic drag or rolling friction)

Others are forces which act laterally on the vehicle (e. g. steering force, centrifugal force when cornering or crosswinds). The tire forces which act laterally on the vehicle are also referred to as lateral force.

Finally, turning forces. They produce a torque in the car, for example when turning and loosing grip.

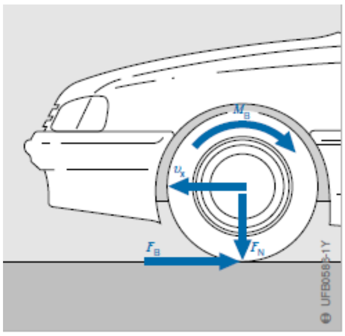


1[Forces acting on a vehicle in movement]

Conditions of the road have a great influence of how these forces act on the vehicle, such as slippery conditions.

2.2.2.2 Type of forces:

- Lateral force: Appear when steering and cause the vehicle to change direction
- Braking torque: Frictional force control by the driver in the longitudinal direction.
- Yaw moment: Different longitudinal forces on the front and read axis.
- Friction force: Generated between the road and the tire. Aquaplaning, brake slip (ABS antilock braking system and TCS traction control system)
- Frictional moment: Rotation of the wheel.
- Vertical force: Has influence on the friction force and braking force related with the friction coefficient.



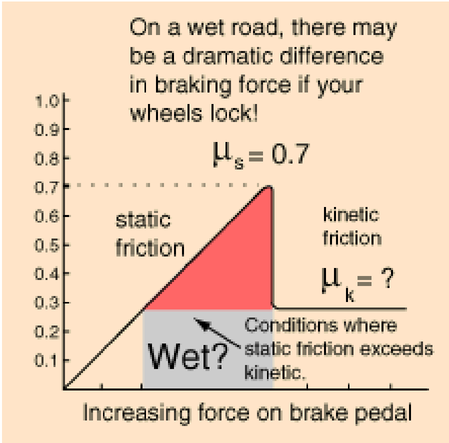
2[Forces acting in the weel of a vehicle]

In the following table an approximation of the friction coefficient is shown for different speed and road conditions.

Vehicle road speed km/h	Tire condition	Dry road μ_{HF}	Wet road (depth of water 0.2 mm) μ_{HF}	Heavy rain (depth of water 1 mm) μ_{HF}	Puddles (depth of water 2 mm) μ_{HF}	Icy (black ice) μ_{HF}
50	new	0.85	0.65	0.55	0.5	0.1 and below
	worn out	1	0.5	0.4	0.25	
90	new	0.8	0.6	0.3	0.05	
	worn out	0.95	0.2	0.1	0.0	
130	new	0.75	0.55	0.2	0	
	worn out	0.9	0.2	0.1	0	

3 [Friction coefficent variation according to speed and road conditions]

In the following picture we can observe the fall of the frictional coefficient when it changes from static (tire rolling on the road) to kinetic (tire slipping in the road). Due to this difference, the brake distance increases when the wheels are blocked during braking. It also is complicated to recover static friction once the vehicle has started slipping (kinetic friction zone).



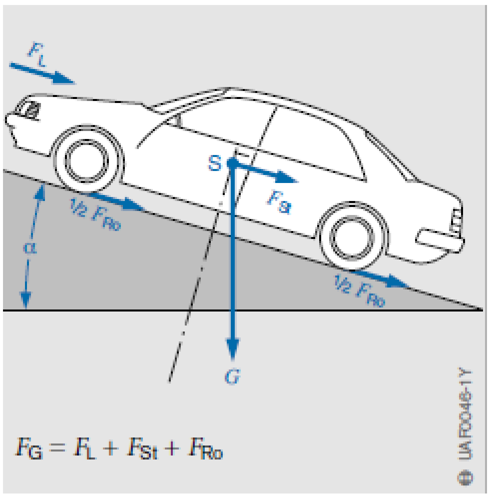
4 [Variation of static and kinetic friction]

- Sideway forces: Act on rolling wheel and produces to move then sideways.
  The angle between the resultant velocity and the forward velocity is called lateral slip angle. There is a relation between the lateral force and the slip angle.
  When a vehicle is cornering the centrifugal force must be in equilibrium with the lateral forces on the wheels.

2.2.3 Dynamics in linear motion

The main forces acting in linear motion are the ones belonging to these categories:

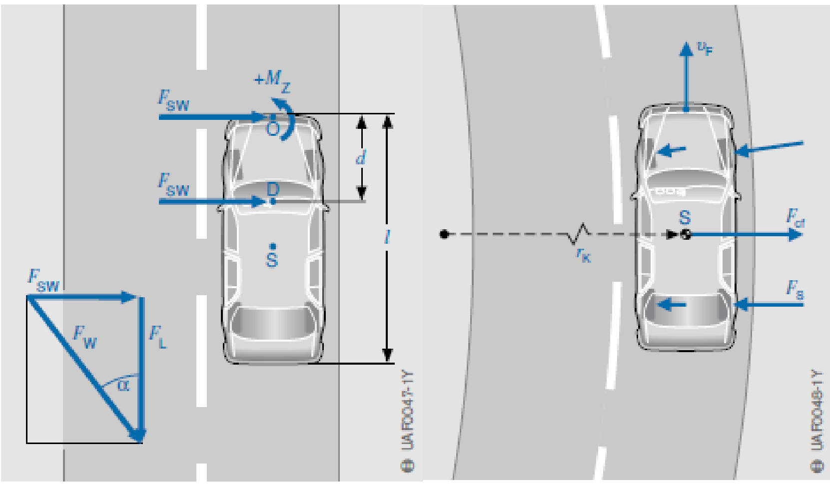
- Resistance to motion: Rolling resistance (friction, tires conditions…), aerodynamic resistance (air density, drag coefficient, frontal cross section area and speed) and climbing resistance (slope, gravity, weight). These forces must be compensated by the engine torque.
- Acceleration and deceleration: Depend on vehicle speed, vehicle load, road condition, tire condition, brake condition, fading (overheating of the brakes). The maximum deacceleration of a vehicle can be achieved when the braking force is at maximum level without losing grip (static friction coefficient).



5 [Forces acting on a vehicle in linear motion]

2.2.4 Dynamics on lateral motion

The forces that have influence on a vehicle during lateral motion are the following: Wind force (lateral), yaw moment, centrifugal force (radius, speed, height of centre of gravity, mass, track, frictional characteristic, load distribution). These forces have influence in the car when turning.

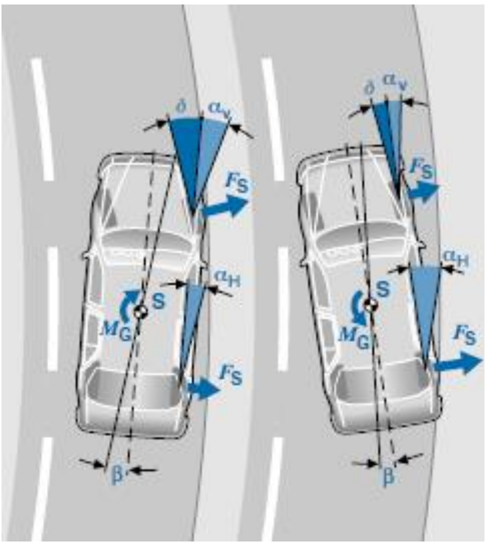


6 [Forces that act on a vehicle in lateral motion]

2.2.5 Understeer and oversteer

Understeer occurs when the front wheels of the vehicle lose grip before the rear ones through a corner. This causes going wide on a corner and steering becoming useless. It happens when the front tires start slipping due to overspeed or hard braking.

Oversteer occurs when the back wheels continue the trajectory without cornering pushing the tyres in the opposite direction of the turn and making it slip. The sliding tail of the vehicle can be observed. The main factors are acceleration, too high demand for the rear tires, a sudden weight transfer from the front to the rear, stab of the brakes or too much steering input.



7 [Understeering and oversteering]

2.3 THE SUSPENSION GEOMETRY

2.3.1 Elements of the suspension

2.3.1.1 Spring

The spring is the element in charge of transforming the energy transferred by the suspension in deformation. There are different types of springs with different behaviours. They can be divided in linear or dynamic springs. The linear ones have same resistance to deformation during all the travel while the dynamic ones can change the resistance in function of the displacement.

8 [Linear and dynamic springs]

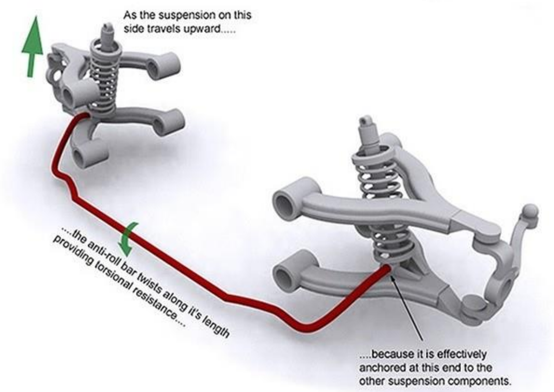
2.3.1.2 Dumper

The dumper is responsible of absorbing the force applied in the suspension and release it in a gradual way. Without the dumper the spring of the suspension would continue oscillating indefinitely because the energy will not be dissipated. Dumpers can be hydraulic, pneumatic or mixt.

9 [Pneumatic damper]

2.3.1.3 Antiroll bar

The antiroll bar is the element that prevents the yaw in the turns, so the centre of gravity does not change, and the inner wheel doesn't lose adherence with respect to the ground.

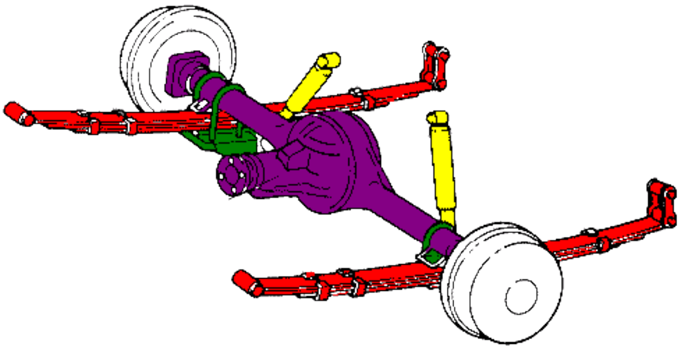


10 [Anti-roll bar]

2.3.2 Types of suspension

2.3.2.1 Rigid suspension

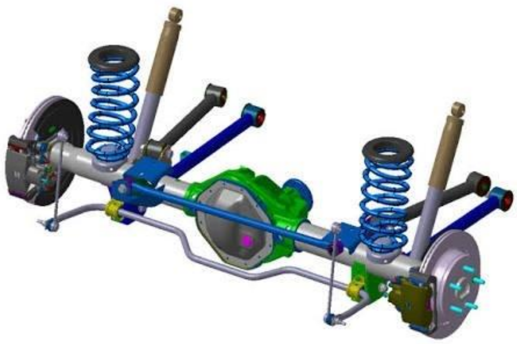
In rigid ones the axis is connected with dumpers and springs to the frame. This produces that vibrations are transmitted from one wheel to the other. It has the problems of instability and causing oversteering in the vehicle.



11 [Rigid suspension]

2.3.2.2 Semirigid

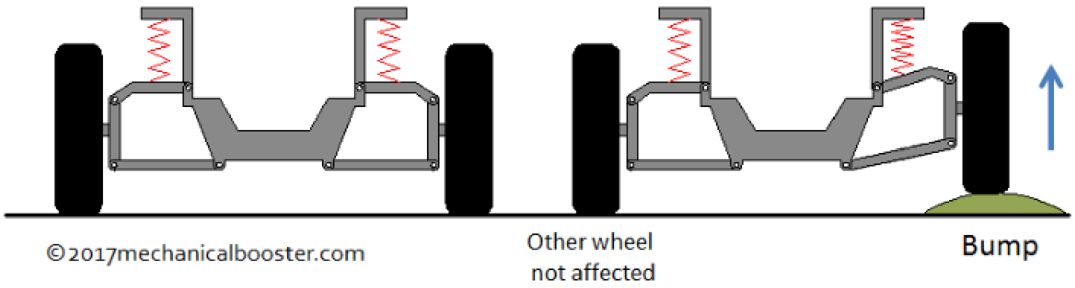
The semiarid suspensions have a similar configuration to the rigid suspension but with less suspended weight.



12 [Semirigid suspension]

2.3.2.3 Independent suspension

In the independent suspensions the movement of one wheel doesn't affect the other one. In this case the frame is less affected to displacement and it absorbs less load. Oscillations and loads are not transmitted from one wheel to the other.

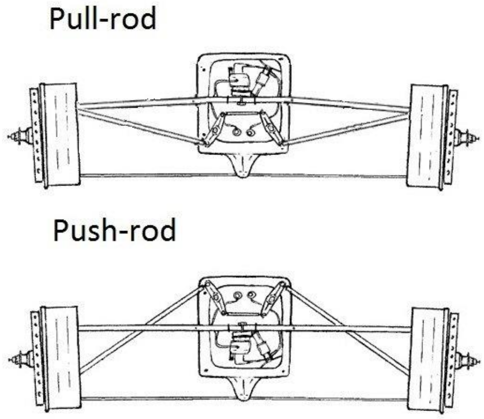


13[Independent suspension]

2.4 THE WORKING PRINCIPLE AND ADVANTAGES/DISADVANTAGES OF A PUSHROD-SYSTEM

2.4.1 Comparison pull-rod and push-rod systems

In a push-rod suspension when the suspension compresses, the pushrod causes the rocker to rotate, which in turn compresses the shock and the spring. In a pull-rod suspension the work principle is exactly the same, but with traction instead of compression.



14 [Pull-rod and push-rod systems]

The principal difference between the pull-rod and the push-rod systems is the geometry and the positioning of the elements of the suspension. Pull-rod systems have the possibility to put the nose lower, they lower the centre of gravity. Pull-rod suspensions work in traction while push-rod suspensions work in compression.

Most of the Formula 1 teams are using push-rod type suspension nowadays, however, in 2013 the Red Bull Racing team proposed a pull-rod based suspension for the racing car. Minardi was one of the last teams using pull-rod suspension until the year 2001.

2.4.2 Advantages of a push-rod suspension

15 [Push-rod system]

With the pushrod suspension we can achieve to have the wheel at every moment in the position we desire independent to the condition of the road, to have full contact with the ground. The spring is separated from the dumper which provides a better performance of each of them individually. It can overall be obtained better mobility and overall performance of driving.

The geometry of a push-rod suspension permits the maximum moments of force to be transmitted, so permits to minimize the size of the equipment and the weight.

It provides a good absorption of vibrations and noise in the car due to the contact of the tires with the ground.

The design allows modification of the angles with which the best configuration for height and strength can be obtained. This flexibility of design and the way that it can be implemented are also advantages of this type of suspension. The flexibility allows the desired kinematics without compromising the geometry.

Push-rod suspension allows short spindle length and a small negative scrub radius.

It also provides a good response for aerodynamics and downforce. The flow of the air along the suspension is important for the effect of the downforce.

Before they only knew the classic way of putting the dumper and the spring in the outside, which was a difficulty for the airflow. Thanks to the pushrod system the location of the spring and the dumper can be changed. Minimizes drag of the suspension components and helps the air to go directly to the radiators who help the performance of the engine.

In formula 1 cars the shape of the rods is modified to have a better aerodynamic behaviour.

16 [F1 suspension rods modification for aerodynamic purposes]

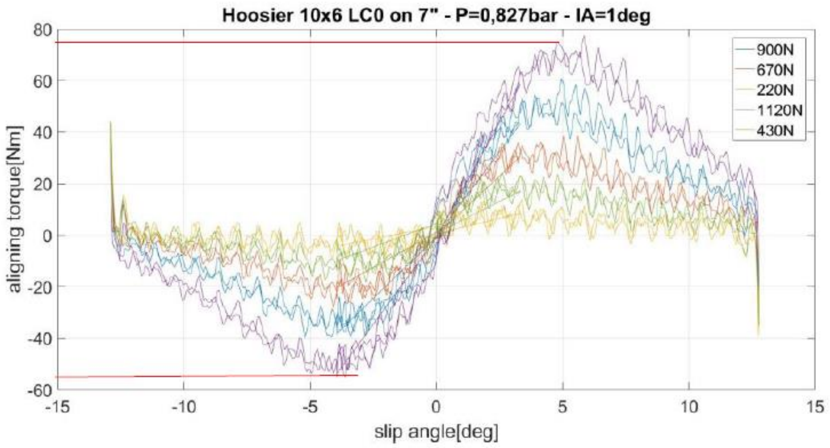
2.4.3 Disadvantages of a push-rod suspension

A push-rod suspension implies higher cost and complexity. That is why is designed especially for high requirement vehicles as racing cars. It requires modification of the length and continuous adjustment. It is a type of suspension that is not so used for production cars.

2.5 ANALYSIS OF THE KINEMATICS OF THE 2017 CAR

The analysis of the kinematics has as objective to give solution to the main parameters of the chassis, for example, the use of tyre compounds, their size, the size of the rim, the positioning of the elements of the suspension, the camber angle, the caster, the heave ratio, the toe angle and the king pin angle.

For this purpose, all the information from the sensor and form test is analysed. Information about temperature, angle, force and positioning is analysed.



17 [Aligning torque vs slip angle for the 10x6 LCO tire under different force inputs]

Then all the positions are validated with the "Optimum Kinematics" software and diagrams about the parameters are obtained.

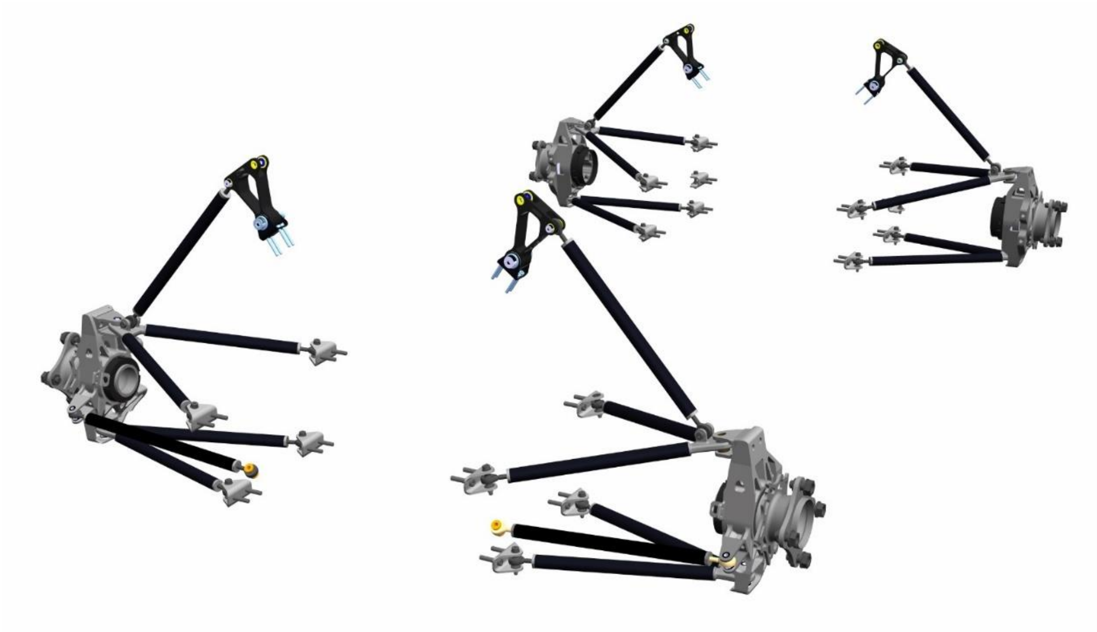
18 Positions of the rim analysed with "Optimum Kinematics"

All the analysis of this parameters is done in the document annexed "Suspension kinematics" written by Markus Ratje for the 11. august 2018.

2.6 SUSPENSION 2018 SEASON

The suspension of the 2017 season is the base of the suspension of the next season. The IRT team has developed the original CAD files in Catia during the 2015 season. Each reason, the suspension of the year before has been taken as basis and develop the improvements based on that one. For this season, the suspension of the season 2017 has been taken as basis, as the 2019 car is an improvement of this season's vehicle.

This is the initial state of the suspension of the 2017 car suspension:



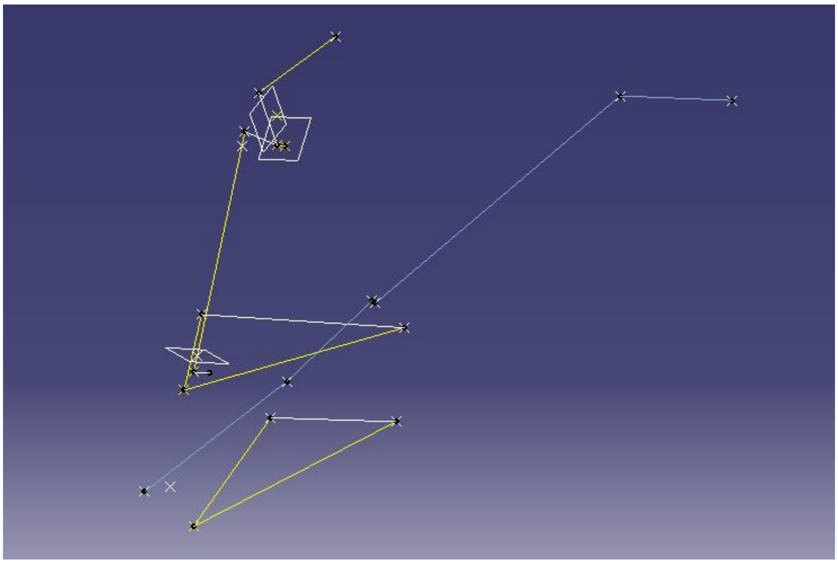
19 [Suspension design for the season 2017]

3 DESIGNING PROCESS

3.1 SUSPENSION GEOMETRY

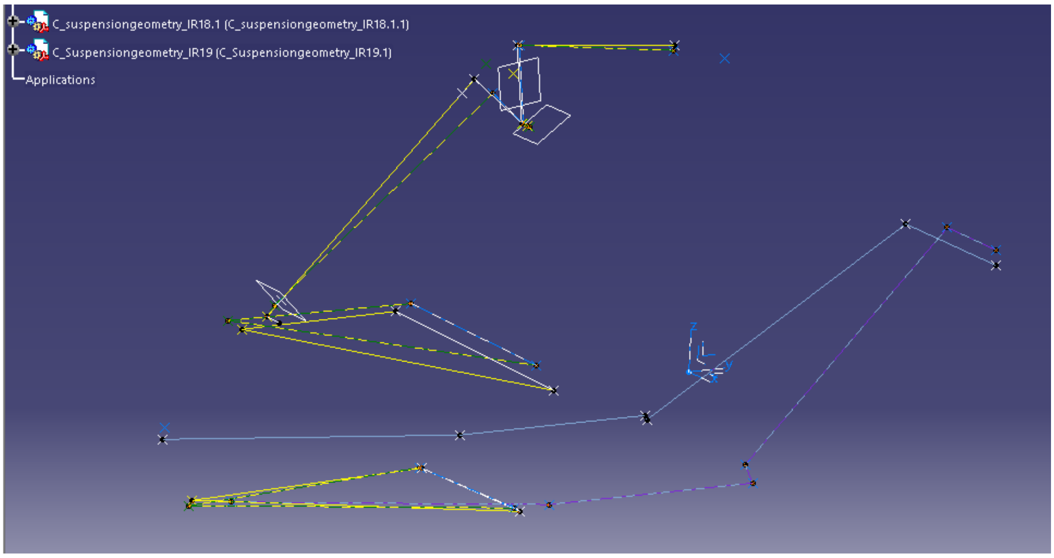
The suspension for the 2018-2019 season will have the same shape as the suspension in the previous year. For that purpose, most of the CAD files of the previous seasons are reutilized and made the necessary modifications in them to fit the new requirements and features.

All the main points of the assembly are built over a structure of points and lines representing the centre and the rotation points of the main elements. These points are simulated with the software "Optimum Kinematics" to have the desired behaviour.



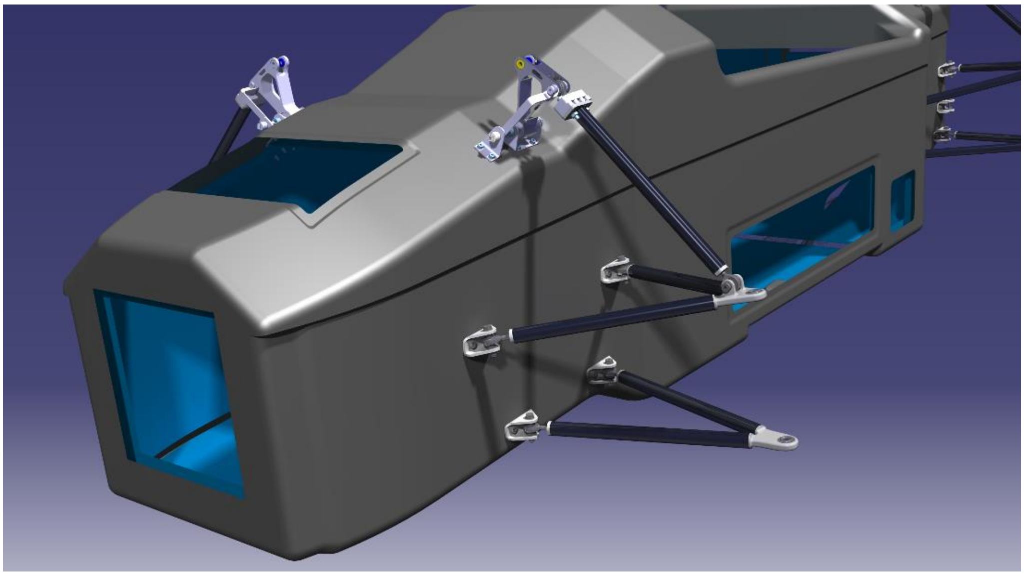
20 [Example of the suspension geometry of the 2018/2019 season]

For this new season the geometry of the suspension had some changes with respect to the previous year geometry. This geometry had minor changes of the positioning of the elements calculated by the kinematic simulation and dynamics team to provide a better performance of the vehicle. However, these changes lead to a repositioning and modification of all the elements in the suspension assembly.



21 [Difference between the 2017/2018 season suspension geometry (dashed) and the 2018/2019 suspension geometry]

The distance and the angle of the suspension elements with respect to the monocoque has also changed. Due to this changes the brackets had to be modified. The final design of the suspension was delivered the 30/11/18 for the ''Design Freeze'' date. This is the date where the design of all the components of the vehicle should be completed.



22[Final result of the CAD files of the suspension (front part)]

3.2 METHOD OF ADJUSTMENT OF THE PUSHROD LENGTH

3.2.1 Introduction and objective

The adjustment of the length of the pushrod is an important feature for the vehicle. This bar is in charge of transmitting the load of the wheels to the rocker. Its length is adjustable, what implies that the positioning of the wheel can be modified, especially in the vertical direction. This modification allows to regulate the weight distribution of the vehicle between the wheels.

23 [Suspension of the 2016/2017 vehicle. The pushrod is the carbon rod positioned with approximately 45 degrees with respect to the ground]

The adjustment of the length in previous years was by the screwed part of the condyle to the carbon tube (see image 23). However, the adjustment of the pushrod must be a fast process. Changes in the elements of the suspension or the tires implies adjustment in the length. For these adjustments sometimes, the team only has 5 minutes available in the box, so a fast and reliable method was needed for this process. In this chapter some of the proposed methods are discussed.

24 [Screwed condyle to the carbon tube. Screwing the condyle is possible to reduce the distance represented by the yellow stripe]

3.2.2 Gage blocks

25 [Commercial box of gage blocks]

3.2.2.1 Concept

Gage blocks are blocks with paralepidid shape that have a very good surface polish in two of their sides that provide very good parallelism and flatness being able to have a length with high precision. They are of different sizes and just by the combination of them it can be reproduced any length with a precision of 0.5 µm.

Once the adjustment of the pushrod is done the first time in the regular way, the distance between the pushrod and the camber can be measured and reproduced with gage blocks. Then if any change is done, the pattern blocks will be placed in the space between the pushrod and the camber and the pushrod will be fastened until it touches the surface gage block.

For example, in image 23 the distance with the yellow stripe would be formed with the gage blocks. Then for the adjustment the gage blocks would be placed in that gap and fasten the condyle until that exact distance.

3.2.2.2 Price

The price of gage blocks can be very diverse according to the accuracy that they can provide, however, for the team purposes a regular set can be used that can be obtained for a price of around 300 €.

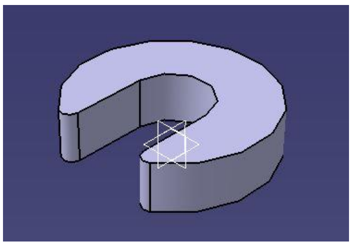
3.2.2.3 Advantages

This method provides high precision of the measurement of the distance due to the accuracy of the gage blocks.

3.2.2.4 Disadvantages

It is slow and uncomfortable to build the measurement with the pattern blocks. Also, some tests must be done to check the validity of the system.

3.2.3 Self-manufactured gage blocks with disc geometry

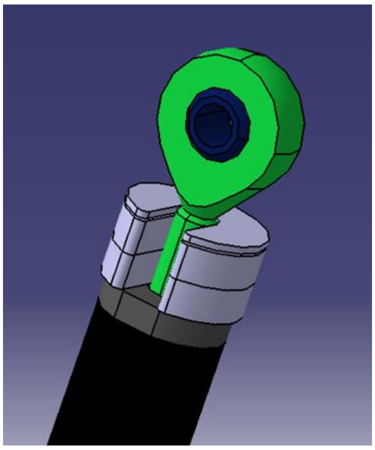


26 [Example of a possible shape for the adjustment with self-manufactured gage blocks]

3.2.3.1 Concept

It will be similar to use gage blocks but with a special geometry adapted to the geometry of the pushrod. Some manufactured plates of different thicknesses will be manufactured with inner diameter of the size of the thread. It will have a flat opening to place it in the correct position.

As in the previous case, once the measurement is done, the distance between the end of the camber and the thread of the pushrod with the gage discs (image 23). Then they will be retired and to repeat the adjustment the discs will be placed, and the pushrod will be fastened until it touches the disc.



27 [Example of adjustment of the discs]

3.2.3.2 Price

It will depend on the manufacturer, but a small tolerance would be needed to provide an accurate result.

3.2.3.3 Advantages

They are Easy to use and adapted to the geometry of the pushrod.

3.2.3.4 Disadvantages

It is complicated and expensive to manufacture to be useful. Moreover, it has similar problems as the regular gage blocks.

3.2.4 Adjustable tool

3.2.4.1 Concept

An extensive tool that measures the distance between the two threads of the pushrod. In this case once the distance is adjusted, the tool can be adjusted to that position and see the distance of that point. Then for future adjustments, this distance is known, so the pushrod must be fixed until it fits the tool.

3.2.4.2 Price

Probably this would be the most expensive solution, as it has to be self-manufactured with very small tolerance. It must be to be adjustable, so it is difficult to set that accuracy.

3.2.4.3 Advantages

It is easy to use and very intuitive.

3.2.4.4 Disadvantages

It is complex to manufacture and probably more expensive than other methods.

As it must be adjusted for every case it is difficult to provide the same accuracy as with other methods.

3.2.5 Sensor

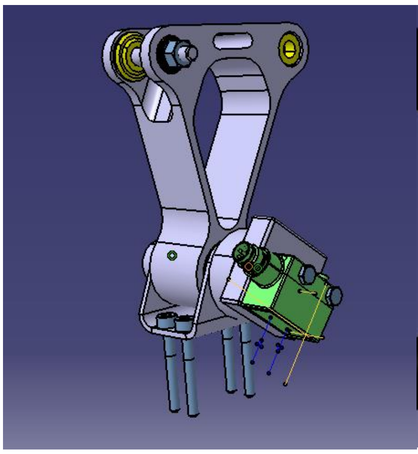
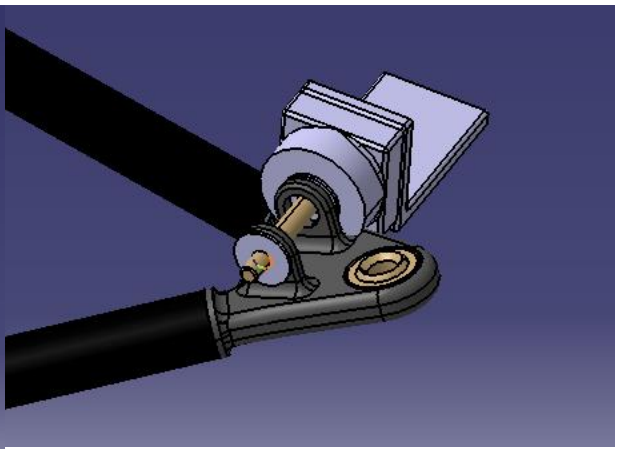
28 [Commercial laser sensor to measure distances]

3.2.5.1 Concept

This method is very similar to the previous one, but instead of having a mechanical tool, we measure the distance with a laser sensor.

This sensor measures the distance between his position and a screen or receptor. Once the pushrod is adjusted the sensor and the screen will be placed in their respective places. Then the sensor will provide the exact distance between the points. To repeat the same adjustment the pushrod must be extended until the sensor provides the same measurement.

A tool must be manufactured to link the sensor and the screen to their respective bolts.

29 [Sensor with tool adjusted to the bolt of the rocker]

30 [Screen adjusted to the lower bolt of the pushrod]

3.2.5.2 Price

The sensor has a price of around 150 €.

3.2.5.3 Advantages

It can provide a very accurate measurement.

Once installed and calibrated it can be very easy and fast to use.

The sensor can be also used for other applications.

3.2.5.4 Disadvantages

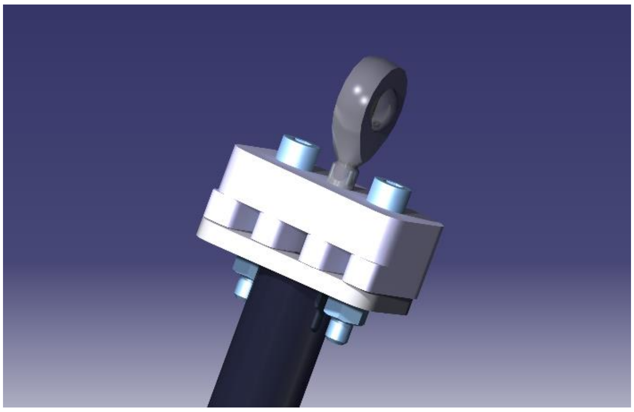
The compatibility and the use method must be studied.

It has more complexity than other systems.

The sensor is a delicate item that the user must know how to use.

3.2.6 Final solution

After discussing the previous solutions, the final idea was developed: A system that allows to add plates of a known thickness to increase the final length of the pushrod. These plates are situated between the plate where the condyle is screwed and the carbon tube of the pushrod. The plates are fixed to the pushrod system with two bolts that should be unscrewed to add the new plates. This method doesn't have the accuracy of the gage blocks but is a developed solution of the self-manufactured gage block proposal that improves the speed of the adjustment. A similar method is used from several years before in the rims of the wheels to adjust the camber with good results.



31 [Final solution of the adjustment of the pushrod]

For the validity of the of the resistance and dimensioning of the bolted union mechanical calculations were performed according to the technical edification code. The results and procedure are attached in the annexes.

3.3 ATTACHMENT OF THE ROTATION SENSOR OF THE ROCKER

The displacement of the elements of the suspension gives important information for the data analysis department about the displacement of the damper, the tires and the forces applied to these elements.

For the 2017 vehicle a linear sensor was used that was compressed at the same time as the damper. However, the information provided by this sensor was not so reliable and was subjected to a lot of noise.

32 [The blue element is the sensor that is compressed at the same time as the damper and gives a measurement of this displacement]

Due to these problems a new sensor was proposed for the 2018 vehicle. This sensor measures rotation instead of displacement. The sensor would be fixed to the monocoque and the rotating part to the rocker, so information about the rotation of the rocker respect to the monocoque could be obtained and with this rotation the displacement of all the elements of the suspension, damper, and wheels can be inferred.

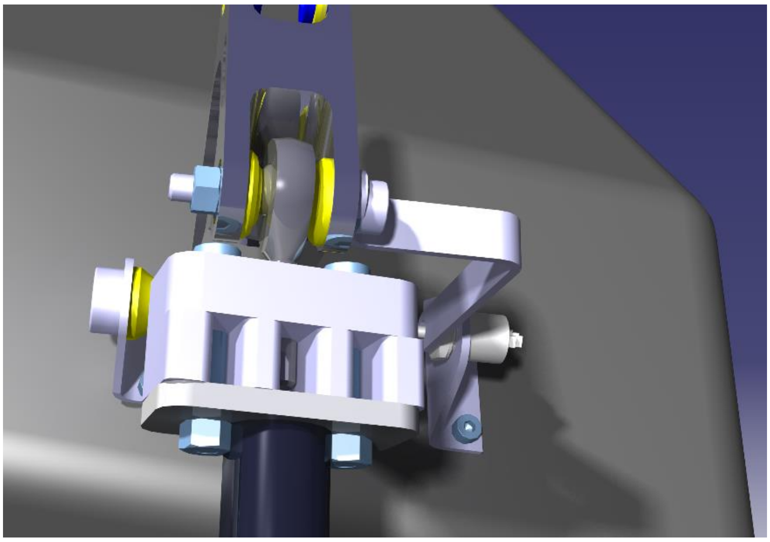
For that purpose, the sensor “Hall-Effect Absolute Encoder Series MAB12A” was chosen by the electronics team. Data sheet added in the annexes.

33 [Hall-Effect Absolute Encoder Series MAB12A sensor]

In the previous season an assembly was proposed fixing the sensor with a bracket to the monocoque and with an arm fixing the rotating part to a mechanized area of the bracket. However, finally the tolerances of the mechanized part of the rocker where not able to be manufactured and the new sensor could not be used.

For this season the proposal is a very similar tool, however, the arm instead of being attached to the tool, it will be attached to the union between the rocker and the dumper. In this case we don’t need a specific place in the rocker manufactured in a different way to attach the arm. The other part of the sensor, as in the previous season, it is attached to the monocoque with a bracket. As it was set in the first case, the rotation axis of the rocker is coincident with the one of the rockers, so the rotation of the rocker is the same that the one of the sensors.

34 [Assembly of the rotation sensor assembly for the 2019 season]



35 [Rotation sensor assembly attached to the suspension assembly]

3.4 TECHNICAL DRAWINGS FOR THE MANUFACTURERS

After the design of all the components, the technical drawings of all the components are done. Then, these drawings are sent to the manufacturers to build the different parts. All the technical drawings made in the season 2018-2019 of the suspension are available in the annexes.

4 MECHANICAL TEST FOR DIMENSIONING THE DIAMETERS OF THE CFRP TUBES

4.1 INTRODUCTION

Dimensioning is one of the most important aspects of the design of the vehicle. Optimizing the size of the components leads to less material which is related to less weight. The carbon tubes in the suspension are not an exception. The size of the carbon tubes must be optimized to use the lower diameter one. However, this tube must withstand the mechanical solicitations that the suspension will be exposed to.

The kinematic analysis area of the IRT team with the recompilation of data of the sensors of the vehicle has determinate the maximum loads applied to the wheels. Then a safety factor is applied to calculate the worst-case scenario for a static failure analysis. The forces applied in the xyz directions are calculated in the axial and radial directions of the carbon tubes. Then the resultant axial and shear stress are calculated. The results of this calculations are compared with the ultimate tensile stress of the material and the ultimate tensile strength of each size of specimen.

Carbon fibre is a complex composite material. It has different properties depending on the manufacturer, the use and the orientation. That's why to have reliable information testing is necessary. For that purpose, a reliable and complete test is proposed where the carbon tubes of all the possible sizes are tested in the three-basic test (tensile, compression and bending) where the carbon tubes of the vehicle are working.

4.2 SOLICITATIONS

4.2.1 Forces

The forces in the suspension from the data of the kinematics of the 2017 car are the following:

$$F_x = 2500\ N$$

$$F_y = 2500\ N$$

$$F_z = 3000\ N$$

The forces have a safety factor of approximately 1.4. That is, the forces with the calculations will be done will be 1.4 times bigger than the actual forces in the suspension. Due to this, we can ensure that the suspension will be able to withstand the actual forces.

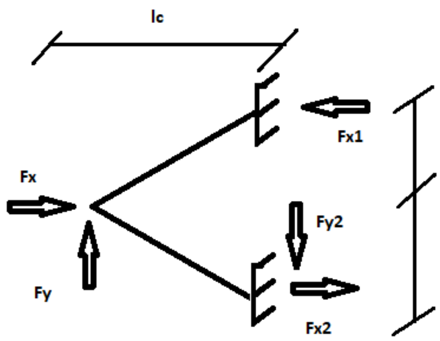
These forces lead to a distribution of forces in the different carbon tubes of the car.

4.2.2 A-Arm low

4.2.2.1 Force diagram

In the low A arm there are only forces in the xy plane, there is not bending. All the vertical forces are transmitted to the upper A arm and the pushrod. Supposing that all the forces in the xy plane are absorbed by the lower A arm and that only one of the arms absorbs the forces in the y direction.

The following sketch resumes the diagram of the forces:



36 [Forces on the A-Arm low]

$$l_a = 72\,mm\,;\; l_b = 120\,mm\,;\; l_c = 300\,mm$$

The reaction forces in the carbon tubes will be the following:

$$\sum F_x = 0 \;\rightarrow\; F_X + F_{X2} = F_{X1}$$

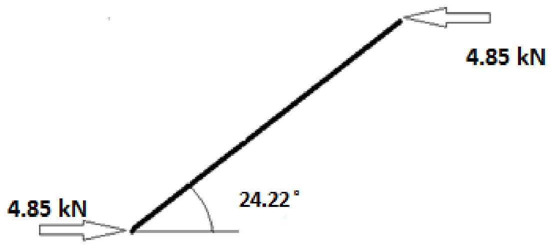
$$\sum F_Y = 0 \;\rightarrow\; F_Y = F_{Y2} = 2.5\;kN$$

$$\sum M = 0 \;\rightarrow\; F_X \cdot l_A + F_Y \cdot l_C = F_{X1} \cdot (l_A + l_B) \;\rightarrow\; F_{X1} = \frac{F_X \cdot l_A + F_Y \cdot l_C}{(l_A + l_B)} = 4.85\;kN$$

$$F_{X2} = F_{X1} - F_X = 2.35\;kN$$

4.2.2.2 First carbon tube

The forces in the X direction are 5.828 kN for the the first carbon tube, however, this is not the axial force in the carbon tube. The axial forces will be the cosine component of that force. The forces that produce shear stress are neglected.



37 [Force diagram in the first carbon tube of the low A-Arm]

The resultant force in the first carbon tube is:

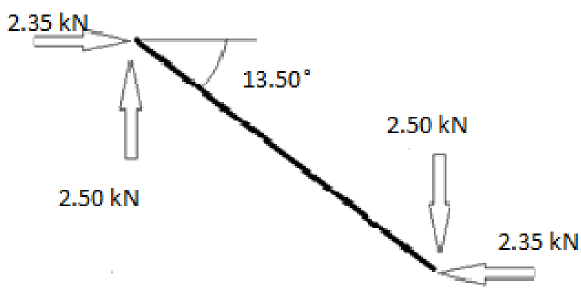
$$Axil_1 = 4.85 \cdot \cos 24.22 = 4.5\;kN$$

$$(V_1 = 4.85 \cdot \sin 24.22 = 2\;kN\;)$$

$$\sigma = \frac{F}{\pi \frac{D^2 - d^2}{4}} = \frac{4 \cdot F}{\pi (D^2 - d^2)}$$

4.2.2.3 Second carbon tube

As in the first case, the resultant of the forces in the axial direction of the tube will be calculated with the components of the forces in the x and y directions. The forces that produce shear stress are neglected.



38 [Force diagram in the second carbon tube of the low A-Arm]

The resultant force in the second carbon tube is:

$$Axil_2 = 2.35 \cdot \cos 13.50 + 2.5 \cdot \sin 13.50 = 2.87\ kN$$

$$(V_2 = 2.35 \cdot \sin 13.50 - 2.5 \cdot \cos 13.50 = 1.88\ kN)$$

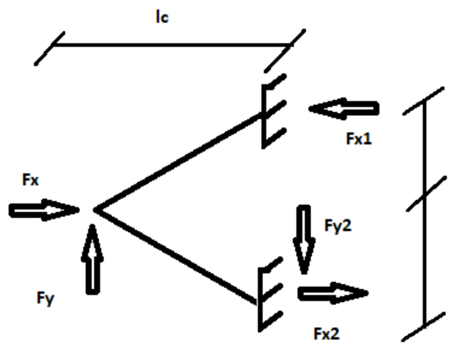
$$\sigma = \frac{F}{\pi \frac{D^2 - d^2}{4}} = \frac{4 \cdot F}{\pi(D^2 - d^2)}$$

4.2.3 A-Arm up

4.2.3.1 Force diagram

For the Upper A-Arm we will consider the combination of bending stress and axial stress.

The axial stress calculation will be as in the lower A-arm. The pushrod will absorb force in the y direction. However, for the worst-case scenario we will consider that all the forces in the xy plane are supported by the A arm as in the lower case.



39 [Forces on the A-Arm up]

$$l_a = 156\ mm\ ;\ l_b = 146\ mm\ ;\ l_c = 263\ mm$$

The reaction forces in the carbon tubes will be the following:

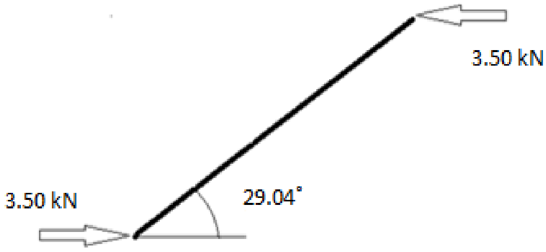
$$\sum F_x = 0\ \rightarrow\ F_X + F_{X2} = F_{X1}$$

$$\sum F_Y = 0\ \rightarrow\ F_Y = F_{Y2} = 2.5\ kN$$

$$\sum M = 0\ \rightarrow\ F_X \cdot l_A + F_Y \cdot l_C = F_{X1} \cdot (l_A + l_B)\ \rightarrow\ F_{X1} = \frac{F_X \cdot l_A + F_Y \cdot l_C}{(l_A + l_B)} = 3.5\ kN$$

$$F_{X2} = F_{X1} - F_X = 1\ kN$$

4.2.3.2 First carbon tube



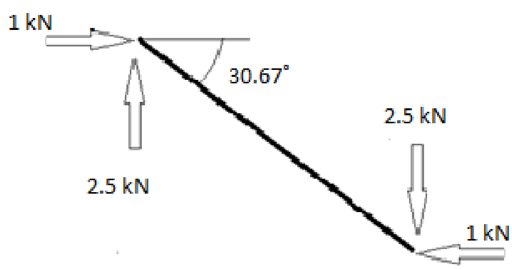
40 [Force diagram in the first carbon tube of the up A-Arm]

The resultant force in the first carbon tube is:

$$Axil_1 = 3.5 \cdot \cos 29.04 = 3\ kN$$

$$(V_1 = 3.5 \cdot \sin 29.04 = \ 1.54\ kN)$$

4.2.3.3 Second carbon tube



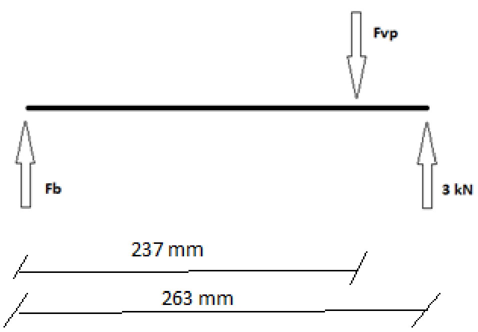
41 [Force diagram in the second carbon tube of the low A-Arm]

The resultant force in the second carbon tube is:

$$Axil_2 = 1 \cdot \cos 30.67 + 2.5 \cdot \sin 30.67 = 2.14\ kN$$

$$(V_2 = 1 \cdot \sin 30.67 - 2.5 \cdot \cos 30.67 = \ 1.64\ kN)$$

The push rod is in charge of absorb the vertical force, however, due to the geometry of the end of the A arm, the push rod is not located in the exact point where the force of the tire is transmitted. Then, this produces a bending effect in the pushrod.



42 [Bending on the low A-Arm]

$$\sum F = 0 \rightarrow 3 = F_{VP} + F_b$$

$$\sum M = 0 \rightarrow F_{VP} \cdot 237 = 3 \cdot 263 \rightarrow F_{VP} = 3.33\ kN$$

$$M_{max} = 3\ kN \cdot 26\ mm = 78\ Nm$$

43 [Moment distribution in the low A-Arm]

This moment is absorbed by both arms, so the stress due to bending in each of the carbon tube will be considering half of the maximum bending moment.

$$I = \frac{\pi(R^4 - r^4)}{4}$$

$$\sigma_{bend} = \frac{M_{max}/_2 \cdot R}{I} = \frac{144 \cdot 10^3 \cdot 4 \cdot R}{\pi(R^4 - r^4)}$$

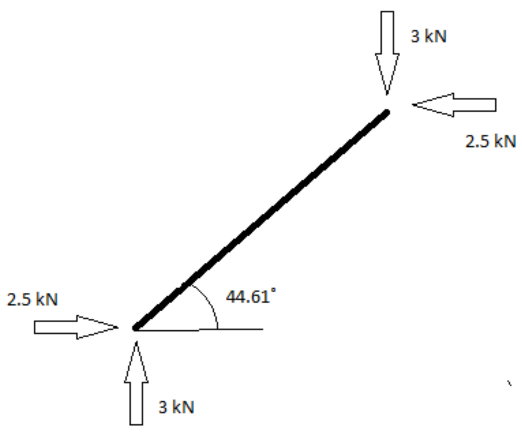
This stress due to bending will be added to the stress due to axial forces.

$$\sigma = \frac{4 \cdot F}{\pi(D^2 - d^2)} + \frac{M_{max}/_2 \cdot 4 \cdot R}{\pi(R^4 - r^4)}$$

4.2.4 Pushrod of the suspension

For the calculation of the forces in the pushrod we will consider that the pushrod is responsible of absorbing all the forces in x and z directions to consider the worst-case scenario.

The pushrod has freedom of rotation in the two unions. It will only withstand axial force. Not bending is applied in the pushrod.



44 [Force diagram in the pushrod]

$$Axil = 2.5 \cdot \cos 44.61 + 3 \cdot \sin 44.61 = 3.89\ kN$$

$$(V_2 = 2.5 \cdot \sin 44.61 - 3 \cdot \cos 44.61 = 0.38\ kN)$$

$$\sigma = \frac{F}{\pi \frac{D^2 - d^2}{4}} = \frac{4 \cdot F}{\pi (D^2 - d^2)}$$

4.2.5 Stress on each carbon tube

In the following table a resume of the stress in each carbon tube with the different diameters can be checked:

Carbon tube diameter	LOW 1 [MPa]	LOW 2 [MPa]	UP 1 [MPa]	UP 2 [MPa]	PUSHROD [MPa]
18	83	54	239	221	73
16	94	61	299	280	82
14	108	70	389	367	95
12	128	83	533	506	112

Table 1 [Stres of the solicitations in each carbon tube according to the diameter size]

4.3 DESIGN OF THE EXPERIMENTS

The aim of the test will be to determine the mechanical properties of the carbon tubes due to different efforts, traction, compression and bending.

Some standard procedures will be followed as much as possible, such as, the American Society of Testing and Materials (ASTM), British standard, JIS standard and DIN standard. However, the specimen to test is not a standard specimen, and it is important to get data about the whole working piece.

The carbon tubes used in the test will be the following ones:

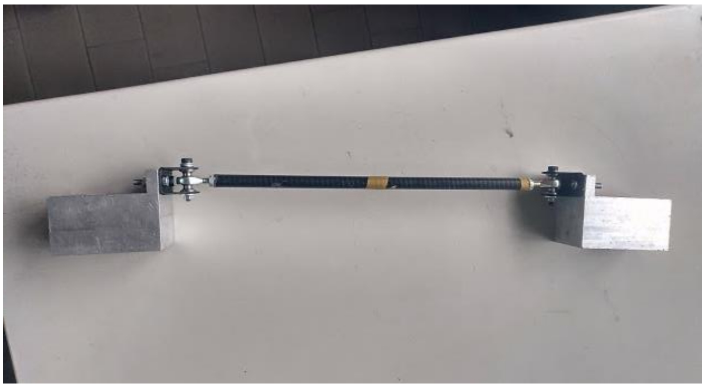
Inner diameter mm	Outer diameter mm	Thickness mm
10	12	1
12	14	1
14	16	1
16	18	1

Table 2 [Test tube diameters]

The failure point of the pushrod is not the carbon tube itself, but the union between the carbon tube and the insert. The unions between the tube and the insert will be glued and after 24 hours the resistance of the union will be tested. This point will be reached in the tensile test before the tube reaches the elastic behaviour.

Experimental procedure

1. The specimen will be mounted in the testing machine. In the case of the tensile and compression test, the samples will be attached to the machine with the help of a self-designed and manufactured tool.
2. The experiment will start and data about elongation and tension will obtained in a text document.
3. The experiment will be repeated 3 times with each of the 4 types of specimens. The length of each specimen will be 300 mm



45 [Specimen with the self-manufactured tool to perform the tests]

The ultimate tensile strength and the force that the tube withstands in each test will be analysed and compared with the solicitations of each tube.

A safety factor will be applied to compare the resistance of the tube with the actual forces, increasing the solicitations to guaranty the static integrity of the tubes under the actual forces.

Carbon fibre is a fragile material, the calculation of the stress will be always calculated using the initial radii and the reduction of the area and the strain-hardening during the test will be neglected.

4.4 TESTING MACHINE

The machine is able to do the tensile and compression test. A tool has been designed in order to modify the machine to be able to perform bending test as well.

46 [Testing machine with both, tensile/compression and bending disposition]

4.5 TENSILE TEST

4.5.1 Introduction

The tensile testing is one of the most fundamental tests in engineering, where a sample is subjected to an axial force opposite to the section of the specimen until its failure. The ultimate tensile strength, the breaking strength, the maximum elongation and the reduction of the area can be obtained from this test. From this date the young modulus, the Poisson's ratio, the yield strength and the strain- hardening can be obtained.

During the test, the elongation of the specimen is determined, and a force-elongation or stress-strain graph is obtained.

$$\varepsilon = \frac{L - L_0}{L_0}$$

$$\sigma = {}^{F}\!/_{A}$$

With this test we will be able to set the resistance of the insert.

The procedure of the experiment will be as mentioned in the previous point.

