Section 8

THE ROBOT

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8 THE ROBOT

8.1 OVERVIEW

This section of the 2009 *FIRST* Robotics Competition manual provides rules applicable to the design and construction of the 2009 ROBOT. ROBOTS will be inspected at each *FIRST* Robotics Competition event to verify rules compliance before being allowed to compete.

COMPLIANCE WITH ALL RULES IS MANDATORY

8.1.1 Getting Started

Please be sure to thoroughly read and understand Sections 4, 6, 7, 8, and 9 of this manual before designing your ROBOT. In particular, pay attention to ***Section 8.3.1 - General Design & Safety Rules*** and ***Section 8.3 - Robot Rules*** before proceeding. The following are just a few important points offered to help teams in getting started:

1. Evaluate the game's physical challenges and identify those that the robot will have to overcome.

- Will it have to climb, pick and place items, push / pull objects or robots, possess a low profile, extend its height, lift items, hang, etc.?
- What are the game's implications regarding the ROBOT'S center of gravity?
- Are unique field surface characteristics important when determining robot driving mechanism design?
- Are there any particular offensive / defensive capabilities important to the ROBOT?

2. Inspect all items provided in the 2009 Kit Of Parts (see ***Section 10 and the Kit Of Parts Checklist***) and review their basic features. Note that suppliers' data sheets are referenced in the Kit Of Parts tables for many of the components in the kit.

3. We recommend that you carefully read the documents listed in ***Section 8.1.3 Related Documents & Resources.***

4. Look over the specifications and technical notes provided for the various Kit Of Parts components.

5. Note all safety rules relating to the robot's design. They include:

- The locations and ratings of circuit breakers where indicated in the wiring diagrams
- Wire size
- Stored energy guidelines
- Attention to sharp corners and edges
- Shields for moving parts and pinch points

8.1.2 Related Documents & Resources

In addition to this chapter, other sections in this manual and other documents should be reviewed before proceeding with the robot design process. Note that all referenced documents are available on-line at http://www.usfirst.org/community/frc/content.aspx?id=452

- ***Section 6: The Arena***, ***Section 7: The Game*** and ***Section 9: The Tournament***
- ***Section 4.10.2: Crate Shipping Deadlines*** as listed in ***Section 4: Robot Transportation***
- ***Section 10: Kit Of Parts***
- Innovation First, Inc. instruction manuals for the *Spike relay modules* and *Victor 884 speed controllers* as provided by their manufacturer
- *FIRST* 2009 Chassis Kit Manual – Information to assemble chassis kit available at: http://www.andymark.biz/.
- *FIRST* 2009 Pneumatics Manual - Valuable information about the pneumatic components and ordering processes are included.
- *FIRST* 2009 Sensors Manual – Helpful information regarding the application, assembly, and programming of the sensors included in the 2009 Kit Of Parts.
- 2009 Robot Power Distribution Diagram
- 2009 Robot Data Diagram
- *FIRST* Official Robot Inspection Sheet - it is strongly recommended that this be used as a guide to pre-inspect your ROBOT before it ships (available mid-January).
- *2009 FIRST* Robotics Competition Suggestions

8.1.3 Conventions

Specific methods are used throughout this section to highlight warnings, cautions, key words or phrases to alert the reader to important information designed to help teams in constructing a robot complying with the rules in a safe and workmanlike manner.

Warnings, cautions, and notes appear in bordered boxes. Key words that have a particular meaning within the context of the 2009 *FIRST* Robotics Competition are defined in Sections 6, 7.2 and 8.2, and indicated in ALL CAPITAL letters throughout this text. References to other sections of the manual appear in ***bold italics***. References to specific rules within the manual are indicated with a bracketed reference to the rule (e.g. “Rule <S01>”). Operating keys, controls, buttons appear in bold capital letters (i.e. **OFF/ON** switch or **RESET** button).

8.2 DEFINITIONS

BUMPERS – Bumper assemblies designed to attach to the exterior of the ROBOT within the BUMPER ZONE, and constructed as specified in Rule <R08>. BUMPERS are excluded from the weight and volume calculations specified in Rule <R11>.

BUMPER PERIMETER – the polygon defined by the outer-most set of exterior vertices on the ROBOT (without the BUMPERS or Trailer Hitch attached) that are within the BUMPER ZONE. To determine the BUMPER PERIMETER, wrap a piece of string around the ROBOT at the level of the BUMPER ZONE - the string describes this polygon. The BUMPER PERIMETER may extend up to, but cannot exceed, the maximum ROBOT volume constraints defined in Rule <R11>.

BUMPER ZONE – the volume contained between two virtual horizontal planes, one inch above the floor and seven inches above the floor.

COMPONENT – A ROBOT part in its most basic configuration, which can not be disassembled without damaging or destroying the part, or altering its fundamental function.

- Example 1: raw aluminum stock, pieces of steel, wood, etc., cut to the final dimensions in which they will be used on the ROBOT, would all be considered components. Bolting pieces of extruded aluminum together as a ROBOT frame would constitute a MECHANISM, and the collection of pieces would not be considered a COMPONENT.
- Example 2: a COTS (see immediately below) circuit board is used to interface to a sensor on the ROBOT, and it includes the circuit board and several electrical elements soldered to the board. The board is considered a COMPONENT, as this is the basic form in which it was purchased from the vendor, and removing any of the electrical elements would destroy the functionality of the board.

COTS – A "Commercial, Off-The-Shelf" COMPONENT or MECHANISM, in it's unaltered, unmodified state. A COTS item must be a standard (i.e. not custom order) part commonly available from the VENDOR, available from a non-team source, and available to all teams for purchase.

- Example 1: a team orders two robot grippers from RoboHands Corp. and receives both items. They put one in their storeroom and plan to use it later. Into the other, they drill "lightening holes" to reduce weight. The first gripper is still classified as a COTS item, but the second gripper is now a "custom part" as it has been modified.
- Example 2: a team obtains openly available blueprints of a drive component commonly available from Wheels-R-Us Inc. and has local machine shop "We-Make-It, Inc." manufacture a copy of the part for them. The produced part is NOT a COTS item, because it is not commonly carried as part of the standard stock of We-Make-It, Inc.
- Example 3: a team obtains openly available design drawings from a professional publication during the pre-season, and uses them to fabricate a gearbox for their ROBOT during the build period following kick-off. The design drawings would be considered a COTS item, and may be used as "raw material" to fabricate the gearbox. The finished gearbox itself would be a FABRICATED ITEM, and not a COTS item.

FABRICATED ITEM – Any COMPONENT or MECHANISM that has been altered, built, cast, constructed, concocted, created, cut, heat treated, machined, manufactured, modified, painted, produced, surface coated, or conjured into the final form in which it will be used on the ROBOT.

- Example 1:A piece of extruded aluminum has been ordered by the team, and arrives in a 20-foot length. To make it fit in their storage room, the team cuts it into two ten-foot lengths. These would not be considered FABRICATED ITEMS, as they have not been cut to the final length in which they will be used on the ROBOT.
- Example 2: A team designs an arm mechanism that uses gears with a 1/2-inch face width. They order a 12-inch length of gear stock and cut it into precise 1/2 inch slices. They do not bore out the mounting bores in the center of the gears. The slices are now considered FABRICATED ITEMS, as they have been cut to final size, even though all the machining operations (the center bore) may not yet be completed.

MECHANISM – A COTS or custom assembly of COMPONENTS that provide specific functionality on the ROBOT. A MECHANISM can be disassembled (and then reassembled) into individual COMPONENTS without damage to the parts.

OPERATOR CONSOLE – the Driver Station unit provided in the *FIRST* Kit Of Parts, and any associated equipment, control interfaces, display systems, structure, decorations, etc. used by the PILOTS to operate the ROBOT.

PLAYING CONFIGURATION - The physical configuration and orientation of the ROBOT while playing the game (i.e. after the MATCH has started, and the ROBOT has deployed mechanisms, moved away from the starting location, and/or interacted with the field, GAME PIECES, or other ROBOTS). This configuration is dynamic, and may change multiple times during the course of a single MATCH.

REPLACEMENT PARTS – A COMPONENT or MECHANISM constructed as a functional duplicate of an existing part of the ROBOT, for the purpose of replacing a broken or defective part. REPLACEMENT PARTS may be either COTS items or FABRICATED ITEMS. They must be functionally identical to the original part but can be modified to provide more robust performance of the function.

- Example 1: A lever arm made of lexan on your ROBOT breaks. You manufacture a REPLACEMENT PART made of aluminum plate, using the design drawings of the original. As the new part provides the same function as the broken part, the new part is a valid REPLACEMENT PART.
- Example 2: A sensor on the ROBOT is connected to the control system with 24guage single-strand wire, and runs across a hinged joint. The flexing of the wire causes it to break, and you want to replace it with 18-guage multi-strand wire. If the new wire follows the same path as the original and connects only the same devices, then it is a valid REPLACEMENT PART (i.e. it has added robustness without changing function). But if the wire is then used to connect an additional sensor to the same circuit, it is providing a functionally different capability, and is no longer a “replacement.”

ROBOT - A *FIRST* ROBOT is a remotely operated vehicle designed and built by a *FIRST* Robotic Competition team to perform specific tasks when competing in the 2009 competition “*Lunacy*.” The ROBOT must include all the basic systems required to be an active participant in the game – power, communications, control, mobility, and actuation. The ROBOT implementation must obviously follow a design approach intended to play the 2009 FRC game (e.g. a box of unassembled parts placed on the field, or a ROBOT designed to play a different game, would not satisfy this definition).

SPARE PARTS – A COMPONENT or MECHANISM constructed as an identical duplicate of an existing part of the ROBOT, for the purpose of replacing a broken or defective part. SPARE PARTS may be either COTS items or FABRICATED ITEMS, but they must be physically and functionally identical to the original part.

STARTING CONFIGURATION – The physical configuration and orientation of the ROBOT when the MATCH is started. This is the state of the ROBOT immediately before being enabled by the Field Management System, before the ROBOT takes any actions, deploys any mechanisms, or moves away from the starting location. This configuration is static, and does not change during a single MATCH (although it may change from MATCH to MATCH).

UPGRADE PARTS - A COMPONENT or MECHANISM intended to provide additional functionality not currently available on the ROBOT. UPGRADE PARTS may be COTS items or custom FABRICATED ITEMS, and may either add to or replace existing functionality.

