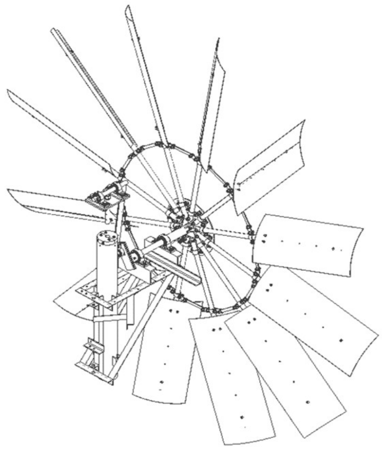
Nacelle

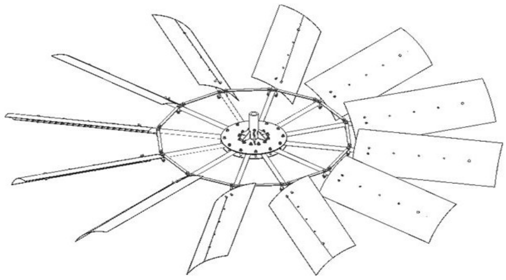
The nacelle of the KUKATE34 is composed of the rotor [2.1], the nacelle frame [2.2] and the crank drive [2.3].

2.1 Rotor
The excellently designed and aerodynamically ingenious rotor of the KUKATE34 is an innovation. It is a universal drive for many applications, very efficient and extremely easy to build and vary. It can withstand gusts of up to 60m/s when turned out of the wind. Aerodynamically, it does not depend on a good laminar and steady wind flow, but works reliably even in turbulence and gusts.

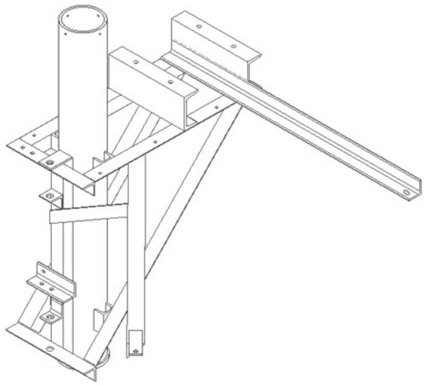


Because of the high initial torque, it starts even at moderate wind speeds.

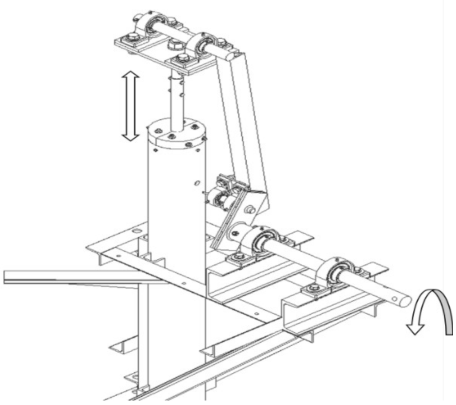
Figure 1 – Nacelle with rotorblades



If the wings are damaged - for whatever reason - they can be repaired or even rebuilt in a very short time. The rotor consists of two metal discs in the center, a ring, wings made of sheet metal and water pipes as spars. It is completely bolted together.



2.2 Nacelle frame
The nacelle is welded from U- and L-sections, flat iron and a central tube of steel.
One half of the control vane hinge is welded to the nacelle frame and the bracket for the side vane is attached.
The art of building the nacelle frame is to position all the parts either exactly parallel or exactly square and at the correct points on the tube.
The tube of the nacelle frame has a thrust bearing at the bottom and two running surfaces on the inside for large-diameter radial plain bearings.
The hardwood bearings installed on the tube and under the tube guide the piston rod. They can be easily replaced.



2.3 Crank drive
Two pillow block bearings, which can be supplied anywhere in the world, allow the shaft to rotate, and four convert the rotary motion of the shaft into the up and down motion of the piston rod. These inexpensive bearings are oversized and therefore last for many years.

Rotor

The required pumping capacity

The rotor of the KUKATE23 converts the wind power into the power of the rotor shaft. Due to the different flow velocities (wind) at the front and rear sides of the blades, a pressure difference is created. Therefore the rotor turns. The rotor diameter of 3.4m in our OPEN WINDMILL concept was dimensioned according to the desired pump capacity:
We want to pump one liter of water per second from a depth of 10m. That is over 86,000 liters per day.
For this we need a pump capacity of 100 watts. In order to guarantee this pump power safely, we calculate with a small efficiency of only 20%. Therefore we need 500W drive power at the shaft. 500W require a rotor area of 6,6m². This area has a rotor with a diameter of 3,4m. We reach this 500W rotor shaft power at a wind speed of about 6-7m/s.

The rotor design

The sheets for the wings can be 1.5 -2mm thick steel sheet or 2-3mm thick aluminium sheet. The tubes for the spars for the wings should have 33.7mm outer diameter. The wall thickness of the tubes should be at least 4mm.
The bent wing plates are screwed onto the spars. To prevent crevice corrosion, apply a strand of silicone, Sikaflex or other elastic sealant exactly on the hole line before screwing. The tube spar and rotor surface must be degreased beforehand!

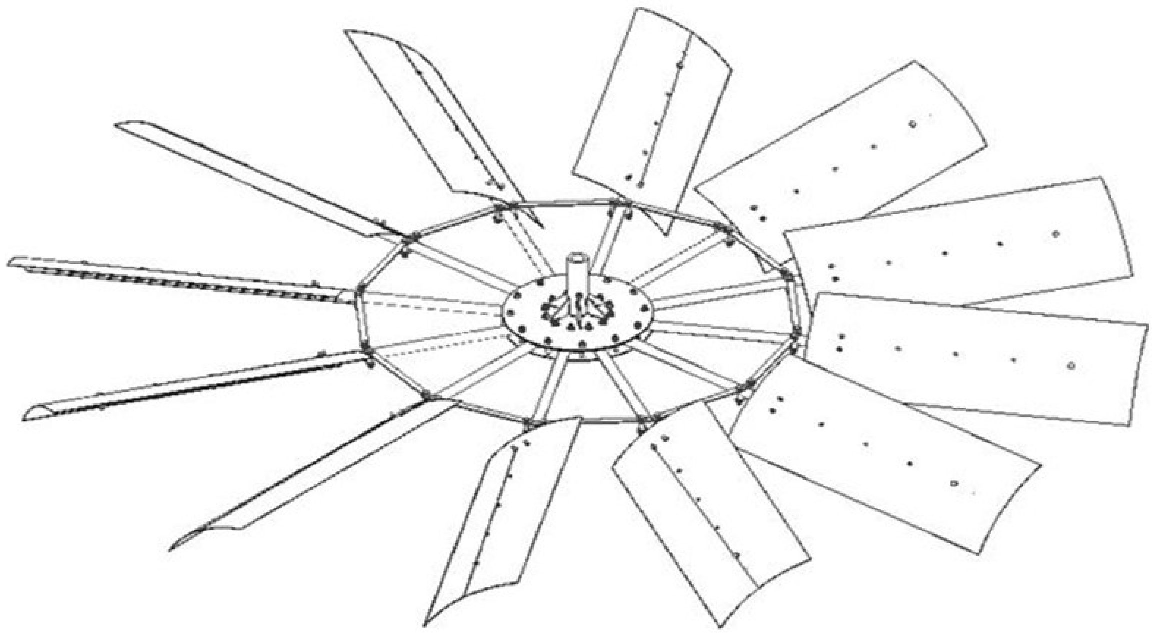
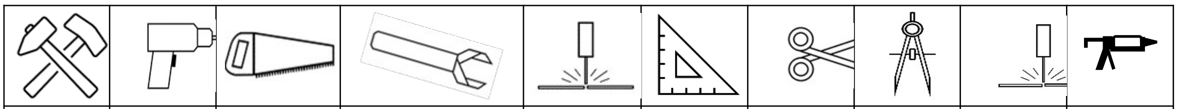


Figure 2 – Complete rotor

Tool



	12; 11	Metal	WS 13; 16; 18		90°	Sheet			

Material

Pos		Raw material	Name	Standard	Dimension	Qty	Material
2.1	**-1**	**R - 13**	Plate	DIN EN 10051	450x450x10mm	1	S235
	-2	**R-13**	Plate	DIN EN 10051	450x450x4mm	1	S235
	-3	**R - 14**	Flat steel	DIN EN 10058	100x40x6mm	6	S235
	-4	**R - 15**	Pipe	DIN EN 10220-1	33,7x4x1500mm	12	S235
	-5	**R - 16**	Sheet	EN 10051	1000x370x2mm	12	S235
	-6	**R - 17**	Flat steel	DIN EN 10058	330x20x5mm	12	S235
	-7	**R - 18**	Pipe	DIN EN 10220-1	60,3x10x224mm	1	S235
	-8	**R - 17**	Flat steel	DIN EN 10058	70x20x5mm	24	S235
	-9	**R - 19**	Pipe		16x20x1,5mm	24	Aluminium
	-10		Hexagon head screw	ISO 4017	M10x65-8.8	36	
	-11		Hex nut with torque part	ISO 4034	M10-8.8	48	
	-12		Washer	ISO 7089	10	62	
	-13		Hexagon head screw	ISO 4017	M12x65-8.8	12	
	-14		Washer	ISO 7089	12	24	
	-15		Hexagon head screw	DIN EN ISO 7040	M6 x 45-8.8	36	
	-16		Hex nut with torque part	DIN EN ISO 7040	M6	36	
	-17		Hexagon head screw	ISO 7380	M10x50-8.8	12	
	-18		Hex nut with torque part	DIN EN ISO 7040	M12-8.8	14	
	-19		Round steel shackels	DIN 3570	M8	12	
	-20		Hex nut with torque part	ISO 4034	M8-8.8	24	
	-21		Hexagon head screw	ISO 4017	M12x80-8.8	2	

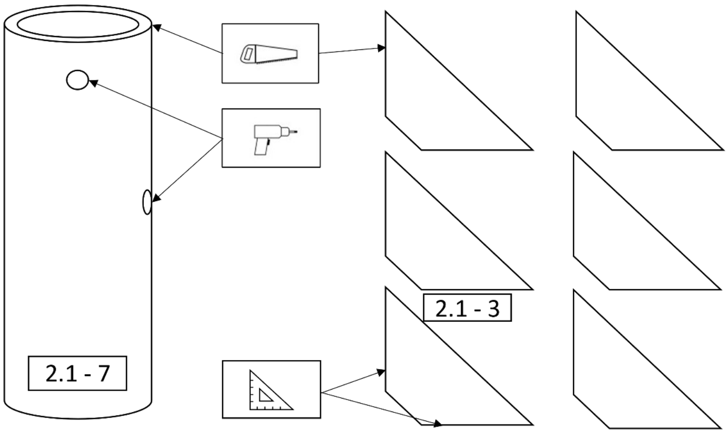
Table 1 -Bill of material 2.1 Rotor

Remark:
The steel tubes for the wing spars [2.1-3] can also be 1inch EN 10255-H S 235 (DIN 2441), EN 10219 S 235 JR, EN 10210 or DIN2448. Important for the KUKATE34 steel rotor spar are the dimensions 33.7mm outer diameter and 4mm wall thickness.