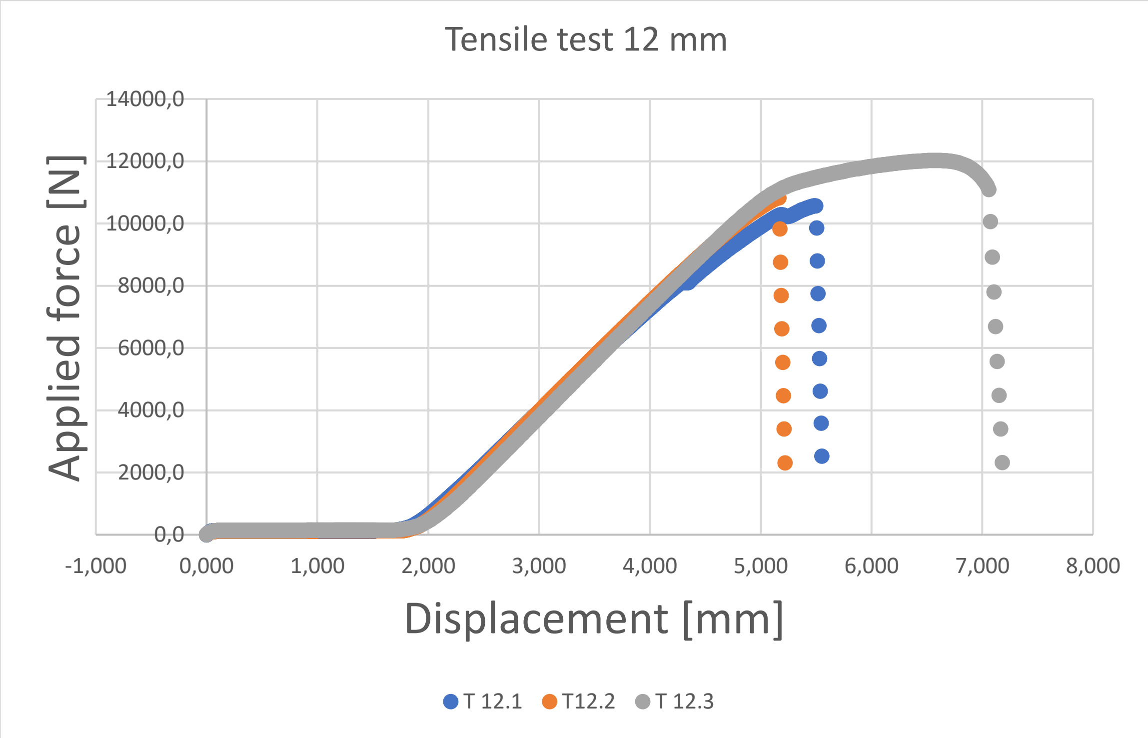
4.5.2 Results and calculations

In the following table the experimental data regarding to the tensile test can be checked:

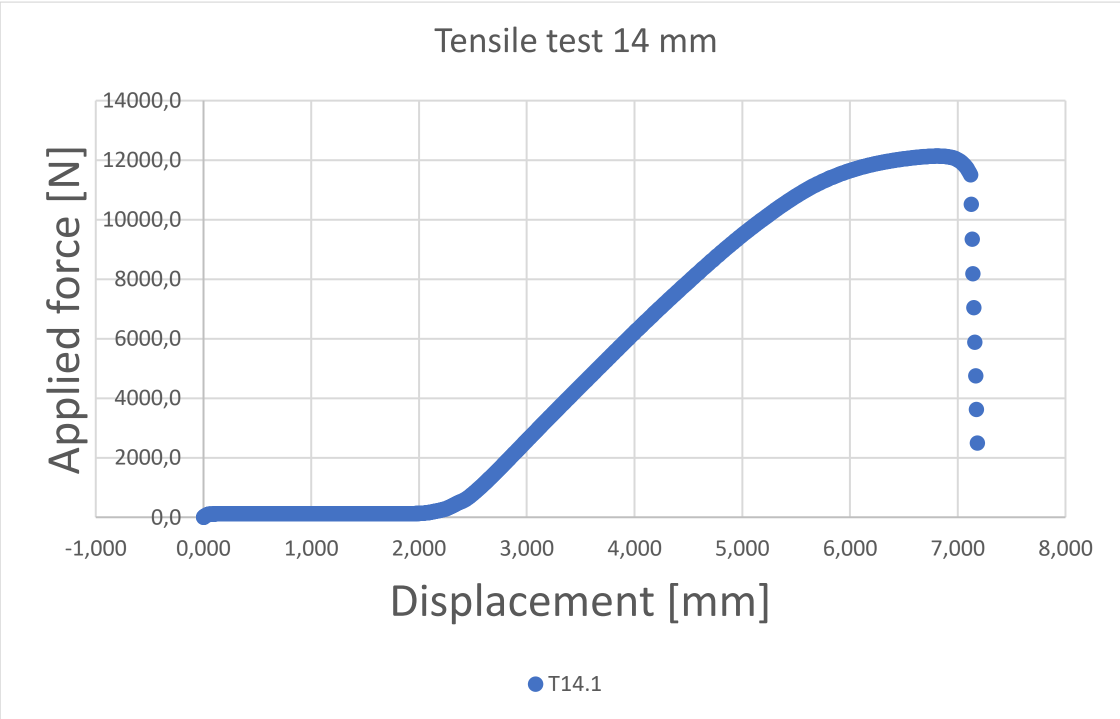
SAMPLE	MAX STRENGTH [N]	MAX STRESS [MPa]	MAX DEFORMATION [mm]
12 mm (1)	10571.8	305.9	5.553
12 mm (2)	10844.9	313.8	5.220
12 mm (3)	12028.1	348.1	7.180
14 mm (1)	12133.8	297.1	7.181

Table 3 [Tensile test maximum values data]

4.5.3 Stress strain graph



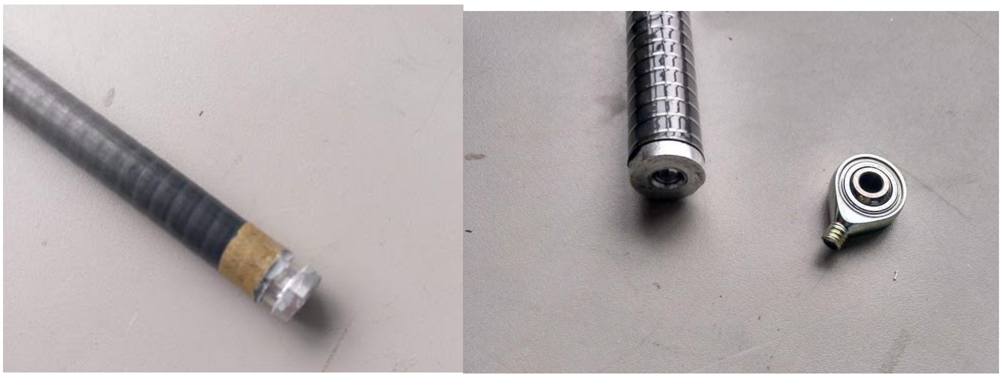
47 [Stress strain graph of the tensile test for the 12 mm samples]



48 [Stress strain graph of the tensile test for the 14 mm samples]

4.5.4 Conclusions

With the 12 mm carbon tubes the carbon tube itself does not fail in any case. With 12 mm two samples failed in the glued part at around 10 kN and the third one failed at 12 kN in the condyle.



49 [Failure modes of the 12 mm tubes]

With the 14 mm carbon tube the screwed condyle fails at a force of approximately 12 kN. The carbon tube or the glued insert does not fail. The test has been stopped at this point, as all the samples will break at a force between 10-13 kN and it is a force much higher than the compression test.

50 [Failure of the 14 mm]

The area of resin is the adequate in this case. It can withstand the same force as the condyle. Increasing the area of contact will not increase the resistance of the sample.

Higher resistance in tensile test will not allow optimization of the diameter of the tubes of the suspension.

4.6 COMPRESSION TEST

4.6.1 Introduction

Most of the materials have different behaviour in the different directions of the tension, however, in composite materials as carbon fibre this behaviour is more notorious.

The behaviour under compression of most of the materials follows a similar pattern to tensile test, an elastic behaviour followed by a plastic deformation.

$$\varepsilon = \frac{L - L_0}{L_0}$$

$$\sigma = {}^{F}/_{A}$$

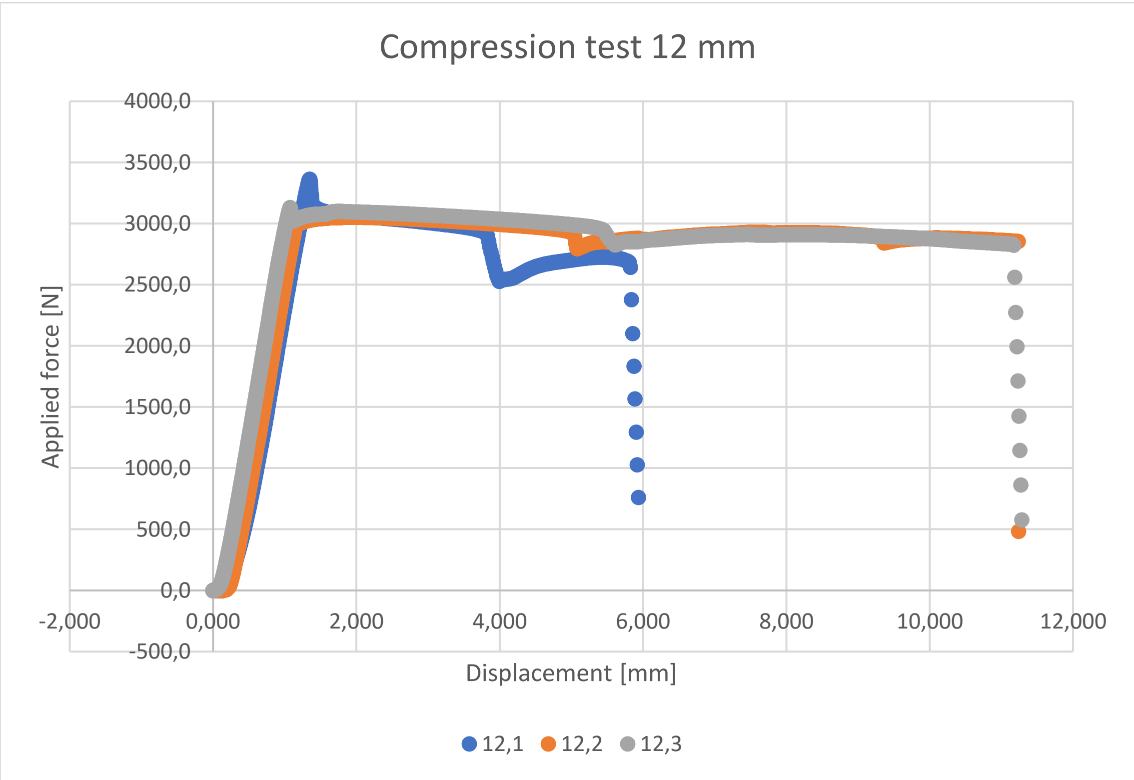
The procedure of the experiment will be as mentioned in the previous point.

4.6.2 Results and calculations

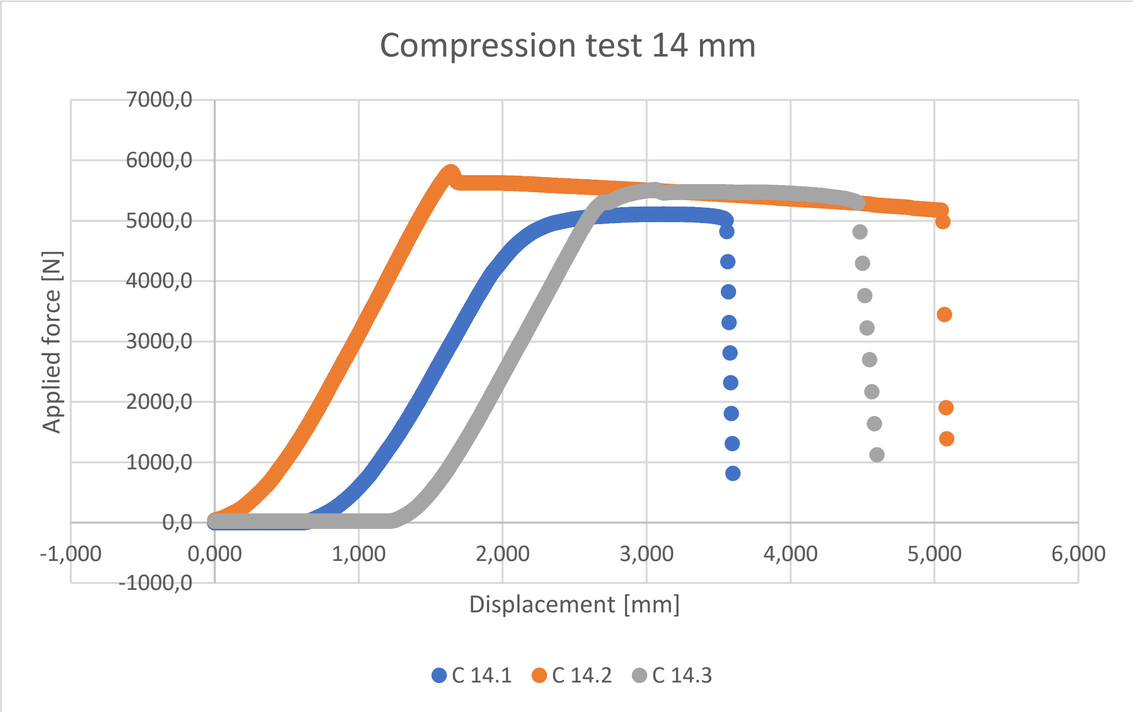
SAMPLE	MAX STRENGTH [N]	MAX STRESS [MPa]	MAX DEFORMATION [mm]
12 mm (1)	3362.1	97.3	5.936
12 mm (2)	3052.3	88.3	11.241
12 mm (3)	3131.0	90.6	11.287
14 mm (1)	5111.6	125.2	3.601
14 mm (2)	5813.2	142.3	5.086
14 mm (3)	5516,6	135.1	4.600
16 mm (1)	7914.4	167.9	3.703
16 mm (2)	6822.3	144.8	2.802
16 mm (3)	8057.4	171.0	3.254
18 mm (1)	11119.0	208.2	4.000
18 mm (2)	10457.6	195.8	6.259
18 mm (4)	9879.0	185.0	4.603

Table 4 [Compression test maximum values data]

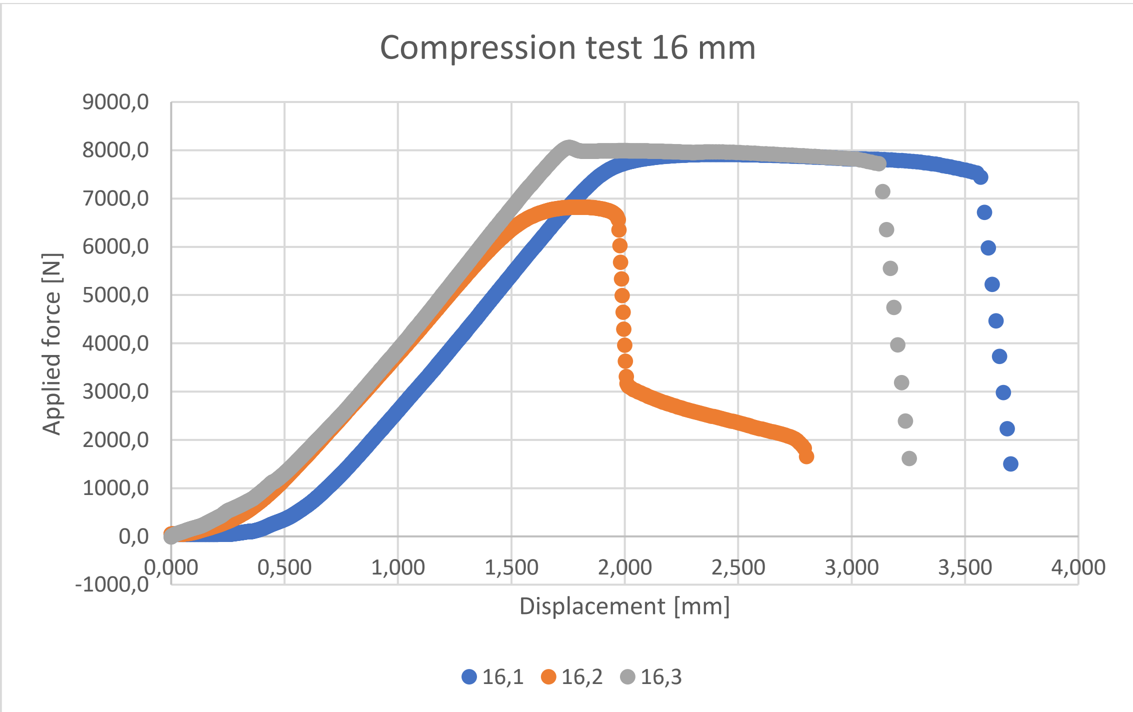
4.6.3 stress strain graph



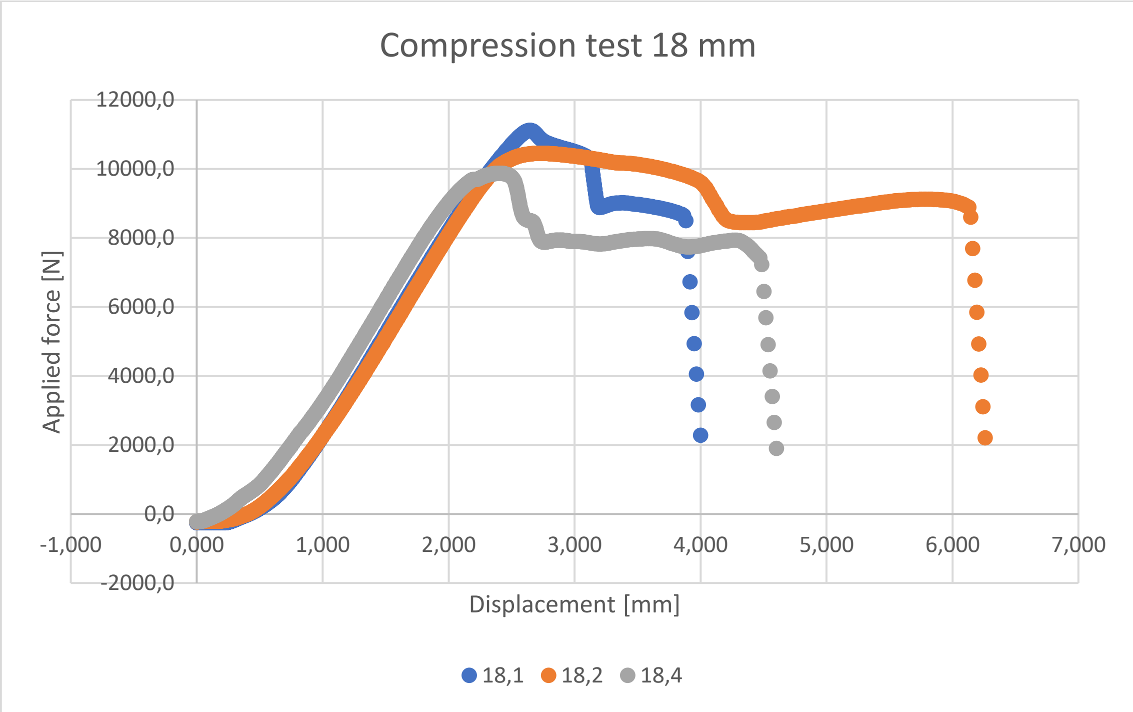
51 [Stress strain graph of the compression test for the 12 mm samples]



52 [Stress strain graph of the compression test for the 14 mm samples]



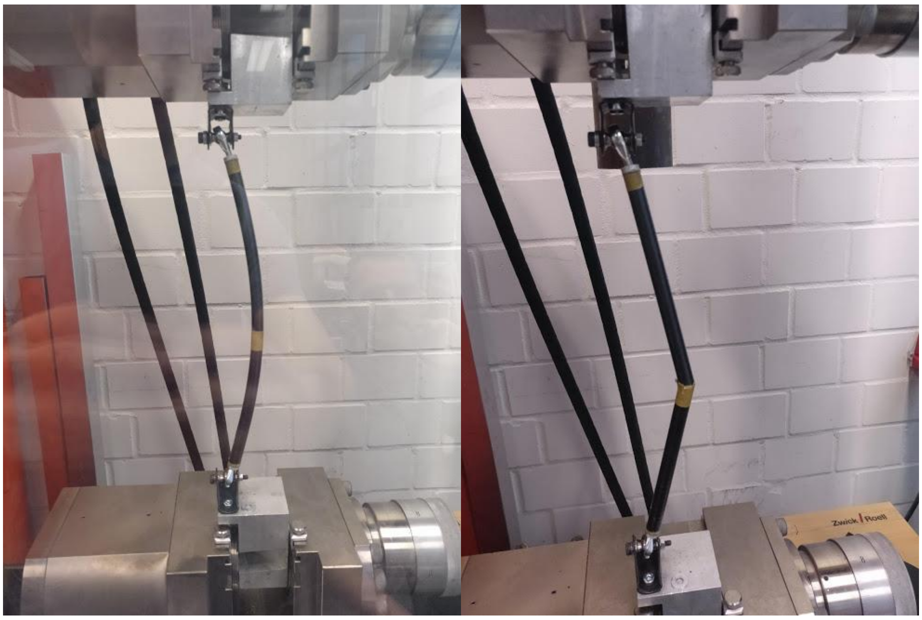
53 [Stress strain graph of the compression test for the 16 mm samples]



54 [Stress strain graph of the compression test for the 18 mm samples]

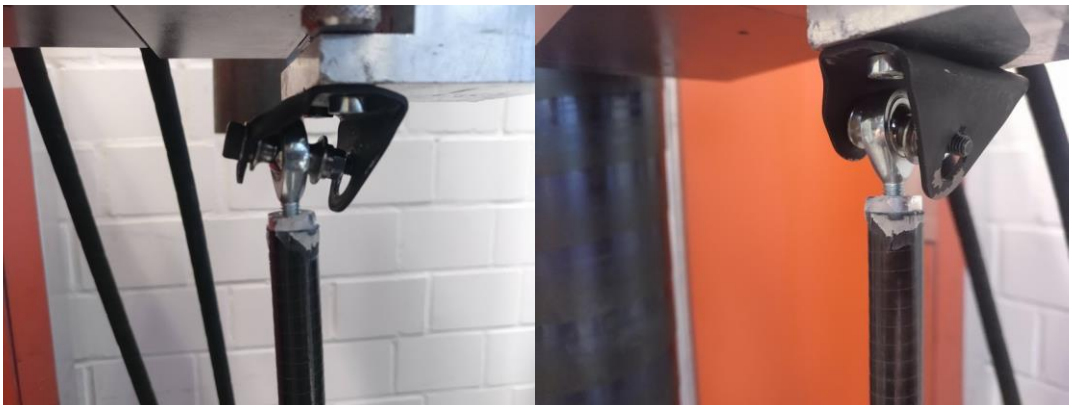
4.6.4 Conclusions

At the compression test with the 12 mm diameter both, the insert or the carbon tube fail at a force of approximately 3 kN.



55 [Failure of the 12 mm carbon tube in the compression test]

With the 14 mm diameter carbon tube the self-manufactured tool for the testes failed causing the interruption of the test.



56 [Failure of the self- manufactured tool in the compression test]

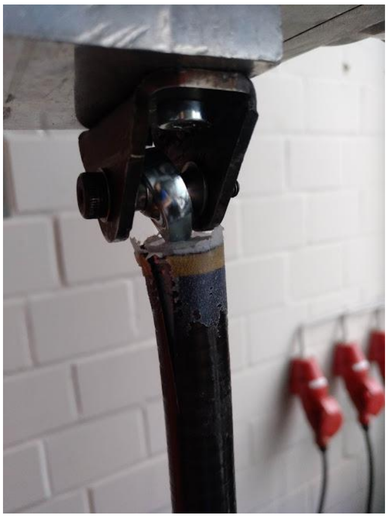
When it was possible to continue with the testing, they were samples breaking in the condyle causing deformation in the insert or braking in the carbon tube.

57 [Sample 16.2 braking in the in condyle]

58 [Sample 16.3 breaking in the carbon tube]

In the 14 mm carbon tubes 14.1 and 14.3 break in the condyle and 14.2 in the carbon tube with similar strength forces.

In 16 mm and 18 mm some of the condyles may have failed with lower strength due to fatigue of the material. In the case of the 18.3 for example the condyle failed with lower value than before. That's why it was changed and repeated the experiment. We can also appreciate in the graph of 16 mm a lower value of break of the condyle of the 16.1 compared with the 16.2. The 16.3 on the other side break in the carbon tube.



59 [Sample 18.4]

18.4 carbon tube broke different to the previous one. The insert broke into the carbon tube causing damage because of the perforation of the tube.

Every time the carbon tube fails a small pick can be appreciated in the maximum strength. This could be a characteristic of the carbon fibre as a composite material. On the other hand, when the condyle fails, a soft curve can be appreciated as in most of the metal materials.

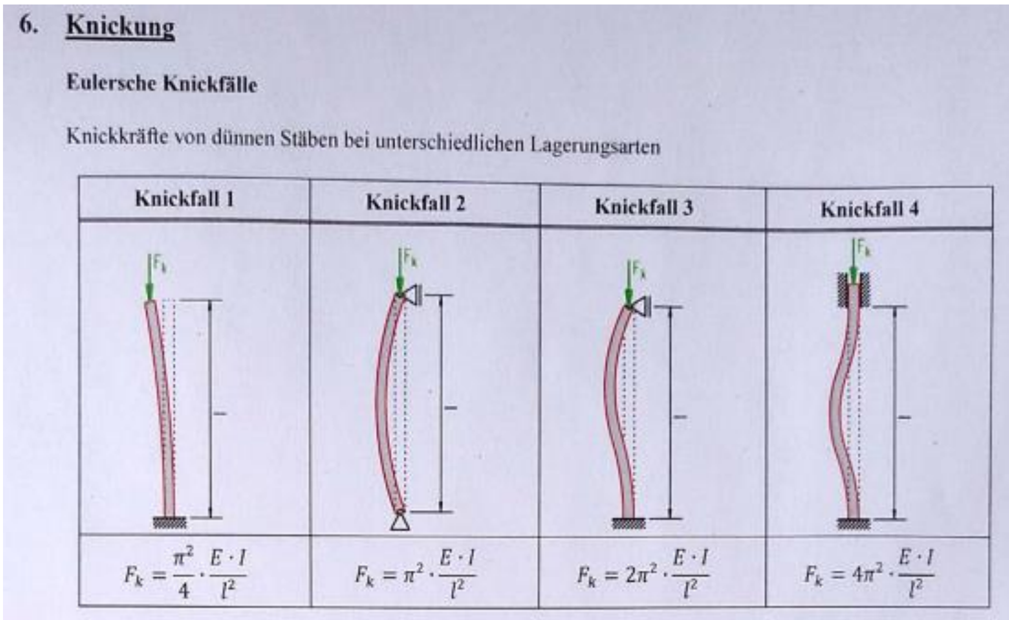
60 [Pick of strength in the failure of the carbon tube]

Compression is more limiting effort than tensile. According to the test the average strength and stress withstand are the followings:

Diameter of the tubes	Strength [N]	Stress [MPa]
12 mm	3181.8	92.1
14 mm	5480.5	134.2
16 mm	7598.0	161.2
18 mm	10485.2	196.3

Table 5 [Average strength and stress in compression tests]

It can be appreciated an increase of the tensile strength of the material in higher diameters. The buckling was analysed to check if the carbon tubes where failing at compression or bending could also appear.



61 [Buckling critical force according to different cases]

In this case, as rotation is allowed in the joints buckling of type two could appear. This will happen when the critical force, F_k is higher than the actual force in the carbon tube. According to the formula, the critical force was calculated for each diameter of the carbon tubes. L of 0.4 m was used and a Young modulus of 135 GPa.

Mean force [N]	R [m]	r [m]	I [m^4]	Critical strength Buckling [N]
3182	0,006	0,005	0,00000000053	4389
5480	0,007	0,006	0,00000000087	7227
7598	0,008	0,007	0,00000000133	11086
10485	0,009	0,008	0,00000000194	16122

Table 6 [Critical strength for buckling calculation for the compression test]

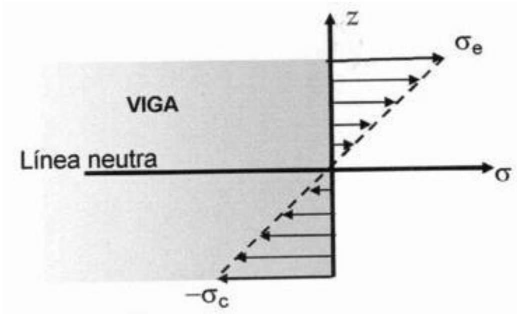
The critical strength is close to the strength in the test and the condyle union reduces the inertia of the sample. For this reason, some of the samples have this type of failure.

4.7 BENDING TEST

4.7.1 Introduction

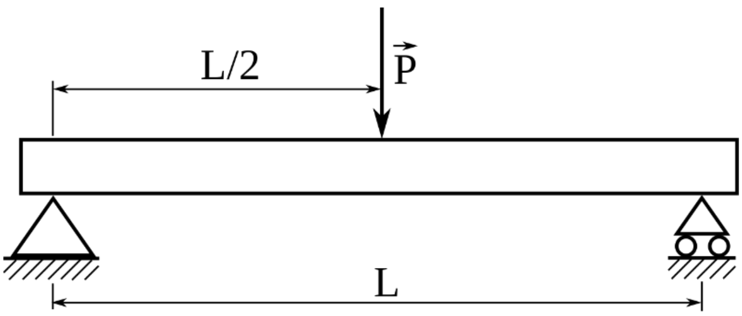
The bending test, like the tensile test, is used to determine the mechanical properties of the materials under tension. This case is another way of producing traction, since it is the way the materials fail in this test. It is done by applying a force in the centre of a bisupported bar (with force at each end). The load can be static, applied at one time or gradually increased. This test is usually performed only for fragile materials. From this test, most of the properties (Young's modulus, resilience, toughness ...) can be determined from the material as in the case of the tensile test. In this case, the bending strength or the modulus of rupture can be determined, corresponding to the effort required to break a specimen due to bending.

The bending produces compressive stresses at the low side of the part (applying the load at the top in a downward direction) and traction at the top. The bending appears when applying loads perpendicular to the axis of the piece or by external moments.



62 [Distribution of tension in the cross section of a beam at bending]

The bending test will be done by a three- point flexural test, with two of the outer points with forces in the vertical direction and applying a known vertical load downwards in the centre of the tube.



63 [Bisuported beam at bending in a testing disposition]

$$Inertia\ of\ cilindrical\ tube: I = \frac{\pi(R^4 + r^4)}{4}$$

$$\sigma_{max} = \frac{M \cdot y}{I} = \frac{F/_2 \cdot L/_2 \cdot R}{\pi/_4\,(R^4 - r^4)} = \frac{F \cdot L \cdot R}{\pi(R^4 - r^4)}$$

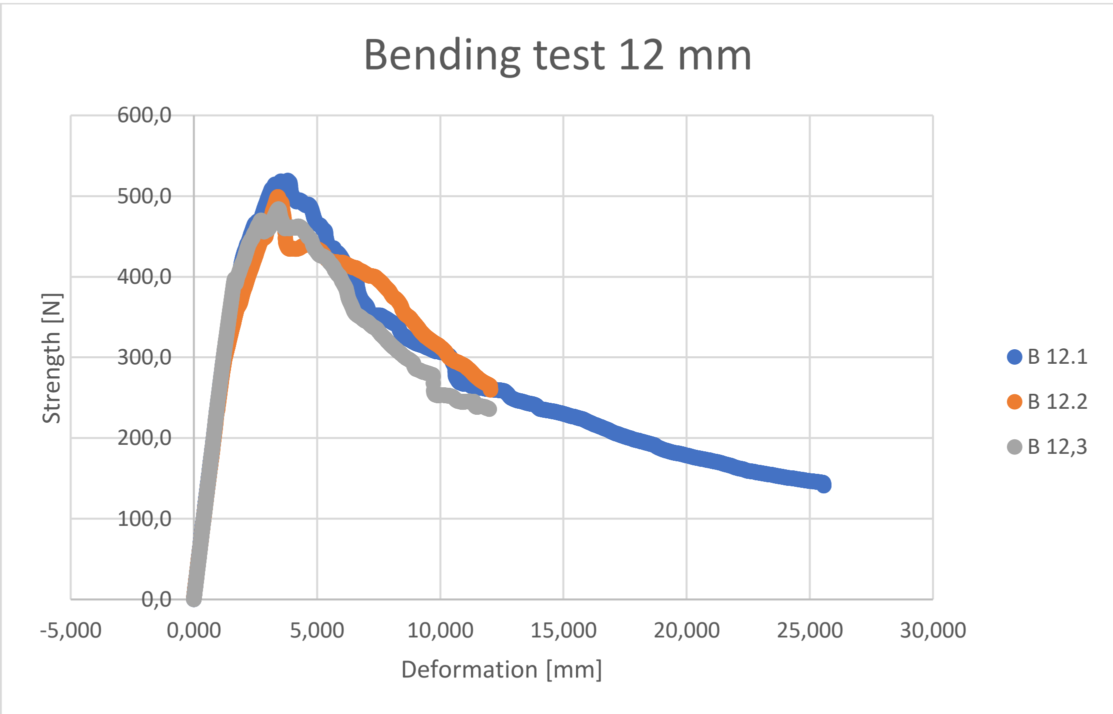
The procedure of the experiment will be as mentioned in the previous point.

4.7.2 Results and calculations

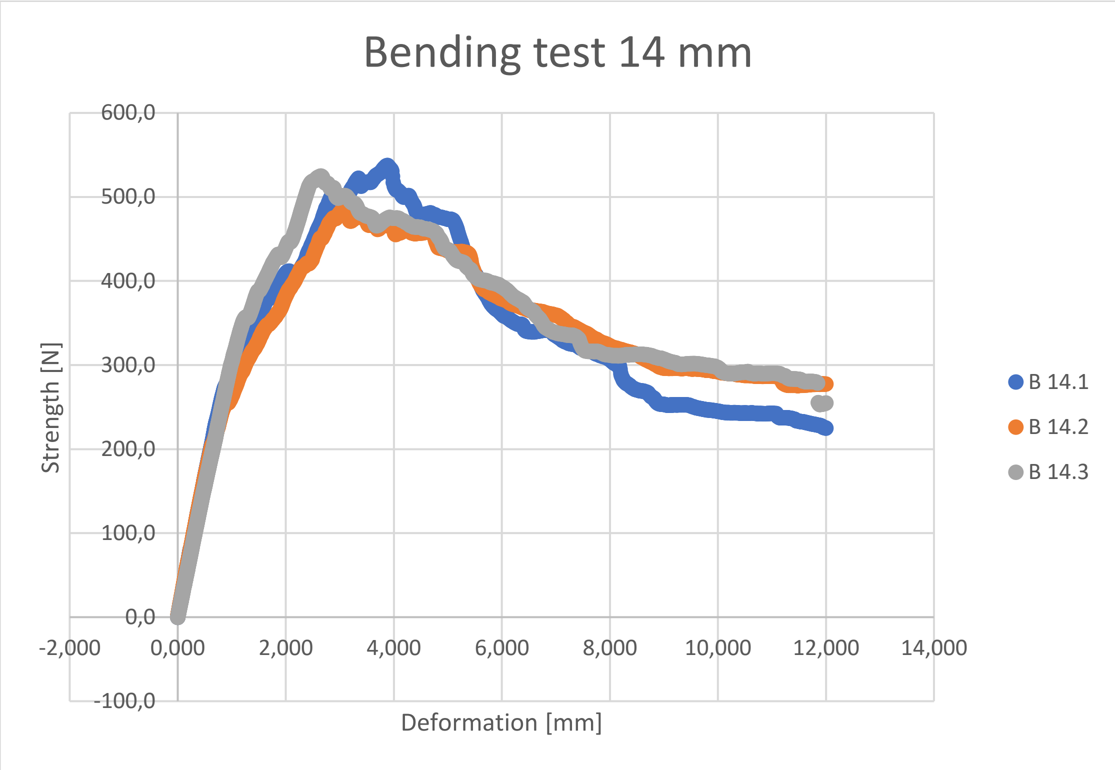
SAMPLE	MAX STRENGTH [N]	MAX STRESS [MPa]	MAX DEFORMATION [mm]
12 mm (1)	519	260.0	25.6
12 mm (2)	499	250.0	12.0
12 mm (3)	484	242.5	12.0
14 mm (1)	534	189.5	12.0
14 mm (2)	490	173.9	12.0
14 mm (3)	525	186.3	12.0
16 mm (1)	627	165.8	12.0
16 mm (2)	661	174.8	12.0
16 mm (3)	664	175.6	12.0
18 mm (1)	662	135.4	12.0
18 mm (2)	711	145.4	12.0
18 mm (3)	721	147.5	12.0

Table 7 [Bending test maximum values data]

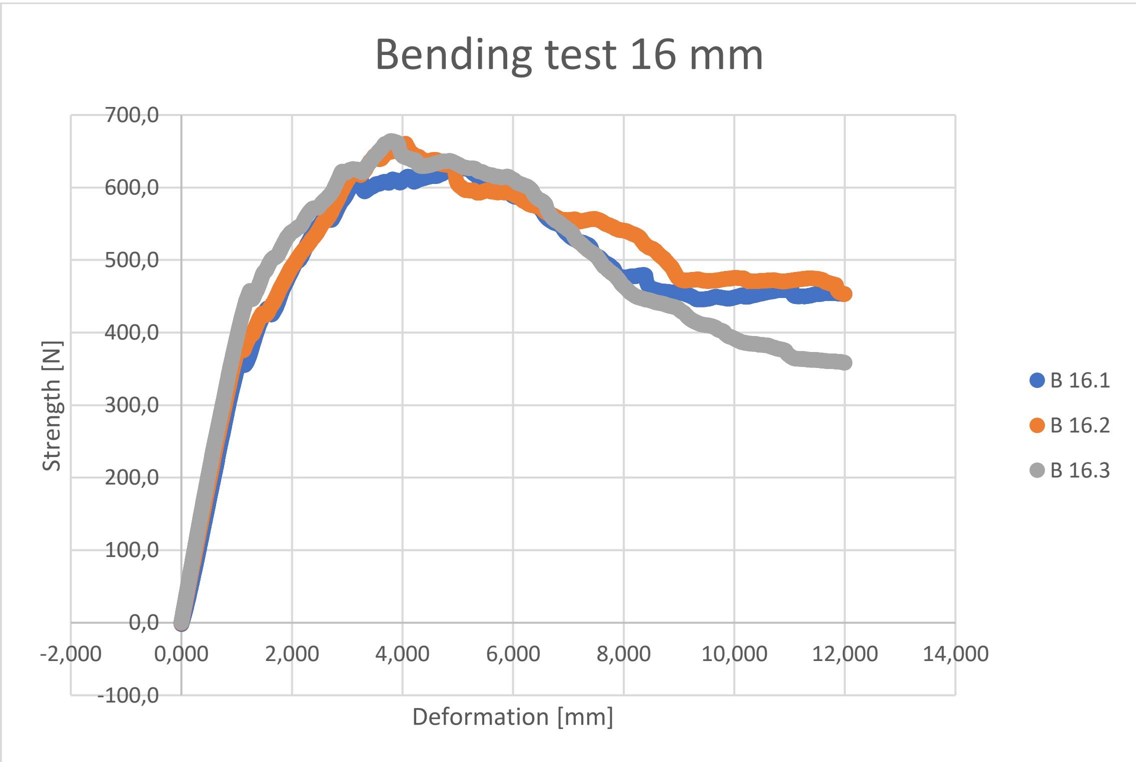
4.7.3 Stress strain graph



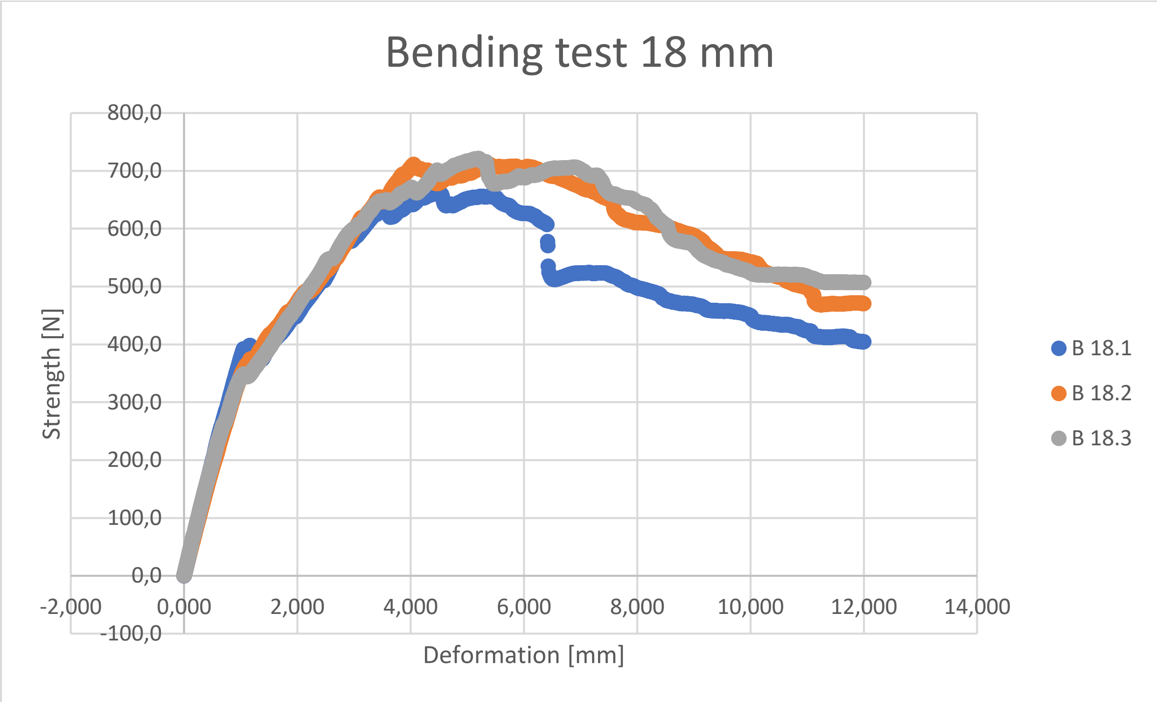
64 [Stress strain graph of the bending test for the 12 mm samples]



65 [Stress strain graph of the bending test for the 14 mm samples]



66 [Stress strain graph of the bending test for the 16 mm samples]



67 [Stress strain graph of the bending test for the 18 mm samples]

4.7.4 Conclusions

Failing in the bending test occurs in the middle of the carbon tube where the effort is applied.

68 [Failure at bending of the carbon tubes]

Bending is the most limiting effort for the carbon tubes. According to the test the average strength and stress withstand are the followings:

Diameter of the tube	Strength [N]	Stress [MPa]
12 mm	500.7	250.8
14 mm	516.3	183.2
16 mm	650.7	172.0
18 mm	698.0	142.8

Table 8 [Average strength and stress values in bending tests]

Due to this characteristic avoiding bending efforts in the carbon tubes should be the criteria to consider.

It can be appreciated an increase of the tensile strength of the material in higher diameters. This behaviour can be explained because of the type of material analysed. Carbon fibre is a composite material and does not have a linear behaviour with strength and diameter. Another cause could be the density of carbon fibres in the cross section. Due to the change of diameter and fabrication, the density of fibres along the cross section may not be constant, what leads to different resistance to different diameters.

4.8 CONCLUSION OF THE MATERIAL TESTS

Resume table of the solicitations with a safety factor of 1.4:

	A-Arm low		A-Arm up		Pushrod	
	Tens./Comp. [kN]	**Bending [MPa]**	**Tens./Comp. [kN]**	**Bending [MPa]**	**Tens./Comp. [kN]**	**Bending [MPa]**
12 mm	4.5	0	3 k N	444	4	0
14 mm				314		
16 mm				234		
18 mm				180		

Table 9 [Solicitations in the suspension with safety factor]

Resume table of the resistance of the material:

	Tensile		Compresion		Bending	
	Strength [kN]	**Stress [MPa]**	**Strength [kN]**	**Stress [MPa]**	**Strength [kN]**	**Stress [MPa]**
12 mm	10	300	3	90	0.50	250
14 mm			5.5	135	0.50	180
16 mm			7.5	160	0.65	170
18 mm			10	200	0.70	140

Table 10 [Average material resistance of the carbon tubes according to the tests]

From these tables we can conclude that the most optimal diameters for the Low A-Arm and the Pushrod are the 14 mm ones.

In the case of the Up A-Arms the 16 mm and the 18 mm diameter withstand the solicitations according to the calculation but with a safety factor of 1.02 and 1.09 respectively. For this reason, using at least 18 mm carbon tubes would be recommendable.

5 BUILDING PROCESS

5.1 Introduction

The building process is the part when all the theoretical part of the design is materialised. Around the 90% of the parts are manufactured while the remaining are bought to different suppliers, such as the engine, the accumulator or the bearings among others. All the parts are collected in the workshop and then used to build the car. The main deadline is the Roll-Out, the event where the car makes an official showing at the 23/05/2019.

5.2 PROGRESS PLAN

The progress plan in a document where all the information about the parts is compiled. A name and a part number are assigned to each of the components, if it is a manufactured or purchased item and the amount. Then the manufacturer(s) are selected, and the status is updated, from the "open" status where only the design is done to the "built in the car" status.

For the purchased items, a list of all the components is made with the exact component number and name and all the necessary information of the supplier and the exact model that must be bought.

Assembly	Part name	Article nr. (Company)	Part number (IRT)	Responsible person	Amount	Price/piece	Company	Notes	Requested	Ordered	In Storage
wheelhub	Bearing FA	3811-B-2RS-TVH	11105	Fabian	4	~50€	Schaeffler		☑	☐	☐
wheelhub	Bearing RA	DRAZ 030 VA	11006	Fabian	4	107€	SBN	Alternatives available	☑	☑	☐
wheelhub	Sealing RA		11005	Fabian	4	~5-9€		https://www.agrolager.de/product_info.php?products_id=31002512	☑	☑	☐
Suspension	Bearing skf 608_2RSH	608_2RSH SKF	10311	Adrián	8	2 €	SKF	http://www.skf.com/de/products/bearings-units-housings/ball-bearings/deep-groove-ball-bearings/deep-groove-ball-bearings/index.html?designation=608-RSH https://www.ekugellager.de/#!/query=6082RSH&Width=0&DiameterInner=0&DiameterOuter=0&PageNum=0	☑	☑	☐
Suspension	Condyle	SMCP 6	10324	Adrián	24		Hirschmann		☑	☑	☐
Suspension	Union A-Arm	SCP type 8	10343	Adrián	8		Hirschmann		☑	☑	☐
Suspension	Carbon Tube A-Arms Front Up Right	CFK-Stab ø 14 x 1.000 mm s141000	10344	Adrián	2	20 €	Carbonwerke		☐	☐	☐
Suspension	Carbon Tube A-Arms Front Up Left	CFK-Stab ø 14 x 1.000 mm s141000	10345	Adrián	2	20 €	Carbonwerke		☐	☐	☐
Suspension	Carbon Tube A-Arms Front Down Right	CFK-Stab ø 14 x 1.000 mm s141000	10346	Adrián	2	20 €	Carbonwerke		☐	☐	☐
Suspension	Carbon Tube A-Arms Front Down Left	CFK-Stab ø 14 x 1.000 mm	10347	Adrián	2	20 €	Carbonwerke		☐	☐	☐

69 [List of purchased items]

For the manufactured items the exact material must be provided. For that purpose, all the raw volume of material according to each of the parts must be compiled and the responsible person of the material orders the material to the corresponding suppliers.

Suspension	Rocker bushing Rear	10362	X8CrNiS18-9	Ø18x17	4		Adrian Rivas Artazcoz	☑
Suspension	Rocker Front	10301	AW7075	100x75x25	2		Adrian Rivas Artazcoz	☑
Suspension	Rocker Rear	10313	AW7075	100x75x25	2		Adrian Rivas Artazcoz	☑
Suspension	Pushrod adjustment insert	10320	AW7075	24x24x45	4		Adrian Rivas Artazcoz	☑
Suspension	Insert pushrod	10321	AW7075	Ø18x24	20		Adrian Rivas Artazcoz	☑
Suspension	Pushrod upper plate	10325	AW7075	45x24x10	4		Adrian Rivas Artazcoz	☑
Suspension	Pushrod intermediate plate	10326	AW7075				Adrian Rivas Artazcoz	☑
Suspension	Y-Piece front up left	10335	AW7075	80x80x20	1		Adrian Rivas Artazcoz	☑
Suspension	Y-piece front up right	10336	AW7075	80x80x20	1		Adrian Rivas Artazcoz	☑
Suspension	Y-piece front low	10337	AW7075	80x80x20	2		Adrian Rivas Artazcoz	☑
Suspension	Y-piece rear up left	10338	AW7075	80x80x20	1		Adrian Rivas Artazcoz	☑
Suspension	Y-piece rear up right	10339	AW7075	80x80x20	1		Adrian Rivas Artazcoz	☑
Suspension	Y-piece rear low	10340	AW7075	80x80x20	2		Adrian Rivas Artazcoz	☑
Suspension	Front Bracket Rocker	10303	25CrMo4	2x40x90	2		Adrian Rivas Artazcoz	☑
Suspension	Rear Bracket Rocker	10314	25CrMo4	2x35x100	2		Adrian Rivas Artazcoz	☑
Suspension	Sensor Arm Front	10315	25CrMo4	2x10x120	2		Adrian Rivas Artazcoz	☑
Suspension	Bracket Tie-Rod Connection	10352	25CrMo4	2x55x80	2		Adrian Rivas Artazcoz	☑

70 [Progress plan]

The progress plan is a living document, it changes with the progress of the vehicle, however and example of the 02/05/2019 is available in the annexes.

5.3 ASSEMBLY BOX

In the storage a box is available for every assembly. In this box all the materials, manufactured parts, technical drawings and necessary tools for the building are collected. A lot of materials are collected in these boxes and it is important to separate what it is not useful, from what it necessary and the things that can be used in further years.

71 [Assembly boxes in the self of the storage]

5.4 MANUFACTURING

The materials are sent to the manufacturers to manufacture the parts in the exact material desired. For that purpose, once the raw material arrives to the workshop is prepared in the bruto material blocks and classified in the different places for the manufacturers with its corresponding label. Then the responsible of the manufacturer takes all the materials to that provider and put the final part in its corresponding place. It is possible that this process is repeated more than once, as there are parts that require more than one manufacturer.

For the suspension the following materials are used:

- **Aluminium (AW7075)** for the main parts such as the rockers and the y pieces
- **Tempered steel (25CrMo4)** for the folded parts such as the brackets.
- **Stainless steel (X8CrNiS18-9)** for the fractioning parts as bushings
- **Carbon fibre** for the carbon tubes

72 [Cutting a bar of alloyed steel of 24 mm diameter for the manufacturer ZF to manufacture the inserts of the carbon tube]

73 [Shelf of materials and finished parts]

The exchange of materials and finished parts happens in this shelf. When the materials must be taken to the manufacturer, the responsible of this manufacturer goes to the shelf and must look in each corresponding section the material prepared and labelled for this process. Then after the manufacturing process, the part is given back to the shelf where the responsible person of that part can take the finished item to his box.

74 [Y-Pieces manufactured by Juhr in a facility of the campus]

When the Y-Pieces and the patterns for the building are in the workshop the building of the A-Arms starts. First the carbon tubes are cut, polished and cleaned. Then the inserts are glued in one side. The angle of the A-Arms is very important for the fitment of the suspension. To ensure a perfect building the building patterns are used. These patterns help the carbon tubes to have the adequate angle when they are glued to the Y-Pieces.

75 [Patterns for the building of the A-Arms]

The brackets for the suspension are parts manufactured by laser cut metal shaft and bended. Last year Engelbrecht was a sponsor of the IRT team and could manufacture those parts without cost for the team. This year unfortunately Engelbrecht is not a sponsor anymore and another way of manufacture was required. The shaft was cut at the workshop of a member’s uncle. This shaft however was 3 mm thick instead of 2 mm. This led to changes in the bending drawing to maintain the distance with respect to the monocoque and the gap inside. These measurements are very important for the kinematics of the vehicle and the fitment of the suspension.

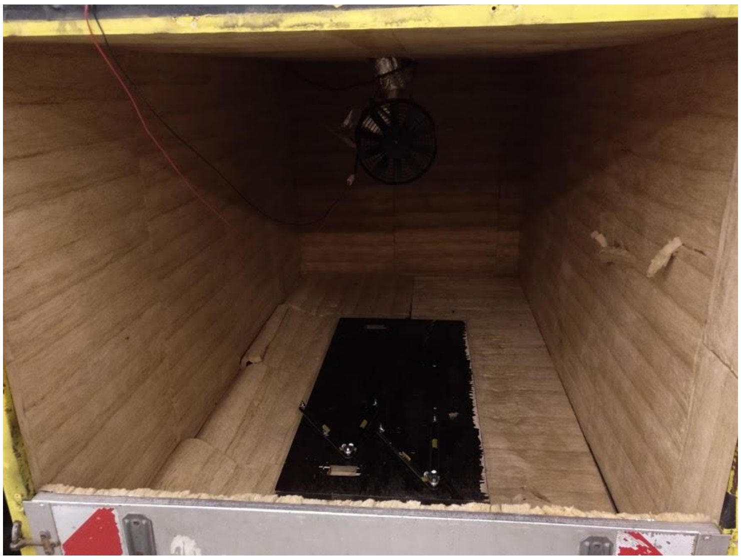
5.5 ASSEMBLING

Once the carbon tubes are cut the instruction of mounting the A-arms is followed to build them. Epoxy resin is used to glue them. The surfaces of contact must be polished and cleaned before applying the resin.

76 [Patterns and epoxy resin]

77 [A-Arm components ready to apply the resin]

After gluing the parts are tempered.



78 [Tempering facility in the IRTe team]

The procedure must be repeated for all the A-arms, push-rods and both sides of the vehicle.

79 [A-Arms built]

5.6 PUSHROD ADJUSTMENT PROBLEM

When building the pushrod, the nuts for the screws were not the ISO ones of the Catia catalogue. These anti rolling nuts instead of being M6 outside are M8 and they collide the carbon tube when building.

80 [Problematic built pushrod]

A provisional mounting was made cutting a part of the nut. However, a new pushrod is manufactured with some more gap with the carbon tube.

The new designed insert has the correct distance beteween the carbon tube and the screws and the shape has been optimized to reduce the weight maintaining the minimum distances calculated to ensure the validity of the union.

81 [Redesigned insert]

5.7 BRACKETS MOUNTING

The bending of the brackets and the gap between them is fundamental to build the other parts of the suspension and obtain the desired kinematics.

To obtain the correct fitment the final adjustment of the holes of the brackets is made in the workshop to obtain a H7 fitment in the hole.

In some cases, the bending must be corrected, or the bushings polished to have a perfect fitment of the components.

6 FINAL RESULT

6.1 EUROPEAN PROJECT SEMESTER

During their European Project Semester, students from partner universities carry out an engineering project at Osnabrück University of Applied Sciences for one semester in an international and interdisciplinary team of students. The project is accompanied by project related subjects in English such as Intercultural Communication, Team Building, Project Management (all in English), and German classes.

With this project we have been able to develop strong abilities in team work, not only with the other colleges from the European project semester but also with the german people of our team. Our team was different from the other EPS team, our team was not only a group of international students but also a bigger team with all the IRTe team. Each of the members of the EPS had its own subteam in the IRTe and different engineering field, which led to some problems in team work in the beginning. However, we managed to focus on our common objectives with the IRTe team and the EPS to be able to work in our common objectives as a team. Each of us had a different objective and part to work on, but we managed to build a final result together.

82 [EPS members in the IRTe]

6.2 IGNITION RACING TEAM

The roll-out event took out place the Friday 24th of May. This is an event where the team shows to the sponsors, the people of the university and all the friends and family of the team the result of the work of the whole year.

The preparation of the car was finished just hours before the presentation, however, thanks to the effort of all the members of the team to finish all the parts and organize the event the result was successful.

The event started with a meet and greeting of the sponsors, followed by a presentation of the IRTe and the “IRT19 Black Pearl”. Finally, food and drinks were delivered for everyone.

83 [IRT19 Black Pearl in the presentation hall]

84 [Comparation between the IRT19 and the IRT12]

85 [Front suspension]

86 [Rear suspension]

87 [Up view of the suspension]

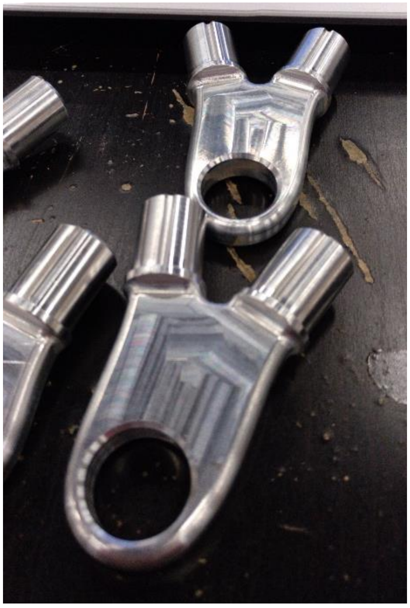
6.3 FUTURE LINES

6.3.1 Symmetry in the A-arms

According to the geometry of the car the suspension was built with antisymmetric suspension in the A-Arms. This allows a better absorbing of the forces in the braking as it is a more demanding situation than the forces generated in the acceleration.