- Example 1: A ROBOT is designed with a four-wheel drive system. The system works well on flat floors, but high-centers when trying to drive up steps. The team adds two more wheels on the centerline of the ROBOT to prevent this problem, and the wheels are identical to those already on the ROBOT. The new wheels would be considered UPGRADE PARTS even though

they are the same as the ones already in place, as they alter the functionality of the ROBOT and provide new capability.

VENDOR – A legitimate business source for COTS items that, as a minimum, satisfies the following criteria:

A. The VENDOR must have a Federal Tax Identification number. The Federal Tax Identification number establishes the VENDOR as a legal business entity with the IRS, and validates their status as a legitimate business. In cases where the VENDOR is outside of the United States, they must possess an equivalent form of registration or license with the government of their home nation that establishes and validates their status as a legitimate business licensed to operate within that country.
B. The VENDOR shall not be a "wholly owned subsidiary" of a team or collection of teams. While there may be some individuals affiliated with both a team and the VENDOR, the business and activities of the team and VENDOR must be completely separable.
C. The VENDOR must be normally able to ship any general (i.e., non-*FIRST* unique) product within five business days of receiving a valid purchase request. It is recognized that certain unusual circumstances (such as 1,000 *FIRST* teams all ordering the same part at once from the same VENDOR) may cause atypical delays in shipping due to backorders for even the largest VENDORS. Such delays due to higher-than-normal order rates are excused.
    - Note that the intent here is to protect the teams against long delays in availability of parts that will impact their ability to complete their ROBOT. The *FIRST* Robotics Competition build season is brief, so the VENDOR must be able to get their product, particularly *FIRST* unique items, to a team in a timely manner.
D. The business should maintain sufficient stock or production capability to fill teams orders within a reasonable period during the build season (less than 1 week). Note that this criterion may not apply to custom-built items from a source that is both a VENDOR and a fabricator. For example, a VENDOR may sell flexible belting that the team wishes to procure to use as treads on their drive system. The VENDOR cuts the belting to a custom length from standard shelf stock that is typically available, welds it into a loop to make a tread, and ships it to a team. The fabrication of the tread takes the VENDOR two weeks. This would be considered a FABRICATED ITEM, and the two weeks ship time is acceptable. Alternately, the team may decide to fabricate the treads themselves. To satisfy this criterion, the VENDOR would just have to ship a length of belting from shelf stock (i.e. a COTS item) to the team within five business days and leave the welding of the cuts to the team.
E. The VENDOR makes their products available to all *FIRST* Robotics Competition teams. VENDORS must not limit supply or make a product available to just a limited number of *FIRST* Robotics Competition teams.
F. Ideally, chosen VENDORS should have national distributors.
    - Example distributors include Home Depot, Lowes, MSC, Radio Shack, and McMaster-Carr. *FIRST* competition events are not usually near home. When parts fail, local access to replacements is often critical.

FIRST desires to permit teams to have the broadest choice of legitimate sources possible, and to obtain COTS items from the sources that provide them with the best prices and level of service available. The intent of this definition it to be as inclusive as possible to permit access to all legitimate sources, while preventing *ad hoc* organizations from providing special-purpose products to a limited subset of teams in an attempt to circumvent the cost accounting rules.

WITHHOLDING ALLOWANCE – A limited amount of FABRICATED ITEMS that are permitted to be withheld from the ROBOT shipping requirements (specified in Section 4.10 and Rule <R25>) and retained by the team following the shipping deadlines. These items may then be hand-carried to a competition event by the team. The OPERATOR CONSOLE is automatically included in the

WITHHOLDING ALLOWANCE. Beyond that, the incoming material maximums specified in Rule <R36> limits the amount of FABRICATED ITEMS included in the WITHHOLDING ALLOWANCE.

8.3 ROBOT RULES

These rules establish the global ROBOT construction and performance constraints dictated by the characteristics of the provided Kit Of Parts, along with the size and weight design limits. **Compliance with the rules is mandatory, and is the responsibility of every team! Any ROBOT construction not in compliance with the rules (as determined at inspection) must be rectified before a ROBOT will be allowed to compete**

When constructing the ROBOT, the team is allowed to use the items supplied in the one 2009 Kit Of Parts provided to each registered *FIRST* Robotics Competition team, and additional materials. Many of the rules listed below explicitly address what parts and materials may be used, and how those items may be used. There are many reasons for the structure of the rules, including safety, reliability, fairness, creation of a reasonable design challenge, adherence to professional standards, impact on the competition, compatibility with the Kit Of Parts, etc. When reading these Rules, please use technical common sense (engineering thinking) rather than "lawyering" the interpretation and splitting hairs over the precise wording in an attempt to find loopholes. Try to understand the reasoning behind a rule.

Part of the purpose of the *FIRST* Robotics Competition is to provide team members with the experience of conceptualizing, designing and constructing their own solution to the challenge posed by the game. This must be a consideration when obtaining MECHANISMS and COTS items as additional parts to use on the ROBOT.

This intent is clearly met when a team obtains a MECHANISM or COTS items that was designed for non-FIRST purposes, and then modifies or alters it to provide functionality for the ROBOT. For example, if a team obtains a gearbox from a power drill and modifies it to use on the ROBOT, they gain insight into the design of the original gearbox purpose, learn to characterize the performance of the original design, and implement the engineering design process to create their customized application for the gearbox.

However, COTS items that have been specifically designed as a solution to portion of the *FIRST* Robotics Competition challenge may or may not fit within the FRC intent, and must be carefully considered. If the item provides general functionality that can be utilized in any of several possible configurations or applications, then it is acceptable (as the teams will still have to design their particular application of the item). However, COTS items that provide a complete solution for a major ROBOT function (e.g. a complete manipulator assembly, pre-built pneumatics circuit, or full mobility system) that require no effort other than just bolting it on to the ROBOT are against the intent of the competition, and will not be permitted.

In addition, another intent of these rules is to have all energy sources and active actuation systems on the ROBOT (e.g. batteries, compressors, motors, servos, cylinders, and their controllers) drawn from a well-defined set of options. This is to ensure that all teams have access to the same actuation resources, and to ensure that the inspectors are able to accurately assess the legality of a given part.

8.3.1 Safety & Damage Prevention

<R01> Energy used by *FIRST* Robotics Competition ROBOTS, (i.e., stored at the start of a MATCH), shall come only from the following sources:

A. Electrical energy derived from the onboard 12V battery

B. Compressed air stored in the pneumatic system, stored at a maximum pressure of 120 PSI in no more than four Clippard Instruments tanks. Extraneous lengths of pneumatic tubing shall not be used to increase the storage capacity of the air storage system.

C. A change in the altitude of the ROBOT center of gravity.

D. Storage achieved by deformation of ROBOT parts. Teams must be very careful when incorporating springs or other items to store energy on their ROBOT by means of part or material deformation. A ROBOT may be rejected at inspection if, in the judgment of the inspector, such items are unsafe.

<R02> ROBOT parts shall not be made from hazardous materials, be unsafe, or cause an unsafe condition. Items specifically PROHIBITED from use on the ROBOT include:

A. Shields, curtains, or any other devices or materials designed or used to obstruct or limit the vision of any PILOTS and/or COMMANDERS and/or interfere with their ability to safely control their ROBOT

B. Speakers, sirens, air horns, or other audio devices that generate sound at a level sufficient to be a distraction or hindrance affecting the outcome of a MATCH

C. Any devices or decorations specifically intended to jam or interfere with the remote sensing capabilities (including vision systems, acoustic range finders, sonars, infra-red proximity detectors, etc.) of another robot (i.e. changing ROBOT color to confuse opponent's vision system)

D. Lasers of any type

E. Flammable gasses

F. Any devices intended to produce flames or pyrotechnics

G. Materials that off-gas noxious or toxic gasses

H. Materials that produce hazardous inhalable particles

I. Caustic chemicals

J. Hydraulic fluids or hydraulic components

Teams should provide MSD Sheets for any materials they use that might be considered questionable during ROBOT inspection.

<R03> Custom circuits and electronics are expressly PROHIBITED if they:

A. Interfere with the operation of other ROBOTS.

B. Directly affect any output devices on the ROBOT, such as by providing power directly to a motor, supplying a PWM signal directly to a speed controller or supplying a control signal directly to a relay module.

<R04> Protrusions from the ROBOT shall not pose hazards to GAME PIECES, team members or event staff. If the ROBOT includes protrusions that form the "leading edge" of the ROBOT as it drives, and are less than one square inch in surface area, it will invite detailed inspection. For example, forklifts, lifting arms, grapplers. etc. may be carefully inspected for these hazards

<R05> Exterior or exposed surfaces on the ROBOT shall not present undue hazards to the team members, event staff or GAME PIECES. Reasonable efforts must be taken to remove, mitigate, or shield any sharp edges, pinch points, entanglement hazards, projectiles, extreme visual/audio emitters, etc. from the exterior of the ROBOT. All points and corners that would be commonly expected to contact a GAME PIECE should have a minimum radius of 0.125 inches to avoid becoming a snag/puncture hazard. All edges that would be commonly expected to contact a GAME PIECE should have a minimum radius of 0.030 inches. All of these potential hazards will be carefully inspected.

Note: inspectors will be looking for sharp corners and edges that could cause injury, pinch points, entanglement hazards, and impaling projections. Please mitigate all such hazards. This is for the protection of team members and field personnel as well as game equipment.

<R06> ROBOTs must use ROVER WHEELS (as supplied in the 2009 Kit Of Parts and/or their equivalent as provided by the supplying vendor) to provide traction between the ROBOT and the ARENA. Any number of ROVER WHEELS may be used. The ROVER WHEELS must be used in a "normal" orientation (i.e. with the tread of the wheel in contact with the ground, with the axis of rotation parallel to the ground and penetrating the wheel hub). No other forms of traction devices (wheels, tracks, legs, or other devices intended to provide traction) are permitted. The surface tread of the ROVER WHEELS may not be modified except through normal wear-and-tear. Specifically, the addition of cleats, studs, carved treads, alterations to the wheel profile, high-traction surface treatments, adhesive coatings, abrasive materials, and/or other attachments are prohibited. The intent of this rule is that the ROVER WHEELS be used in as close to their "out of the box" condition as possible, to provide the intended low-friction dynamic performance during the game

<R07> MECHANISMS or COMPONENTS on the ROBOT shall not pose obvious risk of entanglement. If the structure of a COMPONENT permits easy penetration by an object less than four square inches in cross section, it will invite detailed inspection. Willful entanglement actions are addressed in Rule <G33>.