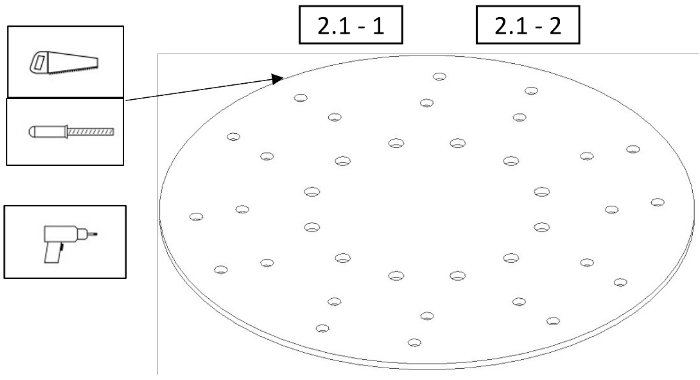
Construction

1. **Reinforcing plates**
First, saw the tube [2.1-7], which is the connection to the shaft, to size and drill the holes with a Ø12mm drill.
Shaft [2.3.1-4] and hub tube [2.1.-7] and eccentric tube [2.3.1-2] must each be drilled at the same time! Make sure that the holes have an offset of 90° to each other.

The 6 plates [2.1-3] are also sawn and deburred. Make sure that the marked surfaces have a 90° angle.



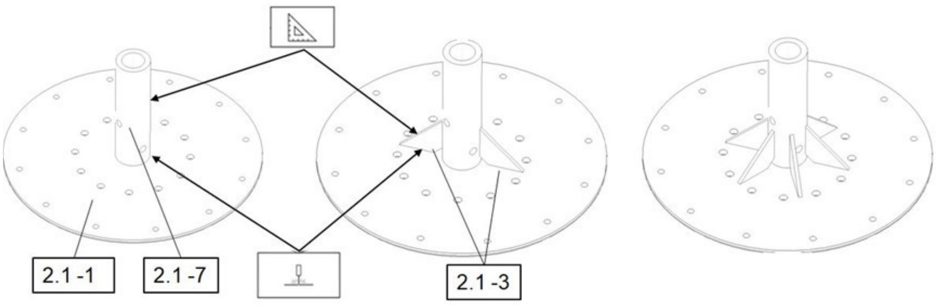
2. **saw out, deburr and drill plates for the rotor hub.**



The 10mm thick plate [2.1-1] is first sawn out round and filed. Then drill the holes for the clamping with a Ø11mm drill and the holes for the wing tubes with a Ø13mm drill. The arrangement of the holes must be observed.

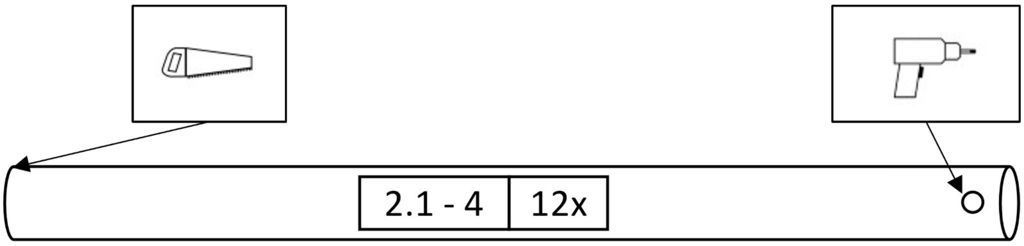
In the second step, the clamping plate [2.1-2] is produced. For this step, the thinner plate is sawn to the same dimensions as the component [2.1-1]. The hole pattern must correspond to that of the plate [2.1-1]. The plate [2.1-1] as a template for the plate [2.1-2] is a possibility.
The position and size of the holes must be identical.

3. **weld rotor hub**
In the next step, the plate [2.1-1] is welded to the tube [2.1-7] and the flat iron [2.1-3]. For this purpose, the pipe is first placed in the center and welded in small sections. It is important here that the tube is **exactly 90° to the plate.** The flat bars are then welded on. Make sure that **the opposite sides** are always welded. This keeps the tube centered and ensures that the rotor runs smoothly.



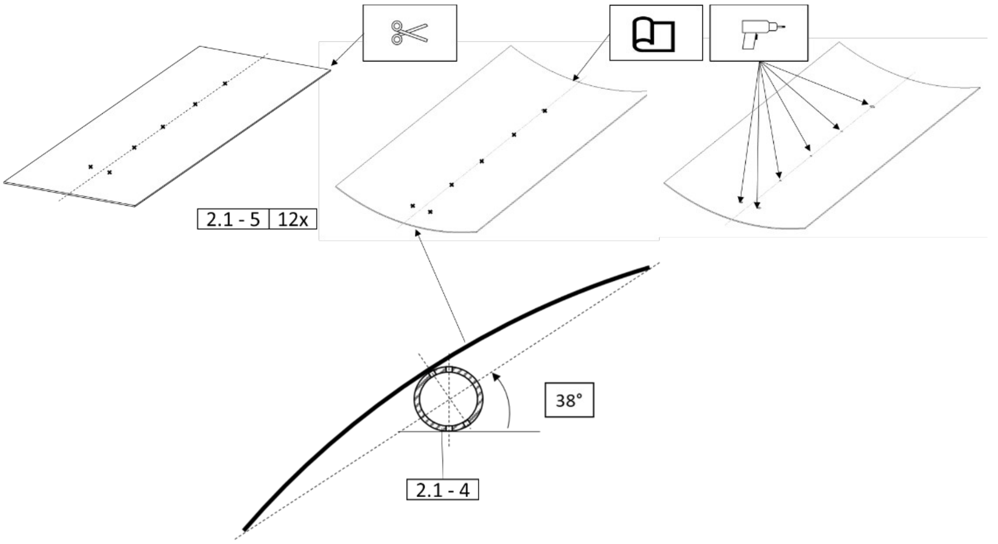
When welding the seams, it is urgent to ensure that they are welded at short intervals and always cooled down. Otherwise, the construction may warp. In contrast to all other welds of the system, the welds of the hub are to be welded with the dimensions 2.5x2.5mm (see drawing).

4. **Saw and mark pipe spars**
   Next, cut the 12 tubes [2.1-4]. Then draw a line parallel to the center line on the outside of the tube [2.1-4].
   Attention: The 13mm hole shown above on the right side of the tube for screwing the wing spars to the hub plates will be drilled later.

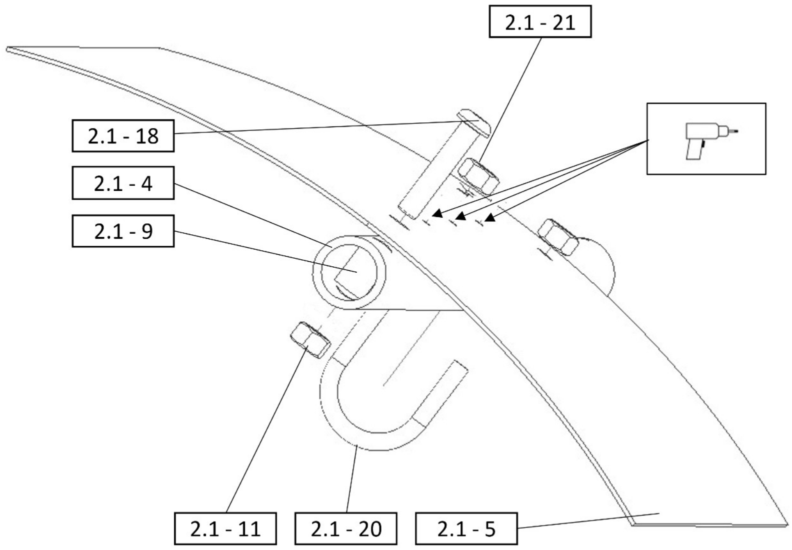


5. **Cut, mark and bend rotor plates**
   In the next step, the wings [2.1-4] are cut to size. The holes are only marked for the time being. Now the surfaces are bent (see technical drawing 2.1-4 Sheet 1000x370x2). The deflection height should be between 36mm and 40mm.

   Drill the tube spar and plates together and mark them in pairs. **Attention:** the 13mm hole in the tube for screwing the wing spars to the hub plates will be drilled later.
   Now drill the outer 11mm hole at a distance of 80mm from the end of the tube TOGETHER with the sheet metal profil [2.1-5] through the tube spar. Then, the other 6mm holes for screwing the sheet metal to the spar are drilled COMPLETELY with the sheet metal profile through the spar [2.1-3].
   After drilling, you must mark the pairs of spar and profile that belong together in pairs so that you do not mix them up later when screwing them together!!!



6. **Bolting pipe spars and sheet metal profiles**
   Now carefully degrease the tie bars and profiles.
   Then apply a strand of elastic sealant (Sicaflex or weather-resistant silicone) exactly on the bore line up to the end of the profile. Now screw the wing profiles to the spar.

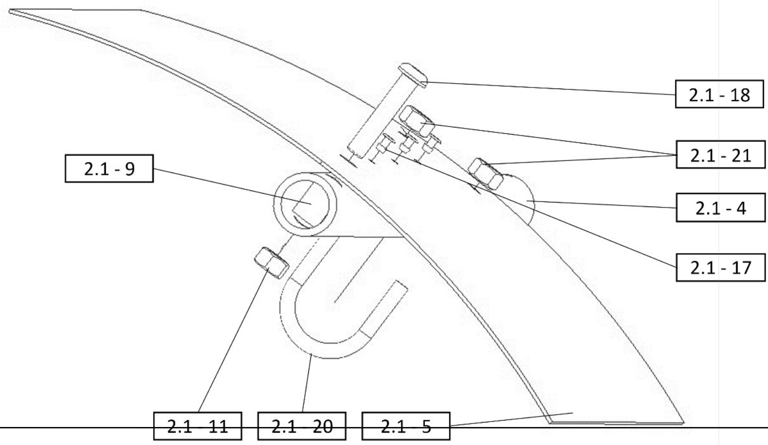


7. **mark and drill the hole for the correct angle of attack.**

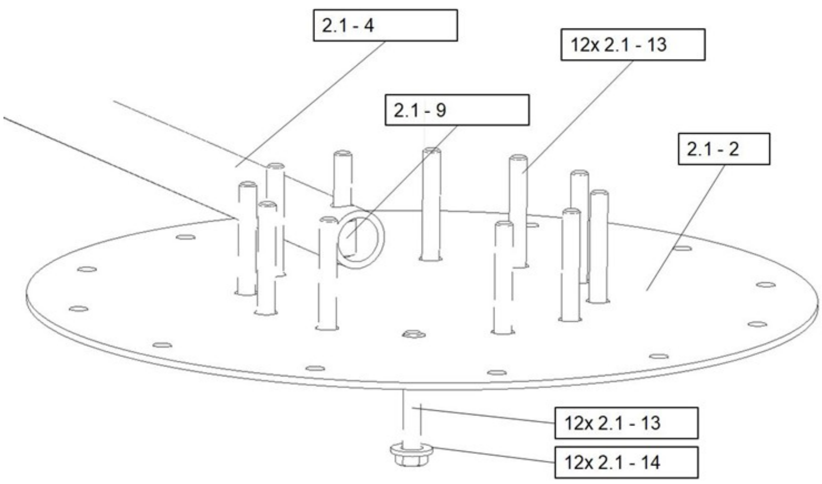
Using a 38 degree angle template made of cardboard, wood or sheet metal, align the wing chord at 38° to the plane of the "rotor face" and now drill the 13mm hole 20mm from the inner end of the spar. Through this hole the wing is screwed between the plates of the hub.

