



Building instructions for a radiation shield



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1.Introduction

What is a radiation shield and why do we need it?

A radiation shield is required to host a thermometer. Have you ever touched a metal surface (such as a car) standing in the blazing sun in the summer? The surface is a lot warmer than the air surrounding it! The same happens with a measuring device. When positioned in the sun, it heats up because it absorbs shortwave radiation. However, if you want to measure the air temperature you need to avoid direct radiation on the thermometer. Therefore, we have to make sure that the measuring instrument is protected from direct sunlight.

Now imagine the car was in a closed tent to protect it from the radiation. In the tent, it also becomes warm and stuffy.

Therefore, while we need a protection from radiation, the measurement instrument must be well ventilated.

Look at the design of the radiation shield on the front page: It keeps solar radiation from reaching the instrument inside but it allows air to flow through and reach the thermometer.

The radiation shield is white because white reflects the shortwave radiation best and the radiation shield does not heat up as much.

The device we use to measure the temperature in the radiation shield in our example is called an iButton. However, there are other small devices to measure temperature, which can be used as well. The iButton not only measures the temperature, it also stores the measured data, so we can measure temperature continuously and automatically. Since it is quite small, a small radiation shield is quite sufficient.

Here we explain how to build a radiation shield.





In the picture, you can see how small an iButton is compared to a 50 cent coin.





2. The pages to take to the hardware store

2.1. List of materials

- 1. 5x plant saucer, plastic, diameter 8 cm (see picture below)
- 50 cm white plastic tube, inner diameter: 0.5 cm, outer diameter: 0.7 cm
- 3. 1x aluminum flat bar 1.5 cm wide 0.2 cm thick 30 cm long
- 4. 10 cm white plastic tube, inner diameter: 0.8 cm, outer diameter: 1 cm
- 5. 1x cable tie
- 6. 1x Styrodur panel about 5x5 cm
- 7. 1x paper clip
- 8. A temperature sensor, e.g. an iButton

Bolts and nuts:

- 1. 1x M6x30 bolt
- 2. 4x M4x60 bolt
- 3. 4x fitting nut (M4)



In the picture, you can see one of the plastic plant saucers required to build the radiation shield.





2.2. List of tools

- 1. A cordless screwdriver
- 2. Drill bits of 3 mm, 4 mm, 6 mm, and 7 mm diameter
- 3. A 40 mm hole saw (attachment for the cordless screwdriver, shown in the picture below)
- 4. A fine saw
- 5. Scissors
- 6. A ruler or folding rule
- 7. A sharp pencil
- 8. A pointed knife
- 9. A hot glue gun
- 10.A compass (to draw circles)
- 11.A hacksaw
- 12.Possibly superglue
- 13.A screwdriver, wrench bit, or ratchet for each of these:
- 14.the big bolt
- 15.the four small bolts
- 16.the four nuts



This is an example of a hole saw attachment for a cordless screwdriver.





2.3. Replacement options

Not all hardware stores stock all things you need. Therefore, we made a short list showing what can be used as a replacement for missing things and what needs to be considered.

The plant saucer:

The plant saucers are probably the items most difficult to get. At the same time, they are the most difficult to replace. They can be a little bigger, but make sure that they are really "white", or "sand" or "cream". The light color is important, as described in the introduction!

The tubes:

The tubes can be replaced by somewhat smaller or bigger ones. However, there are some issues to consider:

- The small tube needs to fit into the big tube!
- The long M4x60 bolts need to fit loosely into the small tube!
- The short M6x30 bolt must fit tightly into the small tube so that it cannot be pulled out. If it is not completely tight, you need a drop of glue.
- The drill holes have to be adjusted to the diameter of the bolts.

The bolts:

Bolts may also be replaced if the points relevant to the tubes are considered. However, the long bolt must be 60 mm long. The short one may be somewhat shorter or longer than given in the list, if it still fits tightly into the small tube. The kind of bolt head is not important as long as you have the right tool to tighten it.

The aluminum bar:

The aluminum bar has to be adjusted anyway so that it fits the way you want to hang the radiation shield! The material, width and thickness may also vary as long as the holes for the bolts can still be drilled safely into the bar.

The Styrodur:

Regarding the Styrodur, it is important that the material is firm and stable. You can also use a packaging material or something similar. However, the material must have good insulating properties.

Styrofoam or other coarse-grained materials are not very suitable, since they are very crumbly and, therefore, microplastics can be released into the environment!