- Note: nets, loose rope or wire, voluminous sheets of fabric, etc. may be carefully inspected for these hazards. A 1/8" x 1/8" tight-mesh net (or very loose mesh fabric, depending on your point of view) may be a reasonable material that would not automatically pose an entanglement hazard. However, any flexible material has the potential to become an entanglement hazard if it is not firmly attached to an appropriate structure or left in a loose, voluminous configuration. Therefore, you must use your best judgment to determine if your particular use of the material will pose an entanglement hazard. However, actual performance on the playing field will determine is the potential for entanglement is significant or not.

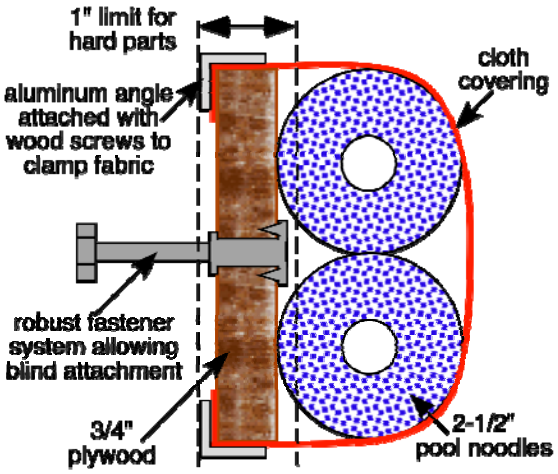
<R08> Teams are required to use BUMPERS on their ROBOTS. BUMPERS have several advantages, such as reducing damage to ROBOTS when they contact other ROBOTS or ARENA elements, and being excluded from the calculation of ROBOT weight and volume constraints specified in Rule <R11>. The BUMPER location and design have been specified so that ROBOTS will make BUMPER-to-BUMPER contact during any collisions. If implemented as intended, a ROBOT that is driven into a vertical wall in any normal PLAYING CONFIGURATION will always have the BUMPER be the first thing to contact the wall. To achieve this, BUMPERS must be constructed as described below and illustrated in Figure 8 – 1.

A. BUMPERS must be built in segments, with a minimum length of six inches, and a maximum length that does not exceed the maximum horizontal dimension of the ROBOT.

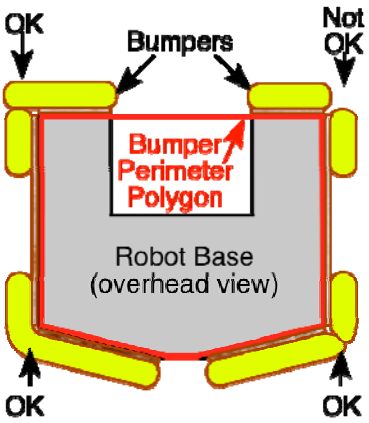
B. BUMPERS must use a stacked pair of 2-1/2 inch “pool noodles” as the bumper material.

C. Each BUMPER segment must be backed by a piece of 3/4-inch thick by 5-inch tall piece of plywood.

D. The BUMPERS must be covered with a rugged, smooth cloth (1000 dernier Cordura Plus® strongly recommended). The cloth must cover all external parts of the bumper material (pool noodle) and backing (plywood).



Cross-section View
Figure 8 – 1



Overhead View
Figure 8 – 2

E. BUMPERS (including any fasteners and/or structures that attach them to the ROBOT) must weigh no more than 18 pounds.

F. BUMPERS must be designed for quick and easy installation and removal, to aid in weighing and inspection (as a guideline, BUMPERS should be removable by one person in ten minutes).

G. BUMPERS must attach to the ROBOT with a rigid fastening system to form a tight, robust connection to the main ROBOT structure/frame (e.g. not attached with Velcro!). The attachment system must be designed to withstand vigorous game play – nut and bolt fasteners are recommended. All removable fasteners (e.g. bolts, locking pins, pip-pins, etc.) will be considered part of the BUMPERS.

H. If a multi-part attachment system is utilized (e.g. interlocking brackets on the ROBOT and the BUMPER), then the elements permanently attached to the ROBOT will be considered part of the ROBOT, and the elements attached to the BUMPERS will be considered part of the BUMPER. Each element must satisfy all applicable rules for the relevant system.

I. BUMPERS must protect all exterior corners of the BUMPER PERIMETER (see Figure 8 - 2).

J. Corners and joints between BUMPER segments may be filled with short pieces of vertically oriented pool noodle, by wrapping the pool noodles around the corners, or by beveling the ends between adjacent segments so they form a tight and complete protective surface (see Figure 8 – 2).

K. BUMPERS must protect a minimum of 2/3 of the BUMPER PERIMETER. Teams are encouraged to maximize the area of the ROBOT protected by BUMPERS. But up to 1/3 of the BUMPER PERIMETER may be unprotected to provide flexibility in design options.

L. The BUMPERS must be fixed to the BUMPER PERIMETER.

M. The entire length of the BUMPER backing must be supported by the structure/frame of the ROBOT (i.e. the backing material must not be in "free space" between or beyond attachment points) (see Figure 8 – 3).

N. BUMPERS may extend beyond the BUMPER PERIMETER by up to a maximum of 3-1/2 inches per side. "Hard" parts of the BUMPER (i.e. plywood backing, fastening system, and clamping angles) may extend up to a maximum of one inch beyond the BUMPER PERIMETER. Only "soft" parts of the BUMPERS (i.e. pool noodles and cloth covering) may extend more than one inch beyond the BUMPER PERIMETER.

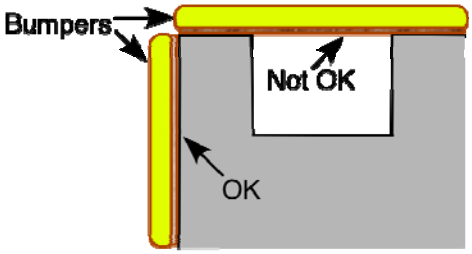


Figure 8 - 3

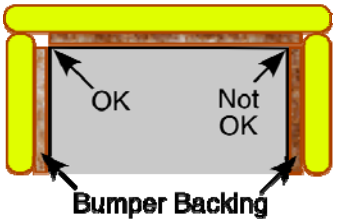


Figure 8 - 4

O. The BUMPER backing must not extend beyond the "edge" of the ROBOT. The backing of adjacent BUMPER segments must not attach to each other if the attachment would require that the joint extend into the corner (see Figure 8 – 4).

P. BUMPERS must be mounted to the ROBOT within the BUMPER ZONE, and must remain there. The BUMPERS must not be articulated or designed to move outside of the BUMPER ZONE.

As bumper mounts are being designed, methods for carrying the ROBOT will have to be considered (bumpers typically do not make good handles!). Also, note that the use of BUMPERS may preclude the use of other technologies in their out-of-the-box configurations. Teams will need to carefully consider the interactions between BUMPER design options and other elements of their ROBOT design.

8.3.2 General Robot Design

<R09> Each registered *FIRST* Robotics Competition team can enter ONE (1) ROBOT into the 2009 *FIRST* Robotics Competition. That ROBOT shall fully comply with all rules specified in the 2009 *FIRST* Robotics Competition manual.

<R10> Robots entered into the 2009 *FIRST* Robotics Competition shall be fabricated and/or assembled from COMPONENTS, MECHANISMS and COTS items that are constructed from:

A. Items provided in the *FIRST*-supplied Kit Of Parts (or their exact REPLACEMENT PART)

B. Allowed additional parts and materials as defined in the rules, and in quantities consistent with the Budget Constraint rules (found in Section 8.3.3).

<R11> At the start of, and during, the MATCH the ROBOT shall fit within the orthogonal dimensions listed below:

Dimension 1 (horizontal)	Dimension 2 (horizontal)	Dimension 3 (vertical)	Maximum Weight
28 inches (71.12cm)	38 inches (96.52cm)	60 inches (152.40cm)	120 pounds (54.43Kg)

A. Exception: solely for the purposes of determining compliance with the weight and volume limitations, these items are NOT considered part of the ROBOT and are NOT included in the weight and volume assessment:
   - The 12V battery and its associated half of the Anderson cable quick connect/disconnect pair (including no more than 12 inches of cable per leg, the associated cable lugs, connecting bolts, and insulating electrical tape),
   - BUMPER assemblies that are in compliance with Rule <R08>,
   - The TRAILER,
   - The Trailer Hitch (as defined in Rule <R18>),
   - The OPERATOR CONSOLE.

<R12> Any restraints (elastic bands, springs, etc.) that are used to restrain the ROBOT in its STARTING CONFIGURATION must remain attached to the ROBOT for the duration of the MATCH

<R13> When determining weight, the basic ROBOT structure and all elements of all additional mechanisms that might be used in different configurations of the ROBOT shall be weighed together**.** Included in the weight limit are the robot control system, decorations, and all other attached parts.
   - Example: A team has decided to design their ROBOT such that, before any given MATCH, they may change the configuration of the ROBOT based on perceived strengths or weaknesses of an opponent. The team accomplished this by constructing a basic drive train platform plus two versions of a GAME PIECE manipulator, each manipulator being a quick attach / detach device such that either one or the other (but not both) may be part of the ROBOT at the beginning of a MATCH. Their ROBOT platform weighs 107 lb, version A of the manipulator weighs 6 lb, and version B weighs 8 lb. Although only one version will be on the ROBOT during a MATCH, both manipulators (and all components of the manipulators that would be used during the MATCH) must be on the scale along with the ROBOT platform during weigh in. This would result in a **rejection** of the ROBOT because its total weight comes to 121 lb.

<R14> ROBOTS shall display their school name (or the name of the supporting youth organization name, if appropriate), and primary sponsor name and/or logo whenever the ROBOT is on the field, including practice sessions. The support provided by the corporate sponsors and mentors on your team is important, and is to be acknowledged with the appropriate display of their names/logos on the exterior of the ROBOT.

<R15> The judges, referees, and announcers must be able to easily identify ROBOTS by team number. Teams shall display their team number in four locations at approximately 90-degree intervals around the perimeter of the ROBOT. **The numerals must be at least 4 inches high, at least in 3/4-inch stroke width and in a contrasting color from its background**. Team Numbers must be clearly visible from a distance of not less than 100 feet.

<R16> Once the MATCH has started, the ROBOT may assume a PLAYING CONFIGURATION that is different from the STARTING CONFIGURATION. The ROBOT must be designed such that the PLAYING CONFIGURATION of the ROBOT shall not exceed the dimensions specified in Rule <R11>. When in the PLAYING CONFIGURATION, no part of the ROBOT may extend outside the vertical projection of the BUMPER PERIMETER.

