Best Practice Safety Protocols and the NRL

Every individual (student, teacher/coach, advisor, volunteer, staff, spectators) participating in the National Robotics League must embrace safety as a core value of the program. The NRL believes that the teams that take the lead in developing safety programs and policies have a positive and lasting impact on each team member and adult teacher/coach, advisor and volunteer, in addition to their communities and present and future work places. The NRL appreciates and supports all teams that demonstrate safety throughout their programs and are truly committed to developing safety as a core value.

This safety manual is an easy-to-use guide for important safety information and provides NRL participants with a basic set of requirements to maintain a safe environment during all aspects of the Bot manufacturing process, special event and competitions. It applies to anyone involved with the NRL including all student team members, teachers/coaches, advisors, volunteers and spectators.

1. Participant Responsibilities

Everyone is responsible for safety during team meetings and the design, build, travel, and event phases of the competition. Please read this entire manual for details on how to establish and maintain safety as a core value within your participation in the NRL. Below are the expectations for NRL participants.

1.1. All Participants

- Be familiar with this manual, NRL technical specifications and NRL competition rules & regulations, as well as understand and follow established safety requirements applicable to your environment.
- Work in a safe and responsible manner.
- Use personal protective equipment, safeguards, and other safety equipment as required.
- Identify and report any unsafe or hazardous conditions to a lead teacher/coach, safety inspector or pit monitor. This includes work practices that may cause an accident.
- Encourage safe behaviors in everyone around you.

1.2. Teachers/Coaches and Advisors

- Lead by example. Practice the same safety behaviors that are expected from the students.
- Provide guidance and encouragement on a safe working environment.
- Provide leadership and guidance on matters of general safety, including the use of personal protective equipment during the Bot building process and at special events/competitions. This includes the handling of Bots as well.
- Utilize hazard based safety engineering principles with team members to eliminate or minimize identified threats to a suitable level.

1.3. Student Teams

- Develop a team safety plan that outlines your team's safety philosophy with consideration to the elements in this manual.
- Encourage your team members to display positive safety behaviors at all times.
- Provide support for each other on any safety questions or concerns that may arise. Seek guidance, as appropriate, from your teachers/coaches or advisors.
- Conduct safety inspections of the general work site at your school or organization. This also applies to your pit area during competitions.

2. General Safety Requirements

The following are areas, practices, and functions for which teams need to be diligent about at all times when working on the Bot and at events/competitions. This list is not all-inclusive.

Running and horseplay is not permitted at any time.

- Follow safe work practices, including safe use of all tools and personal protective equipment (safety glasses, shoes, gloves, hearing protection, etc.). Maintain a healthy attitude regarding safety.
- Always walk and work in a controlled and thoughtful manner. Keep full control of your Bot at all times.
- Be especially careful around high-speed rotating components, both on and off the Bot. If you are putting a high-speed rotating component or weapon on the Bot, make sure the component is designed to be used the way you are using it.
- Take special care when working above normal height or ground level.
- Be careful using tools that generate heat, such as heat guns and soldering irons. Be aware of objects that may be in the vicinity of the heat source and may catch fire. Also, be aware that these tools often retain heat after being shut off, and should be set down only on appropriate surfaces.

2.1. Stored Energy:

Plan the required activities when servicing or making repairs to the Bot. Make sure all team members are aware that work is being done on the Bot. Address the following:

Avoid working on an energized Bot during repairs unless necessary and under supervision.

2.1.1. Electrical Energy:

- Disconnect the electric power source
- Best Practice: Always de-energize the Bot before working on it by opening the main circuit breaker and unplugging batteries

2.1.2. Pneumatic Energy:

- Always vent any compressed air to the atmosphere (this applies to all parts of the pneumatic system)
- Open the main vent valve and verify that all pressure gauges on the Bot indicate zero pressure

2.1.3. Miscellaneous Energy Sources:

- Relieve any compressed or stretched springs or tubing
- Lower all raised Bot arms or devices that could drop down to a lower position on the Bot

2.2. Hand Tools

Constructing a Bot will require the use of hand tools. Most people think of hand tools as wrenches, screwdrivers, chisels, and so forth, but the term also applies to any hand-held tool or implement used to accomplish a task. Always use the proper tool for the job.

2.2.1. Tool Rules

- Before using any tool, check to see if it is in good condition. Don't use defective, dull, or broken tools. Don't put them back on the shelf; remove them from service and notify the safety captain and mentor so the tool can be replaced or sent for repair.
- When using a tool, place the work on a bench or hard surface rather than in the palm of your hand.
- When using knives/blades, direct your cutting strokes away from your hand and body and be aware of those around you. Wear gloves.

