



# NRL TECHNICAL REGULATIONS

*Revision Date: August 2018*

## 1. General

- 1.1. All participants build and operate robots at their own risk. Combat robotics is inherently dangerous. There is no amount of regulation that can encompass all the dangers involved. Please take care to not hurt yourself or others when building, testing and competing. Robots must be free of words, logos or graphics that are offensive in any way.
- 1.2. If you have a robot or weapon design that does not fit within the categories set forth in these rules or is in some way ambiguous or borderline, please contact the Event Organizer. Safe innovation is always encouraged, but surprising the event staff with your brilliant exploitation of a loophole may cause your robot to be disqualified before it ever competes.
- 1.3. Compliance with all event rules is mandatory. It is expected that competitors stay within the rules and procedures of their own accord and do not require constant policing.
- 1.4. Each event has safety inspectors. It is at their sole discretion that your robot is allowed to compete. As a builder you are obligated to disclose all operating principles and potential dangers to the inspection staff.
- 1.5. Cardinal Safety Rules: Failure to comply with any of the following rules could result in expulsion or worse, injury and death.
  - 1.5.1. Radios may not be turned on, at or near events for any purpose without obtaining permission from the event personnel.
  - 1.5.2. Proper activation and deactivation of robots is critical. Robots must only be activated in the arena, testing areas, or with expressed consent of the event personnel or its safety officials.
  - 1.5.3. All robots must be able to be FULLY deactivated, which includes power to the drive and the weaponry, **within 60 seconds by a manual disconnect.** (Removable link or Main Power Switch) The operator must be able to perform the deactivation without handling the robot.
  - 1.5.4. All robots must be able to be fully activated within 30 seconds.
  - 1.5.5. All robots not in an arena or official testing area must be raised or blocked up in a manner so that their wheels or legs cannot cause movement if the robot were accidentally turned on. Runaway bots are VERY dangerous. (We strongly suggest a custom designed block that ensures the robot will not be inadvertently dislodged from the block.)
  - 1.5.6. Locking devices: Moving weapons that can cause damage or injury must have a **clearly visible** locking pin in place **at all times** when not in the arena. Locking pins must be painted in neon orange or another high-visibility color. Locking pins must be clearly capable of stopping, arresting or otherwise preventing harmful motion of the weapon.

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- 1.5.7. Weapon locking pins **must be in place** when weapon switch is turned on during a robot's power-on procedure (the weapon switch will be on, but no power will be applied to the weapon). The locking pin will be removed just prior to closing the arena door. This includes **all** powered weapons regardless of the power source..
  - 1.5.8. It is expected that all builders will follow basic safety practices during work on the robot at their pit station. Please be alert and aware of your pit neighbors and people passing by. Continued failure to follow safety directions could result in an individual's or the entire team's disqualification for the event. This includes and is not limited to wearing SAFETY GLASSES at ALL times while in the pit area and in the arena area while handling or controlling your bot.
  - 1.5.9. Safety offenses will be handled as follows:
    - (1) The first safety offense from any member of the team will result in a warning.
    - (2) The second offense from any member of that same team will result in a 10 second controller impoundment at the beginning of your next match. This means your opponent will be able to attack your immobile robot.
    - (3) Violations stack so if a team has 3 infractions between matches the impoundment period would be 20 seconds.
    - (4) After the penalty is assessed, the team starts over meaning the next offence results in a 10 second impoundment during the next match. No additional warnings will be given.
2. **Weight Classes & Size.** This event offers 15 pound robots. (There is no weight bonus for shufflers or other forms of locomotion which are predicated on rolling - see 3.1.2 for a definition of a non-wheeled robot.)
- 2.1. Wheeled weight = 15 pounds
  - 2.2. Non-wheeled weight = 20 pounds
  - 2.3. Your Bot must be no wider than 3 feet and no taller than 3 feet to ensure that your robot fits in the arena door.
  - 2.4. Your Bot must be able to clear the arena floor during normal driving operations. Consideration must be made by teams to ensure that their Bot will not damage the arena structure.
  - 2.5. Multi-Bots are allowed as long as the combined weight is 15 pounds or less.
- If both bots are exactly the same weight, the team will need to decide which robot is the "primary" robot. If one of the bots weighs more than the other, the heavier bot is automatically the "primary" bot. The primary bot must be clearly marked with a piece of yellow tape. The "primary" bot is identified for the purpose of a countdown or knockout. As long as the "primary" bot is functioning, the match continues. If the "primary" bot is knocked out or it is counted out, the match is over. The other bot cannot compete without the "primary" bot.