<R17> "Wedge" ROBOTS are not permitted. ROBOTS shall be designed so that interaction with opposing ROBOTS results in pushing rather than tipping or lifting. Neither offensive nor defensive wedges are allowed. All parts of a ROBOT between zero and seven inches from the ground (the top of the BUMPER ZONE) that are used to push against or interact with an opposing ROBOT must be within 10 degrees of vertical. If a mechanism or an appendage (e.g. a harvester for retrieving GAME PIECES) becomes a wedge that interferes with other ROBOTS, penalties, disabling, or disqualification can occur depending on the severity of the infraction.

<R18> To attach the TRAILER to the ROBOT, TEAMS must use a Trailer Hitch constructed from materials provided in the 2009 Kit Of Parts. Details on the construction of the Trailer Hitch are provided in Drawings "GE-09040".

A. The Trailer Hitch is composed of the "Trailer Spacer" (Part 2 in the drawing) and the "Trailer Mount Bar" (Part 3 in the drawing). The Trailer Spacer is a 7-inch length of square steel tubing provided in the Kit Of Parts. The Trailer Mount Bar is a length of robot chassis material (C-channel) to be cut from the provided KOP chassis material, and must match any of the three configurations included in the Drawing.

B. The Trailer Hitch must be rigidly attached to a fixed location on the ROBOT, with the long dimension of the Trailer Hitch horizontal and the opening of the C-channel facing away from the ROBOT. The horizontal center line of the Trailer Hitch must be 2-13/16 inches above the floor, +/- 0.25 inches.

C. The Trailer Hitch must be positioned so that the TRAILER may be locked in place with a standard 1/4– inch diameter hitch pin (McMaster-Carr part number 98416A009). During a competition MATCH, this hitch pin will be provided with the TRAILER as part of the ARENA equipment. See Figure 8-5.

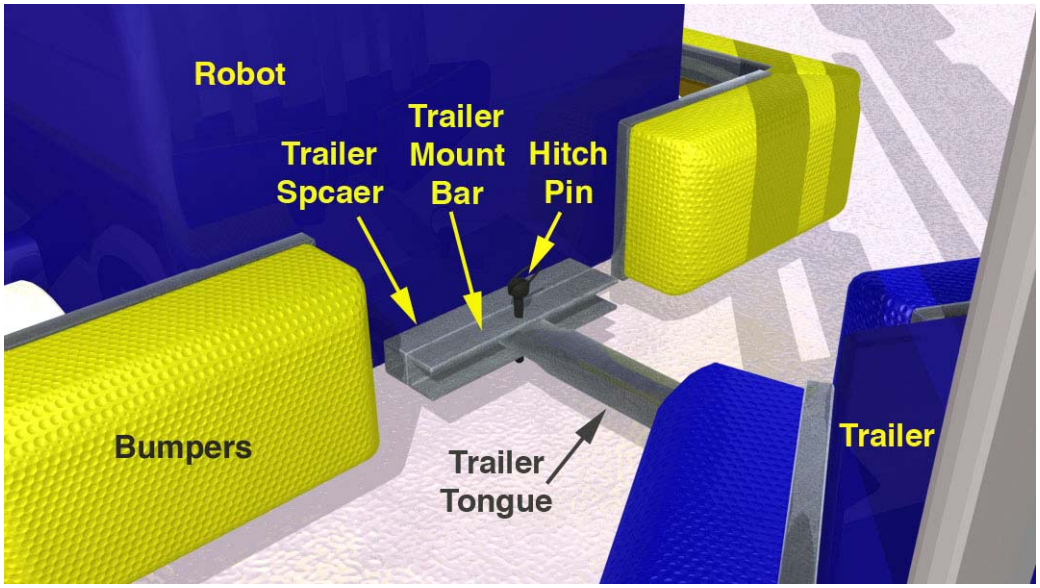


Figure 8 – 5

D. The Trailer Hitch must be located on the BUMPER PERIMETER of the ROBOT structure such that it may easily connect with the tongue of the TRAILER (attached to the TRAILER).

E. The Trailer Hitch must be placed such that, as the TRAILER swings from side to side, the first contact between the TRAILER and ROBOT is BUMPER-to-BUMPER and not TRAILER-tongue-to-BUMPER (to prevent placing excessive stress upon, and possibly damaging, the TRAILER tongue). See Figure 8-6.

F. The color of the TRAILER (red or blue) will be used to indicate the ALLIANCE of the ROBOT.

G. The Trailer Hitch must be designed for quick and easy installation and removal, to aid in ROBOT inspection during sizing and weighing checks (as a guideline, the Trailer Hitch should be removable by one person in ten minutes).

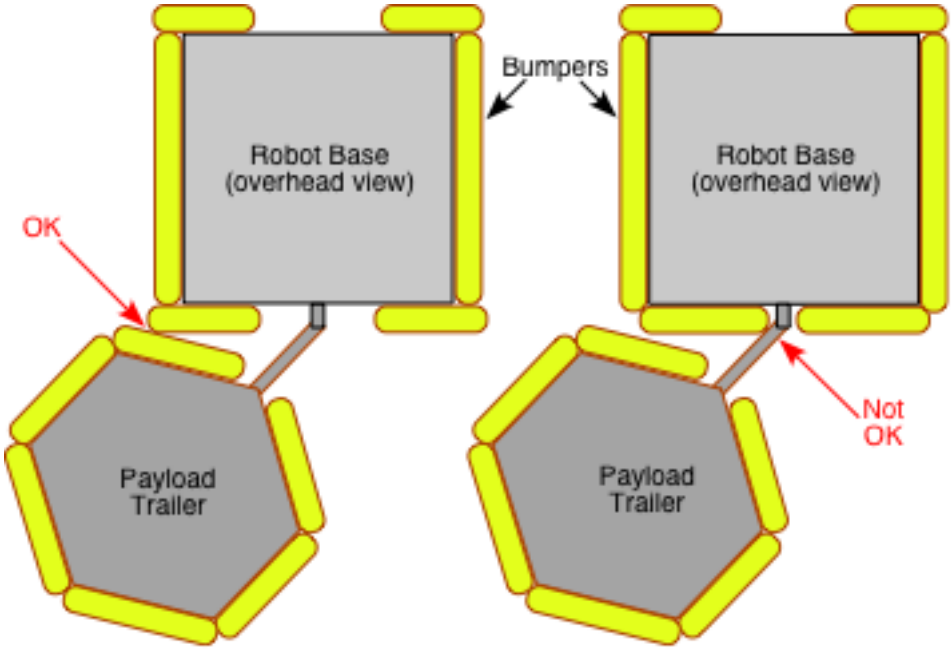


Figure 8-6

<R19> Any non-functional decorations included on the ROBOT must not affect the outcome of the MATCH, and must be in the spirit of "Gracious Professionalism."

8.3.3 Budget Constraints

<R20> All non-2009 Kit Of Parts items and materials used in the construction of a ROBOT (as defined in Section 8.2), and their associated costs, shall be recorded (in US dollars) in a consolidated Bill Of Materials (BOM). A default template BOM will be available for download at http://www.usfirst.org/community/frc/content.aspx?id=452

<R21> The total cost of all non-2009 Kit Of Parts items shall not exceed $3,500.00 USD.

A. All costs are to be determined as explained in Section 8.3.3.1 – Cost Determination of Additional Parts

B. No individual item shall have a value of over $400.00. The total cost of COMPONENTS purchased in bulk may exceed $400.00 USD as long as the cost of an individual COMPONENT does not exceed $400.00.

<R22> The following items are EXCLUDED from the total cost calculation:

A. The cost of any non-functional decorations
B. The cost of individual fasteners, adhesives, or lubricants, unless any one component exceeds $1.00
C. The costs of SPARE PARTS. A SPARE PART used as a direct replacement for a failed or defective ROBOT part (either Kit Of Parts item or non-Kit Of Parts item) that has already been included in the cost accounting is covered by the accounting for the original part
D. All costs for the construction of the OPERATOR CONSOLE

<R23> Individual COMPONENTS or MECHANISMS retrieved from previous ROBOTS and used on 2009 ROBOTS must have their undepreciated cost included in the 2009 robot cost accounting, and applied to the overall cost limits.

8.3.3.1 Cost Determination of Additional Parts

The "cost" of each non-Kit Of Parts item is calculated based on the following criteria, as applicable:

A. The purchase price of a COTS item offered for sale by a VENDOR to any customer.
B. The total cost (materials + labor) of an item you pay someone else to make.
    - Example: A team orders a custom bracket fabricated by a VENDOR to the team's specification. The VENDOR'S material cost and normally charged labor rate apply.
C. The fair market value of an item obtained at a discount or as a donation. Fair market value is that price at which the supplier would normally offer the item to other customers. Also considered to be "fair market value" are the discounted prices offered to all teams by suppliers with established relations with *FIRST*.
    - Example: Special price discounts from National Instruments and Luminary Micro are being offered to all *FIRST* teams. The discounted purchase price of items from these sources would be used in the additional parts accounting calculations.
D. The cost of raw material obtained by a team + the cost of non-team labor expended to have the material processed further. Labor provided by team members and/or by a recognized team sponsor whose employees are members of the team does not have to be included. Note: it is in the best interests of the teams and *FIRST* to form relationships with as many organizations as possible. Teams are encouraged to be expansive in recruiting and including organizations in their team, as that exposes more people and organizations to *FIRST*. Recognizing supporting companies as sponsors of, and members in, the team is encouraged - even if the involvement of the sponsor is solely through the donation of fabrication labor.
    - Example: A team purchases steel bar stock for $10.00 and has it machined by a local machine shop. The machine shop is not considered a team sponsor, but donates two hours of expended labor anyway. The team must include the estimated normal cost of the labor as if it were paid to the machine shop, and add it to the $10.00.
    - Example: A team purchases steel bar stock for $10.00 and has it machined by a local machine shop that is a recognized sponsor of the team. The machinists are considered members of the team, so their labor costs do not apply. The total applicable cost for the part would be $10.00.
E. The cost of items purchased in bulk or large quantities may be prorated on the basis of the smallest commonly available unit that satisfies the need for the item.
    - Example: A team purchases a 4' x 4' sheet of aluminum, but only uses a piece 10" x 10" on their ROBOT. The team identifies a source that sells aluminum sheet in 1' x1' pieces. The team may cost their part on the basis of a 1' x 1' piece, even though they cut the

piece from a larger bulk purchase. They do not have to account for the entire 4' x 4' bulk purchase item.