However, this antisymmetry in the A-Arms leads to some problems:

- The Y-Piece is skewed what implies complicated geometry and shape of the surrounding curves. In the following picture can be appreciated how the left side has a very different shape to the right one to be adapted to this type of suspension geometry. This produces that the forces are not equally distributed along the cross section and can induce torsion in the piece.



88 [Y-Pieces shape]

- The length of the carbon tubes is very different of each other. The precision of this mounting is very important to have the desired kinematics in the car. However, the manufacturing in the workshop has big tolerances, so achieving these differences in the length can become complicated. Equal lengths in the carbon tubes could be easier to obtain the desired performance of the suspension.

For these reasons, in further years symmetric A-Arms could be an interesting idea to consider.

6.3.2 Carbon tube diameter

According to the calculations and the test done on the carbon fibre tubes, in the Low A-Arms and the Pushrod a reduction of the diameter to 14 mm could be done. It has also to be considered that in most of the cases the weakest point is not the carbon tube itself but the condyle of the glued part of the insert.

In the case of the Up A-Arm, due to the bending on it, unless a new geometry is used and the bending is reduced, a reduction of the diameter of the carbon tubes is not recommended and the use of the 18 mm carbon tubes will be the most recommended option.

6.3.3 Positioning of the pushrod

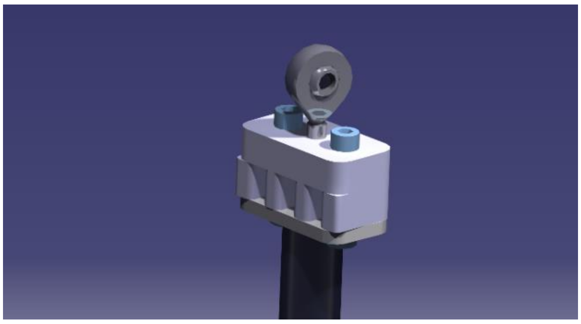
The positioning of the pushrod in the Y-Piece is in a different point than the union between the wheel and the suspension. This distance between the two point produces bending in the low A-Arms.

89 [Positioning of the union of the pushrod]

Reducing this distance will allow a smaller bending effort in the carbon tubes. Positioning the union in the Rad-Trager or a pull-rod system could help this purpose.

6.3.4 Adjustment of the pushrod

The proposed method for the adjustment of the pushrod has the advantage that it is easy and intuitive to change once the adjustments are tested. However, it adds weight to the vehicle and mechanically does not look like the best solution. Having both the screwed condyle and the new introduced system to adjust the length does not seem like the most optimal solution. For further years a solution that could be digitalized would be interesting. A solution using sensors would be the most reliable one.



90 [Adjustment of the pushrod]

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8 ANNEXES

8.1 KINEMATICS OF THE 2017 IRT VEHICLE

8.2 VALIDITY OF THE BOLTED UNION OF THE ADJUSTMENT OF THE PUSHROD

8.3 TECHNICAL DRAWINGS

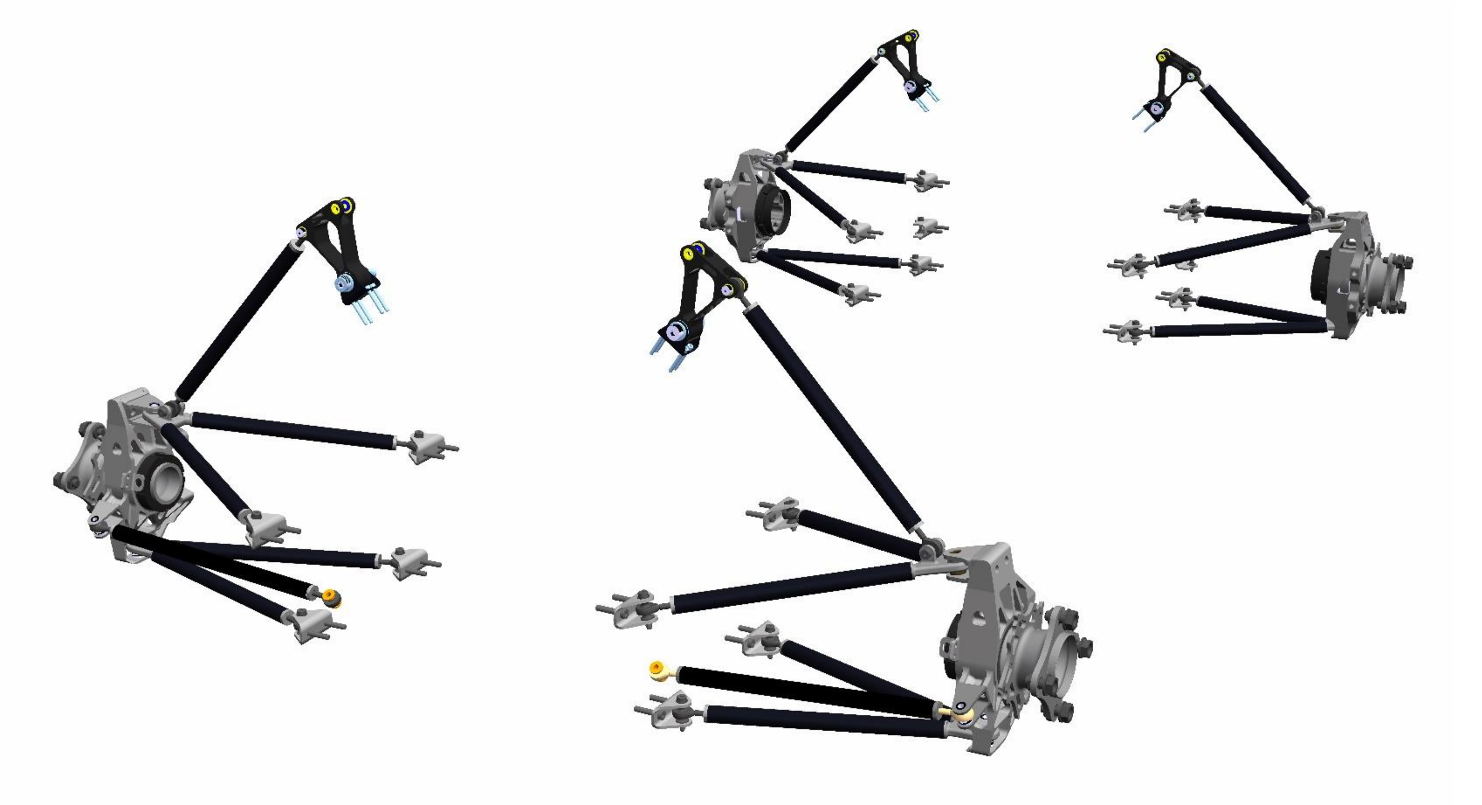
8.4 PROGRESS PLAN

8.5 EUROPEAN PROJECT SEMESTER REPORT

8.6 HALL-EFFECT ABSOLUTE ENCODER SERIES MAB12A DATA SHEET

8.7 RADAUFHÄNGUNG KLEBEN (A-ARMS CONSTRUCTION INSTRUCTION)

Suspension kinematics IR17

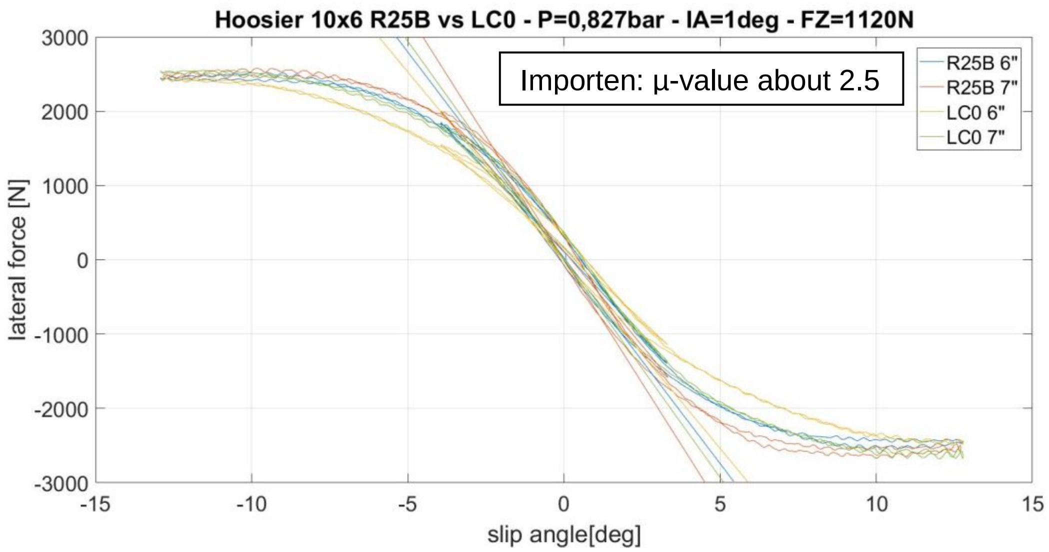


Main goals for IR17

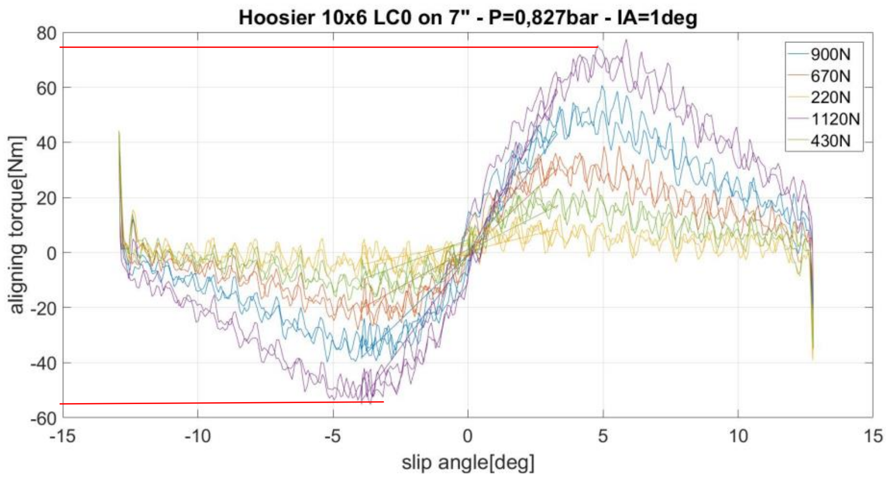
- **Optimized the kinematics for Hoosier R25B tyres**
- **More steering angle in the front**
- **Reduce the wheelbase**
- **New geometry for the monocoque**
- **Optimized ratio rocker for "Fox" air spring**

Analyse Tyres

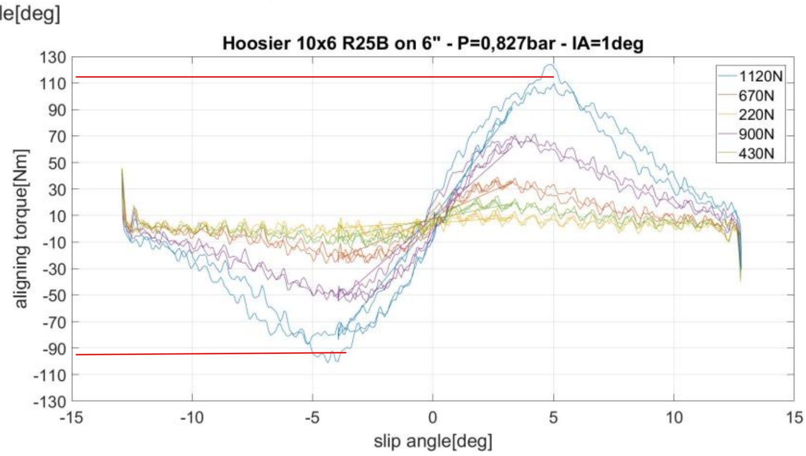
Firstly: Tyre compound



R25B increase lateral force faster than LCO
Our driver can same feedback for this reaction by testing
Test result: LCO increase the tyre temperature faster

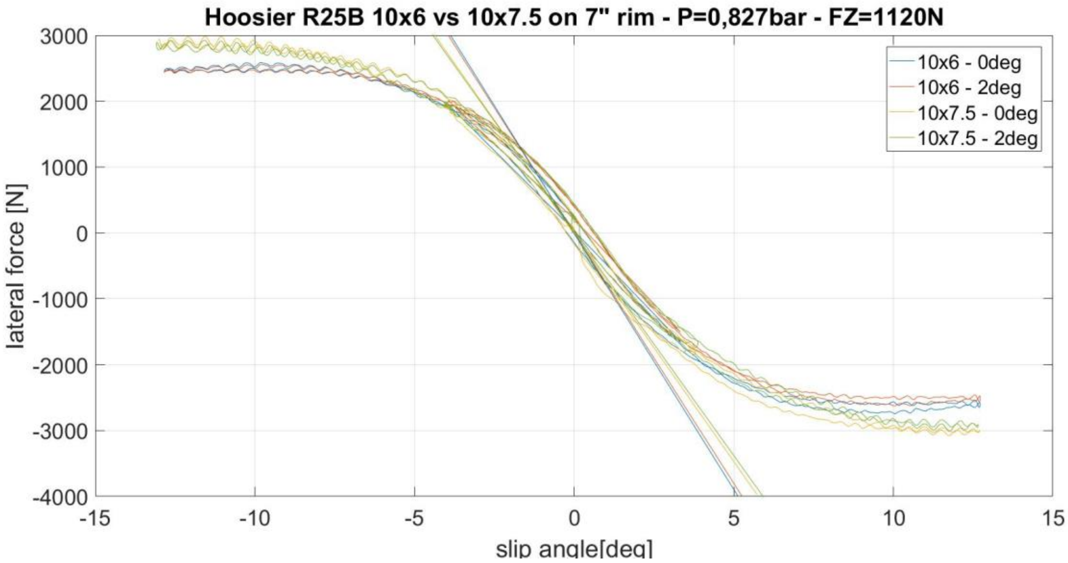


But the aligning torque higher



Secondly: Tyres size

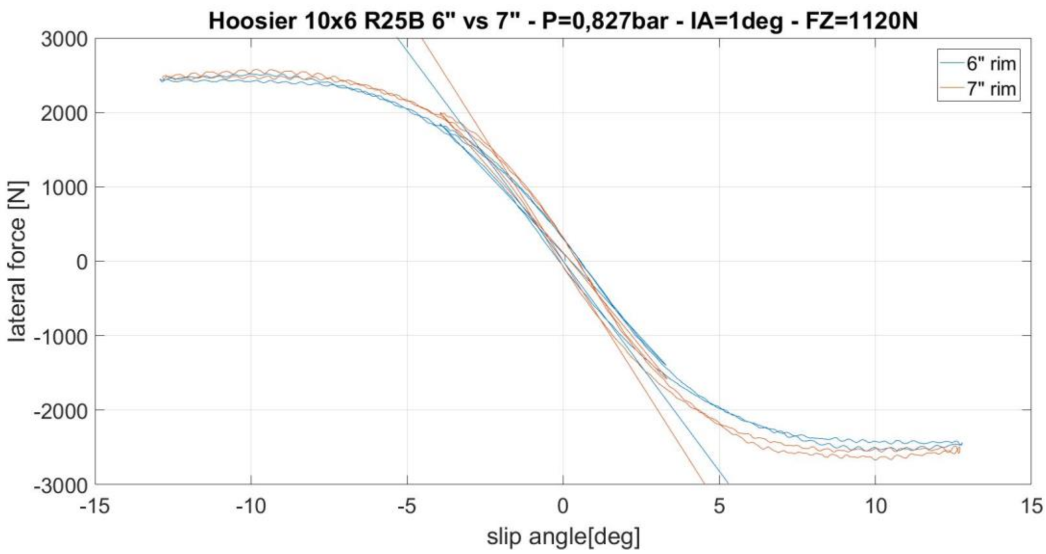
- **7.5 inch higher by 10° slip angle**
- **We drive rare in this slip angle area**
- **Higher slip angle more temperature**

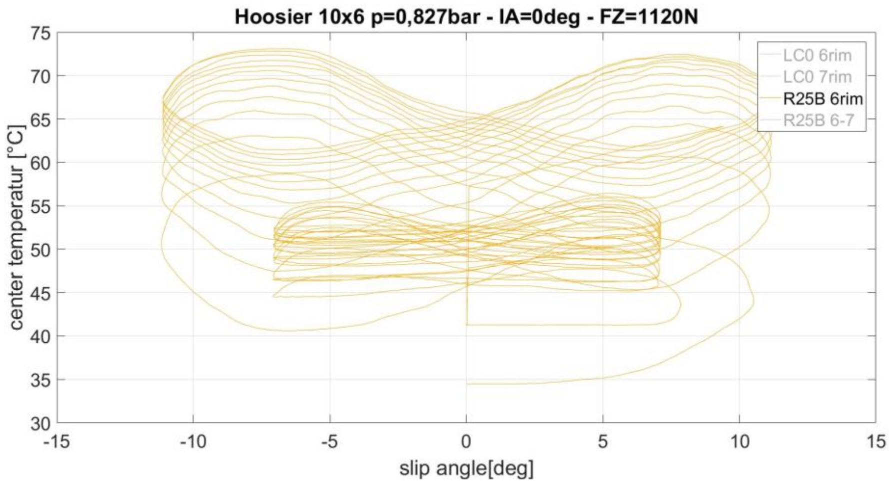


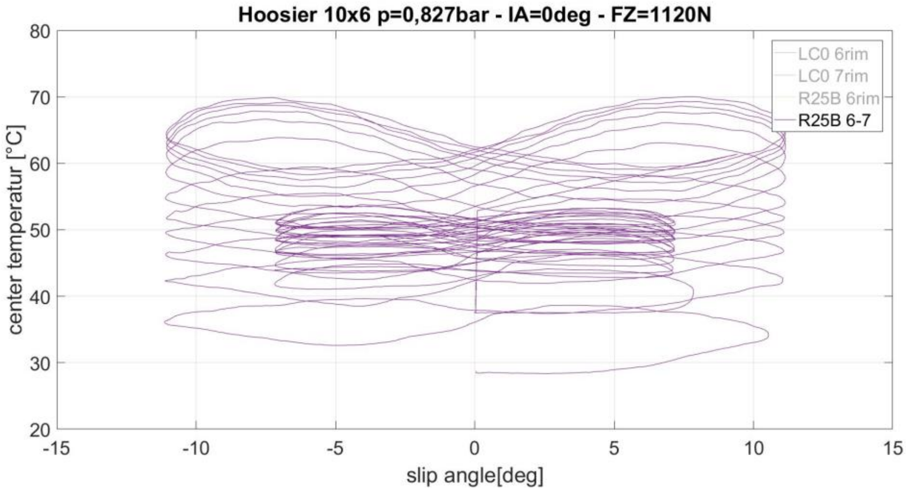
- **7.5 inch heavier than 6 inch**

Thirdly: Tyres rim

- **7 inch rims reduce tyre temperature**
- **little bit more lateral force**

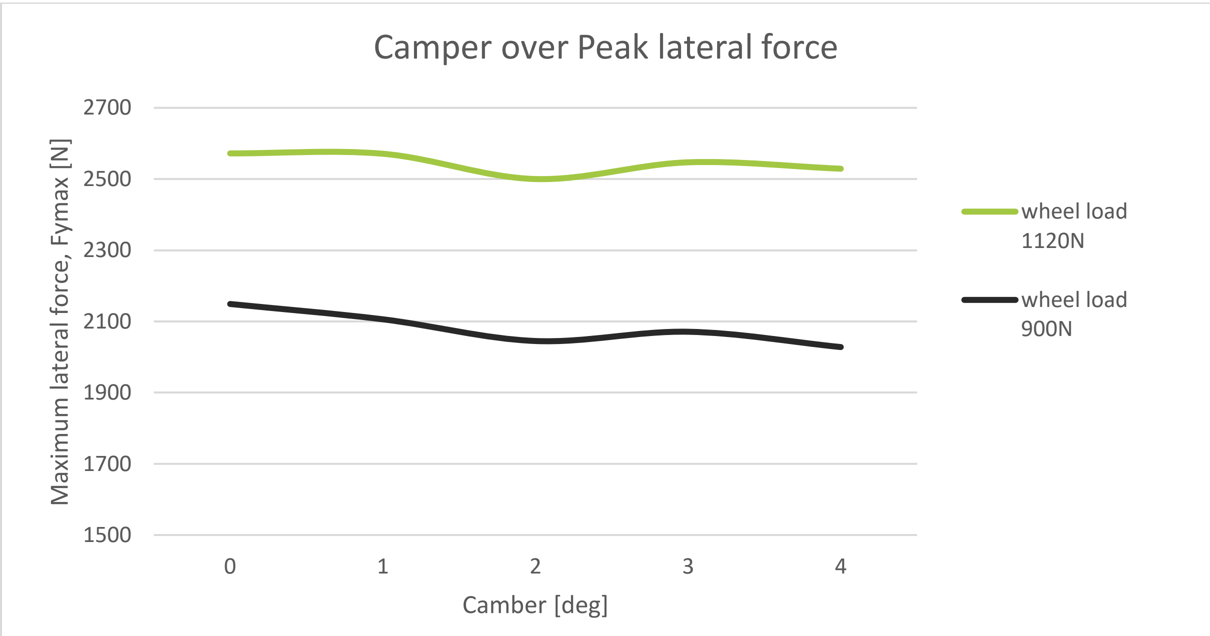






Fourthly: Geometry for suspension

- **Camber and inclination angle optimized for R25B tyres**

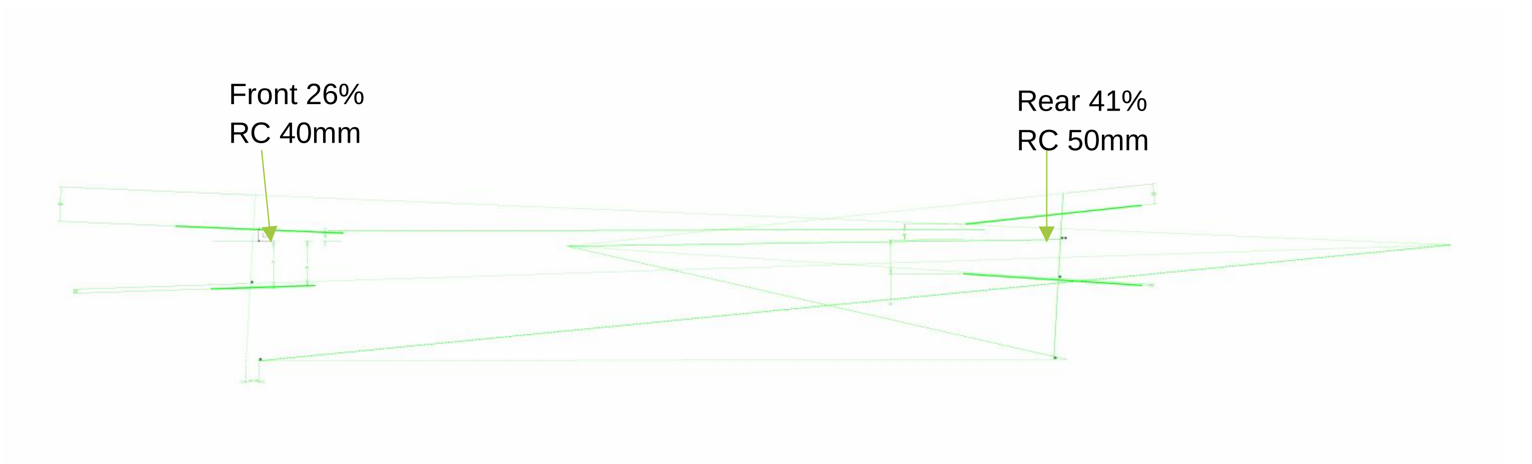


- **The results from our testing with last year car counting that 2,5° Camber**

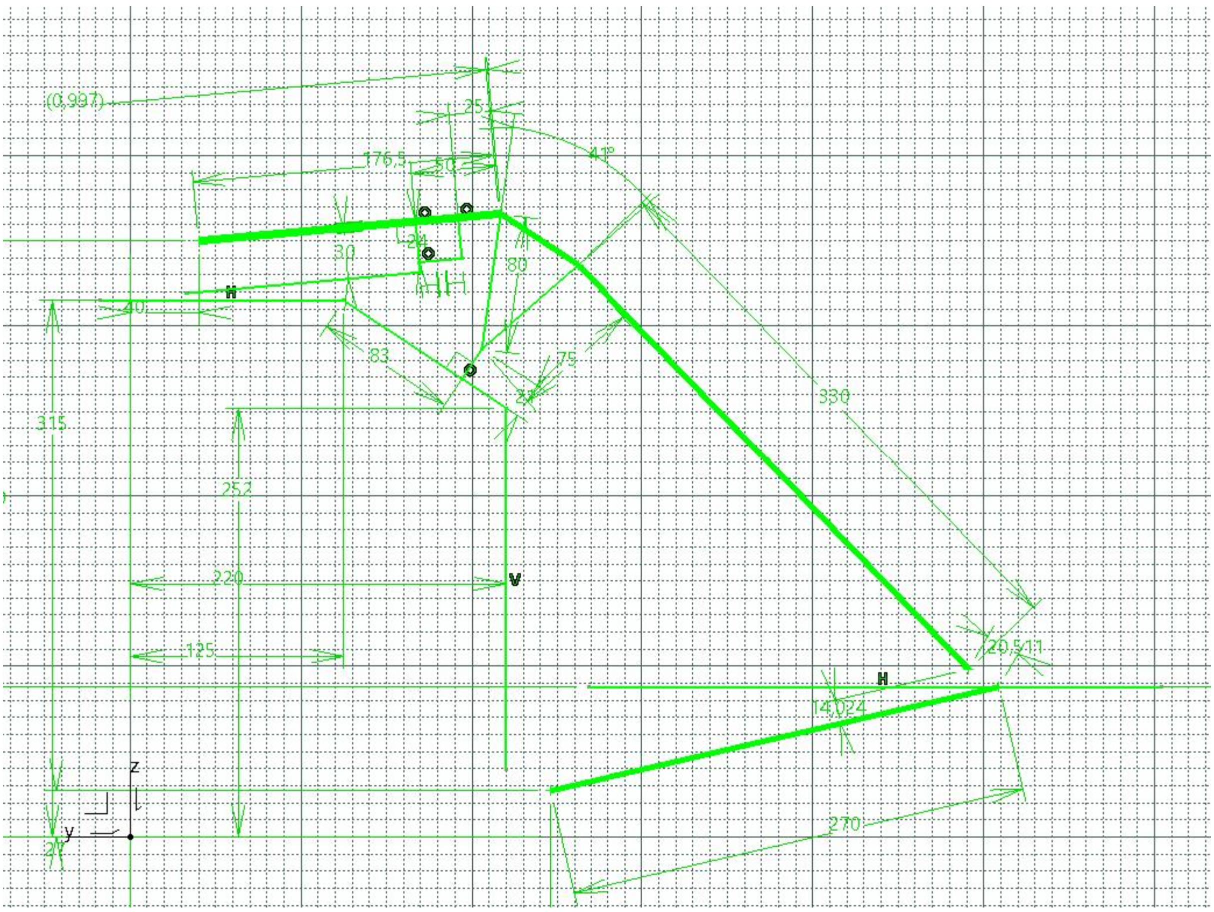
Main goals for the kinematics

- ✓ Constant toe angle over wheel travel for unchanged driving characteristics
- ✓ Smaller wheelbase for smaller turning circle
- ✓ More maximum angle of turn without contact A-Arms and tie rods
- ✓ Maximum camber of 3.5° during steer and compress
- ✓ Constant caster angle over wheel travel
- ✓ Anti-dive front and rear first time
- ✓

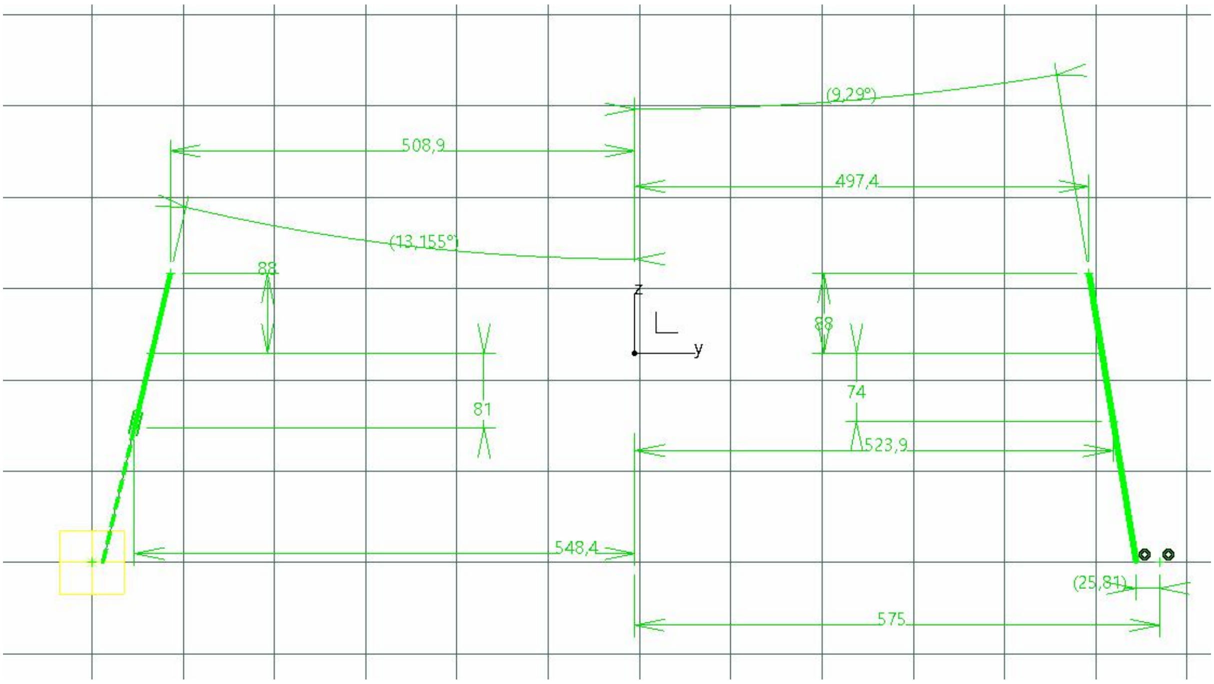
- **Anti-dive determine over longitudinal poles**
  Check correct roll center
  A wee bit anti squat rear 7.6%



- **Rocker geometry**

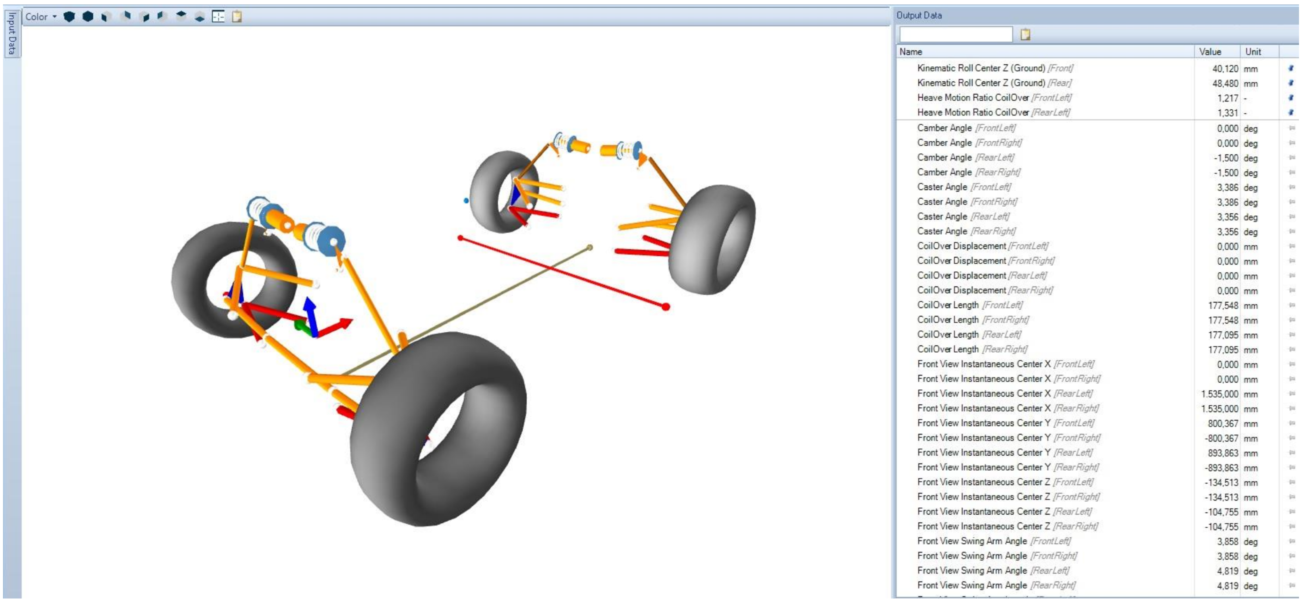


- **Caster/King pin axle geometry**



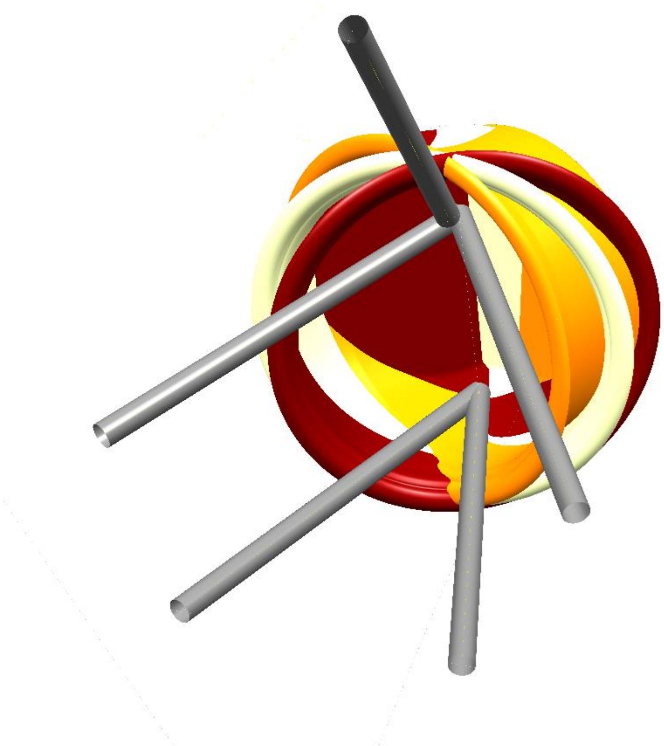
Caster angle 3.4° front/rear
King pin angle 13.2° front
King pin angle 9.3° rear
Wheelbase 1535mm
Track front 1190mm
Track rear 1150mm

- **Kinematic simulation with optimum kinematics**

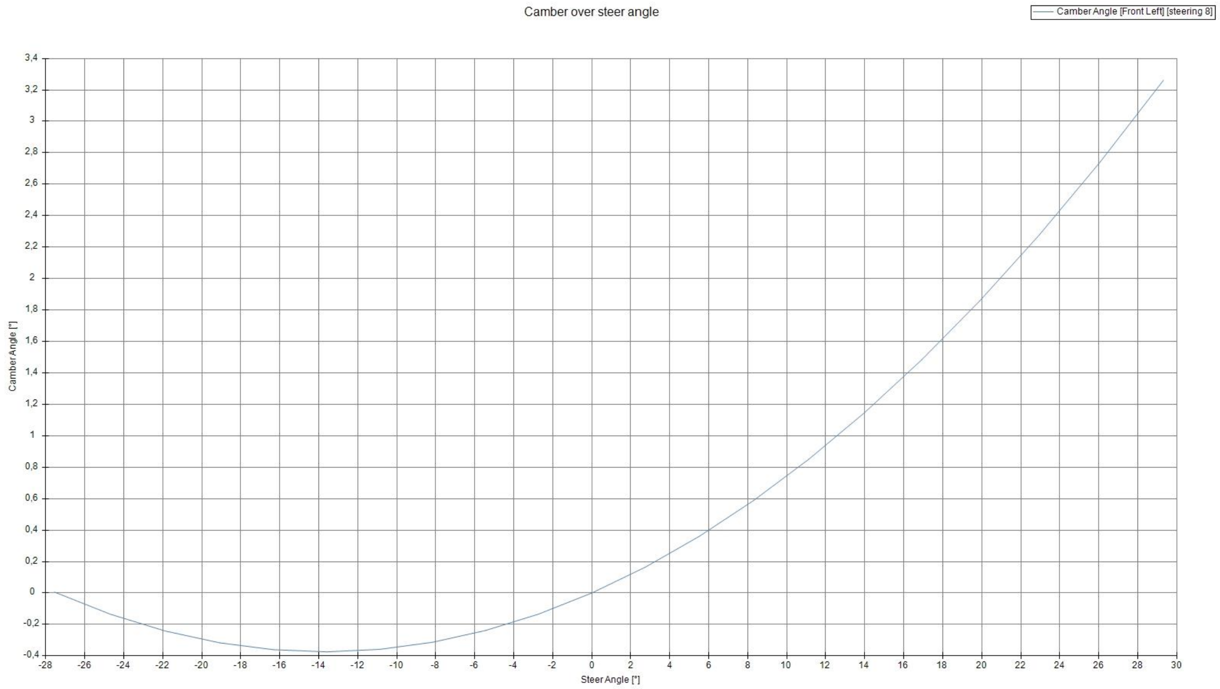


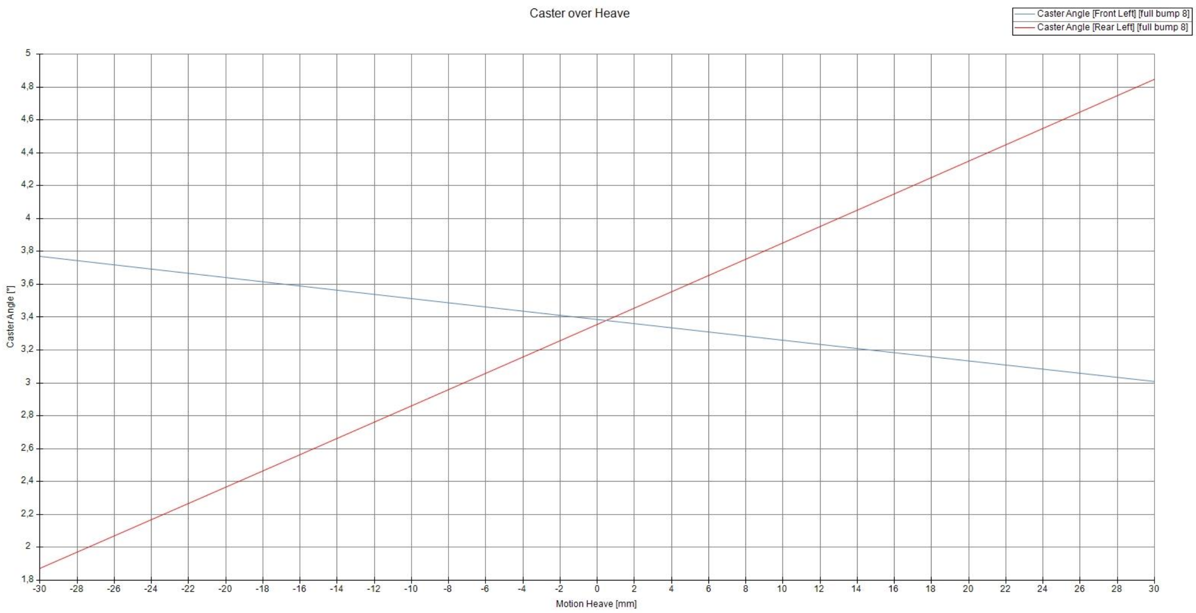
Name	Value	Unit
Kinematic Roll Center Z (Ground) *[Front]*	40,120	mm
Kinematic Roll Center Z (Ground) *[Rear]*	48,480	mm
Heave Motion Ratio CoilOver *[FrontLeft]*	1,217	-
Heave Motion Ratio CoilOver *[RearLeft]*	1,331	-
Camber Angle *[FrontLeft]*	0,000	deg
Camber Angle *[FrontRight]*	0,000	deg
Camber Angle *[RearLeft]*	-1,500	deg
Camber Angle *[RearRight]*	-1,500	deg
Caster Angle *[FrontLeft]*	3,386	deg
Caster Angle *[FrontRight]*	3,386	deg
Caster Angle *[RearLeft]*	3,356	deg
Caster Angle *[RearRight]*	3,356	deg
CoilOver Displacement *[FrontLeft]*	0,000	mm
CoilOver Displacement *[FrontRight]*	0,000	mm
CoilOver Displacement *[RearLeft]*	0,000	mm
CoilOver Displacement *[RearRight]*	0,000	mm
CoilOver Length *[FrontLeft]*	177,548	mm
CoilOver Length *[FrontRight]*	177,548	mm
CoilOver Length *[RearLeft]*	177,095	mm
CoilOver Length *[RearRight]*	177,095	mm
Front View Instantaneous Center X *[FrontLeft]*	0,000	mm
Front View Instantaneous Center X *[FrontRight]*	0,000	mm
Front View Instantaneous Center X *[RearLeft]*	1.535,000	mm
Front View Instantaneous Center X *[RearRight]*	1.535,000	mm
Front View Instantaneous Center Y *[FrontLeft]*	800,367	mm
Front View Instantaneous Center Y *[FrontRight]*	-800,367	mm
Front View Instantaneous Center Y *[RearLeft]*	893,863	mm
Front View Instantaneous Center Y *[RearRight]*	-893,863	mm
Front View Instantaneous Center Z *[FrontLeft]*	-134,513	mm
Front View Instantaneous Center Z *[FrontRight]*	-134,513	mm
Front View Instantaneous Center Z *[RearLeft]*	-104,755	mm
Front View Instantaneous Center Z *[RearRight]*	-104,755	mm
Front View Swing Arm Angle *[FrontLeft]*	3,858	deg
Front View Swing Arm Angle *[FrontRight]*	3,858	deg
Front View Swing Arm Angle *[RearLeft]*	4,819	deg
Front View Swing Arm Angle *[RearRight]*	4,819	deg

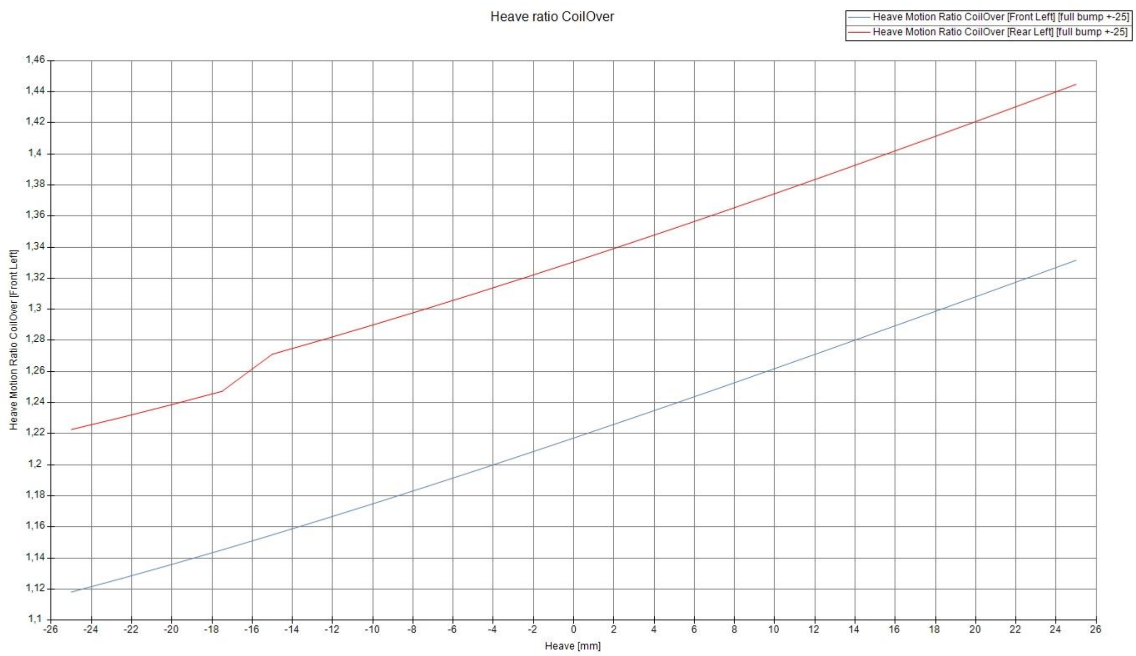
- **Check on contact with A/Arms or tie rods**

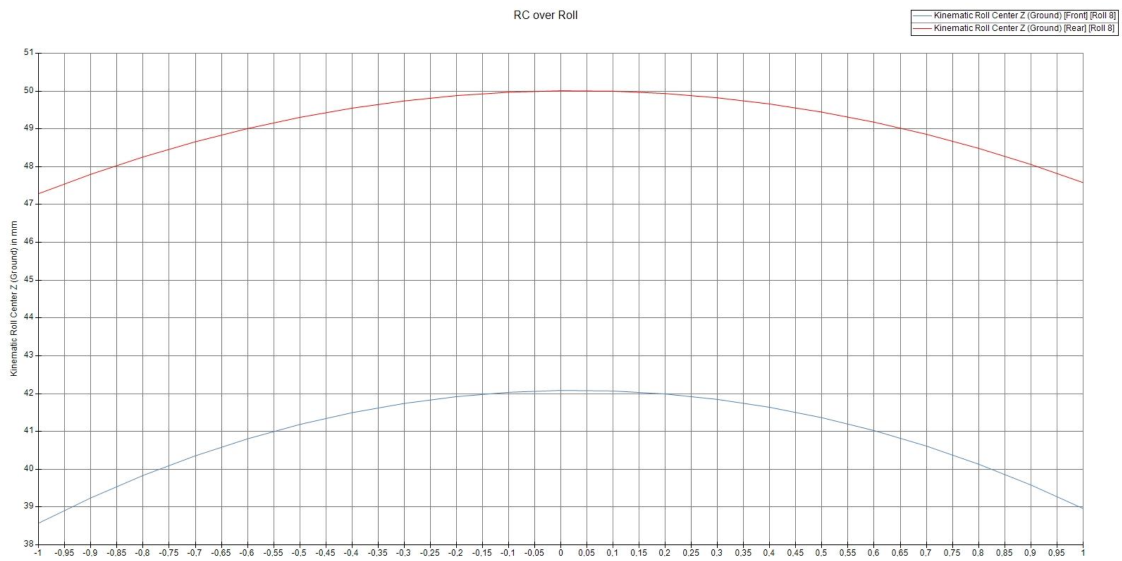


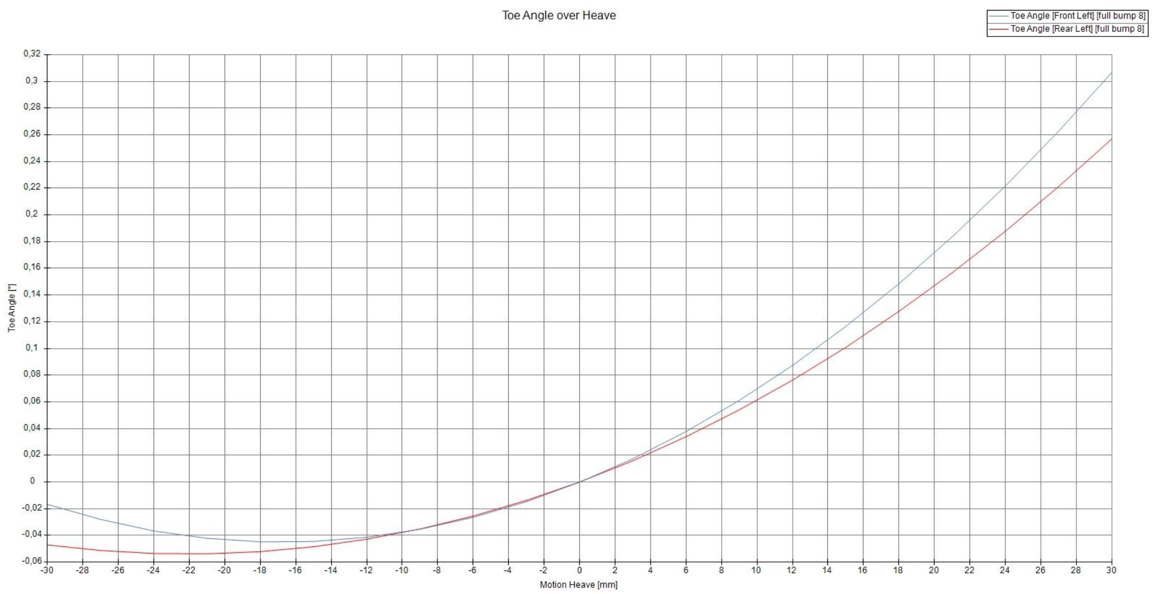
Final kinematics diagrams of "Optimum Kinematics"


Camber over steer angle
Camber Angle [Front Left] [steering 8]
Camber Angle [°]
Steer Angle [°]


Caster over Heave
Caster Angle [Front Left] [full bump 8]
Caster Angle [Rear Left] [full bump 8]
Caster Angle [°]
Motion Heave [mm]

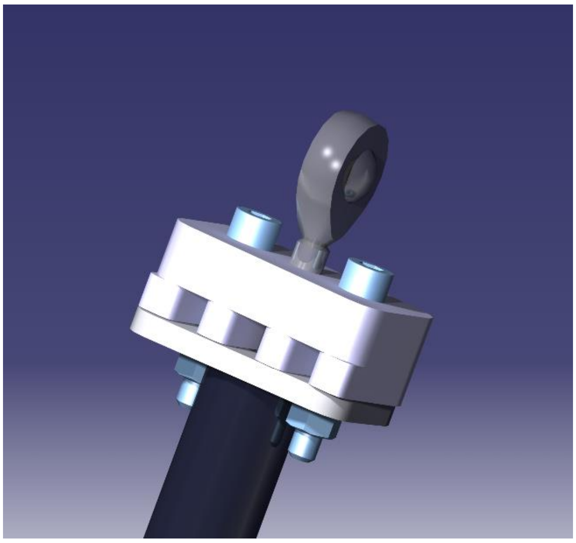

Heave ratio CoilOver
Heave Motion Ratio CoilOver [Front Left] [full bump +-25]
Heave Motion Ratio CoilOver [Rear Left] [full bump +-25]
Heave Motion Ratio CoilOver [Front Left]
Heave [mm]


RC over Roll
Kinematic Roll Center Z (Ground) [Front] [Roll 8]
Kinematic Roll Center Z (Ground) [Rear] [Roll 8]
Kinematic Roll Center Z (Ground) in mm


Toe Angle over Heave
Toe Angle [Front Left] [full bump 8]
Toe Angle [Rear Left] [full bump 8]
Toe Angle [°]
Motion Heave [mm]

BOLTED UNION OF THE ADJUSMENT OF THE PUSHROD

We will check if the validity of the M4 screws for the adjustment of the pushrod.



The validity of the union will be calculated according to the edification technical norm.

GENERAL DATA

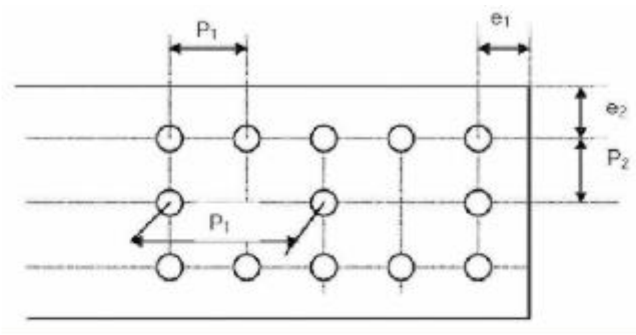
For this bolts and type of union the norm ensures:

fyb = 240 MPa (Elastic limit stress)

fub = 400 MPa (Ultimate tensile stress)

YMb = 1.25 (Safety factor)

DIMENSIONS OF THE PLATE AND POSITIONING OF THE BOLTS



$$e_1 \geq 1.2 \cdot d_0$$

$$8\ mm \geq 1.2 \cdot 4 = 4.8\ mm$$

$$e_2 \geq 1.5 \cdot d_0$$

$$9\ mm \geq 1.5 \cdot 4 = 6\ mm$$

$$p_1 \geq 2.2 \cdot d_0$$

$$12\ mm \geq 2.2 \cdot 4 = 8.8\ mm$$

FORCES APPLIED

The vertical force in the pushrod is 3 kN and its angle is 45˚

Normal stress

$$F_N = \frac{3}{\cos 45} = 4\ kN$$

According to the norm, the maximum normal stress that the joint can withstand is the following:

$$F_{Nmax} = \frac{2.5 \cdot \alpha \cdot f_u \cdot d \cdot t}{Y_{Mb}}$$

Where,

$$\alpha = \min(\frac{e_1}{3 \cdot d_0}, \frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}) = \min\left(\frac{2}{3}, \frac{3}{4}, \frac{2}{3}\right) = 2/3$$

fub = 400 MPa (ultimate tensile stress of the bolt)

fu = 600 MPa (ultimate tensile stress of the union)

d = bolt diameter

t = thickness of the plate

$$F_{Nmax} = \frac{2.5 \cdot 2/3 \cdot 400 \cdot 4 \cdot 10}{1.25} = 32000\ N = 32\ kN$$

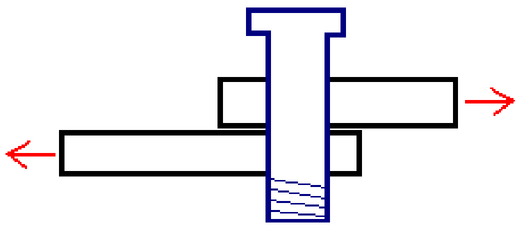
Sheer stress

$$F_V = \frac{3}{\sin 45} = 4.62\ kN$$

According to the norm, the maximum sheer stress that the joint can withstand is the following:

$$F_{Vmax} = \frac{0.6 \cdot f_{ub} \cdot A_s}{Y_{Mb}} = \frac{0.6 \cdot 400 \cdot 10 \cdot 4}{1.25} = 7600\ N = 7.6\ kN$$

As = Effective area of the bolt for sheer stress



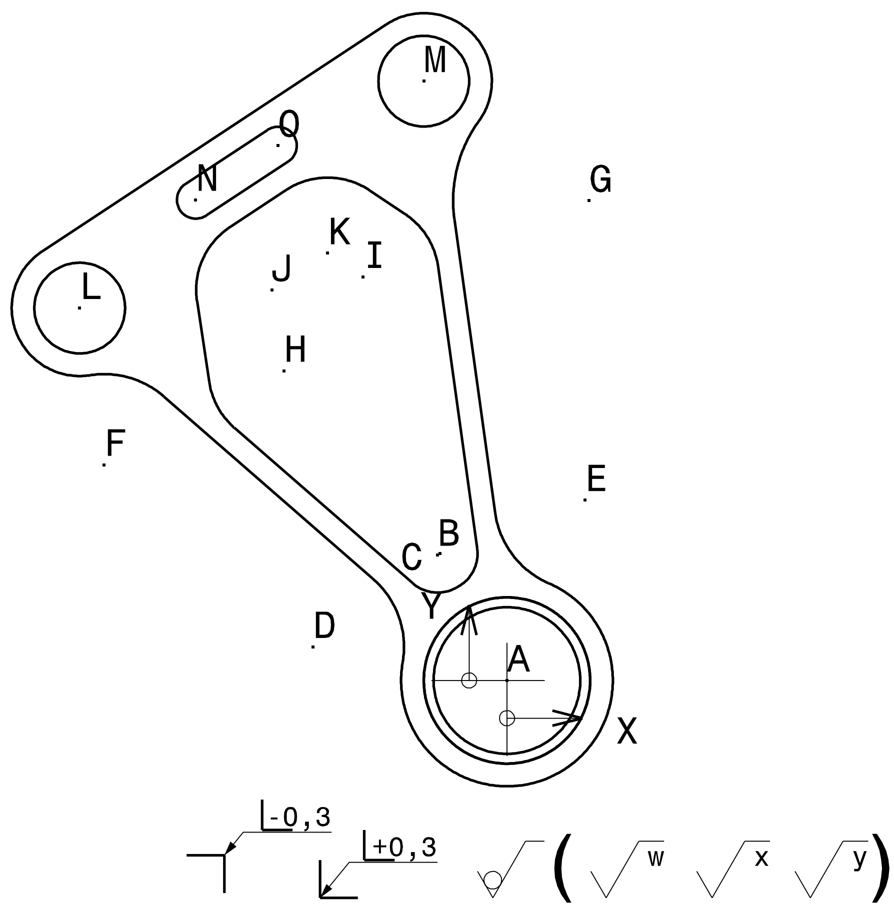
Combination of normal and sheer stresses

$$\frac{F_N}{1.4 \cdot F_{Nmax}} + \frac{F_V}{F_{Vmax}} \leq 1$$

$$\frac{4.62}{1.4 \cdot 32} + \frac{4}{7.6} = 0.63$$

The union withstands all the solicitations.