2.2.2. Tool Storage

- Store sharp-edged or pointed tools in a safe place.
- When carrying tools, cover the point or any sharp edges with shields. NEVER carry unshielded tools in your pocket.
- Don't leave tools on overhead work surfaces. They may fall and strike someone below.
- Store equipment in a location where it will not create a safety hazard or get damaged.

2.3. Mechanical Guards

Provide safety guards for power tools where required. Never use any equipment without safety guards in place. Notify your safety captain and mentor of any broken or defective equipment, and take it out of service until repairs are made.

2.4. Respect of Electricity

Proper use and respect for electricity is paramount. The following are general guidelines for ensuring basic electrical safety requirements are met:

- Inspect your equipment cords and extension cords routinely to ensure they are in good condition.
- DO NOT "daisy chain" – plug a power strip into another power strip. This could cause the potential for fire or electric shock due to overloading of the circuit.
- Avoid the following electrical power supply setups to prevent overloading:
- Extension cord plugged into another extension cord.
- Extension cord plugged into a power strip.
- Multi-device receptacle plugged into a power strip or extension cord.

2.5. Battery Safety

Batteries contain acid. This substance, H_2SO_4, is a corrosive, colorless liquid that will burn your eyes, skin, and clothing. Use proper protection for handling cracked or damaged batteries and for disposal of the battery.

2.5.1. General Damaged Battery Information and Warnings

Any battery that is visibly damaged in any way is dangerous and unusable. Don't take a chance- don't use it! Here are reasons you should not use a damaged battery:

- A battery contains stored electrical energy that could cause it to rapidly heat up due to an internal electrical short circuit, and possibly explode.

- Batteries contain sulfuric acid that will burn human tissue on contact. Set aside a damaged battery and handle accordingly:
    - Immediately flush any contacted skin with a large quantity of water.
    - Seek medical treatment.
- Periodically inspect your batteries for any signs of damage or leaking electrolyte. Remember that a dropped battery may be cracked, but the crack may not be visible and might eventually leak electrolyte.
- Treat it as a hazardous material and process it in accordance with the battery's safety data sheet.
- Don't take a chance- don't use it!

2.5.2.Necessary Safety Materials

NRL recommends that teams keep the following items readily available whenever working with batteries:

- A box of sodium bicarbonate (baking soda) to neutralize any exposed acid electrolyte.
- A pair of acid-resistant rubber or plastic leak-proof gloves to wear when handling a leaking battery.
- A suitable non-metallic leak-proof container in which to place the defective battery.

2.5.3.Procedure for Handling a Leaking Battery

When an electrolyte leak occurs:

- Neutralize it by pouring the sodium bicarbonate on all wetted surfaces. The bicarbonate of soda itself is not dangerous, and will react with the acid in the electrolyte leaving a safe residue that can be disposed of in a conventional manner such as rinsing with water.
- Follow emergency handling instructions of the SDS and notify mentor.
- Put on gloves before handling the battery.
- Place the battery in a leak-proof container for removal.
- Be sure to neutralize any acid on the gloves before removing and storing them.
- Seek medical attention if skin came into contact with any chemicals.
- Properly dispose of the battery, which is now a hazardous material.

At an NRL event/competition:

- Lead teacher/coach should immediately take the person in contact with acid to the safety inspector station/table.
- Report incident to the lead safety inspection or pit monitors so that the individual can fill out a Medical Incident Report form. Provide all available information about the person in contact and how the incident happened.
- Safety Inspector/Pit Monitor will immediately contact event coordinator for further instruction from event and venue authorities.

2.5.4.Battery Disposal

Be sure to dispose of all batteries properly and safety. Most retailers of automotive batteries will accept and properly dispose of them at no cost.

2.5.5. Charging and Handling

- Keep the battery-charging area clean and orderly.
- Place your battery charger in an area where cooling air can freely circulate around the charger.
- Battery chargers can fail without proper ventilation.
- Do not short out the battery terminals. If metal tools/parts contact the terminals simultaneously, it will create a direct short circuit. This may cause high heat to develop in the battery terminal/part/tool area and the battery could explode. To avoid the possibility of shorting out the battery terminals and creating a hazardous situation it is required to cover all exposed battery terminals and connections with appropriate insulating material such as electrical tape or tubing.
- Do not charge battery at greater than the manufacturer's maximum recommended rate.

2.5.6. Ongoing Battery Inspection

- Periodically inspect your battery for any evidence of damage, such as a cracked case or leaking electrolyte.
- Bent terminals can also be a potential leak source.
- Inspect the battery before and after each round of competition.