F. Shipping costs of Non-Kit items are not counted.

G. COMPONENTS or MECHANISMS that teams purchase to replace Kit Of Parts items that were not received from *FIRST* are not subject to the cost limitation (i.e., should not be charged against the $3,500.00 robot limit).

H. If the item is part of a modular system that can be assembled in several possible configurations or applications, then each individual module must fit within the price constraints defined in Rule <R21>. If the modules are designed to assemble into a single configuration, and the assembly is functional in only that configuration, then the total cost of the complete assembly including all modules must fit within the price constraints defined in Rule <R21>.

8.3.4 Fabrication Schedule

FIRST recognizes that it is the responsibility of each team to design and construct their ROBOT within the schedule constraints defined below. As compliance with these rules takes place outside of the competition venues, *FIRST* is not able to directly monitor compliance. One of the fundamental values of *FIRST* is the concept of "gracious professionalism." We are relying upon the honor, integrity, and professional behavior of each team to recognize and abide by the fabrication schedule rules.

Note that schedule rules apply to both hardware and software development. Hardware and software design processes are thought-intensive activities, and team members are likely to continue to consider and analyze their designs long after the ROBOT is "completed." Teams can not be prevented from thinking about their hardware and software designs, and it is not our intention to do so. However, the timeline permitted for the development of the actual competition version of the ROBOT is intentionally restricted. Pondering software issues to be resolved, researching general case solutions, discussing solutions with teammates, collecting raw materials, sketching mechanisms, preparing tools, and outlining high-level descriptions of software algorithms are all reasonable activities before the scheduled build period. However, completing detailed dimensioned drawings of parts, and any actual fabrication of any hardware items intended to go on the actual competition ROBOT is prohibited outside of the approved fabrication periods. On the software side, writing actual lines of code, verification of syntax, final debugging, etc would all be considered development of the final software implementation, and must be completed during the approved fabrication periods.

<R24> Prior to the Kick-off: Before the formal start of the Robot Build Season, teams are encouraged to think as much as they please about their ROBOTS. They may develop prototypes, create proof-of-concept models, and conduct design exercises. Teams may gather all the raw stock materials and COTS COMPONENTS they want. But absolutely no final design, fabrication, or assembly of any elements intended for the final ROBOT is permitted prior to the Kick-off presentation.

- Example: A TEAM designs and builds a two-speed shifting transmission during the fall as a training exercise. When designing their competition ROBOT, they utilize all the design principles they learned. To optimize the transmission design for their ROBOT, they improve the transmission gear ratios and reduce the size, and build two new transmissions, and place them on the ROBOT. All parts of this process are permitted activities.
- Example: The same TEAM realizes that the transmission designed and built in the fall perfectly fits their need for a transmission to drive the ROBOT arm. They build a copy of the transmission from the original design plans, and bolt it to the ROBOT. This would be

prohibited, as the transmission – although fabricated during the competition season – was built from detailed designs developed prior to kick-off.

- Example: A TEAM developed an omni-directional drive system for the 2008 competition. Over the summer they refined and improved the control software (written in C) to add more precision and capabilities. They decided to use a similar system this year. They copied large sections of unmodified code over into the control software of the new ROBOT (also written in C). This would be a violation of the schedule constraint, and would not be allowed.
- Example: The same TEAM decides to use the LabView as their software environment for 2009. Following kickoff, they use the previously-developed C code as a reference for the algorithms and calculations required to implement their omni-directional control solution. Because they developed new LabView code as they ported over their algorithms, this would be permitted.
- Example: A different team develops a similar solution during the fall, and plans to use the developed software on their competition ROBOT. After completing the software, they post it in a generally accessible public forum and make the code available to all teams. Because they have made their software generally available, under the terms of Rule <R65> it is considered COTS software and they can use it on their ROBOT.

<R25> During the Build Season: During the period between the Kick-off and the ROBOT shipment deadline, teams are to design and fabricate all the COMPONENTS and MECHANISMS required to complete their ROBOT. They are encouraged to use all the materials, sources and resources available to them that are in compliance with the rules of the 2009 *FIRST* Robotics Competition. There is no limit to the amount of time that may be put into this effort, other than via the realities of the calendar. When the ROBOT shipment deadline arrives, all work on the ROBOT must cease and the ROBOT must be placed in a "hands-off" condition. The entire ROBOT (including all FABRICATED ITEMS intended for use during the competition in alternative configurations of the ROBOT) must be crated and out of team hands by the shipment deadline specified in Section 4.10 (with the exception of the items covered by the WITHHOLDING ALLOWANCE).

<R26> During the period between the shipment of the ROBOT and the competitions: During this period, all teams may manufacture SPARE, REPLACEMENT, and UPGRADE PARTS, and develop software for their ROBOT at their home facility.

A. Teams may manufacture all the SPARE, REPLACEMENT and UPGRADE PARTS they want.
B. There is no limit to the amount of time that may be put into this effort, other than via the realities of the calendar.
C. Teams may continue development of any items retained under the WITHHOLDING ALLOWANCE, continue to work on them during this period, and then bring them to the competition events.
D. The total weight of the FABRICATED ITEMS (SPARE, REPLACEMENT, and UPGRADE PARTS, plus all WITHHOLDING ALLOWANCE items) worked upon during this period and brought to the competition event(s) must not exceed the limits specified in Rule <R36>.

The primary intent of this rule is to allow teams to withhold the ROBOT control system, the OPERATOR CONSOLE, and selected relevant subsystems, and access them after the shipping deadline. This will allow teams to have the maximum time possible prior to each competition event to develop and complete the software for their ROBOT while maximizing the potential to understand and use the capabilities provided by the new control system.

<R27> At the competitions: Teams are allowed to repair, modify or upgrade their competition ROBOT while participating in a competition event. To support this, teams may bring SPARE, REPLACEMENT and UPGRADE PARTS and COTS items to the competitions (within the limits specified in Rules <R35> and <R36>). Work can only be done on-site in the Pits or at any facility made available to all teams at the event (e.g., in a team's repair trailer or a local team's shop offered to all teams to use). Fabrication may be done when the Pit area is open for normal operations during the period starting with the opening of the Pit area on Thursday and ending at 4:00PM on Saturday. All work must be completed when the Pit area closes each evening. Parts shall not be removed from the competition site and retained overnight after the Pit area closes. At the conclusion of a regional competition event, the entire ROBOT (including all FABRICATED ITEMS intended for use during the competition in alternative configurations of the ROBOT) must be crated and out of team hands for shipping to the next event or back to the team.

A. Exception: A limited amount of FABRICATED ITEMS (not to exceed the limits specified in Rule <R36>) may be retained as part of the WITHHOLDING ALLOWANCE and brought back to the team's home facility for continued development.

<R28> During the period between Regional Competition weekends, and between the Regional Competitions and the Championship: During these periods, all teams (not just those teams attending a Regional Competition) may utilize the same opportunities, and must operate under the same restrictions, as specified in Rule <R26>.

8.3.5 Material Utilization

<R29> The use of non-Kit Of Parts items or materials shall not violate any other robot design or fabrication rule.

<R30> Teams may replace lost or damaged Kit Of Parts COMPONENTS only with identical COMPONENTS of the same material, dimensions, treatment, and/or part number.

<R31> COTS ITEMS that are generally available may be used on the ROBOT. The parts shall be generally available from suppliers such that any other *FIRST* team, if it so desires, may also obtain them at the same price. A specific device **fabricated by a team** from non-2009 Kit Of Parts materials for their use does not have to be available to others; however, the materials it is made from must be available to other teams.

<R32> COTS ITEMS from ROBOTS entered in previous *FIRST* competitions or COTS MECHANISMS that are no longer commercially available may be used under the following conditions:

A. The item must be unmodified, and still in its original condition as delivered from the VENDOR, and

B. The item must not be a part custom made for the *FIRST* competition and provided in the Kit Of Parts for a previous *FIRST* Robotics Competition (e.g. 2006 FRC transmissions, custom-made motor couplers, custom sensor strips, 2006 IFI CMUcam II modules, etc. are not permitted), and

C. The item must satisfy ALL of the rules associated with materials/parts use for the 2009 *FIRST* Robotics Competition)

<R33> FABRICATED ITEMS from ROBOTS entered in previous *FIRST* competitions shall not be used on ROBOTS in the 2009 competition.

<R34> Lubricants may be used only to reduce friction within the ROBOT. Lubricants shall not be allowed to contaminate the playing field or other ROBOTS.

<R35> Teams may acquire and bring an unlimited amount of COTS items to the competitions to be used to repair and/or upgrade their ROBOT at the competition site.

<R36> Teams may bring a maximum of 40 pounds of custom FABRICATED ITEMS (SPARE PARTS, REPLACEMENT PARTS, and UPGRADE PARTS, plus all WITHHOLDING ALLOWANCE items) to each competition event to be used to repair and/or upgrade their ROBOT at the competition site. All other FABRICATED ITEMS to be used on the ROBOT during the competition shall arrive at the competition venue packed in the shipping crate with the ROBOT.

- Exception: the OPERATOR CONSOLE is not included in the incoming parts weight restriction.

<R37> Teams participating in the 2009 *FIRST* Robotics Competition that are located outside North America may not be able to acquire the exact part (as identified by specific part numbers) or materials of the specified dimensions as defined in these rules. In such situations, international teams must submit a request for approval of nearest-equivalent parts (e.g. nearest metric equivalent, etc.) to *FIRST* Headquarters (via e-mail request to frcparts@usfirst.org). *FIRST* will determine suitability of the part. If approved, a confirming e-mail will be sent to the team. The team must bring a copy of the e-mail to any competition event to verify that the use of an alternate part has been approved.

8.3.6 Power Distribution

<R38> The only legal primary source of electrical energy on the ROBOT during the competition is the MK ES17-12 12VDC non-spillable lead acid battery, as provided in the 2009 Kit Of Parts. Additional batteries may be purchased through a local MK Battery supplier. Teams may use other equivalent 12V batteries during development, testing and practice MATCHES. However, during competition MATCHES only one MK Battery, ES17-12 can be used on the ROBOT **(this means <u>NO</u> pre-2007 batteries can be used during qualification and elimination MATCHES at any official 2009 *FIRST* competition)**.

<R39> An automatic battery charger rated for a maximum of 6 amperes must be used to charge the ES17-12 batteries. When recharging the ES17-12 batteries, either the charger provided by *FIRST* or an automatic charger with an equivalent charging current rating may be used.

