

BattleBots IQ Pneumatic Regulations Work Sheet

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8.0 PNEUMATIC SYSTEMS

8.1 PNEUMATICS OVERVIEW

Pneumatics involve the storage, use and control of pressurized gas to power actuators.

8.1.1 CAUTIONS

Pneumatic systems can be very dangerous if not designed, constructed and tested properly. Moreover, damage caused by BattleBots competitions can render any pneumatic system unsafe.

8.1.2 TEAM RESPONSIBILITY

This section contains many requirements intended to assist in the design of a safe and durable pneumatic system. However, it is ultimately the responsibility of each BattleBots IQ Team to ensure the safety of their pneumatic system design.

For some suggestions and recommendations, refer to the BattleBots Builder's Guide.

8.2 COMPRESSED GAS RESTRICTIONS

There are restrictions on the type and use of gas in a BattleBots IQ pneumatic system.

8.2.1 ALLOWED GAS TYPES

The following gasses are the only types that can be stored or used aboard a BattleBots IQ BattleBot:

- a. Nitrogen (N₂), in compressed gaseous form only.
- b. High-Pressure Air (HPA), (21% O₂, 78% N₂), in compressed gaseous form only.

Oxygen-enriched air (e.g., "Nitrox") is prohibited.

8.2.2 MAXIMUM STORAGE PRESSURE

2,500 psi is the maximum pneumatic pressure that may be stored anywhere aboard a BattleBot at any time.

8.2.3 MAXIMUM REGULATED PRESSURE

150 psi is the maximum pneumatic pressure downstream of the regulator that may be used for actuation anywhere aboard a BattleBot at any time.

8.2.4 GAS VOLUME LIMITS

The maximum total volume of pressurized gas that may be stored on a single BattleBot or on a MultiBot cluster is:

- a. **12 cubic feet** at standard temperature and pressure, if the gas is stored in a single pressure tank.
- b. **18 cubic feet** at standard temperature and pressure, if the gas is stored in multiple pressure tanks, provided that no single tank stores more than **9 cubic feet**. More than two tanks may be used.

8.2.5 POWERED PNEUMATIC PUMP

A powered pneumatic pump (compressor) may be used to provide or augment on-board pneumatic pressure, provided that:

- a. There is a pressure-relief valve for each compressor, rated for a flow rate of at least 120% of the compressor output.
- b. Each compressor is rated for a pressure output equal to or greater than the compressor's pressure-relief valve.
- c. The maximum output pressure of the compressor is less than that defined in "8.2.3 MAXIMUM REGULATED PRESSURE".

BATTLEBOTS IQ TECHNICAL REGULATIONS

REV. 2002.0 26 OF 38 COPYRIGHT© 2002

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8.3 PRESSURE TANK REQUIREMENTS

Pneumatic pressure tanks must meet the following requirements:

8.3.1 PRESSURE STORAGE TANK RATINGS

Primary pressure storage tanks must be commercially-available, DOT-approved and rated for at least the maximum pressure allowed, as defined in "8.2.2 MAXIMUM STORAGE PRESSURE".

The maximum rating must be stamped on each tank such that it is clearly readable.

Pressure tanks may be aluminum or fiber-wound. Steel tanks are allowed but are not recommended.

8.3.2 EXPANSION TANK RATINGS

Expansion tanks used downstream of the regulator must be rated for at least two times (2x) the maximum regulated pressure allowed, as defined in "8.2.3 MAXIMUM REGULATED PRESSURE". The tank rating must be either stamped on each tank, or official written documentation of the tank rating will have to be provided.

8.3.3 TANK MANUFACTURE/TEST DATE

For new pressure tanks, or for tanks with finite lifetimes, the date of manufacture must be clearly indicated on the tank. Otherwise, the tank must have a current hydro-test date (per DOT standards) indicated on the tank.

If no date is stamped on the tank, official written documentation will have to be provided of the date of manufacture and/or hydro-testing.

8.3.4 PRESSURE RELIEF

Each pressure tank must be equipped with a burst disc or ASME certified pressure relief device appropriate for the maximum pressure rating of the tank.

The pressure relief exit must be positioned in such a way that it will relieve pressure away from the direction of any persons refilling the tank.

8.3.5 PRESSURE TANK DAMAGE

Any pressure tank must not have any external damage which in any way compromises its structural integrity. Such tanks cannot ever be used to store pressurized gas aboard a BattleBot.

8.4 PRESSURE REGULATORS

Pneumatic pressure regulators are specifically required for any BattleBot pneumatic system, as follows:

8.4.1 REGULATOR LOCATION

A regulator must be mounted directly to each individual pressure storage tank, or it must be mounted directly to a shut-off valve that is mounted directly to the tank. There cannot be connecting hoses or pipes between the storage tank and the regulator.

8.4.2 REGULATOR MAXIMUM PRESSURE

If a regulator is adjustable, the maximum possible pressure setting must be less than or equal to two hundred percent (200%) of the pressure specified in "8.2.3 MAXIMUM REGULATED PRESSURE".