REF.	Radius (mm)	X (mm)	Y (mm)
A	9,7	0	0
A	11 (only 8 mm deep, both sides)	0	0
A	14	0	0
B	5	-9,18	16,63
C	5	-8,89	16,79
D	12	-25,62	4,43
E	12	10,32	23,86
F	18	-53,26	28,54
G	12	10,88	63,5
H	10	-29,49	40,98
I	10	-19,02	53,4
J	10	-31,11	51,67
K	10	-23,72	56,55
L	6H7	-56,51	49,29
L	9	-56,51	49,29
M	6H7	-11	79,32
M	9	-11	79,32
N	2,5	-41,16	63,61
O	2,5	-30,31	70,77

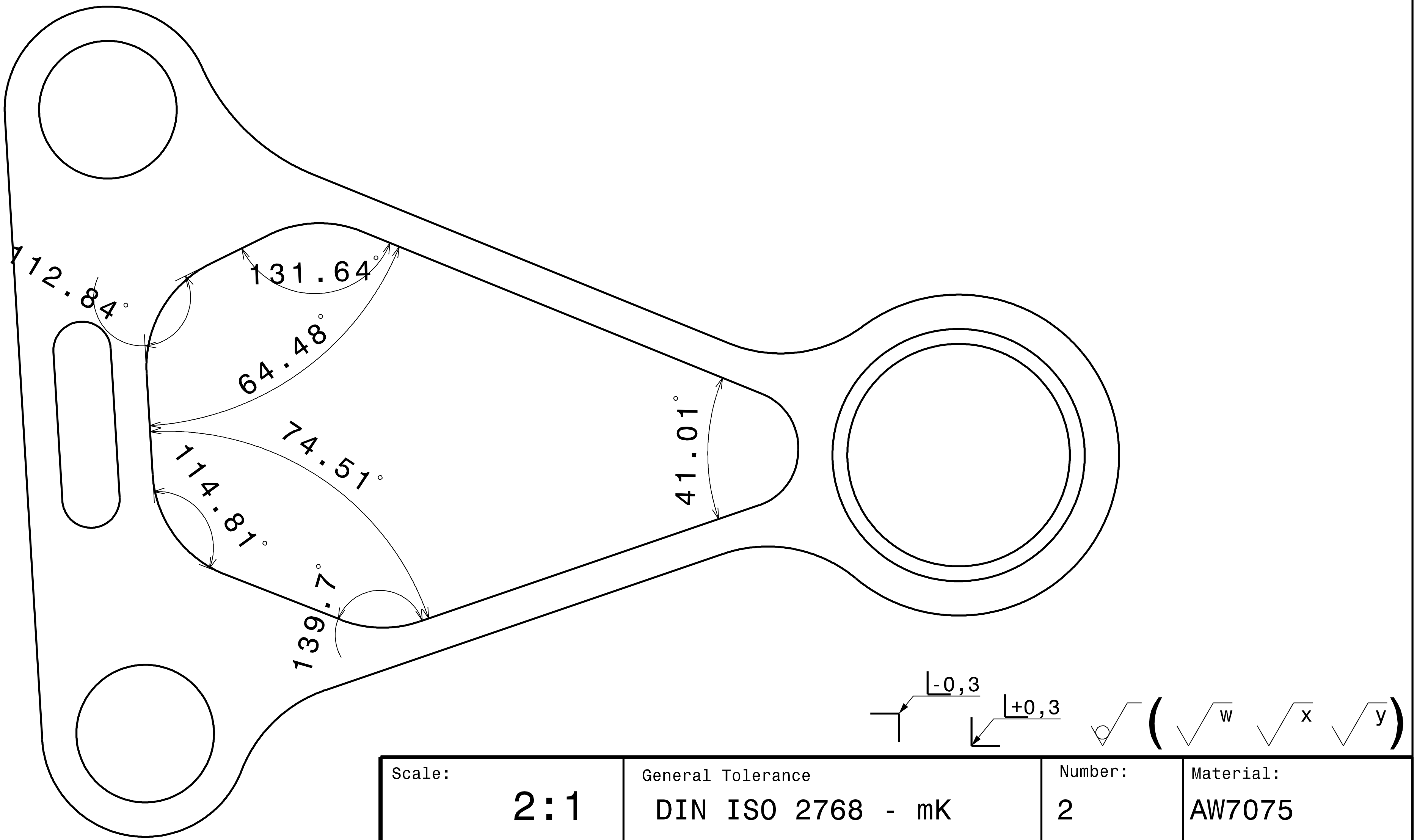


w = Rz 50

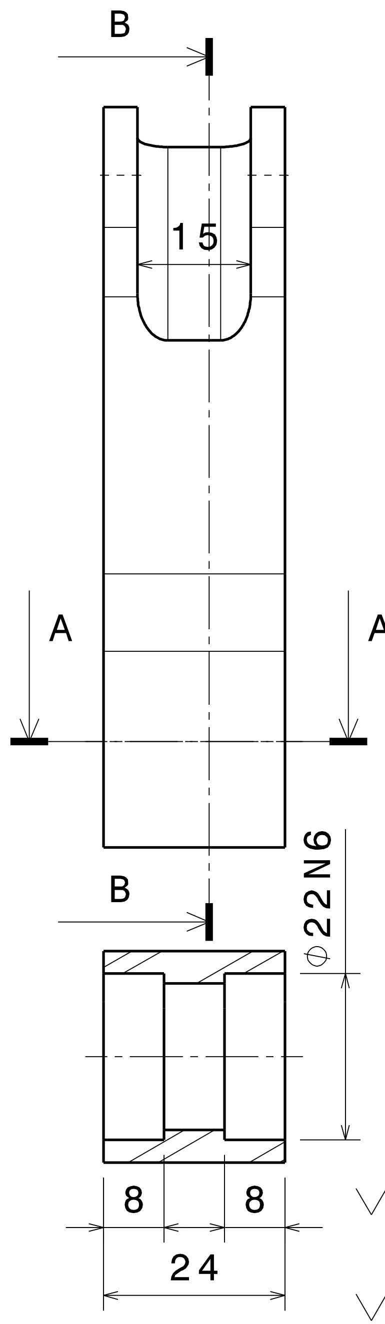
x = Rz 16

y = Rz 6,3

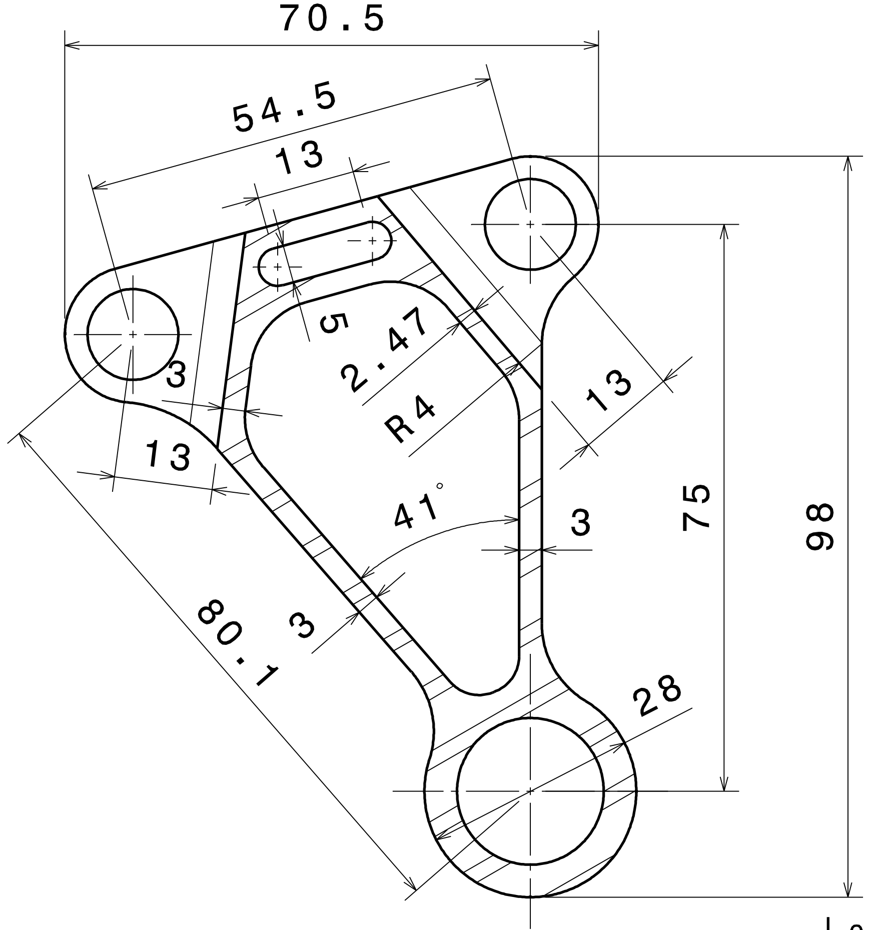
Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 2	Material: AW7075
Date: 18.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
IRTe	Part name: Rocker Front		Part number: 10301
	Document Type: Drawing	Weight: 0.071 kg	Page: 2/3



Scale: 2:1	General Tolerance: DIN ISO 2768 - mK		Number: 2	Material: AW7075
Date: 18.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Front			Part number: 10301
	Document Type: Drawing	Weight: 0.071 kg		Page: 3/3

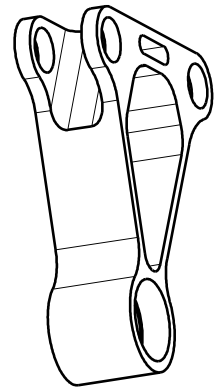


Section view A-A



Section view B-B

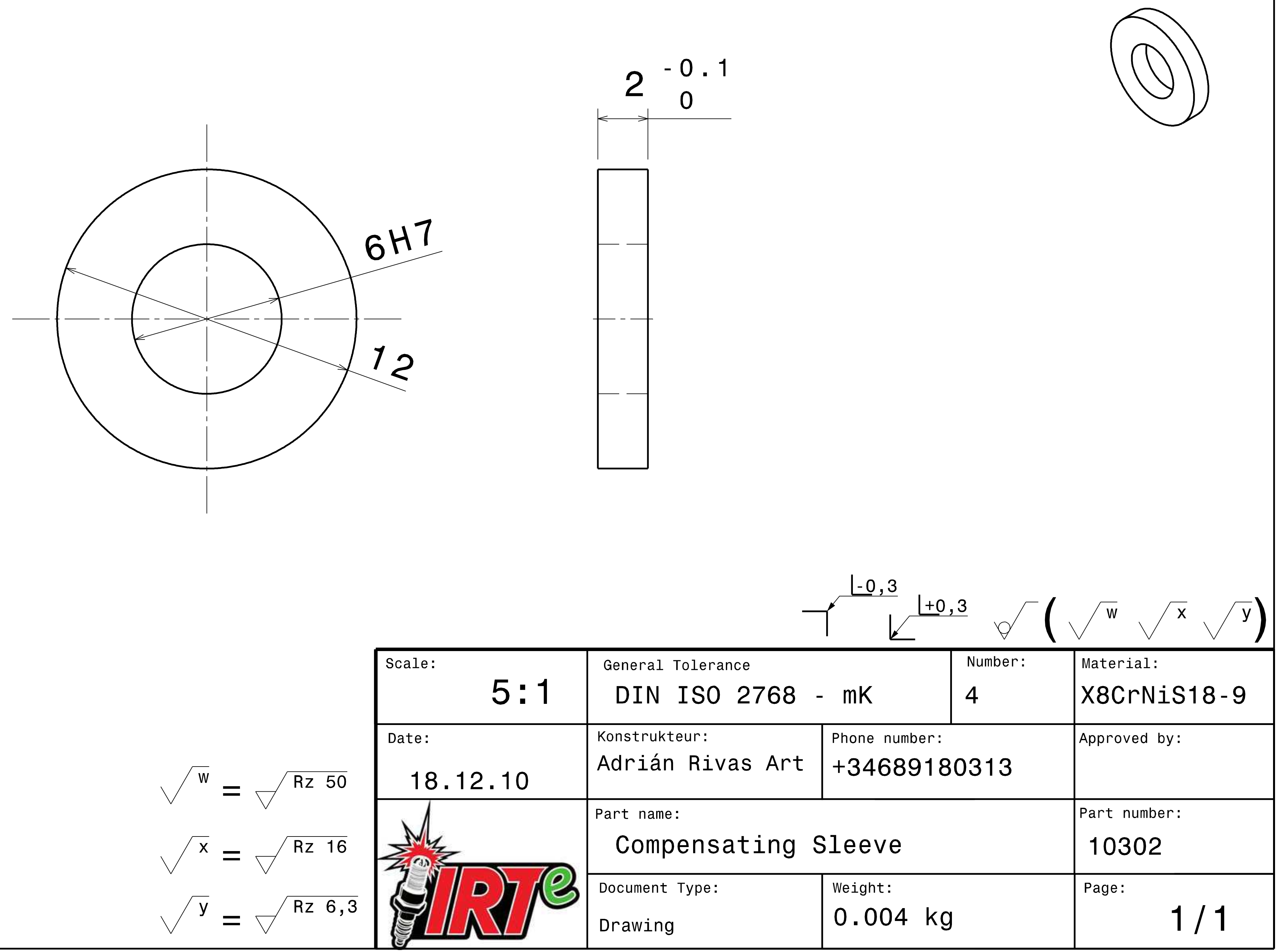
-0,3 +0,3 (w x y)



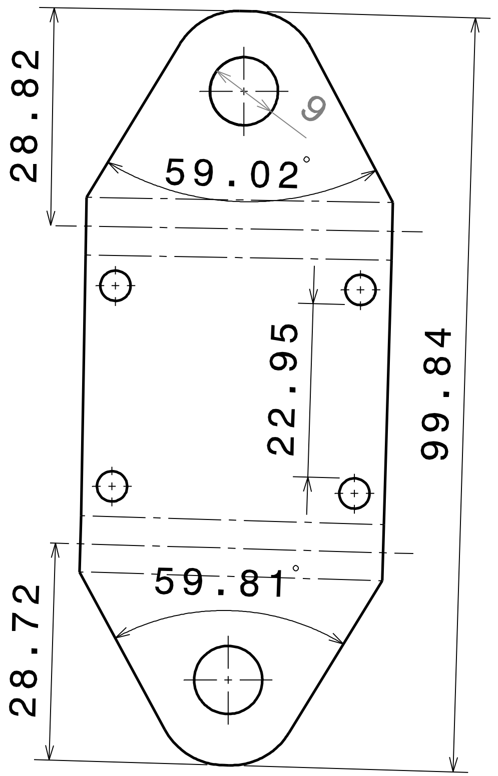
Isometric view
Scale: 1:2

w = Rz 50
x = Rz 16
y = Rz 6,3

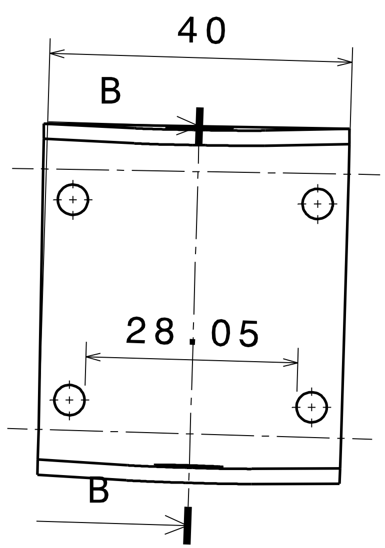
Scale: 1:1	General Tolerance: DIN ISO 2768 - mK	Number: 2	Material: AW7075
Date: 18.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
IRTe	Part name: Rocker Front		Part number: 10301
	Document Type: Drawing	Weight: 0.071 kg	Page: 1/3

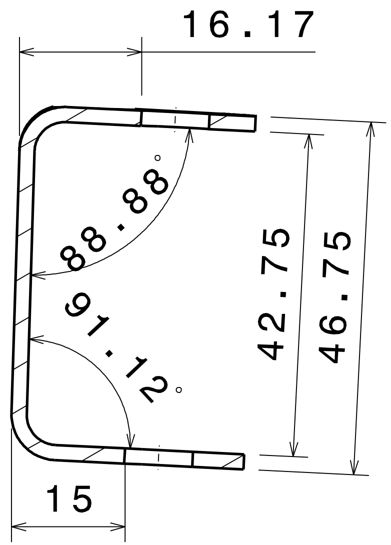


Scale: 5:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: X8CrNiS18-9
Date: 18.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Compensating Sleeve		Part number: 10302
	Document Type: Drawing	Weight: 0.004 kg	Page: 1/1

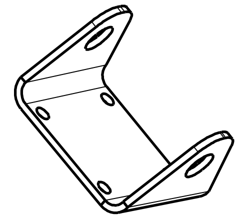


Unfolded view

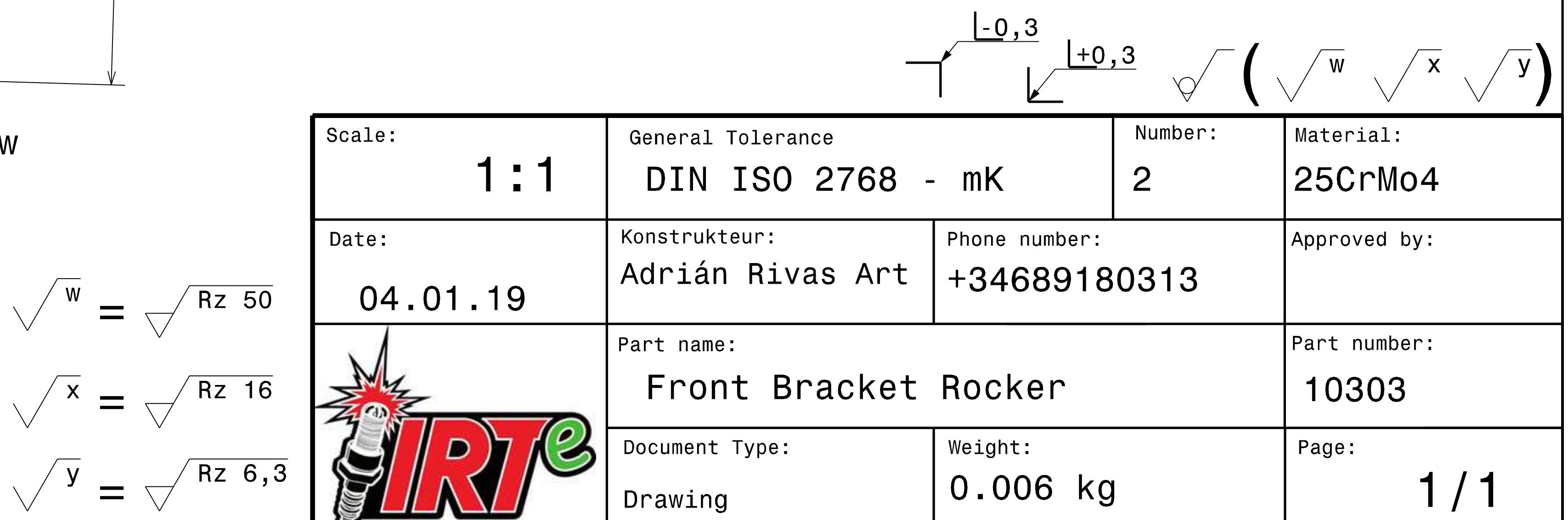




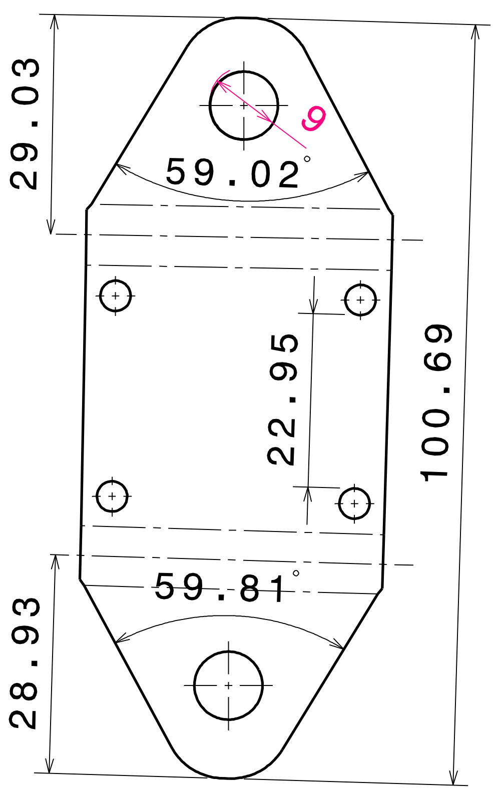
Section view B-B



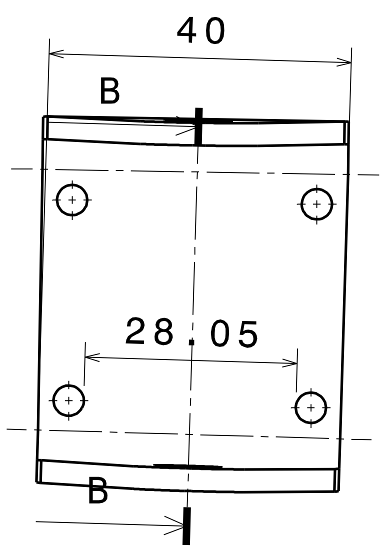
Isometric view
Scale: 1:2

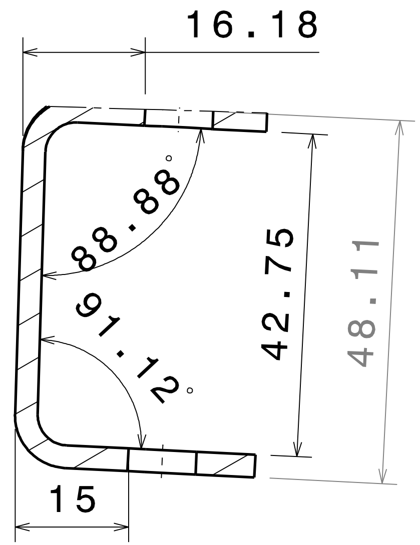


Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 04.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Front Bracket Rocker			Part number: 10303
	Document Type: Drawing	Weight: 0.006 kg		Page: 1/1

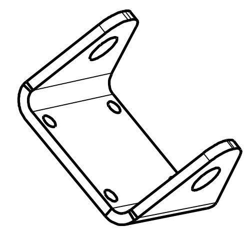


Unfolded view





Section view B-B



Isometric view
Scale: 1:2

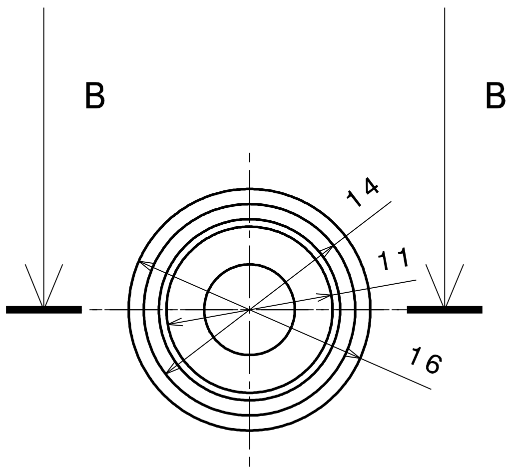
-0,3 | +0,3 | (w x y)

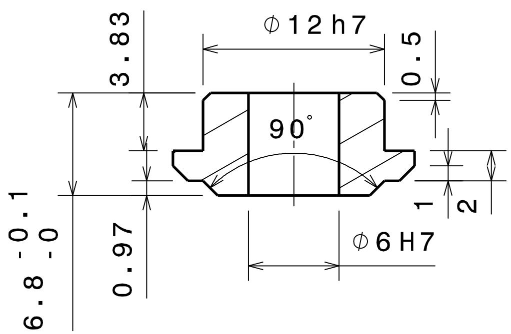
w = Rz 50

x = Rz 16

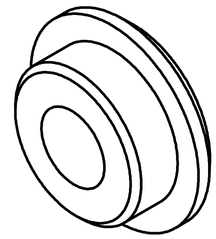
y = Rz 6,3

Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 04.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
IRTe	Part name: Front Bracket Rocker 3 mm			Part number: 10303
	Document Type: Drawing	Weight: 0.006 kg		Page: 1/1

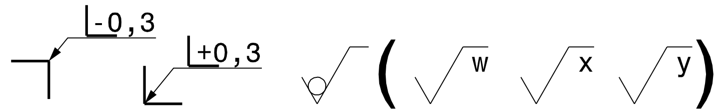




Section view B-B



Isometric view

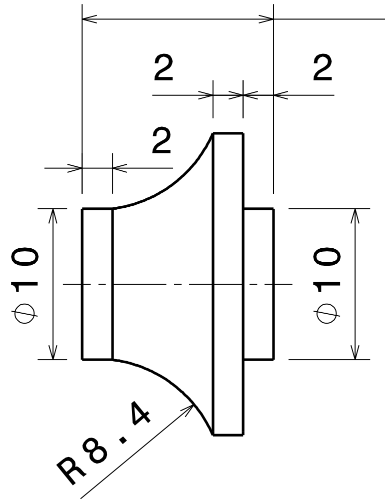


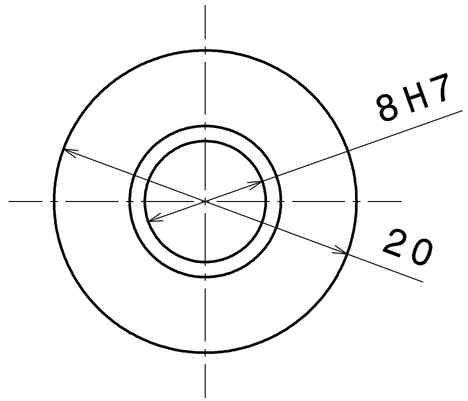
√w = ∇ Rz 50

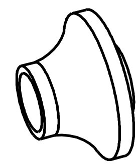
√x = ∇ Rz 16

√y = ∇ Rz 6,3

Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 8	Material: X8CrNiS18-9
Date: 18.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Shell			Part number: 10304
	Document Type: Drawing	Weight: 0.010 kg		Page: 1/1







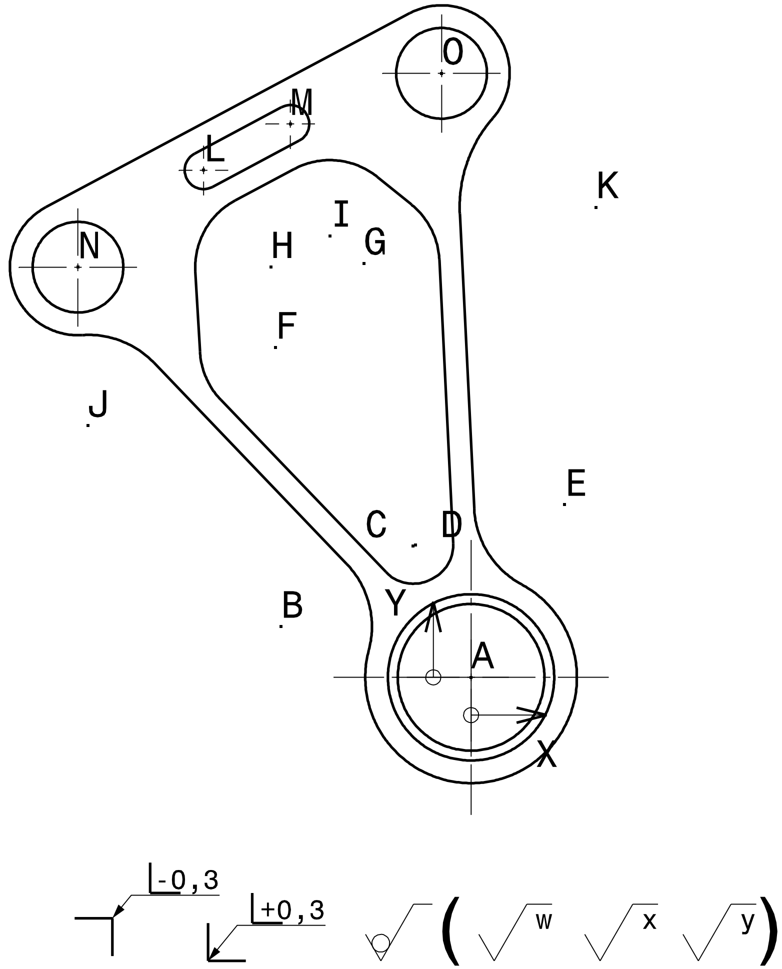
Isometric view
Scale: 1:1

-0,3
+0,3

√w = Rz 50
√x = Rz 16
√y = Rz 6,3

Scale: 2:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: X8CrNiS18-9
Date: 04.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Rocker Bushing Front		Part number: 10312
	Document Type: Drawing	Weight: 0.011 kg	Page: 1/1

REF.	Radius (mm)	X coordinate (mm)	Y coordinate (mm)
A	9,7	0	0
A	11N6 (only 8 mm deep, both sides)	0	0
A	14	0	0
B	12	-25,12	6,71
C	5	-7,66	17,39
D	5	-7,36	17,52
E	12	12,4	22,85
F	10	-25,88	43,64
G	10	-14,19	54,79
H	10	-26,49	54,29
I	10	-18,69	58,45
J	12	-50,62	33,32
K	18	16,49	62,23
L	2,5	-35,38	67,11
M	2,5	-23,91	73,23
N	6H7	-52	54,28
N	9	-52	54,28
O	6H7	-3,9	79,93
O	9	-3,9	79,93

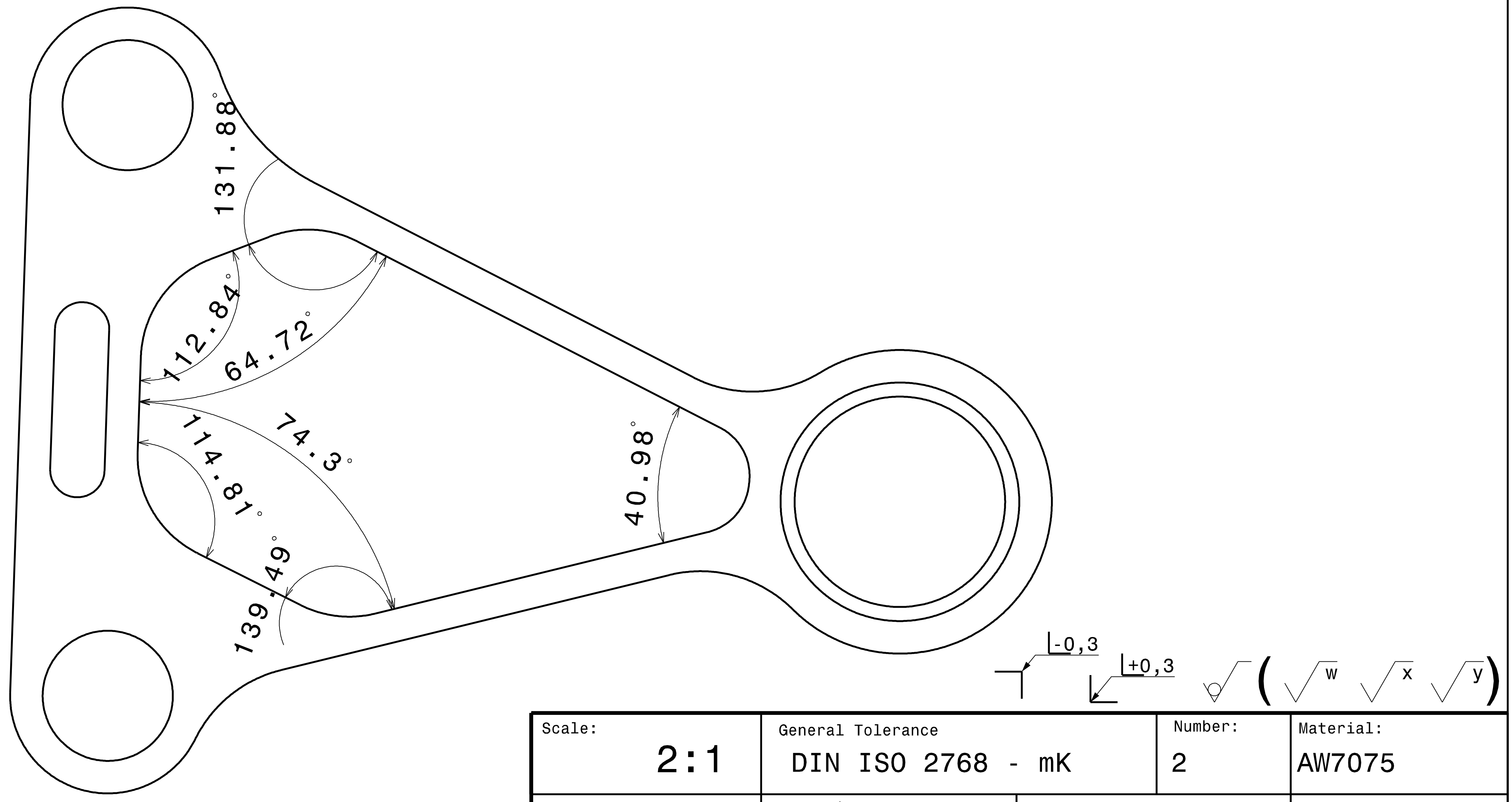


w = Rz 50

x = Rz 16

y = Rz 6,3

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: AW7075
Date: 16.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Rear			Part number: 10314
	Document Type: Drawing	Weight: 0.080 kg		Page: 2/3



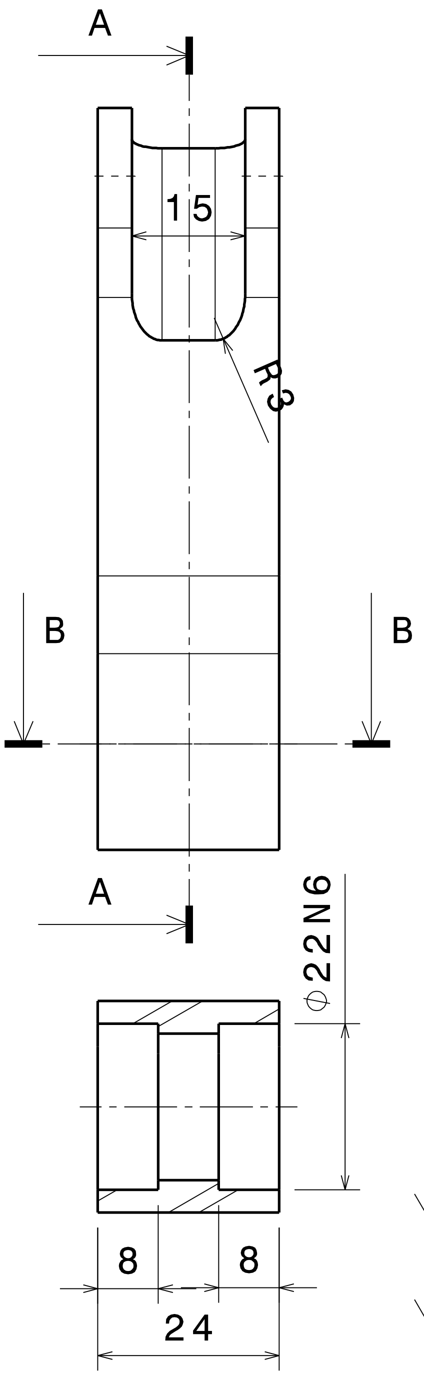
w = Rz 50

x = Rz 16

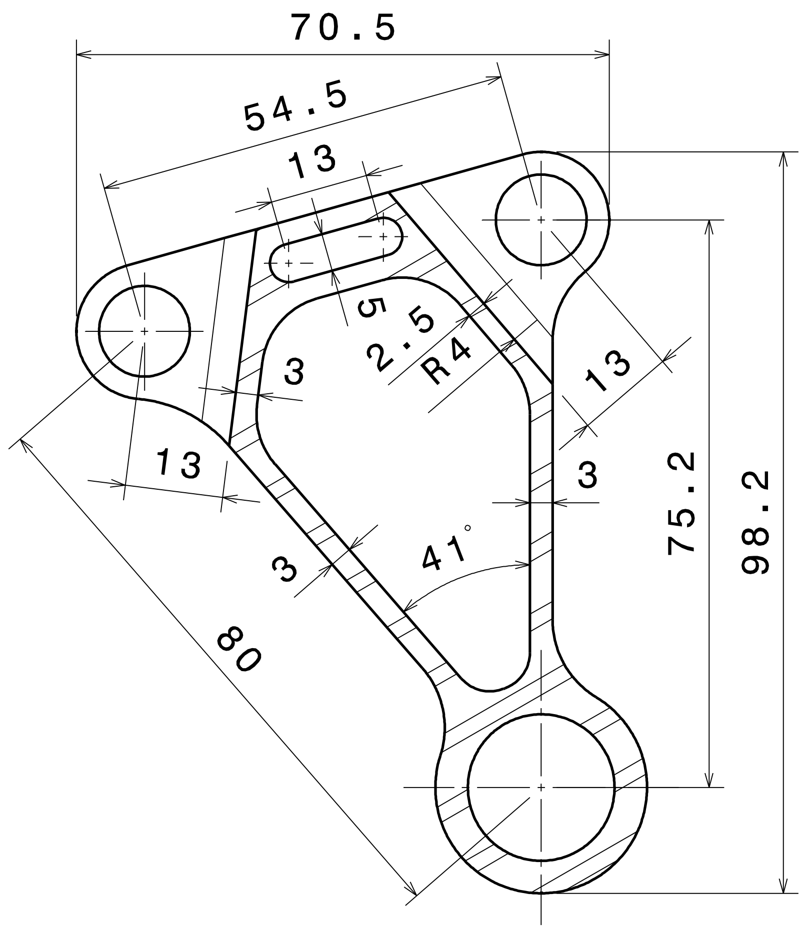
y = Rz 6,3

Front view
Scale: 2:1

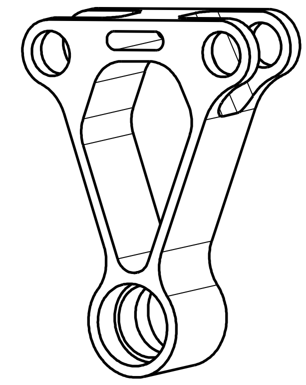
Scale: 2:1	General Tolerance: DIN ISO 2768 - mK	Number: 2	Material: AW7075
Date: 16.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Rocker Rear		Part number: 10314
	Document Type: Drawing	Weight: 0.080 kg	Page: 3/3



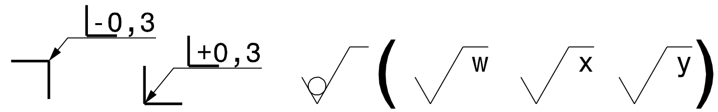
Section view B-B



Section view A-A



Isometric view
Scale: 1:2

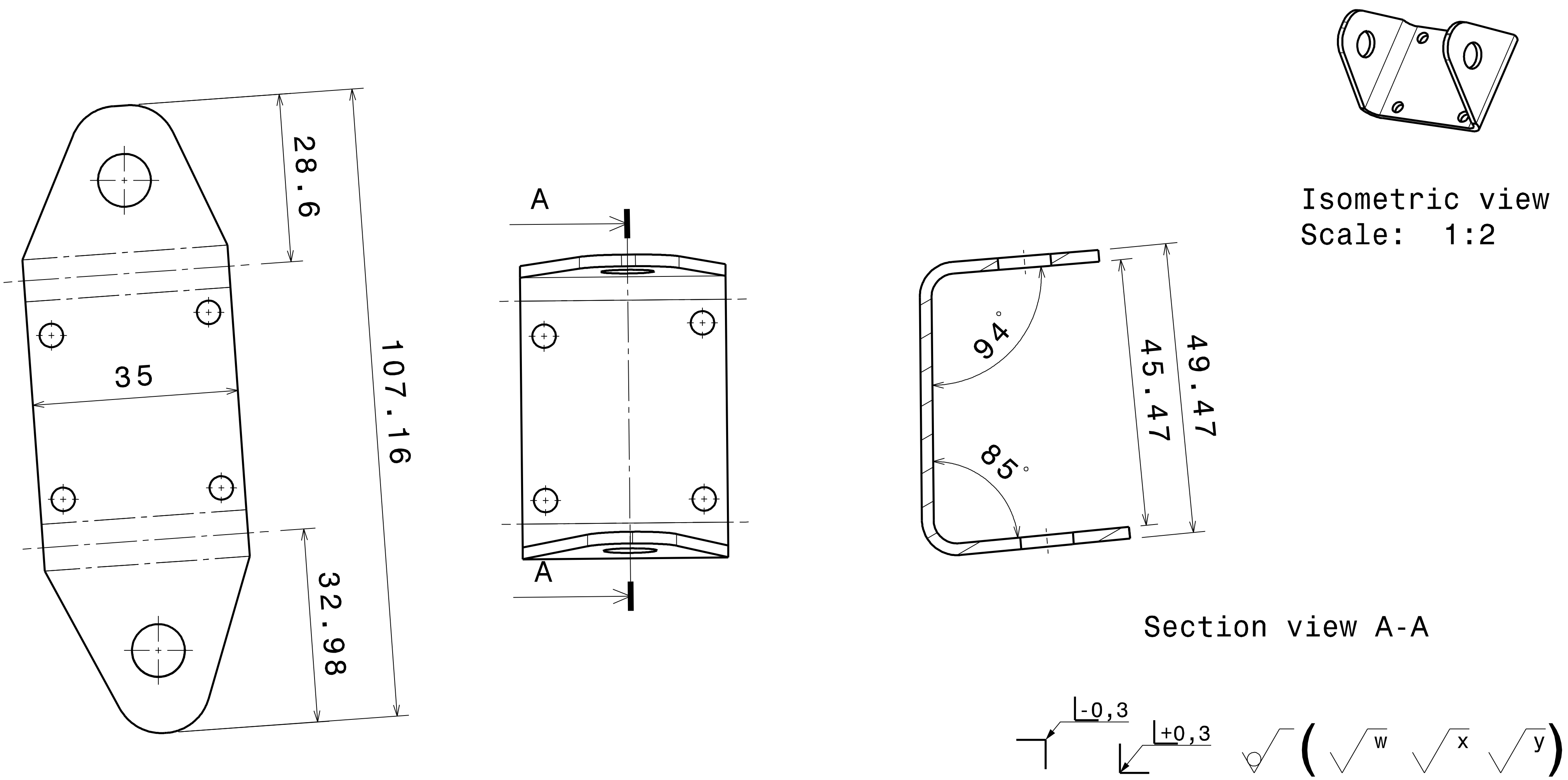


w = Rz 50

x = Rz 16

y = Rz 6,3

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: AW7075
Date: 16.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Rear			Part number: 10314
	Document Type: Drawing	Weight: 0.080 kg		Page: 1/3



Unfolded view
Scale: 1:1

Section view A-A

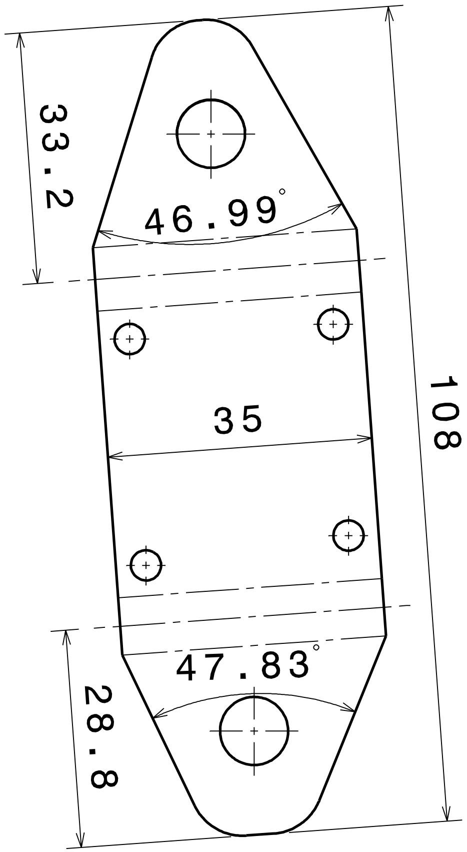
Isometric view
Scale: 1:2

$\sqrt{w}$ = $\sqrt{\text{Rz } 50}$

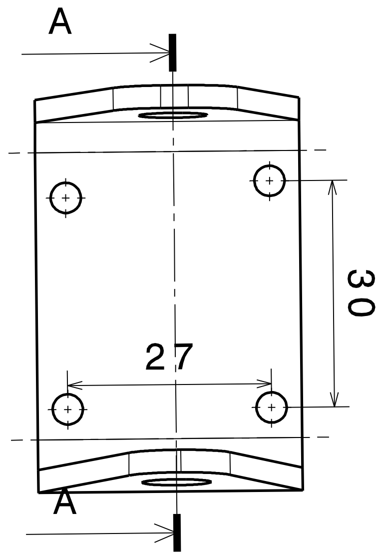
$\sqrt{x}$ = $\sqrt{\text{Rz } 16}$

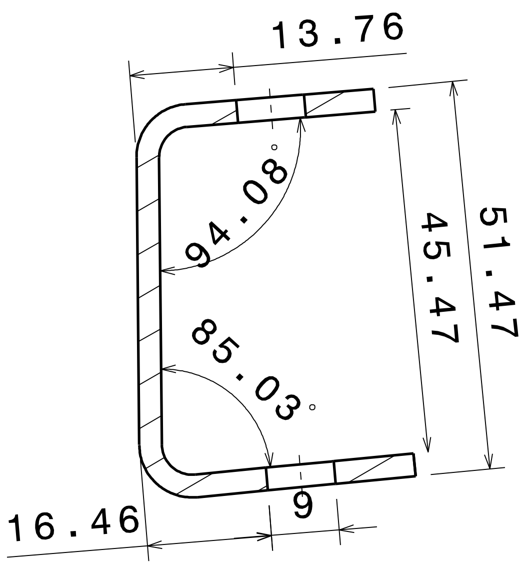
$\sqrt{y}$ = $\sqrt{\text{Rz } 6,3}$

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rear Bracket Rocker			Part number: 10314
	Document Type: Drawing	Weight: 0.030 kg		Page: 1/1

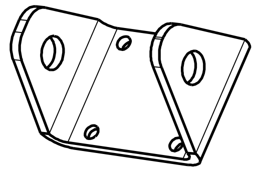


Unfolded view





Section view A-A



Isometric view
Scale: 1:2

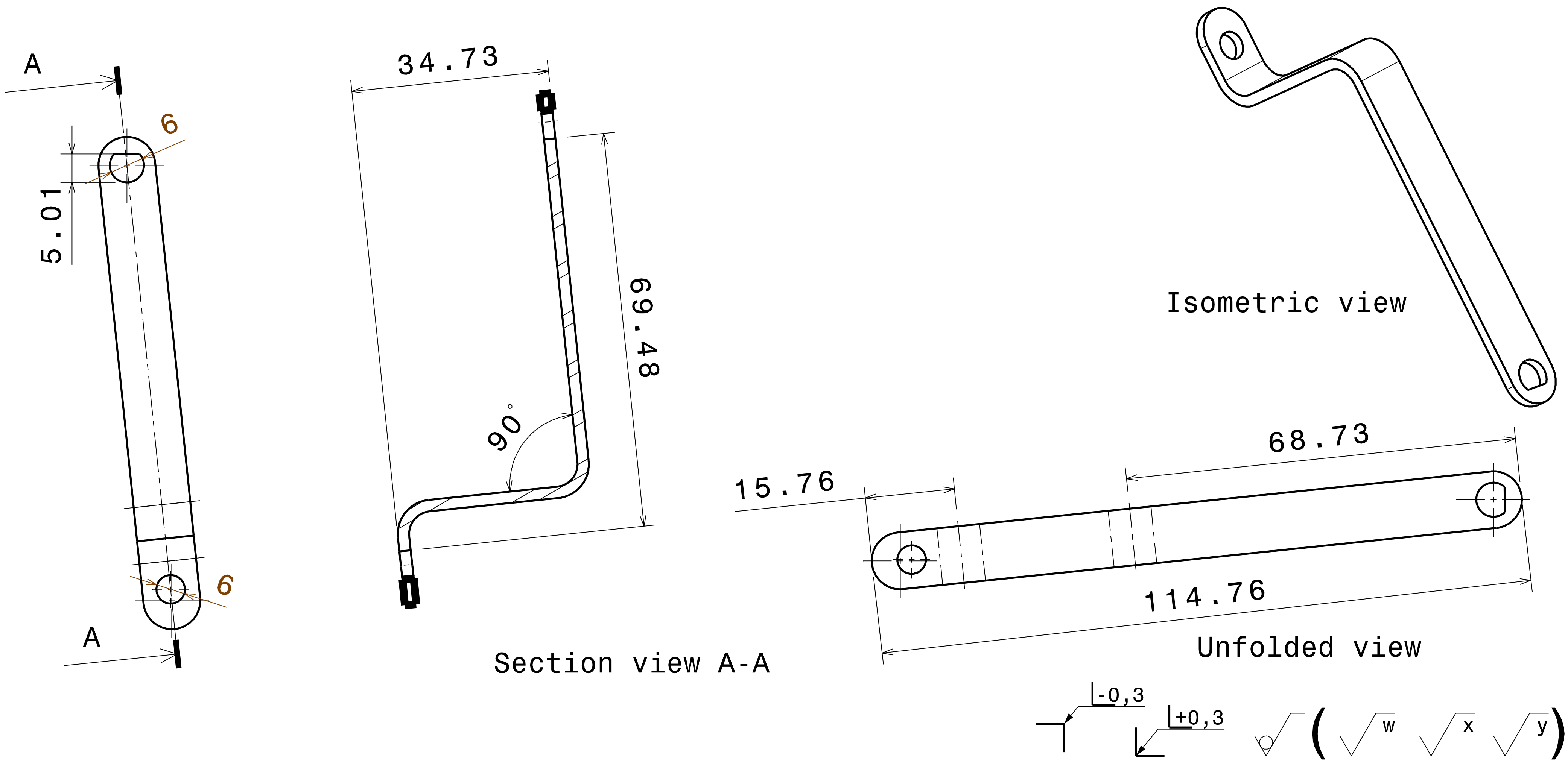
-0,3 +0,3

√w = Rz 50

√x = Rz 16

√y = Rz 6,3

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rear Bracket Rocker 3 mm			Part number: 10314
	Document Type: Drawing	Weight: 0.030 kg		Page: 1/1

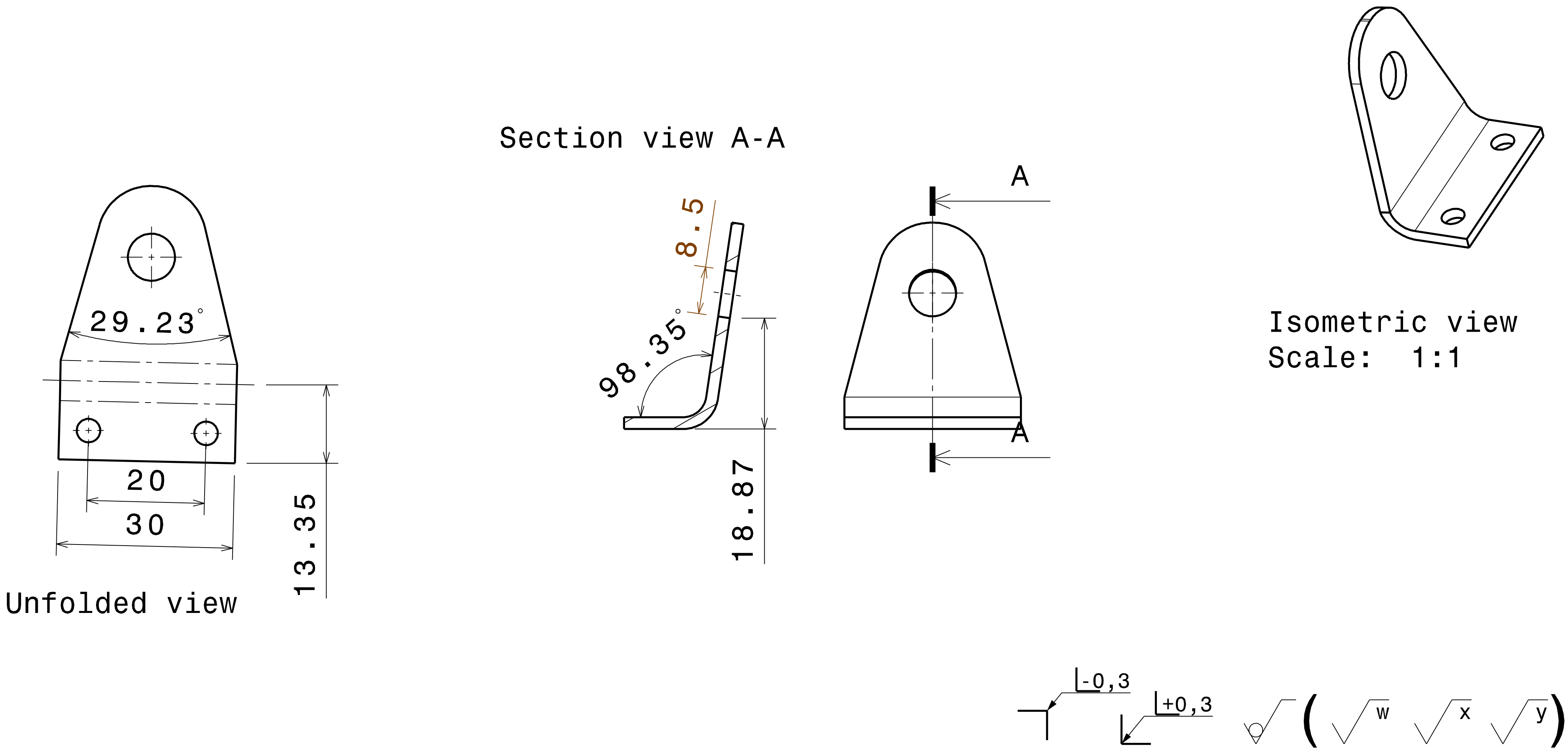


$\sqrt{w}$ = $\sqrt{Rz\ 50}$

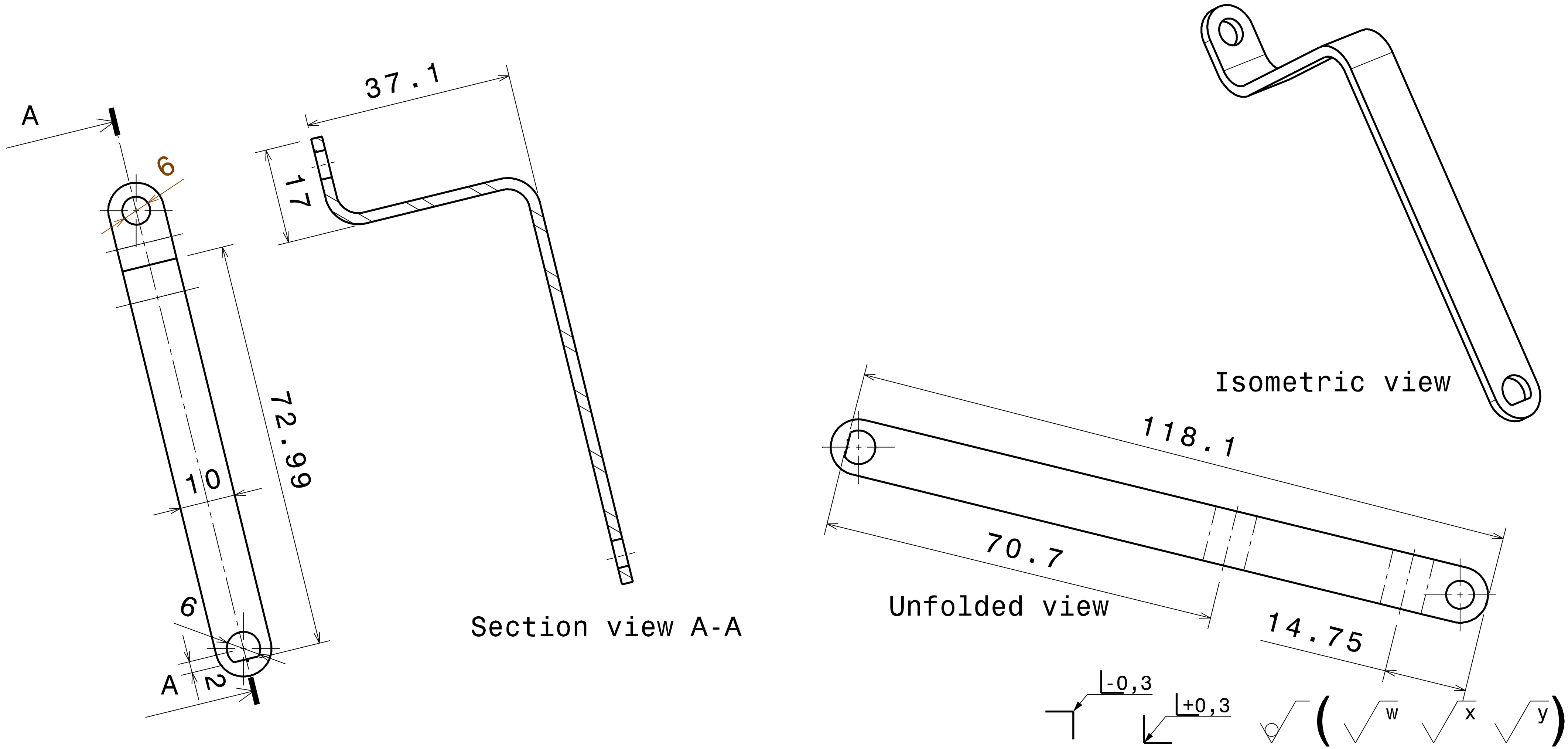
$\sqrt{x}$ = $\sqrt{Rz\ 16}$

$\sqrt{y}$ = $\sqrt{Rz\ 6,3}$

Scale: 1:1	General Tolerance: DIN ISO 2768 - mK	Number: 2	Material: 25CrMo4
Date: 06.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Sensor Arm Front		Part number: 10315
	Document Type: Drawing	Weight: 0.006 kg	Page: 1/1



Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 04.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Front Bracket Sensor			Part number: 10316
	Document Type: Drawing	Weight: 0.017 kg		Page: 1/1

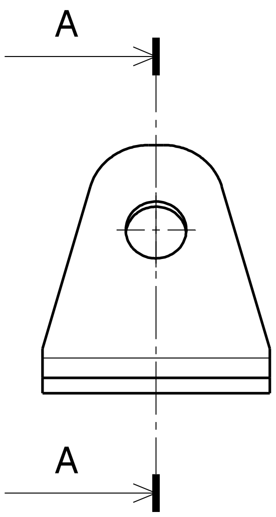


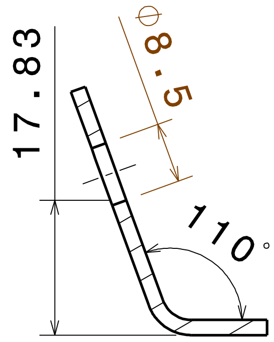
$\sqrt{w}$ = Rz 50

$\sqrt{x}$ = Rz 16

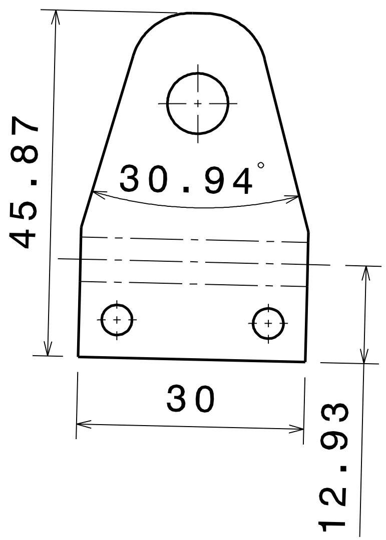
$\sqrt{y}$ = Rz 6,3

Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 2	Material: 25CrMo4
Date: 12.03.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Sensor Arm Rear			Part number: 10318
	Document Type: Drawing	Weight: 0.006 kg		Page: 1/1

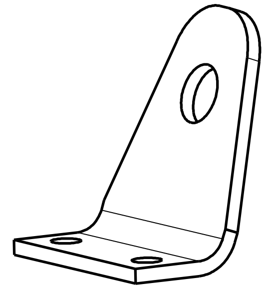




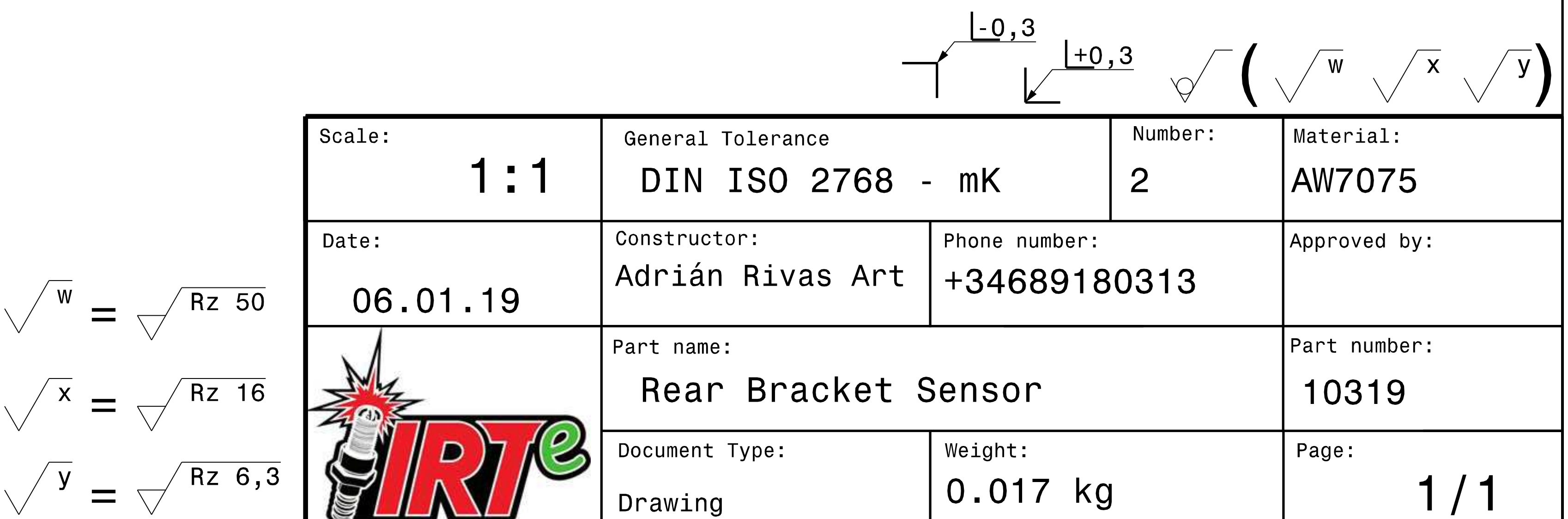
Section view A-A
Scale: 1:1



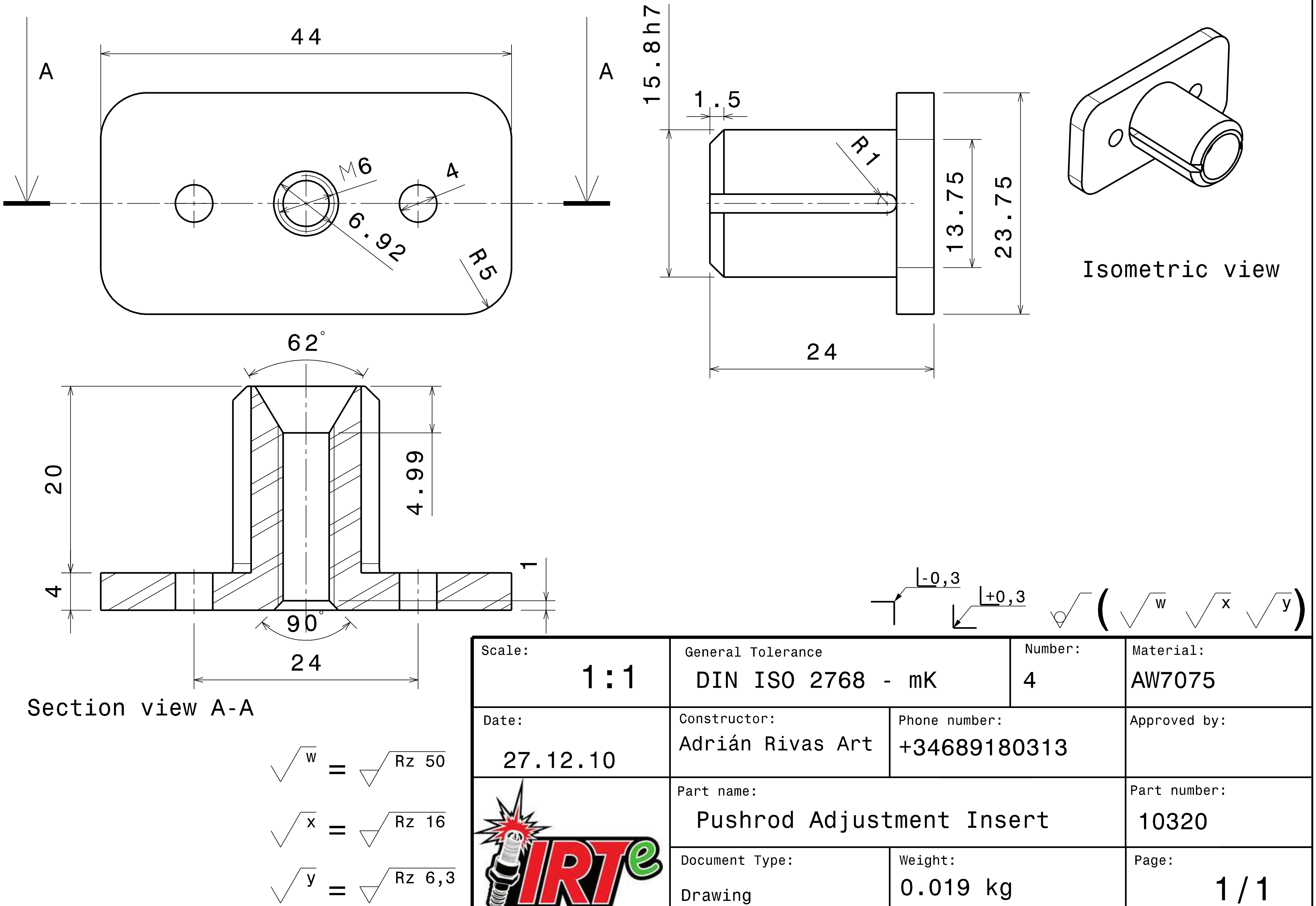
Unfolded view



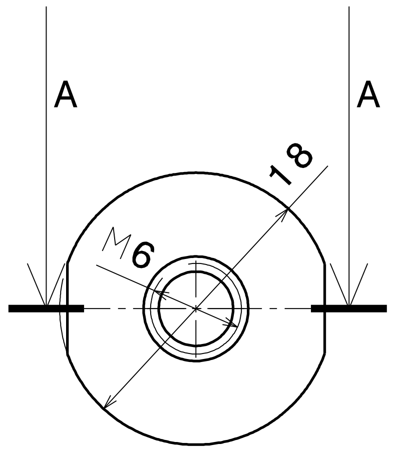
Isometric view
Scale 1:1

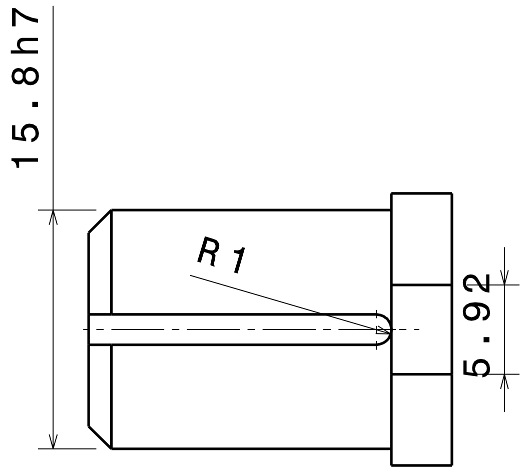


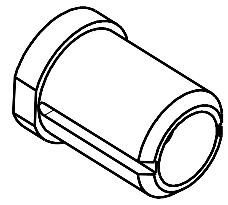
Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 2	Material: AW7075
Date: 06.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rear Bracket Sensor			Part number: 10319
	Document Type: Drawing	Weight: 0.017 kg		Page: 1/1

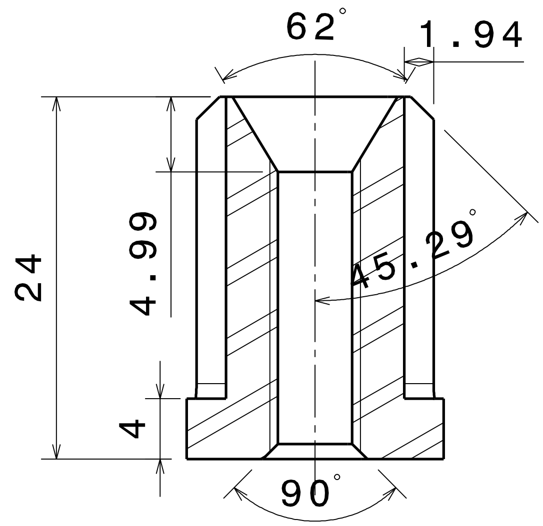


Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 4	Material: AW7075
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Pushrod Adjustment Insert			Part number: 10320
	Document Type: Drawing	Weight: 0.019 kg		Page: 1/1









Section view A-A

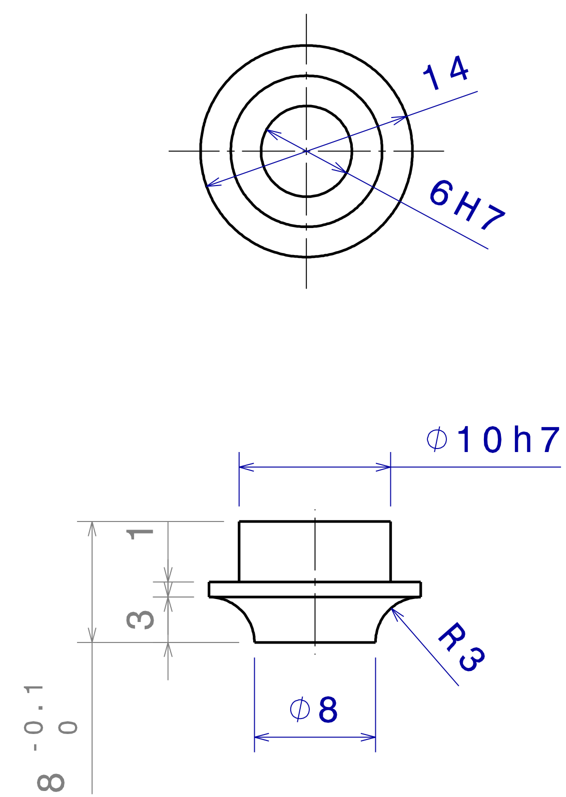
$\sqrt{}^{w} = \sqrt{Rz\ 50}$

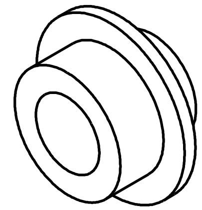
$\sqrt{}^{x} = \sqrt{Rz\ 16}$

$\sqrt{}^{y} = \sqrt{Rz\ 6,3}$

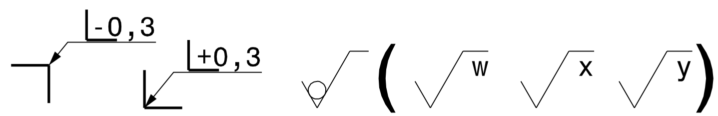
-0,3 +0,3 $\sqrt{}$ ($\sqrt{}^{w}$ $\sqrt{}^{x}$ $\sqrt{}^{y}$)

Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 20	Material: AW7075
Date: 26.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Insert			Part number: 10321
	Document Type: Drawing	Weight: 0.011 kg		Page: 1/1





Isometric view

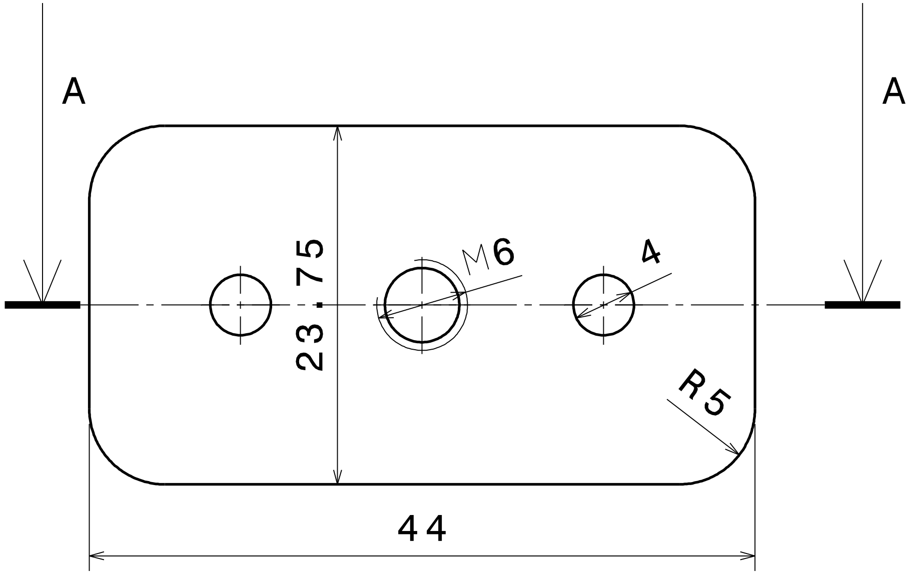


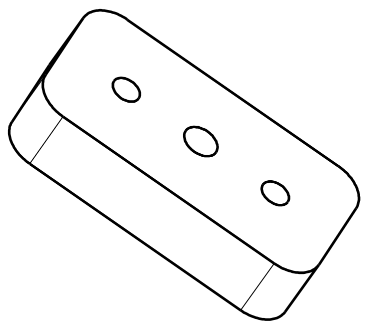
Scale: 2:1	General Tolerance DIN ISO 2768 - mK	Number: 8	Material: X8CrNiS18-9
Date: 26.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Pushrod Shell		Part number: 10323
	Document Type: Drawing	Weight: 0.007 kg	Page: 1/1

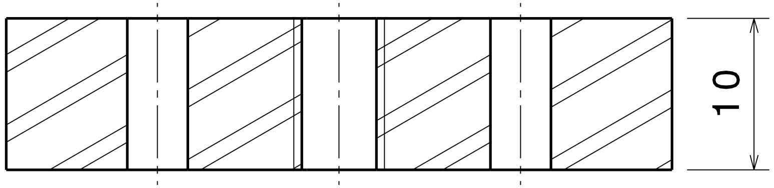
w = Rz 50

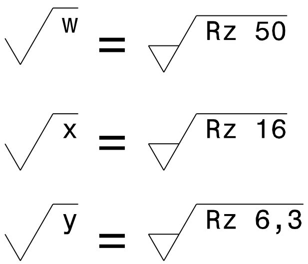
x = Rz 16

y = Rz 6,3

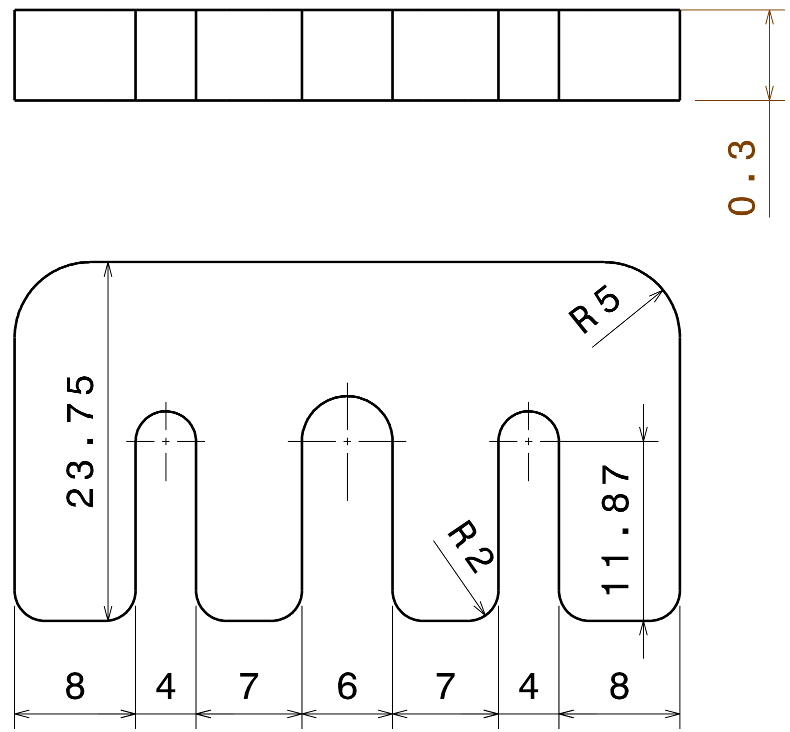


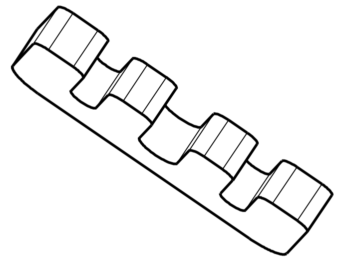






Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: AW7075
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Pushrod Upper Plate			Part number: 10325
	Document Type: Drawing	Weight: 0.027 kg		Page: 1/1



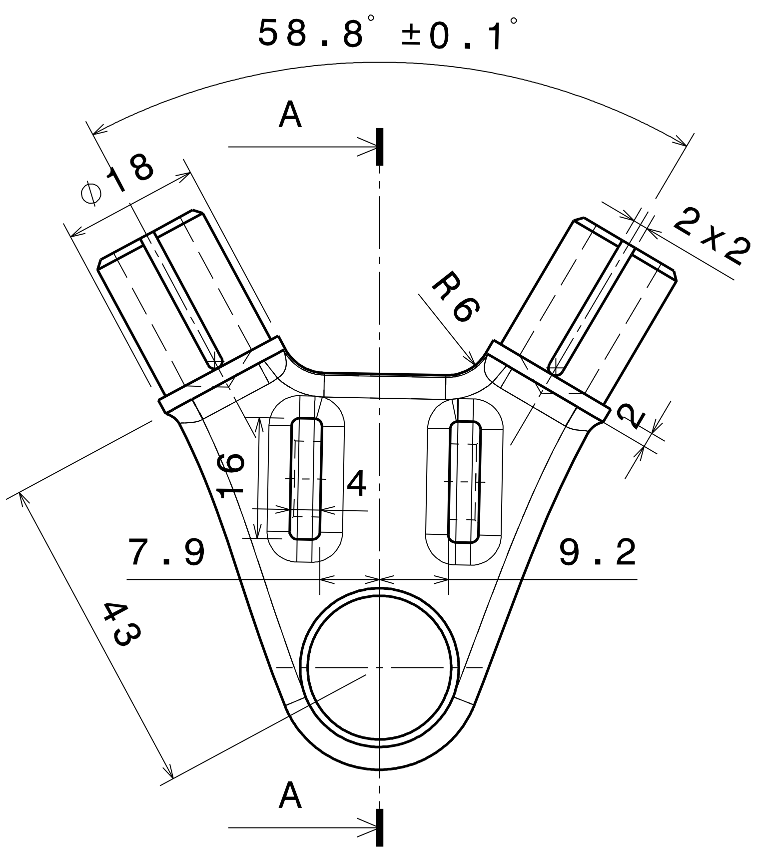


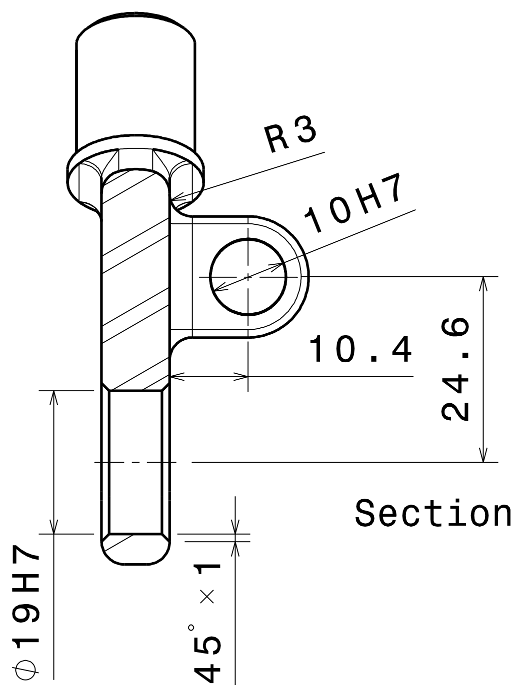
Isometric view
Scale: 1:1

w = Rz 50
x = Rz 16
y = Rz 6,3

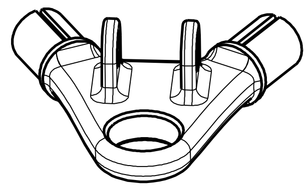
-0,3
+0,3
(w x y)

Scale: 2:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: AW7075
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Pushrod Intermediate Plate 0.3 mm		Part number: 10326
	Document Type: Drawing	Weight: 0.014 kg	Page: 1/1

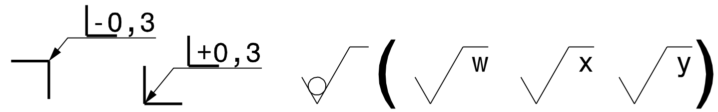




Section view A-A



Isometric view
Scale: 1:2



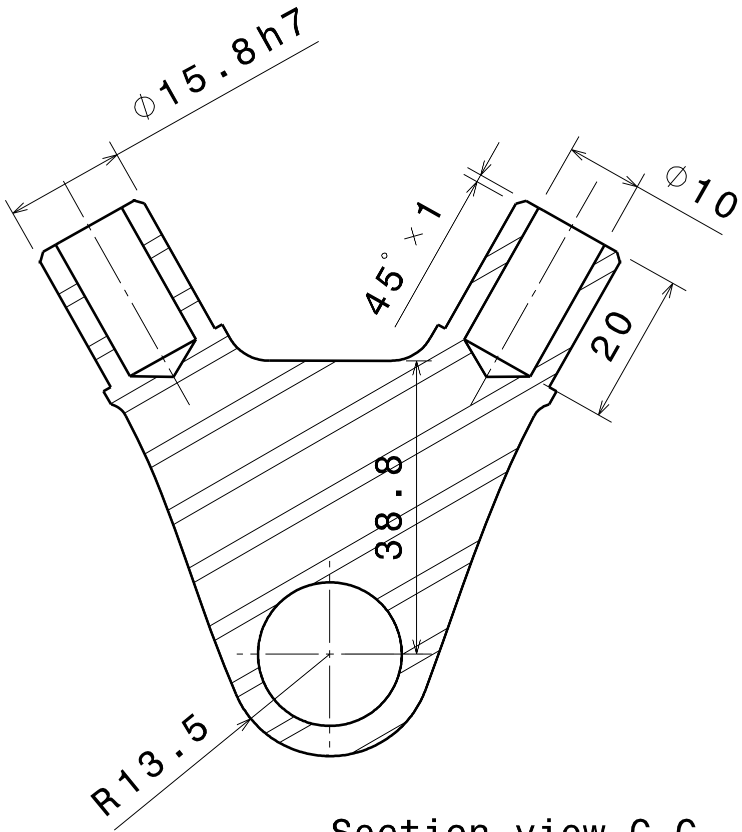
Not dimensioned
radii R = 1 mm

√w = √Rz 50

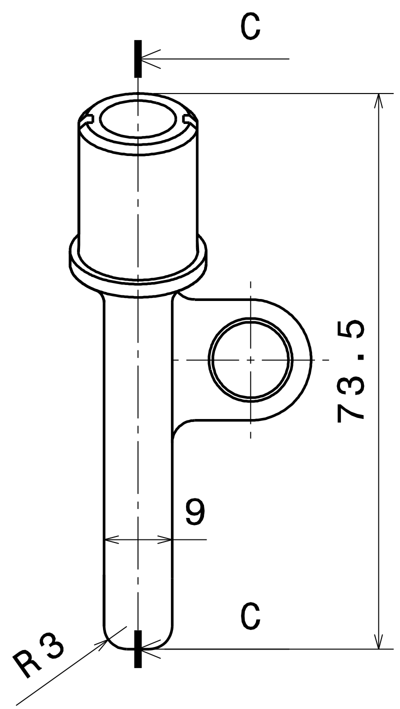
√x = √Rz 16

√y = √Rz 6,3

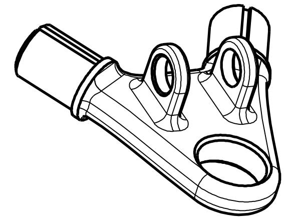
Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 1	Material: AW7075
Date: 18.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Y-Piece Front Up Left		Part number: 10335
	Document Type: Drawing	Weight: 0.059 kg	Page: 1/2



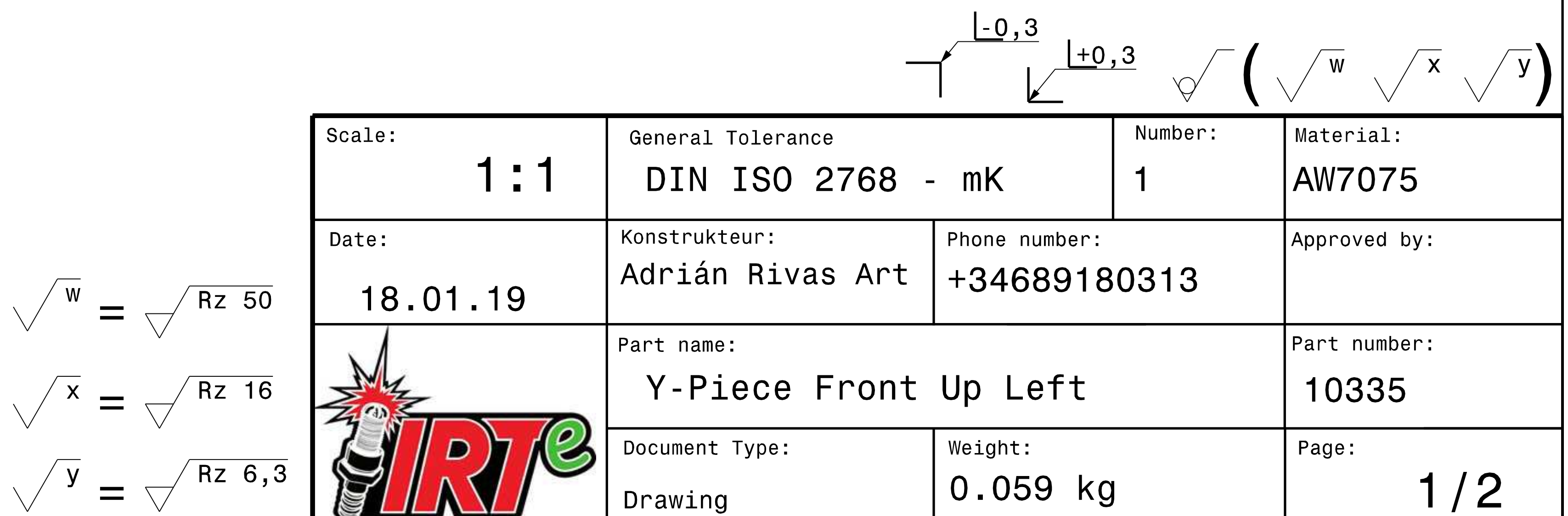
Section view C-C
Scale: 1:1



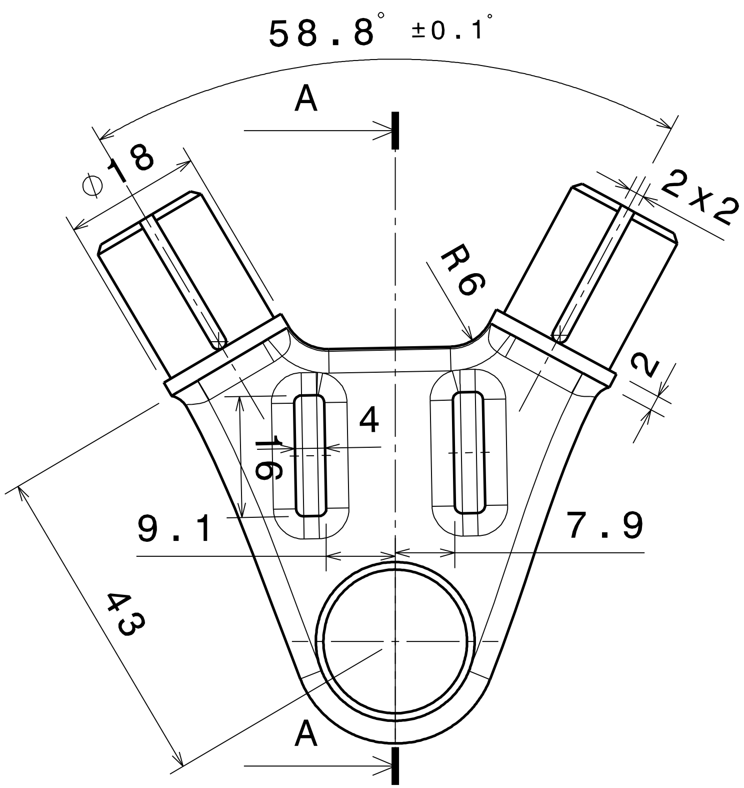
Front view
Scale: 1:1

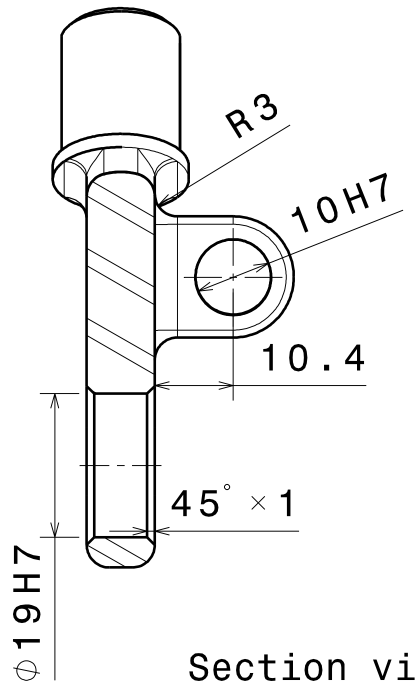


Isometric view
Scale: 1:2

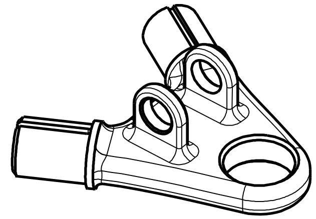


Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 1	Material: AW7075
Date: 18.01.19	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Y-Piece Front Up Left		Part number: 10335
	Document Type: Drawing	Weight: 0.059 kg	Page: 1/2

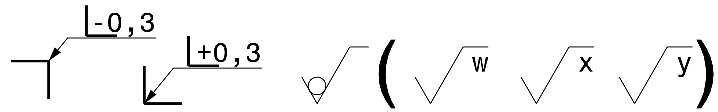


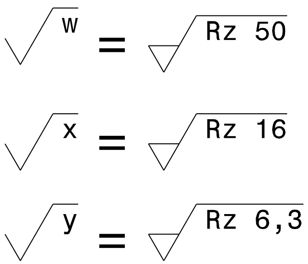


Section view A-A

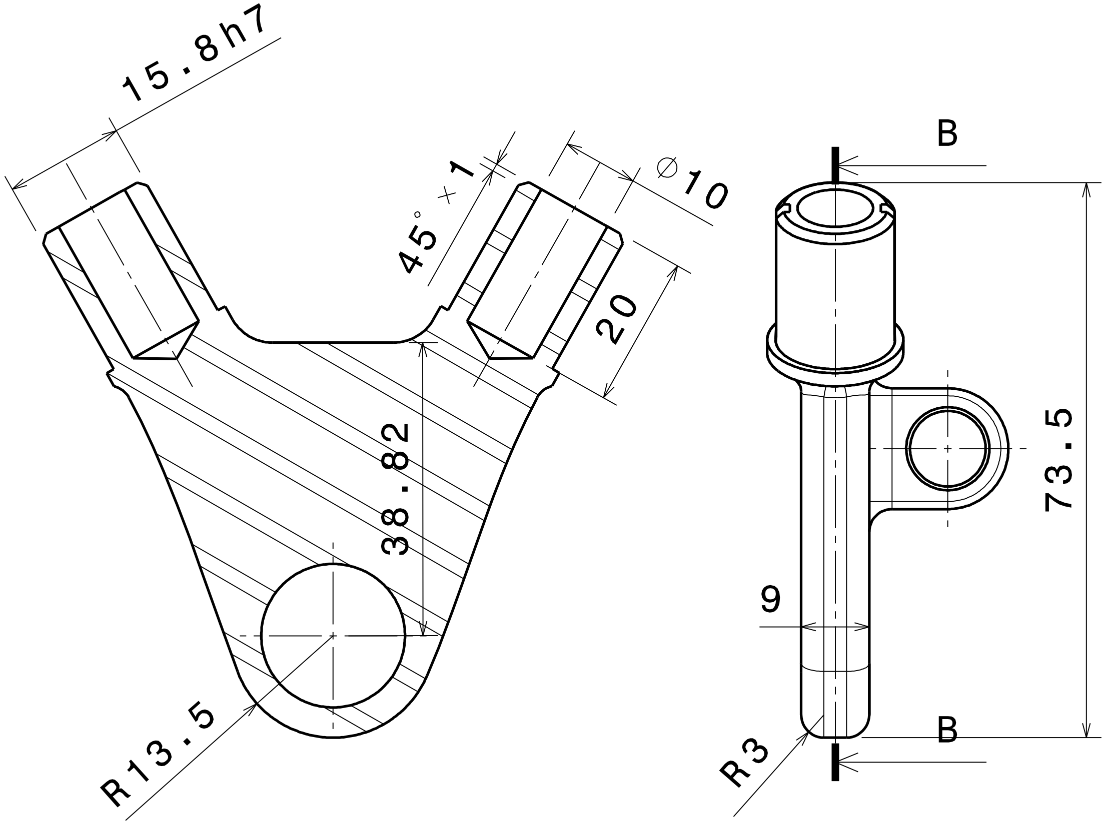


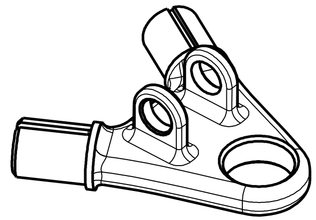
Isometric view
Scale: 1:2



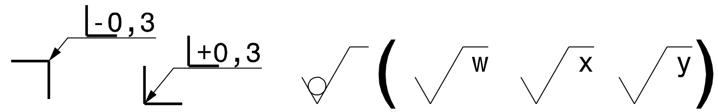


Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 24.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Front Up Right			Part number: 10336
	Document Type: Drawing	Weight: 0.059 kg		Page: 1/1





Isometric view
Scale: 1:2

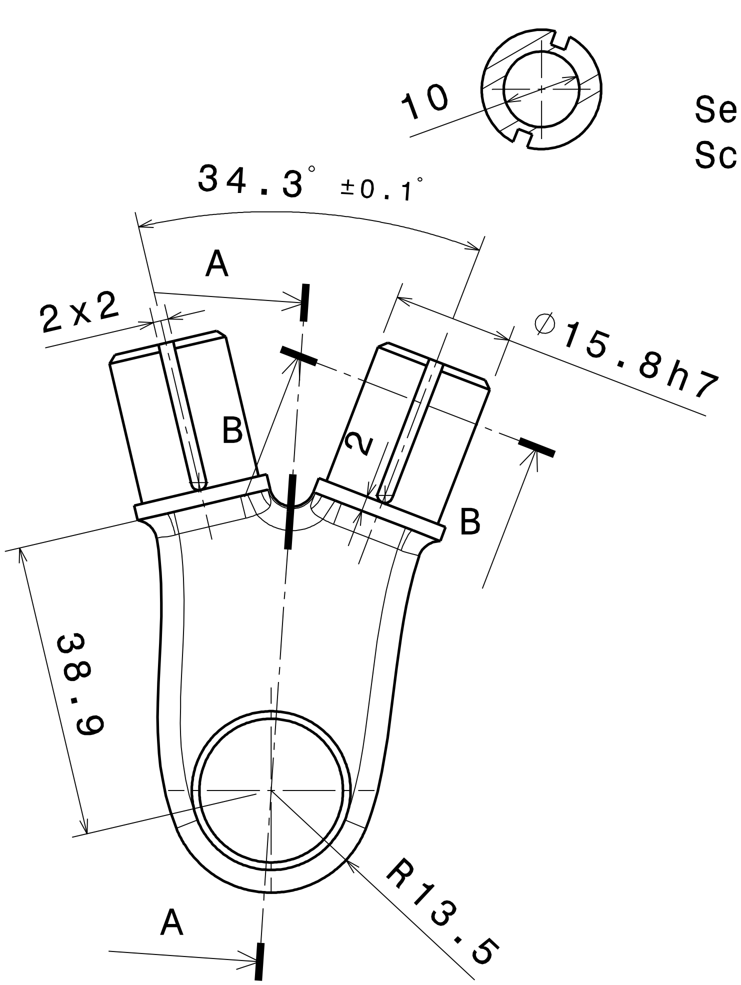


w = Rz 50

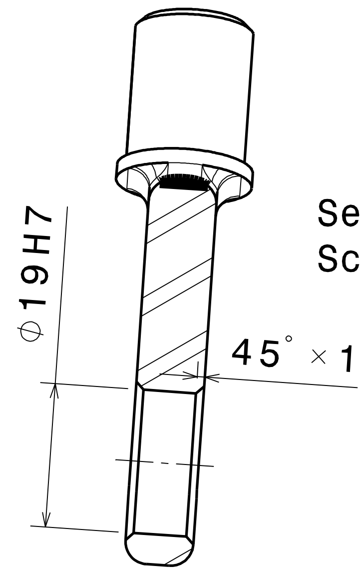
x = Rz 16

y = Rz 6,3

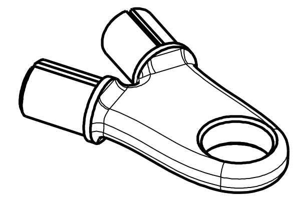
Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 24.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Front Up Right			Part number: 10336
	Document Type: Drawing	Weight: 0.059 kg		Page: 1/1



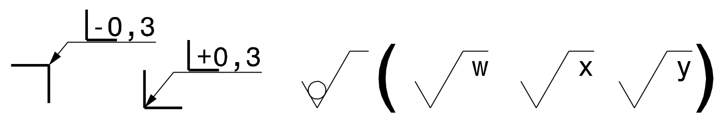
Section view B-B
Scale: 1:1



Section view A-A
Scale: 1:1



Isometric view
Scale: 1:2



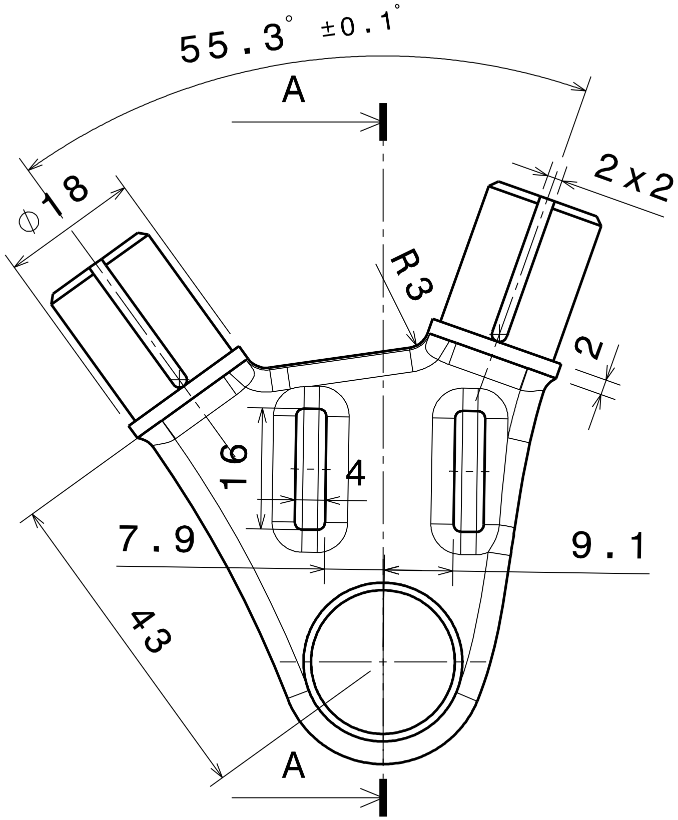
Undimensioned radii R = 3 mm

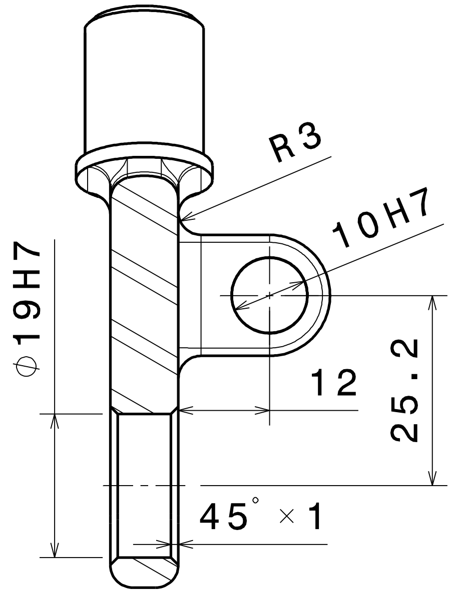
√w = Rz 50

√x = Rz 16

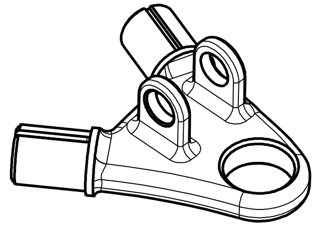
√y = Rz 6,3

Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Y-Piece Front Lower		Part number: 10337
	Document Type: Drawing	Weight: 0.043 kg	Page: 1/1





Section view A-A
Scale: 1:1



Isometric view
Scale: 1:2

Undimensioned radii R = 1 mm

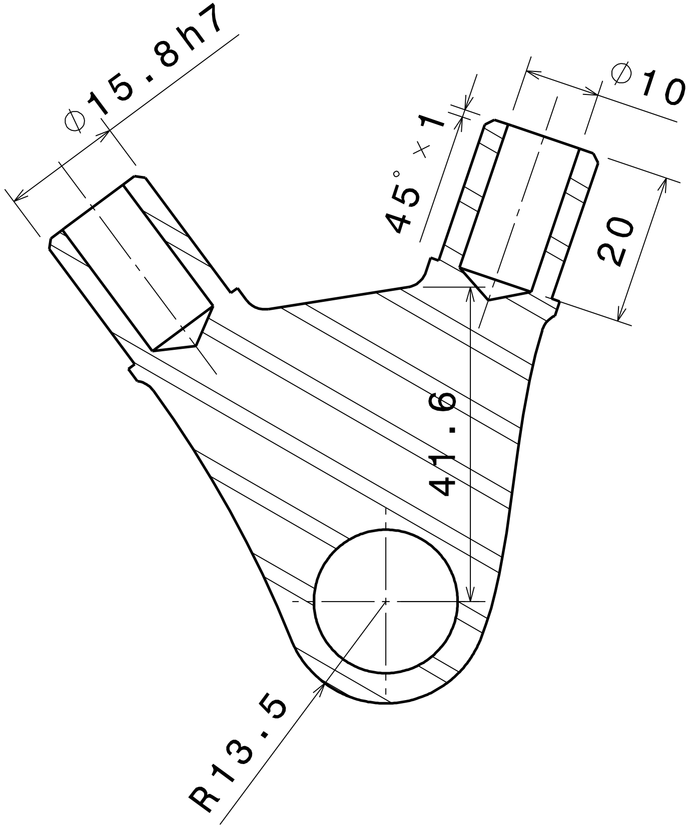
w = Rz 50

x = Rz 16

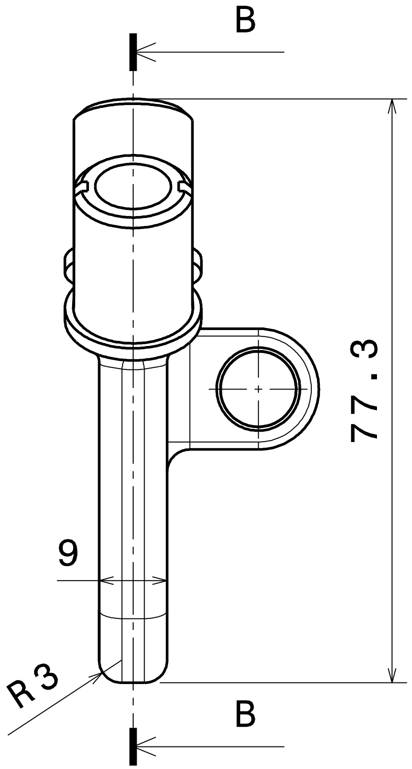
y = Rz 6,3

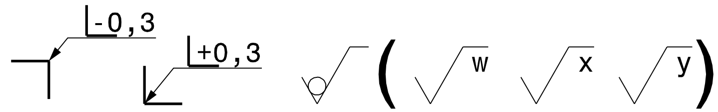
-0,3 +0,3 (w x y)

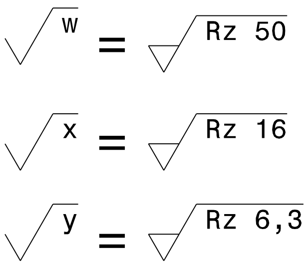
Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Rear Up Left			Part number: 10338
	Document Type: Drawing	Weight: 0.059 kg		Page: 1/2



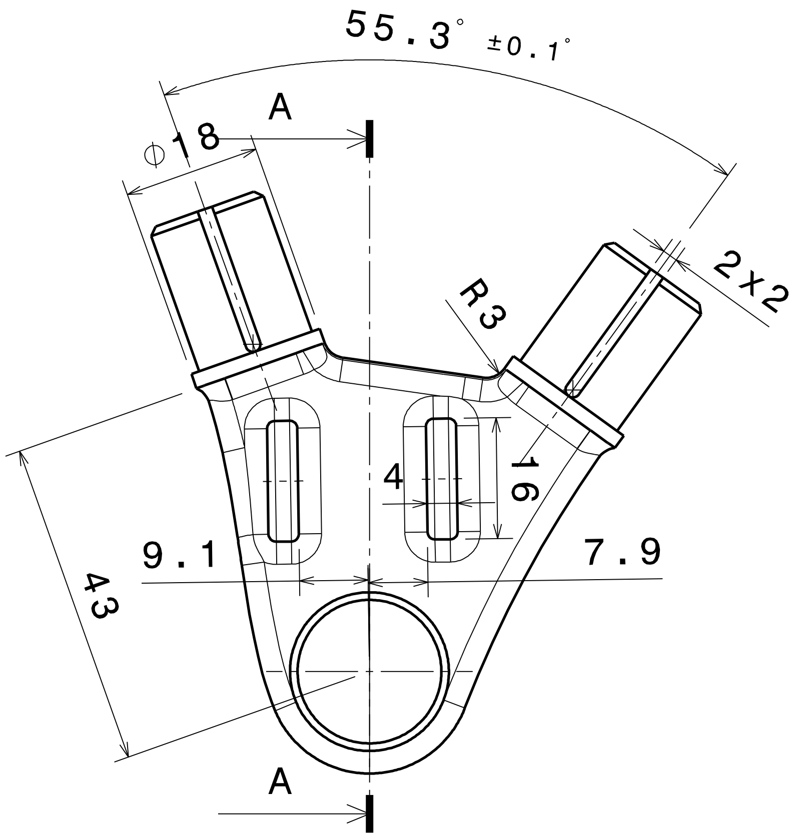
Section view B-B

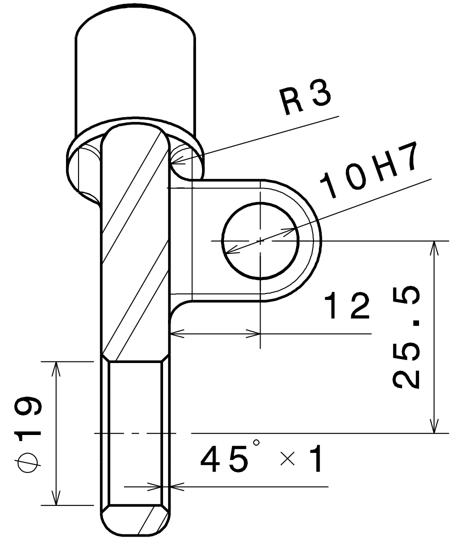




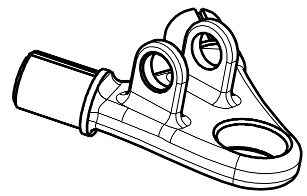


Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Rear Up Left			Part number: 10338
	Document Type: Drawing	Weight: 0.059 kg		Page: 2/2





Section view A-A



Isometric view
Scale: 1:2

-0,3
+0,3
(w x y)