<R40> Items specifically PROHIBITED from use on the ROBOT include:

A. Any battery other than, or in addition to, the one primary battery permitted by Rule <R38>.
B. Circuit breakers used on the Power Distribution Board that are different from those provided in the Kit Of Parts. Note: the Snap Action brand circuit breakers provided have unique “trip” characteristics. No substitute brands are permitted on the Power Distribution Board.
C. Power distribution panels and/or fuse panels different from, or in addition to, the one Power Distribution Board provided in the 2009 Kit Of Parts,
D. Motor speed controllers other than Innovation First, Inc. “Victor 884” speed controllers or Luminary Micro “Jaguar” speed controllers (note: teams may use as many Victor or Jaguar speed controllers as necessary),

E. Relay modules other than Innovation First, Inc. Spike relays (note: teams may use as many Spike relays as necessary),
F. Aluminum or other non-copper wiring.

<R41> All wiring and electrical devices, including all control system components, shall be electrically isolated from the ROBOT frame. The ROBOT frame must not be used to carry electrical current (e.g. this is necessary due to polarity reversals that occur under certain operating conditions such as during motor direction reversals).

The chassis for the cRIO Mobile Device Controller and the supplied camera have grounded enclosures. Under this rule (and for their protection), it is REQUIRED that they be electrically isolated from the ROBOT frame when installed on the ROBOT.

<R42> The 12V battery, the main 120-amp circuit breaker, and the Power Distribution Board shall be connected as shown in Figure 8-6. In particular:

A. The battery must be connected to the ROBOT power system through the use of the Anderson Power Products (APP) connector.
B. The APP connector must be attached to the battery with either the copper lugs provided in the FCI Burndy Bag or appropriate lug connectors.
C. The battery terminals and the connecting lugs must be insulated with shrink tubing and/or electrical tape.
D. The main 120-amp circuit breaker must be directly connected to the hot (+) leg of the ROBOT-side APP connector. Only one 120 amp main circuit breaker is allowed. This breaker must not be bypassed.
E. The Power Distribution Board must be directly connected to the APP connector and main 120-amp circuit breaker. No other loads may be connected to the main 120-amp circuit breaker.
F. Each primary power connection between the battery and Power Distribution Board must be made with 6 AWG red and black wire or larger.
G. Circuit breakers must be accessible for inspection at each *FIRST* Robotics Competition event.

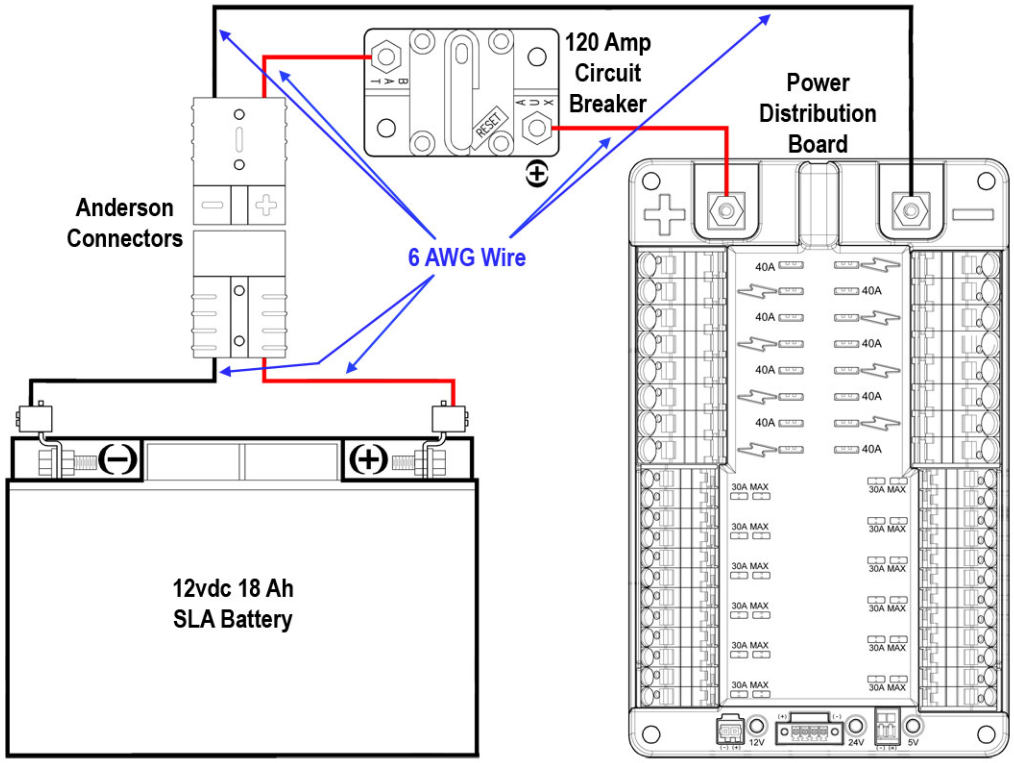


Figure 8 - 6

<R43> All electric power utilized by the ROBOT shall be distributed from the load terminals of the Power Distribution Board, and may not bypass the Power Distribution Board to connect directly to the 120-amp loop.

A. The cRIO Mobile Device Controller power feed must be connected to the 24 Vdc supply terminals on the Power Distribution Board. No other electrical load can be connected to these terminals.

B. The Linksys Wireless Bridge power feed must be connected to the 12 Vdc supply terminals located at the end of the Power Distribution Board (i.e. the terminals located between the indicator LEDs, and not the main WAGO connectors along the sides of the Power Distribution Board). No other electrical load can be connected to these terminals.

C. If the camera supplied in the 2009 Kit Of Parts is used, the camera power feed must be connected to the 5 Vdc supply terminals on the Power Distribution Board. No other electrical load can be connected to these terminals.

D. All other branch circuits must connect to, and have power sourced solely by, a protected 12 Vdc WAGO connector pair on the Power Distribution Board.

E. Only one wire shall be connected to each WAGO connector on the Power Distribution Board. If multi-point distribution of circuit power is required (e.g. to provide power to the three KOP breakout boards via one 20-amp circuit), then all incoming wires must be appropriately spliced into the main lead, and only one lead inserted into the WAGO connector to connect the circuit.

F. Sensors and custom circuits may be connected to the 5 Vdc sources on the Analog Breakout boards or the Digital Sidecars. By being logically downstream from the Power Distribution Board, they are protected by the 20-amp breaker at the circuit root.

G. Servos may be connected to the 6 Vdc sources on the Digital Sidecars (via the designated PWM connections, and with a "6Vdc enable" jumper in place for the corresponding port). By being logically downstream from the Power Distribution Board, they are protected by the 20-amp breaker at the circuit root. No other electrical load can be connected to these sources.

<R44> Custom circuits shall NOT directly alter the power pathways between the battery, Power Distribution Board, speed controllers, relays, motors, or other elements of the robot control system (including the power pathways to other sensors or circuits). Custom high impedance voltage monitoring or low impedance current monitoring circuitry connected to the ROBOT'S electrical system is acceptable, because the effect on the ROBOT outputs should be inconsequential.

<R45> All active Power Distribution Board branch circuits shall be wired with appropriately sized wire:

A. ***12 AWG or larger*** diameter wire must be used for all circuits protected by a 40A circuit breaker.

B. ***14 AWG or larger*** diameter wire must be used for all circuits protected by a 30A circuit breaker.

C. ***18 AWG or larger*** diameter wire must be used for all circuits protected by a 20A circuit breaker.

D. ***20 AWG or larger*** diameter wire must be used for the power connection between the Power Distribution Board and the cRIO Mobile Device Controller.

E. ***20 AWG or larger*** diameter wire must be used for the power connection between the Power Distribution Board and the Linksys Wireless Bridge

F. ***20 AWG or larger*** diameter wire must be used for the power connections between the Power Distribution Board and the Analog Breakouts and/or Solenoid Breakout if individual power feeds are used. ***18 AWG or larger*** diameter wire must be used if a common power feed is used for multiple breakouts.

G. ***24 AWG or larger*** diameter wire must be used for providing power to pneumatic valves.

<R46> All active Power Distribution Board branch circuits shall be protected from overload with an appropriate value auto resetting Snap Action circuit breaker (from the Kit Of Parts or identical equivalent).

A. Each speed controller branch circuit must be protected by one and only one 20-amp, 30-amp, or 40-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.

B. Each relay module branch circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.

C. Each Digital Sidecar branch circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.

D. If the compressor is used, the relay module branch circuit supplying the compressor must be protected with a 20-amp circuit breaker. No other electrical load can be connected to the breaker supplying this circuit.

E. A single branch supply circuit may be used to supply power to one, two or three of the Analog/Solenoid Breakout Boards. This circuit must be protected with one and only one 20-amp circuit breaker on the Power Distribution Board. No other electrical load can be connected to the breaker supplying this circuit.

F. Custom circuits and sensors powered via the cRIO Mobile Device Controller or the Digital Sidecar are protected by the breaker on the circuit(s) supplying those devices. Power feeds to all other custom circuits must be protected with a dedicated 20-amp circuit breaker on the Power Distribution Board.

In addition to the required branch power circuit breakers, smaller value fuses or breakers may be incorporated into custom circuits for additional protection.

<R47> All active Power Distribution Board branch circuit wiring with a constant polarity (i.e., except for relay module, speed controller, or sensor outputs) shall be color-coded as follows:

A. Use red, white, brown, or black with stripe wire for +24 Vdc, +12 Vdc and +5 Vdc connections.

B. Use black or blue wire for common (-) connections.

<R48> Each power-regulating device (speed controller or relay module) shall control one and only one electrical load (motor, actuator or compressor).

A. Exception: Multiple low-load, pneumatic solenoid valves may be connected to a single relay module. This would allow one relay module to drive multiple pneumatic actions. No other electrical load can be connected to a relay module used in this manner.

<R49> Decorations may draw power from the 12 Vdc electrical system as long as they are powered via a dedicated 20 amp circuit breaker on the Power Distribution Board, and do not affect the operation of other control system components.

8.3.7 Motors & Actuators

<R50> Motors from previous robots shall not be used in addition to those provided in the 2009 Kit Of Parts. They may be used as direct one-to-one SPARE PARTS for those provided if the provided part fails or is damaged. They can only be used if they are identical to the part being replaced.

- Note: the Fisher-Price motor found in the 2009 Kit Of Parts (Part number 00968-9015) is different from the Fisher-Price motors used in many previous *FIRST* competitions. Only the Fisher-Price 00968-9015 motor may be used as a SPARE PART for the Fisher-Price motors provided in the 2009 Kit Of Parts.