3.List of parts to be build

You can lay down the next two pages and place each completed part onto the photo. When all parts are completed, you can continue!





1x aluminum bar (caution, not shown in original size)







1x bottom disc

1x top disc

3x middle disc



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4. The tubes

You need:

- 1. The tube with inner diameter 0.5 cm and outer diameter 0.7 cm
- 2. The tube with inner diameter 0.8 cm and outer diameter 1 cm
- 3. A cable tie

And tools:

- 1. The cordless screwdriver
- 2. The drill bit with a diameter of about 3 mm
- 3. The fine saw
- 4. The scissors
- 5. The ruler or folding rule
- 6. The sharp pencil

4.1. The central tube



This tube sits in the center of the radiation shield. The tube with the iButton will be sled over this tube. Finally, the paper clip will keep everything in its place when it is put through the hole.

- You will need the tube with the inner diameter of 0.5 cm and the outer diameter of 0.7 cm, the ruler, the pencil, and the fine saw.
- Measure 10 cm from the pipe and mark this point.
- Saw off the tube at the mark using the fine saw.
- Mark a point 1.5 cm from one end of the tube.
- At this mark, drill a hole straight through the tube using the 3 mm drill bit.
- You can now put the tube to the completed parts.

Tip:

Clamp the tube or fix it with a screw clamp on the table, then you can work easier and do not hurt yourself!





4.2. The pull-over tube



The pull-over tube will be pulled over the central tube. It is removable, so that the iButton can be taken out and data can be read.

- You will need the tube with the inner diameter of 0.8 cm and the outer diameter of 1 cm, the cable tie, and the iButton. Of the tools you will need the scissors, the fine saw, the ruler, and the pencil.
- Measure a 5.5 cm piece from the tube and saw it off.
- Then you attach the iButton to the tube using the cable tie. Cut off the extra piece with scissors.
- You can now put the tube to the completed parts.

4.3. The spacers



Tip:

Take a close look at the saw. If it has a very thick saw blade, it is better to measure and saw the twelve pieces one after the other. Otherwise, the pieces become too short by the thickness of the saw blade. You need these twelve spacers to separate the discs from each other.

- You will need the tube with an inner diameter of 0.5 cm and an outer diameter of 0.7 cm, the ruler, the pencil, and the fine saw.
- Measure twelve 1.5 cm sections and mark them with the pencil.
- Saw off the twelve spacers.
- You can now put the twelve pieces to the completed parts.

Tip: Make sure that the tube sections are as accurate as possible to 1.5 cm! Otherwise, the radiation protection will become crooked!





5. The discs and the aluminum hanger

You need:

- 1. The 5 plant saucers
- 2. The Styrodur
- 3. The aluminum bar

And Tools:

- 1. The cordless screwdriver
- 2. The drill bit with 4 mm diameter
- 3. The drill bit with 6 mm diameter
- 4. The drill bit with 7 mm diameter
- 5. The 40 mm hole saw
- 6. The sharp pencil
- 7. The scissors
- 8. The pointed knife
- 9. The hot glue gun
- 10.The compass
- 11.The hacksaw

5.1. The bottom disc



In the end, the bottom disc will be pushed onto the central tube and thus closes the radiation shield.

- You need a plant saucer, the cordless screwdriver, the 4 mm and 7 mm drill bits, the scissors, the knife, and the drilling template "bottom disc" shown below.
- Cut out the drilling template with the scissors and make a small hole in the middle of each of the five marked drill holes with the tip of the knife.





Drilling template "bottom disc"



Tip:

Before you cut out the drilling template, check that it has a diameter of 6.5 cm. If not, something has gone wrong when printing. In that case, print this page again with the print setting "Original size" or "100 %".

- Put the drill template into the plant saucer and draw a point in each of the holes you made with the knife.
- Use the 4 mm drill bit to drill a hole at each of the four outer pencil marks.
- Use the 7 mm drill bit to drill a hole at the pencil mark in the middle.
- Now you have to cut out the Styrodur disc and glue it in place. To do this, you need the Styrodur, the knife, the compass, the hot glue gun, and the knife.
- Draw a circle of about 4.5 cm diameter on the Styrodur with the compass and cut it out with the knife. (Alternatively, you can use the 40 mm hole saw here). The exact size and shape is not important here, the disc can also be smaller, larger or angular!
- Glue the cut out Styrodur part into the plant saucer using the hot glue gun.
- Finally, drill into the central 7 mm hole in the plant saucer again, so that it goes through the Styrodur.
- You can now put the bottom disk to the completed parts.