8. **Mark and drill hole for the correct angle of attack**

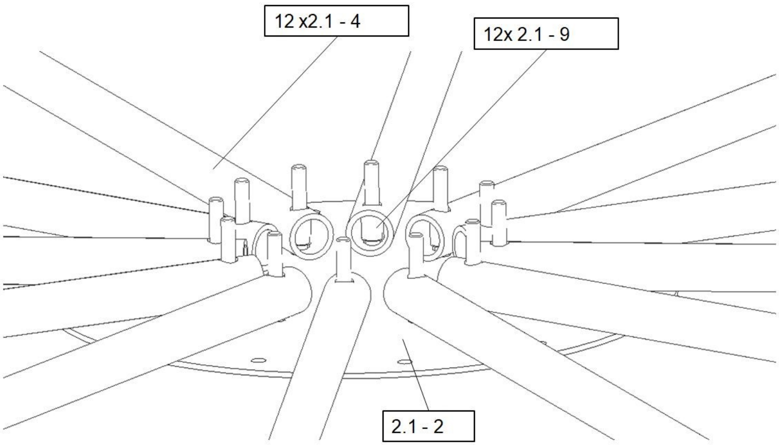
Using a 38 degree angle template made of cardboard, wood or sheet metal, align the wing chord at 38 degrees to the plane of the "rotor face" and now drill the 13mm hole 20mm from the inner end of the spar. Through this hole the wing is screwed between the plates of the hub.



Assembly of the rotor



9. In the next step, the thinner front plate [2.1 - 2] is first fitted with all 12 M12 screws [2.1 - 13] with washers [2.1 - 14]. The screws are inserted into the plate from below and the plate is placed flat on the floor.

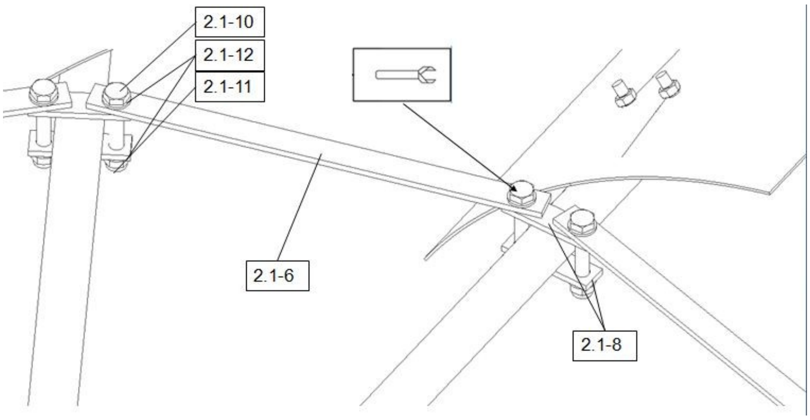


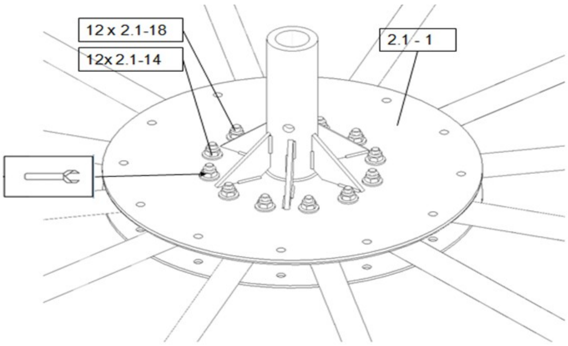
10. **position the tie bar screw connection with spacer sleeves.**

The 12 wing spars [2.1 - 4] are placed on the 4mm hub from above so that the screws [2.1 - 13] point through the holes in the spar. The plates of the spars point upwards. Inside the tube, the aluminum sleeve [2.1 - 9] is inserted again.

11. **Mounting the circumference ring**

After the wings are placed on the flange, the outer ring is mounted. Start with one wing and first insert a screw through the flat bar [2.1 -6] and then through a flat bar [2.1 -8] above the tube spar and then below the tube spar. This screw connection must now be tightened slightly. This step must now be carried out around the complete rotor until the ring is closed. Then the ring is aligned so that it has the same distance to the center point everywhere. Then the screws [2.1 -10] are tightened firmly.

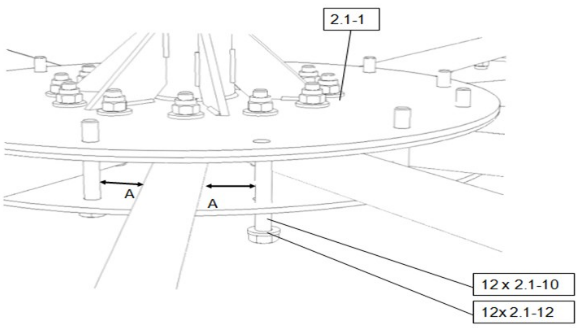




12. **Assembly with the rotor hub**

After the outer ring has been screwed tight, the preassembled flange can be placed on the screws. The screws are then lightly screwed with a washer and the M12 nut

13. After the flanges have been pre-bolted, the M10 bolts must be inserted into the flanges from below. The M10 screws [2.1 -10] are used with washers [2.1 - 12]. The tie bars for the wings are now aligned so that the distance between the tie bars and the M10 screws is the same.

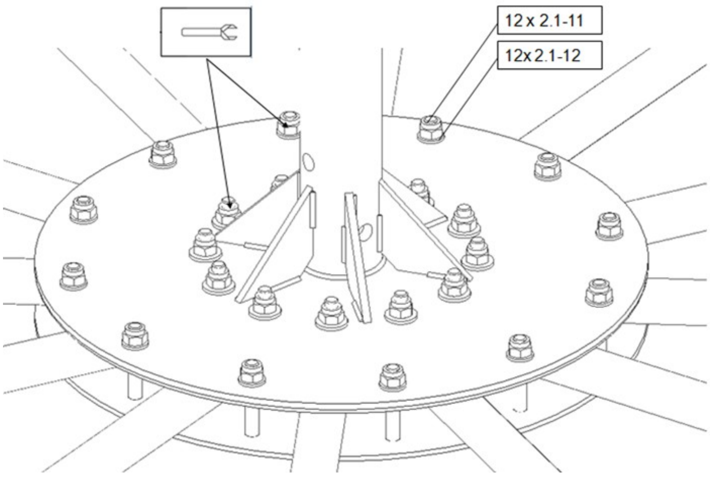


14. **Final inspection of the rotor assembly and securing of the screw connections**

In the last step, the rotor is completely screwed together. Once the blades are correctly aligned, the M10 screws are first tightened. These clamp the blades in position. Tightening the M12 screws further improves the positioning. It makes sense to tighten the screws crosswise to reduce distortion of the plates.

Finally, the rotor is precisely aligned. All screws are tightened. It is good to secure them with a drop of paint, Loctite, Sikaflex or other suitable adhesive.

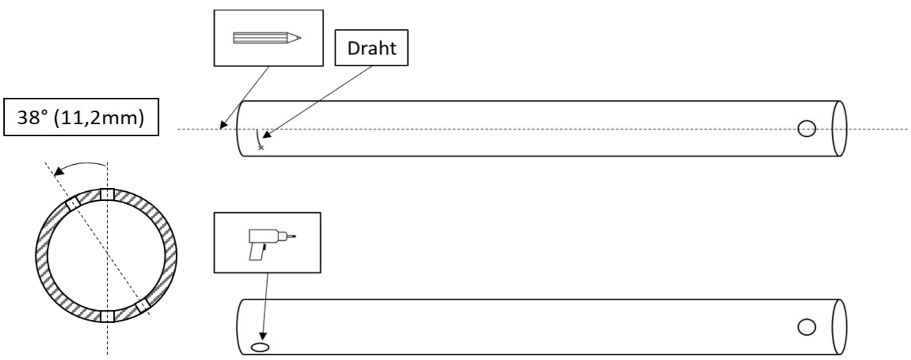
The rotor with its hub is now ready for final assembly.



Alternative: Here is a second possibility to align the holes of the rotor spar [2.1-4] correctly.

Since the wings have an angle of attack of 38°, the remaining holes must have this offset. For this purpose, a wire adjacent to the tube circumference can be used for measuring, which is cut to a length of 11.2mm. With a diameter of 33.7mm, the circumference formula U= π*D gives a circumference of 105.87mm. Dividing this circumference by 360° results in a length of 0.29mm per degree. Now the result must be multiplied by 38 to obtain the circumferential length of 11.2mm by which the tube must be rotated.

This can be used to mark the hole at the other end of the tube. For marking, draw a line on the tube exactly in the center from the center of the 13mm hole to the point where the second hole is to be drilled. On this line you put the wire of 11.2mm length bent to the contour of the pipe and then you can punch and drill there).



Nacelle frame

The nacelle frame of the OPEN WIND KUKATE is the central component to which the other components rotor bearing, control vane, side vane and control weight arms are mounted.

The construction is simple. It consists of the central tube with its bearing surfaces, angle sections and U-sections. The inner diameter is (139.7mm - 2x8mm wall thickness =) 123.7mm. The upright 120mm U-profiles [2.2.1-2] were chosen to provide enough space for the eccentric to turn. On them are the pedestal bearings for the shaft, on which the rotor and the crank drive are placed.

The profiles are welded together. In order to position the frame correctly on the outer tube, U-profiles are added, which lie directly against the tube and are welded on. Additional profile pieces at the rear are needed to attach the hinge for the control vane. The side vane is bolted to the side using plates. The two side vane hinge bolts must be prevented from rotating in the nacelle mounting brackets. The bolts should rotate in the bearing sleeves.

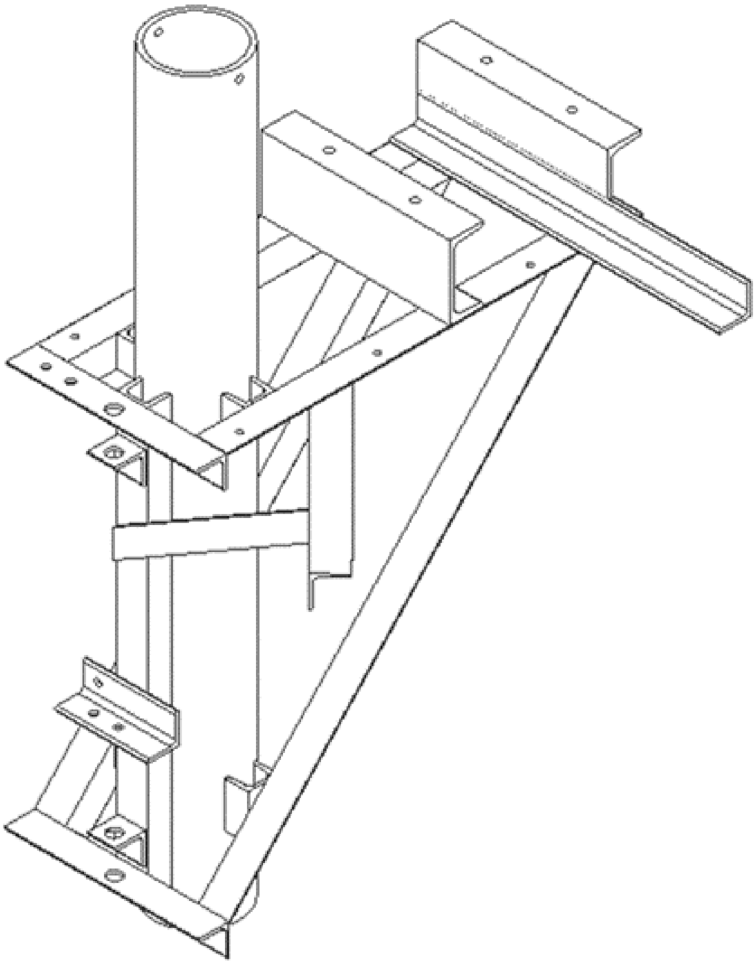
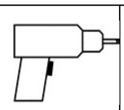
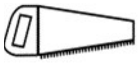
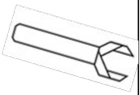
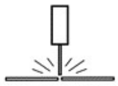
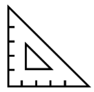