### 3. Mobility

- 3.1. All robots must have easily visible and controlled mobility in order to compete\*. Methods of mobility include:
  - 3.1.1. Rolling (wheels, tracks or the whole robot)
  - 3.1.2. Non-wheeled: non-wheeled robots have no rolling elements in contact with the floor and no continuous rolling or cam operated motion in contact with the floor, either directly or via a linkage. Motion is "continuous" if continuous operation of the drive motor(s) produces continuous motion of the robot. Linear-actuated legs and novel non-wheeled drive systems may qualify for this bonus. []
  - 3.1.3. Shuffling (rotational cam operated legs)
  - 3.1.4. Ground effect air cushions (hovercrafts)
  - 3.1.5. \*In the case of a Multi-bot, only the "primary" bot must have easily visible and controlled mobility in order to compete.

### 4. Robot Control Requirements:

- 4.1. Primary control and fail-safe communications to a Bot have to be via a remote radio link. Tethered control is specifically not allowed.
  - 4.1.1. A Bot may be controlled by a maximum of three Operators/Drivers
  - 4.1.2. A Bot must have a robust radio fail-safe that shuts off all motion-system and weapons power within one second after the remote-control transmitter is switched off, or otherwise stops transmitting. This fail-safe is required in addition to the Master Switch requirements
  - 4.1.3. Binary (on/off) movement speed control is not allowed. Any control of the Bot speed along the ground has to be continuously variable in both forward and reverse directions.
- 4.2. The NRL recommends using the Spektrum Transmitter DX6, due to the corresponding receivers having SmartFail Technology. If a team is utilizing a different transmitter system for the competition, the system must meet the fail-safe protection requirements.
- 4.3. Bluetooth systems must be approved by the NRL safety committee prior to the competition. Operating plans, schematics, and a clear explanation of controls must be presented for review.

The NRL should get this information at least one week before the competition so that the safety committee can verify it at the start of competition. The Bot must comply with all other regulations, meaning the Bot should be in zero energy state when not in the test box or arena (cage). All power must be off and dissipated. The students should not need to handle the Bot in order to bring the robot to a zero energy state. The battery must be disengaged by the master switch and any energy storing devices must automatically drain when the master switch is shut off. The energy storing should only take place when the Bot is on.

Any capacitors or electrical storage devices used in the system must be capable of being safely discharged without putting the students at risk.

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5. **Autonomous/Semi-Autonomous Robots:** Any robot that moves, seeks a target, or activates weapons without human control is considered autonomous. If your robot is autonomous contact the event organizer.
  - 5.1. Autonomous robots must have a clearly visible light for each autonomous subsystem that indicates whether or not it is in autonomous mode, e.g. if your robot has two autonomous weapons it should have two "autonomous mode" lights (this is separate from any power or radio indicator lights used).
  - 5.2. The autonomous functionality of a robot must have the capability of being remotely armed and disarmed. (This does not include internal sensors, drive gyros, or closed loop motor controls.)
    - 5.2.1. While disarmed, all autonomous functions must be disabled.
    - 5.2.2. When activated the robot must have no autonomous functions enabled, and all autonomous functions must failsafe to off if there is loss of power or radio signal.
    - 5.2.3. In case of damage to components that remotely disarm the robot, the robots autonomous functions are required to automatically disarm within one minute of the match length time after being armed.

## 6. Batteries and Power

- 6.1. The only permitted batteries are ones that cannot spill or spray any of their contents when damaged or inverted. This means that standard automotive and motorcycle wet cell batteries are prohibited. Examples of batteries that are permitted: gel cells, Hawkers, NiCads, NiMh, dry cells, LiFePO4, AGM, and Lilon. . **(NO LiPoly batteries will be allowed.)**

[If your design uses a new type of battery, or one you are not sure about, please contact the Event Organizer.]
- 6.2. All nominal onboard maximum voltages are limited to: **28 Volts for 15# class robots** for this league. (It is understood that a charged battery's initial voltage state is above their nominal rated value.)
- 6.3. All electrical power to weapons and drive systems (systems that could cause potential human bodily injury) must have a manual disconnect that can be activated within **15 seconds** without endangering the person turning it off. (E.g. No body parts in the way of weapons or pinch points.) Shut down must include a **manually** operated mechanical method of disconnecting the main battery power, such as a switch (Hella, Whyachi, etc.) or removable link. Relays may be used to control power, but there must also be a mechanical disconnect. Please note that complete shut down time is specified in section 1.5.
- 6.4. All efforts must be made to protect battery terminals from a direct short and causing a battery fire. All charging of batteries must be done outside of the Bot.
- 6.5. All robots must have a separate light per switch that is easily visible from the outside of the robot that shows its main power is activated.

