PNEUMATIC SYSTEM SAFETY

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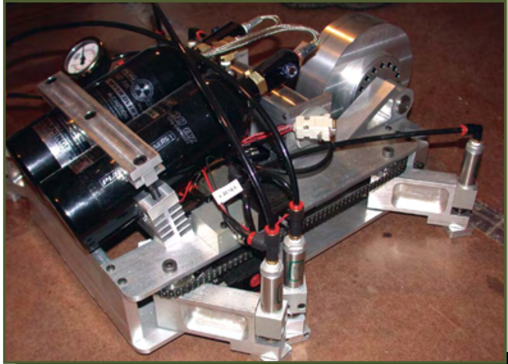

Pneumatic systems can be extremely useful in many areas of robotics, as they provide many possible advantages over other types of actuation. That said, it is of utmost importance that these systems are used safely. In a pneumatic system, things happen very quickly, and only with a full understanding of the principles involved can you properly protect yourself and others.

This article will attempt to give you a generalized understanding of these principles, but every specific situation will vary, so please do your homework! One cannot overlook the value of an experienced eye. If at all possible, find someone with prior experience to review your system throughout the design and construction phases; it will save you time and frustration in the end.

Pneumatic systems can be dangerous, in part because of the potential for extremely rapid failure of components involved. *Never, ever* exceed the recommended ratings for any component in a pneumatic system. The manufacturer is required to go through extensive testing of their parts to ensure that they meet and exceed the ratings that they give the user to work with. They know their own product best.

System Specifics

Let's get a bit into specific components for a typical system. To begin with, you will need a source of gas (just come to our house!). In mobile applications, this is generally a compressed gas cylinder. The most popular types used for smaller robots are paint ball cylinders. All modern paint ball cylinders come with a burst disc in the neck of the cylinder. This is to prevent over-pressurization and explosion of the tank. If the temperature of the tank rises, the pressure also rises. Motors, batteries, and electronics can get really hot. Improper storage of the tank — such as in a hot car on a summer day — can also be dangerous.

If the pressure does get too high, the disc will burst, relieving the pressure in the tank and stopping the metal from turning into high-speed shrapnel. Do not attempt to defeat the burst disc!

After the source tank, you will want a valve so that you can shut off all pressure to the system. This is akin to the main power disconnect in an electrical system. In addition, you will want a second valve after the main shutoff which vents to the atmosphere. This is so that you can de-pressurize the system without venting the entire tank. Make both of these valves easy to reach, without putting any portion of your body in the path of moving or pinching objects.

Work Under Pressure

Although some people run their system at full bottle pressure, the majority of systems out there employ some degree of pressure regulation to bring the full gas pressure in the tank down to a working pressure. This is a popular route, as finding cylinders, valves, etc., to work at high pressures can be difficult.

When connecting the tank and main shut-off valve to the regulator, be sure to use appropriate rated lines. For paint ball type systems, this is easily accomplished with stainless steel braided lines. The vent valve mentioned earlier should be placed after the regulator so that the entire low side can be vented. Any gas remaining on the high side of the regulator will flow through the regulator as the pressure drops, and also be vented.

It is a good idea to place a pressure gauge after the regulator. Not only will this help in setting the regulator to the correct position, but it can indicate problems in the system. These gauges are generally not accurate over their entire scale, so try to pick one with approximately double the pressure you intend to measure.

The last safety specific device you want in the system is a pop off valve. Much like the burst disc on the supply tank, the pop off valve vents excess pressure from the low side. These can be purchased in specific pressure values, or as an adjustable type which you can set with a gauge and adjustable regulator. Unlike the burst disc, these valves will reset once the overpressure condition has been relieved.

The Right Stuff

When choosing valves and cylinders ensure that the parts you choose have appropriate ratings. This does not only apply to pressure ratings. Sometimes cylinders will be rated for multiple media or for specific media. You cannot substitute one rating for another. A 3,000 psi hydraulic rating is not the same as a 3,000 psi air rating! Hydraulic fluid is an incompressible fluid, but air is very compressible and, as such, must be treated differently. In addition, the seals used in a cylinder or valve may only be appropriate for one particular fluid. CO_2 can cause certain seal materials to become brittle (due to its low temperature), so choose a seal of the correct type for what you're using.

Don't Roll Your Own

Whenever possible, use off-the-shelf parts. As stated previously, the manufacturer spends an enormous amount of time and money designing and testing their components. If you absolutely need something that doesn't exist, and can't change your design to suit an off-the-shelf part, you will want to follow a similar test procedure as the manufacturer does.

Custom-made parts need to be checked for safety, usually through a "hydro-test." In this test, a part is subjected to pressures in a controlled environment to determine at what point it fails. While this testing is not terribly expensive, it does add to the overall costs, as well as requiring you to machine more than one custom component. To find someone to "hydro-test" components, you can try asking your local welding gas supplier who they use. Welding gas cylinders need to be "hydro-tested" on a regular basis to maintain certification. Be aware that some hydro shops may not be terribly receptive to testing custom-made components.

Inspect to Detect

When operating a pneumatic system, several precautions must be taken. Prior to turning anything on, inspect the system for damage. Cracked or damaged hoses, dented tanks or cylinders, or any other physical damage can cause a catastrophic failure. Don't take chances here! If something doesn't look right, it probably isn't. The potential damage or personal injury that can result from a failure is never worth the time it would have taken to do it properly.

If the robot is remotely operated, check that your radio or other control system is functioning correctly before turning on the pneumatics. As stated previously, put your valves in an easy-to-access location, away from anything that could possibly actuate when pressure is applied to it.

If this is the first time running the system, use the lowest pressure that you can to test the actuation. Many valves have a minimum pressure requirement; use this as the baseline. This will also help to show where any leaks might be. If your design allows, test the system outside the robot first, and mount it securely to a large stationary object.

Deactivation

When deactivating a pneumatic system, again inspect for damage that might have occurred during use. If there is any chance that the higher pressure components have been damaged, proceed with extreme caution. At this point, it is advisable to vent all the gas from the source tank; open up the atmosphere ventilation valve and the source tank valve. Leave them open for some time, as rapidly expanding gas can get so cold that it freezes to solid. If you close the valves too soon, the gas will unfreeze, then expand and re-pressurize the system.

Summary

These general guidelines will get you well on your way to operating a safe pneumatic system in your robot. If this system is going to be used in a competition, be sure to check with the organizers before you begin construction, as particular rules may vary. If you do plan to use pneumatics, research all aspects of the system and budget accordingly to make the safest system possible, composed only of reputable components. As previously stated, there is no amount of money worth the risk of injury to you or someone else. Be safe! SV