Figure 3 – Narcelle frame

Frame

Tool

					
	11;12;22	Metal	WS 18		90°

Material

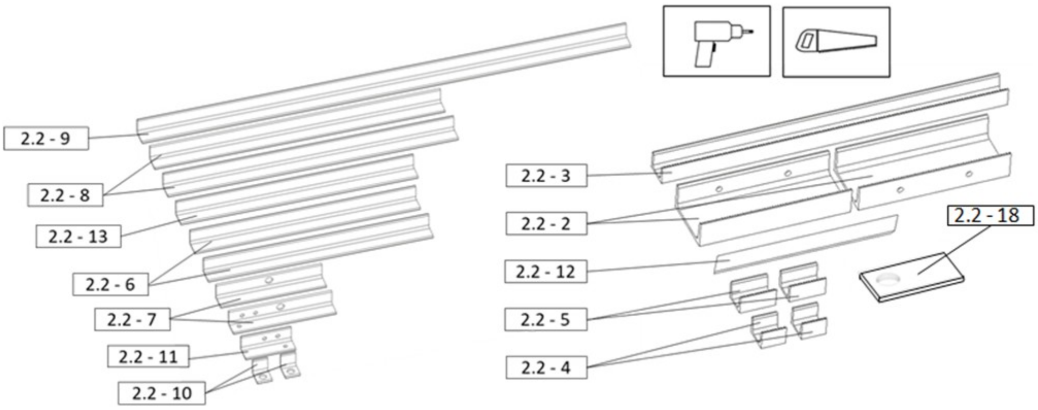
Pos	Raw material	Name	Standard	Dimensions	Qty	Material
2.2 -1	**R - 24**	Pipe	DIN2448/1629, DIN EN 10220-1 / 10210 / 10216 / 10297-1	139,7 x (8 x *7,1*)* 1200mm	1	S235
-2	**R - 20**	U-Profile	EN1026	U120x309mm	2	S235
-3	**R - 21**	U-Profile	EN1026	U50x705mm	1	S235
-4	**R - 21**	U-Profile	EN1026	U50x50mm	2	S235
-5	**R - 21**	U-Profile	EN1026	U50x74mm	2	S235
-6	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x674mm	2	S235
-7	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x309mm	2	S235
-8	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x869mm	2	S235
-9	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x1000mm	1	S235
-10	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x45mm	2	S235
-11	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x150mm	1	S235
-12	**R - 23**	Flat steel	DIN EN 10058	40x5x368mm	1	S235
-13	**R - 22**	L-Profile	DIN EN 10056-1	50x50x5x800mm	1	S235
-14		Pedastal bearing	UCP208		2	S235
-15		Conical grease nipple	DIN 71412	AM6	2	S235
-16		Hexagon head screw	ISO 4017	M12x50-8.8	4	
-17		Washer	ISO 7089	12	8	
-18	**R - 13**	Flat steel	DIN EN 10058	60x50x95mm	1	S235
19		Wedge	DIN EN 434	13	4	S235
20		Thrust ball bearing	DIN 711 51124	A 155/ 120x25mm	1	
21	**R - 17**	Flat steel	DIN EN 10058	447x20x5mm	1	S235

** For a nacelle frame tube of 139.7 x 8mm, 4mm brass plate must be used for the plain bearing sleeves, for a nacelle frame tube of 139.7 x 7.1mm, the brass plate can be 5mm thick. The sheet can also be bronze or gunmetal.*

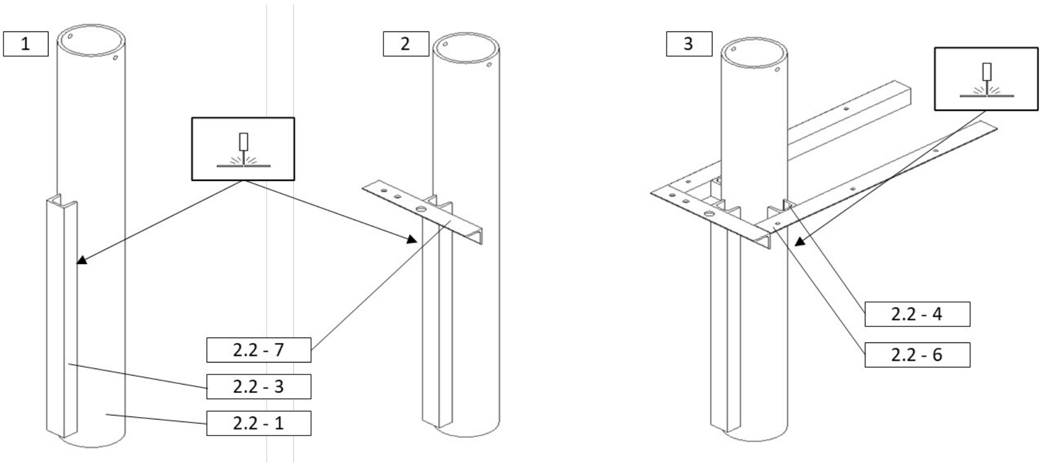
Table 2 – Bill of material 2.2.1 frame

Construction

1. First, the materials must be brought to size and provided with the appropriate holes.

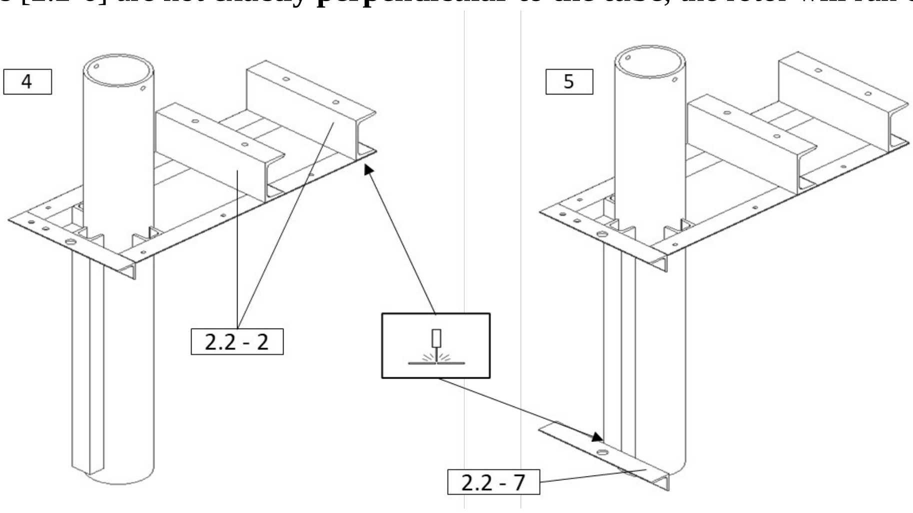


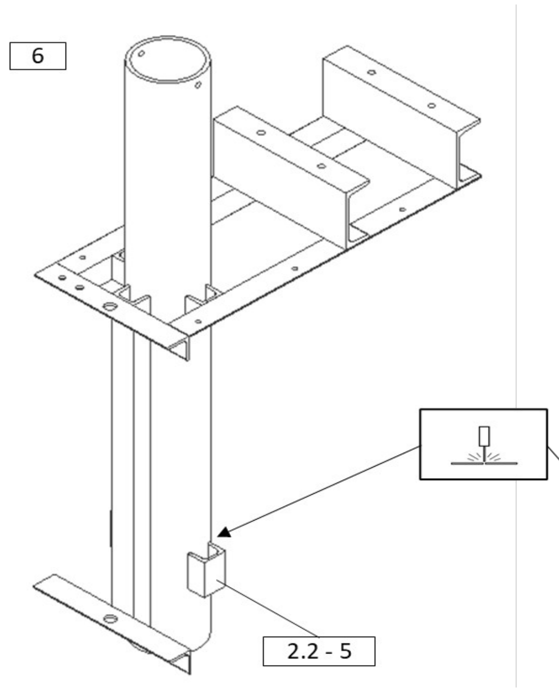
2. Now the nacelle frame is tacked and then welded together. The following illustrations show the sequence of assembly. With the help of angles to maintain the 90 degree joints and screw clamps, the components are carefully aligned.

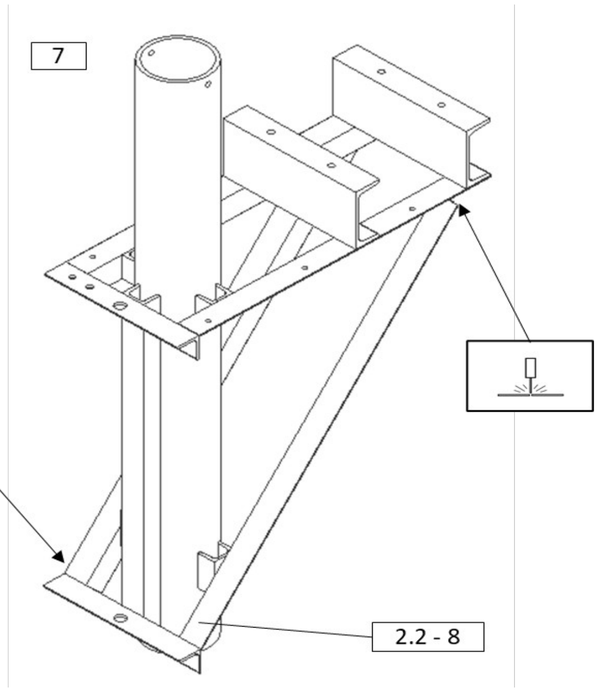


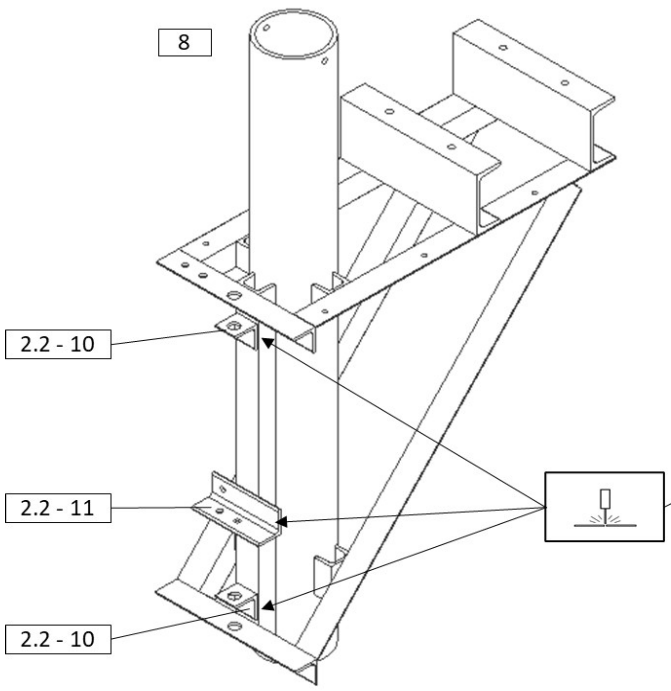
The alignment of these parts will later determine whether the system is well adjusted. You must work very carefully here. If the distances and holes are not exactly correct, the side vane, for example, will hang crooked later [2.2-7 / 2.2-11]!

