

FRC #1351 TKO

Archbishop Mitty Robotics

Safety Manual & Safety Captain Guide

With Safety Tips

2011 Edition

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Foreword: Purpose and Use

This safety manual is for the use of all participants on FRC Team #1351 as well as any other robotics team and spectators. Its purpose is to educate such persons about proper robotics safety and safe practices, as well as Team #1351's rules and policies regarding safety. This manual also serves to document the safety regulations of this team and encourage safe behavior at all times. The rules, regulations, practices, and tips in this manual are for the protection and safety of all members, mentors/coaches, and observers. Safety is the top priority in all robotics, especially within Team #1351 and FIRST, and should always be taken seriously. One's safety comes before all other considerations; safety is far more important than any robot or project. If safe practices are observed and safety made a top priority, then all participants and observers may be able to better enjoy robotics in a safe, injury-free environment. Lastly, the participants and observers should take the safety practices and mentalities found in robotics to further applications outside of FIRST and other robotics competitions. This manual will not only serve to tell you safe policies but also to explain them.

Furthermore, this manual is for the instruction and education of the Team #1351 Safety Captain(s). It lays down the duties of the Safety Captain(s) and gives tips from numerous safety captains and mentors (from this team and others). The Safety Captain(s) should be familiar with all of the rules and regulations in this manual.

The Team #1351 TKO Safety Manual and Safety Captain Guidelines is only a document, thus as a physical object cannot actually guarantee one's safety. The only ways to keep one safe are to follow, practice, and enforce these rules and regulations in robotics. (Of course, do not limit safety to robotics; make safety a life skill!) It is up to the participants and observers reading this manual to take seriously this manual's rules and regulations and put them into practice. This manual cannot make you practice safe behavior. This manual only provides safety rules, regulations, practices, and tips. Only YOU can put these to practice, effectively taking the rules and regulations in this manual and creating a safer robotics environment from them. Thus, use this manual as a tool with which to educate yourself and others about proper safety procedure and mentality. Become familiar with it (especially TKO team members and mentors) and refer to it as necessary. Doing so will help prevent accidents that could cause injury to an individual and/or damage to equipment. Members should, at the very least, be familiar with the key points in this manual, which are either in red font or highlighted.

Chapter 1: Team #1351 General Safety Rules

These are the rules that govern the entire team at all times.

Chapter 1 Section 1 (1.1): Team #1351's Policies Regarding Safety

Team #1351 TKO regards safety as our first concern and takes all matters concerning safety most seriously. Therefore, all infractions of Team #1351's safety regulations will be treated as serious infractions of TKO rules and reprimanded accordingly. Greater infractions of Team #1351 safety regulations will bring more severe consequences. For example, a small infraction of TKO policy, such as forgetting to place the blade guard on the band saw, may earn a small pep talk but is not likely to cause greater consequences. A major infraction of safety rules, like operating a tool without proper safety equipment and/or (if required) a safety observer, cannot be dismissed, and those responsible will be punished accordingly. Serious consequences include but are not limited to indefinite suspension from all Team #1351 TKO activities and/or expulsion from the team. Additionally, repeated minor infractions will be taken seriously and may be cause for suspension or expulsion from the team.

The following is the order in which punishments for safety infractions carry out. Mentors reserve the right to skip levels of punishment and choose the punishment for the infraction(s). A punishment can also include any number of the punishments below. In order of increasing severity:

1. A verbal warning is given to the individual with an explanation of the safety infraction.
2. The individual is assigned extra cleaning duties for a given duration (chosen by mentor). The individual is given a brief review of team safety in the explanation of the infraction.
3. The individual is given a written warning and must attend a review of Team #1351's safety rules and practices.
4. A call is made to the parents of the individual (or other contact is made with them). This may include suspension from the team (either short-term or indefinite).
5. Expulsion from FRC Team #1351.

Considering the possible consequences for Team #1351 members, all Team #1351 members should familiarize themselves with the team's safety rules and regulations. Members are to adhere to Team #1351 TKO safety procedures and practices at all times, including pre-season, build, and post-build. Team members are to respect the team's safety rules, as well any safety advisory from its enforcers (mentors and safety captains). **Take safety seriously; an injury can ruin your season in a hurry (not to mention running the risk of suspension or expulsion).**

In addition, all members of Team #1351 (as well as any other participants) are encouraged to report unsafe activities/conditions to proper individuals (i.e., safety enforcers). Furthermore, anyone witnessing unsafe behavior or practices is responsible for notifying the unsafe individual of the safety concern. **Communication is a critical aspect of safe operations for**

all teams. Even if there is no actual safety hazard, it is better to be safe rather than sorry; speak up if you feel that there is a risk to the safety of an individual.

Finally, any individuals who are uncertain about any safety issue should question a TKO mentor, safety captain(s), or other safety personnel. Questions and comments are welcomed as part of Team #1351's safety policy.

The Top Five:

These are the five most important safety policies that apply to all members of FRC #1351 at all times.

- 1. Always wear proper personal protective equipment (PPE), especially close-toed shoes and certified (Z87+) safety glasses, as these two items must be worn whenever working with tools and/or on, near, or with a robot at any time.**
- 2. Always be aware of what is going on around you at any given time, especially when either you or someone in the general vicinity is operating a tool. Communication is a very important part of this policy.**
- 3. Horseplay is NEVER permitted within FRC Team #1351, especially around any tools and machines.**
- 4. Always understand what is going on in a particular situation, especially if you are operating/using a tool or machine. If you are uncertain about how something operates or what a machine's intended operation is, ask the safety captain or a mentor.**
- 5. Take safety seriously. Use a common sense approach (think SAFELY) when considering safety and do not joke around in any safety-related situation. Regard all infractions of safety policy accordingly.**

Chapter 1 Section 2 (1.2): Team #1351 TKO's General Safety Rules and Regulations

1. All team members are to follow the instructions/examples of Team #1351's mentors and the safety captain(s) on issues regarding safety, unless the instruction/example is contradictory to safe procedure as dictated in this manual and/or the FIRST safety manual.
2. Members are to be familiar with personal protective equipment (PPE). **Members must wear PPE** at any times when there may be a risk to personal safety by not wearing PPE. PPE is inclusive of eye and face protection (safety glasses, face shields, welding masks, etc.), hearing protection, foot protection (close-toed, full-coverage shoes), hand protection (gloves), and proper clothing (no loose clothing, dangling cords, etc.). The specifics of personal protective equipment will be covered in the next section of this manual.
3. **Members are responsible for securing any working environment.** This is inclusive of providing proper shielding from any possible flying particles, ensuring spectators are wearing proper PPE, and maintaining a clean, neat work area with adequate room to prevent fume build up and collisions with bystanders. This responsibility extends to any assistants of persons using tools, not just the machine operator.
4. **All team members must attend a Safety Theory Class** given by one of the Team #1351 mentors (Mr. Chris Fairley) before being given clearance to operate any power tools (including prior to receiving any tool training).
5. For the following tools, members must receive **training and certification from a Team #1351 mentor** before being allowed to use any of these tools. Returning members must receive a renewal on their certification in order to be allowed to use these tools. These tools are the following: the band saw, the drill press, the belt sander, the mill/lathe*, the angle grinder, the jigsaw, the circular saw*, and the TIG welder*. (* indicates that the tool may only be used in the presence of a mentor).
6. For the following tools, a **safety observer must be present** in order to operate these tools. This safety operator must be a member who has attended a Safety Theory Class. Preferably, this person is trained in the proper operation of the tool in use. These tools are the following: the band saw, the drill press, the belt sander, the mill/lathe, the Dremel rotary tool, the angle grinder, the jigsaw, the circular saw, and the TIG welder. The observer may not be occupied by another activity and must be watching the tool operator.
7. **All members are responsible for their own safety as well as the safety of others to some extent.** Thus, all members will use safe practices in both their work and general observation. Common sense, attentiveness, and PPE are the three most important assets for one's safety. Therefore, horseplay and earphones/headphones (not necessarily music itself) are strictly prohibited from all Team #1351 TKO events (inclusive of meetings, sponsor visits, robot exhibitions, competitions, etc.).

8. All members using tools shall be knowledgeable about those tools and will **use these tools correctly**. If a team member does not know how to properly operate a tool, that member is responsible for inquiring how to properly operate the tool.
9. When lifting any object in excess of approximately twenty pounds (or too heavy to easily lift), **members are to use proper lifting technique**. Proper lifting technique requires the member to use his/her legs to lift the object. **The member is to bend at the knees (not bending over with the back) to pick up the object and lift using muscles in the legs**. When lifting large or cumbersome objects (i.e., kit of parts totes), team members should seek the assistance of another team member to avoid an accident. When lifting a robot or other object that has possible injury-causing protrusions or sharp edges, Team #1351 members will use gloves (not latex or plastic gloves).
10. Whenever operating or testing the robot or any part thereof, the operator/tester is to notify all persons in the vicinity prior to turning on power by saying, **“Power ON!”** or a similar announcement. During this time, the operator/tester is responsible for the safety of everyone in the vicinity. He/she is also responsible for the preparation and operation of all emergency shut-off devices. All members not operating the robot (or any part thereof) are to follow the instructions of the operator/tester and request all other people in the vicinity to observe the required Team #1351 safety procedure.
11. Members are to familiarize themselves with **MSDS (Material Safety Data Sheets) sheets** and should know the basic information contained on the MSDS sheet (found at the end of this manual) for the robot battery. Take time to also look over any other available MSDS sheets. On any other chemicals (or chemical-containing objects), follow any and all printed instructions and warnings on the label.
12. Members are to be as **awake and focused** as possible. Members who are feeling tired or distracted should not participate in a situation where there is a need for safe protocol. This includes any time working with tools and any time operating or observing the robot. When observing a tool operator, an individual should also be awake and focused. If a member is tired or distracted, then that individual is putting his/her safety and other members' safety at risk by participating.
13. **No objects shall be thrown at any time**. This holds true for all items, particularly tools, parts, and materials.
14. **No members shall run at any time** for any reason *unless* they must do so to maintain their safety, such as in the event of a runaway robot or an accidental flying object.
15. While only certain tools require an actual safety observer, **it is a good idea to use a buddy system** during competition and the remainder of the season. Whenever any tool is in use, another member should be present besides the operator of that tool. A safety observer may be able to see a dangerous situation developing and can get help in an emergency situation.

Chapter 1 Section 3 (1.3): Personal Protective Equipment (PPE)

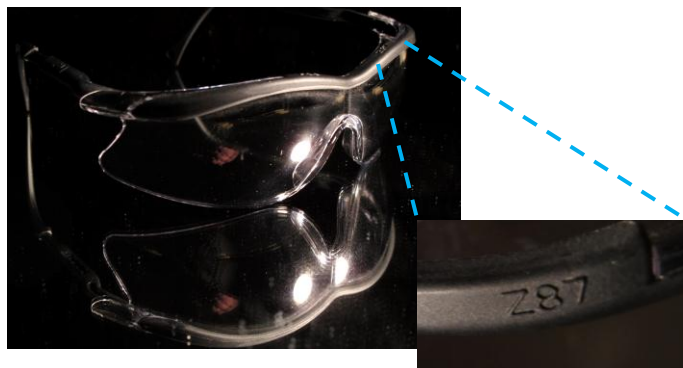
Personal protective equipment, or PPE for short, is essential to robotics safety. All persons should be familiar with the following pieces of PPE: **safety glasses and close-toed shoes**. Not only are these items required for all tool and robot work, but they are also very important for competition, as both are mandatory for all persons within the pit area (area where teams service and store robots during competition).

Personal protective equipment should always be as comfortable as possible while meeting the prescribed criteria for PPE. This includes general clothing, safety glasses, and welding equipment. Comfortable gear allows you to work in the greatest comfort and with the greatest focus on the job at hand.

Eye Protection:

Safety glasses (a.k.a. safety goggles) are the most important safety-related items for any team member to have. All team members *should* have at least one pair of safety glasses. A backup pair is not a bad idea either.

All safety glasses are to be full-coverage glasses that meet ANSI Z87.1 standards. They must bear the ANSI mark of approval, which is typically a “Z87” or a “Z87+” stamped into the frame or lens of the glasses. Therefore, chemical splash goggles are not sufficient for robotics use unless they bear the “Z87” stamp. Additionally, regular prescription/reading glasses are not sufficient for robotics, even if you are just spectating. To qualify as safety glasses, they must bear the ANSI Z87.1 mark of approval and have side shields. **Safety glasses must be clear with no tint.** This is for purposes of eye contact and visual perception. The only exception is yellow-tinted glasses, which may be worn if approved by the safety captain(s). Absolutely no glasses with a reflective outer coating are permitted.



[Left] A typical pair of safety glasses and the Z87 stamp on them.

Safety glasses should be in reasonably good condition. Any major chips, cracks, or deep scratches (especially to the lens of the glasses) can ruin the strength and thus the protective capability of the glasses. Minor scratches are O.K. as long as they do not inhibit the wearer’s vision severely. Glasses with major scratching or damage should be replaced.

Safety glasses must be worn in a manner that protects the eyes from damage from most directions (which typically means over one's eyes). Remember, safety glasses are *not* forehead protectors. **They must be worn whenever you are within 50 feet or eyesight of a tool (any tool, power and hand tools included) or machine (i.e., robot) that is in use.** When there is a sufficient shield or barrier (such as a solid wall) between the tool/machine in use and yourself, safety glasses are not required. **Safety glasses must always be worn in any area that has a requirement for safety glasses posted, regardless of tools or machines in operation.**

When working with or around (five feet or closer) chemicals for any duration of time (not including passing near chemicals), chemical splash goggles are to be worn. These types of goggles should only be used for chemical handling only *unless* they have the "Z87" stamp on them, in which case they are suitable for use as safety glasses.

Safety glasses may be borrowed from Team #1351's safety glasses bin, purchased new through Team #1351, or purchased at most hardware stores (OSH and other hardware stores have decent selections).

Face Protection:

Full-face shields are only required for certain tasks in which there are serious risks of flying particles. Examples of such a situation include cutting *any* material with the circular saw and working with materials such as steel (which often forms very sharp and potentially dangerous shavings when cut) on the mill/lathe. The safety captain(s) and mentors of Team #1351 may request the operator of a tool to use a full-face shield at any time. If you are uncertain as to whether a face shield is required, ask the safety captain(s) or a mentor.

Face shields must meet the above requirements for safety glasses. They must offer protection from particles from most directions and meet ANSI Z87.1 requirements. Face shields may only be clear with no additional tint or yellow tinted (the latter of which only with the approval of the safety captain(s) or mentors).

Only the operator of a tool may be required to wear a full face shield. However, it is advisable for safety observers and spectators to either stay back several (distance dictated by tool) feet or also wear a face shield.

TKO has one face shield which may be borrowed for use. All team members (or at least leads) should know where the face shield(s) is located.

Respiratory Protection:

Team #1351 neither provides dust masks nor requires them for any task. It should be noted, however, that there are multiple situations when **a dust mask is advisable to prevent the inhalation of too many particles**. These situations include the following: use of a belt sander, use of the Dremel rotary tool, use of an angle grinder, use of the circular saw, use of the drill press, and use of the band saw. Naturally, some materials produce more particulates than others when ground or cut, such as wood and aluminum. Therefore, it is useful but not required to have a dust mask.

