

Having a Marvelous Time Filling your Magnets with Helium

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So you want to do your own helium fills. Well, our first and most important advice is, *don't do it*. Leave it to the professionals, or at least to the guys who do it every day and are therefore a bit less likely to make some small mistake. Small mistakes tend to result in fires, explosions, multiple deaths, or, worst of all, in a magnet quench.

There may be times, however, when you must replenish your magnet yourself. Perhaps you don't have money for a proper service contract or you unwisely channeled funds into booze and showgirls (or showboys). Perhaps you want to prove you are a real man (or woman). Or your boss simply made you. Whatever the reason, you may find these hints helpful. Just keep in mind we don't take any responsibility for whatever disaster you may bring upon yourself and your organization, be it by following or by not following our advice. We guarantee nothing, we are not responsible, we don't care.

Magnets come in many sizes and shapes, one fill does not fit them all. Consult at least your magnet documentation. In other words, not everything in here may be relevant or correct in your particular case. If in doubt, find someone with common sense and use her (or him).

Having dealt with the legal questions, let us get to the technical part. You should get things ready well ahead of time, it's too late to start looking for gloves when your naked hand is permanently merged with the cryostat.

You will need:

- At least one more person who feels sufficiently lucky that day to agree to help. Never ever do it all by yourself, it's unpleasant and dangerous.

- A helium dewar, or several of them (see Fig. 1). Typically 100–500 liters a piece. Not to be stored for too long since they lose about 1% of their maximum volume every day. In 10 days, you will have wasted 10–50 liters. There are usually three valves, green (1 psi safety valve), yellow (for venting or introducing pressure), and white (for helium extraction). Always keep the green safety valve open during transport and manipulation. Closing all the valves at the same time is obviously not terribly clever. Don't do it. Manipulate the dewar with respect. Don't make the helium all excited before you even begin.
- A helium gas tank to push out the liquid, equipped with a reliable regulator. The regulator has an in-tank pressure indicator (up to about 4000 psi) and an outgoing pressure indicator (up to about 15 psi). The pressure in the tank is easily 2000 psi while the helium liquid should be pushed out by about 3 psi. Hence the need for a good regulator. A suitable hose and fittings will securely connect the tank to the dewar vent (the yellow valve).
- A transfer line. It better be a good one. Such a line is isolated by a vacuum layer “wrapped” around it along its whole length. When the vacuum is gone or the layer is pinched, air and water will freeze and accumulate on it during the transfer. That's hazardous. When air freezes, nitrogen will evaporate sooner than oxygen and you end up with liquid oxygen, a very reliable catastrophic ingredient. As a precaution, you may want to discourage anybody who attempts to come close with anything sparking or flaming.
- A pair of gloves for everybody. Loose fitting and high quality, insulating well. The loose fit is important for getting rid of them quickly, should they come into contact with the cryogenic liquid. Wave them off as fast as you can, before your hands become brittle.
- Eye protection. Liquid helium is known to be incompatible with any part of your eyeball.
- A ladder to get on top of the magnet and another one to easily reach the dewar from top.
- It helps if all of the above items are non-magnetic, especially if you intend to remove them from the magnet room when you are done.

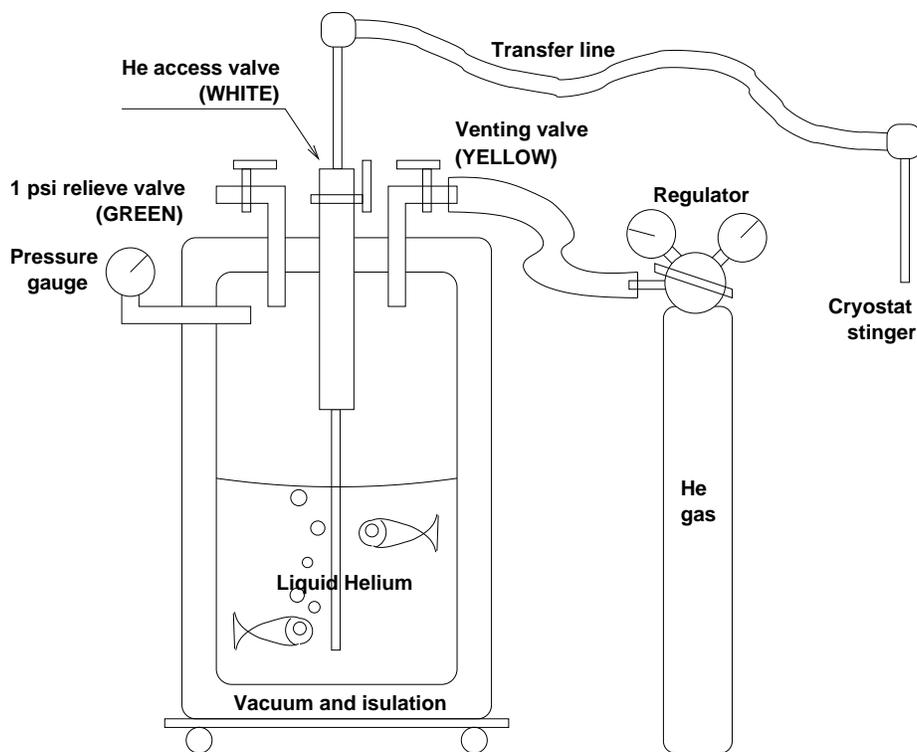


Figure 1: Helium fill schematics.