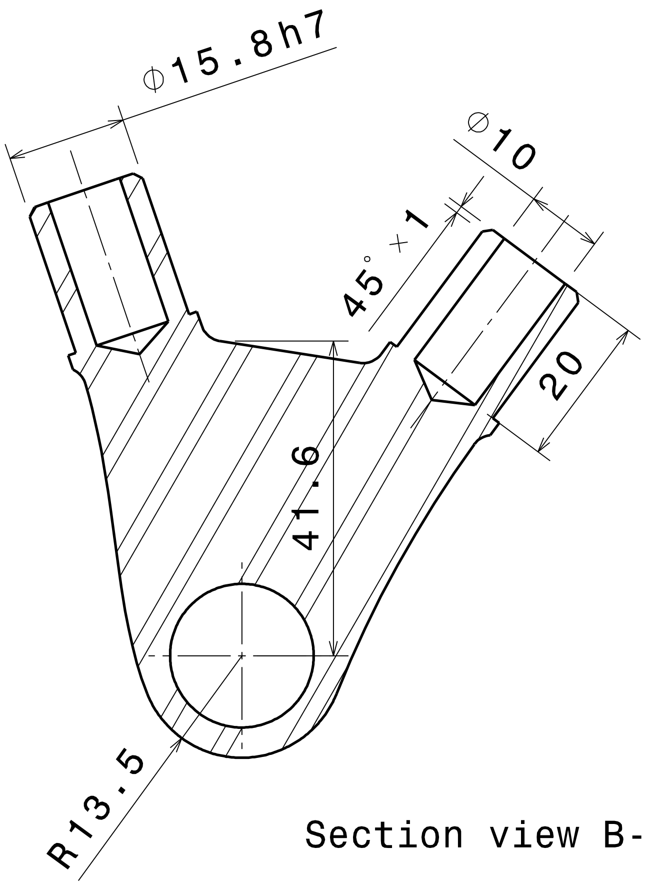
Undimensioned radii R = 1 mm

w = Rz 50

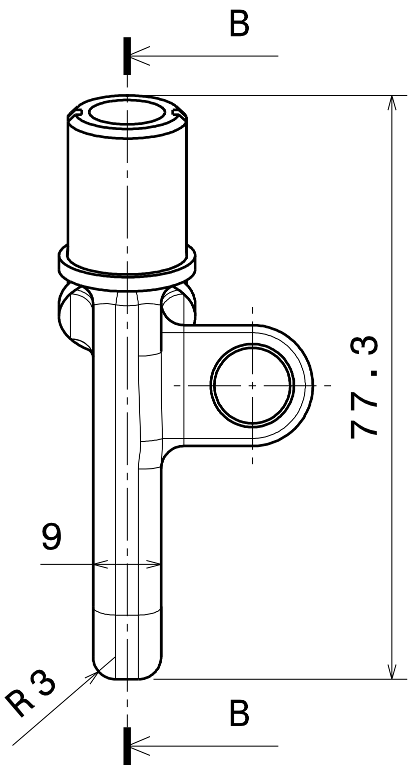
x = Rz 16

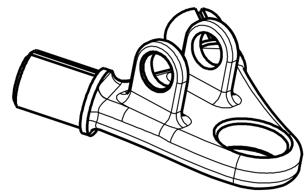
y = Rz 6,3

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Rear Up Right			Part number: 10339
	Document Type: Drawing	Weight: 0.059 kg		Page: 1/2



Section view B-B





Isometric view
Scale: 1:2

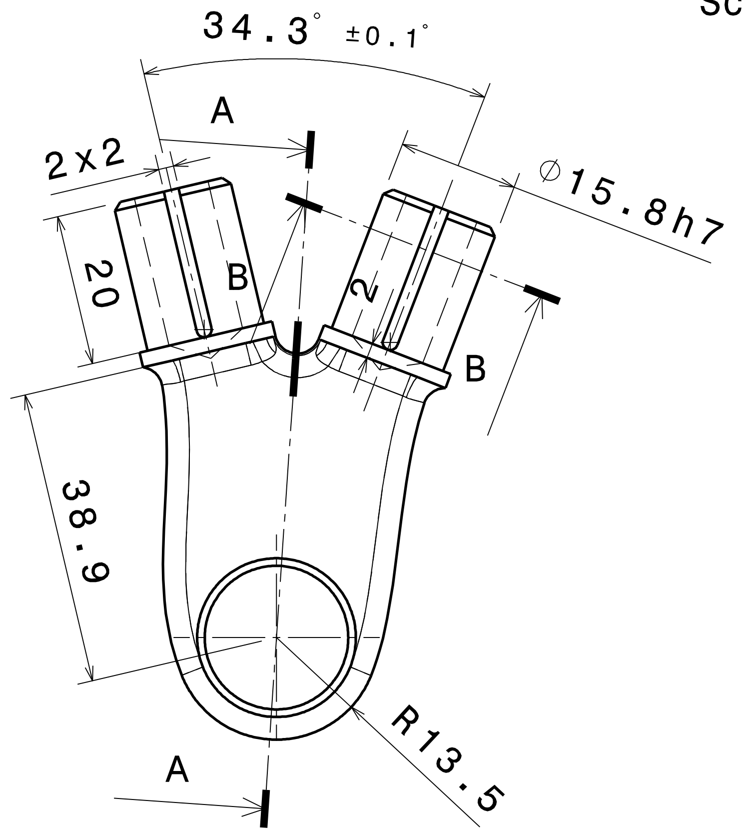
-0,3 / +0,3 / √ (√w √x √y)

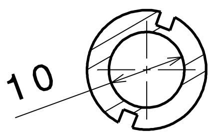
√w = √Rz 50

√x = √Rz 16

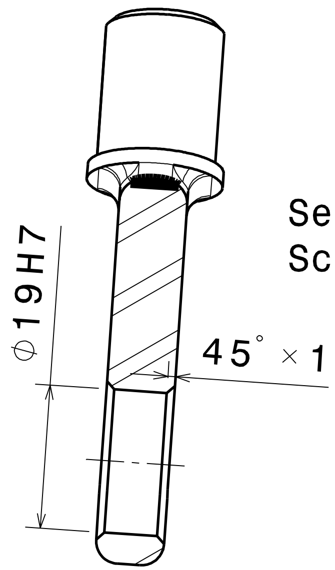
√y = √Rz 6,3

Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Rear Up Right			Part number: 10339
	Document Type: Drawing	Weight: 0.059 kg		Page: 2/2

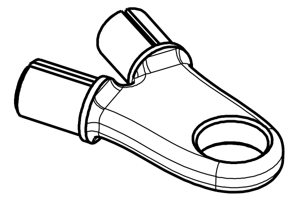




Section view B-B
Scale: 1:1



Section view A-A
Scale: 1:1



Isometric view
Scale: 1:2

-0,3 +0,3

√ (√w √x √y)

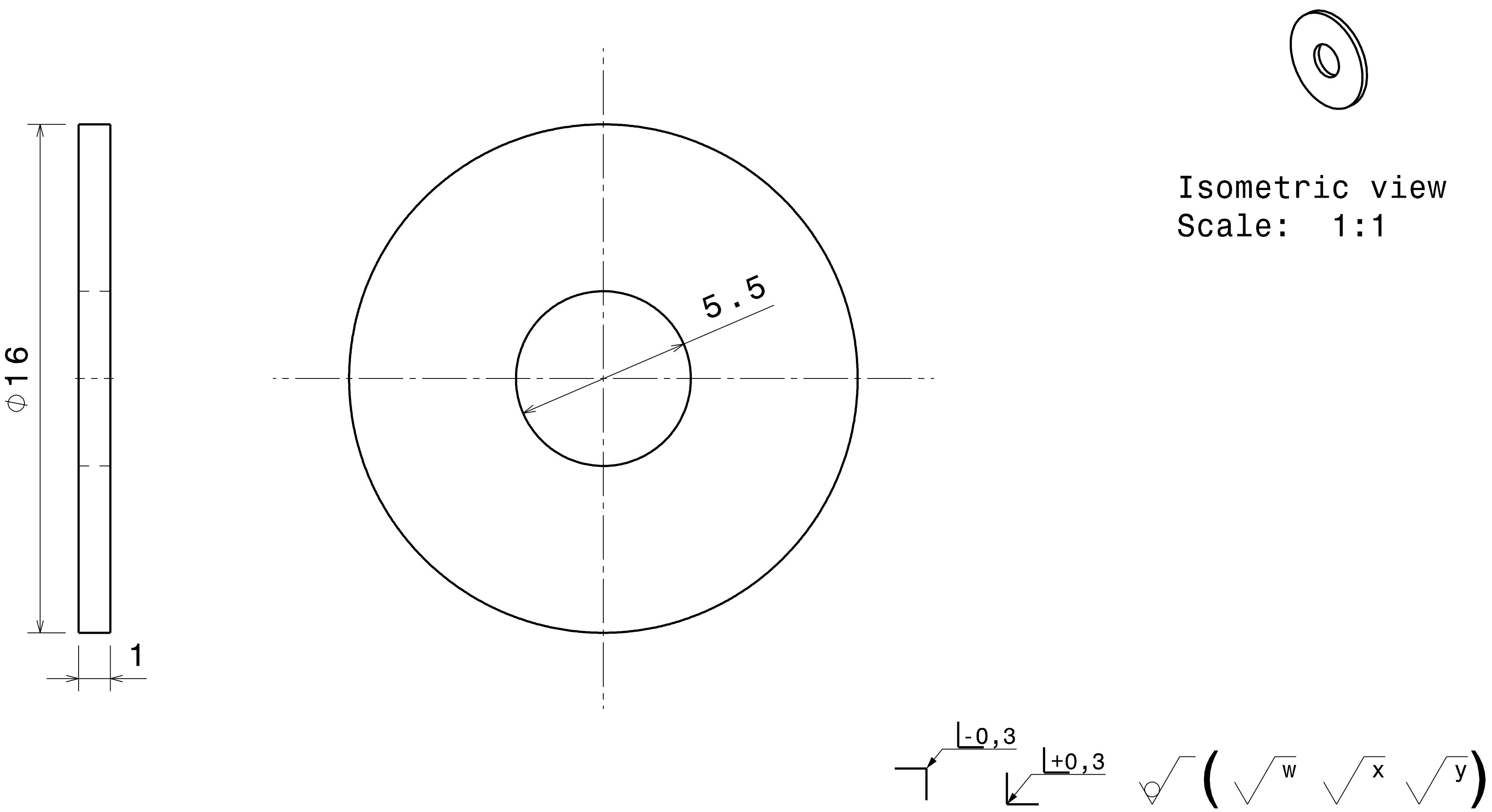
Undimensioned radii R = 3 mm

√w = √Rz 50

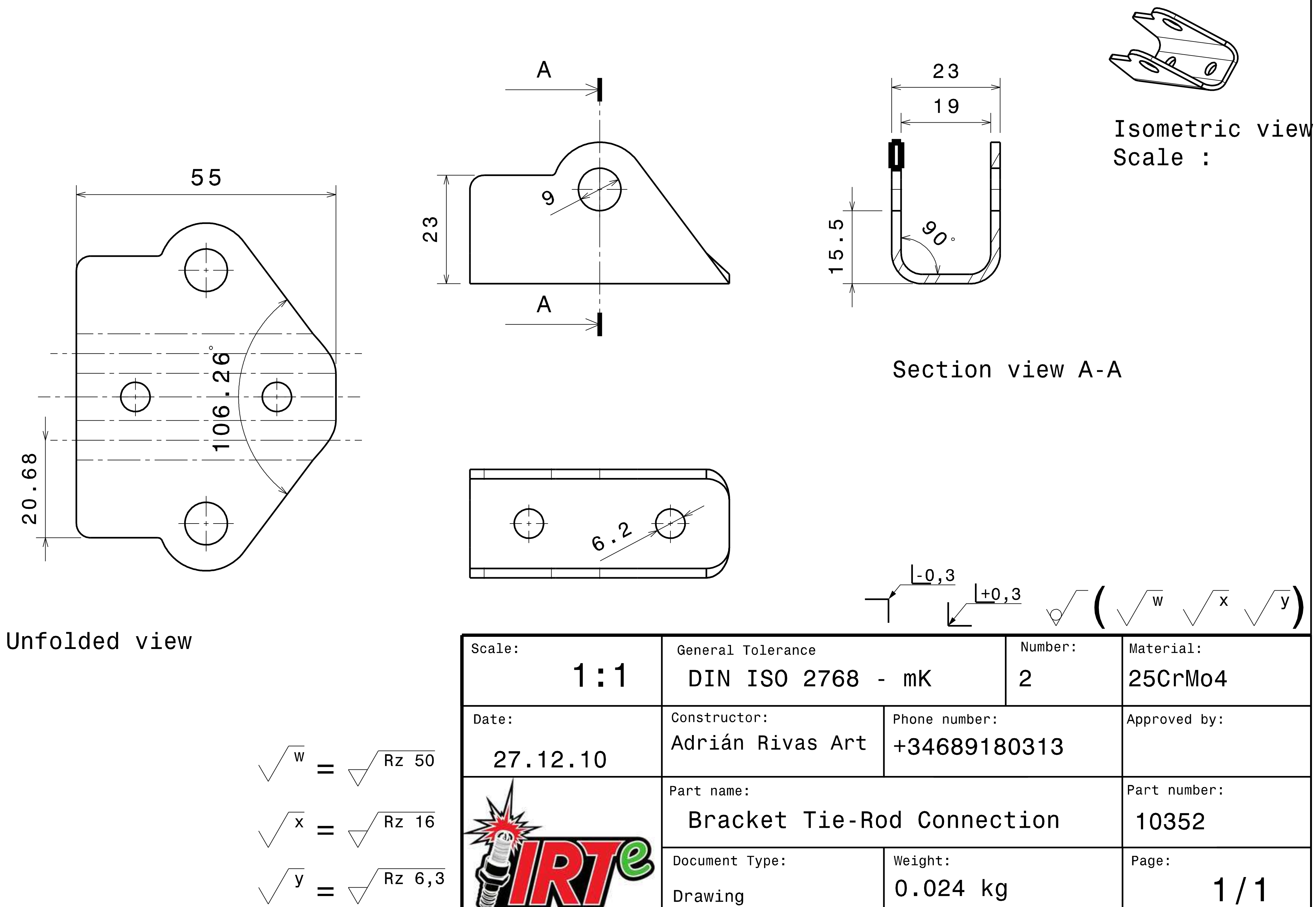
√x = √Rz 16

√y = √Rz 6,3

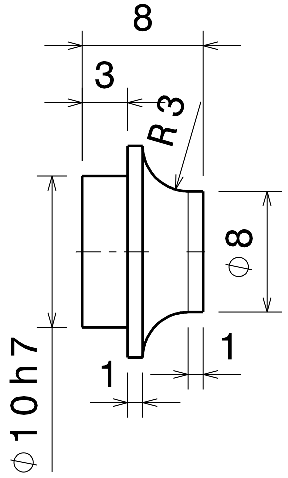
Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: AW7075
Date: 27.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Front Lower			Part number: 10337
	Document Type: Drawing	Weight: 0.043 kg		Page: 1/1

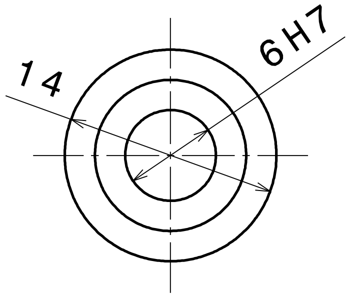


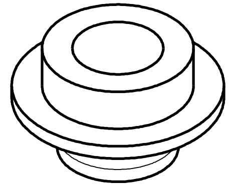
Scale: 5:1	General Tolerance: DIN ISO 2768 - mK		Number: 8	Material: AW7075
Date: 04.01.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Y-Piece Separator			Part number: 10341
	Document Type: Drawing	Weight: 0.001 kg		Page: 1/1



Scale: 1:1	General Tolerance: DIN ISO 2768 - mK	Number: 2	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art / Phone number: +34689180313		Approved by:
	Part name: Bracket Tie-Rod Connection		Part number: 10352
	Document Type: Drawing / Weight: 0.024 kg		Page: 1/1





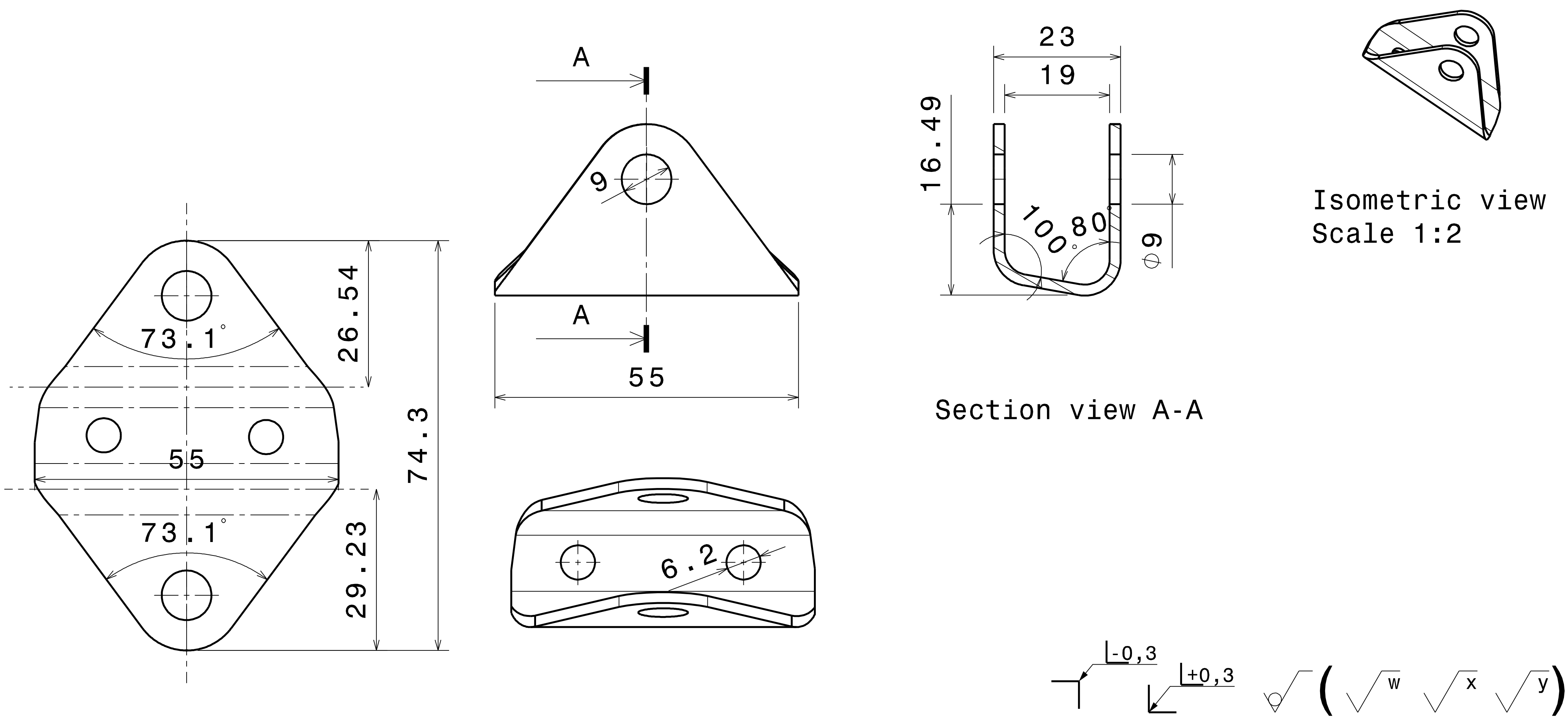


Isometric view

-0,3
+0,3

√w = Rz 50
√x = Rz 16
√y = Rz 6,3

Scale: 2:1	General Tolerance: DIN ISO 2768 - mK	Number: 4	Material: X8CrNiS18-9
Date: 26.12.10	Konstrukteur: Adrián Rivas Art, Laura Hernandez W	Phone number: +34689180313	Approved by:
	Part name: Shell Tie-Rod		Part number: 10354
	Document Type: Drawing	Weight: 0.013 kg	Page: 1/1

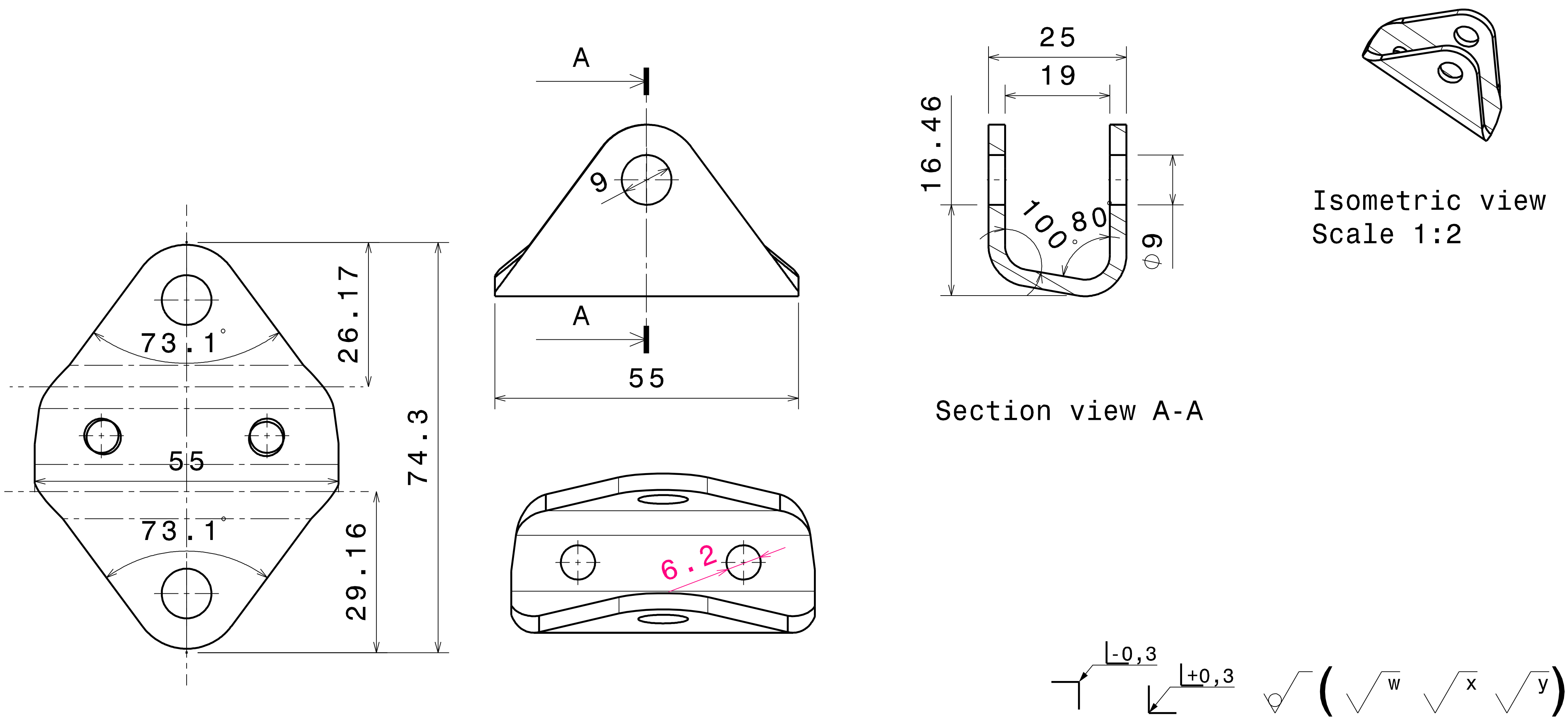


$\sqrt{w}$ = $\sqrt{Rz\ 50}$

$\sqrt{x}$ = $\sqrt{Rz\ 16}$

$\sqrt{y}$ = $\sqrt{Rz\ 6,3}$

Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Front Up		Part number: 10357
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1

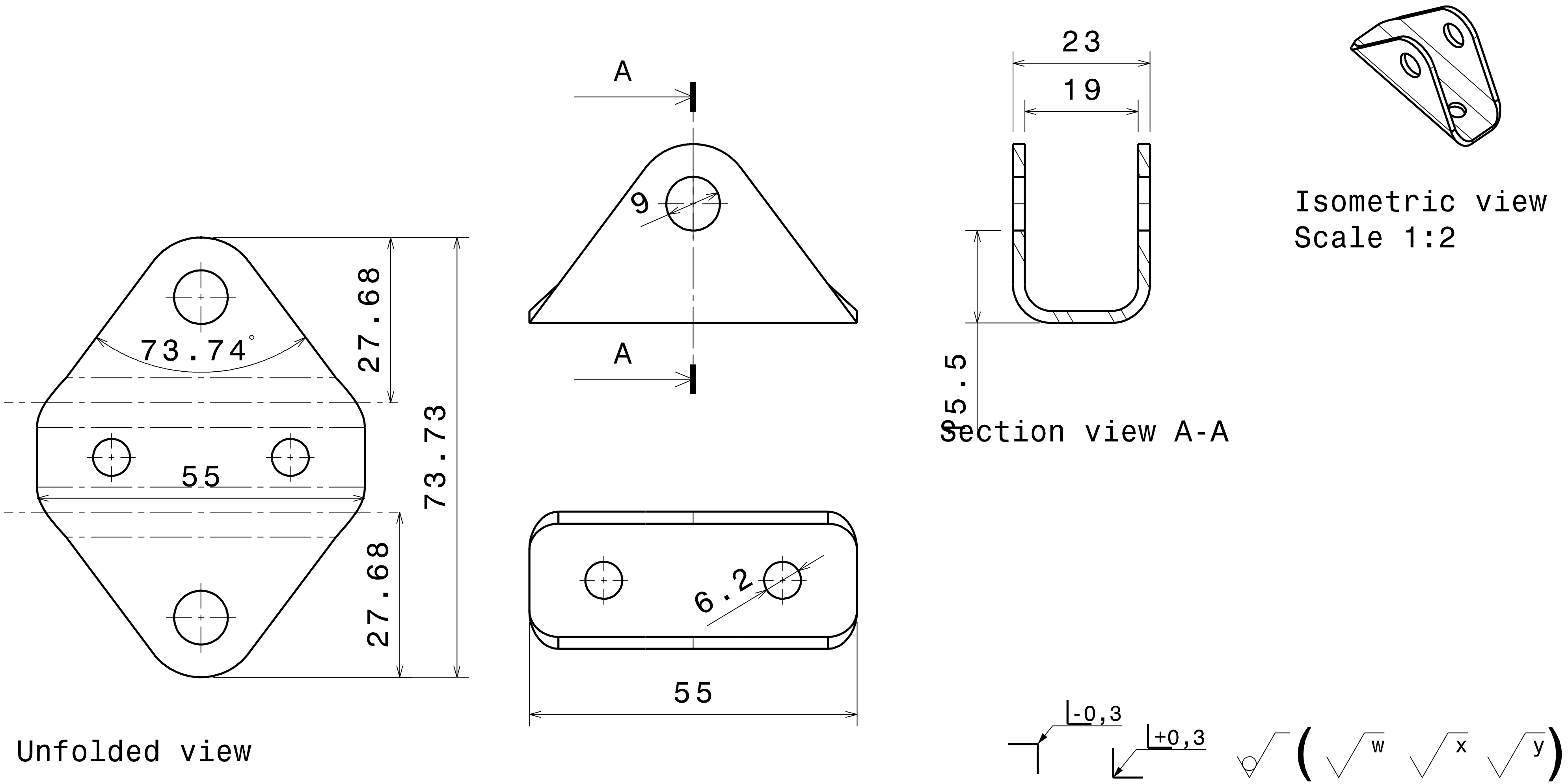


Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Bracket A-Arm Front Up 3 mm			Part number: 10357
	Document Type: Drawing	Weight: 0.020 kg		Page: 1/1

w = Rz 50

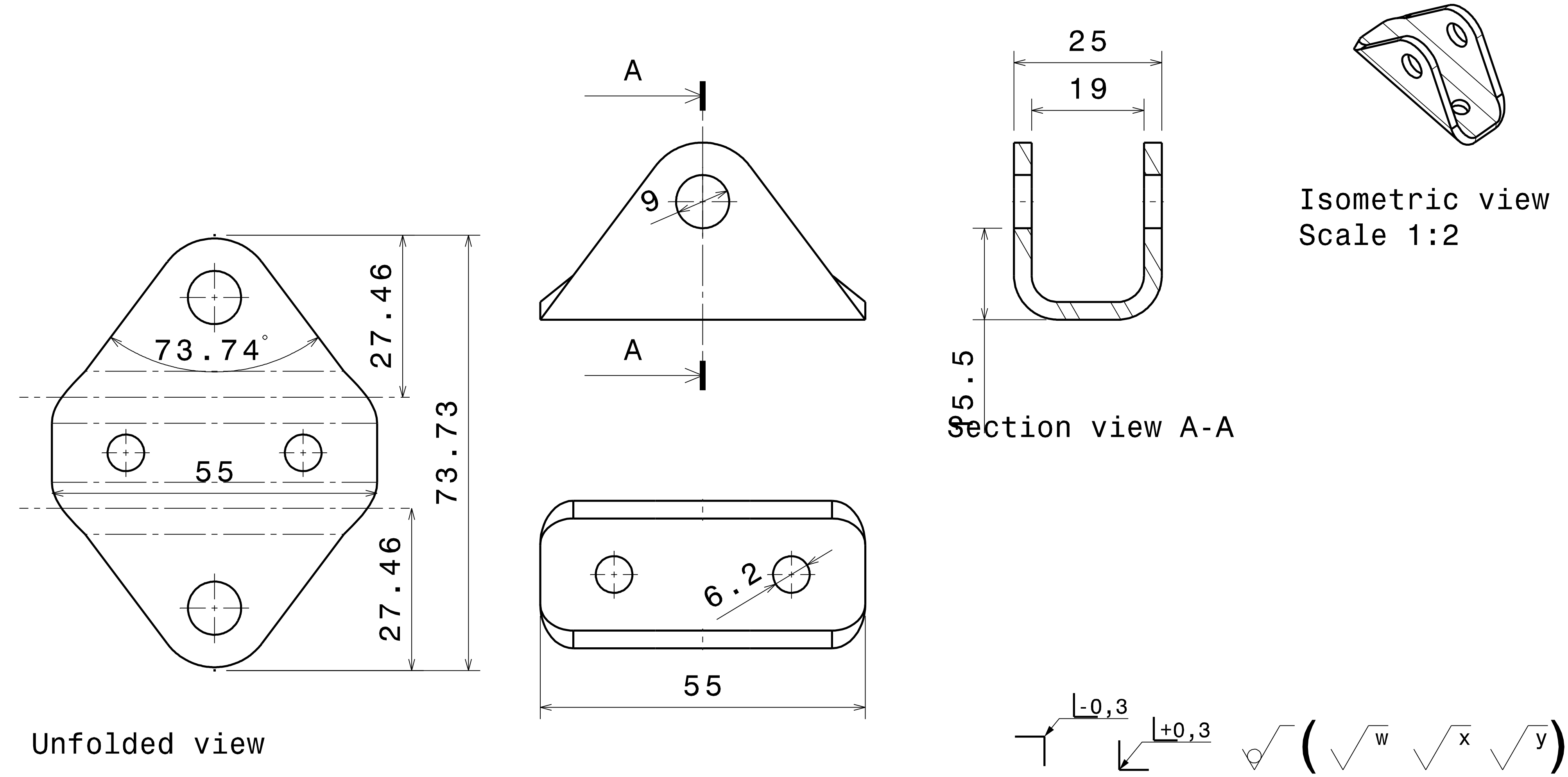
x = Rz 16

y = Rz 6,3

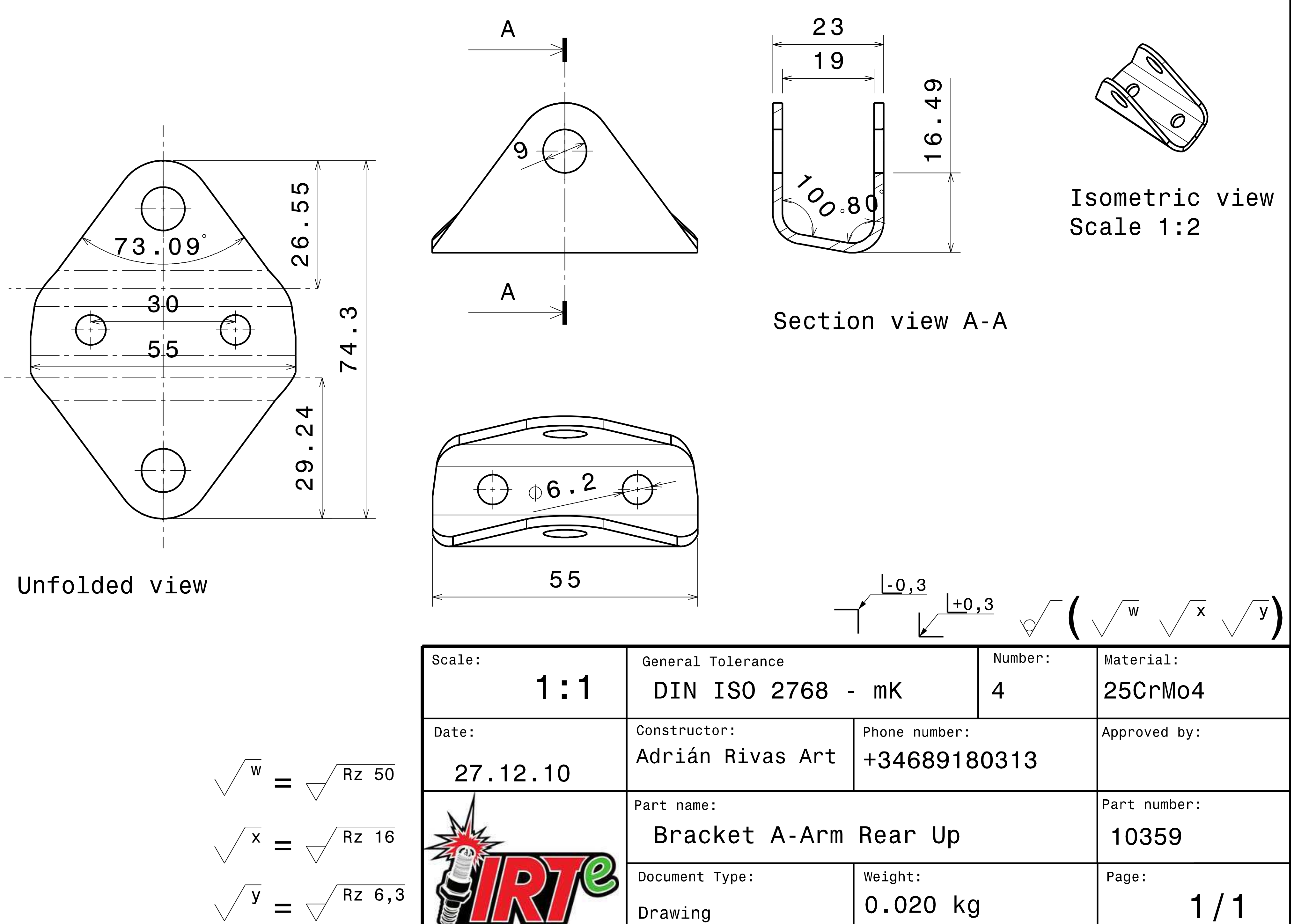


w	=	Rz 50
x	=	Rz 16
y	=	Rz 6,3

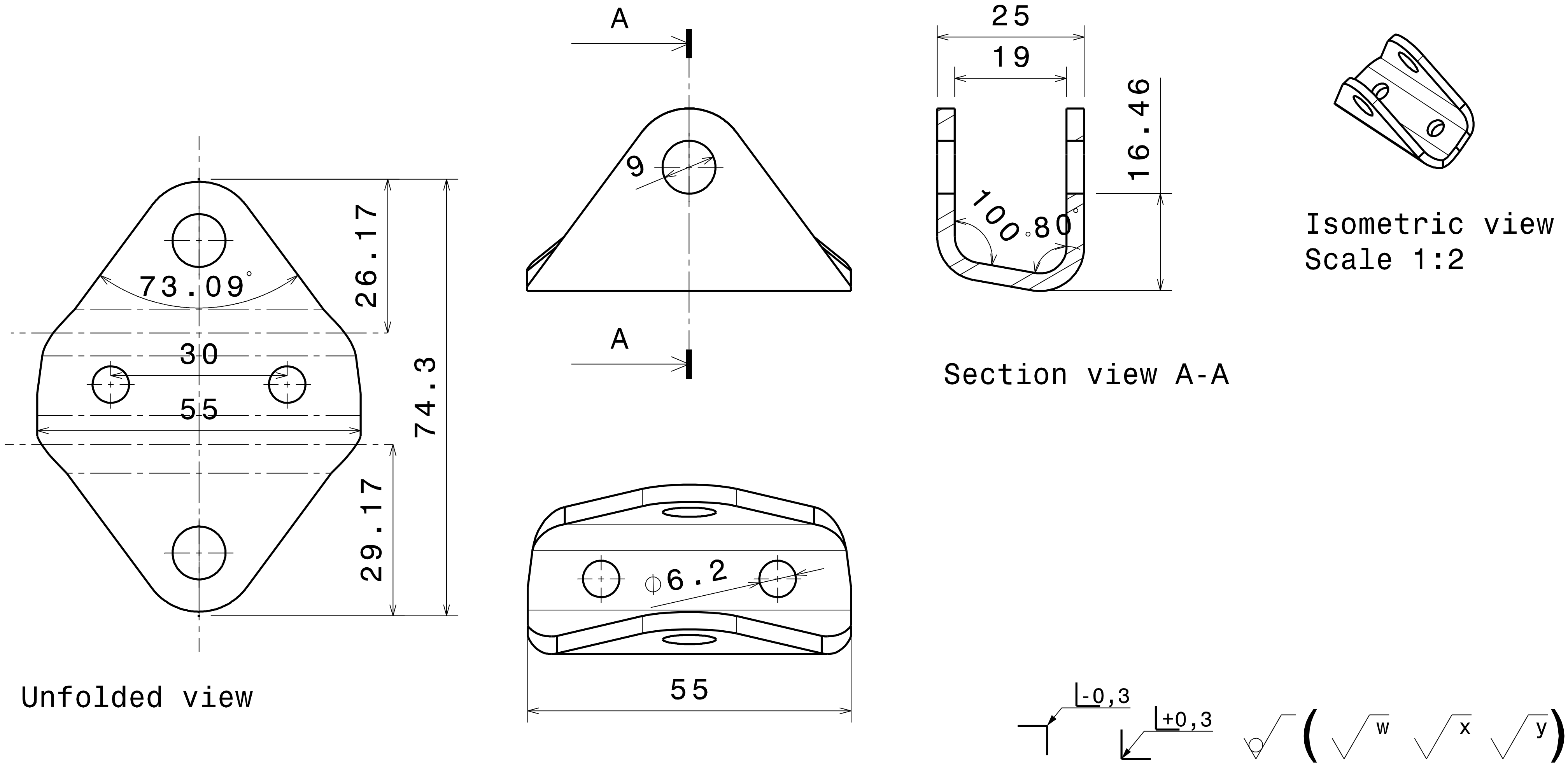
Scale:	General Tolerance	Number:	Material:
1:1	DIN ISO 2768 - mK	4	25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Front Down		Part number: 10358
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1



Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Front Down 3 mm		Part number: 10358
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1



Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Rear Up		Part number: 10359
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1

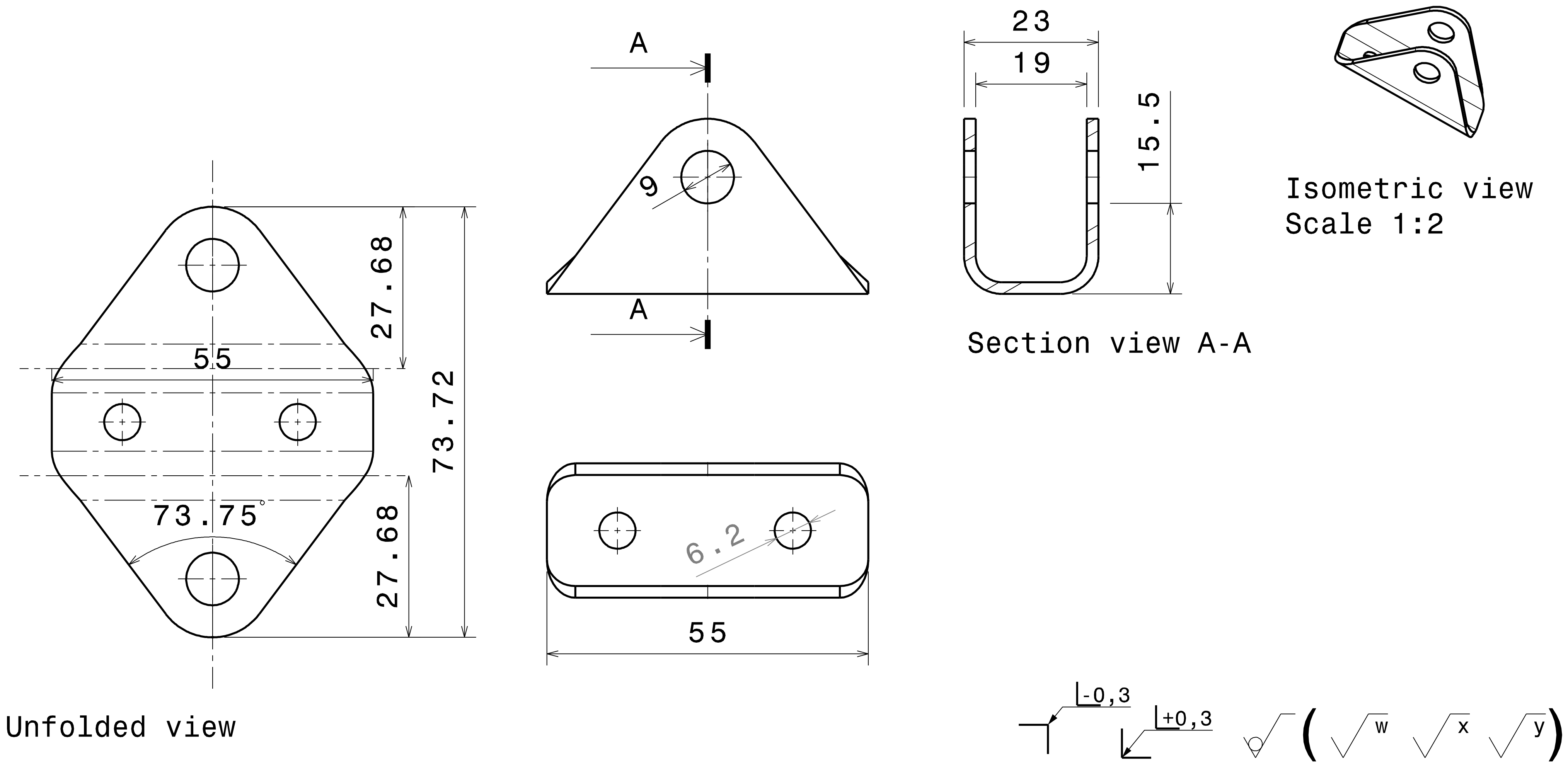


$\sqrt{w} = \sqrt{Rz\ 50}$

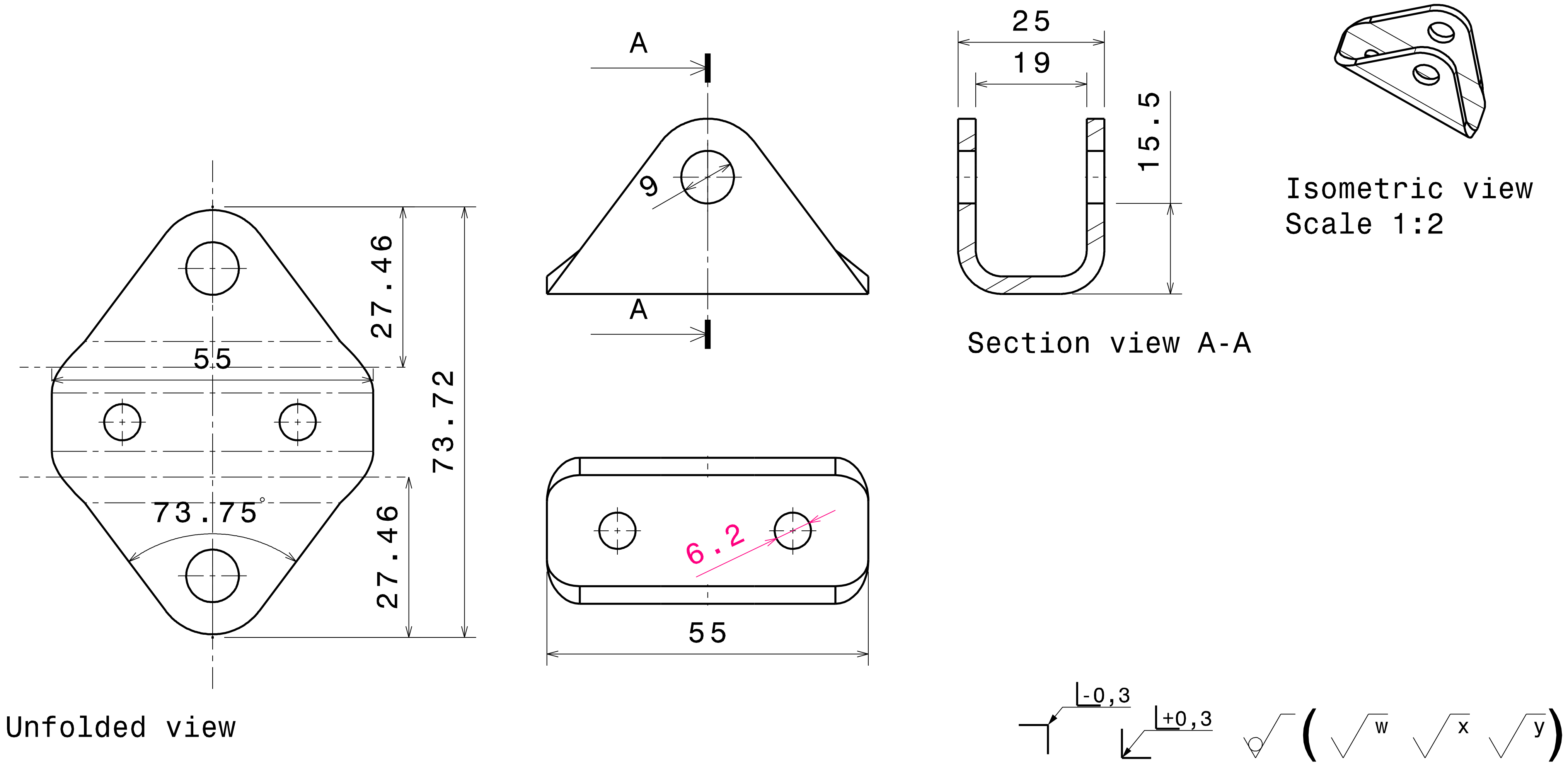
$\sqrt{x} = \sqrt{Rz\ 16}$

$\sqrt{y} = \sqrt{Rz\ 6{,}3}$

Scale: 1:1	General Tolerance: DIN ISO 2768 - mK		Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Bracket A-Arm Rear Up 3 mm			Part number: 10359
	Document Type: Drawing	Weight: 0.020 kg		Page: 1/1



Scale:	General Tolerance	Number:	Material:
1:1	DIN ISO 2768 - mK	4	25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Rear Down		Part number: 10360
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1

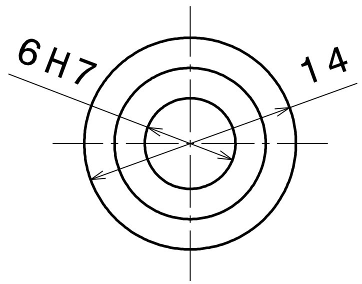


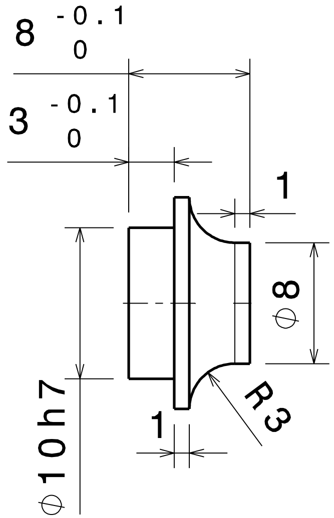
Scale: 1:1	General Tolerance DIN ISO 2768 - mK	Number: 4	Material: 25CrMo4
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Bracket A-Arm Rear Down 3 mm		Part number: 10360
	Document Type: Drawing	Weight: 0.020 kg	Page: 1/1

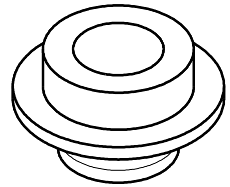
$\sqrt{w} = \sqrt{Rz\ 50}$

$\sqrt{x} = \sqrt{Rz\ 16}$

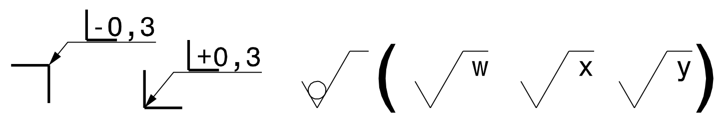
$\sqrt{y} = \sqrt{Rz\ 6,3}$







Isometric view

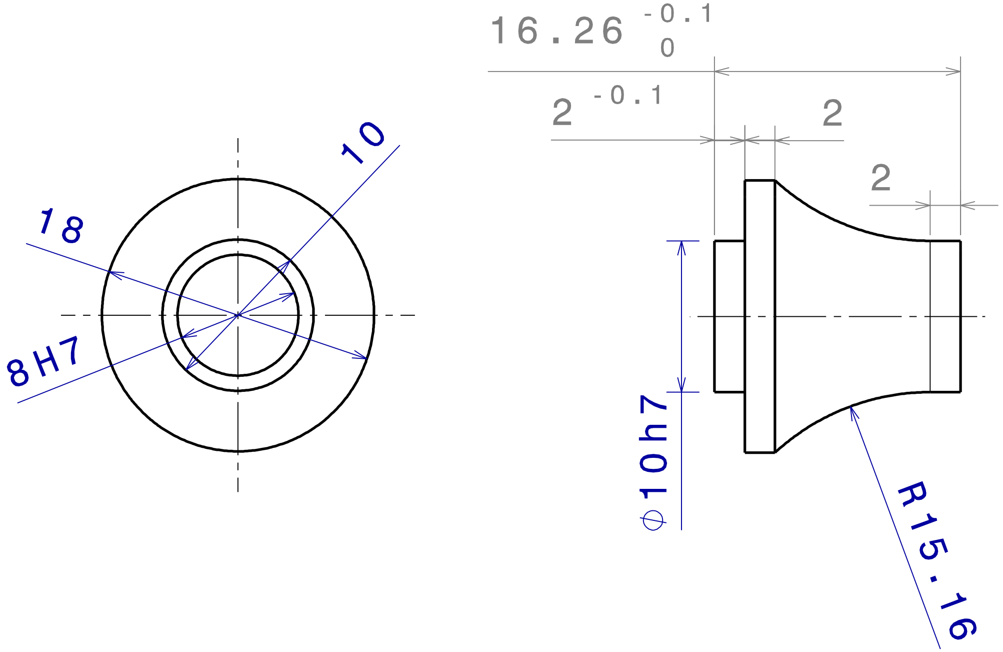


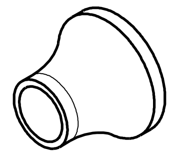
√w = √Rz 50

√x = √Rz 16

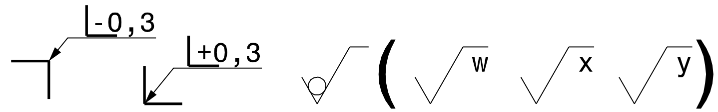
√y = √Rz 6,3

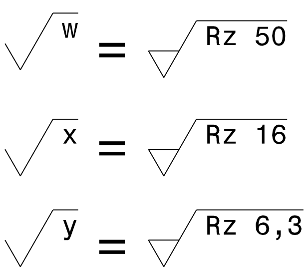
Scale: 2:1	General Tolerance DIN ISO 2768 - mK	Number: 32	Material: X8CrNiS18-9
Date: 26.12.10	Konstrukteur: Adrián Rivas Art, Laura Hernandez W	Phone number: +34689180313	Approved by:
	Part name: Bushing A-Arms		Part number: 10360
	Document Type: Drawing	Weight: 0.007 kg	Page: 1/1



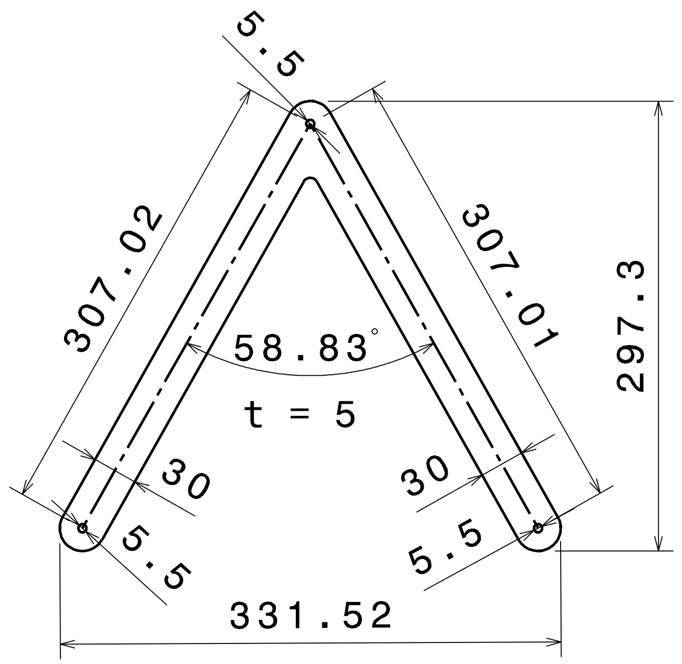


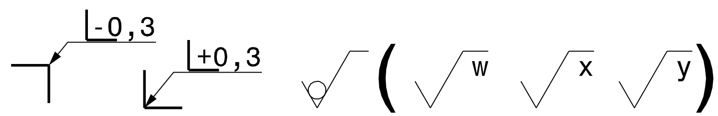
Isometric view





Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: X8CrNiS18-9
Date: 26.12.10	Konstrukteur: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Bushing Rear			Part number: 10362
	Document Type: Drawing	Weight: 0.010 kg		Page: 1/1