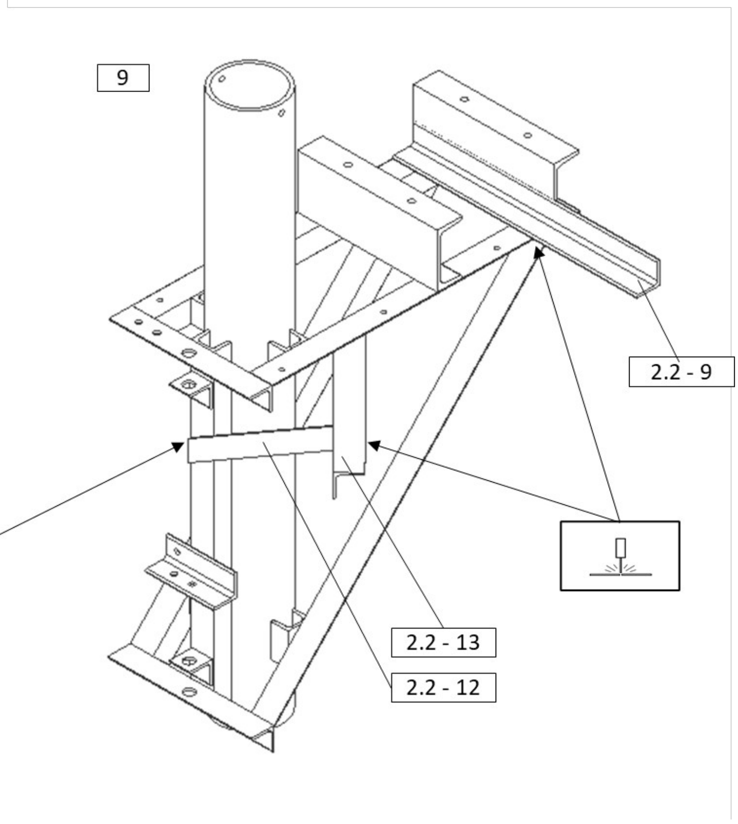
If the L-profiles [2.2-6] are not **exactly perpendicular to the tube**, the rotor will run crooked.











Hinge attachment reinforcement

On the upper nacelle frame angle section 2.2-7 and the U-section 2.2 -3 a flat iron [2.2-18] is welded up to the stop on the nacelle frame tube 2.2-1 and provided with the 20 mm hole for the hinge pin (reinforcement of the angle iron due to the high tractive force by the control vane).

Wooden bearing cover

The wooden bearing cover is screwed to the upper end of the nacelle frame. This serves not only as protection against water, but also as a bearing guide for the rod that lies between the mortise joint and the piston of the pump.
The long piston rod is centered by these wooden bearings. The aluminum piston rod has a diameter of 40mm. The bearing holes in the wooden bearings should be drilled with a 41mm or 42mm drill bit. It is important to use a wear-resistant hardwood.
With linseed oil, olive oil or any other oil, you can lubricate the wooden bearings. Then they will last longer than without oil.
Wear and tear on the bearings is a fact of life. If the bearing play is too large, the bearing must be replaced.
This is very simple. The piston rod does not have to be removed for this.
The bearing parts must be clamped together and drilled simultaneously before drilling.

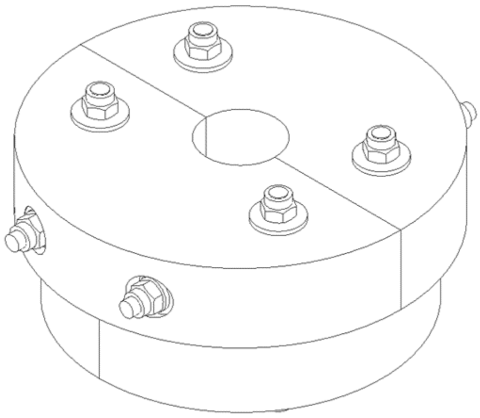
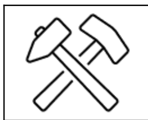
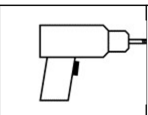
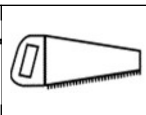
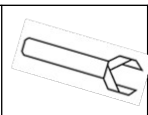
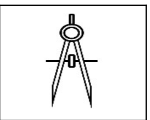


Figure 4 – Complete wooden bearing cover

Tool

				
	6,6; 30	Metal	WS 10	

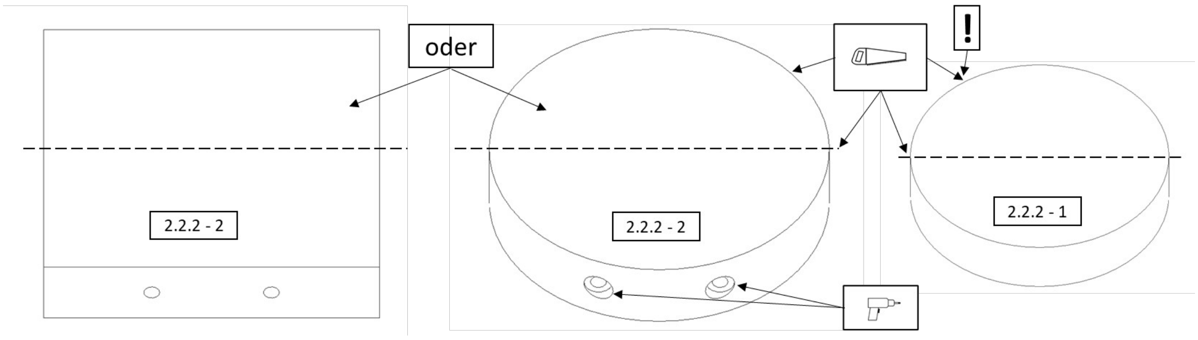
Material

Pos	Raw material	Name	Standard	Dimensions	Qty	Material
2.2.2 -1		Wood bearing		123x30mm	2	Oak
-2		Wood cover		140x30mm	2	Oak
-3	**R - 27**	Threaded rod	DIN 976 - A2	M6x150	2	
-4	**R - 27**	Threaded rod	DIN 976 - A2	M6x80	4	
-5		Washer	ISO 7089	6	4	
-6		Washer	DIN 9021 - A2	6	8	
-7		Hex nut with torque part	DIN EN ISO 7040	M6-8.8	12	
-8		Wood screw	DIN 571	5x30mm	4	

Table 3 – Bill of material 2.2.2 wooden bearing cover

Construction

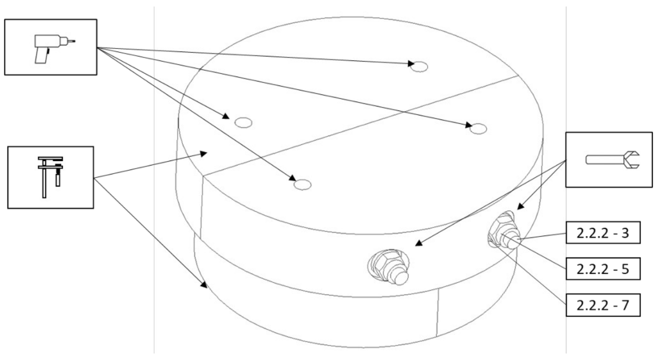
1. wood storage is divided into upper and lower half. This I important because wood is not a homogeneous material due to the grain. The wear should be symmetrical. Therefore, the grains of the lid and the second part are offset by 90 degrees.
   The wooden lid [2.2.2-2] is first sawn to the outside dimension and filed. In the illustration, a round shape was chosen.

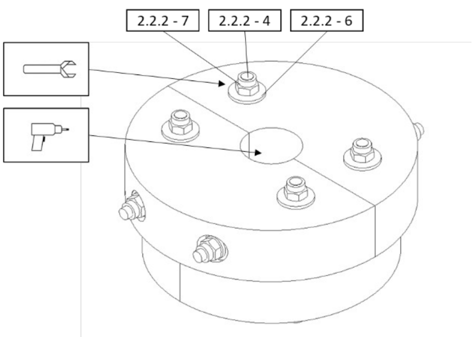


   The lid can also take a square shape.
   The two through holes on the sides are then drilled.
   Finally, the lid is sawn through in the middle. This ensures easy installation and removal.
   For the lower part of the wooden bearing [2.2.2-1], the round shape is required, since this will later be inserted and screwed into the tube [2.2.1-1] of the nacelle frame.
   When sawing out the wooden bearing parts, it is important that the outer diameter is chosen larger than indicated on the technical drawing. Since the subsequent splitting of the bearing will result in an offcut by the saw, the diameter must be sawn out correspondingly larger.
   After the wooden bearing has been sawn through in the middle, it can be filed to size. The tube [2.2.1-1] can serve as a template.

2. First, the wooden lid [2.2.2-2] is screwed together. Then the wooden bearing [2.2.2-1] is fixed to the lid. Screw clamps can be used for this purpose. The indicated holes are then drilled.

   The last step is to drill the large central hole for the piston rod in the assembled state. This provides an offset-free hole in which the linkage [4.3] can later slide cleanly up and down. If this sliding bearing for the linkage is accurate and the surface smooth, it will last a long time.

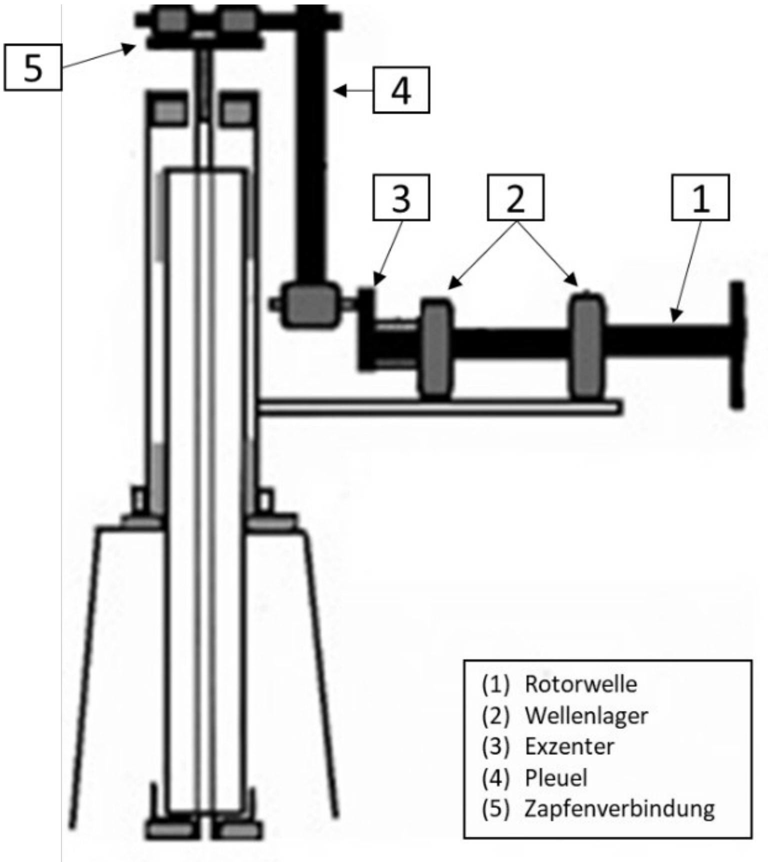




Fix bearing in tube
For mounting, it is convenient to drill two or three 8mm holes 20mm from the ends at the circumference of each end of the rack tube [2.2-1]. With the help of wood screws, you can easily fix the bearings this way.
This should be done before assembly. If drilling is done later, the steel chips from the upper holes can fall onto the azimuth slide bearing (made of brass!) above and damage it.