Suppose all the prerequisites are ready and you still are in your superman dare-devil mood. Very well then, here is a rough outline of the procedure that might increase the odds of your survival:

1. Open the vent of the magnet cryostat. Do it *very, very slowly* and *just a little bit*, let the pressure decrease gradually over time. When the magnet is very low on helium, it may take 15–30 minutes. Faster release of pressure when the magnet is already unhappy will cause a quench. Since pressure is going down, more evaporation takes place and the helium level further drops, sometimes significantly. Escaping helium should obviously go to a dedicated duct. If you let it enter the magnet room, open at least the door and ventilate properly. Good ventilation is important even if you don't try to create a helium gas chamber in this way. Have someone ready to drag you out when you asphyxiate.

2. Open *slowly* the yellow valve on the dewar. This releases the dewar pressure into the atmosphere. Don't stand with your face in front of the vent when you do this. Spare your colleague as well.
3. Open the top upward-pointing white valve on the dewar and *slowly* insert the long transfer line stinger, bit by bit, while your colleague holds the other end. It needs time to cool down, don't hurry. Insert it all the way down until it touches the bottom and then immediately draw back by about 10 cm (4 inches). Secure it in place. Make sure your colleague does not point the other stinger at something stupid, such as the glass lighting fixture or your pants (or skirt).
4. Close the yellow dewar vent, open the gas tank main valve, then open up the regulator slightly (usually by turning its handle to the right) and let the helium fill the unconnected hose. No air must ever enter the dewar, and certainly not the cryostat. It would freeze, block, contaminate, make trouble. Connect the hose to the dewar (the yellow inlet) but don't open the dewar valve yet. Set the pressure very low, to 0–1 psi.
5. Observe the free stinger. Helium gas should be escaping from it. When it cools down and the line fills with liquid, you should see a plume at the end. *Only then* is the stinger ready to be inserted into the magnet. Premature insertion will quench the magnet.
6. Open the filling port (usually on top of the magnet), don't loose the cap or the o-ring seal. Then *very slowly and steadily* insert the stinger into the cryostat. Any fast or sudden movement may (and probably will) quench the magnet, especially when the cryostat is already unhappy about something. If you don't know the exact distance, insert the stinger all the way down and then draw back by about 2–3 cm (1 inch). Don't be a cowboy, be gentle. This is the most critical part of the whole procedure.
7. If everything is fine and quiet, slowly open the yellow valve, then close the green valve, and finally increase the gas pressure to about 3 psi. Did we mention you should do it *slowly*? Check continually both the gas tank gauge and the dewar gauge. They should agree.

8. Listen closely to the dewar and observe the magnet. Never leave it unattended, not even for a little while. Have your colleague check the helium level meter periodically. Liquid transfer will take time, be patient. Be grateful nothing exciting is happening.
9. When the magnet is full (and the dewar is not yet empty), you can interrupt the transfer by closing the yellow valve, opening the green valve, disconnecting the helium gas-tank hose, and slowly drawing out the stinger from the cryostat. When it's out, put the fill port cap back on immediately before the opening freezes. Now have your colleague open the yellow valve to vent the dewar and remove the dewar stinger. Close the top dewar valve and close the yellow valve. Again make sure the green safety valve is open. The dewar is now ready for transport by your local illegal alien¹.

A more complicated (and therefore more likely) scenario is that the dewar becomes empty before the magnet is full. You will be able to tell by listening to the dewar. A low whistling sound will appear. It is *vitally important* to lower the stinger immediately to the liquid when this happens. If you hesitate, warm helium gas enters the cryostat and you will quench the magnet. It will be only your fault, so listen to the dewar and not to your colleague cracking jokes. Instead, have him listen to the dewar with you. Dipping the stinger by about 5 cm (2 inches), which still leaves 5 more cm (2 inches) to the bottom of the dewar, gives you just enough time to act in the same way as described in the paragraph above, to stop the transfer and pull out the cryostat stinger. Don't push the stinger all the way down, it may get blocked by "sludge".

10. If you need to continue with another dewar, just repeat the whole thing. *Never ever* leave the stinger in the cryostat while changing the dewars. It's an equivalent of provoking the cryostat with a red-hot poker. It will retaliate with a thick white smog. In that case, consider yourself lucky if the fog is not shortly followed by an electrical smell of some fried former superconductor.
11. OK, time to close the cryostat venting valve and clean up the mess. If your EPI sequence didn't suddenly become very quiet, you succeeded

¹We mean this in a completely harmless, inoffensive, PC way.

this time. Congratulations.

12. In a couple of hours or the next day, when your heart palpitations settle back to normal, check the nuts and bolts of the venting and filling ports and tighten them. The frost should have subsided by now.

To drive home several important points, this is the list of *big NO-NOs*:

- Do not push the gas (air or helium) into the cryostat.
- Do not insert the cryostat stinger before inserting the dewar stinger.
- Do not pull out the dewar stinger before pulling out the cryostat stinger.
- Do not hurry. Nice and slow does it, especially when venting the cryostat and inserting the stinger into it. Never cause any sudden change in pressure, position, anything. An exception: when the magnet quenches, run fast.
- Do not pull on the frozen stinger with all your might. Twist it instead.
- Do not touch anything with bare hands. Also, do not lick the cold parts, even if you think your friends may appreciate a mute.
- Do not exceed the filling pressure of about 4 psi. A fast fill may be the last thing you ever do on that magnet.
- Do not come to us if you screw up. We told you not to try it in the first place. Don't blame us, don't sue us. We don't have anything worth suing for anyway.

It is our hope that you will enjoy filling your magnet as much as we do. It's scary, it's tense, it's full of unpleasant surprises. But it keeps us away from real work. We love it.