2.6. Chemical Safety

- Keep chemical containers in good condition.
- Make sure all chemical containers have labels placed by the manufacturer.
- Ensure all labels are legible.
- Become familiar with the chemicals you may use as part of the NRL Robotics Competition.
- Read safety precautions and instructions for use located on the chemical's label.
- Store all chemicals in an orderly way. Obtain Safety Data Sheets (SDS) for the chemicals your team uses. These sheets provide information on the correct handling of a spill or injury.
- If you are exposed to a chemical, notify your safety captain and mentor immediately and consult the SDS if necessary.
- Don't use any highly flammable materials, such as cleaning solutions, at NRL events.

2.7. Soldering

- Soldering can be dangerous because of the heat from the iron and the chemical fumes and vapors released from the solder and flux. When soldering, observe the following points:
- Use lead-free solder only and solder with electrically heated soldering iron/gun only.
- No torches or open flames of any kind are allowed in event venues, except by authorized personnel in specified areas (such as the working pit area).
- Wear eye and face protection.
- Solder in well-ventilated areas.
- Never touch the iron/gun. It heats to extreme temperatures that will cause severe burns.
- Prevent burns by wearing cotton clothing that covers your arms and legs.
- Always wash your hands with soap and water after handling solder.
- Work on a fire resistant surface.
- Keep your soldering iron in its protective holder when not actually being used.
- Do not leave any hot tools where someone can accidentally contact the hot element.

3. Personal Protective Equipment

The proper use of personal protective equipment is an important element to help ensure NRL participants are protected from hazards in the work area. The following describes the common personal protective equipment that you are required to wear as part of constructing, use, maintenance and transport of a Bot. All PPE must be ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified or CSA rated, as applicable.

3.1. Eye and Face Protection

There are several forms of eye/face protection available to provide protection from related hazards, including safety glasses with side shields, goggles, and face shields. Inspect equipment for damage each time it is worn.

3.1.1. Use and Application

Always wear eye protection in the following situations:

- When performing any work on the Bot including grinding, drilling, soldering, cutting, welding, etc.
- When there is a risk of exposure to flying particles or chemical exposure (such as splashes, splatters, and sprays).

At NRL events, wear eye protection:

- Anywhere in the pit area, this also includes walkways and open spaces.
- In the vicinity of the arena.
- In the working pit area.
- Any area posted with signs requiring the use of eye protection

3.1.2. Safety Glasses & Protective Eyewear

Safety glasses and protective eyewear are designed to provide a shield around the entire eye to protect against hazards such as splashes of liquids, burns from steam, compressed air, and flying objects or metal debris.

To prevent injury, all individuals in the pit area, the practice field area and the arena must wear safety glasses or protective eyewear that is ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified or CSA rated. Only lightly tinted yellow, rose, blue, and amber tints are NRL approved. Reflective lenses are prohibited; your eyes must be clearly visible to others.

The use of anything other than ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified or CSA rated eye protection is prohibited.

3.1.3. Prescription Glasses

If you wear prescription glasses that do not have a marked safety rating, you must wear rated safety goggles over them to achieve adequate protection. If you wear marked safety rated glasses, you may use ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified or CSA rated side shields. Safety rated glasses, side shields and frames can be identified by markings stating the standard that they are rated to (ex. Z87.1).

3.2. Hand Protection

Hand protection is designed to protect against heat, electrical, chemical and mechanical hazards. Use proper gloves and mechanical tool guards for the application. NRL participants should work with their teacher/coach to ensure the selected glove is the correct one to use for each activity. For example, wear chemical-resistant gloves when handling chemicals. Check your gloves for proper size, absence of cracks and holes, and good flexibility and grip before you wear them.

3.3. Hearing Protection

Make hearing protection devices available, such as earplugs, where there are objectionable/questionable sound levels. At events, hearing protection is often available at pit administration. A mentor can provide assistance in evaluating high-noise tasks and determining appropriate hearing protection devices.

3.4. Foot Protection

When engaged in NRL activities, participants must wear shoes that completely cover the entire foot. Shoes must be substantial and have closed-toes and heels to protect against foot injuries, regardless of work location. Flip-flops, sandals, mules, lightweight slippers, etc. are not acceptable when working on or near the Bot. In some cases, safety shoes or toe guards are appropriate for areas where heavy objects can fall on your foot.

Spectators attending NRL competitions should follow the same footwear rules as participants. If substantial close-toed shoes are not available, they may enter the pit area as long as they remain in the pit aisles. Spectators that do not meet the footwear requirement for participants, as described above, are not allowed inside individual team pits or in any locations where Bots are being worked on. Please note that loose sandals (like flip-flops) or bare feet are not permitted in the pit area under any circumstances.