Hand Protection:

As mentioned before, **good work gloves made of leather or similar material are required whenever lifting or handling objects with sharp edges that could potentially cause injury**. These gloves are to prevent injury from any sharp edges or protrusions (such as a burr from drilling). When drilling, cutting, or grinding steel, similar gloves should be worn to prevent cuts and so-called “steel splinters” (which can be painful). When handling hot objects, use similar gloves to prevent burns.

Latex gloves are required when dealing with chemicals, such as chemical cleaners. Chemical spill gloves, which are located with the first aid supplies, are to be used in the event that a dangerous chemical, such as battery acid, leaks.

Hearing Protection:

As a general rule, use common sense to dictate when and where to use hearing protection. **If a noise is so loud that it is painful or uncomfortable, then you should use hearing protection**. The only situations that require the use of hearing protection are use of the angle grinder and cutting large holes in metal with a hole saw.

Disposable earplugs are the best method of hearing protection for most situations. However, if you often work in loud environments, then other methods, such as earmuffs, are probably better suited for you.

Earplugs and other methods of hearing protection should not be worn when there is no need for them. They can detract from your hearing, thus your situational awareness; it is difficult to hear someone telling you to avoid a runaway robot if you have earplugs in your ears. For this same reason, earphones/headphones are prohibited.

Clothing Requirements (General):

If you are working with the tools/robot or observing the use of the same, **you must wear close-toed shoes**. Close-toed shoes must fully cover the entire foot, from toe to heel, with full coverage over the top of the foot. The only exception to this rule is when observing robots at competition from the stands, when non-close-toed shoes *may* be worn.

Long pants, while not required to be worn while working or observing, are not a bad idea. Similarly, long-sleeve shirts can serve a similar function in protecting you from shavings and flying particles.

Loose clothing may be worn for observing work or robots in operation, but it may not be worn whenever working with the robot or with tools. Loose clothing can catch in tools or on the robot, posing a risk to the wearer. This includes dangling cords/strings, baggy sleeves, and dangling necklaces. Similarly, long hair can just as easily get caught in tools or the robot, and it poses a much greater risk as it tends to pull one's *head* towards either the robot or tool. Also, long hair can obstruct vision, which can be just as dangerous. Thus, members with long hair should have methods of controlling their hair. Any hair 14 inches long or longer may not be loose.

Prescription eyeglasses do not qualify as safety glasses as noted previously. However, safety glasses may be worn over eyeglasses.

Hoods may be worn by observers but are not to be worn by the operators of any tool or robot at any time. Hoods restrict your situational awareness, which can be a serious issue, especially when working around others.

Welding Personal Protective Equipment:

Welding is arguably the most dangerous task in FIRST robotics (compared to cutting or grinding, it poses numerous risks). Consequentially, personal protective equipment requirements for welding are greater than those for just about any other task.

All exterior clothing is to be free of synthetic material, as this material is more likely to melt in high heat than are natural fibers. This includes the required close-toed shoes, which should be made of leather or another non-synthetic material. **Long-sleeve shirts and pants are mandatory to protect from splattering molten metal** (not common in TIG welding but can occur) **and harsh UV rays** (produced in high amounts by the TIG welding process). The shirt, if button-down or zippered, should be done all the way to the highest point to prevent flash burn (from heat and/or UV rays) to the neck. These clothing requirements apply to all welders and observers.

When welding, good welding gloves (which may be provided by the mentor supervising the welding) **must be worn at all times by the welder.** These gloves must also be worn whenever handling the work or torch during (or after) welding, as the metal will get extremely hot regardless of the type of metal. While observers need not wear gloves, they also must wear gloves when handling the work or the torch. These gloves should be non-synthetic and serve to protect the hands from electrical shock, molten metal, heat, and UV rays.

Since the UV rays and visible light given off during arc welding (such as TIG welding) are intense, eye protection is probably the most important part of welding safety (at least for spectators). **In addition to the standard safety glasses, which must be worn** (as specified under eye protection) **at all times by anyone within 50 feet of the ongoing welding, all welders and observers must wear a full-face welding mask.** This mask may be either electronic (using an

auto-darkening screen) or fixed tint. The latter, while more difficult to use as you will have to repeatedly take off the mask to view your work, provides better protection to observers and welders as they do not change tint. (Team #1351's electronic masks use solar panels to power an LCD in the face plate. If insufficient light reaches the solar panel, the screen will not darken sufficiently to protect from flash burn to the eyes. Also, as it takes a very small amount of time to change tint, your eyes are exposed to UV light in small doses, which over the course of a long period of welding may cause flash burn to the eyes).

The two electronic welding masks used by Team #1351 members and mentors are a Lightswitch auto-darkening welding mask and a Chicago Electric PIN 9-13 auto darkening welding mask.

Hearing protection is not required for DCEN (direct current electrode negative) TIG welding, such as welding on steel. However, when using AC to weld aluminum or magnesium, the welders and observers may wish to wear earplugs (earmuffs are pretty much impossible to wear with welding masks), as TIG welding in AC produces a somewhat loud buzzing noise.

Chapter 2: Tool Safety

The rules in this section dictate proper and safe tool use.

Chapter 2 Section 1 (2.1): Basic Tool Safety

The following safety practices are very important to working with tools. Many come directly from the Safety Theory Classes given by Team #1351 mentors. These are the basics of tool safety and apply to the use of just about every tool. **ANY MEMBER WORKING WITH TOOLS SHOULD BE FAMILIAR WITH THESE BASIC RULES.**

Before using any power tools and any cutting/grinding tools, members must attend at least one Safety Theory Class given by a Team #1351 mentor. For all power tools, new members must be walked through the proper use of the tool by a member with at least one season's experience in working with power tools. Some tools require training and certification by a Team #1351 mentor. **TRAINING AND CERTIFICATION RULES ALSO APPLY TO RETURNING MEMBERS, WHO MUST RENEW THEIR CERTIFICATION.**

Common Sense and Tool Usage:

As in all robotics, the two biggest factors that will play into your safety in the FRC are safety glasses (and other PPE) and common sense. In regards to PPE, all members are to wear proper PPE while working with or around tools. Common sense pretty much covers most situations. First, **never goof off around tools**, especially tools in use; horseplay is prohibited. Also, never work with power tools in an extremely crowded area, as one accident could cause a collision between operator and observer/bystander. That said, **observers should give any tool operator enough room to work safely**. Common sense also comes into play with tool use. You should know how to properly and safely use/operate any tool before using it, including how the machine operates and where the power switch is located. **Tools are only to be used for their intended purposes and for no other "makeshift" or "improvised" purposes**. For example, a screwdriver is not a chisel. As part of understanding tools, the operator should also understand the dangers of working with a given tool and how to maintain that tool to lower those risks. If you are not sure how a tool works or how to maintain it, asking another team member/mentor and reading the manufacturer's operating manual can help you understand the tool.

Select the proper tool for the proper job. If you are uncertain as to what tool to use, consult a mentor or another member, such as a department lead. Keep in mind the material that the work is made out of (**steel** is particularly hard to work with). Some tools are better suited to a particular task than others.

Tools should only be operated by a single person at any given time, as it is difficult for two people to coordinate their actions with a tool.

Situational Awareness and Work Area Preparation:

Another basic policy is situational awareness and work area preparation. **When working with any tool, the operator is responsible for securing his/her working environment and alerting all persons in the area of the tool in use.** A work area should be kept relatively clear of clutter, including scrap materials and shavings. A clean work station allows for more efficient work (less searching for bit, tool, piece of work, etc.) and fewer hazards in the work area. When securing a working area, a tool operator must also be aware of where his or her shavings (if created by tool) are flying. This is especially important when working around others, in a small space, and/or near the robot (which could cause electrical and mechanical problems). The operator should devise a method of containing or deflecting these shavings when working, such as covering other nearby machines or putting up shielding material (i.e., thin composite board). A clean working environment should be free of any clutter, scraps, shavings, and liquids on the ground. Remove any such materials from the work area using a gloved hand, cloth, or brush. **No tool or part thereof should be left on the ground at any time.**

When operating the tool, **the operator should never look away from the tool/work while the tool is powered on.** No tool that is powered is to be left unattended at any time for any reason. Machines found running unattended are to be shut down immediately (using proper protocol for safe shutdown). When an operator has finished use of a power tool, that tool is to be shut down properly. The operator is to wait for the machine to come to a complete stop. (This holds true for any time when the operator is changing out bits or maintaining the tool.) The operator then must place any required guards and remove any bits (cutting, drilling, grinding, etc.) in that tool.

More importantly, **tool operators must be aware of others in their work area.** This is one area where a safety observer/spotter (a.k.a. safety buddy) is useful. For the tools which require a safety observer/spotter, there must *always* be a spotter, no exceptions. In addition, it is the operator's responsibility to make sure that all observers in the work area are wearing proper PPE and are aware of the tool in use. The operator of a tool is to always notify any personnel in the area of power tools being turned on. When connecting the power to the tool cart, an individual must notify a team mentor and other people in the area. These people also bear the responsibility of making sure that they know that a tool is in use in the area. This goes for all power and hand tools.

Reporting Accidents:

If an incident occurs where a person is injured during the use of a tool, it is imperative to notify both the safety captain(s) and a mentor. (Some very small or insignificant injuries do not need to be reported, such as a minor burn or small scrape.) This allows those persons to check the tool for injury-causing defaults and, if necessary, help with first aid. First aid kits are located in numerous areas. Two small orange first aid bags are located on the robot cart. During build, a safety bag containing first aid supplies can be found in the inside closet. At competition, a first aid box is located on the tool cart in addition to the bags on the robot cart.

If a tool is damaged in any way, even if by your own actions, then do not hesitate to inform the safety captain(s) and a mentor about the damage. A damaged tool can be dangerous to the next person to use it if he/she does not know about the damage. A damaged tool can cause any number of problems and poses a safety hazard until it is repaired. **REPORT ANY INJURY AND DAMAGED TOOL.**

Basic Tool Use:

Before using any tool, you should always inspect the tool to ensure that it is in proper working order. Maintenance of all tools ensures that they operate most efficiently and safely.

Whenever a member is performing maintenance any power tool, ensure that the tool is **fully unplugged** so that it cannot accidentally turn on. This includes whenever changing bits, blades, or belts. When not in use, any power tools should be disconnected from their respective power source to prevent accidents.

One safety tip that can reduce risk of injury with handheld tools is to use a short loop. The term “short loop” refers to the size of the loop created between: your hand’s contact with the tool, the tool’s contact with the work, the work’s contact with the clamp/table, the table’s contact with the ground, and the ground’s nearest point of contact with you (or, in some situations, the loop can be without the ground, such as when resting on the table). You should *never* work with an open loop (i.e., you hold the work off of a table/rest in your hand). To make a short loop, use a rest for your arm, hand, and/or tool that is either on the work, clamp, or table. In addition to using both hands to hold the tool, this will give you the greatest stability and control of the tool.



[Above] A member uses a short loop with a power drill. Note that he is holding the drill close to his body and resting against the table to create a short loop. Also, the work is properly clamped in place.

Before working with any material, make sure to remove any burrs and sharp edges to the best of your ability. After working with any material, remove any new burrs and sharp edges created during the work.

A basic tool safety rule that is often forgotten (even by experienced members) is to **CLAMP STUFF IN PLACE when working**. Clamping refers to the use of a vice, clamp, weight, or other object to hold the work steady. Failure to clamp down a work can cause many problems to arise. When drilling, the work could easily snag the bit (as the bit bites into the material), either breaking the bit or causing the work to spin violently. At other times, not clamping the work could result in a ruined work or injury. Clamping is easy enough to do and, for the time it takes to clamp your work down, is worth the effort. Do it.

Some materials will produce sparks when cut/ground (especially steel), which can ignite nearby flammable materials. Besides removing these materials, the operator should also use proper shielding to contain the flight of all sparks produced. **At competition, the creation of sparks in the pit area is prohibited.** At no time for any reason should a member be using or creating flames when working.

If any tool begins to make unusual sounds or function unusually, **turn it off and disconnect it from its power source immediately**, then report the incident to a team mentor and notify all team members of the unusual occurrence. Unusual sounds may be indicative of a potential safety hazard within the inner workings of a tool. Remember that the safety of the individual always takes priority over the condition of the tool. Typically, in this sort of situation, it is best to turn off the machine *first* before backing out the bit/blade/work, but there are a few exceptions.

Knives and Multi-tools:

Although these are not power tools and are often carried by members and mentors on other teams, knives can be dangerous, and multi-tools with knives can be equally dangerous. Furthermore, all such tools (including any knife or multi-tool with a knife) are considered by Team #1351 TKO (in following the policies of the team's supporting high school, Archbishop Mitty High School) to be weapons. Therefore, all knives and multi-tools with knives are **banned** from all team events and should not be carried by team members to such events. Any member found using and/or possessing such a tool will be considered to be in violation of Team #1351 TKO's safety rules and will be treated accordingly. Remember that just about any task in robotics that can be preformed be a knife can be performed just about as well with a good craft knife (i.e., X-ACTO knife), such as those used by the team. Also, any task that can be completed with a tool on a multi-tool can probably be better completed by using an actual tool (such as a screwdriver or wire cutters) rather than using an attachment on a multi-tool. Thus, members may not carry knife-containing multi-tools (i.e., Leatherman multi-tools) and call them tools rather than weapons. They still have knife blades, and thus they are still considered dangerous. Note that this rule only applies to all knives and multi-tools with knives. If Team #1351 members wish to carry multi-tools without knife blade attachments, then they still may do so without being in violation of Team #1351's safety rules.

(This is also known as the "AA Clause")

Chapter 2 Section 2 (2.2): Safety with Handheld Power Tools

Understand that the operator of a handheld power tool is responsible for controlling and safely operating that tool, as its movement is controlled by the operator alone. As they are free to move about, handheld tools can be far more dangerous than table tools if not used with care and focus. **Handheld power tools are not to be set on the ground** (except in a situation where you set the tool down to change bits, change orientation of a work, etc. while working) **or placed in a location they could easily fall from** (i.e., the edge of a self). Disconnect handheld tools from their power sources when setting them down for prolonged periods of time.

Hand Drills:

For the purposes of this manual, hand drills will include cordless drills, corded drills, impact drivers, and all included bits.

Hand drills, despite their ease of use, can cause an injury to the careless operator. This is especially true with corded drills, which produce the highest torque of the handheld drills used by Team #1351. The most common accident (other than breaking bits) occurs when the drill bit catches on a clamped work. This causes the drill to twist violently in the operator's hand with enough force to sprain the operator's wrist. There are several ways to avoid a drill spinning out of the operator's hand:

1. **Hold the drill tight against your torso and use a small loop** (see above). Holding the drill to yourself (also use two hands on the drill whenever possible) prevents the drill from wrenching itself out of your hand.
2. **Step up bit size in small increments**. Do not, for example, go from a 1/16 inch pilot bit to a 3/8 inch bit, especially on harder materials. Instead, take it in steps and use intermediate bit sizes, such as a 1/4 inch bit. On softer materials like wood (but not plastic), it is O.K. to go directly to the desired size. Use this method with all drills.
3. **Use cutting fluid** (where necessary).
4. Start with the bit out of the work; then, **get the drill up to speed before starting the cut**.
5. Use high RPMs (except on plastic and sometimes steel).