Crank drive

Figure 5 shows the design of the linkage on the nacelle. The rotor shaft is mounted to the nacelle through the shaft bearings. This shaft connects the rotor with the linkage. The crank consists of the eccentric, the connecting rod and the upper mortise joint. These components form the mechanical transmission of the rotating motion in the oscillating (up and down) movement. The eccentric is mounted on the rotor shaft and rotates with it. The design of the eccentric on the rotor shaft allows the connecting rod to move up and down. This up-and-down movement is transmitted to the piston rod. The rod is pushed onto the threaded rod of the mortise joint and screwed together.



Function

The translation of rotating motion into oscillating movement is called crank drive. The crank drive is generated by the linkage. shows the up and down movement of the crank mechanism. At the end of the rotor shaft the eccentric is mounted. Therefore, it rotates accordingly. The bolt of the eccentric is rigidly welded to the outer edge of the eccentric. This means the bolt will rotate with the radius of the eccentric. The piston rod mounted on the bolt is moved around the axis of the eccentric as the eccentric rotates. This results in a pivoting up and down movement of the piston rod. The movement is transmitted to the mortise joint at the upper end of the piston rod. This transmits the up and down movement to the linearly moving rod which is connected to the pump.

Figure 5 – Structure of crank drive

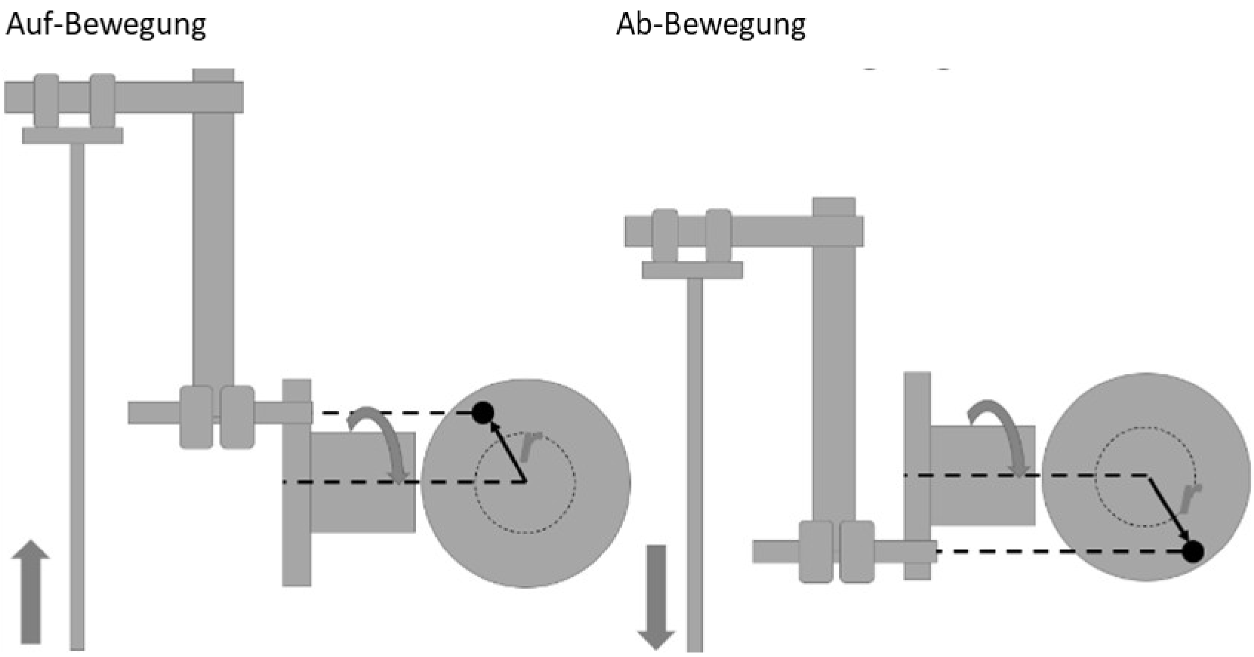


Figure 6 – Operating principle of the crank drive

Eccentric

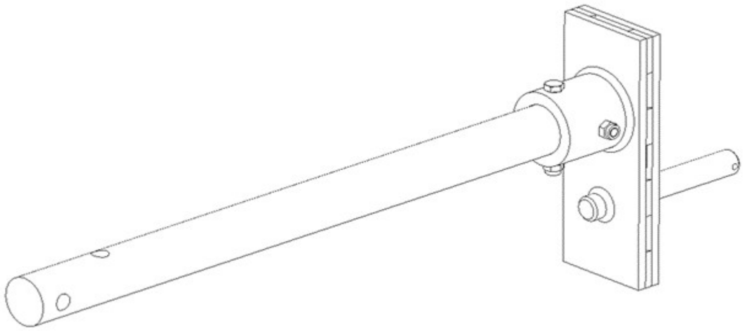
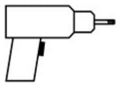
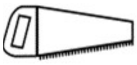
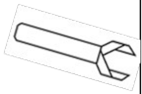
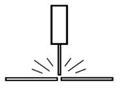
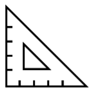


Figure 7 – Complete eccentric

Figure 26 shows the eccentric. This is made from a tube, two flat steels and a bolt. The rotor shaft is inserted into the tube and bolted. The tube is welded to the flat steel. The bolt is passed through the hole in the flat steel bundle and welded. The connecting rod is attached to the bolt.

Tools

					
	9; 13,5; 20	Metal	WS 13; 18		90°

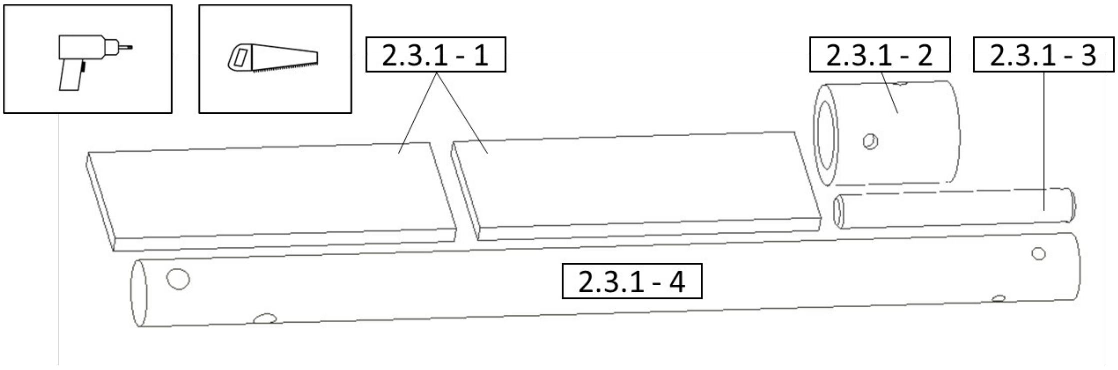
Materials

Pos	Raw materials	Name	Standard	Dimensions	Qty	Material
2.3.1 -1	**R - 25**	Flat steel	DIN EN 10058	210x80x10mm	2	S235
-2	**R - 18**	Pipe	DIN EN 10220-1	60,3x10x75mm	1	S235
-3	**R - 26**	Round profile	DIN EN 10060	Ø20x115mm	1	S235
-4		Round profile	DIN EN 10060	40x575mm	1	S235
-5		Hexagon head screw	ISO 4017	M10x70-8.8	2	
-6		Hexagon nut with torque part	DIN EN ISO 7040	M10-8.8	2	
-7		Splint pin	DIN EN ISO 1234	4,6x32mm	1	S235
-8		Hexagon head screw	ISO 4017	M12x80-8.8	2	
-9		Hexagon nut with torque part	DIN EN ISO 7040	M12-8.8	2	

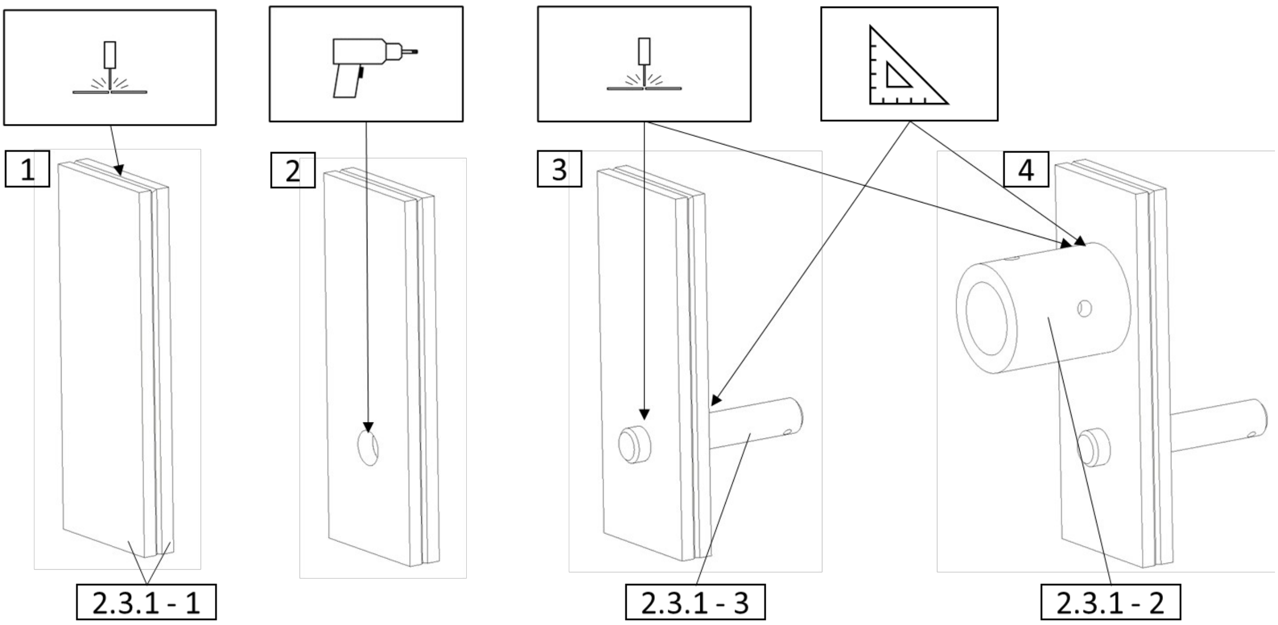
Table 4 – Bill of material 2.3.1 eccentric

Construction

1. At the beginning, all components are made to measure and provided with the appropriate drillings. **Make sure that the shaft [2.3.1-4] is first inserted into the pipe [2.3.1-2] and then drilled together.** The flat steel [2.3.1-1] is not drilled at the beginning. This is done in step 2



2. The two flat steels [2.3.1-1] are then welded together. Then the 20mm hole is drilled through both. Then the shaft tube [2.3.1-2] is positioned and welded to the two plates. Make sure that the components [2.3.1-2] and [2.3.1-3] are **placed very precisely at 90° to the joint welded from two plates [2.3.1-4].** They must not distort during welding.



The assembly with the shaft is done only during the assembly.