8.4.3 REGULATOR LOCK-DOWN

If a regulator is adjustable and its maximum setting exceeds the limit specified in "8.2.3 MAXIMUM REGULATED PRESSURE", then the regulator adjustment must have a positive locking method that prevents the regulated pressure from increasing due to vibration or shock.

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REV. 2002.0 27 OF 38 COPYRIGHT© 2002

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8.5 SHUT-OFF VALVES

Each individual pressure storage tank on a BattleBot must have a method to isolate the highpressure

gas stored in the tank. The requirements are as follows:

8.5.1 REGULATOR SHUT-OFF VALVE

If a regulator attached to a pressure storage tank contains an integral shut-off valve, that is an acceptable shut-off valve implementation.

NOTE: Adjusting the regulator to shut off pressure is not acceptable.

8.5.2 DEDICATED SHUT-OFF VALVE

If a regulator shut-off valve is not used, then:

a. A separate dedicated shut-off valve is required for each pressure storage tank, mounted directly to the tank.

b. The shut-off valve must be manually operated. Electrically operated shut-off valves are not allowed.

c. Each valve must be rated for the maximum pressure used in the pressure storage tank to which it is attached.

8.5.3 SHUT-OFF VALVE ACCESS

Access to all shut-off valves must be such that the BattleBot will comply with the access, total time and safety conditions for pre-match Activation, and post-match Deactivation, as described in "5.3 ACTIVATION/DEACTIVATION REQUIREMENTS".

8.6 PURGE VALVES

Any BattleBot pneumatic system must have a method to relieve all gas pressure in the system downstream of the Shut-Off valve(s). The minimum requirements are as follows:

8.6.1 PURGE VALVE OPERATION

Any dedicated purge valve must be manually operated. Electrically operated purge valves are not allowed.

Any purge valve must operate such that it remains open in the purge position. Spring-closure purge valves are specifically prohibited.

8.6.2 REGULATOR COMBINATION VALVE

If a regulator contains an integral purge or a combination shut-off/purge valve, that is acceptable, provided the shut-off action is fully complete before the purge action begins.

8.6.3 PURGE VALVE RATING

The purge valve must be rated for the maximum pressure of the pneumatic section in which it is located.

8.6.4 PURGE VALVE LOCATION

Purge valves may be located anywhere in the pneumatic system, provided that their combined activation relieves all pressure in the pneumatic system downstream of the shut-off valve even if any electrically-controlled actuator valve is stuck in any position.

8.6.5 PURGE VALVE ACCESS

Access to all purge valves must be such that the BattleBot can comply with the access, total time and safety conditions for pre-match Activation, and post-match Deactivation, as described in "5.3 ACTIVATION/DEACTIVATION REQUIREMENTS".

8.7 DOWNSTREAM PRESSURE RELIEF

Any BattleBot pneumatic system must have ASME pressure reliefs or blow-out plugs installed downstream of the pressure regulator, as required, to limit pressure on the downstream side.

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REV. 2002.0 28 OF 38 COPYRIGHT© 2002

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8.7.1 RELIEF VALVE SETTING

Relief valves must be set to start relieving pressure at no more than two-hundred percent (200%) of the pressure rating of the lowest-rated component in that part of the pneumatic system.

8.7.2 BLOW-OUT PLUGS

Pressure blow-outs must be designed to start relieving at no more than three-hundred percent (300%) of the pressure rating of the lowest-rated component in that part of the pneumatic system.

8.8 PRESSURE TEST POINTS

A BattleBot pneumatic system must have a method of quickly and easily checking all system pressures at any point in the pneumatic system.

8.8.1 TANK PRESSURE

Each individual pressure storage tank must have a pressure gauge or test point which allows reading the unregulated gas pressure in that tank.

8.8.2 SYSTEM PRESSURE

Any pneumatic system must have at least one pressure gauge or test point downstream of any regulator, which allows reading the regulated system pressure.

8.8.3 PRESSURE GAUGE SPECIFICATIONS

Each pressure gauge must indicate a minimum of one hundred twenty-five percent (125%) and a maximum of three hundred percent (300%) of the maximum rated pressure that the gauge is measuring.

8.8.4 TEST POINT FITTINGS

If a gauge is not mounted to the BattleBot test point, a Stauff SMA-20, SMA-15, SMA-12 or directly compatible fitting is allowed in lieu of a gauge.

8.8.5 PRESSURE TEST ACCESSIBILITY

Design and placement of the gauges and/or test points must allow quick and safe reading of the pressure values. Specifically:

- a. Accessibility of the gauges and/or test points must be such that it requires no more than one (1) minute to read all test point pressures on a battle-ready BattleBot.
- b. Gaining access to and reading of the test-point pressures must not require placing any body part in the path of any weapon system or other powered moveable part of the BattleBot.

8.9 PNEUMATIC COMPONENTS

8.9.1 STANDARD COMPONENTS

Use of standard commercially-available rated pneumatic components is required. Custommade pneumatic components are not allowed.

8.9.2 COMPONENT RATINGS

All primary pneumatic components on the BattleBot, including tanks, regulators, valves, and actuators must be clearly marked as rated for the pressures being used in the pneumatic system.

If any pneumatic component is not visibly marked for inspection, the BattleBot's Team must supply the necessary data sheets to prove that it is properly rated for the pressures being used.

8.9.3 COMPONENT DAMAGE

If a pneumatic component is damaged in any way that compromises its structural integrity, then that component must not be used in a pressurized BattleBot pneumatic system.

BATTLEBOTS IQ TECHNICAL REGULATIONS

REV. 2002.0 29 OF 38 COPYRIGHT© 2002

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8.9.4 HEATERS NOT ALLOWED

No active heating system can be used for pressure tanks, expansion tanks or anywhere else in a pneumatic system on board a BattleBot.

8.9.5 PRESSURE BOOSTERS

A pressure booster (intensifier) is a component designed to raise the system operating pressure. Using pressure boosters anywhere in a pneumatic system is not allowed.

8.10 COMPONENT INSTALLATION AND MOUNTING

There are minimum requirements for the installation and mounting of pneumatic components. These are intended to mitigate the effects of the high inertial forces and weapons damage that

can occur during BattleBot combat.

8.10.1 PRESSURE TANK SECURING

Each pressure storage tank must, at a minimum, be secured as follows:

- a.** The tank must be constrained at multiple points, such that a load on any part of the tank will be taken primarily by the hold-downs, not the tank structure.
- b.** The tank cannot not constrained primarily at the outlet "neck" or at any attached shut-off valve or regulator.
- c.** A load of thirty (30) pounds applied at any point on the pressure tank will not cause any damage to, or more than one-eighth inch (1/8") movement of, any restraint securing the tank.
- d.** Vibration or impact inertial shock will not cause release of the securing method.

NOTE: Tie-wraps or other non-reusable tank hold-downs are not allowed.

8.10.2 PNEUMATIC COMPONENT MOUNTING

In addition to the mounting of the pressure tanks, other pneumatic components must be mounted in such a way as to minimize the hazard created when part of the pneumatic system is damaged. Some specific requirements are:

- a.** Other than hoses and piping, any pneumatic system component, such as a valve, gauge or manifold, must be positively secured to the BattleBot structure such that it can withstand a force of ten (10) pounds in any direction without damage to the component or its securing method.
- b.** Any flexible connecting hose longer than six inches (6") must be constrained to prevent vibration or impact loading from applying a bending force to any fittings.
- c.** Where necessary, a hose or pipe must be curved or looped to prevent strain on the hose or pipe and its fittings due to expansion and contraction during operation.

8.10.3 PNEUMATIC COMPONENT INSULATION

All pneumatic components must be insulated against sources of heat. These heat sources include electric motors, fuel-powered engines and certain types of batteries.

- a.** For electric motors and non-Lead-Acid batteries, a free-air space of at least one-eighth inch (1/8") between any part of the heat-producing component and any part of the pneumatic system.
- b.** For any fuel-powered engine exhaust pipe or muffler, at least one-half inch (1/2") of free air space, with a metal heat shield securely mounted midway between the exhaust pipe and the pneumatic component.

BATTLEBOTS IQ TECHNICAL REGULATIONS

REV. 2002.0 30 OF 38 COPYRIGHT© 2002

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8.10.4 PRESSURE TANK PROTECTION

Any pneumatic pressure storage tank must not be directly exposed at any point on the outside or underside of the BattleBot. The tank must be protected on all sides with armor consisting of a minimum of one of the following:

- a.** 1/4-inch thick polycarbonate plastic.
- b.** 3/16-inch thick glass, carbon or aramid fiber composite.
- c.** 1/8-inch thick Aluminum.
- d.** 1/16-inch thick Steel or Titanium.

The armor must not be wrapped tightly around the tank, but must be generally spaced a minimum of one-quarter inch (1/4") from the tank on all sides.

The external armor of a BattleBot may qualify as part or all of the pressure tank protection, provided that it meets the material and thickness requirements specified above.

8.10.5 PNEUMATIC COMPONENT PROTECTION

All pneumatic components should be mounted well inside the interior of the BattleBot, and protected such that impacts and weapon blows will not damage them.

8.11 FILLING APPARATUS

To allow safe and convenient filling of high-pressure tanks:

8.11.1 FILLING PRESSURE

The filling apparatus must be designed and constructed such that during filling, the maximum allowed pressure in any on-board storage tank does not exceed the limit defined in "8.2.2 MAXIMUM STORAGE PRESSURE".

8.11.2 APPROVED COMPONENTS.

Only standard, commercially-available, rated pneumatic components can be used on the filling apparatus. All components must be rated for the pressures used.

8.11.3 FILLING ACCESS

Access to the BattleBot for filling must not require the BattleBot to be held or supported in any unstable position.

8.11.4 CONNECT/DISCONNECT

The filling apparatus must be able to be connected and disconnected in a safe and controlled manner to a filling port on the BattleBot, or to an individual pressure tank.