Another common accident occurs when a drill bit refuses to stay in one spot when starting to drill (most common on metals). **The solution is to use a center punch to create an indent in which to place the bit to start drilling**.

Remember that drill bits can get very hot when drilling, so use caution when changing or removing recently used bits.

When driving screws with Phillips or flathead bits, the best suggestion is to go slowly and put the most pressure you can on the drill/impact driver.

The hole saw bits allow hand drills to cut circular holes in thin materials, such as wood. Though a relatively safe bit to use (as are most), there are some tips that can make operation easier and safer. Remember that the bit is a saw, thus can more easily cut you than the drilling bits. A pilot hole is necessary with this bit for safe use. The bit develops higher torque than most other bits, so use two hands and your torso to control it. Using higher RPMs will reduce the likelihood of the bit grabbing the work (as a saw, high RPMs = less material per tooth per pass). To prevent making the work so hot that it expands and pinches the bit (the most common problem), take the cutting slowly and do not press very hard on the drill. As always, clamp down when using this bit.

Dremel Rotary Tool:

The Dremel tool is highly versatile, but it requires attention to operate safely, especially with the cutting disc bit. Its combination of small size, high RPMs, and moderate torque can be troublesome to new operators. **THE DREMEL TOOL REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

The most serious accident that can occur with the Dremel is a cutting disc shattering during a cut. Breaking a disc during use can send sharp shards of the disc flying in all directions of the plane in which the disc is lying. This can seriously injure/damage anyone and anything in that same plane. Therefore, **any observers and the operator should never stand in or cross the plane the cutting disc occupies while the Dremel tool is in operation.**

Preventing the disc from breaking is simply a matter of observing the following guidelines:

1. **Never twist the cutting disc while it is in a groove or push it against the walls of a groove.** The only part of the cutting disc that should be pressed against any part of the work is the edge of the disc, preferably in one location on the disc only. Only make curved cuts with the Dremel tool when absolutely necessary; then, make the cut with as little curve as possible and as shallow as possible. The discs are not meant to take pressure on the sides of the disc, only the edges and center (point of attachment to the tool).
2. **Never use a cracked disc or a disc that shows damage** (i.e., chipped at the edges). It is more prone to shatter. **ALWAYS CHECK DISCS PRIOR TO USE.**
3. When screwing or tightening the disc in place, never over tighten the screw. This could damage the disc.
4. Do not press very hard on the disc when cutting. This will not greatly improve cutting speed and could break the disc.

Cutting discs get worn down over time. It is inadvisable to use discs of smaller diameter than the body/handle of the tool (for clearance reasons). **Do not use cutting fluid with the Dremel;** it will gum up the cutting disc and sander bits. When cutting, do not touch the edges of the disc and work (sometimes all of the work) immediately after making a cut. The cutting disc bit creates very high heat (sometimes, it will glow a faint orange from heat buildup) in both the disc and the work. If you must touch any area of the disc or the work, use a cloth or gloves (leather or similar non-synthetic material).

To counteract the moderate torque and tendency to suddenly catch on the work (causing a similar effect to a drill bit grabbing the work), use a steady, two-handed grip on the tool and use the smallest loop possible. Remember, the Dremel is more of a precision tool.

To prevent the tool from overheating (which can destroy the tool and burn you), never cover the ventilation holes on the tool and do not run the tool continuously for excessive periods of time (exact time dependent on RPMs). If using the tool for a long job, give the tool several

minutes to cool down in between cutting sessions. Never set the tool to its maximum speed, as this speed could destroy the tool.

The Dremel may be used on substances such as steel. However, when using the tool for cutting steel, **the Dremel creates numerous sparks as the high-speed cutting disc contacts the steel.** (As a note, steel will likely produce some sparks whenever it is being cut or ground with a power tool). Plan ahead for these sparks during work area preparation and pay attention to these sparks when operating these tools. **SPARKS ARE A SAFETY HAZARD AND MUST BE DIRECTED AWAY FROM ALL ELECTRONICS, FLAMMABLE MATERIALS, ETC. USE SHIELDING AS NECESSARY.**

Note: The Dremel tool makes a fine dust rather than flying chips (this is true with all cutting and grinding bits). This dust hangs in the air and can be a problem. Whenever using the Dremel, cover all nearby machines, especially electronics. Work in areas with the best ventilation possible and, if necessary, use a dust mask.

Jigsaw:

The jigsaw (a.k.a. saber saw) allows the operator to make curved or straight cuts through a variety of materials. However, it is also dangerous if you do not adhere to proper use of this tool. Learn the tool, how it works, and how to properly operate it. To use this tool, you must be **CERTIFIED** by a Team #1351 mentor. Preferably, a Team #1351 mentor is present during operation of the jigsaw. **THE JIGSAW REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

Understanding how the jigsaw works can help ensure the safety of the operator. With all saws, the same basic rules apply: **the harder the material, the higher the teeth count per inch and the smaller those teeth; the softer the material, the faster the blade speed and, thus, the rate at which you cut.** On the jigsaw, changing teeth requires changing blades, which is done by pulling a lever to release the blade and holding it open (it is spring loaded) to insert another blade. **UNPLUG THE JIGSAW WHEN CHANGING BLADES.**

All saws work by pulling teeth against a work, which is prevented from moving by a “table” of sorts (which could be a multitude of objects and is often part of the saw). The cutting action occurs as the teeth of the blade scrape (not cut as with a knife or razor) off minute amounts of material. Thus, saws can only cut in one direction (most files work based on the same principle).

On the jigsaw, the table is the foot of the saw, and the teeth are pointed up towards this table. The “speed” of cutting (rate of blade advance) is controlled by the reciprocating action of the blade (it travels in an elliptical pattern along the cut). The more aggressive the reciprocating action, the further the blade advances on a single cut. For harder materials, a less aggressive action is required. On the team’s jigsaw, a lever (multi-position switch) on the side of the tool changes this elliptical pattern for cutting different materials, from straight up and down for harder metals to larger patterns for soft materials such as plywood. The jigsaw also has different blades for cutting various materials (as noted above), including a **fine-tooth blade (high tooth count) for metal (aluminum) to a large-tooth (low tooth count) blade for soft woods.** The method of changing blades is noted above by pushing and holding another lever.

The largest safety concern while using the jigsaw is the risk of cutting oneself. This is easy to prevent if you pay attention and are careful. The jigsaw is an aggressive tool and can remove a lot of material quickly, including flesh. **Never place any part of your body (or someone else’s) near the blade of the saw while it is plugged in.** Always use a two-handed grip on the saw and clamp your work as best as possible. Do not put *anything* that you do *not* want cut in the path of the saw when it is moving, as it can move faster than anticipated. It is inadvisable to use the jigsaw on more delicate projects.

The jigsaw is one tool that has restrictions as to the materials that it can cut. **The jigsaw may be used for aluminum, wood, and composite board.** It may not be used to cut steel or substances of equal or greater hardness. It can cut plastic, but it is not recommended.

One problem that can occur during use is heat buildup. Both blade and work can get warm enough to melt the work (supposing that it is metal or plastic). The heat buildup can cause

burns, so use gloves whenever possible to remove a recently used blade. The melting can also result in solidified material stuck to the blade of the jigsaw. This blade is no longer suitable for use, though it can be refurbished by removing the melted material once the blade has cooled with a hand file, sandpaper, etc. Heat buildup can be detected before it becomes a problem. If excess noise occurs while cutting, then it is likely that excess heat is being produced (noise = energy transferred to the motion of the work rather than the cutting process). For this reason, aluminum perforated plates are not recommended for cutting using this tool.

Handheld Belt Sander:

The handheld belt sander is a high-torque tool that aggressively removes material. While useful for smoothing surfaces and removing surface material from objects with a large surface area, it requires control and attention to use. While it can be used on metals, **it is mostly for use on wood**. Since this tool is so aggressive and is used mostly on soft materials, it is best for rough jobs and heavier material removal. Use the Dremel tool's sanding bit or a hand filing tool for delicate jobs. For use of this tool, you must be **CERTIFIED** by a Team #1351 mentor. **THE HANDHELD BELT SANDER REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

The belt sander requires good control to use, but **it is a tool that can be used best with larger loop**. This large loop allows you to use your body's entire strength to handle the tool (vs. using just arm strength). The belt sander works by driving the belt so that the area in contact with the work is moving towards the handle, or rear end, of the tool. This means that the belt sander is always trying to advance forward. To prevent the tool from advancing faster than expected, **NEVER use the tool with a one-handed grip**. Also, advancing the tool in the reverse direction (so that you are constantly pulling against the pull of the belt sander) can help you better control the sander. As with the jigsaw, do not put anything in the path of the belt sander, especially body parts. **NEVER allow any thin, loose object to get caught between the work and the sander's belt**, as this could cause the object to be shot out the back of the sander at high velocity.

The belt sander, like all tools, can overheat if operated for extended periods of time without rest. The main thing to watch out for with the belt sander is overheating near the motor compartment. If the motor area is too hot to touch with bare skin, then it should be allowed to rest and cool.

Like the Dremel tool, the handheld belt sander can create large amounts of dust. Always work in the most open, well-ventilated areas possible. Be considerate of others in the area and use shielding if necessary. Cover all nearby machines. Operators and bystanders may wish to wear dust masks while operating this tool.

Angle Grinder:

Angle grinders are aggressive grinding tools that produce high RPMs and are capable of working on a variety of materials, including steel. While this tool is not difficult to control, it is very important to be focused when using this tool. Always make sure that nothing can get tangled in the grinding disc, especially hair and articles of clothing, as this tool produces significant torque. For this tool, the operator must be **CERTIFIED** by a Team #1351 mentor. **THE ANGLE GRINDER REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

The angle grinder is not a delicate/precision tool and can quickly remove large amounts of material. Never place any body parts (yours or another person's) near the grinding disc. It is **recommended that the operator wears gloves while operating this tool** to protect his/her hands from flying particles and sparks. The use of gloves can also save your skin and fingers should they momentarily contact the spinning disc. Lastly, gloves can help prevent hand fatigue from the tool's weight and vibrations.

On this tool, the cutting/grinding surface includes both the edge and face of the disc. While more pressure may be applied to the tool than with the Dremel tool, not much pressure is ever needed to operate this tool. Also, as with the Dremel tool, **never use a cracked or damaged disc, as such a disc should shatter**. Similarly, never impact the grinding disc against a hard surface such as concrete as this could cause cracks in the disc. Like the Dremel disc, the grinding wheel of the angle grinder should be carefully inspected for any damage before use. Consult a mentor or another team member if you are unsure whether or not to use the disc.

Angle grinders are loud machines when running and even louder when grinding any material. Therefore, **operators and spectators are required to wear hearing protection.**

Again, the angle grinder may be used on substances such as steel. However, when grinding steel, the grinder will produce a shower of sparks (imagine this tool as a larger, more powerful Dremel). Account for these sparks during work area preparation and operation of this tool. Note the direction that any sparks are traveling and keep hands, clothing, and other flammables away.

Unlike the Dremel tool, different cutting discs are required for cutting different substances, and the operator should always check that the disc being used is properly rated for the substance being cut.

Circular Saw:

First and foremost, **the circular saw is for use on wood and composite board only**. It shall not be used for any other materials. The circular saw is for straight cuts on large jobs. It is capable of handling large materials that cannot fit into the band saw yet are too thick (or simply too massive) to be efficiently cut by the jigsaw. The circular saw is not for delicate jobs, as it can aggressively remove material. Prior to operation of this tool, members must be **CERTIFIED** by a Team #1351 mentor. A **MENTOR** must supervise use of this tool. **THE CIRCULAR SAW REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

As the circular saw is a saw, it works off the same principles as the jigsaw and other saws. The saw blade appears to rotate counterclockwise when viewed from the left side of the tool (so that it appears to be rotating backwards). The table on the circular saw is the foot of the saw as it is with the jigsaw.

The circular saw produces a large amount of dust and small flying chips, so eye and face protection is required. Safety glasses are absolutely mandatory, and face shields are preferred. Depending on the type of material being cut, use of a face shield may be required. Dust masks and hearing protection are advisable, but they are by no means required.

The circular saw can advance very quickly, so use two hands whenever possible and never put an object other than the work in the path of the saw. **NEVER cut objects in a manner that runs the risk of contact with material other than wood or composite board.**

The circular saw can also kick and throw larger amounts of material. To prevent this, **NEVER rotate the circular saw while cutting or attempt to otherwise make a curved cut**. Also, NEVER cut along the edge of the material. Try to always cut with at least one inch of material extending from either side of the tool's table. There are a few exceptions. If ever in question about a proposed cut, ask the safety captain(s) or a team mentor.

Chapter 2 Section 3 (2.3): Safety with the Band Saw

With the exception of handheld power tools, the band saw is one of the most commonly used and useful tools. The band saw can cut a variety of materials with ease, but it does have numerous material restrictions. Also, since the band saw cannot move (as can handheld tools), the orientation of the work entering the band saw must be taken into consideration before making a cut. The band saw is efficient at cutting many materials, and it can seriously injure an operator who fails to respect and pay close attention to this tool. Prior to operating the band saw, team members must be **TRAINED and CERTIFIED** by a Team #1351 mentor. **THE BAND SAW REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

The band saw operates by turning a blade in a continuous circle. This blade moves at high speeds in a clockwise direction, pulling the teeth against the table. The band saw blade has a high tooth count, but **it is suitable for cutting materials from wood to aluminum**. Materials are pushed by the operator by hand into the moving blade (thus are *not* clamped in position by a clamp or vice). The band saw has an adjustable blade guard (integrated), and it is typically fitted with a foam blade guard when not in use. The table has a slot for use with a T-square; it can also be used with a fence (for multiple cuts of equal length). The band saw has an access door in the front that can be opened to give the operator access to the wheels and blade. The power switch is located to the left of the table. The power switch has a yellow key that can be removed to prevent the tool accidentally being turned on. Since this key is small and easy to lose, it is typically better to unplug the tool rather than remove the key.

It is important to use proper technique when cutting with the band saw. The following are the main rules and regulations governing the use and operation of the band saw:

1. **Do not attempt to cut any material with a dull blade.** You should never have to force the band saw to cut a material. If the blade is dull, notify a mentor to assist in the process of changing blades. With any cutting tool, excessive force should never be necessary. Applying excessive force invites accidents.
2. **NEVER attempt a sharply curving cut on the band saw (use the jigsaw).** Shallow curves are possible but should be taken slowly and carefully. Most cuts made on the band saw are straight cuts.
3. Do not make any cuts on the band saw freehand unless it is absolutely necessary. Use the fence or T-square to guide your cut. When using the fence, never make long cuts, as the fence may not be parallel to the blade and could cause the material to pinch the blade.
4. **Whenever the operator must back the blade out of a partial cut, do NOT turn the machine off.** Unless a safety concern dictates that the machine must be turned off while a cut is being made, the band saw should never be turned off while the blade is in a partial cut.
5. **NEVER cut off the table.** The list of things that could go wrong when this rule is violated is endless.