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- 6.6. Batteries must be visible for inspection and must have marking from the manufacturer that clearly identifies the type of battery. If such markings are not possible, be prepared to show another form of proof that your battery is allowed (vendor receipt, etc).

### 7. Pneumatics

Pneumatic systems on board the robot must employ non-flammable, nonreactive gases. Only LPA (low pressure air [150 PSI max]) or single use CO2 cartridges are permissible. LPA systems may use certified refillable tanks; CO2 systems may NOT use refillable tanks. (The terms 'pressure vessel, bottle, and source tank' are used interchangeably.)

- 7.1. All components must be used within the specifications provided by the manufacturer or supplier.
- 7.2. All pneumatic components on board a robot must be securely mounted. Particular attention must be made to pressure vessel mounting and armor to ensure that if ruptured it will not escape the robot.
- 7.3. All pneumatic components within the robot must be rated or certified for AT LEAST the maximum pressure in that part of the system. You are required to have rating or certification documentation on all components in the pneumatic system. This includes the following:
- Onboard air compressors
  - Air Tanks/Air Storage Devices
  - All Valves (Solenoid, Purge, Shut-off, Pressure Relief, Check & Shraeder)
  - Pressure Switch
  - Manifolds
  - Tubing/Hose
- 7.4. All pressure vessels must be rated for at least **120%** of the pressure at which they are used. (This is to give them a margin of safety if damaged during a fight.)
- 7.5. If regulators are used anywhere in the pneumatic system there must be an (additional) over pressure safety valve downstream of the regulator set for no more than **100%** of the lowest rated component in that part of the pneumatic system and there must be a gauge easily visible from outside the robot not on the bottom.
- 7.6. All pneumatic systems must have a manual main shut off valve to isolate the rest of the system from the source tank. This valve must be easily accessed for robot deactivation and refilling. It must also be out of any danger areas. It must be clearly marked.
- 7.7. All pneumatic systems must have a manual bleed valve downstream of the main shut off valve to depressurize the system. This bleed valve must be easily accessed for deactivation. This valve must be left OPEN whenever the robot is not in the arena to ensure the system cannot operate accidentally.



- 7.7.1. You **MUST** be able to be able to easily bleed all pressure in the robot before exiting the arena. (You may be required to bleed the entire system, including the source tank, if it is believed that you have any damaged components.)
- 7.8. If back check valves are used anywhere in the system you must ensure that any part of the system they isolate can be bled and has an over pressure safety valve..
- 7.9. All pneumatic systems must have an appropriate gauge on the low side of the regulator to show maximum resolution of the pressure in that part of the system. The gauge should be easily readable from outside the bot, not on the bottom.
- 7.10. Source Specifications for Pneumatic Systems:
  - 7.10.1. Source Specifications for CO2 Based System

The max pressure that may be stored on board when using CO2 is relative to ambient temperature. The pressure at the liquid to vapor phase of CO2 at 70 degrees F ambient temperature is 853 PSI. No form of tank heater is allowed, including mounting of tanks near components that heat up during use. The max total volume of pressurized gas stored on board is 8 cubic ft at standard temperature (70 degrees).and pressure (14.7 PSI or 1 atmosphere).

    - 7.10.1.1. No refillable tanks may be used for CO2.
    - 7.10.1.2. Source system must be hard plumbed down to 150 PSI (no flexible tubing).
    - 7.10.1.3. Minimum requirement for component stream:  
Single use CO2->Puncture Valve->Burst disc->Regulator->Pop-off valve-> Gauge->150 PSI (max)
    - 7.10.1.4. Burst disc must be rated at 1.8k (1800 PSI standard CO2 Safety Burst Disc or less)
    - 7.10.1.5. Over pressure safety valve must be rated at 175 PSI or less
    - 7.10.1.6. Gauge must show maximum resolution for 150 PSI max and must be readable from outside the robot.
  - 7.10.2. LPA Based Systems

The maximum pressure that may be stored on board when using LPA is 150 PSI.

