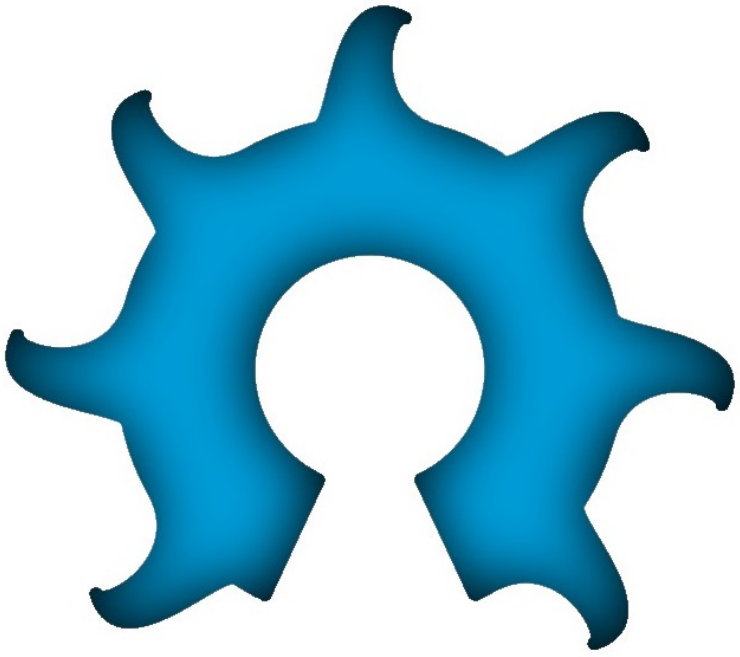

OpenWater

DIY Solar Multiple-Effect Desalination System

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Contents

1 License

2 Abstract

This document describes the solar desalination system called OpenWater. This system works of a well known process called Multiple Effect Desalination/Destillation. It is commonly used in large-scale industrial plants to generate fresh water from salt water using heat. OpenWater uses this well-known process, simplifies it and makes it accessible for you to build, learn from and use.

Throughout the following pages these key-questions will be answered:

- Design Goals – How do we want to build the system?
- Working Principle – How does this system work?
- Bill of Materials – What components/parts are needed?
- Procurement – What extra commercial components are needed?
- Manufacturing – How to build the parts and assemble the system?
- Operation – How to make fresh water with it?
- Maintenance – How to keep the system running?

3 Design Goal

The goal is to design a system, that is

- affordable – Although still a sizable investment for communities in certain countries in the world, the unit should be designed to be as cheap as possible.
- accomplishable – components and parts should be available for purchase around the world.
- buildable – manufacture of the individual components should be as easy as possible and not require specialised tools.
- maintainable – easy maintenance (repairability) should be a main focus.
- long living – factors like corrosion should be taken into account to increase the units lifetime between maintenance.

4 Working Principle

Multiple Effect Destillation is basically just a more effective way to destill water.

4.1 Basic Water Destillation

Generally speaking, water destillation is the process of evaporating (to produce steam from liquid) salt water in one container, then leading the steam into another container, where it condenses (steam becomes liquid again). The condensate is in this case destilled water (pure H_2O).

This process needs a source of heat. This heat energy is used to evaporate (or cook) the water. When the water condenses in the second cylinder, this heat energy is released again. The second cylinder becomes hot and needs to be cooled in order to keep the process running.

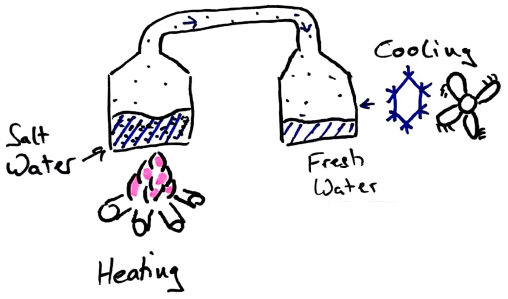


Figure 1: Basic Principle of Destillation of Water

4.2 Multiple Effect Water Destillation

The process used in OpenWater expands on this basic principle. Instead of plainly cooling the second chamber, the condensation heat is not just dissipated (blown away by the cooling fan) but reused to evaporate more salt water in a third chamber. One connected evaporation-condensation-chamber-pair is called "Effect". There can be many effects in one system, hence the name "Multiple Effect Destillation" (later called "MED").

Besides reusing the invested heat in multiple effects, the process is further improved. By using vacuum pumps to lower the ambient pressure in the containers, the boiling temperature of the water is reduced and non-watersteam-gas (Nitrogen, Oxygen, etc. from the air) is sucked out of the system. It is now possible to commence rapid boiling without having to use a heat source hotter than 100°C.