6. **NEVER start the machine with the blade already in a partial cut.** This could break the blade.
7. **NEVER apply pressure to the sides of the blade or twist the work sharply while making a cut.** This could break the blade. Broken band saw blades are DANGEROUS (as described by an anonymous TKO mentor, like a “snake on crack”). If a blade breaks, turn off and unplug the machine IMMEDIATELY. Report the accident to a mentor, who can assist with removing and replacing the blade, as well as inspecting the tool.
8. Very thin cuts (with little material on either side of the blade) should not be attempted as slivers of material could be kicked out by the blade or sucked into the machine (carried by the blade). This could damage the tool (and/or yourself).
9. **Always use the integrated metal blade guard when working.** This blade guard protects the operator from the blade while it is moving and keeps the blade straight. It also works to keep the work from flying away from the blade area during operation of the tool. The blade guard should always be adjusted to height of the work. The blade guard should be adjusted so that it is anywhere from **1/8 in. to 1/4 in.** above the tallest part of the work (the exact height is not important). Adjust the guard by loosening the knob of the front, twisting the knob of the back of the machine to raise/lower the guard, and tightening the knob of the front to lock the guard in place.
10. Use two hands whenever possible to hold and control the work. If this places your fingers within one inch of the blade, then use a consumable **push stick** or use a different tool. **NEVER push with your fingers directly in line with the blade.**

The band saw has many rules and regulations governing the material type and thickness cut by it. They are as follows:

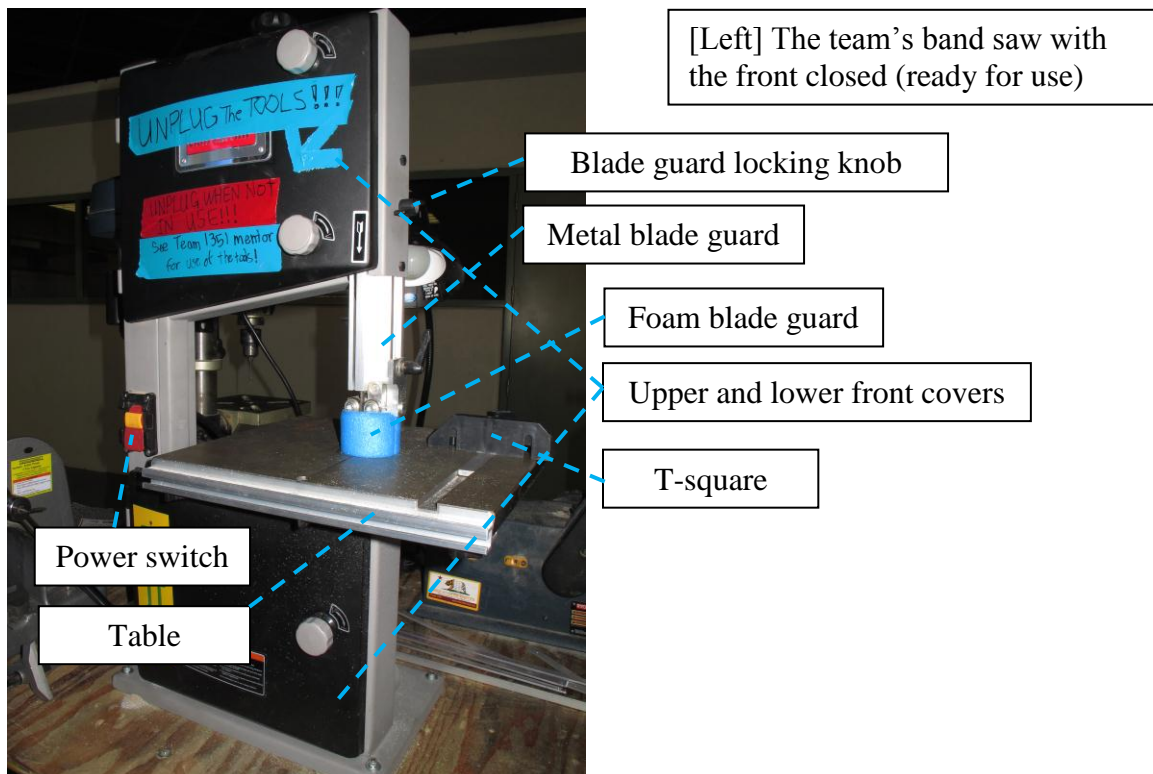
1. **NEVER cut steel or materials of similar hardness.** It will damage the tool (break/dull the teeth). This could potentially break the blade and/or send the broken-off teeth flying.
2. **NEVER cut materials thinner than 1/16 of an inch thick.** Several teeth should always be in contact with the material at any given time to prevent damage to the blade (less stress per tooth). Preferably, the material is 0.1 inches thick or thicker. With materials that can split easily (such as wood and plastic), material thickness should be 1/8 of an inch thick or thicker to prevent the work from splitting.
3. When inserting materials into the band saw, ensure that the orientation of the work allows for the greatest thickness of material to enter the blade. It is best if a similar thickness of material is passing through the blade throughout the cut.
4. **Make sure that any object being inserted into the band saw will not likely rotate or flip when it comes into contact with the band saw.** Objects should be placed so that the greatest surface area is in contact with the table as possible.

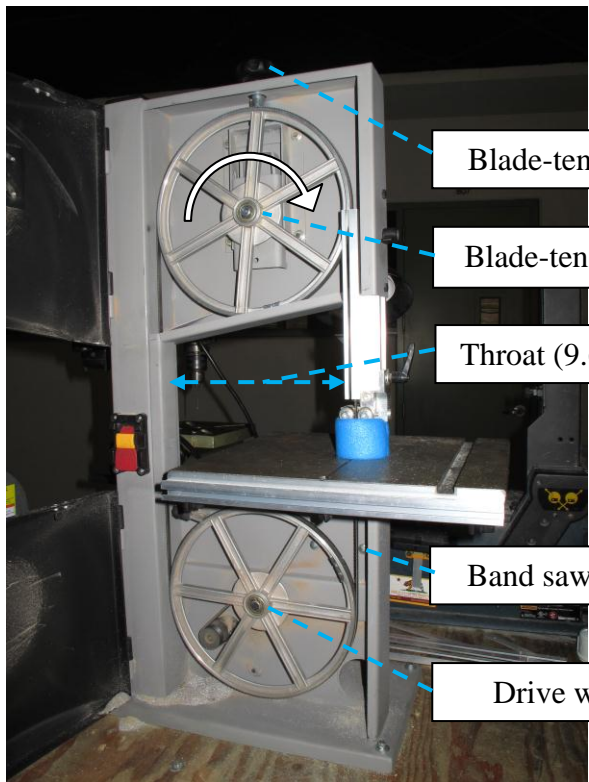
5. Round materials (round tube, axle/shaft material, PVC pipe, etc.) can be cut on the band saw. Use caution and a secure grip to prevent the work from rotating during the cut. Rolling the work during the cut (use extreme caution while doing this!) can help make a straight cut. Always use a guide when cutting round materials.
6. **Do not cut very small objects or cut objects that require very precise cutting.** While the band saw is far more precise than any other saw used by Team #1351, it still removes material quickly and should not be used on brittle materials. If you must cut a small object, one option is to use a push stick. The operator can also choose to attach the small work to a larger, preferably consumable handle.
7. **Some objects may be too large to be cut with the band saw.** Any work that is taller than the maximum height of the blade guard may not be cut on the band saw. The physical dimensions of the band saw (such as the distance from the main body of the saw to the blade) may limit the size of a cut. Several cuts may be necessary to complete a single task.

Like all tools, the band saw requires some maintenance. Periodically open the band saw and remove dust and shavings from inside the tool, particularly around the wheels. Scrape off any particles that are stuck to the wheels. Make sure that the blade tension (controlled by a knob on the top of the machine) is kept tight. Whenever working on the tool, make sure to unplug it.

Tool Specs:

Team #1351 TKO has and operates a Craftsman 10 inch table-mounted band saw with a 9.625 inch throat (distance between blade and the band saw's body). The manufacturer's model number for the band saw is 119.214000. The band saw uses a 70.5 inch long blade.





[Left] The team's band saw with the front open for maintenance.

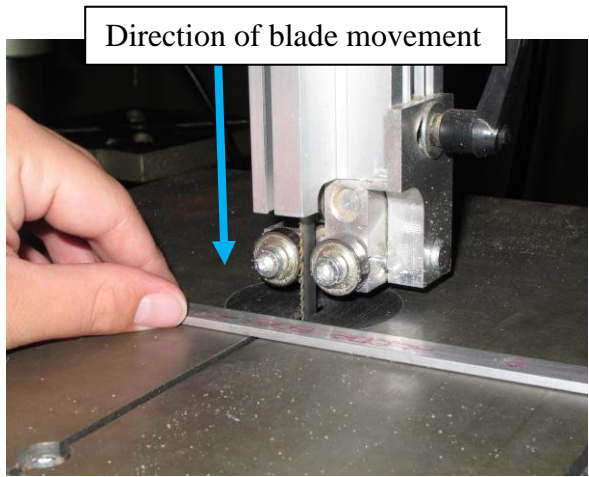
Blade-tensioning knob

Blade-tensioning wheel and direction of rotation

Throat (9.625 in.)

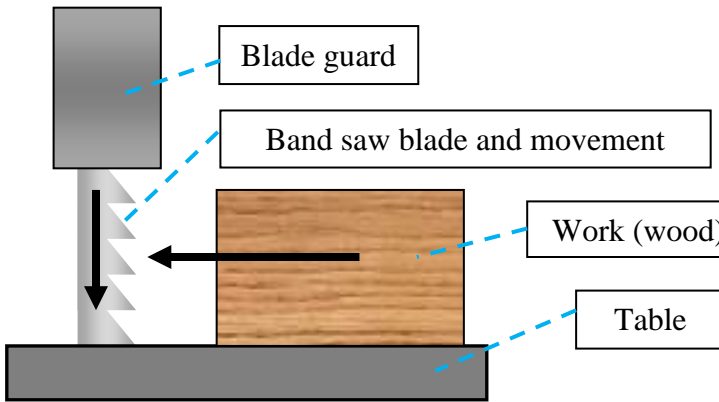
Band saw blade

Drive wheel



Direction of blade movement

[Left] This is the proper method for cutting materials on the band saw. Note that the operator's fingers are not in line with the blade and are sufficiently far enough away to be out of the blade's path. The blade guard has been lowered to the proper height and the work is thick enough to be safely cut (> 0.0625 inches).



[Lower left] A diagram of the band saw's operation: The teeth scrape off bits of the work as they pull it against the table.

Blade guard

Band saw blade and movement

Work (wood) and feed direction

Table

Chapter 2 Section 4 (2.4): Safety with the Drill Press

The table-mounted drill press allows for somewhat precise drilling through any materials used by FRC Team #1351. The drill press is a variable-speed drilling/cutting tool that can be fitted with all of the bits that handheld drills may use with the exception of any of the driver bits. This tool may be used with steel. Prior to using this tool, members must be **TRAINED** and **CERTIFIED** by a Team #1351 mentor. **THE DRILL PRESS REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

The drill press has a moveable table that can be adjusted for both height and position (it can also be adjusted for angle, but it never should be). The table is locked and unlocked via a knob at the back of the table. The table's height can be adjusted by turning a handle also located on the back of the table. Whenever moving the table, make sure that the hole in the middle of the table is lined up with the bit. The height of the chuck (thus the bit) is adjusted by the three-armed lever on the right side of the tool. Turning this lever backwards towards the operator lowers the chuck. To tighten/loosen the chuck, a key is located on the left side of the press. To adjust the speed of the tool, the upper compartment of the drill press can be opened and the gear ratio altered to give greater speed/torque to the chuck by moving the drive belt between sets of drive wheels. Like the band saw, the drill press has a small key to prevent the tool from accidentally powering on, but it is better to simply unplug the tool.

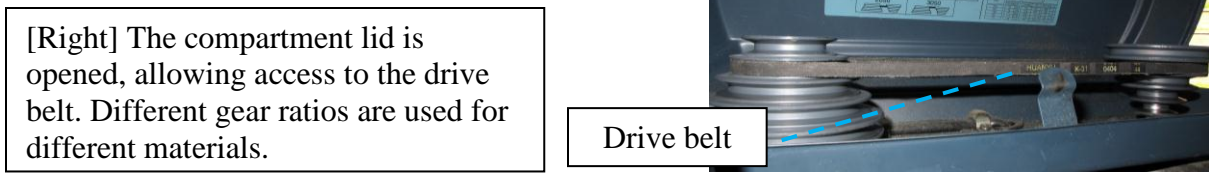
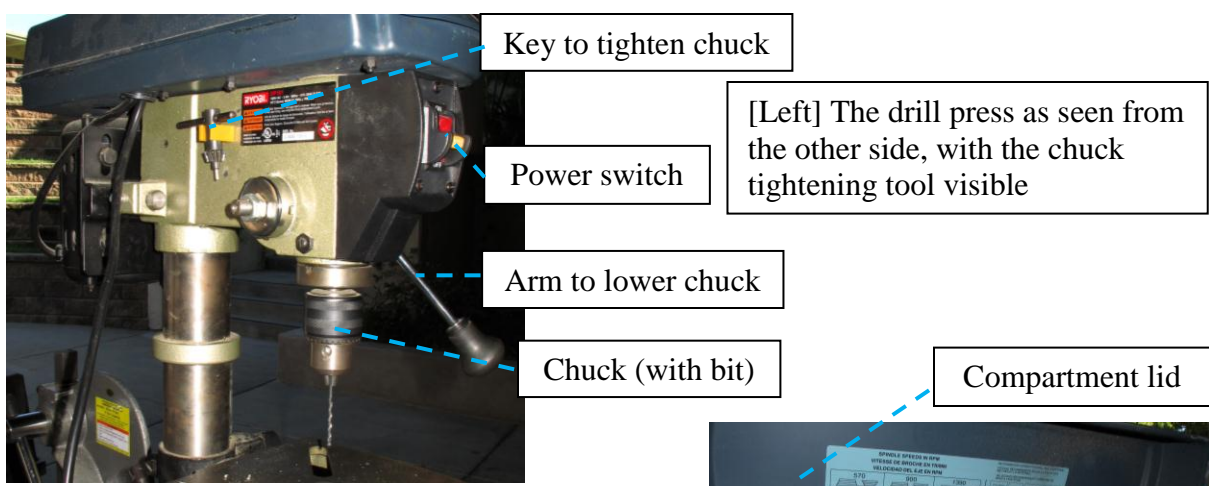
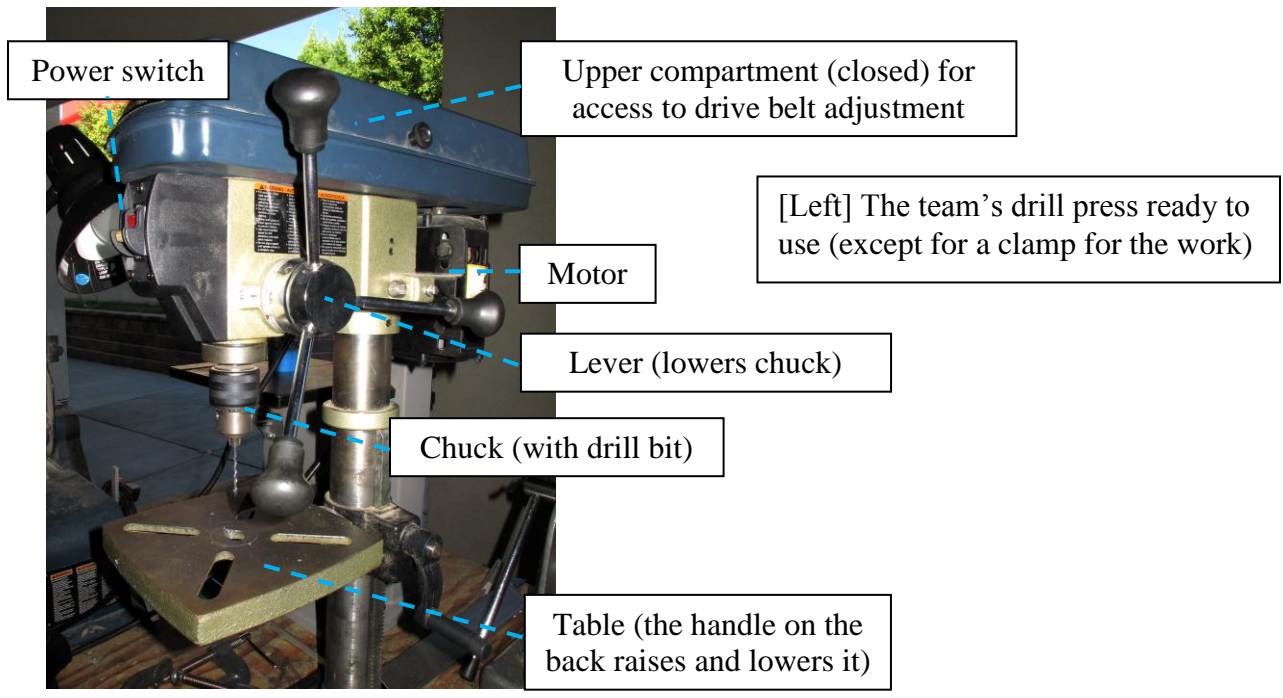
The drill press has a few simple rules of operation for safe use of the tool. They are as follows:

1. **Unplug the machine or remove the key when changing bits and RPMs.**
2. Never tighten the chuck down on the cutting portion of any bit.
3. **Use cutting fluid for any cuts through steel and thick (greater than .25 in.) aluminum.** Depending on the type of bronze, cutting fluid may be required. It is recommended to use cutting fluid whenever drilling metals. Cutting fluid should not be used on materials such as wood or plastic, as this could gum up the drill bit. However, move slowly on these materials to avoid heat buildup.
4. **ALWAYS clamp the work to the table or use a vice.** This will prevent the work from moving during the cut.
5. **Never move the work while drilling.** This could break the bit.
6. Be aware of any long shavings caught on the bit. These can cut the operator as they rotate on the bit.
7. After drilling steel or thick aluminum, do not remove the bit with bare hands. Use gloves or a cloth.

- 8. **ALWAYS** allow the machine to reach its full speed before beginning to drill. Never start the machine with the bit in the work or touching the work. Always use a pilot hole or a center punch before drilling.

Tool Specs:

Team #1351 TKO has and operates a RYOBI 10 inch drill press (manufacturer's model number DP101). The drill press's speed varies from 570 to 3,050 RPMs and can accommodate 1/16th inch to 1/2 inch size drill bits.



Chapter 2 Section 5 (2.5): Safety with the Belt Sander

This tool is essentially a larger, table-mounted version of the handheld belt sander. It aggressively removes material and is used mostly for smoothing edges and removing burrs. The belt sander is not recommended for delicate or precise projects. Prior to use of the belt sander, the member must be **TRAINED** and **CERTIFIED** by a Team #1351 mentor. **THE BELT SANDER REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

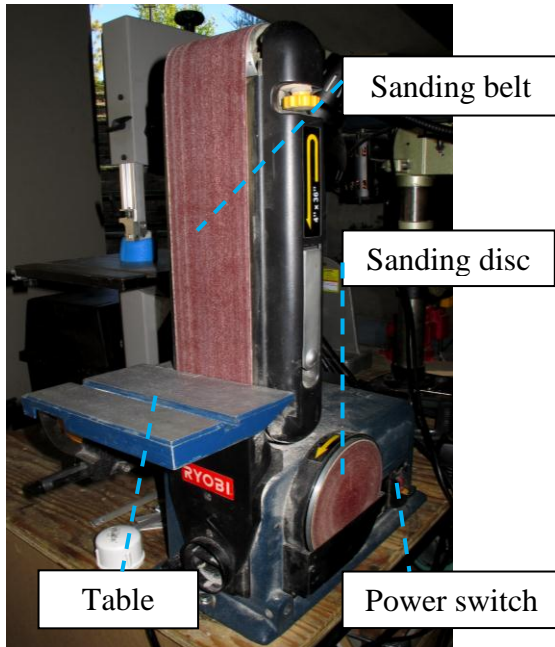
The belt sander has two grinding surfaces, one sanding belt and one sanding disc, on the right side of the tool. The sanding belt has a table that any work should be placed on before use. The sanding belt can be moved from the vertical position to the horizontal position by loosening and tightening a pair of hex bolts located on the left side of the machine. There is a knob to adjust the tension and position of the belt. The belt sander can be used for most materials, but be aware of sharp edges that could cut the belt.

The belt sander has several rules and regulations in place to ensure safe operation of this tool. They are as follows:

1. **NEVER grind any work off the table.** The belt sander can pull the work out of your hand.
2. Do not grind any hard, sharp objects, such as a sharp piece of steel. This could cut the belt.
3. **NEVER grind any object thinner/smaller than the gap between the table and the belt.** The object could be pulled into the machine.
4. **NEVER** put your fingers within one inch of the belt while grinding. Use a clamp or pliers. This keeps your fingers away from the belt.
5. Do not push hard against any object that could flip or rotate while grinding. This could cause your fingers to contact the moving belt (which *will* remove skin).
6. **Do not touch any surface that has recently been ground on the belt sander**, especially metal, as it could be extremely hot.
7. **Do not use cutting fluid with the belt sander.**
8. Do not adjust the belt's tension or position while running the machine. Turn off the tool before working on it.

Tool Specs:

Team #1351 TKO has and operates a RYOBI belt and disc sander (manufacturer's model number BD4600). The belt sander runs at 3,600 RPMs and uses a 4-inch wide belt and a 6-inch diameter disc.



[Left] The team's previous belt sander was replaced with another sander of the same make and model. Here, the table is positioned to be used for grinding on the vertical belt sander.

Chapter 2 Section 6 (2.6): Safety with the Arbor Press

The arbor press is a simple, hand-operated tool used to broach sprockets and used as a general press. The arbor press does not require tool certification or a safety observer to use. However, it is best to be trained in broaching by a mentor or another member before first use of the press.

The main safety rule with the arbor press is to never place hands or fingers in the press. The tool is operated by rotating a lever (like using the drill press), which moves a steel block to press against the work.



[Left] The arbor press (in image, moving the lever counterclockwise moves the steel block down)

Chapter 2 Section 7 (2.7): Safety with the Mill/Lathe

The mill/lathe tool is a hand-controlled, precision cutting tool and is one of the few tools capable of cutting a near-perfect circle. The tool can cut wood, aluminum, plastic, and steel. It is a very powerful tool that can perform a multitude of operations. Before operating this tool, ensure that you are fully awake and focused, as this tool requires use of both hands simultaneously to operate the tool. Prior to use of this tool, members must be **TRAINED** and **CERTIFIED** by Team #1351 mentor Mr. Chris Fairley. When in use, **Team #1351 mentor Mr. Fairley must SUPERVISE use of this machine. THE MILL/LATHE REQUIRES A SAFETY OBSERVER TO ACCOMPANY THE OPERATOR.**

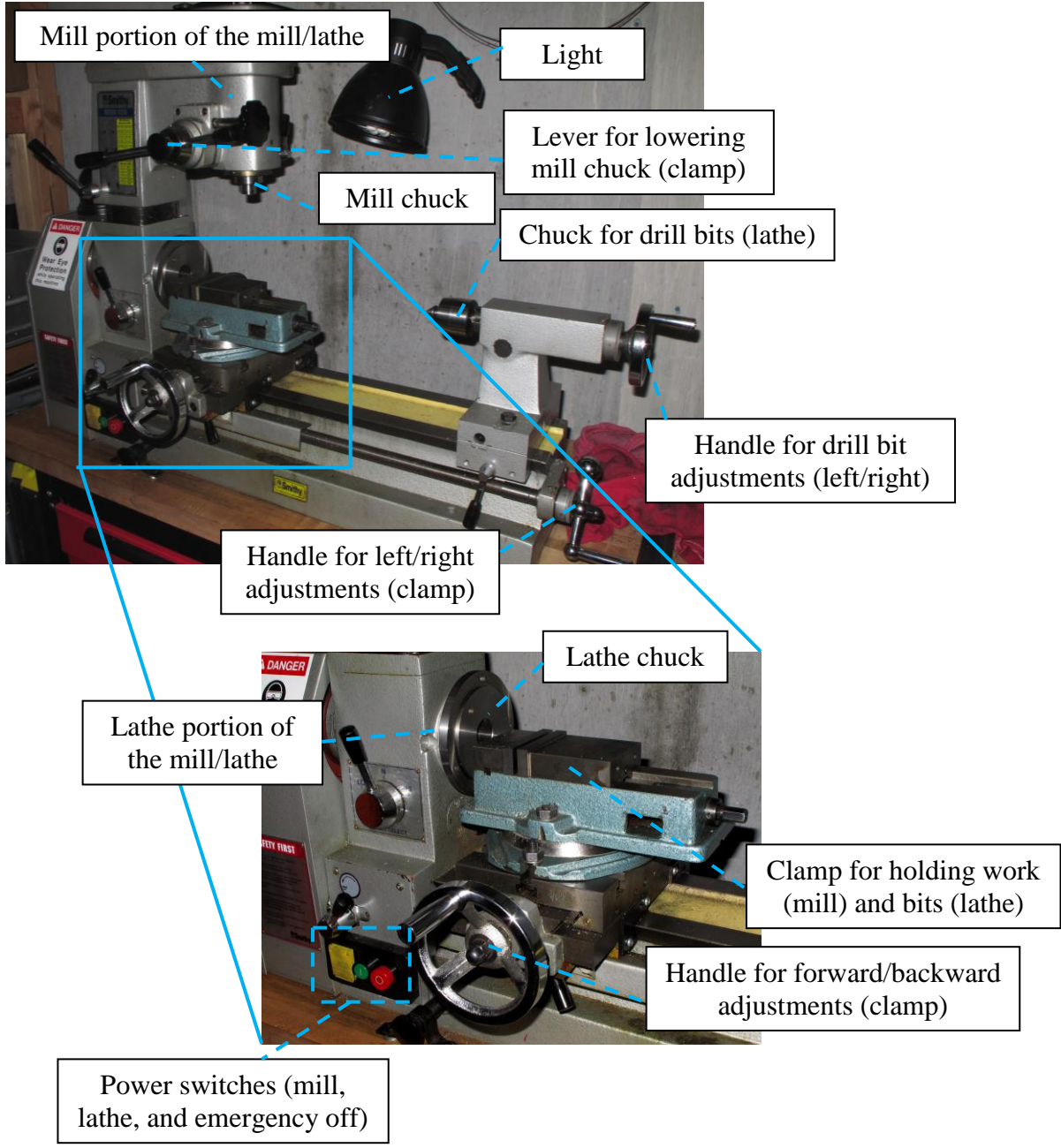
The mill/lathe requires the operator to have a very good understanding of this tool's operation. The mill is the vertically mounted, drill-press-like machine that is used for cutting grooves and flat surfaces in the work. It can be used as a precision drill press with a drill bit or as a cutting tool with a milling bit. The lathe is the horizontally mounted tool that rotates the work to allow for a perfectly circular cut. The lathe can be used to bore holes in the center of the work, widen the inner diameter of the work, or decrease the outer diameter of the work. The mill/lathe is controlled by rotating sets of knobs, which turn screws to move the work/tool. The tool has two separate on/off buttons located on the left side of the machine.

The mill/lathe is a powerful tool that requires respect and focus to operate. It is a serious tool. The following are the rules and regulations that are in place for the safety of the operator:

1. **Always clear the area around the tool of any loose items that could get caught in the tool, especially shavings.** These can become very dangerous if they are spinning rapidly on either the mill or the lathe.
2. NEVER perform maintenance of the tool alone. Always have Mr. Fairley either guide you through the maintenance or do the maintenance for you.
3. **Use cutting fluid often**, especially when cutting metal on the lathe.
4. Tighten down everything before use, especially the bit and the work.
5. **Do not turn the machine off when the bit is in the work** (except in an emergency), **or start the machine with the bit in the work.**
6. Inspect the machine often during use, and ask Mr. Fairley if the tool seems to be operating unusually.
7. Wear a face shield if you must cut steel on the mill/lathe. Always be alert when cutting steel, as **steel shavings** (especially from the lathe) **can be literally razor sharp.**
8. If the machine ever makes an unusual noise, back the bit out, turn the machine off (in that order unless safety dictates otherwise), and ask Mr. Fairley before continuing.

Tool Specs:

Team #1351 TKO has and operates a Smithy MIDAS 1220 mill/lathe under the direction and supervision of team mentor Mr. Chris Fairley.



Chapter 2 Section 8 (2.8): Safety with Electronics Power Tools

The electronics department's power tools do not have the same likelihood of injuring the operator as do other power tools. However, there tends to be a greater likelihood of burning oneself while using electronics power tools than with other power tools.

Soldering Iron:

Soldering irons are the most commonly used power tools in electronics. They are used for soldering wires to any of the following: other wires, switch terminals, PC boards, and other electrical hardware components (diodes, resistors, LEDs). Soldering is also used for "tinning" multi-stranded wire together. "Tinning" is the application of solder to the combined, exposed strands of multi-stranded wire to make them behave as solid core wire. The soldering iron requires the member to be **TRAINED** and **CERTIFIED** by a member with at least one season of experience. No safety observer is required for soldering.

The most common injury with the soldering iron is first and second degree burns caused by contact with molten solder, the soldering iron (not including the handle), or hot wires. Burns can be prevented by abiding by the following rules and regulations:

1. **NEVER pick up a soldering iron like a pen or pencil**, whether it is powered on or not (the temperature of the soldering iron will remain at several hundred degrees Fahrenheit for a few minutes after powering off the tool). It can cause serious burns. Do not touch the soldering iron (not including the handle) for at least five minutes after powering off the tool.
2. Do not feed solder from less than one inch from the work.
3. Do not attempt to quickly feed solder into the work, as this may cause solder "sparks." (This occurs when small droplets of solder are ejected from the work. They rarely stick to the skin, but they do cause small burns on contact.)
4. **NEVER** hold a wire while soldering it, as the wire may get very warm.
5. **NEVER touch a recent solder job.**
6. When tinning the soldering iron's tip (to put away the tool), do not create a large pool of molten solder on the tip, as this can form a drop of solder that could fall from the iron.
7. Always turn off a soldering iron and place it in its holder when not in use.

