1.0 PNEUMATIC SYSTEMS SAFETY REGULATIONS

Pneumatics involves the storage, use and control of pressurized gas to power actuators.This section contains many requirements intended to promote the design of a safe and durable pneumatic system. However, it is ultimately the responsibility of each Team to ensure the safety of their pneumatic system design.

1.1 COMPRESSED GAS SPECIFICATIONS

1.1.1 ALLOWED GAS TYPES

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

a. Nitrogen (N2), in compressed gaseous form only.

b. Compressed Air

1.1.2 MAXIMUM ACTUATION PRESSURE

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

1.1.3 GAS VOLUME LIMITS

The maximum total volume of pressurized gas that may be stored on a single Robot 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.

1.1.4 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 output volume and set to no more than **130%** of the output pressure.

b. Each compressor is rated for a pressure output equal to or greater than the compressor's pressure-relief valve.

1.2 PRESSURE STORAGE TANKS

Pressure storage tanks refer to all pneumatic tanks or vessels used for primary gas storage. They do not refer to regulated-pressure downstream buffer tanks. Pressure tanks may be aluminum, Steel or fiber-wound.

1.2.1 PRESSURE RELIEF

Each pressure storage tank is required to have a directly attached burst disc or ASME certified pressure relief device set to no more than **130%** of the tank's pressure rating. This pressure relief must be upstream of the high-pressure shut-off valve. The

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

1.2.2 TANK SHUT-OFF VALVE

Each pressure storage tank on a Robot is required to have a mechanical shut-off valve to isolate the high-pressure gas stored in that tank. This valve has to be mounted directly to the tank, downstream of the high-pressure relief and upstream of a regulator or any other pneumatic component. Unscrewing or rotating a tank to shut off pressure is not acceptable. Adjusting a regulator to shut off pressure is not acceptable. Custom made or modified tanks are specifically not allowed.

1.2.3 PRESSURE RELIEF VALVES

One or more burst disks or ASME pressure relief valves are required to be installed downstream of any regulator or compressor, as necessary, to limit pressure in all low-pressure areas of the pneumatic system. Any pressure relief's have to start relieving pressure at no more than 130% of the pressure rating of the lowest-rated component in that area of the pneumatic system. Note: It is expected that actuators will be subject to loads due to the actuator operation.

1.2.4 PURGE VALVES

A pneumatic system is required to have one or more purge valves to vent all pneumatic pressure.

2.0 ELECTRICAL SYSTEMS SAFETY REGULATIONS

The electrical system has to be designed and constructed to minimize the possibility of a short circuit or electrical arcing.

2.1 PRIMARY-POWER WIRING

Primary-power electrical wiring has to be installed such that:

a. Multi-stranded wiring is used for connecting the primary-power batteries to the input of any master switch.

b. Exposed terminals and bare wire-ends from the primary-power batteries to the input of any master switch are covered with electrical insulation.

c. Electrical wiring from the primary-power batteries to the input of any Master Switch is attached to or supported by the Robot structure.

d. All wires are insulated using the factory-applied insulation and/or heat-shrink tubing and/or quality electrical tape.

e. All insulation is applied so that it cannot easily come loose or be penetrated. Non-electrical type tapes (e.g., masking tape) cannot be used for insulation.

2.2 PRIMARY POWER MASTER SWITCH

Any primary-power electrical system is required to have a Master-Switch or a combination of master switches. Each switch has to:

a. Directly shut off power from the primary-power batteries, and not indirectly shut off power using a relay or contactor.

b. Be completely mechanical and operate directly to make or break the circuit, without any electronic components.

c. Be a two-position switch that is stable in both the ON and OFF positions. Momentary operation and push-on/push-off Master Switches are not allowed.

d. Be an enclosed type, so that any electrical arcing will occur on the interior of the switch. A removable link may be used in lieu of a Master Switch if the link complies with all of the above requirements. If a primary-power battery is connected to a conductive RMP chassis, a switch is required to cut power between the battery and the chassis.

2.3 SECONDARY POWER DEACTIVATION

If the secondary-power system has an on-off switch, the switch has to be positioned such that it can e operated without placing any body part in the path of any weapon system or other powered moveable part of the RMP.

2.4 POWER INDICATOR LIGHT

It is recommended that the Robot have an external light, or combination of lights, that are lighted whenever the primary power is turned on.

2.5 ELECTRIC MOTOR TYPES

Electric motors used on RMPs can be of any type, including DC or AC, brushed or brushless, permanent magnet, series or parallel wound. There are no specific

restrictions on the physical size or the output power of any electric motors that can be used on a RMP.

2.6 NOISE-SUPPRESSION CAPACITORS

It is recommended that noise-suppression capacitors be used on all Primary Power brush-type motors.

3.0 BATTERY SAFETY REGULATIONS

3.1 SEALED LEAD-ACID TYPES

The only types of Lead-Acid batteries that can be used on a Robot are "Sealed Lead-Acid" (SLA) batteries that are both "spill-proof" and "leak-proof". A "spill-proof" (or "non spillable") battery means that it can be used in any position, including upside down, without leaking battery acid. A spill-proof battery is not necessarily leak-proof also.

Note: Some SLA batteries are described as "Lead-Calcium". These are acceptable if they also meet the leak-proof requirements specified below.

3.2 LEAK-PROOF REQUIREMENTS

A leak-proof SLA is designed such that the battery case can be cracked or punctured without leaking acid. Leak-proof SLAs meet one or more of the following requirements:

a. They are described in their specifications, or on the battery case, as using "AGM" (Absorbed Glass Mat) construction, and/or as using an "absorbed" electrolyte, and/or as using "electrolyte retaining separators".
b. They are described in their specifications as being a "Gel-Cell" type and/or as using a "Gelled" or "Stabilized" electrolyte.
c. They are specifically described as "Leak-Proof" in the manufacturer's or distributor's documentation.

3.3 PRE-APPROVED SLA BATTERIES

The following specific SLA battery series have been pre-approved for use on RMPs and require no additional documentation:

a. Hawker Genesis, Odyssey and Cyclon series.
b. Panasonic LC series.
c. Powersonic PS series.
d. Interstate AGM, BSL, DCS and YTX series.
e. Sonnenschein Dryfit A and AGM 8A series.
f. Steatite RG series.
g. Yuasa YT series.
h. SVR B series.
i. Optima series.
j. Lifeline AGM series.

Pre-approval of the above batteries is based upon the manufacturer's claims, not actual testing. If at any time it is determined that an above-named battery series does not meet the leak-proof requirement, it will be disallowed.

Note: Some of the above-named manufacturers also make battery series that are not AGM or
Gel-Cell construction. Only the specific battery series specified above are pre-approved.

3.4 BATTERY DOCUMENTATION

If a battery is not marked as "leak-proof", or is not in the list above, written or on-line documentation will be required to show that the battery uses AGM or Gel-Cell construction.