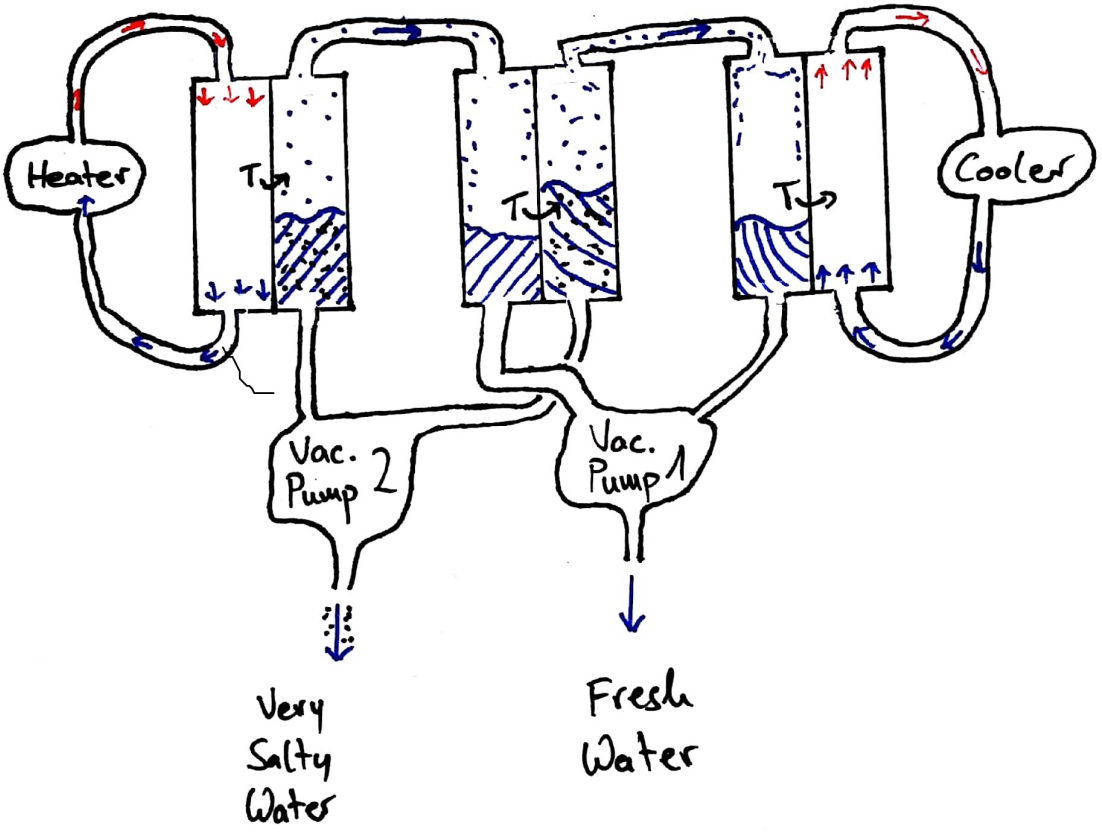


Figure 2: Principle of Multiple Effect Destillation

Figure 2 shows a very basic sketch of how a Two Effect Destillation System can look like. It consists of three MED-Units. One MED-Unit has two chambers. Chamber 1 heats the first effect (chambers 2,3). In chamber 2 salt water evaporates and is sucked into chamber 3 where it condenses. The resulting fresh water is then pumped out. The condensation heat is transferred to more salt

water in chamber 4 ("$T \hookrightarrow$" in Figure 2)...and so on. The final chamber is for cooling the last effects condensation heat.

In General an N Effect Desalination System consists of N+1 MED-Units or $2 \cdot (N + 1)$ chambers. Two of its chambers are used for heating/cooling at the ends. The more effects a system has, the more fresh water can be produced for a given amount of heat as more heat gets reused. However the manufacturing costs of the system also rise with the amount of effects.

4.3 Solar Panels

As mentioned, the MED-System requires a source of heat – warm water. This can be either obtained through the waste heat of a combustion engine. Maybe there is a generator running nearby that could provide the warm water?

Another way is to build a simple solar panel – a thermosolar panel, not electrical. This may consist basically of two sheets of metal separated by square rods on the outside. Through an inlet on the bottom water is guided into the panel. On the top there is an outlet to pull the water out of the panel. This panel is then connected to the first chamber of the MED-System. An aquarium pump is used to push the water through this heater-circuit.

Depending on how much heat is required and how much solar power available, multiple solar panels can be connected in series to achieve a water inlet temperature into the MED system of 75-80°C.

5 Bill of Materials

5.1 General

General Materials required both for the solar panels and the MED-Unit.

Table 1: General Supplies

Designation 1,2,3...	Quantity -	Description -	Material -	Specifications -
1	4 tubes	Sealant	Flowable Silicone	TSE397C[a)b)]
2	5m	Tubing	Silicone or similar	∅ 6mm (outer)

[a)] Suggestion for Prototype. For final product, use any cheap silicone.

[b)] E.g. from www.conrad.de, Art.No.: 532602 - 62

5.2 For Solar Panels

Components for One Solar Panel

5.2.1 Metals

Metal Raw-Materials

Table 2: Metallic Components for one Solar Panel

Designation 1,2,3...	Quantity n	Description -	Material -	Geometry /mm
1	4	Square Rod	EN AW-6060[a)]	10x4x990
2	2	Sheet	EN AW-6082[b)]	1000x1000x0.8

[a)] AlMgSi0,5

[b)] AlMgSi1

5.2.2 Accessories

Screws, Nuts, etc.

Table 3: Accessories for one Solar Panel

Designation 1,2,3...	Quantity n	Description -	Standard -	Geometry /mm
1	50	Blind Rivet (flat head)	Al/St	∅: 3, length: 10
2	2	3D-printed in-/outlet fitting	ABS	Appendix

5.3 For Multiple Effect Destillation Unit

5.3.1 Metals

Metal Raw-Materials

Table 4: Metallic Components for one MED Unit[a)]

Designation 1,2,3...	Quantity n	Description -	Material -	Geometry /mm
3	3	Sheet	EN AW-6082	1000x120x0.8
4	4	Square Rod	EN AW-6060	10x8x1000
5	4	Square Rod	EN AW-6060	10x8x100
6	20	Square Rod	EN AW-6060	10x8x50

[a)] An N Effect Desalination System consists of N+1 MED-Units (see Figure 2).

5.3.2 Systems

Systems and components for the MED Unit

Table 5: Systems for the MED Units

Designation 1,2,3...	Quantity n	Description -	Standard -	Requirements /mm
1	1	China Vacuum Pump	N/A	neg. Press: <0.3bar Voltage: 12V Flow: >1LPM E.g.: Aliexpress

5.3.3 Accessories

Screws, Nuts, etc.

Table 6: Accessories for the MED Units

Designation 1,2,3...	Quantity n	Description -	Material -	Geometry /mm
1	26	Blind Rivet (flat head)	Al/St	∅: 3 length: 25
2	40	Blind Rivet (flat head)	Al/St	∅: 3 length: 6
2	20	Pneumatic connector[a)]	any metal	sideA: 6mm tube sideB: M5 thread

6 Procurement

7 Manufacturing

7.1 General

7.1.1 Sealing

The Solar Panel and the MED-Units both are comprised of sheets of metal separated with recangular rods. Between each rod and sheet, appropriate sealant is to be provided as shown in Figure 3.

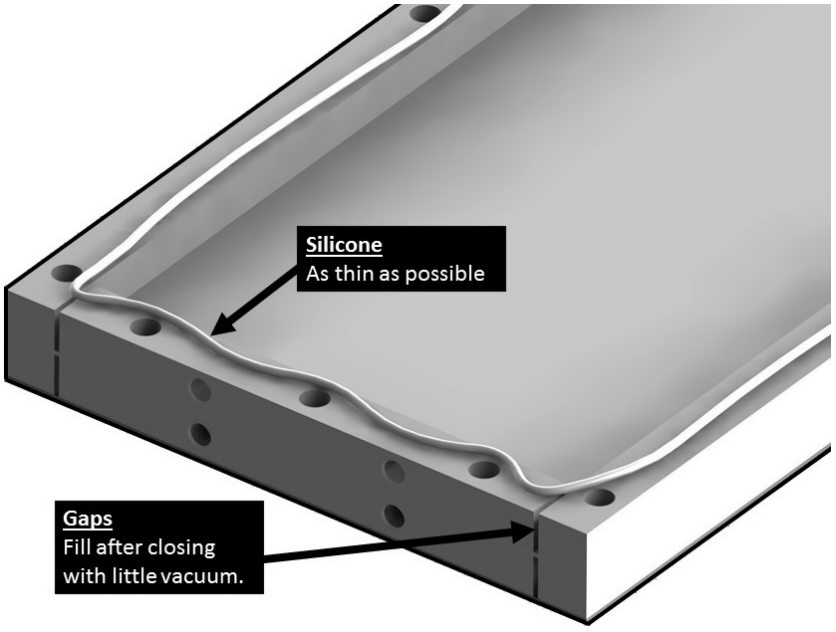


Figure 3: Sealing the MED Unit with Silicone

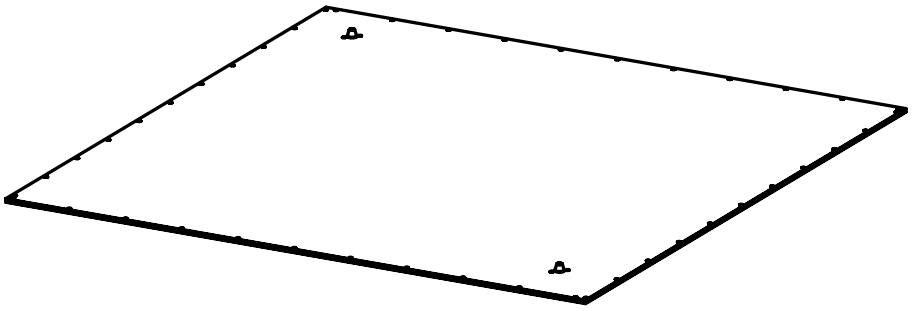
The sealing result can be improved/ corrected by pulling a (light) vacuum on the closed and sealed chamber and applying sealant from the outside.

7.2 Solar Panels

The Solar Panels (Assembly Part Name: ow-sp-a-sp) are built from two sheets (upper and lower) of aluminum sheet metal (ow-sp-s-usls) separated by aluminum rods (ow-sp-s-ro). Diagonally two fittings (ow-sp-s-ft) are inserted to form an in-/ outlet for water. The sheets and rods are drilled to fit either M5 screws or D5 blind rivets.

Name: ow-sp-a-sp-01
Open Water
Solar Panel
Assembly
Solar Panel
v01

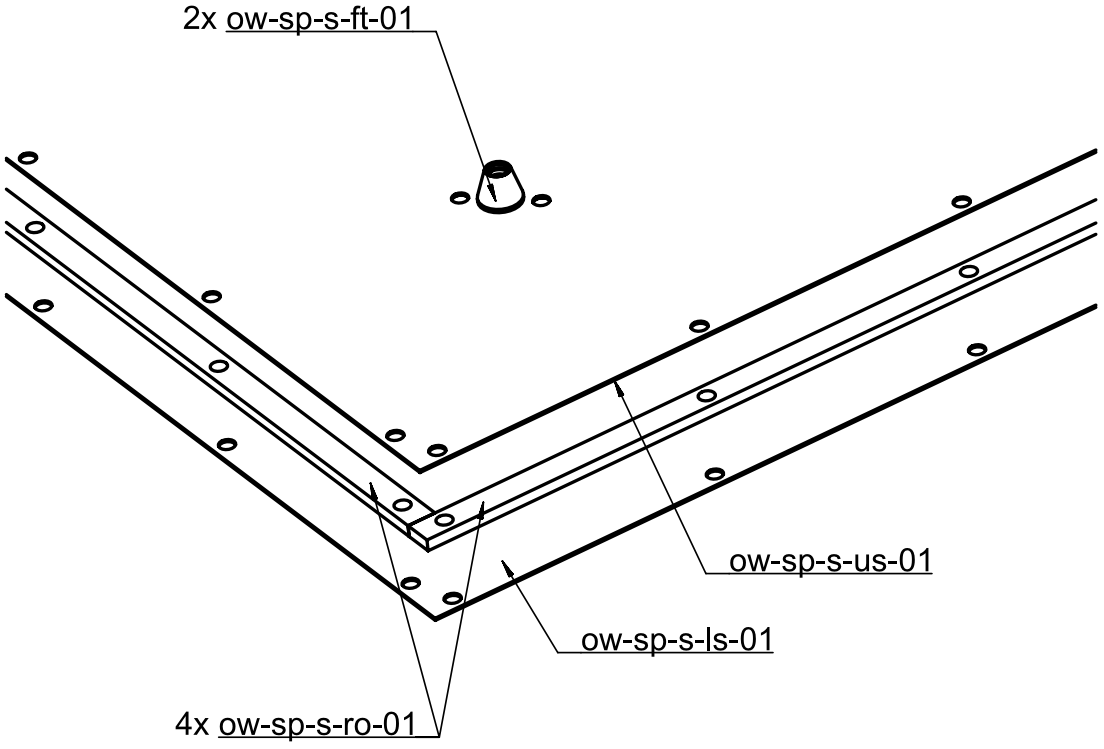
(1:10)

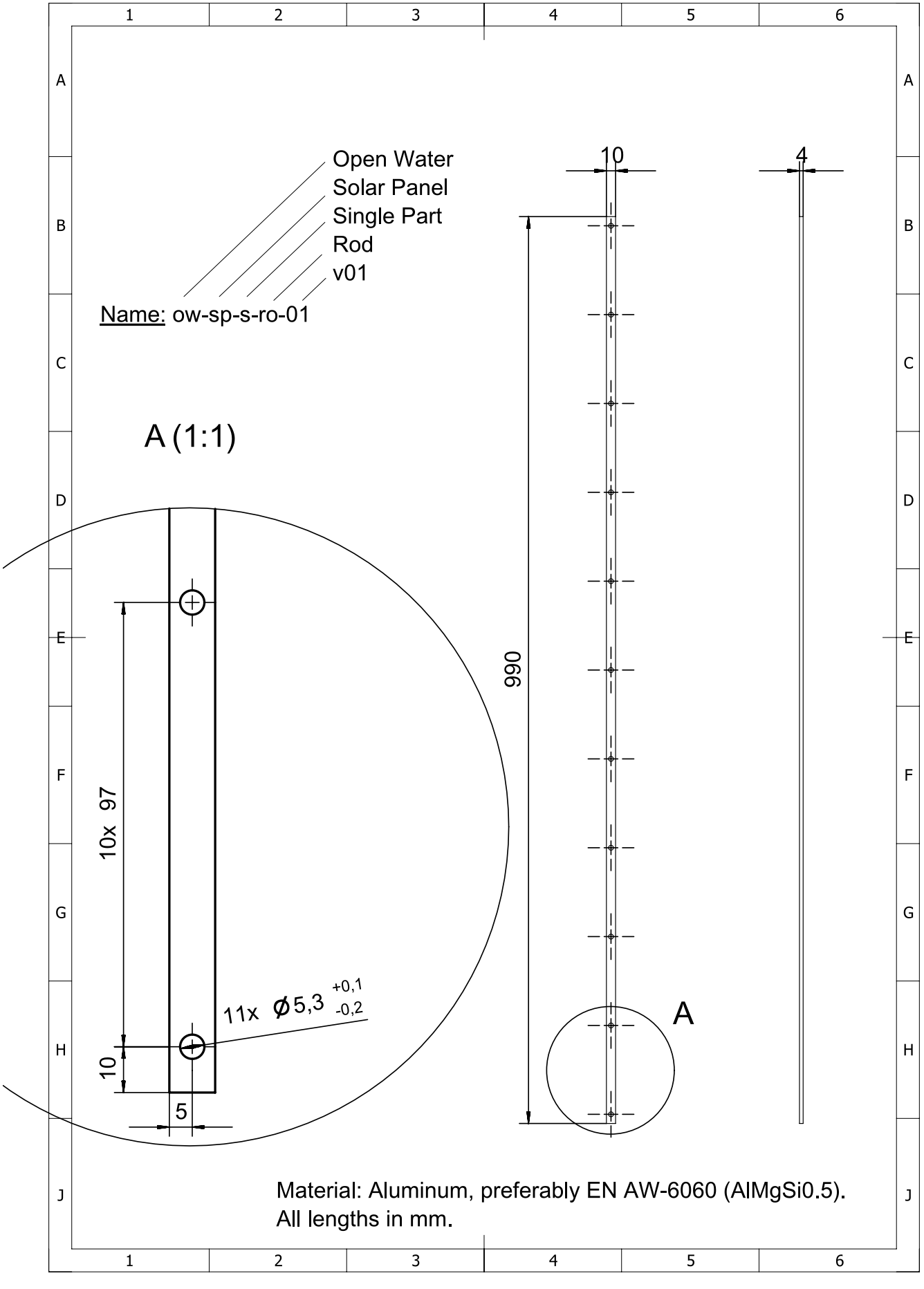


Note:
Fittings are larger than the rods.
Sheets will bulge around the fitings.

Note:
Seal as shown in general section

(1:2) Exploded View




Open Water
Solar Panel
Single Part
Rod
v01
Name: ow-sp-s-ro-01
A (1:1)
10x 97
11x Ø5,3 +0,1 -0,2
10
5
990
10
4
A
Material: Aluminum, preferably EN AW-6060 (AlMgSi0.5).
All lengths in mm.

Material: Aluminum,
preferably EN AW-6081
(AlMgSi1).
All lengths in mm.

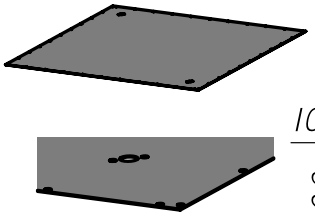
(1:10)

Name: ow-sp-s-us/ls-01
OpenWater
Solar Panel
Single Part
(Upper/Lower) Sheet
v01

1000

1000

0,8



G (1:1)

2x 2x Ø5,3

25

Ø14

141 +5 -5

90°

4x 11x Ø5,3

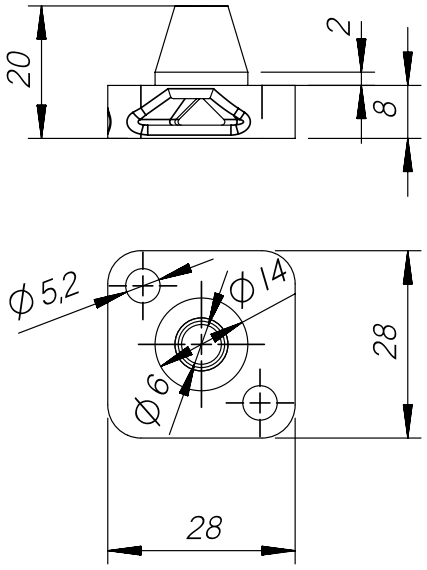
4x 10x 97

45°

5

10

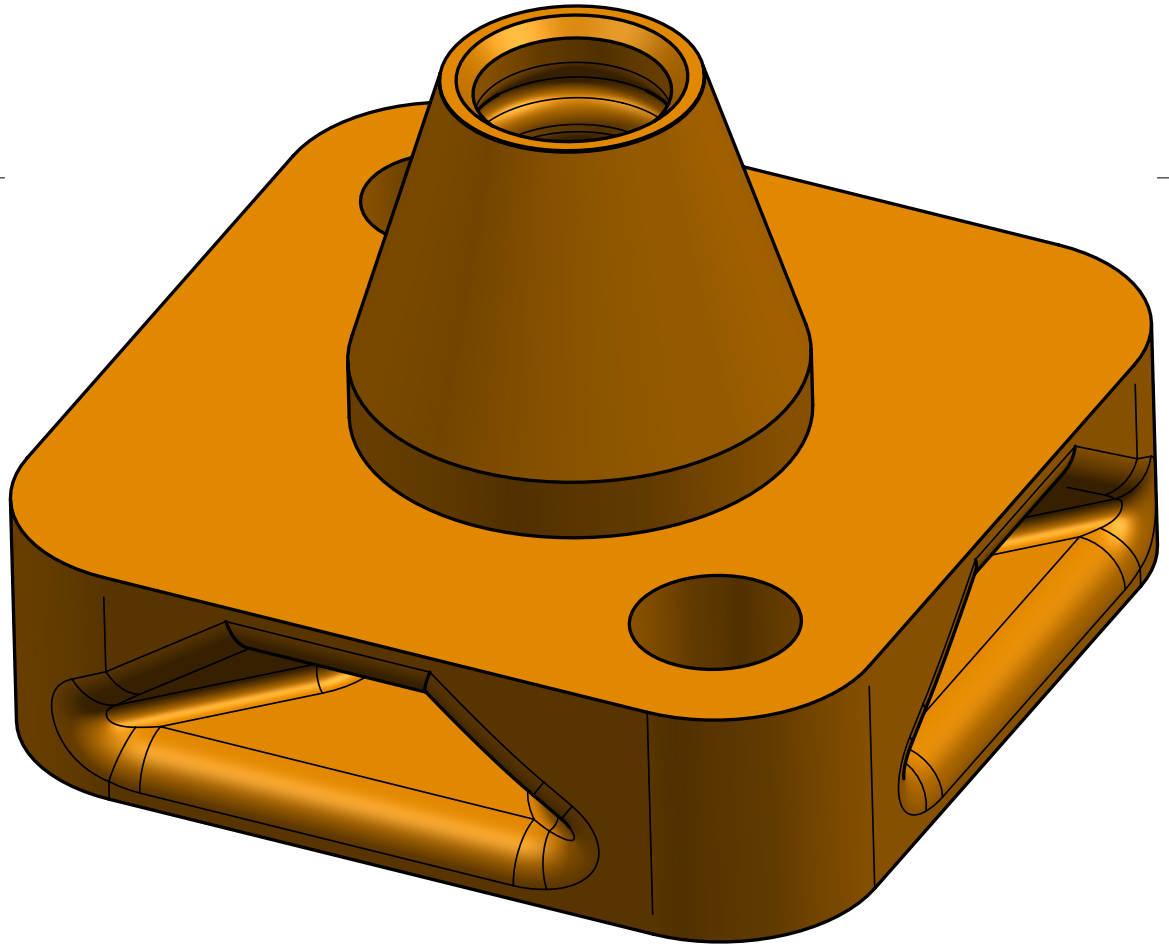
Note:
Ø14 holes only for
"upper sheet". Not for
"lower sheet".



Material: 3D- printed Plastic,
Temperature resistant to 100°C
E.g. ABS
All lengths in mm.

OpenWater
Solar Panel
Single Part
Sheet
v01

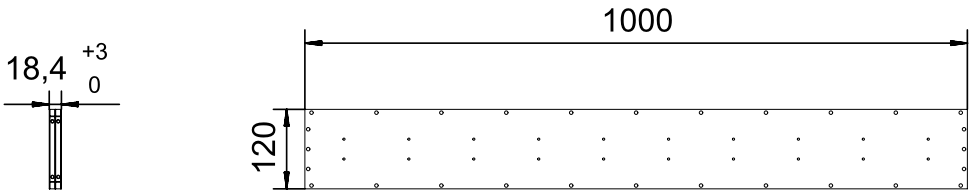
Name: ow-sp-s-ft-01
Refer to ow-sp-s-ft-01.stl (or -.step)

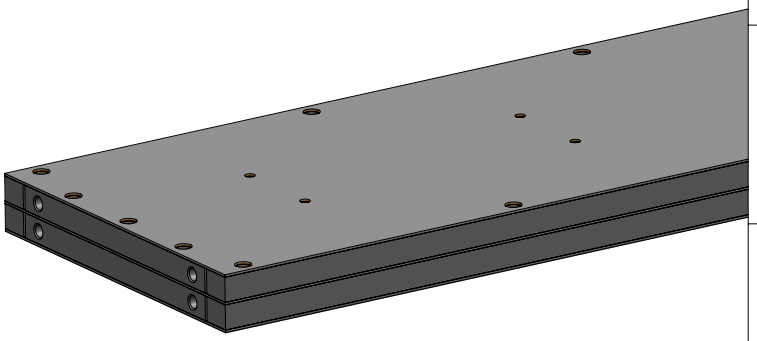


7.3 MED-Unit

The MED-Units (Assembly Part Name: ow-mu-a-mu) are built from three sheets of aluminum sheet metal (two outer: ow-mu-s-so, one middle: ow-mu-s-sm) separated by aluminum rods (long: ow-mu-s-rl, short: ow-mu-s-rs). Riveted (D3,2) to the outer sheets are ten distance pieses (ow-mu-s-dp) to limit the sheet deformation due to vacum.

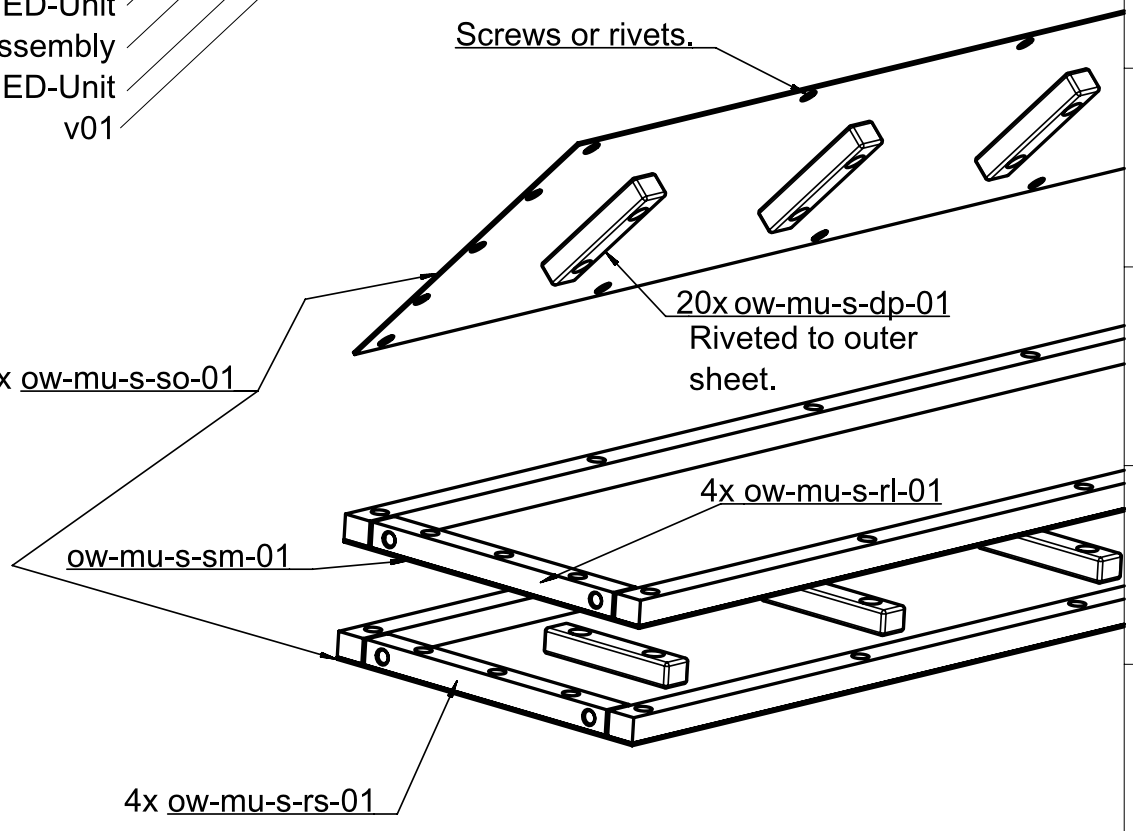
The sheets and rods are drilled to fit either M5 screws or D5 blind rivets.

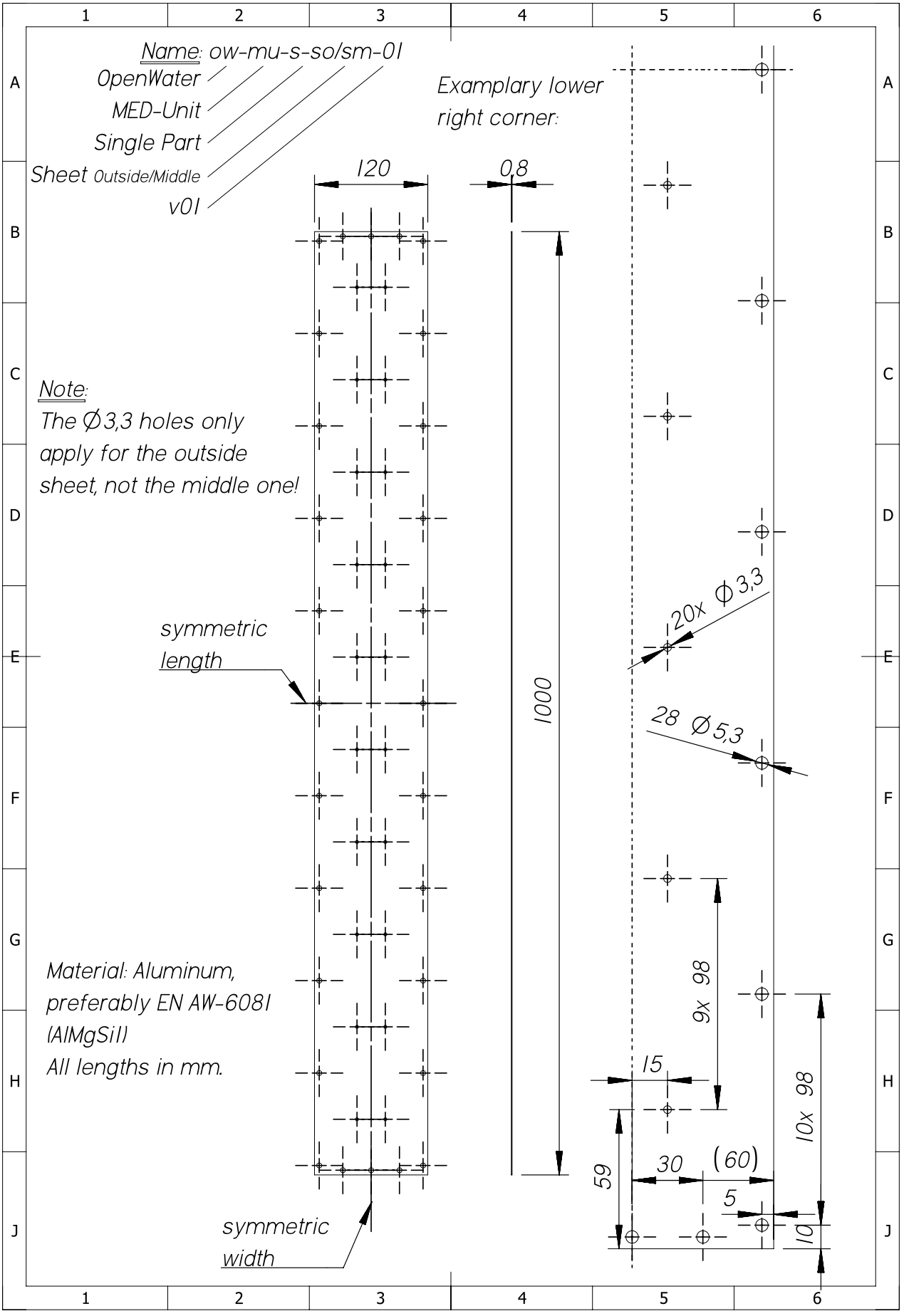


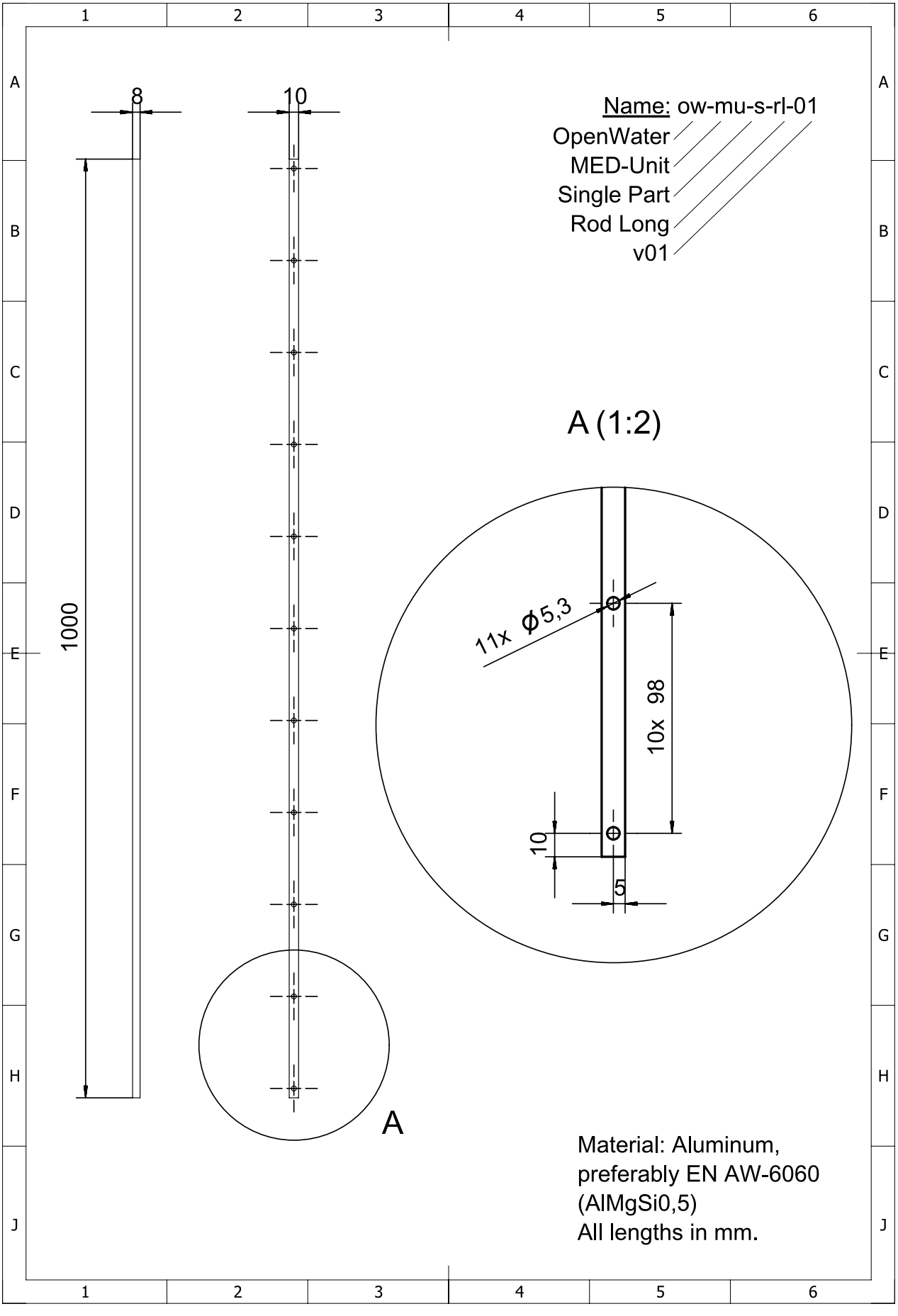


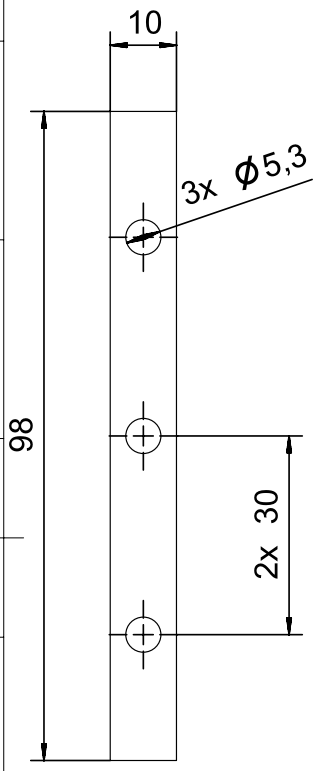
Name: ow-mu-a-mu-01
OpenWater
MED-Unit
Assembly
MED-Unit
v01

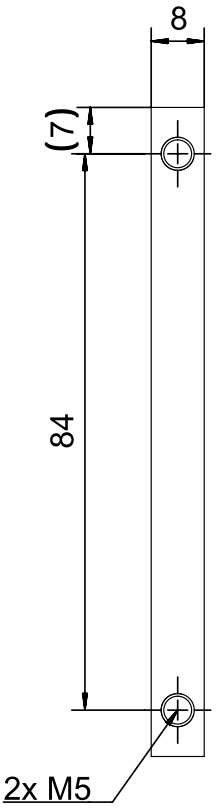
Seal as shown in general section.




Name: ow-mu-s-so/sm-01
OpenWater
MED-Unit
Single Part
Sheet Outside/Middle
v01
Examplary lower right corner:
120
0,8
1000
Note:
The Ø3,3 holes only apply for the outside sheet, not the middle one!
symmetric length
20x Ø3,3
28 Ø5,3
9x 98
15
10x 98
59
30
(60)
5
10
symmetric width
Material: Aluminum, preferably EN AW-6081 (AlMgSi1)
All lengths in mm.


1
2
3
4
5
6
A
B
C