In addition to preventing burns, there are also a few other safety rules when using soldering irons. Never touch the soldering iron to plastic or rubber, as this action could create nauseating fumes. Do not solder in a poorly ventilated area or directly inhale large amounts of fumes while soldering.

Heat Gun:

The heat gun is essentially a very powerful hair dryer. It directs a blast of very hot air into a concentrated area. This tool is used for shrinking shrink tubing and heating other various objects. Prior to use, members should be walked through use of this tool by another member with experience on this tool.

The main safety issue with this tool is the risk of being burned while using this tool. While operating this tool, do not touch the metal nozzle on the tool. **Do not point the gun at any person or yourself.** Never point the tool at any flammable materials. Do not touch the heat gun for at least five minutes after powering off the tool. Do not touch any recently heated materials.

Chapter 2 Section 9 (2.9): Safety with the TIG Welder

Whole books could be written on TIG welding. Whole books *have* been written on TIG welding. For this reason, this manual will only cover matters related to safety and TIG basics. For the best safety when welding, read about TIG welding before attempting any weld. (Files about TIG welding are available on myMitty.) This will best inform you on proper welding technique.

TIG welding is very useful for welding a variety of metals, from steel and iron to aluminum and magnesium. It is controlled and precise, and it produces minimal fumes and splatter (exact amount depending on type of metal). It also produces no flux. TIG welding also requires the most skill and physical dexterity (arguably) of any welding process.

THE TIG WELDER IS ARGUABLY THE MOST DANGEROUS TOOL USED BY TEAM #1351 AND SHOULD BE TREATED AS SUCH. IT MAY BE USED ONLY BY A SELECT GROUP OF MEMBERS WITH THE PERMISSION AND DIRECT SUPERVISION OF A TEAM MENTOR (MR. CHRIS FAIRLEY). IT MAY ONLY BE USED UNDER CERTAIN CONDITIONS, AND ALL MEMBERS OF THE SELECT GROUP MUST HAVE BEEN TRAINED AND CERTIFIED BY A TEAM MENTOR (MR. CHRIS FAIRLEY).

TIG Welding Basics:

As with all tools, it is best to learn the basics of how a tool operates before using it.

TIG welding stands for tungsten inert gas welding. This is one of three arc welding processes. **Arc welding uses electricity to create and sustain an arc between the electrode and the work, using the heat created by the arc to create a pool of molten metal.** The electrode in TIG welding is made of non-consumable tungsten. The term “inert gas” refers to the inert gas (pure helium, pure argon, or a helium/argon mixture) that is used to shield the heated metal from atmospheric gases, which would oxidize the metal and weaken the weld.

The Team #1351 TIG welder is an air-cooled welder. For the purposes of this manual, the welder components will be separated into the following: torch, welding rod, remote control, ground clamp, power source, inert gas pump, and inert gas tank. The power source (which supplies and controls electrical power given to the torch and ground clamp) and gas pump are located inside of the main welder unit. The torch holds the electrode and gas cup, which funnels the gas around the arc. The torch is the part of the welder that is held by the welder during welding. The welding rod is the consumable metal rod that is the filler metal placed in a weld. The remote control is the foot pedal that controls the power (amperage) given to the arc during the weld; it is essentially the power switch for the welder. The ground clamp completes the electrical circuit required for the arc by connecting the work to the main welder unit. The inert gas tank supplies the shielding gas. There is a flow regulator that controls the gas flow in CFH (cubic feet per hour).

Understanding the Dangers:

TIG welding has many dangers, but most can be avoided if proper respect and attention are given to the tool during welding. Understanding the dangers of welding is essential to safe welding practices. The following are some of the dangers associated with TIG welding:

1. **Eye damage is a serious risk.** Poorly prepared metal can produce sparks when welding, which could then enter the eyes. Arc welding produces very intense UV radiation, and TIG welding produces the most UV of any arc welding process. This intense UV light can cause flash burn to the eyes. Symptoms of minor eye damage include itchy and/or sore eyes. Permanent eye damage can occur from UV radiation.
2. Though TIG welding does not, under ideal conditions, produce sparks and splatter, the process can produce sparks and splatter in certain conditions. When there is contamination of any sort, sparking and splatter can occur. This can also occur depending on the angle of the torch in relation to the work; a shallow angle is more likely to produce splatter, especially when approaching the edge of the work. **Splatter from welding is EXTREMELY HOT** (it is molten metal after all). It can easily cause first and second degree burns to the skin.
3. UV radiation produced by the welding process can create the equivalent of **severe sunburn** on any areas of exposed skin.
4. **Heat from the arc and molten metal can cause burns despite protective equipment.** The areas of highest heat (not including the arc) are the gas cup, torch (near the gas cup), and the work.
5. If any contamination is present, fumes could be produced by the welding process. These fumes could be toxic and may possibly contain carcinogens.
6. Arc welding uses electricity and introduces the risk of exposed contacts (the work, clamp, and electrode). **There is a very real risk of electrical shock.**
7. The heat and potential splatter produced by welding could ignite nearby flammable materials, including synthetic clothing (thus no such clothing as a PPE requirement).

TIG Welding Safety:

TIG welding requires the operator to have a thorough knowledge of proper technique and to be focused entirely on the task of welding. The following are rules and tips to help ensure the safety of operator and bystanders:

1. **ALWAYS USE THE FOLLOWING TERMS FOR SAFE COMMUNICATION.** Say, **“Welding!”** before starting the arc. When welding, the term **“back off”** means to back off the foot pedal, not remove the torch. After stopping the arc (removing your foot from the

foot pedal) and allowing the work to cool below glowing, say, “Safe!” to announce that welding masks can be removed.

2. **NEVER touch a recent weld, the end of the torch, the gas cup, or the end of the welding rod during or after welding.** Even with welding gloves, you *will* be burned by contact with any of these. Never handle the work or torch without welding gloves.
3. **NEVER look at welding in progress (or in the direction of welding in progress) without proper eye protection.** Proper eye protection includes safety glasses under a properly-tinted welding mask.
4. Do not weld under any circumstances if you experience symptoms of eye damage. The main symptoms of eye damage are itchy eyes and sore eyes.
5. Ensure that there is no exposed skin when welding, as this skin will get burned if it is not covered.
6. Do everything possible to prevent contamination before welding. Use a dedicated (no other materials) grinder/emery cloth to remove any surface contaminants from the work and welding rod. NEVER touch the electrode to the work or the welding rod. Clean and sharpen the electrode with a dedicated grinder. Members are not permitted to sharpen the tungsten electrode.
7. **NEVER weld in moist or wet conditions,** as moisture will increase risk of electrocution.
8. Clear the area of any surrounding flammable materials.
9. **Use a rest for both hands whenever possible for welding.** Try not to rest your hands on the work, as the work will get warm during welding.
10. **Always point the torch in the direction of the weld and never at yourself.** Ideally, the torch is held 10 degrees off vertical. The welding rod should be held 15 degrees off horizontal. Try to keep 8-12 inches of welding rod between the arc and your hand.
11. When using an electronic welding mask, **NEVER cover or block the sensors.** It is recommended that only the operator and closest observer (typically Mr. Fairley) should ever wear electronic masks in order to prevent flash burns to the eyes (see Chapter 1.3)
12. NEVER weld in a poorly ventilated area. If large volumes of fumes are being created, do not directly inhale these fumes and do not continue to weld under such conditions.
13. The CFH setting for the shielding gas should be set to 20-25 cubic feet per hour. **Turn the shielding gas on before use.**
14. Always put away the welding equipment correctly after giving it ample time to cool. This will ensure that the TIG welder is operating in a safe and proper manner.

Chapter 3: Robot Safety

Know how to safely work with and around robots.

Chapter 3 Section 1 (3.1): Know Thy Robot

First and foremost, any person working with or around a robot should know the following: how the robot moves, movement and operation of robot appendages, location of main breaker, and location of the emergency shut-off switch. It is also better if all persons working with or around the robot understand how the robot is controlled. In other words, be familiar with the robot. Members should never work with or around a robot if they are unfamiliar with any of the above. All members operating the robot **MUST** know all of the above. Whenever working with, around, or on a robot that may be turned on in any way, you must be wearing appropriate safety glasses.

Understand the dangers of working with any robot and how to avoid them:

1. **Robots in the FRC are (for the most part) strong, heavy, and fast.** The robots made by FRC Team #1351 tend to all weigh close to 120 pounds *without* bumpers and a battery (which can increase the weight to around *140 pounds*). They can move quickly, up to 12 feet per second (some robots can move faster!). They also tend to be made out of *welded aluminum plates*, so the human is likely to lose in the event of a collision. The best way to avoid this is to stay away from the front and back of the robot while it is in operation.
2. **Robots that are NOT tethered can be very dangerous.** Even robots that are being controlled directly (tele-operated mode) are still controlled by software. Robots in autonomous are more dangerous, as no human is actually controlling them at this time. The best way to stop an out of control robot is to use the emergency stop button or to disable the robot. If this does not work, then your options are very limited. If a robot is seriously out of control, then just steer clear of it! Two methods of stopping rampaging robots are to flip the robot off its wheels/treads and to trip the main breaker (power off the robot). Since these methods require the member to approach the robot, then they should only be used when **ABSOLUTELY NECESSARY**. **Remember, human safety is far more important than the robot's condition.**
3. Moving parts of the robot can be dangerous whenever the robot is turned on, so all personnel should have **hands out of the robot and be out of the path of motion for all robot appendages when the robot is powered on.**

Chapter 3 Section 2 (3.2): Batteries

Before handling or operating robot batteries, it is imperative to **know the basics of the MSDS (material safety data sheet) sheet for robot batteries**. There is such a MSDS attached at the end of this manual. MSDS sheets provide data about a substance's chemical properties.

Weight:

In terms of other parts of most robots, the battery is fairly heavy for a single object. This makes unsecured batteries a falling hazard. In addition to injuring people, a falling battery can also crack and leak acid. Do not place batteries high on shelves or close to the edge of a table. Always lay batteries flat (when possible) when they are higher than three feet off the ground. **Never carry batteries by the leads**, as these could pull loose. NEVER carry a tote full of batteries by yourself.

Electrical Charge:

The robot batteries are 12 volt, high-capacity batteries (essentially motorcycle batteries). Both fully and partially charged batteries can electrocute a careless person. However, skin tends to provide decent insulation.

When working with batteries, members must follow the following rules for their safety and the safety of others:

1. NEVER make skin to metal contact with both contacts of the battery at once.
2. NEVER work on a battery with moist hands or in moist conditions.
3. **NEVER short the battery** (make direct contact between both terminals). This can destroy the contacts and the battery.
4. **Use electrical tape** to prevent the battery from shorting by covering the contacts.

Acid:

The robot batteries are all lead acid batteries. All robot batteries contain highly concentrated sulfuric acid (H_2SO_4), which is a very strong acid. If the battery case sustains significant damage, this acid can leak. (Note: this acid is so concentrated that it somewhat resembles a thick paste/gel, so it will not gush out like water.) **NEVER touch this acid** with anything other than acid proof gloves. **IMMEDIATELY contact a mentor and other adult personnel if an acid spill occurs**. Alert everyone in the area to the spill. Take such an incident very seriously.

The best way to deal with such an accident is **to neutralize the acid as quickly as possible by adding ample amounts of baking soda (strong base) to the acid**. Using cat litter is a good way to absorb the neutralized acid.

Batteries that have developed a leak are unusable and must be *properly* disposed of. Only do so once the spill has been properly dealt with.

Charging Batteries:

Battery charging is a straightforward process. When charging batteries, ensure that there is **plenty of space (> 1 in.) between chargers for air to circulate and cool the chargers**. Charge any battery that has been used. However, charging batteries for 24 hours is *never* a good idea, as the battery can begin to produce hydrogen gas if it is overcharged; **batteries should not be charged for more than 10 consecutive hours**. Indicate full charge by putting the white card in both terminals of the battery lead; placing the card in one or no terminals indicates partial charge. A more complex and accurate system of battery charging is also used for those members who become heads of battery charging during competition; this method is taught multiple times throughout the year.

Battery Maintenance:

Batteries maintenance is simply a matter of keeping the leads tightly connected and avoiding damaging the battery casing.

Chapter 3 Section 3 (3.3): Pneumatics and Springs

Pneumatic systems can be dangerous to anyone who is not paying attention to them. They are capable of moving quickly with lots of strength, so team members and bystanders should always stay clear of pneumatic systems in operation. Remember, a pneumatic piston can move an object that even a CIM motor cannot (i.e., pneumatics cocked the Mark V spring-powered catapult).

Pneumatic systems are different from other parts of the robot in that they continue to be a safety hazard *after* the battery has been disconnected. They rely on air pressure, which is stored in a series of tanks. **Before working on any robot with pneumatics, release the pressure from the tanks.**

Springs are similar to pneumatics in that they can move quickly with plenty of power. They also continue to be a safety hazard after the robot has been powered off. **Any spring that is under tension can be a safety hazard.** Carefully relieve tension/pressure from all springs before working on any robot.

Chapter 3 Section 4 (3.4): Electronics

The electrical systems of any robot pose two main risks: **electrocution/electrical shock and burns**. The first risk, electrical shock/electrocution, can be easily avoided by not making direct contact with any live wires. Also, check the electronics for any possible shorts and **ALWAYS cover the electronics when cutting or grinding on or near the robot**.

Burns can come from any electrical system that is in use or recently has been used. Motors are the main source of burns, as they can get very warm during operation (especially CIM motors). The leads of any motor can also get very warm, so use caution before touching any motor leads or power/ground wires.

Chapter 3 Section 5 (3.5): Robot Transportation

Robots should be transported primarily on the robot cart; that is the robot cart's main purpose. To move the robot on and off the cart, be sure to always have the robot powered off and to use gloves. If possible, have the battery disconnected. **Never move the robot with any pressure in the pneumatics system.**

When transporting the robot, always observe the following rules and regulations:

1. Always place the robot on blocks to lift its wheels/treads off the robot cart and ground. Ensure that any moving parts of the robot are not in contact with the cart or the blocks.
2. **Never transport the robot while it is powered on.** It is acceptable to transport the robot with the battery connected. Members must have the battery either secured to the robot or not on the robot at all.
3. **Never transport the robot with any pressure stored in the pneumatic cylinders or any springs under tension.**
4. Do not transport a robot unless all robot appendages are in their default resting position (nothing cocked or under tension).
5. Always have two people with the robot cart at any time. This is to help maneuver the robot and help keep the robot on the cart.

Chapter 3 Section 6 (3.6): Testing Code

Testing software is an essential part of any build season. Knowing proper safety practices when testing code can help make this process easier and safer for all participants.

Whenever testing new code for the first time, it is very important that all participants and bystanders observe the following rules:

1. **Have the robot off the ground, preferably on blocks.** This will prevent the robot from moving out of control (with the possible extension of robot appendages). Observe the robot while it is on the blocks to ensure that any new code does not cause any damage or injuries should the robot behave/move unexpectedly.
2. **Check and recheck the mechanical/electrical systems** to ensure that any problems that may occur during testing are from *the code* and not a mechanical/electrical error. This can also help to find potential safety hazards during operation.
3. Have all participants stand away from the robot during initial testing on blocks. **No one is to work on the robot during testing.**

Once an off-the-floor test has been completed, a floor test should be performed. During a floor test, every person within 50 feet (other rooms/areas not included) should be notified of the test in progress and the anticipated robot movement during that time. Use the same announcements and directives used for operation of the robot (see below). All persons should be at least 5 feet away (10 feet preferred) from an enabled robot.