3.5. Other Preventatives

Ensure that team members and teachers/coaches/advisors are not wearing ties, loose clothing, jewelry, hanging key chains or similar when near or working on moving or rotating machinery so as to avoid the potential risk of draw in to rotating parts. In the case of individuals with long hair, this risk should be mitigated by tying back or covering long hair.

4. Safe Bot Handling and Transportation

Take a few moments to ensure your team knows how to lift your Bot properly and safely. Practice the procedures prior to beginning the season so everyone has the same method and goals at the events.

4.1. Transporting Bot Procedures

Ensure all transporters are wearing appropriate personal protective equipment (safety glasses at a minimum are required.)

Make sure the Bot is safe to move:

- Are all parts of the Bot secured? Are all safety covers and restraints in place?
  - Is the Bot powered off?
  - Is anyone still working on the Bot?
- Ensure that the areas and paths are clear of debris and hazards.
- Use patience and control when moving the Bot, especially in crowded areas (do not run).

4.2. Post-Battle Procedures

- Before entering the arena, ensure that no parts of the Bots are moving and the driver is holding the remote control away from his or her body.
- Turn off the Bot and put all safety covers and restraints in place.
- Ensure that the Bot is made safe prior to lifting it off the arena floor, no dangling parts, etc.
- Remove debris from the arena.

5. Safety In Your Work Spaces

We recommend that teams implement a safety program to deliver on ensuring a culture of safety for the team throughout the season covering all aspects of the program. Safety inspectors and Pit monitors will be on site to assist teams on proper safety practices.

We recommend that teams implement a checklist of their own to monitor their unique work facility safety considerations. Check for items such as:

- Are stacked items at least 18" below sprinkler heads?
- Are stacks stable and secure against sliding and collapse?
- Are heavy or bulky items stored below shoulder level?
- Are floors free of slipping and tripping hazards?
- Are all light fixtures functional?
- Is illumination level sufficient for the detail of work performed?

Review your workspace, take notes, and make any improvements to the safety of the environment and those working there. The mentors and student safety captain should constantly monitor team safety and the conditions at the work facility so the area is secure from injury, danger, risk, or liability.

6. Safety at NRL Events

6.1. Safety Considerations

- At events, the pure anticipation and excitement can sometimes overshadow common sense and safety fundamentals. One safety area teams sometimes overlook is the need to wear appropriate clothing when working on or being around Bots. In addition to the ANSI-approved, UL-Listed, CE EN166 rated, AS/NZS certified or CSA rated safety glasses required for eye protection, NRL highly recommends that team members and mentors:
- Refrain from wearing dangling jewelry or loose, baggy clothing near the Bots;
- Tie back long hair so that it will not get caught in the Bot or other machinery; and
- Wear gloves to protect hands and fingers when needed.

- The following safety considerations apply at all NRL Competitions:
  - To gain entrance to the pit, every person will have to wear a pair of safety glasses or safety rated prescription glasses with side shields.
  - Don't leave all safety glasses or side shields in the pit. Be sure to bring a few pairs with you, so someone from your team can enter the pit and get the safety glasses for all other members.
  - Use safe handling and transportation techniques around the Bots at all times.
  - Do not use skateboards, 'hoverboards', or drones at events.
  - Do not bring bottled gas tanks (e.g. helium) to events.
  - Do not throw objects (such as paper airplanes) from the stands/bleachers.
  - Use the buddy system when traveling and while at the event.
  - Note that NRL staff and volunteers are distinguished by their name badges.
  - Travel safely and carefully between the pit and the arena.
  - Demonstrate safe behaviors at all times, even in the heat of competition.
  - Make sure the Bot is properly secured if you must work on it. Never work on the Bot on an unstable surface.
  - Assist and mentor other teams with safety issues.

6.2. Pit Table Safety

- Control access to your pit area.
- Keep the work area neat and orderly.
- Properly use power strips. Do not 'daisy chain' (plugging power strips into one another) or overload the rated capacity of the power strip.
- Keep the aisle immediately outside your pit station clear for pedestrians and Bot transit.
- Participants and spectators should be wearing approved personal protective equipment, PPE, in the pit at all times.
- Teams may not build any structure to support people or items for storage over the top of the work area in their team pit station.
- Securely mount team signs, banners, and displays.
- Be aware of your neighbors. Alert them if there is a hazard in your pit or near theirs. Maintain a clean, neat, and orderly pit area at all times.
    - Clean floor in and around your pit station
    - Proper tool storage
    - Proper care of batteries and battery chargers
    - Tidy storage of personal belongings and equipment
- When transporting your Bot, politely keep pedestrians alert to your movement.

6.3. Pit Age Requirement

Children twelve (12) and under must have a person eighteen (18) or older with them at all times. There will be child safety glasses available to borrow and return at the safety glass station. Child strollers and baby carriages are not allowed within the Pit Area.