D
E
F
G
H
J
8
10
1000
Name: ow-mu-s-rl-01
OpenWater
MED-Unit
Single Part
Rod Long
v01
A (1:2)
11x ϕ5,3
10x 98
10
5
A
Material: Aluminum,
preferably EN AW-6060
(AlMgSi0,5)
All lengths in mm.

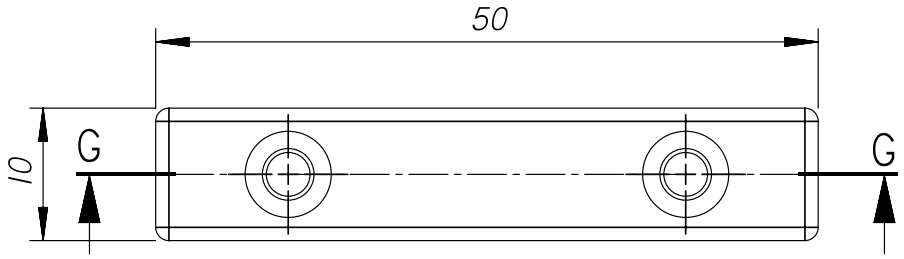


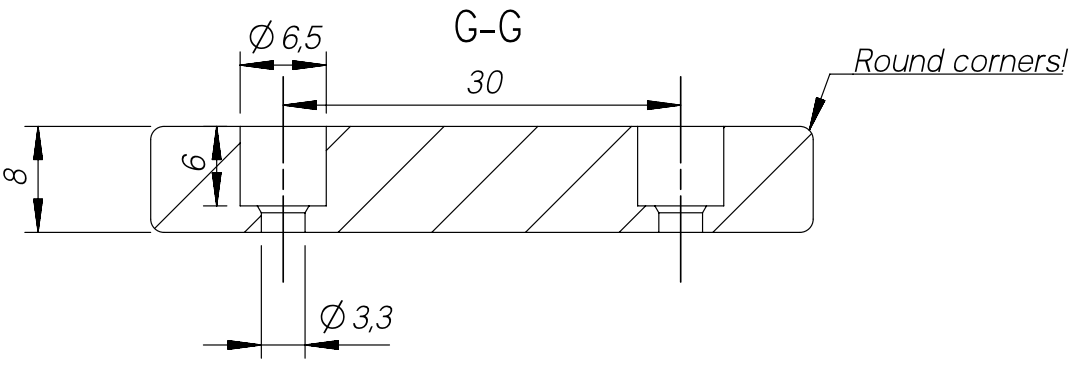


Name: ow-mu-s-rs-01

OpenWater
MED-Unit
Single Part
Rod Short
v01

Material: Aluminum,
preferably EN AW-6060
(AlMgSi0,5)
All lengths in mm.





Name: ow-mu-s-dp-01

OpenWater
MED-Unit
Single Part
Dist. Piece
v01

Material: Aluminum,
preferably EN AW-6060
(AlMgSi0,5)
All lengths in mm.

8 Operation

Still to be documented.

9 Maintenance

Still to be assessed.