Chapter 3 Section 7 (3.7): Operating the Robot

Operating any robot should only be done after an off-the-ground test has been performed to check that the robot responds properly to the operators' commands. When operating a robot, all observers are to remain at least 5 feet from the robot. Never step in the path of a robot that is powered on and always be out of the path of motion of all robot appendages.

When operating a robot, the operators and their assistants are to communicate (to themselves and the public) using the following terms (for the given purpose):

1. **“Robot on!”/“Power on!”** indicates that the main breaker is *about* to be closed.
2. **“Enabling!”** indicates that the robot is *about* to be enabled by an operator at the O/I, entering either tele-operated mode or autonomous mode. The mode should be indicated prior to enabling the robot.
3. **“Testing!”/“Firing!”/“Operating!”/“_____ on!”** indicates that one or more of the appendages of the robot is being activated during tele-operated mode.
4. **“Disabling!”** indicates that the robot has *been* successfully disabled and is safe to approach.
5. **“Robot off!”/“Power off!”** indicates that the main breaker has *been* successfully opened, cutting power to the robot. Only after this announcement has been given might it be safe to remove safety glasses.

Chapter 4: Pit and Competition Safety

Bring the safety to the competition.

Chapter 4 Section 1 (4.1): General Competition Safety

Safety at the FRC competitions can be broken down into two categories: safety in the stands and safety in the pits. These are the two main areas of the competition. For purposes of this manual, the pits include all of the following: the playing field, robot transport areas, and all areas within the designated pit area. The stands include any observation areas designated for public crowds and any public walkways. This includes any areas that overlook the pit area.

General safety in the crowds is simple. **Whenever going somewhere, either go with another member or notify a mentor** (preferably both). Always tell someone where you are headed before you leave to go somewhere. **Do not block any public walkways**; move aside if someone is moving through with a large or bulky object. Remember that part of FIRST's philosophy is **Gracious Professionalism**, which should be shown both on and off the playing field at all times.

As a general rule, persons at competition should abide by the basic PPE regulations in terms of general clothing, foot protection, and eye protection. Members should bring close-toed shoes and safety glasses to the competition, as both are required to enter the pits. Safety glasses may be borrowed from the pit entrance, but these are limited in number and are meant to be worn by non-participating visitors.

All FRC Team #1351 safety rules and regulations apply at the competition. Also, follow any posted instructions and any verbal instructions given by FIRST safety officers.

Chapter 4 Section 2 (4.2): Working in the Pits

Every person in the pits must wear proper safety glasses and close-toed shoes at all times, regardless of any tools/machines in operation. This particular safety rule is to be enforced at all times. Encourage safety to everyone and do not hesitate to request that a person put on proper PPE while in the pit area. There is also to be no running in the pits for any reason (other than personal safety).

The size of a team's pit is never large, and teams must be able to store all of their materials, tools, and the robot within the dimensions of the pit. Within the designated pit area, teams must perform the majority of their robot maintenance.

The following are general rules for working in a team's pit area:

1. No sparks or flames may be produced by any tool/machine at any time.
2. Grindings and shavings must be shielded from entering neighboring pits and the walkways.
3. Never crowd the pit area. Six members at the most should be working in the pit area at a given time. When running software tests, no more than six people, including the operator of the robot (at the O/I) should be in the pit area.
4. All robots are to be tethered when powered on in the pits.
5. No tool is to be connected to its power source when it is not in use.
6. No "pig tailing" of multiple-outlet extension cords is allowed; do not connect one multiple outlet extension cord to the other. This is to prevent overloading the main extension cords provided by FIRST to deliver electrical power to each pit.
7. Never exceed the given maximum amperage load for the provided extension cords. Ask a FRC safety official the specifications of the main power cables. As a general rule, most power tools will draw 1.5-2 amps of electricity, while battery charges will draw about 1 amp individually. Some tools will draw more amps, so always read a machine's power specifications before connecting that tool to the main power cables. (Vacuums are well-known for their high current draw, so only use them when absolutely needed and when no other power toolschargers are in use in your pit).
8. Never allow a non-member/non-mentor to use any power tools without consent. Tabletop tools are not to be used by any person not on Team #1351. Tools may be lent out to other teams, but it is the responsibility of the lender to check with other members that the tool may be borrowed and to document which team is borrowing that tool.

9. In the pits, the robot batteries are to be charged properly. Using the black battery rack, hang the chargers 1-2 inches apart to allow air to circulate completely around the chargers. Battery chargers are to be properly powered off before leaving the pits.

Chapter 4 Section 3 (4.3): Observers/Bystanders in the Pits

Any observers and bystanders in the pits are to be aware of their surroundings, especially of any tools/machines in use. **Always be alert for verbal warnings.** Remember that robots and people with equipment have the right of way. For this reason, do not crowd pits or block the walkways for extended periods of time; do not hold group meetings in the walkways. Never enter another team's pit without permission from a member or mentor from that team.

Wear PPE at all times and request that others do so. NEVER wear any sort of personal listening device in the pits. Always abide by any posted safety notices, especially those regarding PPE.

Chapter 4 Section 4 (4.4): Other Pit Safety Rules

Here are some other basic rules for anyone in the pits to follow:

1. Whenever transporting a robot in the pits, say, “**ROBOT!**” in a clearly audible voice to let everyone in the path of the robot know to clear a path for the oncoming robot. You may need to speak very loudly to make yourself heard. Do this for any approaching robots at any time while in the pits, other teams’ robots included (it is part of gracious professionalism).
2. **Always be ready to help out any other teams with safety needs.**
3. When setting up the team’s pit, ensure that any and all banners are **within the specified height limits set by FIRST**. All objects should be secure and unable to fall, especially heavy and/or bulky objects. All handheld power tools are to be lying in their most stable position and all batteries are to be in a location where they cannot fall to the ground.
4. A clean working environment is essential to safe and efficient work, so **keep the pit area clean and orderly**. No tools are to be left loose on the robot cart or on the floor. All shavings are to be removed from the pit and placed into the proper receptacle. All work surfaces are to be clear of debris. At least one member is to be designated a pit manager during competition.
5. **All members are to be aware of the location of safety equipment in Team #1351’s pit area.** Within the pit area, the following materials are to be within easy access at all times: baking soda, paper towels, basic first aid supplies, MSDS sheets for robot batteries, and safety glasses.
6. If a fire extinguisher is kept in the pit area, it shall always be kept in a secure harness **where it cannot fall**. It should also be easy to access on a moment’s notice.
7. Team #1351’s pit area is to be occupied by a team member while the pits are open.

Chapter 5: Safety Captain Guide

Here are the basic guidelines for being a safety captain.

Chapter 5 Section 1 (5.1): Basic Responsibilities of the Safety Captain

The appointed safety captain(s) has the job of **monitoring and encouraging safe practices within the team**. The safety captain(s) also has the responsibility of teaching and enforcing the safety rules and regulations explained in this manual. The appointed safety captain may delegate responsibilities to assistants if he or she chooses to do so (sort of similar to the Co-Lead system applied to department leadership). **The safety captain should have all members informed on at least the basics of robotics safety as outlined in Chapter 1.**

The safety captain should be an example of safe protocol to all other members. The safety captain should also be a source of information on safety, able to answer most questions about the team's safety protocol. The safety captain should be able to inform other members on safe procedure as called upon, and he/she should be willing to ask mentors and/or FIRST safety personnel about safe protocol as necessary.

Chapter 5 Section 2 (5.2): At the Competition

During all competitions, the acting safety captain is to identify himself by wearing the safety captain button provided by FIRST for competition. The safety captain's assistants may wish to do likewise using team buttons or other markers. **The safety captain's primary responsibility is to ensure that all members are following proper safety protocol (including keeping focused during competition) and are encouraging others to do so as well.** The safety captain is to communicate between the team and the FIRST safety officials. The safety captain is responsible for alerting all members to safety concerns brought to attention by FIRST personnel. The safety captain should also be willing to promote safety among other teams and bystanders in the pits.

The safety captain should always monitor pit safety and often ends up as the pit manager as the result (see Chapter 4.4). As the pit manager, the safety captain should work to maintain a clean and organized pit. The safety captain is also responsible for supervising battery charging and the lending of tools to other teams. The safety captain will ultimately bear the responsibility of ensuring that all members of the team follow safe protocol.

Whenever a safety concern arises in the pit area that requires attention from FIRST personnel, the safety captain must inform such persons immediately.

Chapter 5 Section 3 (5.3): During the Build Season

The safety captain should primarily be concerned with tool safety during build season, as more tools are used at this time than at any other point in the year.

Additionally, the build season is practice for the safety captain in preparation for the competitions. The safety captain is responsible for **monitoring safety and leading by example**. During the build season, the safety captain must also ensure that all members follow proper safety procedure in preparation for competition. The safety captain should also take this time to inventory safety materials and go over safety procedures at competition.

Chapter 5 Section 4 (5.4): During the Off-Season

During the off-season (all other times other than build and competition), the safety captain has the following responsibilities:

1. Ensure that all members know and understand safety and safe practices. **All members should know all of the basic safety rules.**
2. **Plan and direct safety talks and tool trainings** with mentors.
3. Create an accurate spreadsheet of all members and their respective level of safety training.
4. Supervise safety during all robotics-related events in which Team #1351 participates, such as robot demonstrations, rallies, and sponsor visits.
5. Update and revise *this* safety manual as needed (or create a new one if needed).
6. Create presentations to explain and teach safety to members.
7. Ultimately help the mentors and veteran members choose your successor. **Train and advise your successor on how to follow your lead as safety captain.**
8. Choose any other members whom you wish to aid you as safety personnel and prepare them for that task.
9. **Ensure that all safety materials are acquired as needed**, including the following: safety glasses (coordinate team purchase of safety glasses), paper towels, baking soda, fire extinguisher (not yet acquired by team but a possibility), acid-proof gloves, and hearing protection.

Chapter 6: FRC Team #1351's Safety Tips

In addition to all of the rules, here are a few tips to help keep you safe.

Chapter 6 Section 1 (6.1): General Safety Tips

1. Safety glasses are cheap compared to eyesight; own one pair and keep it with you for all robotics events.
2. In the order of importance, your most important assets for robotics are: common sense, safety glasses, and situational awareness/focus.
3. Read the FIRST safety manual.
4. Use common sense and start to think with safety always in mind. If you can use a safe mentality, then safety can come almost naturally.
5. Practice safety during the off-season so it is a habit by competition.
6. Communication is critical to *team* safety.

Chapter 6 Section 2 (6.2): Tool Safety Tips

1. Tools do not have brains; you will have to use your own.
2. Treat all tools with the respect that they deserve.
3. Never think that you are smarter than the manufacturer when it comes to knowing about a tool's proper usage. Follow all printed instructions for operating a tool.
4. Put guards in place to prevent accidents.
5. Take time to train on a tool and get comfortable and confident using it before doing any major tasks with that tool.

Chapter 6 Section 3 (6.3): Robot Safety Tips

1. If the power is off, the robot is not going anywhere on its own; when not in use, power the robot off.
2. Wood planks make good blocks to lift the robot off its wheels.
3. Always have a person ready on the enable/disable button when testing and operating the robot. The designated robot coach should always be ready to press the emergency shutoff button.
4. Look for any stored energy (springs, raised arms, unbalanced objects) that could pose a safety risk.
5. Check wiring for any pulled-out, broken, or otherwise damaged wires, especially those that could cause an electrical short.
6. Ground yourself before touching any sensitive electronics, such as the cRIO and digital sidecars.

Chapter 6 Section 4 (6.4): Competition Safety Tips

1. Always route wires and cords in an orderly manner, keeping them out of the way yet untangled. This removes tripping hazards.
2. Put baking soda in an easily opened container from which it can be applied quickly to an acid spill such as a battery leak.
3. Keep the pit orderly. It is easier, safer, and more efficient to work in a clean, organized environment.
4. Have safety materials readily available in case something happens.
5. Have a team safety manual (such as this one) readily available to refer to and to show judges during competition.
6. Keep your head on a swivel (be aware of your surroundings) during competition, especially while in the pits.

Chapter 6 Section 5 (6.5): Tips for the Safety Captain(s)

1. Consider appointing two safety co-captains (or a safety captain and an assistant safety officer) to help bear the responsibilities of being safety captain, at least during the competitions.
2. Work on training a successor so that he/she is prepared to take on the job of being safety captain with confidence in his/her ability.
3. Speak out for safety in all situations.

Appendix A:
Material Safety Data Sheet for Robot Batteries

To access the PDF document for the MSDS for robot batteries, go to:
http://www.mkbattery.com/images/MSDS_smallsealed_line.pdf

Material Safety Data Sheet (MSDS)

Date: June 10, 2003

PRODUCT IDENTIFICATION

Trade Name	MK Battery
Brand	MK Powered, Small Sealed Line
Telephone Number	714-937-1033
Fax Number	714-937-0818
Email	info@mkbattery.com

Manufacturer:

MK Battery

Tel: 714-937-1033

Fax: 714-937-0818

E-mail address: info@mkbattery.com

Web site: www.mkbattery.com

HAZARDOUS COMPONENTS

Component	% Weight	TLV (mg/M3)	Ld50 Oral (mg/Kg)	LC50 Inhalation	LD50 Contact
Lead (Pb, PbO ₂ , PbSO ₄)	~70	N/A	500	N/A	N/A
Sulfuric Acid (H ₂ SO ₄)	~20	1	2,140	N/A	N/A

PHYSICAL DATA

Component	Density (mg/cc)	Melting (Boiling) Point °C	Solubility (mg/L)	Odor	Appearance
Lead (Pb)	11.34	327.4	Insoluble	None	Silver-gray
Lead Sulfate (PbSO ₄)	6.2	1,070	40	None	White Powder
Lead Oxide	9.4	290	Insoluble	None	Brown
Sulfuric Acid H ₂ SO ₄	~1.3	(114)	100	Acrid	Colorless

FLAMMABILITY

Component	Flash Point	Explosive Limits (%)	Comments
Lead (Pb)	None	None	SLA battery can generate Hydrogen (H ₂) gas only if it were overcharged.
Sulfuric Acid (H ₂ SO ₄)	None	None	
Hydrogen (H ₂)	N/A	4-74.2	

REACTIVITY DATA

Component	Sulfuric Acid (H ₂ SO ₄)
Stability	Stable under normal temperature
Polymerization	Will not polymerize
Incompatibility	Reacts with most metals, all alkali, and most organic compounds
Decomposition Products	Sulfur Dioxide (SO ₂), Trioxide (SO ₃), Hydrogen Sulfide (H ₂ S), and Hydrogen (H ₂)
Conditions To Avoid	Avoid mixing acid with other chemicals, Avoid Pouring water on to the acid.