<R51> Motors specifically permitted on 2009 FRC ROBOTS include:

A. All motors, actuators, and servos provided in the 2009 Kit Of Parts,

B. An unlimited number of COTS servos with a maximum output torque of 55 oz-in and maximum rotational speed of 100 rpm at 6 Vdc (e.g. HITEC model HS-322HD or HS-325HB servos, as provided in the Kit Of Parts),

C. An unlimited number of *FIRST* Tech Challenge (FTC) servos (HITEC HS-475HB servos),

D. One or two additional 2-1/2" CIM motors (part #FR801-001 and/or M4-R0062-12) in addition to those provided in the Kit Of Parts. This means that up to four, and no more, 2-1/2" CIM motors can be used on the ROBOT.

E. COTS motors used as one-to-one replacements (i.e. identical vendor and part number) for motors, actuators and servos provided in the 2009 Kit Of Parts that may have failed or become inoperable.

<R52> Items specifically PROHIBITED from use on the ROBOT include:

A. Electric motors and/or servos different from, or in addition to, those in the Kit Of Parts, with the exception of those specifically permitted by Rule <R51>.

B. Electric solenoid actuators (note: electric solenoid actuators are NOT the same as pneumatic solenoid valves – the latter are permitted, the former are not).

<R53> So that the maximum power level of every ROBOT is the same, motors and servos used on the ROBOT **shall not be modified in any way**, except as follows:

A. The mounting brackets and/or output shaft/interface of the motors may be modified to facilitate the physical connection of the motor to the ROBOT and actuated part.

B. The gearboxes for the Fisher-Price and Globe motors are not considered "integral" and may be separated from the motors.

C. The electrical input leads on the motors may be trimmed to length as necessary.

The intent is to allow teams to modify mounting tabs and the like, not to gain a weight reduction by potentially compromising the structural integrity of any motor. The integral mechanical and electrical system of the motor is not to be modified. Note that *FIRST* will not provide replacements for modified parts.

<R54> All electrical loads (motors, actuators, compressors) must be controlled by relay or PWM output signals sent by the Digital Sidecar to an appropriate power regulating device

A. Each CIM motor and Fisher-Price motor must be connected to one Victor or Jaguar speed controller. They must not be connected to relay modules.

B. Servos must be directly connected to the PWM ports on the Digital Sidecar. They must not be connected to speed controllers or relay modules.

C. If used, the compressor must be connected to one Spike relay module.

D. Each other electrical load (motors or actuators) must be connected to one Victor or Jaguar speed controller or one Spike relay module.

8.3.8 Control, Command & Signals System

The 2009 Kit Of Parts includes a new control system that has been designed to provide advanced capabilities for the ROBOTS. The system has been designed around an open architecture that will allow teams to easily develop custom software to control the ROBOT and add electronics and custom circuits to expand the functionality of the ROBOT. Custom circuits may be used to indirectly affect the robot outputs by providing enhanced sensor feedback to the Mobile Device Controller to allow it to more effectively control the ROBOT.

Note that with increased capability comes increased responsibility. Teams are ultimately responsible for any software bugs introduced into the standard robot control software, or undesirable effects from added custom circuits. So, teams will have to exercise care to prevent these conditions. To assist with this, teams are encouraged to investigate, learn and practice industry-standard software Validation and Verification (V&V) techniques and develop thorough hardware testing plans.

<R55> ROBOTS must be controlled via the wireless, programmable National Instruments cRIO Mobile Device Controller provided in the 2009 Kit Of Parts. Controllers from previous FRC competitions shall not be used.

<R56> The cRIO Mobile Device Controller, Driver Station, wireless bridge, and wireless router must be configured to correspond to the correct team number (assigned to the team by *FIRST*). The procedures for configuring these devices are contained in the FRC control system documentation. Software and firmware used during the competition must be at the appropriate revision in order to pass inspection and compete. The software/firmware and permitted revisions are listed in the table below.

Software/firmware	Revision
LabVIEW for FRC	Update 3.0a and newer
cRIO FPGA Image	FRC_2009_v11. Zip and newer
WPI Robotics Library	3.0.1718 and newer
Driver Station	2009-02-010a3 and newer

<R57> The wireless bridge provided in the 2009 Kit Of Parts is the only permitted mechanism for communicating to and from the ROBOT during the MATCH. The signal output from the wireless bridge must be connected directly to the cRIO Mobile Device Controller using one of the Ethernet cables provided in the 2009 Kit Of Parts. No other form of wireless communications shall be used to communicate to, from or within the ROBOT (e.g. radio modems from previous *FIRST* competitions and Bluetooth devices are not permitted on the ROBOT).

<R58> ROBOTS shall use the diagnostic Robot Signal Light provided in the Kit Of Parts. It must be mounted on the ROBOT such that it is easily visible while standing three feet in front of the ROBOT in the STARTING CONFIGURATION. The Robot Signal Light must be connected to the "RSL" supply terminals on the Digital Sidecar, which provides power and control for the light. The team has no direct control over the light and no programming is required.

<R59> The control system is designed to allow wireless control of the ROBOTS. The Driver Station, cRIO Mobile Device Controller, digital sidecar, breakout boards, power distribution module, speed controllers, relay modules, wireless bridge, batteries, and battery charger shall not be tampered with, modified, or adjusted in any way (tampering includes drilling, cutting, machining, gluing, rewiring, disassembling, etc.), with the following exceptions:

A. Programmable parameters on the Driver Station may be set as appropriate.
B. User programmable code in the Mobile Device Controller may be customized.
C. Dip switches on the Mobile Device Controller may be set.
D. Speed controllers may be calibrated as described in owner's manuals.
E. The supplied fans attached to the Victor speed controllers may be powered from the Victor power input terminals.
F. The fuse on the Spike relays may be replaced with a 20 Amp Snap-Action circuit breaker.
G. The alligator clips on the battery charger leads may be replaced with Anderson Power Pole connectors (note: this is a recommended modification).
H. Wires, cables, and signal lines may be connected via the standard connection points provided on the devices.
I. Appropriate fasteners may be used to attach the device to the OPERATOR CONSOLE or ROBOT.
J. The ESD protection modification specified rule <R85.1>

<R60> Digital outputs of the Digital Sidecar may be connected directly to brake/coast headers on the speed controllers to permit programmable control of this speed controller function. The brake/coast header on the speed controller may NOT be connected to any other circuit or input.

<R61> Relay module outputs, speed controller outputs, or PWM outputs shall not be connected to the analog/solenoid breakout boards or the Digital Sidecar. 12Vdc power shall not be connected to any terminal on the analog/solenoid breakout boards or the Digital Sidecar except the designated 12Vdc input terminals.

<R62> Every speed controller, relay module, and servo shall be connected via PWM cable to the Digital Sidecar, and be controlled by signals provided from the Mobile Device Controller via the Digital Sidecar. They shall not be controlled by signals from any other source.

A. Support for the CAN bus port on the Jaguar speed controllers is prohibited for this competition, and the port is not to be used. Nothing shall be connected to the CAN bus port. It is recommended that the port be protected with a piece of tape to prevent debris from entering the port.

<R63> Solenoid Breakout outputs shall be connected to pneumatic valve solenoids only. No other devices shall be connected to these outputs.

<R64> A National Instruments 9201 module must be installed in slot 1 of the cRIO Mobile Device Controller. An analog breakout must be connected to this module. A jumper must be installed on the "Battery Voltage" and "Power" pins on the analog breakout. The analog breakout must be powered from the Power Distribution Panel. Please refer to Section 3.4 of the "FRC Control System Component Data Sheets" for information on these connections.

These connections enable monitoring of the battery charge by the team and the Field Management System. This is a required element of the ROBOT configuration.

<R65> For the purposes of the *FIRST* Robotics Competition, generally available software modules obtained from open sources (e.g. professional publications, commonly used FRC community-accessible web resources, industry source code repositories, etc.) that are not specifically affiliated with individual FRC teams shall be considered COTS items, and may be used.

<R66> Inputs to custom circuits can be connected only to the following sources:

A. Power Distribution Board protected 12Vdc outputs
B. Speed controller outputs,
C. Relay module outputs,
D. Analog Breakout outputs,
E. Digital Sidecar PWM Out, I2C, Relay or Digital I/O ports,
F. Other custom circuits, or
G. Switches, potentiometers, accelerometers, sensors, and other additional permitted electronics.

<R67> All outputs from sensors, custom circuits and additional electronics shall connect to only the following:

A. Other custom circuits, or

B. PWM Out, I2C, Relay or Digital I/O ports on the Digital Sidecar, or
C. Analog In ports on the Analog Breakout.
D. Ethernet Port 2 on the cRIO Mobile Device Controller (to which the Kit Of Parts-provided camera, and only that camera, may be connected).

<R68> A signal filter may be wired across motor leads or PWM leads. For the purposes of inspection and rules compliance, such filters will not be considered custom circuits, and will not be considered a violation of Rule <R53> or Rule <R67>. Acceptable signal filters are:

A. A one microfarad (1 μF) non-polarized capacitor may be applied across the power leads of any motor on your ROBOT (as close to the actual motor leads as reasonably possible)
B. A ten kilo-ohm (10 kΩ) or larger resistor may be used as a shunt resistor in-line with the PWM control signal feeding a servo

<R69> Any decorations that involve broadcasting a signal to/from the ROBOT, such as remote cameras, must be cleared with *FIRST* Engineering (via e-mail to frcteams@usfirst.org) prior to the event and tested for communications interference at the venue. Such devices, if reviewed and approved, are excluded from Rule <R57>.

8.3.9 Pneumatic System

<R70> To satisfy multiple constraints associated with safety, consistency, robot inspection, and constructive innovation, no pneumatic parts other than those explicitly permitted by the Pneumatic System Rules may be used on the ROBOT.

<R71> In addition to the items included in the Kit Of Parts, pneumatic system items specifically permitted on 2009 FRC ROBOTS include the following items. All included items must be "off the shelf" pneumatic devices rated by their manufacturers for pressure of at least 125psi, and used in their original, unaltered condition (except as required for assembly with other components).