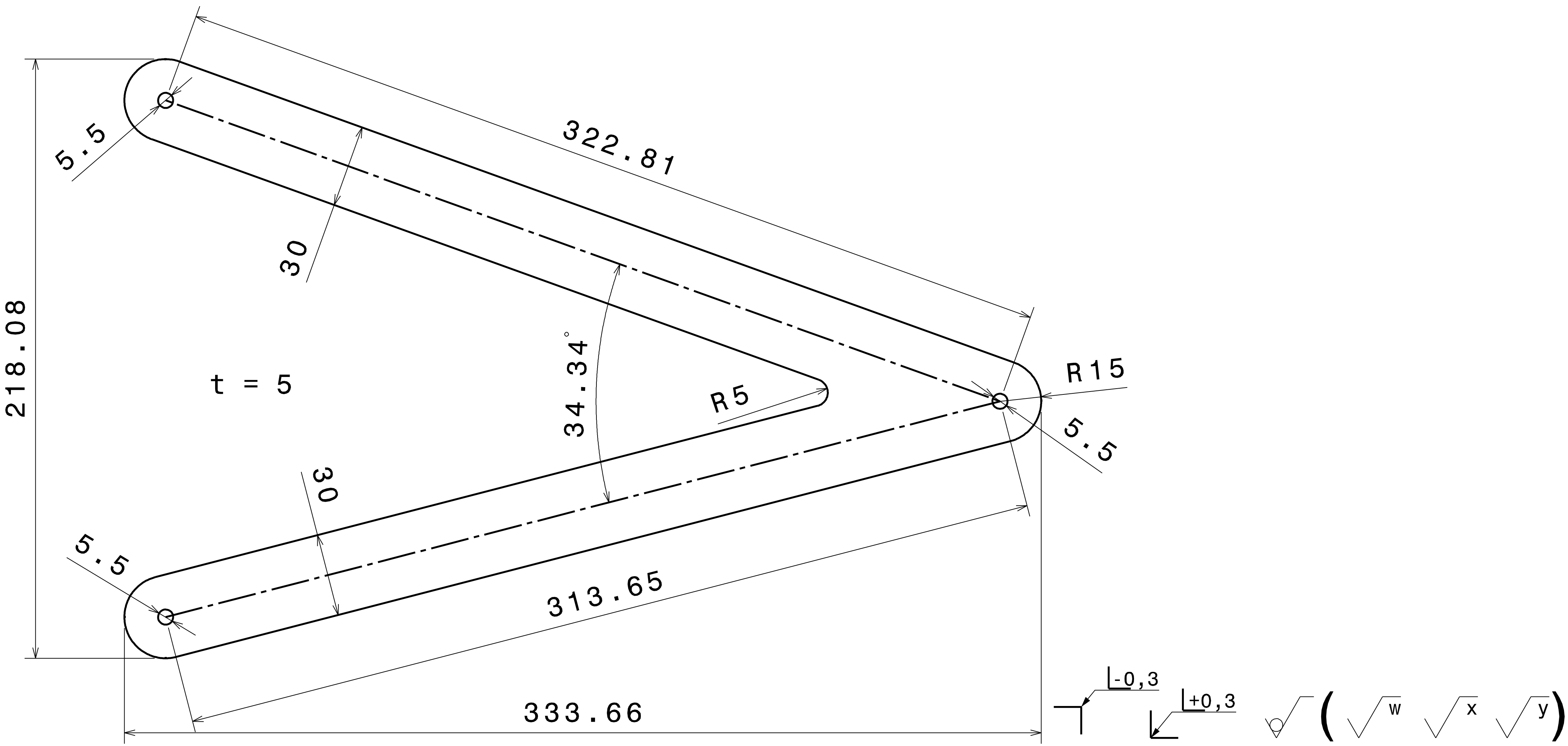


w = Rz 50

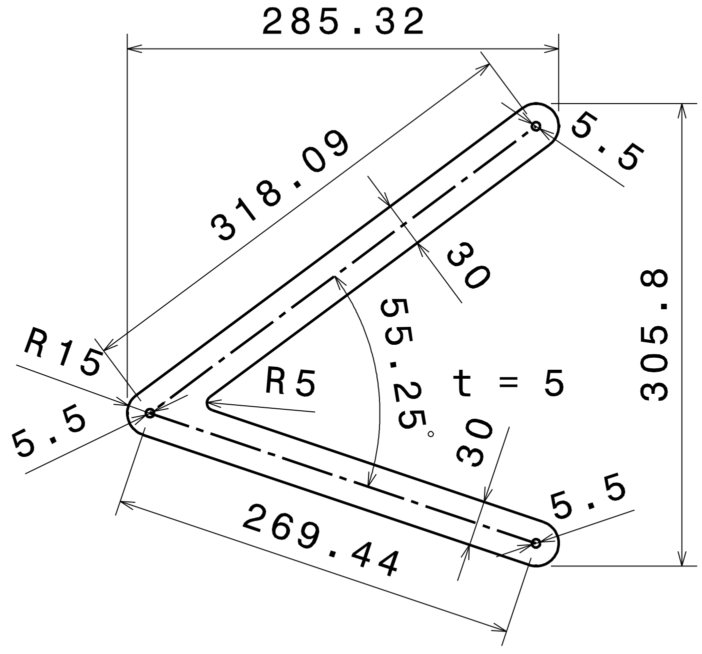
x = Rz 16

y = Rz 6,3

Scale: 1:5	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: S235/S355
Date: 08.03.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
IRTe	Part name: Manuf. pattern A-arm UCA front			Part number: 10363
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1



Scale: 1:2	General Tolerance: DIN ISO 2768 - mK		Number: 1	Material: S235/S355
Date: 08.03.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Manuf. pattern A-arm LCA front			Part number: 10364
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1

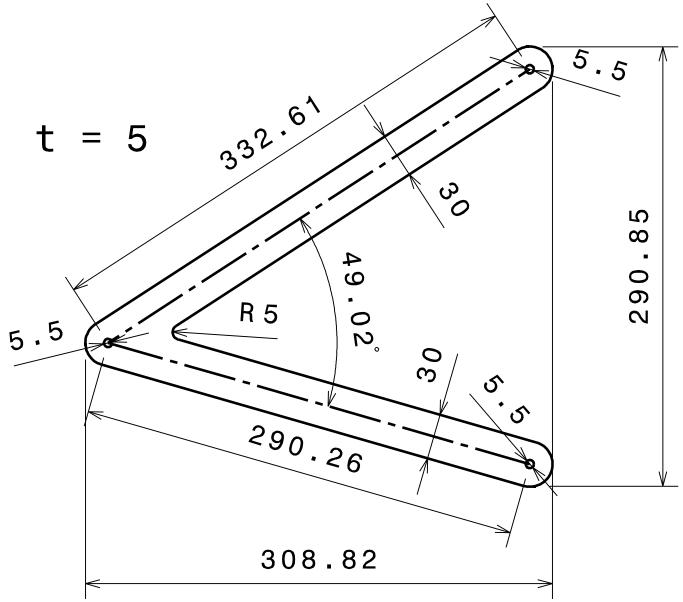


Scale: 1:5	General Tolerance: DIN ISO 2768 - mK	Number: 1	Material: S235/S355
Date: 08.03.19	Constructor: Adrián Rivas Art	Phone number: +34689180313	Approved by:
	Part name: Manuf. pattern A-arm UCA rear		Part number: 10365
	Document Type: Drawing	Weight: 0.0 kg	Page: 1/1

√w = √Rz 50

√x = √Rz 16

√y = √Rz 6,3



-0,3

+0,3

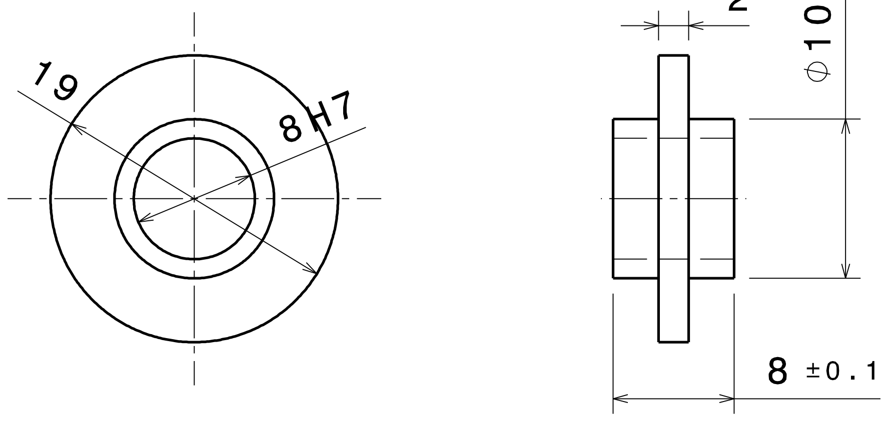
$\sqrt{}$ ($\sqrt{w}$ $\sqrt{x}$ $\sqrt{y}$)

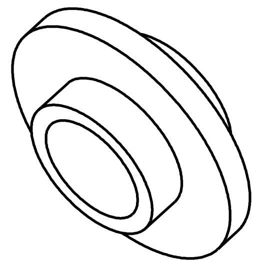
$\sqrt{w}$ = $\sqrt{Rz\ 50}$

$\sqrt{x}$ = $\sqrt{Rz\ 16}$

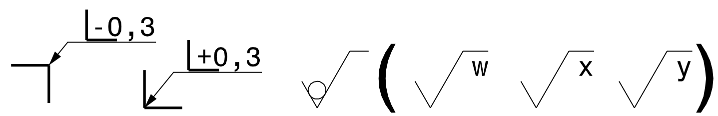
$\sqrt{y}$ = $\sqrt{Rz\ 6{,}3}$

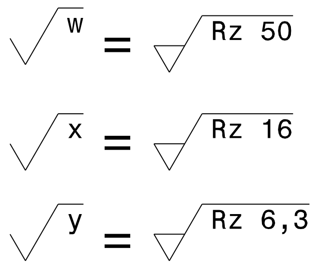
Scale: 1:5	General Tolerance DIN ISO 2768 - mK		Number: 1	Material: S235/S355
Date: 08.03.19	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Manuf. pattern A-Arm LCA rear			Part number: 10366
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1



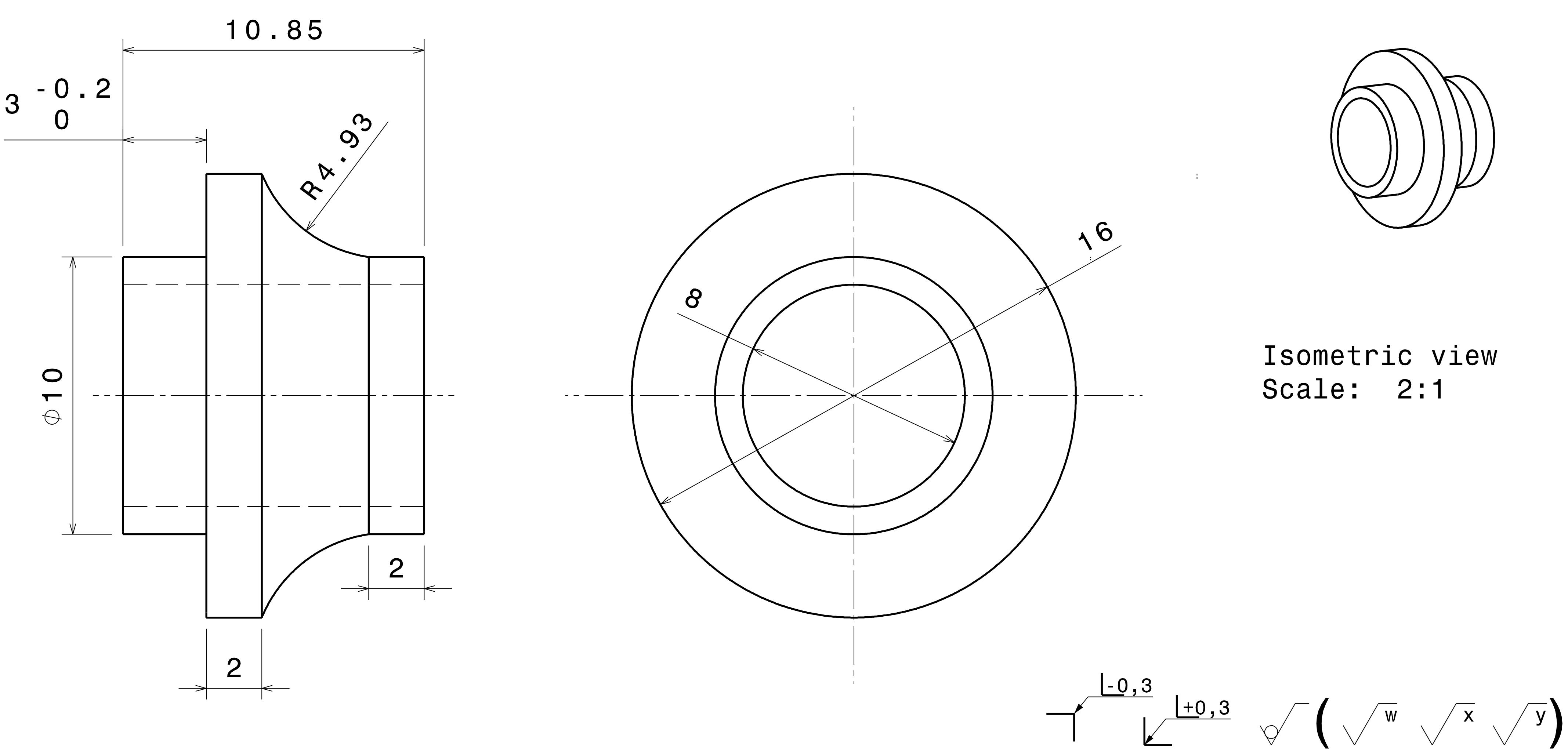


Isometric view
Scale: 2:1

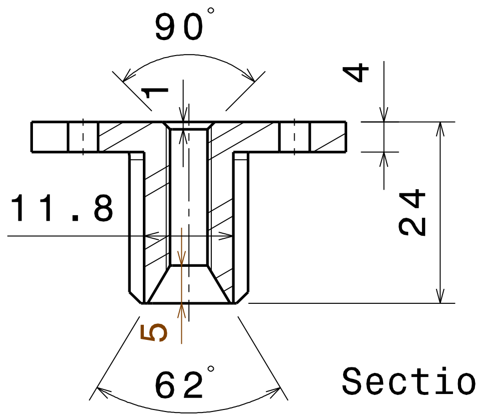




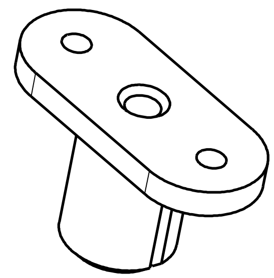
Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: Aluminum
Date: 27.12.10	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker Bearing Ring			Part number: 10367
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1



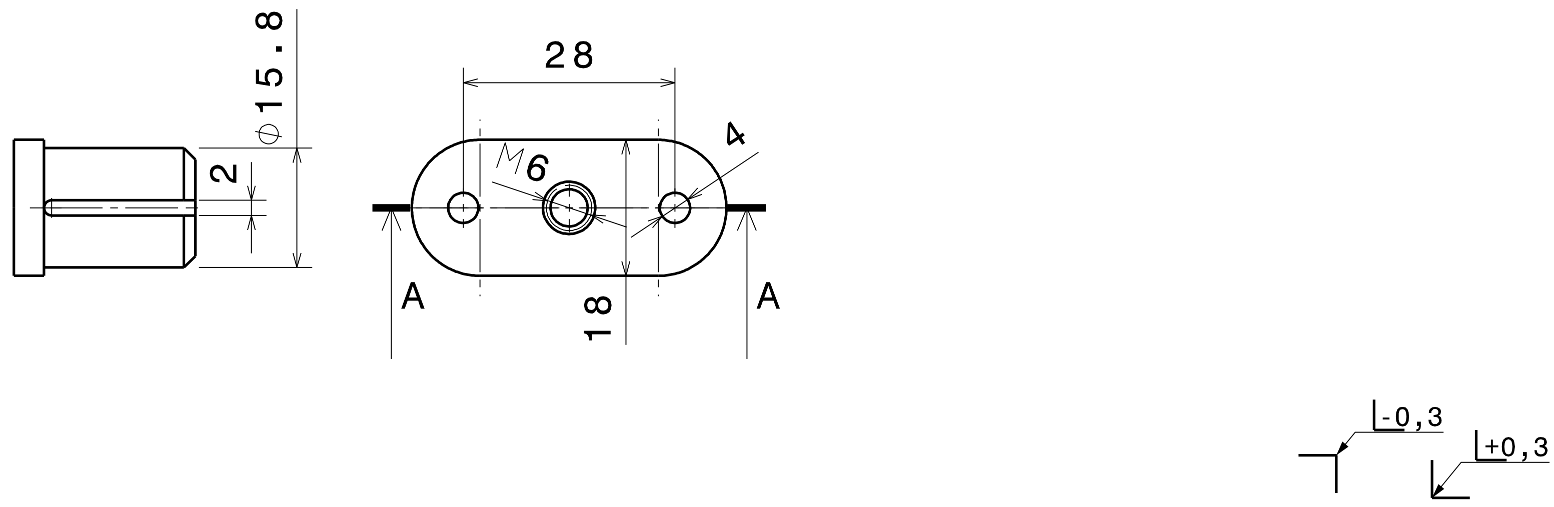
Scale: 5:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: X8CrNiS18-9
Date: 19.05.02	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Rocker bushing front shortened			Part number: 10369
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1



Section view A-A



Isometric view
Scale: 1:1

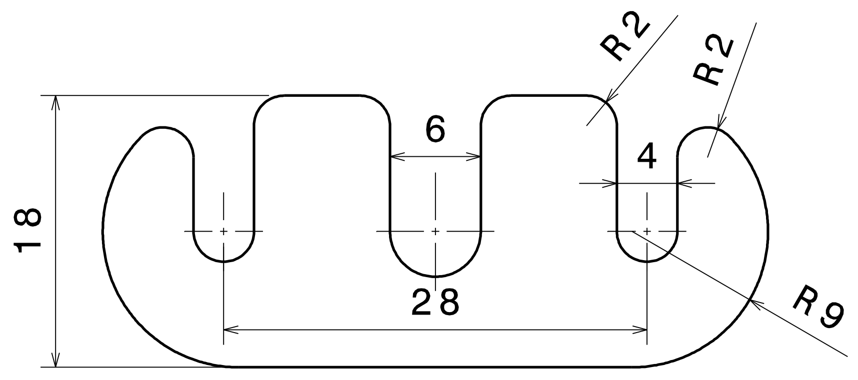


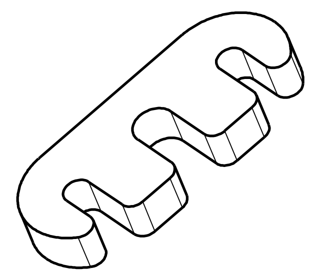
$\sqrt{w}$ = $\sqrt{Rz\ 50}$

$\sqrt{x}$ = $\sqrt{Rz\ 16}$

$\sqrt{y}$ = $\sqrt{Rz\ 6,3}$

Scale: 1:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: AW7075
Date: 13.05.2019	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Adjustment insert corrected			Part number: 10370
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1





Isometric view
Scale: 1:1

Thickness: 0.25 mm, 0.5 mm, 1 mm, 2 mm, 5 mm

-0,3 +0,3

$\sqrt{w} = \sqrt{Rz\ 50}$

$\sqrt{x} = \sqrt{Rz\ 16}$

$\sqrt{y} = \sqrt{Rz\ 6,3}$

Scale: 2:1	General Tolerance DIN ISO 2768 - mK		Number: 4	Material: AW7075
Date: 13.05.2019	Constructor: Adrián Rivas Art	Phone number: +34689180313		Approved by:
	Part name: Pushrod intermediate plate c.			Part number: 10371
	Document Type: Drawing	Weight: 0.0 kg		Page: 1/1

Assembly	Part	Part Number	Amount	Notes	Responsible Person	Purchased item/ Manufactured item	Status	Manufacturer 1	Manufacturer 2	Manufacturer 3	Manufacturing notes	Notes 2. Manufacturer	Gewicht in g
Wheels	slicks 18 x 6.0-10 R25B	105	4		Friedrich Holtz	Purchased item	open						
Wheels	wets 18 x 6.0-10 R25B	105	4		Friedrich Holtz	Purchased item	open				Nachschauen		
Rims	Sturace 10´´	105	4		Friedrich Holtz	Purchased item	Requested						
Balance Bar	Shaft	10101	1		Jonas S	Manufactured item	In storage				Drehteil + Fräsen		
Balance Bar	Bearing carriage right	10102	1		Jonas S	Manufactured item	1. Manufacturer	Pöppelmann			kleines Frästeil		
Balance Bar	Clevis pins	10103	2		Jonas S	Manufactured item	In storage				Drehteil + Bohrung		
Balance Bar	Clevis	10104	2		Jonas S	Manufactured item	1. Manufacturer	Pöppelmann			Frästeil		
Balance Bar	Thrustwasher clevis	10105	4		Jonas S	Purchased item	In storage	IGUS			GTM-1018-010		
Balance Bar	Joint bearing	10106	1		Jonas S	Purchased item	In storage	IGUS			EGLM-20		
Balance Bar	Bowden stop lower part	10107	1		Jonas S	Manufactured item	In storage				Drehteil + Bohrung auf dem Umfang		
Balance Bar	Thrustwasher bearing	10108	4		Jonas S	Purchased item	In storage	IGUS			GTM-2036-015		
Balance Bar	Bearing carriage left	10109	1		Jonas S	Manufactured item	In storage				Strahlen + Fräsen		
Balance Bar	DIN_471_SICHERUNGSRING	10110	4		Jonas S	Purchased item	In storage				9,6x1		
Balance Bar	Frame	10112	1		Jonas S	Manufactured item	In storage				Strahlen + 2 Bohrungen		
Balance Bar	Slide bearing frame 8x10	10113	2		Jonas S	Purchased item	In storage	IGUS			FFM-0608-06		
Balance Bar	Raster rail	10114	1		Jonas S	Manufactured item	In storage				Strahlen		
Balance Bar	Bowden stop - Hand gear	10115	1		Jonas S	Manufactured item	In storage	Boge			Drehteil einfach		
Balance Bar	Spring screw - Selber fertigen	10116	1	M4x20 cylinder Scre	Jonas S	Manufactured item	In storage	Own Manufacturing					
Balance Bar	M4x20 cylinder screw	10117	2		Jonas S	Purchased item	In storage				ISO 4762		
Balance Bar	Scalar?	10118	1		Jonas S	Manufactured item	In storage				?		
Balance Bar	Shoulder screw M5	10120	1		Jonas S	Purchased item	In storage				ISO 7379-6-M5-20		
Balance Bar	Cover	10122	1		Jonas S	Manufactured item	1. Manufacturer	Pöppelmann			Frästeil		
Balance Bar	Slide bearing pivot	10123	1		Jonas S	Purchased item	In storage	IGUS			FFM-0608-06		
Balance Bar	Button spring ?	10124	1		Jonas S	Purchased item	In storage				Febrotec		
Balance Bar	M4x15 Shoulder screw	10125	1		Jonas S	Purchased item	In storage				ISO 7379-5-M4-16		
Balance Bar	Button	10126	1		Jonas S	Manufactured item	In storage				Strahlteil + Fräsen		
Balance Bar	Slide bearing clutch - eig 16 lang, jz 2x 8 lang	10127	2		Jonas S	Purchased item	In storage	IGUS			FSM-0507-08		
Balance Bar	Clutch	10128	1		Jonas S	Manufactured item	In storage	WundH			Fräsen		
Balance Bar	EN ISO 4762 ZYLINDERSCHRAUBE	10129	1		Jonas S	Purchased item	In storage				M3x16 DIN 6912		
Balance Bar	DIN 125 Scheibe Form A	10130	1		Jonas S	Purchased item	In storage				d = 3,7		
Balance Bar	EN ISO 4034 SECHSKANTMUTTER M5 5,6›	10131	1		Jonas S	Purchased item	In storage				ISO 4032		
Balance Bar	EN ISO 7040 SKTMUTTER MIT KLEMMTEIL	10132	2		Jonas S	Purchased item	In storage				M4 DIN 985		
Balance Bar	Bowden cable - Shimano?	10133	1	Fahrradteil	Jonas S	Purchased item	In storage						
Balance Bar	Inserts	10134	1		Jonas S	Manufactured item	In storage	Boge			Drehteil einfach		
Balance Bar	M4x16 cylinder screw	10135	1		Jonas S	Purchased item	In storage				ISO 4762		
Balance Bar	BigHead M6x25	10136	2		Jonas S	Purchased item	In storage				https://shop.kvt-fastening.de/de/itemgroup/2004.html		
Steering	Steeringwheel	10201	1		Julian Papenbrock	Manufactured item	In storage	Bartsch					86
Steering	Snapcloser	10202	1		Julian Papenbrock	Purchased item	On vehicle	ISR					127
Steering	Gearschaft	10203	1	s.o.	Julian Papenbrock	Purchased item	On vehicle	ISR	BW				112
Steering	Dashboard Axis	10204	1		Julian Papenbrock	Manufactured item	On vehicle	BW			Drehteil		s.o.
Steering	Bearing Dashbord	10205	2		Julian Papenbrock	Purchased item	On vehicle	IGUS			FFM-1820-12		1
Steering	Dashboard Sleeve	10206	1		Julian Papenbrock	Manufactured item	On vehicle	Krone			Drehteil		21
Steering	Dashboard Counterpart	10207	1		Julian Papenbrock	Manufactured item	On vehicle	Krone			Drehteil		19
Steering	Singel Kardan Join	10208	1	Artikelnr.63112600	Julian Papenbrock	Purchased item	On vehicle	Mädler	BW		Von der BW abdrehen lassen		119
Steering	Colum	10209	1		Julian Papenbrock	Manufactured item	On vehicle	Own Manufacturing			Stahlrohr -> Muss nur gebohrt werden		
Steering	Driversafe	10210	1		Julian Papenbrock	Manufactured item	1. Manufacturer	Own Manufacturing			1 Lage Sichtcarbon		
Steering	Pod Colum	10211	2		Julian Papenbrock	Manufactured item	On vehicle	BW					
Steering	Shaft Rackwheel	10212	1		Julian Papenbrock	Manufactured item	On vehicle	BW			Drehteil + Nut und Bohrung		
Steering	Bearing Gearbox	10213	2		Julian Papenbrock	Purchased item	On vehicle	IGUS			FFM-1012-06		
Steering	Gearbox Mainpart	10214	1		Julian Papenbrock	Manufactured item	On vehicle	Krone			Fräsen - angefragt		
Steering	Gearbox Counterpart	10215	1		Julian Papenbrock	Manufactured item	On vehicle	Krone			Fräsen - angefragt		
Steering	Rackwheel	10216	1	Artikelnr. 22881812	Julian Papenbrock	Purchased item	On vehicle	Mädler					
Steering	Rack	10217	1	Artikelnr. 22868300	Julian Papenbrock	Purchased item	On vehicle	Mädler					
Steering	Rackholder Left	10218	1		Julian Papenbrock	Manufactured item	On vehicle	Bartsch	BW				
Steering	Platform	10219	1		Julian Papenbrock	Manufactured item	On vehicle	Nuero	BW		Strahlen und Biegen		
Steering	Platform Support	10220	1		Julian Papenbrock	Manufactured item	On vehicle	Nuero	BW		Strahlen und Biegen		
Steering	Platform Support Support	10221	1		Julian Papenbrock	Manufactured item	1. Manufacturer	Bartsch					
Steering	Pod Gearbox	10222	1		Julian Papenbrock	Manufactured item	On vehicle	BW					
Steering	Steeringpoti	10223	1		Julian Papenbrock	Purchased item	In storage						
Steering	Pod Steeringpoti	10224	1		Julian Papenbrock	Manufactured item	1. Manufacturer	Own Manufacturing					
Steering	Bearing Holder Down	10225	2		Julian Papenbrock	Manufactured item	On vehicle	Bartsch	BW		Strahlen und Fräsen / vllt auch uni-bw		
Steering	Bearing Holder Up	10226	2		Julian Papenbrock	Manufactured item	On vehicle	Bartsch	BW		Strahlen und Fräsen / vllt auch uni-bw		
Steering	Bearing Support	10227	2		Julian Papenbrock	Manufactured item	On vehicle	BW			Drehteil		
Steering	Bearing Rackholder	10228	2		Julian Papenbrock	Purchased item	On vehicle	IGUS			WJ200QM-01-20		
Steering	M3x18	10229	2	Dashbord	Julian Papenbrock	Purchased item	On vehicle						4
Steering	Shoulderscrew M6x20	10230	3	Colum and Join	Julian Papenbrock	Purchased item	On vehicle						
Steering	Shoulderscrew M6x15	10231	2	Rackholder outside	Julian Papenbrock	Purchased item	On vehicle						
Steering	M5x60	10232	4	Bearingholder	Julian Papenbrock	Purchased item	On vehicle						
Steering	M4x19	10233	4	Platform Mono	Julian Papenbrock	Purchased item	On vehicle						
Steering	M4x8	10234	2	Platform Support	Julian Papenbrock	Purchased item	On vehicle						
Steering	M4x10	10235	2	Support Gearbox	Julian Papenbrock	Purchased item	On vehicle						
Steering	Shoulderscrew M4x30	10236	2	Platform Gearbox	Julian Papenbrock	Purchased item	On vehicle						
Steering	Shoulderscrew M4x24	10237	2	Gearbox	Julian Papenbrock	Purchased item	On vehicle						
Steering	Safety ring 19x1,2	10238	1	Dashboard Axis	Julian Papenbrock	Purchased item	On vehicle				Nicht in Schraubenliste		
Steering	Steeringstop Left	10239	1		Julian Papenbrock	Manufactured item	On vehicle	Pöppelmann			leichtes Frästeil		5
Steering	Steeringstop Right	10240	1		Julian Papenbrock	Manufactured item	On vehicle	Pöppelmann			leichtes Frästeil		5
Steering	Rackholder Right	10241	1		Julian Papenbrock	Manufactured item	On vehicle	Bartsch	BW		Strahlen+Fräsen (sehr geringer Druchm. Beim	Fräser	
Steering	Passfeder	10242	1	Between Rackwheel	Julian Papenbrock	Purchased item	On vehicle	Mädler					
Steering	M4x14	10243	3	Steeringwheel	Julian Papenbrock	Purchased item	On vehicle						
Steering	Pot Mono	10244	8	Down in the Mono	Julian Papenbrock	Manufactured item	On vehicle	Own Manufacturing					6
Steering	Insert Tie Rods right-handed thread	10243	5		Friedrich Holtz	Manufactured item	In mnfctr. folder	BW					
Steering	Insert Tie Rods left-handed thread	10244	5		Friedrich Holtz	Manufactured item	In mnfctr. folder	BW					
Steering	Carbon tubes Tie Rods	10245	5		Friedrich Holtz	Purchased item	Ordered	Carbon- Werke					
Suspension	Rocker Front	10301	2		Adrián Rivas Artazcoz	Manufactured item	On vehicle	Krone					
Suspension	Rocker Compensating Sleeve	10302	4		Adrián Rivas Artazcoz	Manufactured item	On vehicle	ZF					
Suspension	Front Bracket Rocker	10303	2		Adrián Rivas Artazcoz	Manufactured item	On vehicle	Nuero	MKS Dörken		Strahlen und Biegen	Beschichter	
Suspension	Rocker shell	10304	8		Adrián Rivas Artazcoz	Manufactured item	On vehicle	ZF					
Suspension	Screw M4x30 ISO 4762	10305	32		Adrián Rivas Artazcoz	Purchased item	On vehicle						
Suspension	Nut M5 ISO 4032	10306	4		Adrián Rivas Artazcoz	Purchased item	On vehicle						
Suspension	Washer 5x10 ISO 7090	10307	12		Adrián Rivas Artazcoz	Purchased item	On vehicle						
Suspension	Shoulder Screw ISO 7379 M6x60	10308	4	https://www.ganter-g	Adrián Rivas Artazcoz	Purchased item	On vehicle						
Suspension	Screw M8x50 ISO 4762	10309	4		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Nut M8 ISO 4032	10310	4		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Bearing skf 608_2RSH	10311	8		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Rocker bushing front	10312	4		Adrián Rivas Artazcoz	Manufactured item	On vehicle	ZF					
Suspension	Rocker Rear	10313	2		Adrián Rivas Artazcoz	Manufactured item	In storage	Krone					
Suspension	Rear Bracket Rocker	10314	2		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Sensor Arm Front	10315	2		Adrián Rivas Artazcoz	Manufactured item	In mnfctr. folder	Engelbrecht	MKS Dörken		Strahlen und Biegen		
Suspension	Front Bracket Sensor	10316	2		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Sensor MA3-x-125-D	10317	4		Adrián Rivas Artazcoz	Purchased item	not our business						
Suspension	Sensor Arm Rear	10318	2		Adrián Rivas Artazcoz	Manufactured item	In mnfctr. folder	Engelbrecht	MKS Dörken		Strahlen und Biegen		
Suspension	Rear Bracket Sensor	10319	2		Adrián Rivas Artazcoz	Manufactured item	In mnfctr. folder	Engelbrecht	MKS Dörken		Strahlen und Biegen	Beschichter	
Suspension	Pushrod Adjustment Insert	10320	4		Adrián Rivas Artazcoz	Manufactured item	In storage	Krone					
Suspension	Insert	10321	20		Adrián Rivas Artazcoz	Manufactured item	In storage	BW			Frästeil einfach		
Suspension	Carbon Tube Pushrod Front	10322	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Pushrod shell	10323	8		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	BW					
Suspension	Condyle	10324	24		Adrián Rivas Artazcoz	Purchased item	Ordered						
Suspension	Pushrod Upper Plate	10325	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Pushrod Intermediate Plate 0,3 mm	10326	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Pushrod Intermediate Plate 0,5 mm	10327	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Pushrod Intermediate Plate 1 mm	10328	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Pushrod Intermediate Plate 3 mm	10329	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Pushrod Intermediate Plate 5 mm	10330	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Nut M4 ISO 4032	10332	32		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Carbon Tube Pushrod Rear	10333	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Y-Piece Front Up Left	10335	1		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Front Up Right	10336	1		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Front Low	10337	2		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Rear Up Left	10338	1		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Rear Up Right	10339	1		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Rear Low	10340	2		Adrián Rivas Artazcoz	Manufactured item	In storage	Karsten Juhr					
Suspension	Y-Piece Separator	10341	8		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch					
Suspension	Fitment screw 6x25	10342	22		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Union A-Arm	10343	8		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Carbon Tube A-Arms Front Up Right	10344	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Front Up Left	10345	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Front Down Right	10346	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Front Down Left	10347	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Rear Up Right	10348	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Rear Up Left	10349	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Rear Down Right	10350	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Carbon Tube A-Arms Rear Down Left	10351	2		Adrián Rivas Artazcoz	Purchased item	In storage	Carbon- Werke					
Suspension	Bracket Tie-Rod Connection	10352	2		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Nuero	MKS Dörken		Strahlen und Biegen	Beschichter	
Suspension	Washer 6x12	10353	36		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Shell Tie-Rod	10354	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	BW					
Suspension	Nut M5 ISO 7040	10355	4		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Screw M6 ISO 7040	10356	36		Adrián Rivas Artazcoz	Purchased item	In storage						
Suspension	Bracket A-Arm Front Up	10357	4		Adrián Rivas Artazcoz	Manufactured item	2. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Bracket A-Arm Front Down	10358	4		Adrián Rivas Artazcoz	Manufactured item	2. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Bracket A-Arm Rear Up	10359	4		Adrián Rivas Artazcoz	Manufactured item	2. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Bracket A-Arm Rear Down	10360	4		Adrián Rivas Artazcoz	Manufactured item	2. Manufacturer	Nuero	BW	MKS Dörken	Strahlen und Biegen	Beschichter	
Suspension	Bushing A-Arms	10361	32		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	BW					
Suspension	Rocker bushing rear	10362	4		Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	BW					
Suspension	Manufacturing pattern A-Arm UCA front	10363	2	For gluing the A-Arn	Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch	Own Manufacturing				
Suspension	Manufacturing pattern A-Arm LCA front	10364	2	For gluing the A-Arn	Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch	Own Manufacturing				
Suspension	Manufacturing pattern A-Arm UCA rear	10365	2	For gluing the A-Arn	Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch	Own Manufacturing				
Suspension	Manufacturing pattern A-Arm LCA rear	10366	2	For gluing the A-Arn	Adrián Rivas Artazcoz	Manufactured item	1. Manufacturer	Bartsch	Own Manufacturing				
Suspension	Rocker bearing ring	10367	4	To support the axial loa	Adrián Rivas Artazcoz	Manufactured item	In storage	BW					
Suspension	Bracket A-Arm front down 2	10368	2		Adrián Rivas Artazcoz	Manufactured item	open	Bartsch	BW				
Suspension	Rocker bushing front shortened	10369	4	Due to the 3 mm bracke	Adrián Rivas Artazcoz	Manufactured item	Drawing finished						
Suspension	Pushrod Adjustment Insert corrected	10370	4	corrected mistake of dis	Adrián Rivas Artazcoz	Manufactured item	Drawing finished						
Suspension	Pushrod intermediate plate corrected	10371	4	corrected mistake of dis	Adrián Rivas Artazcoz	Manufactured item	Drawing finished						
Anti-Roll-Bar	Carbon Tube	10401	2		Stefano Segneri	Purchased item	In storage	Carbon- Werke					
Anti-Roll-Bar	Spherical Bearing M6 right hand thread	10402	6		Stefano Segneri	Purchased item	In storage						
Anti-Roll-Bar	Spherical Bearing M6 left hand thread	10405	2		Kevin Feldmann	Purchased item	In storage						
Anti-Roll-Bar	Spring Barrel	10406	2		Stefano Segneri	Manufactured item	In storage						
Anti-Roll-Bar	Spring Small Piston	10407	2		Stefano Segneri	Manufactured item	In storage						
Anti-Roll-Bar	Spring Big Piston	10408	2		Stefano Segneri	Manufactured item	In storage						
Anti-Roll-Bar	Spring Cover	10409	4		Stefano Segneri	Manufactured item	In storage						
Anti-Roll-Bar	ARB Lever New	10411	2	Einfacher zu fertigen	Friedrich Holtz	Manufactured item	On vehicle	Bartsch	BW				50
Anti-Roll-Bar	Carbon Tube insert right hand thread	10412	2		Kevin Feldmann	Manufactured item	In storage	BW					
Anti-Roll-Bar	Carbon Tube Insert left hand thread	10413	2		Kevin Feldmann	Manufactured item	In storage	BW					
Anti-Roll-Bar	ARB_Lever_Mount	10414	4		Kevin Feldmann	Manufactured item	On vehicle	BW					8
Anti-Roll-Bar	ARB_Lever_Bushing	10415	4	Q2FM 0608-06	Kevin Feldmann	Purchased item	In storage						
Anti-Roll-Bar	ARB_Springs	10440	4		Kevin Feldmann	Purchased item	In storage						
Carbonrims	inner part	10501	4		Florian Albers	Manufactured item	1. Manufacturer	Own Manufacturing			1 Felge wurde gefertigt		
Carbonrims	outer part	10502	4		Florian Albers	Manufactured item	1. Manufacturer	Own Manufacturing			1 Felge wurde gefertigt		
Carbonrims	screw M (Radschrauben)	10503	16		Florian Albers	Purchased item	open						
Carbonrims	washer	10504	16		Florian Albers	Purchased item	In storage						
Carbonrims	pressure valve	10505	4		Florian Albers	Purchased item	In storage						
Carbonrims	Schraubenhülse	10506	16		Julian Papenbrock	Manufactured item	In storage	BW			Drehteil		
Spring-Damper	Damper Bridge	10601	2		Friedrich Holtz	Manufactured item	On vehicle	Wolff			vllt auch Harting		118
Spring-Damper	Damping System	10602	4		Stefano Giulio Segneri	Purchased item	In storage						
Spring-Damper	Damper Screw	10603	4		Stefano Giulio Segneri	Manufactured item	In storage						
Spring-Damper	Backing Plate	10606	2		Stefano Giulio Segneri	Manufactured item	1. Manufacturer	Bartsch					
Spring-Damper	Spacer_Shock_Bridgeside	10608	8		Kevin Feldmann	Manufactured item	In storage	BW					
Spring-Damper	Shoulder screw ISO 7379-6-M5-30	10608	6		Stefano Giulio Segneri	Purchased item	In storage						11
Spring-Damper	Sleve_Bridge_to_Shock	10609	8		Kevin Feldmann	Manufactured item	In storage	BW					
Spring-Damper	mother_iso_10511-m5-04.1	10609	14		Stefano Giulio Segneri	Purchased item	In storage						1
Spring-Damper	Bridge mounting screw to Mono front	10610	2	SCREW M8x25 ISC	Stefano Giulio Segneri	Purchased item	In storage						14,5
Spring-Damper	Bridge mounting screw to Mono rear	10611	2	SCREW M8x35 ISO 4762									17,5
Spring-Damper	Bushes ISO 7089 WASHER 6x12	10612	8		Stefano Giulio Segneri	Purchased item	In storage						
Spring-Damper	Layup_Insert_Damperbridge	10613	2		Kevin Feldmann	Manufactured item	1. Manufacturer	Own Manufacturing					2
Spring-Damper	Large Washers to Mono front	10614	2	8x30x1	Kevin Feldmann	Purchased item	On vehicle						7
Spring-Damper	washer Lever shoulderscrew	10614	2	M5	Kevin Feldmann	Purchased item	On vehicle						
Wheelcarrier	camberplate 0.3	10701	20		Dominic Meyer	Manufactured item	1. Manufacturer	Bartsch					
Wheelcarrier	camberplate 0.5	10702	20		Dominic Meyer	Manufactured item	1. Manufacturer	Bartsch					
Wheelcarrier	camberplate 1	10703	28		Dominic Meyer	Manufactured item	1. Manufacturer	Bartsch					
Wheelcarrier	camberplate 3	10704	4		Dominic Meyer	Manufactured item	1. Manufacturer	Bartsch					
Wheelcarrier	camberplate 10	10705	4		Dominic Meyer	Manufactured item	1. Manufacturer	Bartsch					
Wheelcarrier ra	wheelcarrier ra left	10706	1		Dominic Meyer	Manufactured item	1. Manufacturer	Wolff					
Wheelcarrier ra	wheelcarrier ra right	10707	1		Dominic Meyer	Manufactured item	1. Manufacturer	Wolff					

Wheelcarrier ra	UCA bracket		10708	2		Dominic Meyer	Manufactured item	1. Manufacturer	Krone					
Wheelcarrier ra	UCA bushing		10709	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier ra	LCA bushing		10710	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier ra	tie rod bracket		10711	2		Dominic Meyer	Manufactured item	1. Manufacturer	Krone					
Wheelcarrier ra	tie rod bushing		10712	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier fa	wheelcarrier fa left		10713	1		Dominic Meyer	Manufactured item	1. Manufacturer	Wolff					
Wheelcarrier fa	wheelcarrier fa right		10714	1		Dominic Meyer	Manufactured item	1. Manufacturer	Wolff					
Wheelcarrier fa	UCA bracket		10715	2		Dominic Meyer	Manufactured item	1. Manufacturer	Krone					
Wheelcarrier fa	UCA bushing		10716	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier fa	LCA bushing		10717	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier fa	tie rod bracket		10718	2		Dominic Meyer	Manufactured item	1. Manufacturer	Krone					
Wheelcarrier fa	tie rod bushing		10719	4		Dominic Meyer	Manufactured item	In storage	Boge					
Wheelcarrier fa	sensor attachment		10720	2		Dominic Meyer	Manufactured item	1. Manufacturer	Nuero			Strahlen und Biegen		
Brake	brake caliper front		10801	2	22-048-OB	Frederik Gerdes	Purchased item	In storage	ISR					
Brake	brake caliper HL		10802	1	22-049-OD	Frederik Gerdes	Purchased item	Requested	ISR					
Brake	brake caliper HR		10803	1	22-049-OC	Frederik Gerdes	Purchased item	Requested	ISR					
Brake	main brake cylinder		10804	2	21-010.OA	Frederik Gerdes	Purchased item	In storage	ISR					
Brake	aluminium brake line		10805	1	Best.-Nr.:E104062	Frederik Gerdes	Purchased item	In storage	ISA-Racing			D4,75mm 3m		
Brake	screw-in nipple M10x1		10806 ?		Art.-Nr.: 2121-0	Frederik Gerdes	Purchased item	In storage	ISA-Racing			D4,75mm		
Brake	banjo bolt M10x1		10807 ?		Art.-Nr.: 2035-2	Frederik Gerdes	Purchased item	In storage	ISA-Racing			Alu 2035-2		
Brake	T-Stück 3xM10x1		10808	2	Art.-Nr.: 2136-0	Frederik Gerdes	Purchased item	In storage	ISA-Racing					
Brake	Kreuzverteiler mit Entlüfter 4xM10x1		10809	1	Best.-Nr.: 2145-2	Frederik Gerdes	Purchased item	In storage	ISA-Racing					
Brake	brake lining		10810	12	EAN-Nr.: 5050953002359	Frederik Gerdes	Purchased item	In storage	EBC			FA184 Blackstuff Bremsbeläge (organisch)		
Brake	Variofitting (Ringstück)		10811	3	MV10B20S	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	Variofitting (Ringstück)		10812	5	MV10A00S	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	Variofitting (Ringstück)		10813	3	MV10C45S	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	Variofitting (Ringstück)		10814	7	MVG100E	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas			screw-in nipple for flexible line		
Brake	banjo bolt M10x1,25		10815	7	MCH901	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	banjo bolt M10x1		10816	5	MCH921	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	flexible brake line VR		10817	1	MV113S	Frederik Gerdes	Purchased item	Ordered	TRW moto/Lukas					
Brake	flexible brake line VL		10818	1	MV075S	Frederik Gerdes	Purchased item	Ordered	TRW moto/Lukas					
Brake	flexible brake line HAL		10819	1	MV023S	Frederik Gerdes	Purchased item	Ordered	TRW moto/Lukas					
Brake	flexible brake line HAR		10820	1	MV035S	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	flexible brake line HL		10821	1	MV075S	Frederik Gerdes	Purchased item	In storage	TRW moto/Lukas					
Brake	flexible brake line HR		10822	1	MV053S	Frederik Gerdes	Purchased item	Ordered	TRW moto/Lukas					
Brake	Dichtringsatz		10823	1	MCH991W50	Frederik Gerdes	Purchased item	Ordered	TRW moto/Lukas			Im Lager gucken		
Brake	brake disc V 4mm		10825	2		Frederik Gerdes	Manufactured item	Requested	Ronge Motorsport					
Brake	brake disc H 3mm		10826	2		Frederik Gerdes	Manufactured item	Requested	Ronge Motorsport					
Brake	brake sensor		10827	2	VSP	Frederik Gerdes	Purchased item	not our business	I2S					
Brake	Federscheibe		10828	26	0W61350	Frederik Gerdes	Purchased item	In storage	Febrotec					
Brake	Federscheibe		10828	26	0W0622-006	Frederik Gerdes	Purchased item	In storage	Febrotec			Checken, ob genügend im Lager sind		
Brake	wave locking disc		10829			Frederik Gerdes	Purchased item	In storage						
Brake	Unterlegbleche Bremsbeläge		10830			Frederik Gerdes	Purchased item	In storage						
Brake	Floater		10831	24		Frederik Gerdes	Manufactured item	In storage	BW			Einfaches Drehteil		
Brake	Variozubehör		10832	1	MV1518	Frederik Gerdes	Purchased item	Ordered	TRWmoto/Lucas			Checken ob wir das haben…		
Brake	Brakezylinder Spacer		10833	6		Friedrich Holtz	Manufactured item	1. Manufacturer	Bartsch					
Pedals	BOT		10901	1		Felix Gümpel	Purchased item	Not our business						
Pedals	BOT Mount		10902	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Biegen		
Pedals	Brake Bolt		10903	1		Felix Gümpel	Purchased item	In storage						
Pedals	Brake Stopper Block		10904	1		Friedrich Holtz	Manufactured item	1. Manufacturer	Bartsch	BW		Strahlen + Bohren		
Pedals	Brake Masterzylinder Mount		10905	1		Felix Gümpel	Manufactured item	In storage	Bartsch			Strahlen		
Pedals	Brake IGUS Gleitlager		10906	2	Q2FM 0810 10	Felix Gümpel	Purchased item	In storage						
Pedals	Brake Recu Sensor		10907	2		Felix Gümpel	Purchased item	not our business						
Pedals	Brake IGUS Gleitlager Springzylinder		10908	2		Felix Gümpel	Purchased item	In storage						
Pedals	Brake Fluid Reservoir		10909	2		Felix Gümpel	Purchased item	In storage						
Pedals	Brake Fluid Reservoir Mount		10910	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Biegen		
Pedals	Brake Pedal		10911	1		Felix Gümpel	Manufactured item	In storage						
Pedals	Gas Pedal		10912	1		Felix Gümpel	Manufactured item	1. Manufacturer	Own Manufacturing			Alu Pedal aus IR18 wird angepasst		
Pedals	Gas Bolt		10913	1		Felix Gümpel	Purchased item	In storage						
Pedals	Gas Stopper Block		10914	1		Friedrich Holtz	Manufactured item	1. Manufacturer	Bartsch	BW		Strahlen + Bohren		
Pedals	Gas IGUS Gleitlager		10915	2		Felix Gümpel	Purchased item	In storage				Welches?		
Pedals	Gas LinPot		10916	2		Felix Gümpel	Purchased item	not our business						
Pedals	Gas Springzylinder		10917	2		Felix Gümpel	Purchased item	In storage						
Pedals	Gas Springzylinder Bearing Braket		10918	2		Friedrich Holtz	Manufactured item	1. Manufacturer	Bartsch			Strahlen+ Bohren	Bohren (genau)	
Pedals	Gas Springzylinder Sondermannauge		10919	2	EF-E066S	Felix Gümpel	Purchased item	In storage						
Pedals	Gas Springzylinder Hollowbolt		10920	2		Felix Gümpel	Purchased item	In storage						
Pedals	Gas Springzylinder Lockingring		10921	2		Felix Gümpel	Purchased item	In storage						
Pedals	Gas Steppin		10923	1		Felix Gümpel	Manufactured item	1. Manufacturer	BW					
Pedals	Gas Tappet		10924	1		Felix Gümpel	Manufactured item	1. Manufacturer	BW					
Pedals	Master Adapter		10925	2		Felix Gümpel	Purchased item	In storage						
Pedals	Master Push Rod		10926	2		Felix Gümpel	Purchased item	In storage						
Pedals	Master Cylinder Left		10927	1		Felix Gümpel	Purchased item	In storage						
Pedals	Master Cylinder Right		10928	1		Felix Gümpel	Purchased item	In storage						
Pedals	Master Cylinder Mount		10929	1		Felix Gümpel	Manufactured item	In storage				Strahlen		
Pedals	Master Cylinder Connection Mount		10930	1		Felix Gümpel	Manufactured item	In mnfctr. folder	Engelbrecht			Strahlen + Biegen/ In Ordner "Laser-Kant Teile"		
Pedals	Outerrail Brake		10931	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Fräsen		
Pedals	Outerrail Gas		10932	1		Felix Gümpel	Manufactured item	In storage	Bartsch	BW		Strahlen + Fräsen		
Pedals	Footrest		10933	2		Felix Gümpel	Manufactured item	In storage						
Pedals	Pedal Toe		10934	2		Felix Gümpel	Manufactured item	In storage						
Pedals	Pedal Recu		10935	1		Felix Gümpel	Manufactured item	1. Manufacturer	Own Manufacturing					
Pedals	Adjusting Rod		10936	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Fräsen		
Pedals	Railingsystem		10937	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Fräsen		
Pedals	Sliding Element		10938	1		Felix Gümpel	Manufactured item	In storage				Strahlen + Fräsen		
Pedals	Springholder		10939	1		Felix Gümpel	Manufactured item	In storage						
Wheelhub ra	wheelhub RA left		11001	1		Fabian	Manufactured item	3. Manufacturer	BW	Karsten Juhr	Schornberg Galvanik			
Wheelhub ra	wheelhub RA right		11002	1		Fabian	Manufactured item	3. Manufacturer	BW	Karsten Juhr	Schornberg Galvanik			
Wheelhub ra	hubnut RA left		11003	1		Fabian	Manufactured item	In storage	WundH					
Wheelhub ra	hubnut RA right		11004	1		Fabian	Manufactured item	In storage	WundH					
Wheelhub ra	sealing RA		11005	4		Fabian	Purchased item	In storage						
Wheelhub ra	bearing RA		11006	4		Fabian	Purchased item	Requested				INA CSEA 030 or SBN DRAZ 030 VA		
Wheelhub ra	thread inserts		11007	8		Fabian	Manufactured item	1. Manufacturer	BW			same on FA, 16 in total		
Wheelhub ra	axle boot		11008	2		Fabian	Purchased item	not our business						
Wheelhub fa	wheelhub FA left		11101	1		Fabian	Manufactured item	3. Manufacturer	BW	Karsten Juhr	Schornberg Galvanik			
Wheelhub fa	wheelhub FA right		11102	1		Fabian	Manufactured item	3. Manufacturer	BW	Karsten Juhr	Schornberg Galvanik			
Wheelhub fa	hubnut FA left		11103	1		Fabian	Manufactured item	In storage	WundH					
Wheelhub fa	hubnut FA right		11104	1		Fabian	Manufactured item	In storage	WundH					
Wheelhub fa	bearing FA		11105	4		Fabian	Purchased item	In storage				Schaeffler 3811-2RS		
Wheelhub fa	thread inserts		11106	8		Fabian	Manufactured item	1. Manufacturer	BW			same on RA, 16 in total		
Wheelhub fa	inkrementring		11107	2		Fabian	Manufactured item	1. Manufacturer	Bartsch					
Wheelhub fa	inkrementrinh holder		11108	2		Fabian	Manufactured item	1. Manufacturer	Bartsch					
Push & Pull-Bar	U-Profil Stahl	1m												
Push & Pull-Bar	Vierkantrohr Stahl	3m												
	Schaumstoff (500mm)	3mx2m												
Balance Bar	Lever	BeschichterMu		1		Jonas S	Manufactured item	In storage				Drehteil + Fräsen		
Gesamtgewicht														0
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Anti-Roll-Bar														
Wheels														
Rims														
Rims														
Rims														
Push & Pull-Bar	Schaumstoff/Gummi													
Push & Pull-Bar	Rohr 20mm													
Quick-Jack	Vierkantrohr Stahl (Dick)													
	Vierkantrohr Stahl (schmal)													

HOCHSCHULE OSNABRÜCK

UNIVERSITY OF APPLIED SCIENCES

FACULTY OF
ENGINEERING AND COMPUTER SCIENCE

PROJECT MANAGEMENT DOCUMENTS

IGNITION RACING TEAM

VERSION 1.0

1. Modification History

Modification			Changed Chapter	Description of Changes	Author
Nr.	Date	Version			
1	05.11.2018	1.0	All	Creation of Document	EPS IRT
2	10.12.2018	2.0	Risks, communication	Add more informaion	EPS IRT
3	04.01.2019	3.0	Individual report	Add individual results	EPS IRT

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14. Adrián Rivas Artazcoz 18
15. Stefano Segneri 21

3. Statement of work

ORGANIZATION	
CLIENT NAME	Thomas Mechlinski
CLIENT E-MAIL	T.Mechlinski@hs-osnabrueck.de

PROJECT		
NAME	EPS IRT	
CLIENT	Hochschule Osnabrück	
BRAND	EPS Team	
PRODUCT	2019 Formula Student Race Car	
BEGIN DATE	END DATE	PROJECT DURATION
24.09.2018	09.01.2019	15 weeks
TEAM LEADER	Stefano Segneri (stefanosegne@gmail.com)	
TEAM MEMBERS	Laura Milena Hernández Wilches (lala.hernandez.w@gmail.com) Mariana Carbajal Curiel (marianacarbajal97@gmail.com) Adrián Rivas Artazcoz (adrianrivasart@gmail.com)	

SUMMARY
The goal is to design a new and improved electric car for the Formula Student competition on 2019.

4. Project Scope

The Project Scope is designing the IRT 2019 car by means of the different groups our team members are a part of.

PROJECT SCOPE FOR EACH MEMBER	
STEFANO SEGNERI	Tasks on the **chassis** sub team
LAURA HERNÁNDEZ	Tasks on the **electronics** sub team
MARIANA CARBJAL	Tasks on the **monocoque** sub team
ADRIÁN RIVAS	Tasks on the **chassis** sub team

5. Introduction

1.1 General remarks

The Osnabrück Ignition Racing Team has been competing in the Formula Student electric event since 2011. The objective of this competition is for university students to build a single-seat formula racing car and complete a series of requirements including sign-up, design check and eventually during the official event the endurance, acceleration, breaks and energy efficiency tests. Students must also present a business plan, which includes the designs and costs of the car.[1]

This winter semester is the first time EPS students will work with the Ignition Racing Team. Four international students from Mexico, Spain, Colombia and Italy are going to work in different construction sub teams such as chassis, electronics and monocoque and help design the 2019 Osnabrück IRT car.

1.2 Description of the Undertaking

EPS students joining the IRT are trainees in their respective sub teams which will need to learn to use programs such as CATIA, OneNote and TARGET in order to design and test pieces for the 2019 race car. Additionally, the IRT will hold different lectures, presentations and workshops trainees can attend in order to learn about hand lamination, electronics and additional design and mechanical knowledge. Once EPS students know the Formula Student rules and have basic knowledge on the programs, each team leader from the sub teams will assign them multiple tasks that require daily documentation and weekly reports.