5.2. The top disc



Drilling template "top disc"



In the end, the top disc will be screwed to the aluminum hanger. It holds everything in its place.

- You need the cordless screwdriver, the 4 mm and 6 mm drill bits, the drilling template "top disc", the knife, and the scissors.
- Cut out the drilling template with the scissors and make a small hole in the middle of each of the five drilling marks with the tip of the knife.
- Put the drill template into the plant saucer and draw a point in each of the holes you made with the knife.
- Use the 4 mm drill bit to drill a hole at each of the four outer pencil marks.
- Use the 6 mm drill bit to drill a hole at the pencil mark in the middle.
- You can now put the top disk to the completed parts.





5.3. The middle discs



Drilling template "middle disc"



In the end, the three middle discs will be fixed to the top discs by the four long bolts.

- You need the cordless screwdriver, the 4 mm drill bit and the 40 mm hole saw.
- Cut out the drilling template with the scissors and make a small hole in the middle of each of the four outer drilling marks and the center of the disc with the tip of the knife.
- Put the drill template into the plant saucer and draw a point in each of the holes you made with the knife.
- Use the 4 mm drill bit to drill a hole at each of the four outer pencil marks.
- Use the 40 mm hole saw to cut a hole at the pencil mark in the middle.
- Do the same with the other two middle discs.
- You can now put the three middle disks to the completed parts.





5.4. The aluminum hanger



(Caution, the aluminum bar is not shown in its original size)

In the end, the radiation shield will be mounted to something by the aluminum bar. Therefore, its shape and length may have to be adjusted.

- You need the aluminum bar of 2 mm thickness and 1.5 cm width, the hacksaw, the cordless screwdriver with 4 mm and 6 mm drill bits, the ruler, the pencil, the drilling template "top disc", and the scissors.
- Measure 30 cm from the aluminum bar and mark it with the pencil.
- Saw off the aluminum bar at the mark using the hacksaw.
- At one end of the bar, the top disc will be fixed. Therefore, you can use the drilling template "top disc", which has to be cut out along the dashed lines using the scissors:

- Now the template looks like the figure above and fits on the aluminum bar.
- Move the template to one end of the aluminum bar and mark the three drilling holes.
- Drill the two outer holes with the 4 mm drill bit and the hole in the middle with the 6 mm drill bit.

Tip:

Make sure to use a metal drill bit for the aluminum! You can recognize it by the fact that the tip looks more like this in cross-section,







- The other end of the bar is the end with which you fix it to a wall, a beam, a tree, or similar. On that end of the bar, you must therefore drill holes the way you need them! But it is practical, if you do it like this, for example:
 - Put your ruler on the end of the bar and make a mark at 3 and at 8 cm, respectively
 - At both marks, put the ruler rectangular to the bar and mark the middle of the bar.
 - Use the 4 mm drill bit to drill a hole at both marks.
- Now, the aluminum bar has to be bent.
- Put a mark 10 cm from the end with the two holes (<u>not</u> the end with the three holes).
- Place the bar over an edge, e.g. the edge of a table and bend it carefully until it has a right angle.
- You can now put the aluminum hanger to the completed parts.





6. The assembly

You need:

- 1. All completed parts!
- 2. The paper clip

And tools:

A screwdriver, wrench bit, or ratchet for each of these:

- 1. the big bolt
- 2. the four small bolts
- 3. the four nuts
- and possibly superglue

6.1. The central tube



- Here, you attach the cantral tube and the top disc to the aluminum bar.
- You need the screwdriver, wrench bit or ratcher for the big bolt.



- Use the big bolt to attach the top disc to the aluminum hanger by screwing it through the hanger into the central tube.





Now the assembly of the radiation shield can begin!



6.2. The discs

- Here, the other discs and the temperature sensor (iButton) are added to complete the radiation shield.
- You need the screwdriver, wrench bit or ratcher for the long bolts and for the nuts.
- Put the four long bolts through the four outer holes in the top disc, which has been attached to the aluminiium bar in the previous step.
- Alternately, put the spacers and the middle disks onto the long bolts as shown in the figure.
- After the third middle disc, screw the nuts onto the long bolts.
- Pull the pull-over tube with the iButton over the central tube.
- Put the bottom disc on the central tube and close the radiation shield by threading the paper clip through the hole in the central tube.
- You can see if everything looks right by looking at the picture on the front of the manual.
- Now you can install the temperature sensor (iButton) with its radiation shield in a place you want to measure the air temperature.