Piston rod

The connecting rod consists of two bearings, an angle steel, a steel plate and a bolt with flat steel reinforcement. The steel plate is welded to the angle section. The pin [2.3.1 - 3] of the eccentric is inserted in the two lower pedestal bearings. These are screwed to the plate. At the other end of the profile, the bolt is aligned and welded on as accurately as possible in all three directions. For stiffening, two flat steels are welded to the bolt and the angle steel. The bolt connects the connecting rod to the bearings of the upper trunnion joint

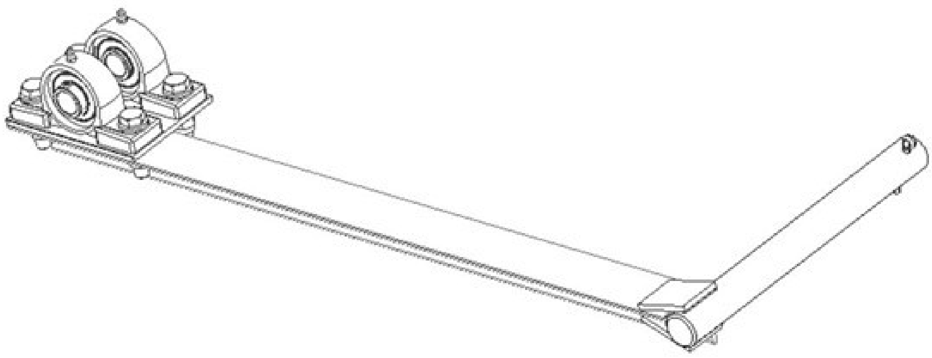
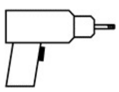
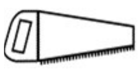
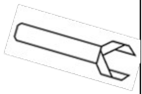
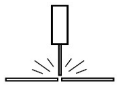
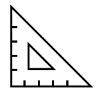


Figure 8 – complete piston rod

Tools

					
	6,6; 13,5	Metal	WS 18		90°

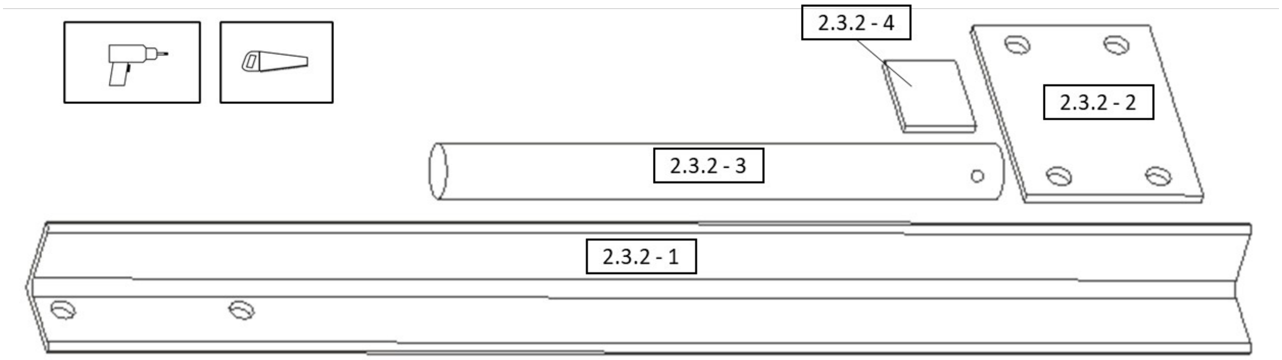
Materials

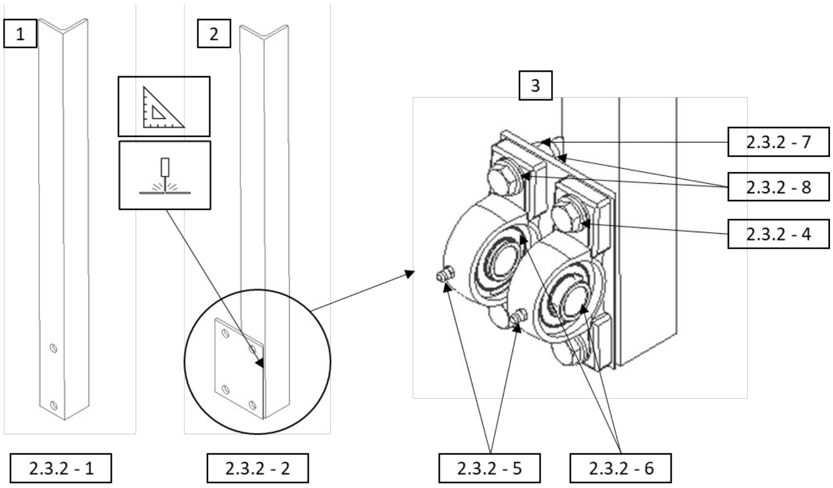
Pos		Raw materials	Name	Standard	Dimensions	Qty	Material
2.3.2	-1	R - 22	L-Profile	DIN EN 10056-1	50x50x5x680mm	1	S235
	-2		Plate	DIN EN 10025	100x130x5mm	1	S235
	-3		Round profile	EN 10060	Ø30x400mm	1	S235
	-4	R - 23	Flat steel	DIN EN 10058	50x40x5mm	1	S235
	-5		Conical grease nipple	DIN 71412	AM6	2	S235
	-6		Pedestal bearing	UCP204		2	S235
	-7		Hexagon nut with torque part	DIN EN ISO 7040	M12-8.8	4	
	-8		Washer	ISO 7089	M12	8	
	-9		Hexagon head screw	ISO 4017	M12x50-8.8	4	
	-10		Splint pin	DIN EN ISO 1234	6,3x45mm	1	S235

Table 5 – Bill of material 2.3.2 piston rod

Constuction

1. Saw all parts to size and drill the holes. You can connect the parts [2.3.2-1] and [2.3.2-2] with a screw clamp, align them and drill them together.

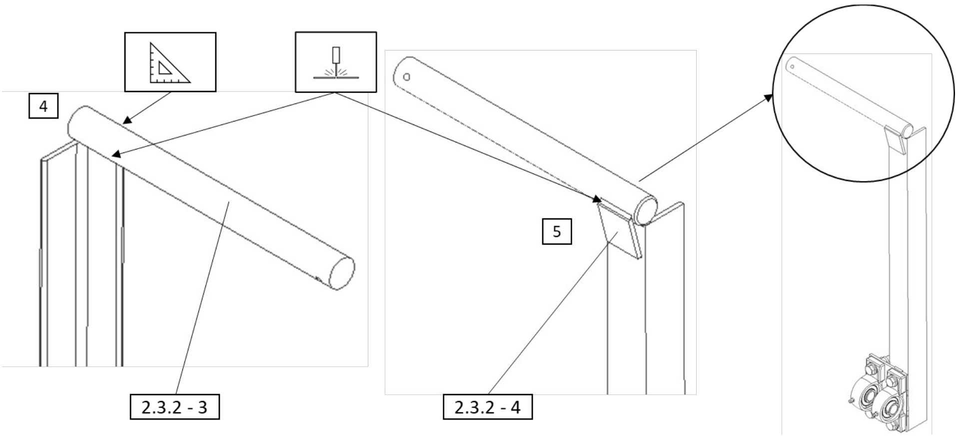




2. The plate is then welded to the angle steel. Make sure that the welding of the plate [2.3.2-2] is carried out exactly at 90°. In order to reduce the bending load on the bolt of the eccentric and to ensure the rigidity of the construction, two pedestal bearings [2.3.2-6] are also mounted here. The mounting holes in the bearing housings have a large tolerance. Therefore, it is possible to align the bearings precisely when screwing them tight. For this purpose, a long 20 mm round steel bar is inserted through both bearings. With a right angle the exact adjustment can be done. Then the bearings are screwed tight

On the upper part of the connecting rod of KUKATE34 the 30mm round steel [2.3.2-3] is welded with two reinforcements [2.3.2-4]. These welds must transmit a lot of force.
First, the round steel is aligned three-dimensionally at right angles with the upper angle steel edge and then welded on both sides. Then the two flat steels [2.3.2-4] are welded to the stud and the angle steel on both sides. Large forces occur here during operation

Here, too, care must be taken that the round steel is exactly at 90° to the L-profile [2.3.2-1] in all three directions.



Mortise joint

The movement of the connecting rod is transmitted to the pump linkage via the 30mm connecting rod pin [2.3.2-3]. The threaded rod [2.3.3-3] loosely connects the piston pin to the linkage. To reduce the bending load on the pin and to ensure the rigidity of the structure, two pedestal bearings are mounted. The mounting holes in the bearing housings have a large tolerance. Therefore, the bearings can still be precisely aligned when they are screwed tight.

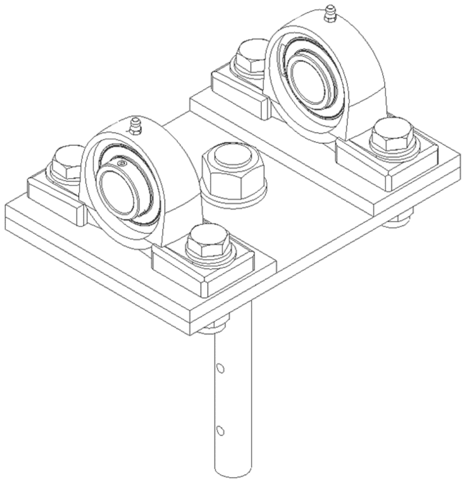
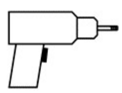
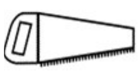
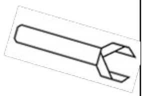
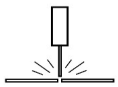
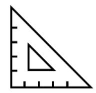


Figure 9 – Complete Mortise joint

Tools

					
	17,5; 26	Metal	WS 24; 36		90°

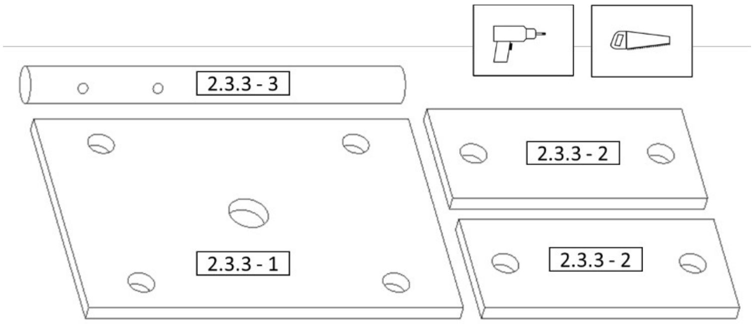
Materials

Pos		Raw material	Name	Standard	Dimensions	Qty	Material
2.3.3	**-1**		Plate	DIN EN 10025	250x170x10mm	1	S235
	-2	**R - 25**	Flat steel	DIN EN 10058	170x80x10mm	2	S235
	-3		Threaded rod	DIN 976 - A2	Ø24x200mm	1	S235
	-4		Pedestal bearing	UCP206		2	S235
	-5		Conical grease nipple	DIN 71412	AM6	2	
	-6		Hexagon head screw	ISO 4017	M16x65-8.8	4	
	-7		Hexagon nut	ISO 4032	M16-8.8	4	
	-8		Washer	ISO 7089	16	8	
	-9		Hexagon nut	ISO 4032	M24-8.8	2	
	-10		Washer	ISO 7089	24	2	
	-11		sheet		50x50x3	1	Brass

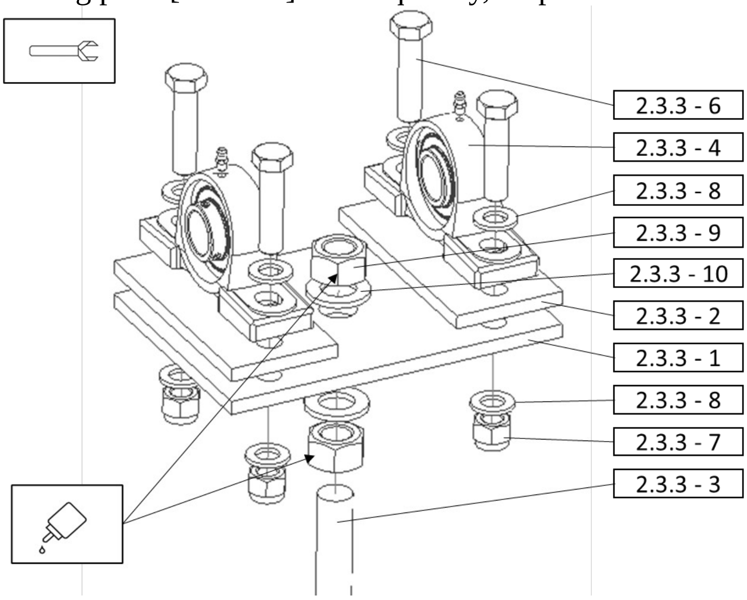
Table 6 – Bill of material 2.3.3 mortise joint

Construction

1. Saw all parts to size and drill the holes. It is advisable to bore the threaded rod [2.3.2-3] together with the uppermost pipe of the rod [4.3-1].