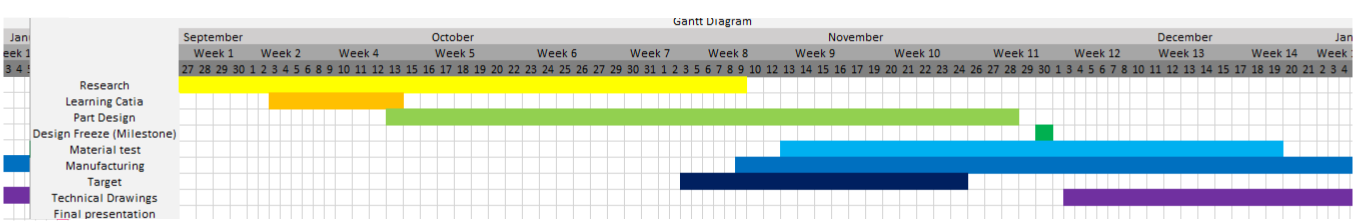
6. Requirements

REQUIREMENTS		
ID	SPECIFIC SUBJECTS	EXPLANATION
1	IRT	**1.1** Study Student Formula Rules 2019 **1.2** Learn to use the software CATIA
2	Chassis (Stefano)	1.1 Improve the Damping bridge 1.2 Damping system settings
3	Electronics (Laura)	**1.1** Document in OneNote each piece included in the

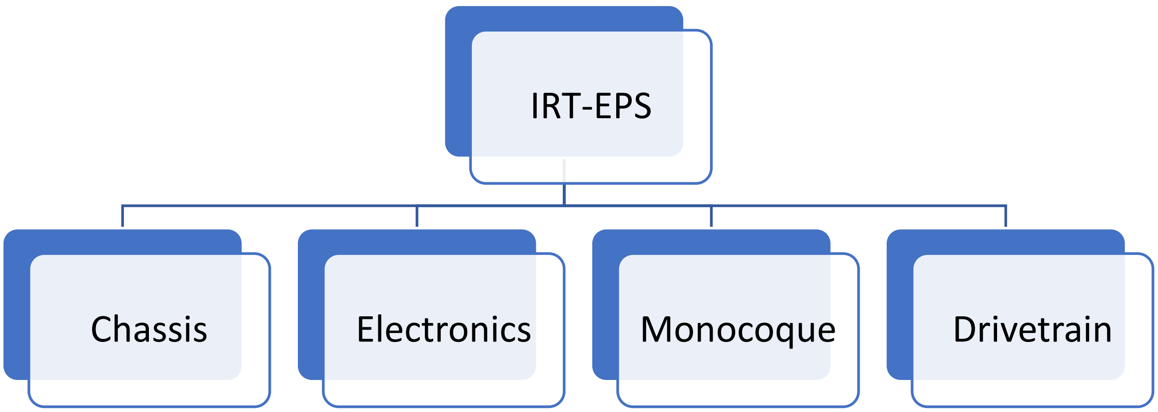
[1] https://www.noz.de/lokales/osnabrueck/artikel/984815/e-rennauto-der-hochschule-osnabrueck-eins-der-weltbesten

		accumulator **1.2** Design pieces in Catia for the 2019 accumulator box **1.3** PumpCart Project **1.4** Learn to use the software Target **1.5** Study 2018 IMD and design 2019 IMD
4	Monocoque (Mariana)	1.1 Learn Catia 1.2 Accumulator container 1.3 PumpCart 1.4 Hand lamination 1.5 Technical drawings
5	Chassis (Adrián)	1.1 3D modeling 1.2 Pushroad adjustment and mechanical calculation 1.3 Attachment of the rotation sensor of the rocker 1.4 Technical drawings
ID	**NON-FUNCTIONAL SPECIFIC SUBJECTS**	**EXPLANATION**
1	Project Team	**1.1** International Team **1.2** Language of the Project: English
2	Project Scale	**2.1** 20 ECTS Credits

7. Project Schedule (Gantt Chart)



8. Work Packages



9. RISK ANALYSIS

Possible risks during the project.

Possible risks manufacturing

Risk Management

Risk assement Matrix

Risk Analysis manufacturing:

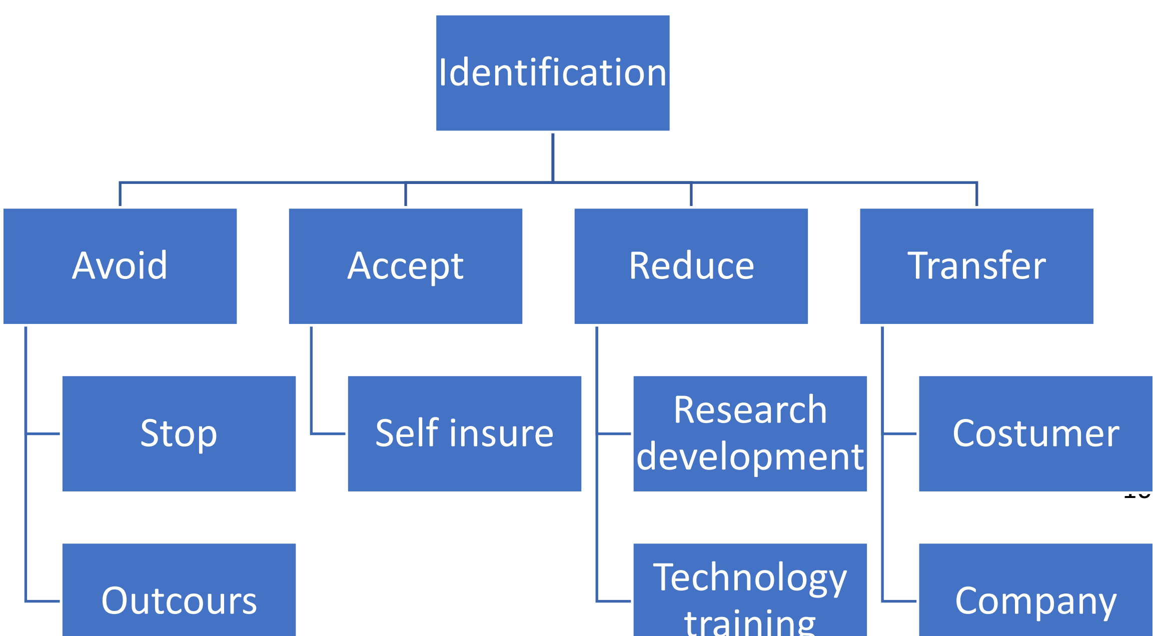
Risk	What can happen	Impact	How to prevent it	Measures
Someone doesn´t know how to do a task	Task is not finished, poorly done,	Waste time correcting or doing it out of time	Explain and ask	Ask the other IRT members
Team members don't show up or late	Work won't get done, people get angry	Get behind on schedule	Set up rules	Talk to a professor
Laptop doesn´t work	Work won't get done on time	Get behind on schedule	Be careful with it	Work in the library, borrow one
Miss milestone	Delay everything	Bad reputation with the IRT members	Work hard and on time	Skip parties

Conflicts with IRT members	Bad atmosphere	Don´t get tasks	Try to fix it	Talk about it
Bad relation with IRT guys	Only negative feedback, not being welcome	Team members don't feel support, won't work hard	Be nice and try to understand	Talk to Prof. Mechlinsky
Misunderstanding	Incorrect work	Done work for nothing	Ask regularly	Ask if you're not sure
Someone doesn´t study for the rule test	Fail the weekly test	Fail in the actual test in the competition	Study	Encourage studying the rules
Risk	What can happen	Impact	How to prevent it	Measures
Doesn't meet the Rules	Prototype is failing	competition is in danger	Check the work with the rules	Ask team leaders
Material doesn´t come on time	Waste time	Project delay	Keep in contact with sponsors, keep track of the material location	Ask for the material with more time

Not enough material	We don´t have enough materials to produce	Prototype delay	Buy the material with time	Have a timeplan
Product fails to accomplish the rules of the formula student	Project failed	Project failed	Put it on a safe place and put contact nr. on it	If there is time build that part again. Talk to principal
Design failures	Doesn´t resists or perform properly	Project is in danger	Double check everything	Think of a solution

4.3 Risk Management

There are many risks in the project, part relates to project management and the other part relates to building the prototype. The risks can be managed the according to the figure below.



Risk Assement Matrix

		Likelihood				
		Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost Certain (5)
Impact	Catastrophic (5)	Moderate Risk	Moderate Risk	High Risk	Critical Risk	Critical Risk
	Major (4)	Low Risk	Moderate Risk	High Risk	High Risk	Critical Risk
	Medium (3)	Low Risk	Moderate Risk	Moderate Risk	High Risk	High Risk
	Minor (2)	Low Risk	Low Risk	Moderate Risk	Moderate Risk	Moderate Risk
	Insignificant (1)	Low Risk	Low Risk	Low Risk	Low Risk	Moderate Risk

Legend

Risk Score	Level	Description
1 to 4	Low Risk	Manage by routine procedures and operations; should not require much attention but should be reviewed at least every 2 months.
5 to 10	Moderate Risk	Manage by specific monitoring or response procedures; should be monitored and reviewed monthly.
11 to 18	High Risk	Requires escalation to project team; should be constantly monitored and reviewed every 2 weeks.
19 to 25	Critical Risk	Requires escalation to project leader for risk management overview; should be constantly monitored and reviewed weekly.

Risks for project

Risk	Score	Level
Someone gets sick	2*4	moderate
Team members don't show up or late	2*2	low
Laptop breaks down	2*2	low
Conflicts with IRT members	3*3	moderate
Bad relation with IRT members	2*1	low
Misunderstanding	2*3	moderate

Risk	Score	Level
Material failures	3*2	moderate
Doesn't meet the rules	3*2	moderate
Production failures	3*2	moderate
Design failures	2*3	moderate

10. Statement of work

Hochschule Osnabrück

MECI team

Organization	
Client Name	Kai Veldhoff
Client e-mail	kaivelhoff@ignition-racing-de

Project	
Project Name	Electric Car (IRT)
Client	Hochschule Osnabrück
Brand	IRT
Product	Electric Car
Begin date	24/08/2018
End date	07/01/2019

Project duration	15 weeks
Team leader	Stefano Segneri
Team members	Mariana Carbajal Curiel Adrian Rivas Artazcos Laura Milena Hernandez Wilches

11. Stakeholders & communication plan

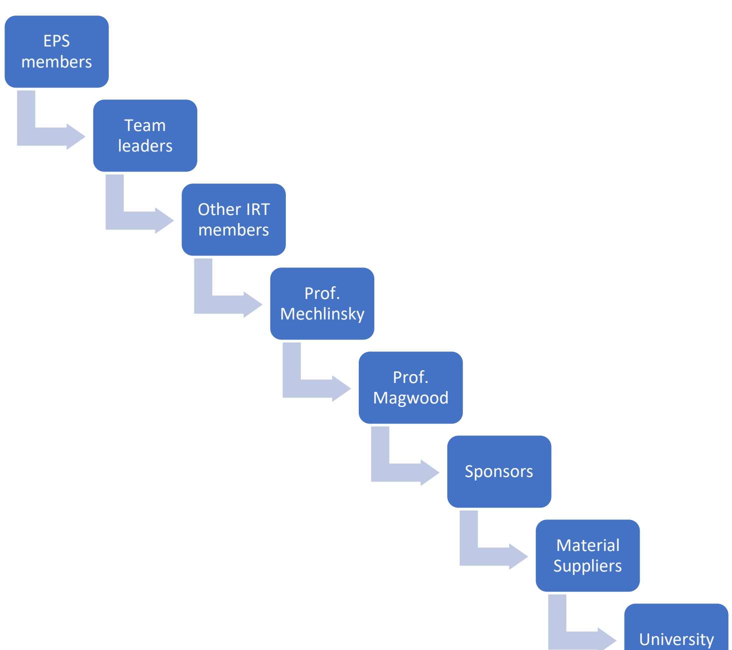
A stakeholder is the one who is impacted by the outcome of a project. They have an interest in the success of the project, and can be within or outside.

In this case we have several stakeholders given the size of our project, the way of communication and the way we works is very hierarchical, for us the EPS memebers is easier to communicate with each other given we all speak English and we share the same goal, after that we have to communicate with our sudteam leaders so we get feedback and new tasks. The communication with other IRT members if for general information or help regarding our work.

After that is professor Mechlinsky because we don´t have contact daily, we do have every week and he is the one that helps us with some problems with our project. Professor magwood helps us with communication with our teams and give us tips for presentations.

At the end we have Sponsors and material suppliers, with them we don´t have direct contact but their presence and how they work affects our times. And finally the University which is the one that gave us the opportunity to join the EPS.

The way of communications we try to do it in person but we also use Whatsapp and the most important one is OneNote.



12. Mariana Carbajal Curiel

This is the report about the knowledge and the work done during the time of the European Project Semester in the Ignition Raing Team; subteam Monocoque. During the first weeks the most important task was learning how to use the CATIA program and also learning all of the rules or at least understand them. The rules were about the car, the regulations, what is allowed, what is not allowed, the parameters, etc.

My main goal at the beginning was to design and construct the accumulator container, these pieces are located on the sides of the car and they are the boxes surrounding the accumulator which is the battery of the car. I had to also reasearch about some possible materials for this containers and a new way to access the accumulator, the final decisions were: Steel for the material and access from the top of the container.

The tasks that I managed to finish for the container were the exploration of the form, and also to construct the different pieces that go inside and over the container. I also gave some ideas about how to access the accumulator in an easier way, because the entire car had to be lifted and the access was from the bottom of the container. My suggesions were to access the accumulator from the sides and secure it like a drawer.

In the block week I had to swap my work from the accumulator to a trainee Project which was a pumpcart, this Project was planed to last just one week and I did it with my other teammate Laura. We were asked to follow some requirements, to create a Gantt diagram, sketches, CATIA 3D models, technical drawings and finally a presentation to show the monocoque members how we did it.

When we had the monocoque weekly meetings we had to solve a rules test about the monocoque rules, I did the test once. This meetings were usefull because we had feedback and got help from the guys that had more experience with CATIA. Also in one of the meetings I had to give a presentation about hand lamination because I already had experience with this technique.

Because during the block week the side pod and the container needed to be finished I wasn´t able to continue with that, so my next task was to help with the SES test plates. This test plates are some panels where we arranged in different ways the layers of carbon fibers, the point of this was to find the most convenient arrangement, for this the team leader wanted to make 4 different arrangements with 12 different plates. This process was really long because we had to cut the material, prepare the glass table, prepare the resin, layer all of the layers, put in place and set everything for the pum infusuion, wait for the resin to get hard let the plates for 24 hours over the glass table which change temperatura every 3 hours, and finally cut the plates in small rectangles so they could be tested. The way they knew which was the best was to weight them and put the plate under 2 different tests: the 3- point bedind test and the hit test. At the end 2 different arrangements were chosen for the different parts of the monocoque.

Other tasks regarding hand lamination were me starting to laminate the seat for the driver, and also making test holders for the accumulator container with glass fibers, in this task I spent a lot of time in the preparation rather tan in the actual process, working with both of the fibers was really interesting because I saw the advantages and disadvantages of both.

After our main milestone that was the design freeze I was given some pieces to correct, the brake light holder and the head restraint, the monocoque team was late 3 days for the design freeze but at the end it was done wit no mistakes.

For the main work that was laminating the monocoque I helped cutting material, laminate the middle part of the monocoque and when the first layers were finished we had to make some foam shapes that fit perfectly over them.

During this experience my main knowledge was how to use a new software, I got new knowledge in different techniques of laminating and the most important one was to work in a really big team which is really similar to an actual job. Being in the IRT was a really interesting experience.

13. Laura Milena Hernández Wilches

This Winter semester at Osnabrück Hochschule I was a part of the European Project Semester (EPS) and a trainee at the IRT, a student-led project whose goal is the design and construction of an electric race car.

For us trainees to clearly understand the main goal of the Formula Student competition it was essential to read carefully through the official 2019 rules. These rules include: Administrative Regulations, General Technical Requirements and specific rules for Electric Vehicles as well as for Technical Inspections, Static Events and Dynamic Events. To guarantee that we understood and clearly know the rules, there were weekly quizzes about the Formula Student Rules and three general quizzes to prepare for the official quiz held during the 2019 competition.

During the first phase of the project the main goal was learning to use CATIA, a software suite for computer design, manufacturing, engineering and 3D models. After understanding and the basics CATIA and being a trainee for the electronics group, I began to develop 3D models of components for the race car´s accumulator (Energy storage device). These components were: Fuse, cable shoes and the Inductive Voltage Transformer (IVT).

Once the 3D model for the accumulator was finished on the 30th of November (Design Freeze), I moved onto my next task. During this next phase of the project, I worked on the actual circuits of the Low Voltage (LV) Distribution System of the car. For this I had to learn to use TARGET 3001!, which is a CAD computer program that supports the design of electronic schematics, Printed Circuit Boards (PCBs) and device front panels. For this, I worked hand in hand with my electronics team leader Konstantin Book on the LV, more specifically on the car´s connectors, fuses, sensors, voltage regulator and controller. We had to correct last years circuits, by placing new resistors, Schmitt triggers, changing the routes for multiple connections, improving the controller and by grounding more circuits. Once the circuits were finished, we moved on to the LV schematic, which is the 3D model of the PCB, were we must place the physical components in an ordered and logical manner.

Finally, for the last phase of the project I had to practice welding PCBs, this in order to be able to solder the official LV Distribution System PCB. I practiced welding millimetric LEDs onto a 4cmx4cm PCB and later one Konstantin´s last years projects which involved multiple components such as bigger LEDs, buttons, capacitors, resistors and other components. However, I was not able to solder the actual LV PCB since the components will arrive once the EPS is over.

Additionally, me and my teammate Mariana Carbajal were in charge of a mini project called PumpCart during the block week from the 26th to the 29th of November. For this project we had to create a Gantt diagram, make sketches, CATIA 3D models, technical plans and a final presentation of the Pumpcart needed to store the pumps that are used in the IRT lab.

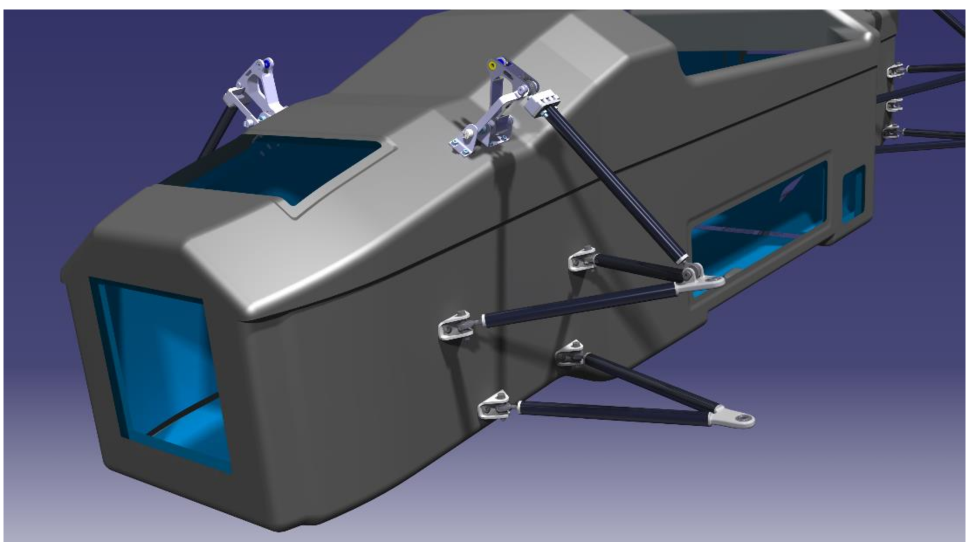
14. Adrián Rivas Artazcoz

In the European Project Semester Mariana Carbajal Curiel, Stefano Segneri, Laura Hernandez Wilches and I joined the Ignition Racing Team electric in the Hochschule of Osnabrück to participate in the design of the vehicle for the formula student competition of the season 2018-2019.

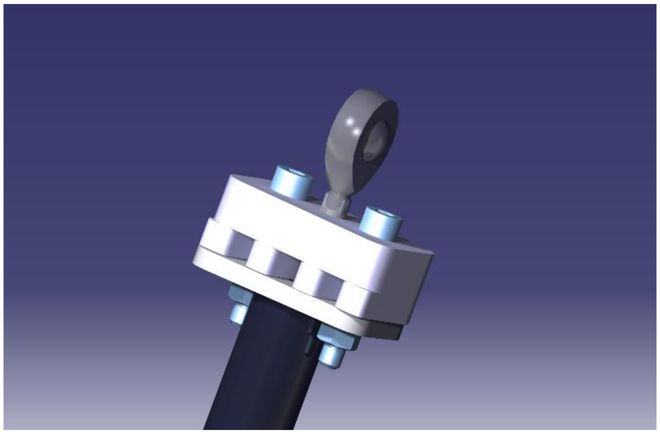
I joined the chassis sub team formed by 11 people: Julian Papenbrock, Fabian Vogel, Henrik Schlichtmann, Felix Gümbpel, Florian Albers, Dominic Meyer, Frederik Gerdes, Jonas Stephan, Stefano Segneri, the team leader Fredrich Holtz and myself.

The first task for everyone who joins the IRT team is the ''Trainee Project''. A small project to develop information about the IRT team. For this project some topics were delivered to me and had to make a presentation. The topics I researched about were general vehicle dynamics, the suspension geometry of the last years formula student vehicle, the working principle and advantages/disadvantages of a pushrod-system and an analysis of the kinematics of the 2017 car. Trainee project presentation was completed the 11/10/18.

Once in the team I was in charge of the development of the suspension of the 2018-2019 season for the chassis team. The requirements for this new year were to modify the position of some elements of the suspension. The position of the rocker, main element of the suspension, was lowered 20 mm, what led to the modification of all the positioning of the rest of the elements. The monocoque of the vehicle where the suspension is attached also changed, then, the distance between the rocker and the monocoque was different. Due to this changes the brackets should be modified. The final design of the suspension was delivered the 31/11/18 for the ''Design Freeze'' date.



Another requirement of this season was to have a simple and effective method of adjustment of the length of the pushrod. The length of the pushrod allows to regulation of the weight distribution of the vehicle between the wheels. After some ideas including gage blocks, self-designed tools and sensors the final idea was developed: A system that allows to add plates of a known thickness to increase the final length of the pushrod. These plates are situated between the plate where the condyle is screwed and the carbon tube of the pushrod. The plates are fixed to the pushrod system with two bolts that should be unscrewed to add the new plates. This method allows changes in the weight distribution that can be made in 5 minutes in the box.



A sensor of rotation of the rocker is needed in order to provide information of the displacement of the suspension and the dampers. This sensor is attached to the top part of the rocker with an arm. The other part of the sensor is attached to the monocoque with a bracket. The rotation axis of the rocker is coincident with the one of the rocker, so the rotation of the rocker is the same that the one of the sensor.

Mechanical calculations were performed to validate the resistance of the bolted union.

In order to dimension the size of the carbon tubes of the 2018-2019 season suspension some mechanical test were designed. The test were tensile tests, compression test and bending test for 4 different diameters of the carbon tubes. The necessary parts to perform the test were send to manufacture to the workshop of the Hochschule but they were not delivered on time to perform the test to include the results in the European Project Semester results.

Finally, the technical drawings of the self-designed parts were made to send to the manufacturers. For the bought parts, all the providers must be found and the exact product that should be ordered. The tracking of all the products and the technical drawings was completed for the 06/01/18.

15. Stefano Segneri

In the first week I knew the guys of the Ignition Racing team. I asked to work in the suspension, so I was assigned in the chassis subteam. I knew chassis subteam leader and I started speaking with him about my first task. I had to understand and learn a lot about the IRT team organization and about racing cars, in particular about the suspension. First I downloaded all the software I would have needed: Catia, Microsoft Excel, Microsoft OneNote, Microsoft Power point. After this Friedrich (my subteam leader) gave me the book of the Formula SAE rules to study. As engineers in the IRT we had to know what is allowed to do and what is not, there are a lot of restriction in the car design. He also gave me a research to do about the suspension and about the anti-roll bar. For this he gave me a book ("Race car vehicle dynamics"). I had to study some chapters for a total of around 200 pages. I also used some websites the they advise me and I met some experts from the pasts years. The results of the research were a presentation in front of the team members. The second thing I had to learn was how to use Catia, a 3D modelling software. For this scope they gave me some pieces of the car, I had to measure the dimensions of its, draw its and realize its with the software.

After this I was finally ready for my first real task. I had to redesign the damping system and the anti-roll bar. There were some stuff to be changed from the pasts years: the orientation of the dampers, the damping bridge, the backing plate of the damping bridge and all the related bushes. However, the main thing was to adapt the all assembly to the new suspension geometry. During those tasks there have been a lot of problem, mainly with the Catia assemblies. Usually when you move a piece to make an assembly with the normal Catia tools you move also the reference axis. However, we needed all the axis to be in the same point of the overall system axis of the car. For this reason I had to learn a lot about Catia, practicing, doing research and watching tutorials. After this, I was finally able to finish the task.

The suspension geometry was different in the front and in the rear part, so after I had finished the front part I had to do everything another time for the rear part. During the process I also had to redesign with Catia the old parts, the ones that we didn't change. The past designed parts were wrong because they had problem with the axis.

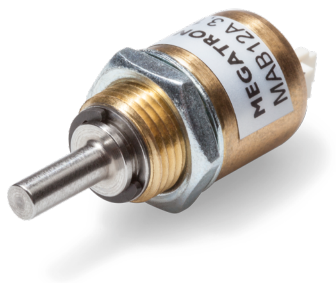
After the design phases we had to collect all the pieces. So first we had to make technical drawings for all the pieces that needed to be manufactured. We had to make the material list (list of the material we had to buy and sent to the manufacturer), the screw list (the screw needed in our assembly) and the purchased item list. Moreover, to manage these phases, I had to fill the progress plan, a Microsoft Excel file with the information and the status of all the pieces.

My second task (done in the second part of the EPS) was to find the best setting for the damping-spring system. In order to complete this task I have needed to do a lot of research. In the first

period I have been studying all the typologies of springs and dampers in a car, then I focus more in the Fox Float X2, the shocks absorber model we use in our car. After this I knew how exactly they works and what actually change when you change one of the parameters. After this I had to understand how the damper setting affect the behavior of the car and how it should be in order for the car to be as fast as possible. The last step was to get deeper into the topic, understand how I could use my mathematical knowledge to make my calculations for the shocks absorbers settings. The final result of this work is a “guide” that explain how to set the dampers and the springs with all the consideration and calculation of the case.

Data Sheet for Angle Sensors

Hall-Effect Single-Turn Rotary Encoder with Analog Output — Series MAB12A



- Only 12,2 mm housing diameter
- Sleeve bearing or ball bearing
- 6 mm, 6.35mm or 3.175mm shaft diameter
- Supply voltage 5 VDC
- Output signal analog absolute or PWM
- Integrated MOLEX coupling

Very compact magnetic absolute encoder. Easy to mount by central thread with hex nut. With the MOLEX plug-in connection, the encoder could be easy connected to the evaluation unit. This improves the handling during installation and service.

Electrical Data	Analog	PWM	
Effective electrical angle of rotation 1.)	360°		
Independent linearity (best straight line) 1.)	±0.28 % @ 25°C		
Output signal	0...5 V analog	5 V PWM	
Resolution	10 Bit	10 Bit	12 Bit
Update rate	0.38 ms	1 ms	4,1 ms
Supply voltage	5 V ±10 %		
Power consumption (no load)	≤ 20 mA		
Output load	≥ 10 kOhm		

Mechanical and environmental data, Miscellaneous	Sleeve bearing low torque	Sleeve Bearing increased torque	Ball bearing very low torque
Mechanical angle of rotationl 1.)	360° without Stopp		
Lifetime 2.)	> 1 Mio. shaft revolutions	> 1 Mio. shaft revolution	-
Bearing	Sleeve bearing	Sleeve bearing	Ball bearing
Max. operational speed	100 rev./min	100 rev./min	15.000 rev./min
Operational torque /@ RT 1.) 2.)	< 0.3 Ncm	< 0.35 ±0.2 Ncm	< 0.035 Ncm
Operating temperature range	-40..+125 °C		
Storage temperature range	-40..+125 °C		
Protection grade shaft side (IEC 60529) standard	IP40		
Vibration (IEC 68-2-6, Test Fc)	(5 Hz to 2 kHz) 20 g		
Housing diameter	12.2 mm		
Housing depth	10.6 mm		
Shaft diameter	3.17 mm, 6 mm, 6.35 mm		3.17 mm
Shaft type	Solid shaft		
Max. allowed radial load	10 N		5 N
Max. allowed axial load	< 1 N		

Hall-Effect Single-Turn Rotary Encoder with Analog Output — Series MAB12A

Mechanical and Environmental Data, Miscellaneous	Sleeve bearing low torque	Sleeve Bearing increased torque	Ball bearing very low torque
Connection type		Molex connector: 53398-0371	
Connection position		Axial	
Sensor mounting		Bushing	
Mass	app. 14 g		app. 11 g
Fastening parts included in delivery		Hex nut and tooth washer	
Fastening torque mounting nut		< 2.25 Nm	
Material shaft	Stainless steel		Brass
Material housing		Brass	

Immunity	
ESD	Human Body Model MIL-STD-883E, Method 3015.7 ± 2 kV

1.) According IEC 60393
2.) Determined by climatic conditions according to IEC 68-1, para. 5.3.1 without load collectives

Data Sheet for Angle Sensors

Hall-Effect Single-Turn Rotary Encoder with Analog Output — Series MAB12A

Order Code

Description	Selection: standard=black/bold, possible options=grey/cursive							
Series	**MAB12A**							
Shaft diameter / shaft length: **Standard: Ø6 x 17.1 mm (not available in combination with ball bearing)** *Option Ø6.35 x 17.1 mm (not available in combination with ball bearing)* *Option Ø3.17 x 17.1 mm length with sleeve bearing (17.3 mm length with ball bearing)* *Option user defined shaft length [mm] (*)* *Option user defined shaft length [mm] Ø ≤6.35mm (*)*		**6** *6,35* *3,17* *Ax,xx* *Dx,xx*						
Resolution: **Standard: 10 Bit for absolute output (0...5V) or PWM- output** *Option 12 Bit only in combination with PWM output*			**10** *12*					
Supply voltage **Standard: 5 V ±10%**				**0505**				
Output signal: **Standard: absolute 0...5 V (ratiometric)** *Option pulse width modulation (PWM)*					**-** *PWM*			
Sense of rotation: **Standard: CW (output signal / duty cycle increases clockwise)** *Option CCW (*) (output signal/ duty cycle increases counter clockwise)*						**-** *CCW*		
Effective electrical angle: **Standard: 360°** *User defined angle of rotation (*)*							*-* *XXX*	
Bearing: **Standard: Sleeve bearing low torque** *Option sleeve bearing increased torque* **Ball bearing very low torque (not available in connection with Ø6mm, Ø6.35mm shaft diameter, only in connection with Ø3.17 mm shaft diameter)**								**LT** *MT* **KL**

(*) A customer specific sense of rotation and/or a user defined rotation angle obliged to a minimum order quantity

Order example MAB12A:

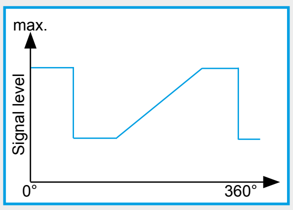
Requirement:
Shaft Ø 6.00 mm / shaft length 17,1 mm, VSUP=5 V / OUT=0...5 V, resolution 10 Bit, absolute output signal 0...5 V, sense of rotation CW, effective electrical angle 360°, sleeve bearing low torque

Example for order code: MAB12A 6 10 0505 LT

Additional options

For higher quantities or on-going demand, additional options are available as described below on request

For example:
- Special shaft design
- Special cable and connection design
- Special torque

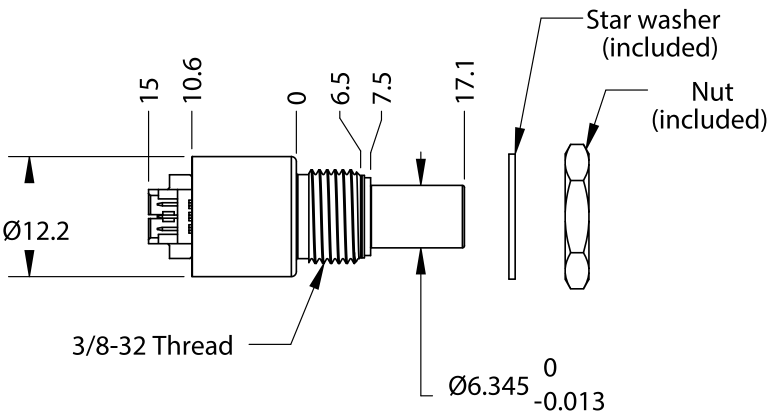


Customized signal characteristic

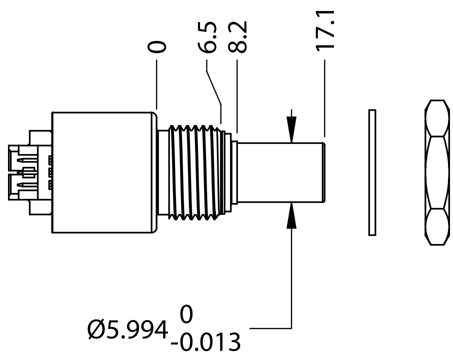
For Example:
- minimum/maximum signal level
- signal plateaus

Drawing

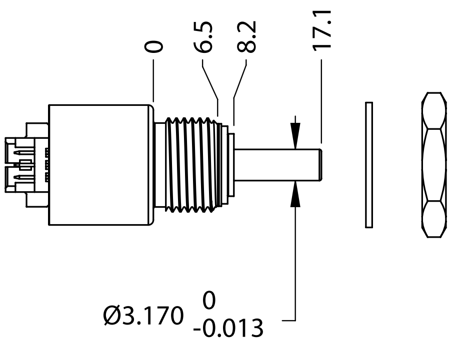
Ø6,35 mm (1/4") sleeve bearing



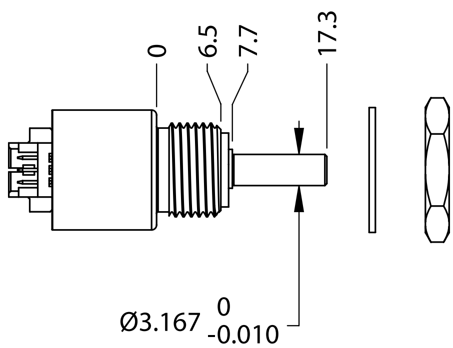
Ø6 mm sleeve bearing

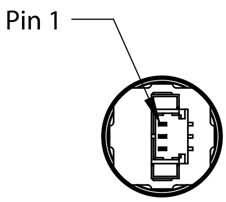


Ø3,17 mm (1/8") sleeve bearing



Ø3,17 mm (1/8") ball bearing



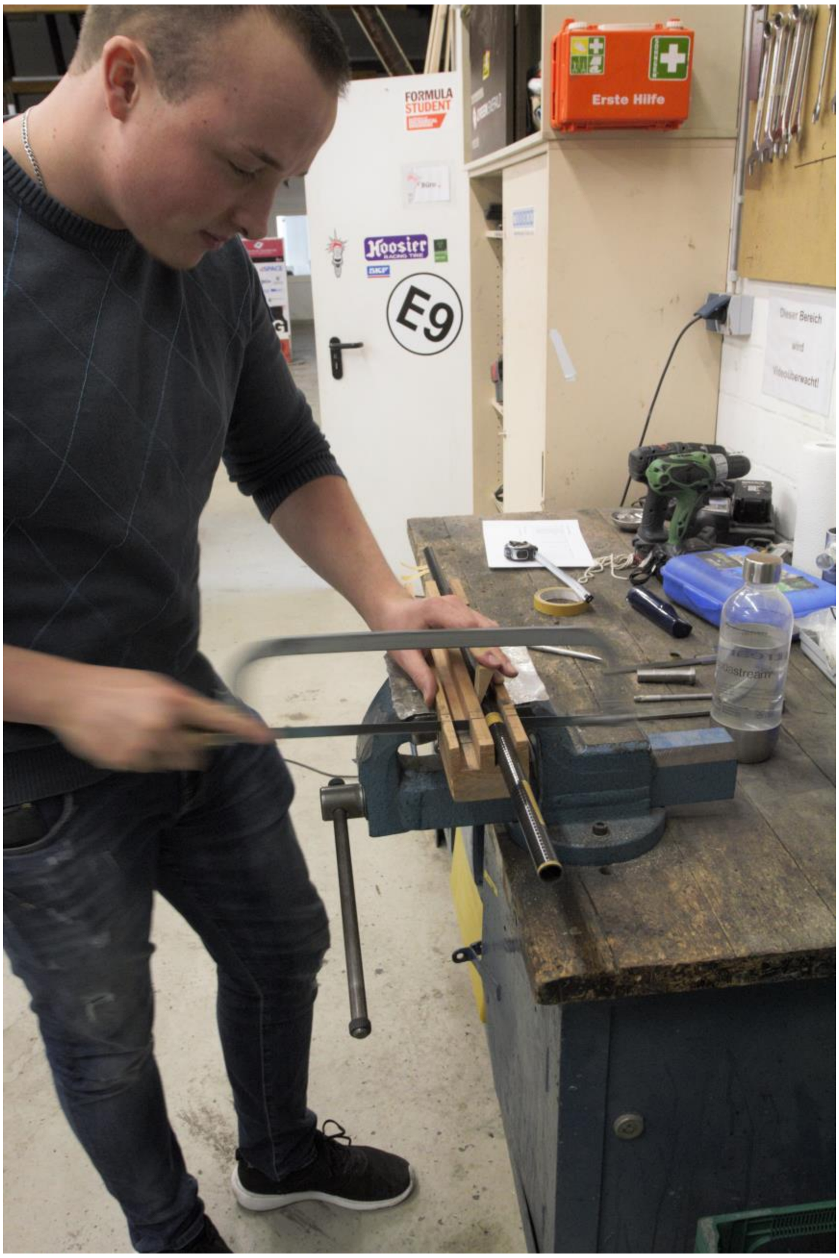


Pin	Analog Output:	PWM Output:
1	+5VDC power	+5VDC power
2	Analog output	PWM output
3	Ground	Ground

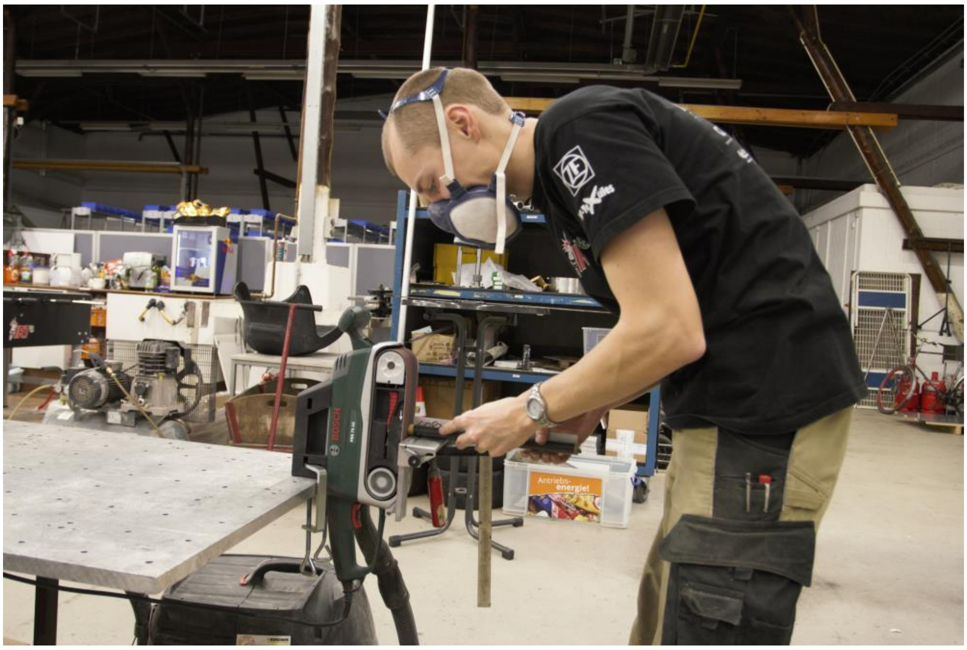
Radaufhängung kleben

Samstag, 25. Februar 2017

20:08

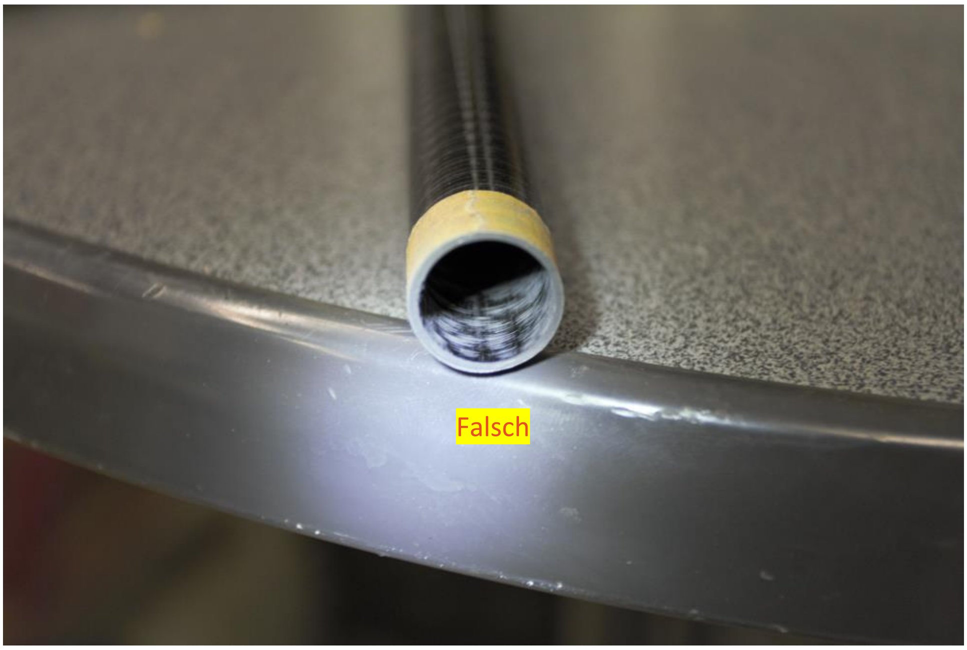


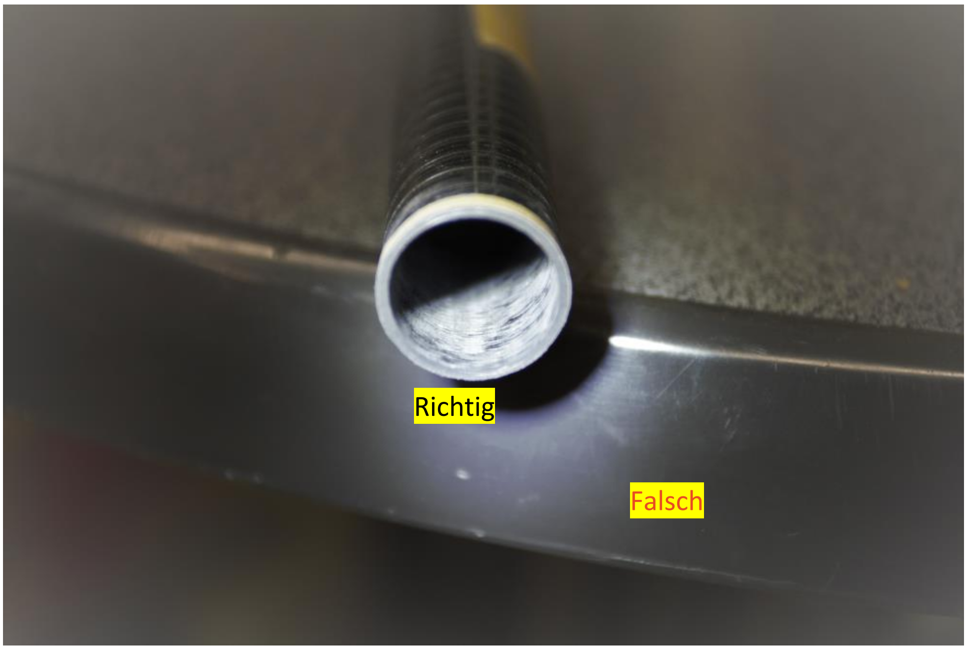
Rohre mit Bügelsäge oder Multicutter und Rohrhaltevorrichtung durchtrennen
Liste der benötigten Rohrlängen erstellen und auf den Rohren mit Klebeband markieren



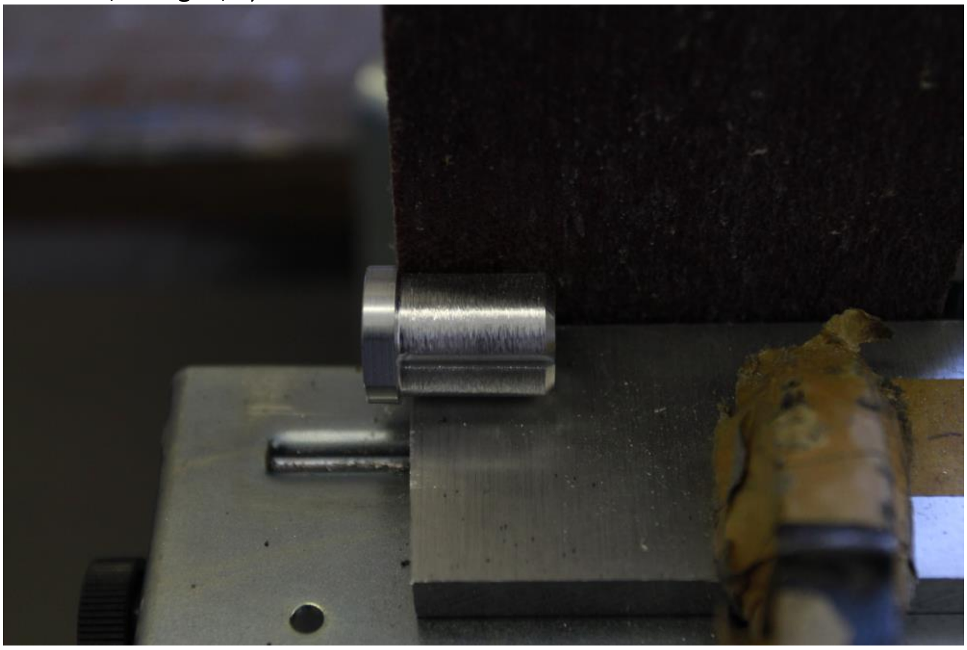
Rohrenden mit dem Bandschleifer Senkrecht schleifen und mit den großen Messschieber auf korrekte Länge prüfen, gegebenfalls weiterschleifen


SKF

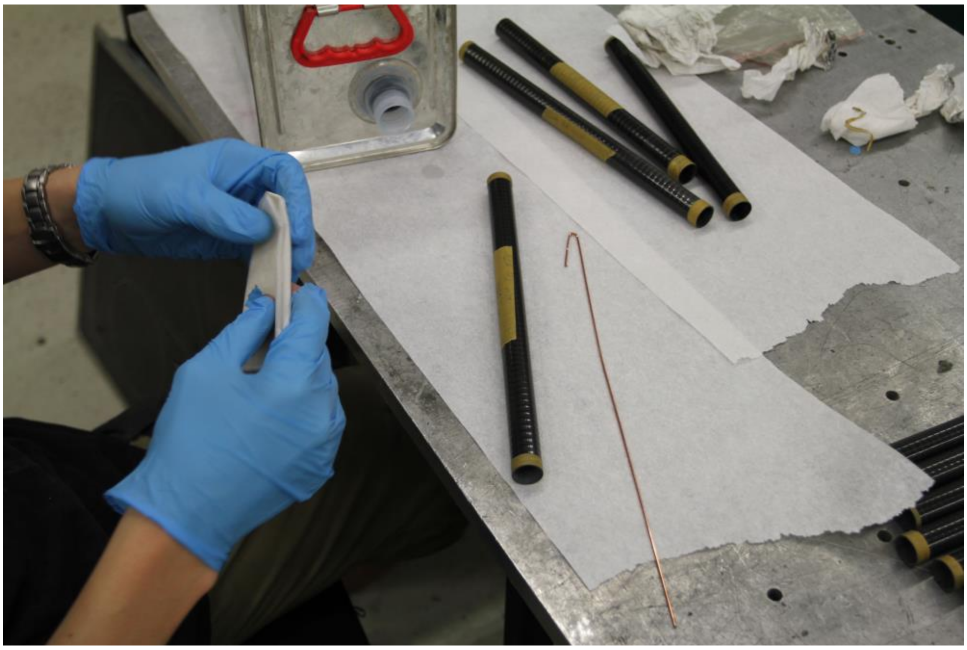

Falsch



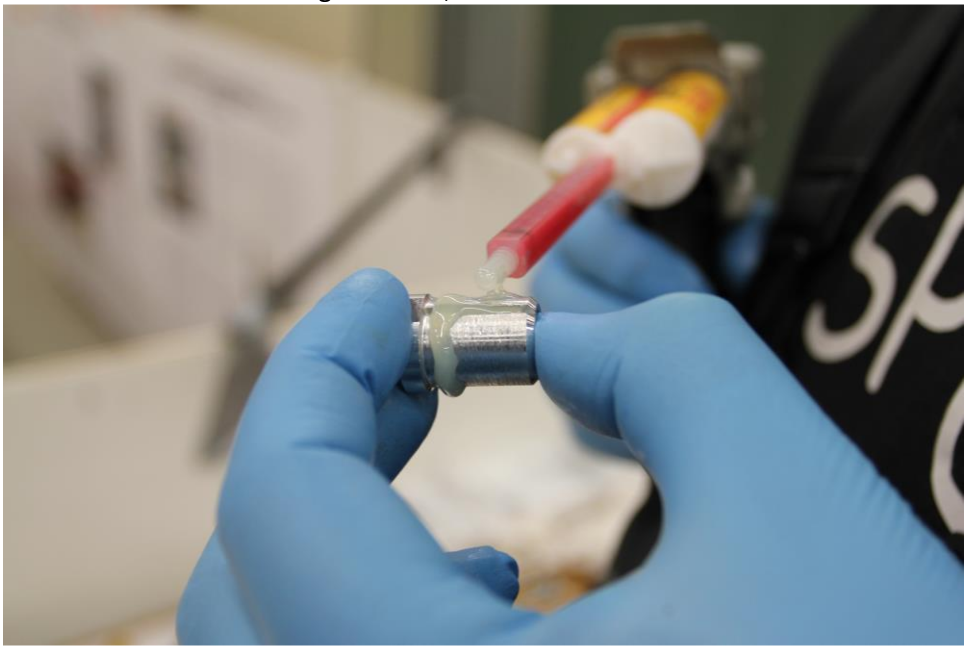
Die ersten 30mm des Rohres müssen auch von Innen angeschliffen werden damit der Kleber eine optimale Haftfläche hat. Erstes Bild zeigt ein nicht ausreichendes angeshliffenes Rohr. Die gesamte Oberfläche muss schleif Spuren vorweisen.
Alle Arbeitsschritte werden mit einen Haken in der anfangs erstellten Liste dokumentiert (schneiden, schleifen, reinigen,…)



Alle Einschübe müssen mit 40 oder 60er Schleifpapier tangential angeschliffen werden damit der Kleber beste halte Möglichkeit hat. Die Y-Stücke werden genau so vorbereitet.
Alle Linksgewindeeinschübe sollten mit Farbe markiert werden, um Fehler zu vermeiden.
Rohre und Einschübe werden danach mit Aecton oder andere Fettlösern gereinigt.

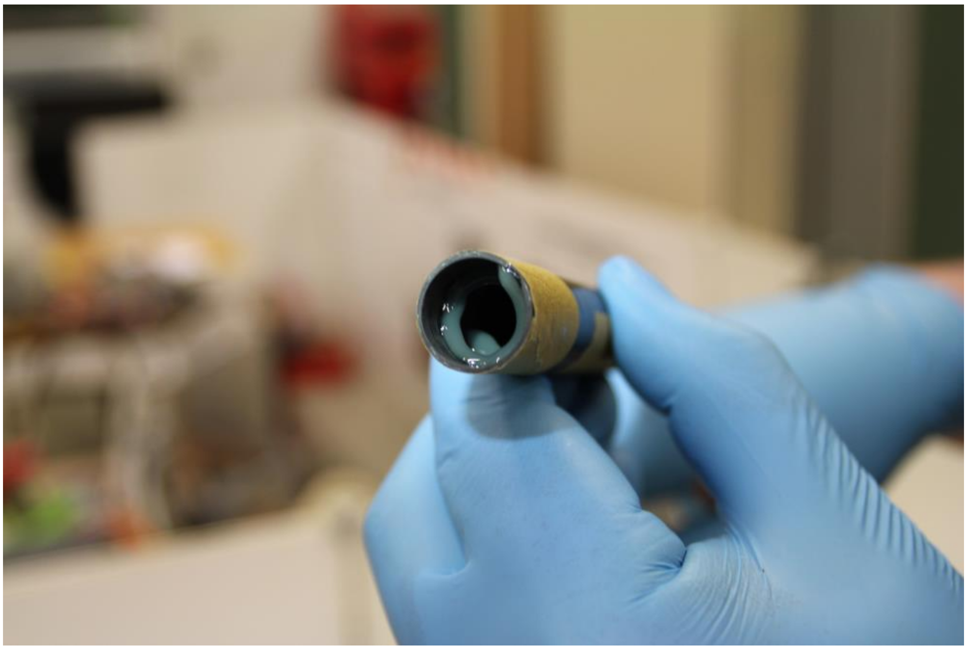


Ein Draht sollte beim Reinigen helfen, um weit in die Rohre zu kommen.



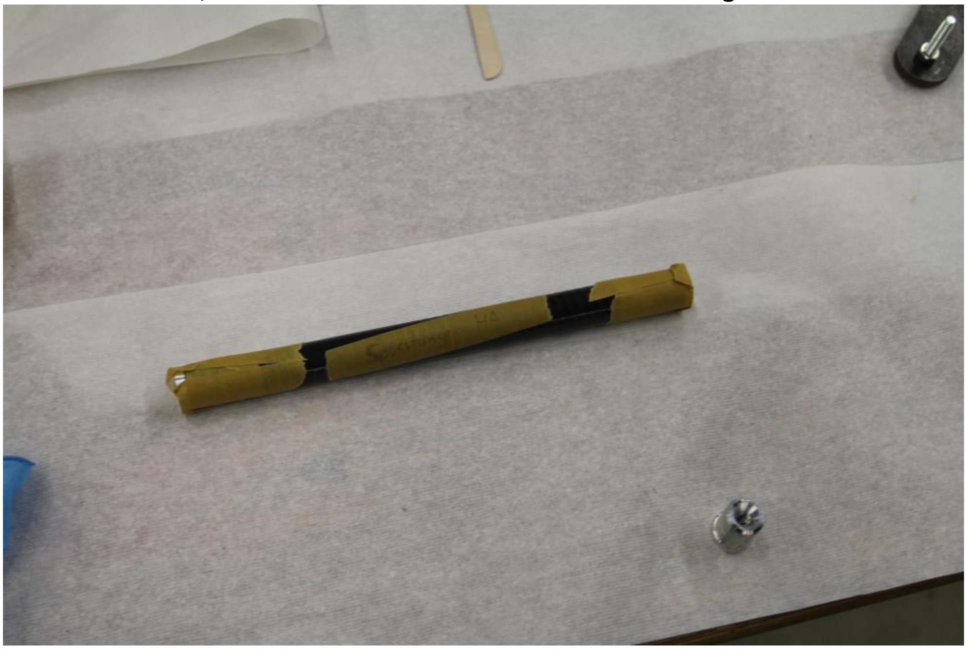
Der Kleber (Loctite EA 9466) wird am Einschub als Ring aufgetragen und diese Menge auf die gesamte Oberfläche verteilt.

Für alle A-Arms wird eine Schablone nach den Hardpoints aus 5mm Stahlblech gefertigt.
Als erstes werden immer die Y-Stücke verklebt und auf der Schablone eingeklemmt. Im Ofen bei 80°C 30min lang getrocknet. Danach können erst die Einschübe eingeklebt werden.



Im Rohr wird eine Spirale von Kleber aufgetragen. Diese Menge wird auf die benötigte Oberfläche verteilt, so dass alles mit Kleber benetzt ist.

Mit einer Drehbewegung wird der Einschub in das Rohr eingedrückt. Überflüssiger Kleber muss entfernt werden, damit das Entfernen der Klebereste im ausgehärteten Zustand einfacher ist.



Beim Trocknen entstehen Druckkräfte, die die Einschübe nach aus drücken möchten. Dafür muss der Einschub mit Klebeband gesichert und mit ein Loch versehen werden.