On-Board Compressor LPA System:

    - 7.10.2.1. Minimum requirement component stream for On-Board Compressor System:  
On Board LPA Compressor->Pressure Switch->Over pressure safety valve->pressure gauge->150 PSI (max)
    - 7.10.2.2. Pressure Switch must be set at 150 PSI (max)
    - 7.10.2.3. Over pressure safety valve must be rated at 175 PSI or less

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- 7.10.2.4. Gauge must show maximum resolution for 150 PSI max and must be readable from outside the robot.

Refillable LPA System:

- 7.10.2.5. Minimum requirement component stream for refillable LPA System: Fill valve-> LPA tank-> Pop-off Valve->Gauge
- 7.10.2.6. Over pressure safety valve must be rated at 175 PSI or less
- 7.10.2.7. Gauge must show maximum resolution for 150 PSI max and must be readable from outside the robot.
- 7.10.2.8. You must have a safe and secure method of refilling your pneumatic system.

### 8. Hydraulics

- 8.1. Robots in the 15# class are **NOT** allowed to use hydraulics.

### 9. Internal Combustion Engines (ICE) and liquid fuels.

- 9.1. Robots in the 15# class are **NOT** allowed to use ICE.

### 10. Rotational weapons or full body spinning robots:

- 10.1. Spinning weapons cannot contact the outer arena walls during normal operation. (Contact with an inner arena curb, or containment wall is allowed).
- 10.2. Spinning weapons must come to a full stop within **30 seconds** of the power being removed.

### 11. Springs and Flywheels

- 11.1. Springs used in robots will use the remaining rules in this section. Safe operation, good engineering and best practices must be used in all systems.
- 11.2. Any springs used for drive or weapon power must have a way of loading and actuating the spring remotely under the robots power.
  - 11.2.1. Springs used for active weapons must not be loaded when the robot is out of the arena or testing area.
  - 11.2.2. Springs used within switches or other internal operations are exempt from this rule.
- 11.3. Any flywheel or similar kinetic energy storing device must not be spinning or storing energy in any way unless inside the arena or testing area.
  - 11.3.1. There must be a way of generating and dissipating the energy from the device remotely under the robots power.

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11.4. All springs, flywheels, and similar kinetic energy storing devices must fail to a safe position on loss of radio contact or power.

12. **Forbidden Weapons and Materials.** The following weapons and materials are absolutely forbidden from use:

12.1. Weapons designed to cause invisible damage to the other robot. This includes but is not limited to:

12.1.1. Electrical weapons

12.1.2. RF jamming equipment, etc.

12.1.3. EMF fields from permanent or electro-magnets that affect another robot's electronics.

12.1.4. Weapons or defenses that stop combat completely of both (or more) robots. This includes nets, tapes, strings, and other entanglement devices.

12.2. Weapons that require significant cleanup, or in some way damages the arena to require repair for further matches. This includes but is not limited to:

12.2.1. Liquid weapons. Additionally a bot may not have liquid that can spill out when the robot is superficially damaged.

12.2.2. Foams and liquefied gasses

12.2.3. Powders, sand, ball bearings and other dry chaff weapons

12.3. Un-tethered Projectiles (see tethered projectile description in Special Weapons section 13.1)

12.4. Heat and fire are forbidden as weapons. This includes, but is not limited to the following:

12.4.1. Heat or fire weapons not specifically allowed in the Special Weapons section

12.4.2. Flammable liquids or gases

12.4.3. Explosives or flammable solids such as:  
DOT Class C devices

Gunpowder / Cartridge Primers

Military Explosives, etc.

12.5. Light and smoke based weapons that impair the viewing of robots by an Entrant, Judge, Official or Viewer. (You are allowed to physically engulf your opponent with your robot however.) This includes, but is not limited to the following:

12.5.1. Smoke weapons not specifically allowed in the Special Weapons section

12.5.2. Lights such as external lasers above 'class I' and bright strobe lights which may blind the opponent.

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- 12.6. Hazardous or dangerous materials are forbidden from use anywhere on a robot where they may contact humans, or by way of the robot being damaged (within reason) contact humans.

### 13. Special Weapon descriptions allowed:

- 13.1. Tethered Projectiles are allowed, but must be no longer than 3 feet and may not entangle the opponent.

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