Adjust and secure the play of the M24 screw connection of the piston rod with the trunnion connection. Between the washer [2.3.3-10] of the upper nut and the plate [2.3.3-1] loosely mount the brass bearing plate. The two M24 nuts are not tightened. A gap of 1/10mm should be set. Nevertheless, the two M24 nuts must not be able to loosen. They must be secured against loosening with a punch with a center punch and/or adhesive (for example Loctite). The M24 threaded rod must be able to rotate in the trunnion connection: Because of the rubber ropes that compensate for the weight of the piston rod and the trunnion joint, the piston rod cannot rotate. The rubber ropes are connected to each other at the mast and at the piston rod. However, the nacelle will rotate with changes in wind direction. Since the threaded rod is loosely connected to the trunnion joint, this rotation works. In this way, the rubber cables cannot then twist around the piston rod. The washer rests on the brass bearing plate [2.3.3-11]. Subsequently, all parts are screwed together. When



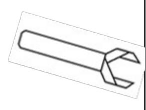
tightening the two nuts [2.3.3-10], make sure that they are not tight.

Reminder:
The threaded rod [2.3.3-3] must not sit rigidly on the plate [2.3.3-1] and [2.3.3-11]. There should be 0.1mm of play. To prevent loosening or misalignment of the two nuts, they are taped or otherwise secured against loosening, e.g. by center punching between bolt and nut.
At the top, the nut must not protrude over the edge of the nut. The connecting rod bolt must not be touched by the M24 threaded bolt.

Assembling

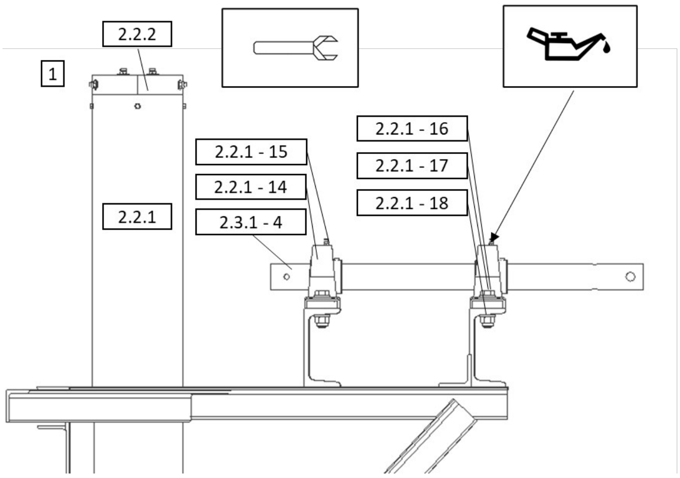
To ensure proper operation, the crank drive must be subjected to a test. This should take place in the workshop.

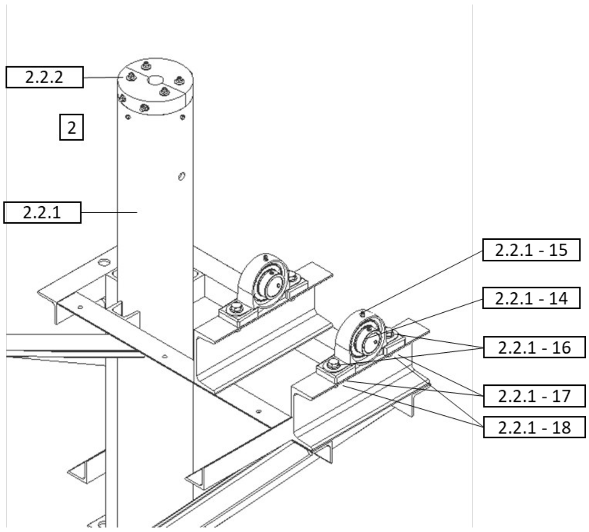
Tools

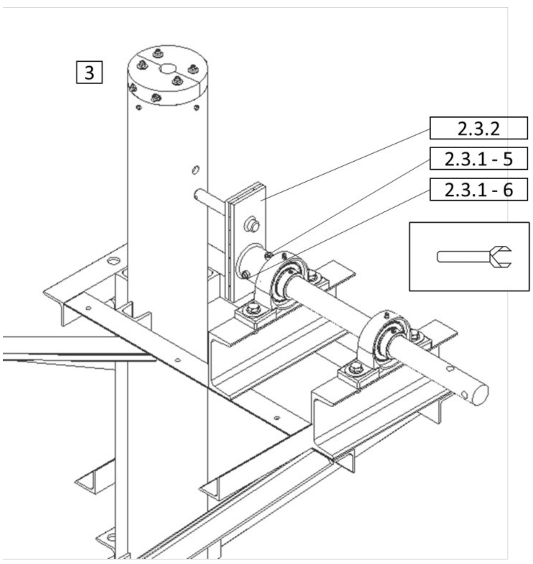
		
		WS 13; 18

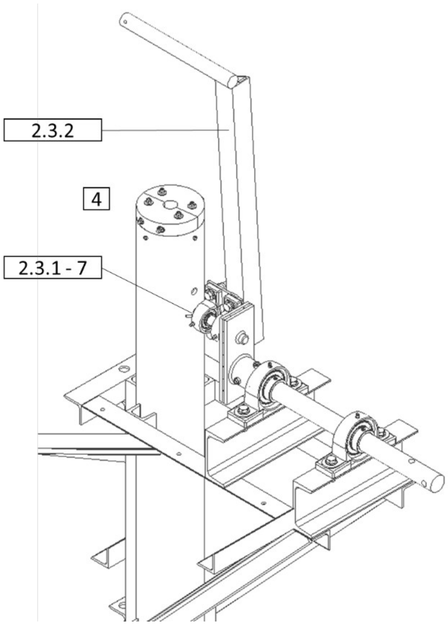
Construction

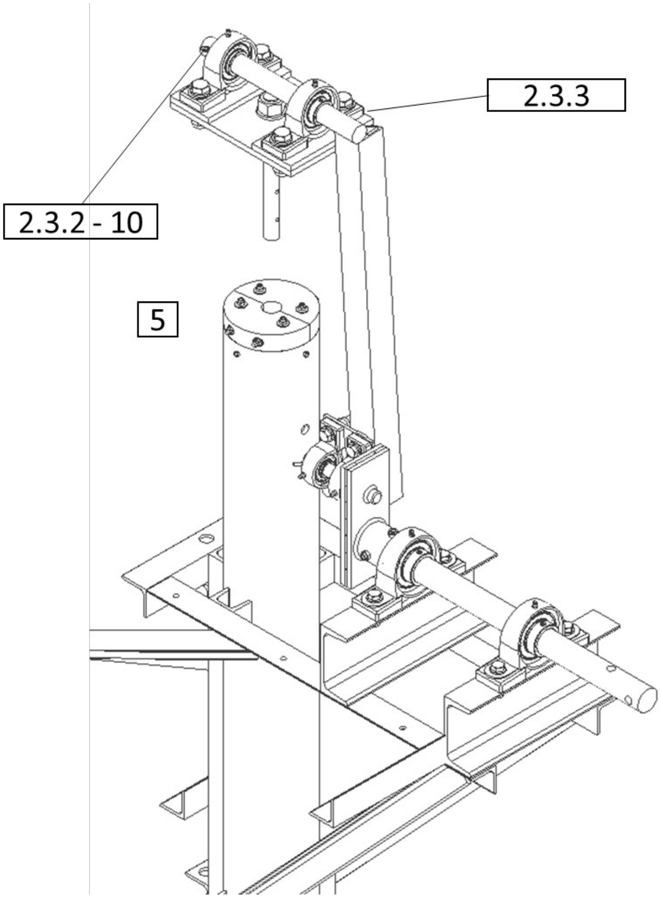
First, the bearings [2.2.1-14] are loosely screwed to the U-profiles of the nacelle. Before the shaft is inserted, the bearings should be greased. This serves to protect the bearings. In order to enable smooth running when the shaft is inserted, it should also be greased. Then the screws and the bearings are tightened. The rear bearing on the crank mechanism is the fixed bearing. The following series of pictures shows the assembly of the crank mechanism.

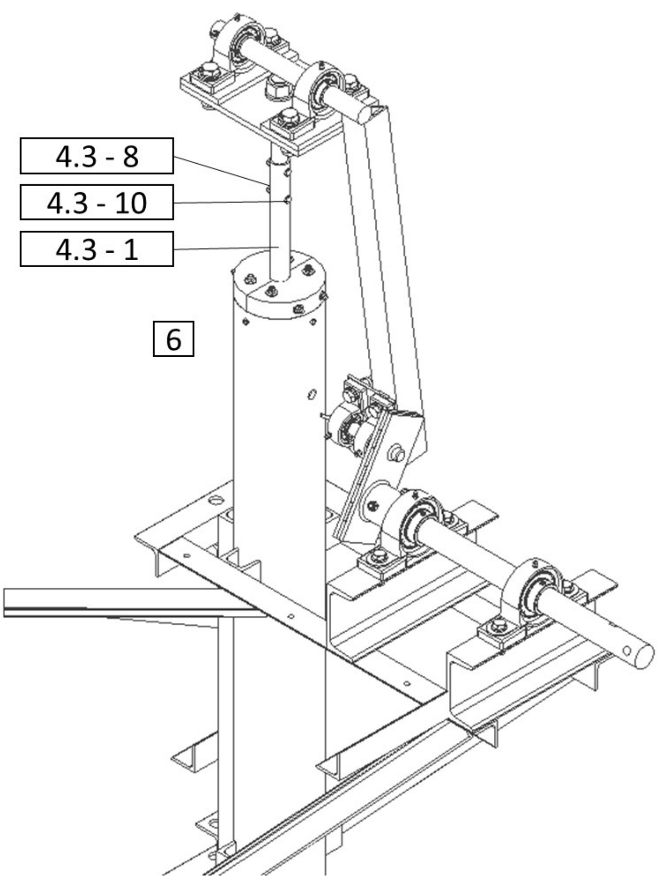












Finally, a functional test should be performed. To do this, simply turn the shaft. When functioning correctly, the linkage moves up and down smoothly.