A. One or two additional Clippard air storage tanks (Clippard Part Number AVT-32-16), equivalent to those provided in the kit. This means that up to four, and no more, Clippard air storage tanks can be used on the ROBOT.
B. Pneumatic pressure relief valves identical to those provided in the Kit Of Parts (Parker Part Number PV609-2).
C. Solenoid valves. All such valves must have a maximum 1/8" NPT port diameter, and a maximum Cv of 0.32 (if non-Kit Of Parts valves are used, the team will be required to provide part documentation validating that the valves meet these constraints).
D. In addition to the pneumatic cylinders provided in the Kit Of Parts and the "free" pneumatic cylinders available for order through the Free Pneumatic Components Order Form, additional air cylinders or rotary actuators may be used. Cylinders may be of any configuration, and may be of any size up to a maximum of 24-inch stroke and 2-inch diameter.
E. Additional 0.160" inch inside diameter pneumatic tubing functionally equivalent to that provided in the Kit Of Parts, with the pressure rating clearly factory-printed on the exterior of the tubing (note: alternate tubing colors are acceptable).
F. Pressure transducers, pressure gauges, and connecting fittings.
G. Pressure regulators with a maximum bypass pressure of no more than 60psi.
H. For the purposes of the *FIRST* competition, a device that creates a vacuum is not considered to be a pneumatic device and is allowed. This includes, but is not limited to,

venturi-type vacuum generators and off-the-shelf vacuum devices (as long as they are powered by provided or permitted motors).

I. For the purposes of the *FIRST* competition, closed-loop pneumatic (gas) shocks are not considered pneumatic devices, and are permitted additions to the ROBOT.

<R72> Items specifically PROHIBITED from use on the ROBOT include:

A. Any air compressor other than, or in addition to, the one provided in the Kit Of Parts.

B. Any pneumatic part or component rated for less than 125psi.

C. Any pneumatic part or component that has been altered, modified, machined, coated, or changed from its original "out of the box" condition, except as required for normal assembly with other components. The only acceptable modifications are:

- Tubing may be cut.
- Wiring for valves and sensors may be modified to interface with the control system.
- Assembling and connecting pneumatic components using the pre-existing threads, mounting brackets, quick-connect fittings, etc.
- Removing the mounting pin from a pneumatic cylinder, provided the cylinder itself is not modified.

Do not, for example, file, machine, or abrasively remove any part of a pneumatic cylinder – this would cause the part to become a prohibited item. Consider pneumatic components sacred.

<R73> If pneumatic components are used on the ROBOT, the pneumatic system on the ROBOT must contain <u>as a minimum</u> the following components, connected in accordance with this section.

A. Pressure gauges to display the "stored" and "working" air pressure (see Rule <R75>),

B. A pressure relief valve, calibrated and set to release at 125psi (see Rule <R76>),

C. A pressure switch, calibrated and connected to the ROBOT control system (see Rule <R77>),

D. An easily visible and accessible pressure vent valve to manually relieve the stored pressure (see Rule <R78>).

<R74> Compressed air for the pneumatic system on the ROBOT must be provided by the Thomas Industries compressor provided in the 2009 Kit Of Parts. Compressed air shall not come from any other source. The compressor may be mounted on the ROBOT, or it may be left off the ROBOT and used to pre-charge compressed air in the storage tanks prior to bringing the ROBOT onto the playing field. Off-board compressors must be controlled and powered by the ROBOT.

- Note: The only difference between an on- and off-board compressor is that the off-board compressor is physically removed from the ROBOT. The intent of this rule is to permit teams to take advantage of the weight savings associated with keeping the compressor off-board. However, using the compressor off-board of the ROBOT does NOT permit non-compliance with any other applicable rules.

<R75> "Working" air pressure on the ROBOT must be no greater than 60psi. All working air must be provided through one primary Norgen adjustable pressure regulator.

A. All "working" pneumatic components (e.g. valves, cylinders, rotary actuators, etc.) must be downstream from this regulator.

B. Only the compressor, relief valve, pressure switch, pressure vent valve, pressure gauge, storage tanks, tubing, and connecting fittings may be in the high-pressure pneumatic circuit upstream from the regulator.

C. Pressure gauges must be placed in easily visible locations upstream and downstream of the regulator to display the "stored" and "working" pressures.

D. If the compressor is not included on the ROBOT (under the provisions of Rule <R74>), the regulator may be located on-board or off-board, provided all other pneumatic rules are satisfied. Note that if the regulator is kept off-board the ROBOT with the compressor, then only low-pressure (60psi or less) "working" air can be stored on the ROBOT.

<R76> The relief valve must be attached directly to the compressor. **Teams are not allowed to adjust the 125-psi relief valve**. The valve has been calibrated prior to shipping.

<R77> The Nason pressure switch must be connected to the high-pressure side of the pneumatic circuit (i.e. prior to the pressure regulator) to sense the "stored" pressure of the circuit. The two wires from the pressure switch must be connected directly to a digital input and ground port on the Digital Sidecar, and the cRIO Mobile Device Controller must be programmed to sense the state of the switch and operate the relay module that powers the compressor to prevent over-pressuring the system.

<R78> The Parker pressure vent valve must be connected to the pneumatic circuit such that, when manually operated, it will vent to the atmosphere to relieve all stored pressure. The valve must be placed on the ROBOT so that it is visible and easily accessible. If the compressor is not used on the ROBOT, then an additional vent valve must be obtained and connected to the high-pressure portion of the pneumatic circuit off board the ROBOT with the compressor (see Rule <R74>).

8.3.10 Operator Console

<R79> The Driver Station provided in the 2009 Kit Of Parts is the only device permitted to collate driver/operator inputs and communicate them to the ROBOT. Operator Interfaces from previous *FIRST* competitions shall not be used.

<R80> The OPERATOR CONSOLE designed by the team must fit on the 60" wide by 12" deep shelf in the Alliance Station (excluding any items that are held or worn by the PILOTS during the MATCH).

<R81> Teams are permitted to connect a portable computing device (Laptop computer, PDAs, etc.) to either of the Ethernet ports on the Driver Station for the purpose of displaying feedback from the ROBOT while participating in competition MATCHES. Portable computing devices *may only connect to the Driver Station through one of the Ethernet port*s – they shall not connect to the Driver Station through any other port. Portable computing devices may only connect to the Driver Station – they must not directly connect to any ARENA ports or equipment. Please note that ***AC power will not be available at the playing field so these devices will have to run on internal batteries.***

<R82> The Driver Station must be positioned within the OPERATOR CONSOLE so that the LCD display can be clearly seen during inspection and during operation in a MATCH. The competition port and Ethernet ports on the Driver Station must be easily and quickly accessible. This will greatly facilitate installation and removal of the OPERATOR CONSOLE from the ARENA, and analysis by field personnel in case of problems during the competition.

<R83> Nothing can be connected to the power connector on the Driver Station during a MATCH.

<R84> All devices connected to the USB ports of the Driver Station shall be powered solely through the USB port. All devices connected to the analog and digital ports of the Driver Station shall be powered solely through the provided 5Vdc connection pins on the Driver Station. External power sources of any type are not permitted on any equipment connected to these ports.

- Please note that the power available through the USB ports, digital I/O, and analog input pins is limited to 2 amps total. Care must be taken to ensure that any team-provided devices connected to these sources do not over tax the available Driver Station supplied power.

<R85> During competition MATCHES, the competition cable at the Alliance Station must connect directly to the competition port on the Driver Station. The competition Ethernet cable must connect directly to an Ethernet port on the Driver Station. No intermediate connectors, cables, or "pigtails" are permitted. Only the Driver Station may connect to the competition cables – no direct connection of team-provided portable computers, PDAs, or alternate devices is permitted.

<R85.1>All Driver Stations must have their circuit board grounded to the metal case. The document that describes the process for grounding the Driver Station is posted under *Section 8 - The Robot* of the Competition Manual at http://www.usfirst.org/community/frc/content.aspx?id=452.

<R86> The Driver Station must be configured with current software images prior to a team competing in a match. The Field Management System will verify that the Driver Station software is correct before it will permit a ROBOT to operate on the field.

<R87> Other than the system provided by the ARENA, no other form of wireless communications shall be used to communicate to, from or within the OPERATOR CONSOLE (e.g. wireless network cards and Bluetooth devices are not permitted on the OPERATOR CONSOLE).

<R88> The wireless router provided in the 2009 Kit Of Parts shall not be included as part of the OPERATOR CONSOLE during competition matches.

8.3.11 Robot Inspection

<R89> At the time of inspection, the ROBOT must be presented with ***all*** MECHANISMS (including ***all*** COMPONENTS of each MECHANISM) ***and configurations*** that will be used on the ROBOT during the entire competition event. It is acceptable, however, for a ROBOT to play MATCHES with a **subset** of the MECHANISMS that were present during inspection. Only MECHANISMS that were present during the inspection may be added, removed or reconfigured between MATCHES. If subsets of MECHANISMS are changed between MATCHES, the reconfigured ROBOT must still meet all inspection criteria.

<R90> At the time of inspection, teams must present a Bill Of Materials of all non-2009 Kit Of Parts items used in the construction of their ROBOT, and their associated costs, to the inspector (see Rule <R20>).

<R91> The ROBOT will be inspected for compliance with the dimension constraints specified in Rule <R11> while in its STARTING CONFIGURATION, by being placed within a *FIRST* Sizing Device that has inside surface dimensions consistent with the rule. Other than resting on the floor of the Sizing Device, no part of the ROBOT can break the plane of the sides or top of the Sizing Device during size inspection. The ROBOT must be self-supporting while in the Sizing Device.

<R92> All decorations must be on the ROBOT at the time of final inspection.

<R93> Any ROBOT construction technique or element that is not in compliance with the Robot Rules (Rule <R01> through Rule <R97>) must be rectified before a ROBOT will be allowed to compete or continue competing.

<R94> ROBOTS will normally be allowed to participate in scheduled practice MATCHES prior to passing inspection. However, the lead inspector and/or head referee may determine at any time that the ROBOT is unsafe, and may prohibit further participation in practice MATCHES until the condition is corrected and the ROBOT passes inspection.

<R95> If a ROBOT is rejected by inspectors due to a safety issue or concern related to the team's method of storing energy (see Rule <R01>), the concerned items must be disabled or removed from the ROBOT before it can compete in a MATCH. The team bears the burden of proof that such a rejection is not valid. Teams should be prepared to provide justifiable test data or calculations during inspection to support their design.

<R96> If a ROBOT is modified after it has passed inspection, that ROBOT must be re-inspected. If an observation is made that another team's ROBOT may be in violation of the robot rules, please approach *FIRST* officials to review the matter in question. This is an area where "Gracious Professionalism" is very important.

<R97> *FIRST* Officials may randomly re-inspect ROBOTS participating in competition MATCHES to assure compliance with the rules.

8.4 PARTS USE FLOWCHART

To help determine the legality of a part, please refer to the following 2009 Parts Use Flowchart: