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Hydraulic

5 MODELS

Welcome to the world of fischertechnik ROBOTICS!

Hello!

We are happy that you have chosen the “PROFI Hydraulic” construction kit of fischertechnik. This construction kit helps you learn the basics of hydraulics.

You will be gradually introduced to the topic of Hydraulics by reading through this didactical information and by testing out the different models. We wish you lots of fun and success for experimenting with the “PROFI Hydraulic” kit.

Your team of

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Some general information

Before we get started with the construction kit, you must know a few things. The components that we work with may be very robust, but if not treated correctly, they can get damaged in some situations.

The hydraulics

You encounter pressurised liquids every day and almost everywhere. As soon as you open the tap, you come in contact with hydraulics. Because the water reaches you only through the pressure in the water line, e.g. on the 3rd floor.

Nowadays, hydraulics is used in many construction and industrial machines. Hydraulic power transmission helps, for example, to move the arm of an excavator. If something needs to be compressed in the industry, hydraulics are frequently used since a lot of power can be used very purposefully.

The word Hydraulics originates from the ancient Greek words “hydro” and “aulos” and means “water” and “pipe”. Thus, hydraulics stands for the science of the flow behaviour of liquids. Hydraulics is all about pumping liquids to and fro in a closed circular flow and to perform mechanical work in this manner.

Benefits of hydraulics

The benefits of hydraulics are

- Pressurised liquids can be stored
- Pressurised liquids can be transported over long distances without great pressure loss
- The pressure on liquids is maintained for a relatively long time and hardly changes
- No power is lost during any movements
- Hydraulic cylinders help to make many movements without elaborate mechanism
- A high positioning accuracy can be achieved
- It is possible to generate high powers and torques
- Uniform movements can be made easily

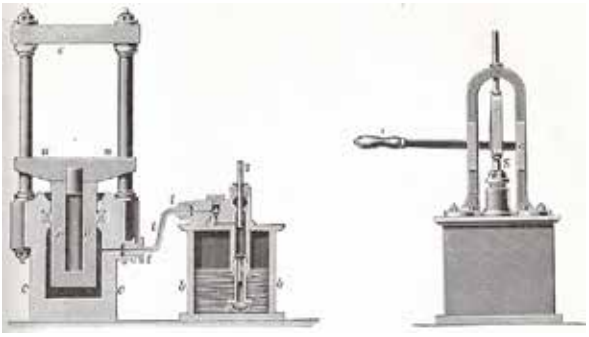
We would like to illustrate these benefits and lots of other interesting information with the PROFI Hydraulics construction kit.

In addition, we would like to show you how hydraulic components function. For this purpose, we will give you a step-by-step explanation on the individual components and will show you how they function.

Moreover, the construction kit contains numerous model cases that show the method of using hydraulics.

A little history

During the 18th century, the Englishman Joseph Bramah invented the first hydraulic press powered by water pressure, which worked according to the hydrostatic law by Blaise Pascal. The so-called Bramah Press worked such that a piston was pressed and the resulting power was multiplied.



Press invented by Joseph Bramah in 1795 in London

Joseph Bramah pressed down the piston of a water-filled cylinder with a lever and with less effort. The resulting pressure on the water was then passed on to other cylinders and was thereby strengthened. At the end, an object with great power was compressed.

Since the middle of the 20th century, the hydraulics have been used in agricultural machinery and tools such as excavators and forklifts. Be it the movement of the excavator's arm or the forks of the forklift are hydraulically moved upwards.

Even in the industry, more and more work processes are being supported by hydraulics. For example, large presses are moved by hydraulic power to bend sheets for automobiles.

Automatic doors in building, buses and trains are slowed down by hydraulic cylinders so that they cannot bang shut.

As you can see, many areas of our everyday life is supported and simplified by hydraulic drives.

Hydraulic systems and components

- A hydraulic system comprises **four** sub-systems:
- Liquid storage
- Liquid pressure generation
- Liquid distribution
- Generation of movement

Liquid storage

In large machines, the hydraulic oil is stored in containers or tanks.

In our case, the hydraulic liquid is water and is saved in the hoses.

Liquid pressure generation

The pressure of the liquid is generated in hydraulic machines by a hydraulic pump.

The pressure for the models of the PROFI Hydraulic construction kit is generated by pressing down the control cylinder. This is a simplified hydraulic system.

Liquid distribution

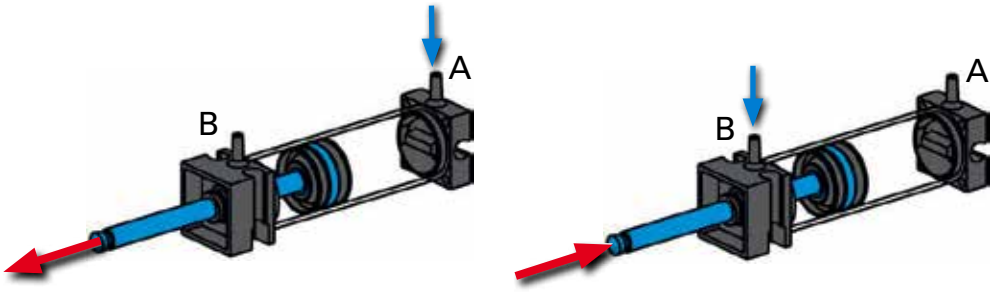
In hydraulic systems, the path of the liquid is controlled by valves, led by different hoses and thus, reaches the working cylinder that is to be moved.

The models of the PROFI Hydraulic construction kit work without valves, because a control cylinder is always directly connected to each working cylinder. This is a simplified hydraulic system.

Generation of movement

To generate movements with liquids, we use hydraulic cylinders. The blue piston rod is movable and the cylinder is sealed. If water is pressed into the cylinder by one of the two hose connectors, the piston rod moves.

The connector over which the piston rod can be extended is known as Connector A, the connector for retraction is known as Connector B.

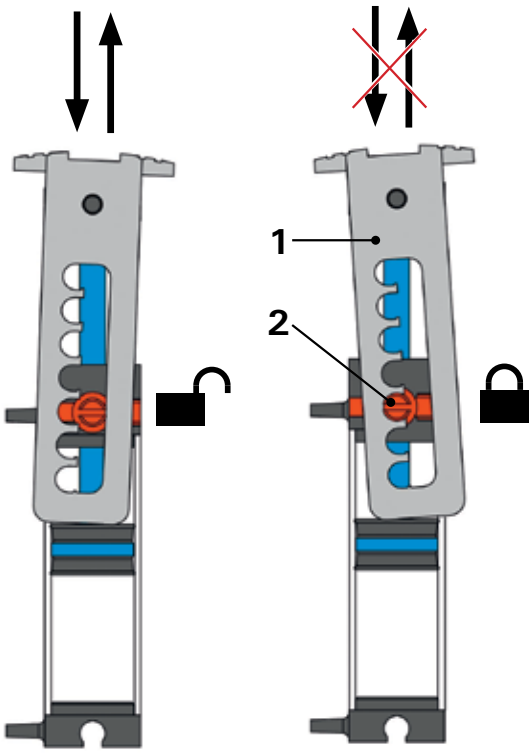


Simplified fischertechnik hydraulic system

The control cylinder

Most of the times, the control cylinder is filled and extended with liquid - water, in our case - at the beginning. Now as soon as pressure is exerted on this cylinder from above, the water is squeezed out of the cylinder. The water then flows through the connected hose into the next cylinder or into the water tank or in the open.

The latch bar on the control cylinder



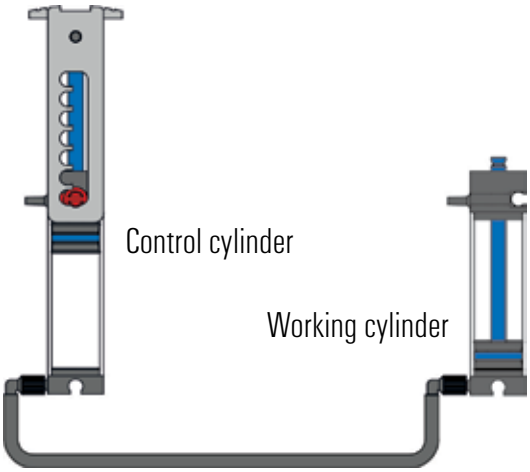
You may use the latch bar (1) to fix the control cylinder at a desired position. This works simply by snapping the latch bar (1) in the strut adapter (2).

With the latch bar locked in this way, the control cylinder and even the working cylinder are fixed at the desired position. Now, both the cylinders can neither be retracted nor extended.

Here's an example: You can use this function for the Crawler Excavator model to lock the heavy excavator arm at a desired position. Without this function, the heavy excavator arm would push the working cylinder back again, as soon as you release the control cylinder.

The working cylinder

This cylinder is mostly empty and retracted at the beginning. Now, as soon as pressure is exerted on the control cylinder and water thus flows from the control cylinder into the working cylinder through a hose, the working cylinder is automatically extended and filled with water. The working cylinder is filled with water just as quickly as the control cylinder is emptied.

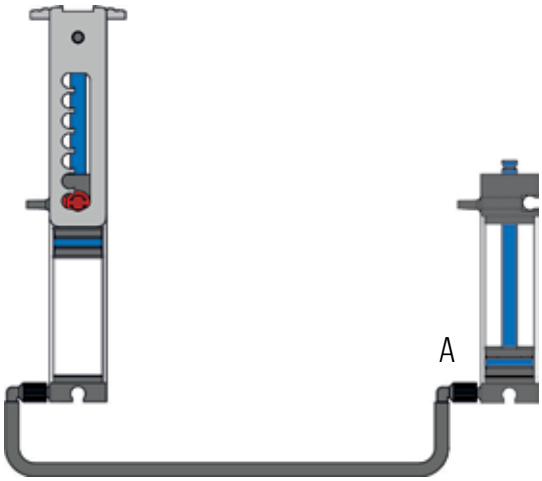


Fill the cylinder with water

And here's how:

1. Take a control cylinder and retract it completely.
2. Fix a hose with suitable length on Connector A.
   Tip: The suitable hose length for the respective model is described in the Assembly Instructions.
3. Immerse the open end of the hose in a vessel with water (distilled water is perfect).
4. Hold the cylinder such that the connector with the attached hose points upwards (see illustration).
5. Now, slowly pump the water through the hose into the cylinder and out again.
   Repeat this a few times till no air bubble is seen at the upper end of the cylinder.

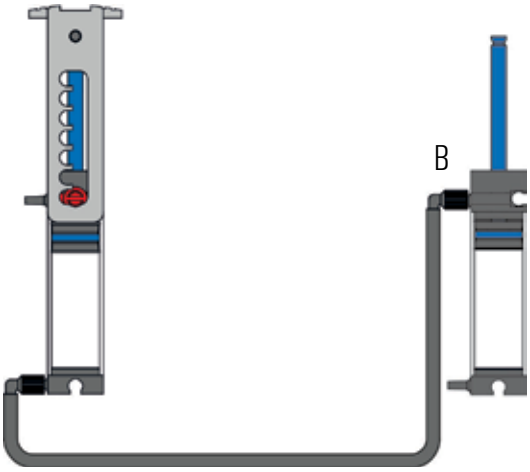
6. Now, before you take the open hose end out of the water and connect it to your working cylinder, you must retract the working cylinder completely.
7. Then, attach the hose end on the lower inlet (Inlet A) of the working cylinder. Done!



You can now pump water out of the control cylinder into the working cylinder to and fro, as often as you like.
If you have done it well, the system will contain hardly any air.

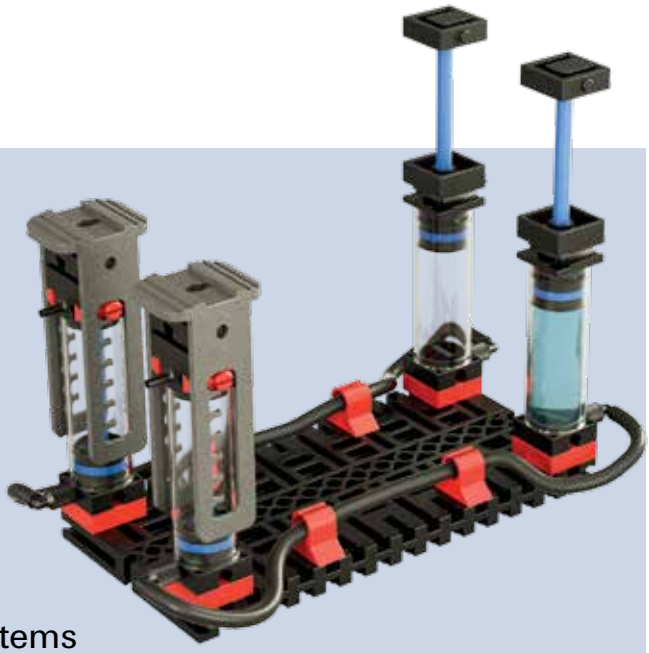
Note: Speciality of the Piste Basher model

In the Piste Basher model, the hoses are connected to Inlet B in three working cylinders (H2, H4 and H8). In this working cylinders, the piston rod must be **extended** completely before you connect the hose to Connector B.



Hydraulic functional models

Demo model



Trial:

Take four cylinders, connect two each to one hose and fill a system with water, as described in the last chapter. The other should be filled with water, this means that you must connect a hose only to the control cylinder and the working cylinder. Attach your two systems on a small base, as given in the demo model. Now, compress both the control cylinders and fix them with the silver latch bars. Now try to compress both the working cylinders.

Observation:

One working cylinder in the system with air can be compressed very far. However, the working cylinder in the system with water can be hardly moved. Do you know why?

Explanation:

Gases that also include our air, can be compressed. Air even up to 300 times with relatively little effort. Liquids - water, in our case - can be hardly compressed, because liquids automatically occupy as little space as possible. On one hand, this helps the gravitational force, which pulls the liquid down and on the other hand, there is air pressure, which exerts pressure on the liquid from above and thus pushes the liquid down.

The force applied by you by pressing on the control cylinder can also be calculated by multiplying the area of the piston by the pressure exerted on the cylinder. The amount of force can be calculated by:

Force = Area x pressure or in short, F = A x p

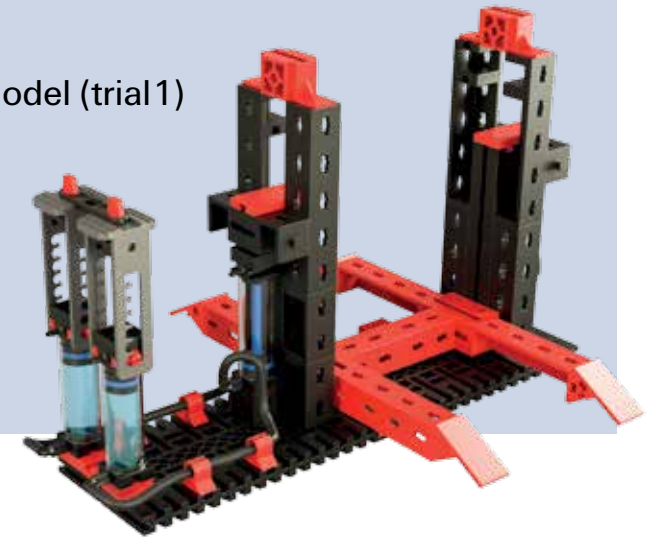
It is evident from the formula that the amount of force depends on the amount of pressure exerted on the round area in the cylinder or on the size of the round area in the cylinder. The rule is: the more the pressure, higher is the generated force.
As you have identified in your trial, the water can be hardly compressed. In case of the demo model (system with water), this means that the force exerted on the control cylinder is transferred directly 1:1 to the working cylinder.

Same is the case with the distance covered by the working cylinder. For this, we will now have a trial with the Lifting platform model.

Lifting platform model (Trial 1)

Trial:

Recreate the Lifting platform model (trial1) on the basis of the Assembly Instructions. Connect one control cylinder to one working cylinder and fill both the systems with water. Now, press down both the control cylinders at the same time.



Observation:

The lifting platform goes up as far as you press the control cylinder downwards. Now, press the lifting platform downwards, ensure that the control cylinders are not fixed to the silver latch bars. You will now see that the amount of power required to move the lifting platform downwards is equal to the power required to move it high up. Do you know why?

Explanation:

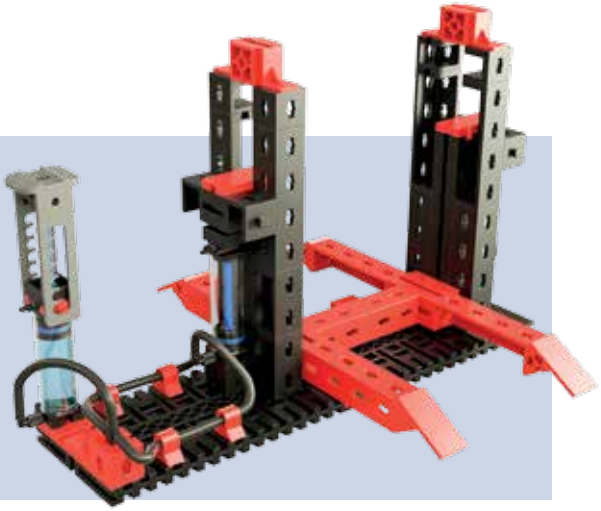
Since the water flows from a control cylinder directly into a working cylinder, the force ratio and the distance ration between the control cylinder and the working cylinder is 1:1. Once the control cylinder is pressed down completely, the working cylinder moves high up.

But now, we would like to lift a heavy car with the lifting platform using less effort.

Lifting platform model (Trial 2)

Trial:

Now, recreate the Lifting platform model (trial 2) on the basis of the Assembly Instructions. Connect one control cylinder to two working cylinders and fill the system with water.



Observation:

Once you push down the control cylinder completely, both the working cylinders travels only halfway out. If you try to lower the lifting platform again by pressing on it, you will notice the following: You require double the power to push the lifting platform downwards again than the power required to move the lifting platform up. Do you know why?

Explanation:

Since only **one** control cylinder is connected to **two** working cylinders, the water flowing out of the control cylinder must be distributed to two working cylinders.

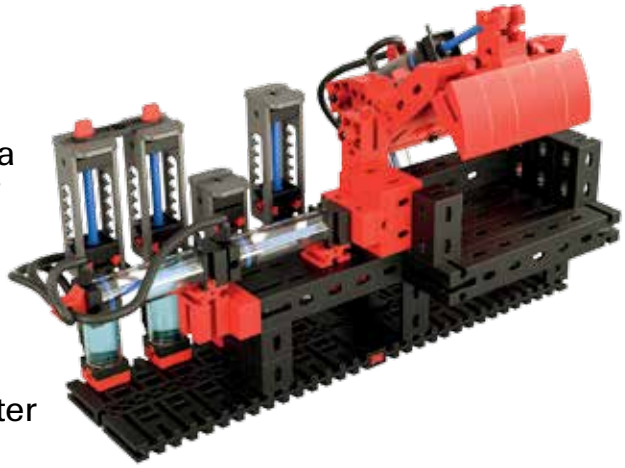
The ratio between force and distance is no longer

1:1 as in trial 1, because the piston areas and the volume of the working cylinder compared to the control cylinder are twice as large.

Thus, we have a power ratio of 1:2 in trial 2. This means that the power on the working cylinders is twice as high as the power on the control cylinder.

The opposite is true for the distance of the control cylinder and the working cylinders. The water from the control cylinder is distributed to two working cylinders. This means that only half the water arrives into every working cylinder, say only half the volume of the control cylinder. Thus, each of the two working cylinders extends only to half the distance of the control cylinder and we have a distance ratio of 2:1. The distance towards both the working cylinders is only half as much as towards the control cylinder.

Scrap baling press model



But what if you want to overcome a distance greater than the length of a cylinder? For such applications, we have the so-called telescopic cylinder. In reality, these do not come out just once, but have several parts that come out one after another. In the Scrap baling press model, this is simulated by the linking of two cylinders together.

Telescopic
cylinder on a dumper truck

Hydraulic play models

Apart from the functional models, the PROFI Hydraulic construction kit consists of two other models with exciting play functions.

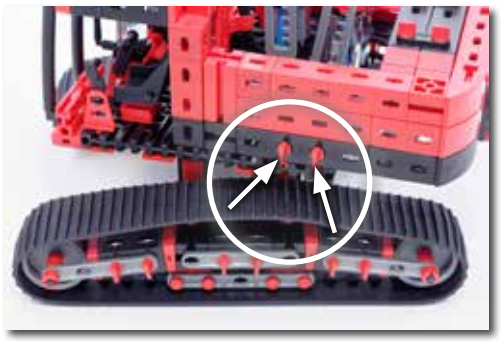
These are the realistic models

- Piste Basher
- Crawler Excavator

Crawler Excavator

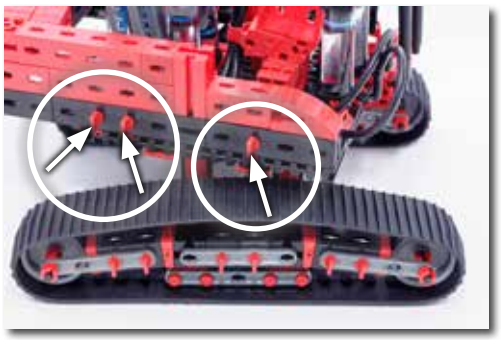
Here again, you can build closed systems with control and working cylinder. All systems are always filled with water. To make this a bit easier, here are a few tips to help you fill the crawler excavator.

Tips:



To fill, dismantle the control cylinders. And here's how:

1st Loosen and remove both the S-bolts on the left.



2nd Loosen and remove the three S-bolts on the right.

3rd Lift the complete U-shaped lining element from the excavator.

4th Dismantle the control cylinders one after the other.

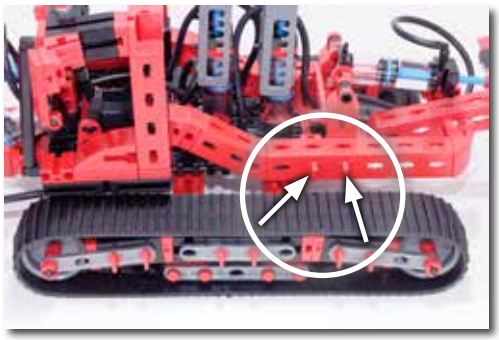
Now you can easily get to all the control cylinders to fill the individual systems with water.

The filling process is described in detail in chapter “Fill the cylinder with water”.

Piste Basher

In the Piste Basher model, you can similarly remove the side lining, so that you can reach the control cylinders better and can dismantle for filling with water.

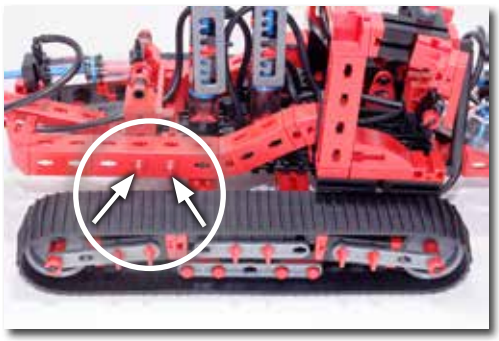
Tips:



To fill, dismantle the control cylinders. And here's how:

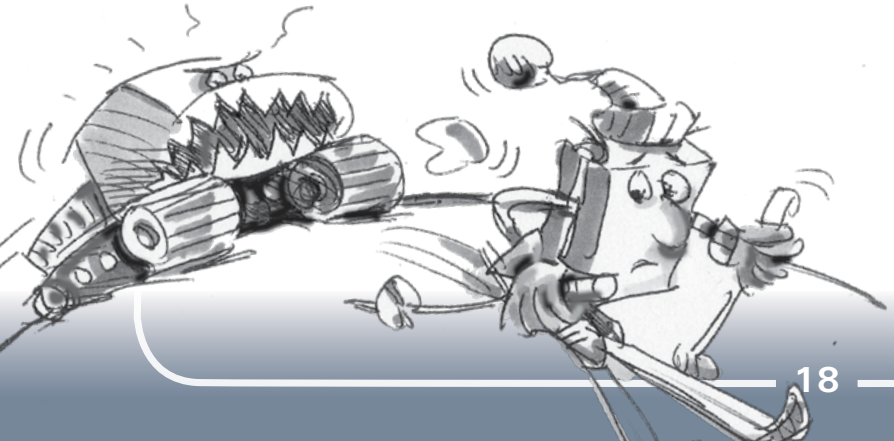
1st Loosen and remove both the S-bolts on the left.

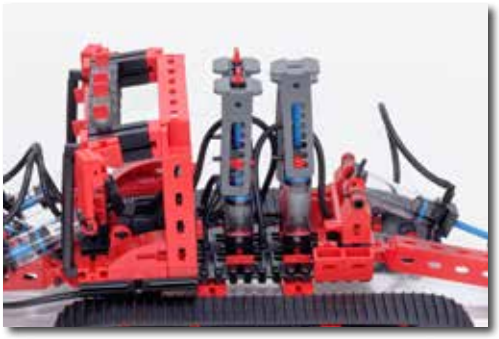
2nd Remove the complete side lining.



3rd Loosen and remove both the S-bolts on the right.

4th Remove the complete side lining.





5th Dismantle the control cylinders one after the other.

Now you can easily get to all the control cylinders to fill the individual systems with water.

The filling process is described in detail in chapter “Fill the cylinder with water”.

In reality, such machines rely on hydraulics. You have now understood how the technology works and how you can calculate the force and the distance covered by the cylinders.

Happy modelling - whether you choose to build or play!

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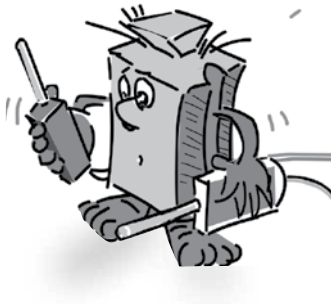
If something isn't working right



If something isn't working right in your models, then please pay attention to the following table. There, you will find a list of possible errors and associated causes of errors. Moreover, we would like to give you some tips with the table to show you how you can rectify the errors in an individual case.

Fault	Possible cause	Remedy
Movement isn't working.	• There is no water in one of the systems. • A hose is not connected.	• The system must be filled with water and ventilated. • Take the loose hose and connect it properly. Refer to the connection plan in the Assembly Instructions.
I am pushing the control cylinder but the working cylinder isn't moving.	• A hose is not connected.	• Take the loose hose and connect it properly. Refer to the connection plan in the Assembly Instructions.
I cannot move the control cylinder.	• Water is present in both, the control and the working cylinder. • The silver latch bar is fixed and does not allow the control cylinder to move. • A hose is kinked. • A hose is blocked.	• The working cylinder is emptied and only the control cylinder can be filled with water. • Loosen the fixing with the silver latch bar and try again. • Try to lay the hose in another way so that the kink in the hose disappears. • Try to locate the blocked hose and replace it (please contact fischertechnik Service: info@fischertechnik.de).

Fault	Possible cause	Remedy
Water runs out of the model.	• A hose is not connected. • A leaky hose. • A leaky cylinder.	• Take the loose hose and connect it properly. Refer to the connection plan in the Assembly Instructions. • Replace the hose (please contact fischertechnik Service: info@fischertechnik.de). • Replace the cylinder (please contact fischertechnik Service: info@fischertechnik.de).