PROTECTION REQUIREMENT

Exposure	Protection	Comments
Skin	Rubber gloves, synthetic apron	Protective equipment must be worn when handling cracked or damaged batteries
Respiratory	Acid fume respirator	
Eyes	Safety goggles, face shield	

ELECTRICAL SAFETY

Since VRLA batteries have low internal resistance and fairly high power density, VERY HIGH SHORT CIRCUIT CURRENT can be generated across the battery terminals. **DO NOT** rest tools or cables on the battery. Battery should be **HANDLED WITH INSULATED TOOLS ONLY**. Follow installation instruction and diagram when installing or maintaining battery or battery system.

Short-circuiting the battery may cause bodily harm. Prolong shorting may cause battery to explode.

HEALTH HAZARD

Lead (Pb) poisoning is cumulative in nature and slow to appear. It affects the kidneys, reproductive, and the central nervous system. Symptom of lead poisoning are: anemia, constant headache, nauseates frequently, acute stomach pain (lead colic), dizziness, loss of appetite, muscle and joint pain, and wakening of muscle strength.

Exposure to **LEAD (Pb)** from a battery most often occurs during Lead (Pb) reclamation operations through breathing or ingestion of Lead (Pb) dust and fumes.

Sulfuric Acid (H₂SO₄) is a strong, corrosive and colorless liquid. It has a distinct acrid odor. Direct contact with the acid can cause severe burns to the skin and blindness if prolong contact with the eye. Ingestion of the acid will cause painful gastric intestinal tract burns. Acid from the battery can be released if the battery case is damaged or if the vents or tempered with.

RE: FIRST AID INSTRUCTION

EMERGENCY HANDLING

In case of leaks or spill of acid from a battery, neutralize the acid with:

Sodium bicarbonate (NaHCO₃ - baking soda), or sodium carbonate (Na₂CO₃ - soda ash) or calcium oxide (CaO - lime). Flush the area with plenty of water.

DO NOT allow un-neutralized acid drain into the sewage system.

Disposal of spent batteries must be treated as hazardous waste and disposed of according to local, state, provincial, and federal regulations.

A copy of this material safety data sheet must be supplied to any dealer or lead smelter.

FIRST AID

Sulfuric Acid (H₂SO₄)

Skin Contact

Immediately flush contact area with plenty of cold, clean water and consult a physician right away.

Eye Contact

Immediately flush eye for at least 5 minutes with plenty of cold clean water. Call or visit a physician right away.

Ingestion

Immediately flush mouth with plenty of cold clean water. Drink milk or sodium bicarbonate solution.

DO NOT induce vomiting.

DO NOT give anything to any unconscious person.

Transportation

MK Batteries are non-spillable, electric storage, conform to and meet the requirements of the International Civil Aviation Organization, (ICAO) Technical Instructions for the safe Transport of Dangerous Goods by Air, Special Provision A67 and Packing Instruction 806.

Appendix B:
Material Safety Data Sheet for
Tap Magic EP-Xtra Cutting Fluid

To access the document for the MSDS for Steco Tap Magic EP-Xtra Cutting Fluid, go to:
http://www.tapmagic.com/MSDS_TME.htm

This MSDS covers part numbers 10004E, 10016E, 10128E, 10640E, 13840E and 17040E for **Tap Magic EP-Xtra Cutting Fluid**.

MATERIAL SAFETY DATA SHEET U.S. DEPARTMENT OF LABOR, OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, HAZARD COMMUNICATION STANDARD, 29 CFR 1910.1200 The Steco Corporation 2330 Cantrell Road P.O. Box 2238 Little Rock, AR 72203 Emergency Response: (800) 255-3924 Information: (800) 643-8026 Fax #: (501) 374-4278 Date Reviewed: March 12, 2009 TRADE NAME: TAP MAGIC EP-XTRA Formula Cutting Fluid CHEMICAL NAME & SYNONYMS: Petroleum hydrocarbons and additives DOT SHIPPING NAME: Not a regulated material HMIS/NFPA CODE: Health 1; Fire 1; Reactivity 1 MANUFACTURING CODE NO.: 8358 COMMODITY CODE NO.: 332-9150 **I. HAZARDOUS INGREDIENTS** Chlorinated Paraffins: CAS # 61788-76-9 • OSHA PEL ppm, (N/A) • ACGIH TLV ppm, (N/A) • Other limits recommended, (N/A) • Max. %, <20.

II. INGREDIENTS Naphthenic Oils: CAS # 64742-53-6 • OSHA PEL ppm, (N/A) • ACGIH TLV ppm, (N/A) • Other limits recommended, (N/A) • Max %, <80. Sulfarized Paraffins: CAS # 64742-54-7 • OSHA PEL ppm, (N/A) • ACGIH TLV ppm, (N/A) • Other limits recommended, (N/A) • Max %, <5. Petroleum Sulfonic Acid Salt: CAS # 68608-26-4 • OSHA PEL ppm, (N/A) • ACGIH TLV ppm, 10 • Other limits recommended, (N/A) • Max %, <5. Petroleum Olefins: CAS # 64743-02-8 • OSHA PEL ppm, (N/A) • ACGIH TLV ppm, 10 • Other limits recommended, TWA 1 mg/m³ • Max %, <5.

* These products do not have a unique regulatory limit, however, the OSHA Pel for mineral oil is 5 mg/m³.

III. PHYSICAL DATA BOILING RANGE, (760 mm, Mercury): N/A SPECIFIC GRAVITY (Water =1), lbs/gal.: .94, (7.8 lbs/gal) VAPOR PRESSURE (mm of Mercury) @ 68 degrees F: <5 VAPOR DENSITY (Air = 1): >1 SOLUBILITY IN WATER, % by weight: <1 EVAPORATION RATE (Butyl Acetate = 1): <1 % VOLATILE BY VOLUME: <1 APPEARANCE: Yellow liquid ODOR: Mild Sulfur Odor pH: N/A (non-aqueous)

IV. FIRE & EXPLOSION DATA FLASH POINT, TOC, TCC, PMCC: >300 degrees F AUTOIGNITION TEMPERATURE: N/A EXTINGUISHING MEDIA: CO2, Dry Chemical Foam, Water Fog SPECIAL FIRE FIGHTING PROCEDURES: Containers will self-pressurize on heating and should be cooled as possible during any fire fighting event to prevent explosive rupturing of containers. UNUSUAL FIRE AND EXPLOSION HAZARD: This product may release toxic fumes when burned; including but not limited to : hydrogen chloride, hydrogen sulfide, carbon monoxide, and short chain hydrocarbons. Under fire conditions, sufficient evolution of such agents will occur to necessitate the use of self-contained breathing apparatus.

V. HEALTH HAZARD INFORMATION ROUTES OF ENTRY: Exposure may occur via inhalation, skin contact or ingestion. EFFECTS OF ACUTE OVEREXPOSURE: INHALATION – (Unlikely due to low vapor pressure). Mist may cause headache, nasal, respiratory and eye irritation. SKIN CONTACT – Prolonged or repeated exposure may cause irritation. INGESTION – Headache, drowsiness, nausea, fatigue. EYE – May cause pain and irritation. EFFECTS OF CHRONIC OVEREXPOSURE: Same as for acute overexposure. CARCINOGENICITY: Not a carcinogen or suspect carcinogen. EMERGENCY AND FIRST AID PROCEDURES: EYE – Flush eyes gently with water for at least 15 minutes, forcibly holding eyelids open to ensure complete irrigation of all eye and lid tissue. See physician. SKIN – Wash with soap and water. If rash or irritation persists, see physician. INHALATION – Remove to fresh air. See physician if irritation persists. In case of exposure to fumes from fire, remove person to fresh air. If unconscious, have professional administer oxygen. If breathing stops, administer mouth to mouth resuscitation. INGESTION – Do not induce vomiting. Call physician. If individual is conscious, give large quantities of water (milk if available). If vomiting occurs spontaneously, keep airway clear and give more water. . **VI. REACTIVITY DATA** STABILITY – Stable at ambient temperatures and pressure. Elevated temperature and exposure to strong alkalis, oxidizers, and/or acids will promote decomposition. Such decomposition results in the release of hydrogen

chloride, hydrogen sulfide, and sulfur from the product. At normal room temperatures, decomposition is virtually nil. Exposure to strong direct sunlight may cause decomposition and discoloration of some components present in this product. **INCOMPATIBILITY** – Contact with alkali materials, oxidizers, or acids should be avoided. **HAZARDOUS DECOMPOSITION PRODUCTS** – This product may release toxic fumes when burned; including but not limited to: hydrogen chloride, hydrogen sulfide, carbon monoxide, and short chain hydrocarbons. **CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION** –None

VII. DISPOSAL, SPILL OR LEAK PROCEDURES **AQUATIC TOXICITY** – Not Determined. **SPILL OR LEAK PROCEDURES** – For small spills, soak up with shop towels or absorbent material such as oil-dry or vermiculite. For large spills, any leaks should be stopped. Spill should be contained, then cleaned up using vacuum truck or absorbent material. **WASTE DISPOSAL METHOD** – Dispose of in accordance with all local, state and federal regulations. "If inert absorbents are employed in spill containment or cleanup, these absorbents must be non-biodegradable materials if destined for landfill disposal. Suitable absorbents include natural minerals (clay), activated charcoal, man-made polymers (HD polyethylene)." **NEUTRALIZATION CHEMICALS** – N/A

VIII. SPECIAL PROTECTION INFORMATION **EYE PROTECTION** – Standard eye protection should be worn when using this product. **SKIN PROTECTION** – No special equipment is needed. However, good personal hygiene practices should be followed. **RESPIRATORY PROTECTION** – If application to which this product is being applied generates excessive mist or fumes, then appropriate respiratory protective equipment should be used. No special requirements under ordinary conditions of use and proper ventilation of work area. **VENTILATION** – No special requirements under ordinary conditions of use and with adequate ventilation.

IX. SPECIAL PRECAUTIONS N/A.

X. ADDITIONAL INFORMATION CAUTION: Any cutting fluid can be "overworked" or "overheated", causing it to break down. This overuse is identified by the sight of or strong odor of vapors or fumes not normally present. The effects of these vapors or fumes on human health have not been fully determined. After use of this product, clean and lubricate metal surfaces to avoid staining and/or corrosion. Tap Magic with EP-Xtra® DOES NOT CONTAIN 1,1,1-trichloroethane or any ozone depleting substances. Incomplete combustion can produce carbon monoxide. Tap Magic with EP-Xtra® does not contain any chemical compound listed on the SARA list of "Extremely Hazardous Chemicals" and is in compliance with all of the requirements of the TSCA at the time of shipment.

Appendix C:
Material Safety Data Sheet for Loctite Threadlocker Blue 242

To access the PDF document for the MSDS for Loctite Threadlocker Blue 242, go to:
<http://www.loctiteproducts.com/techdata-msds.shtml>

Material Safety Data Sheet

Revision Number: 000.0

Issue date: 11/23/2010

1. PRODUCT AND COMPANY IDENTIFICATION

Product name: Loctite Threadlocker Blue 242 **IDH number:** 209728
Product type: Anaerobic Sealant

Company address:
 Henkel Corporation
 One Henkel Way
 Rocky Hill, Connecticut 06067

Region: United States
Contact information:
 Telephone: 800.624.7767
 MEDICAL EMERGENCY Phone: Poison Control Center
 1-877-671-4608 (toll free) or 1-303-592-1711
 TRANSPORT EMERGENCY Phone: CHEMTREC
 1-800-424-9300 (toll free) or 1-703-527-3887
 Internet: www.henkelna.com

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Physical state:	Liquid	HEALTH:	*2
Color:	Blue	FLAMMABILITY:	1
Odor:	Mild	PHYSICAL HAZARD:	1
		Personal Protection:	See MSDS Section 8

WARNING: CAUSES EYE IRRITATION.
 MAY CAUSE SKIN IRRITATION.
 MAY CAUSE ALLERGIC SKIN REACTION.
 MAY CAUSE RESPIRATORY TRACT IRRITATION.

Relevant routes of exposure: Skin, Inhalation, Eyes

Potential Health Effects

Inhalation: May cause respiratory tract irritation.
Skin contact: May cause allergic skin reaction. May cause skin irritation.
Eye contact: Contact with eyes will cause irritation.
Ingestion: Not expected to be harmful by ingestion.

Existing conditions aggravated by exposure: Eye, skin, and respiratory disorders.

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous components	CAS NUMBER	%
Polyglycol dimethacrylate	25852-47-5	60 - 100
Oleic acid 5.5EO	9004-96-0	10 - 30
Saccharin	81-07-2	1-5
Silica, amorphous, fumed, crystal-free	112945-52-5	1-5
Cumene hydroperoxide	80-15-9	1-5
Propanediol-1,2	57-55-6	1-5
Titanium dioxide	13463-67-7	0.1 - 1

4. FIRST AID MEASURES

Inhalation:	Move to fresh air. If breathing is difficult, give oxygen. If breathing has stopped, give artificial respiration. Keep warm and quiet. Get medical attention.
Skin contact:	Wash with soap and water. Remove contaminated clothing and footwear. Wash clothing before reuse. If symptoms develop and persist, get medical attention.
Eye contact:	Flush with copious amounts of water, preferably, lukewarm water for at least 15 minutes, holding eyelids open all the time. Get medical attention.
Ingestion:	Do not induce vomiting. Keep individual calm. Get medical attention.

5. FIRE FIGHTING MEASURES

Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Flame projection:	Not applicable
Autoignition temperature:	Not determined
Flammable/Explosive limits - lower:	2.6 % (propylene glycol)
Flammable/Explosive limits - upper:	12.5 % (propylene glycol)
Extinguishing media:	Foam, dry chemical or carbon dioxide.
Special firefighting procedures:	None
Unusual fire or explosion hazards:	None
Hazardous combustion products:	Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapors.

6. ACCIDENTAL RELEASE MEASURES

Use personal protection recommended in Section 8, isolate the hazard area and deny entry to unnecessary and unprotected personnel.

Environmental precautions:	Do not allow product to enter sewer or waterways.
Clean-up methods:	Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Store in a partly filled, closed container until disposal.

7. HANDLING AND STORAGE

Handling:	Prevent contact with eyes, skin and clothing. Do not breathe vapor and mist. Wash thoroughly after handling.
Storage:	For safe storage, store at or below 38 °C (100.4 °F) Keep in a cool, well ventilated area away from heat, sparks and open flame. Keep container tightly closed until ready for use.

For information on product shelf life, please review labels on container or check the Technical Data Sheet.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous components	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Polyglycol dimethacrylate	None	None	None	None
Oleic acid 5.5EO	None	None	None	None
Saccharin	None	None	None	None
Silica, amorphous, fumed, crystal-free	10 mg/m3 TWA Inhalable dust. 3 mg/m3 TWA Respirable fraction.	20 MPPCF TWA 0.8 mg/m3 TWA	None	None
Cumene hydroperoxide	None	None	1 ppm (6 mg/m3) TWA (SKIN)	None
Propanediol-1,2	None	None	10 mg/m3 TWA Aerosol.	None
Titanium dioxide	10 mg/m3 TWA	15 mg/m3 TWA Total dust.	None	None

Engineering controls:	No specific ventilation requirements noted, but forced ventilation may still be required if concentrations exceed occupational exposure limits.
Respiratory protection:	Use NIOSH approved respirator if there is potential to exceed exposure limit(s).
Eye/face protection:	Safety goggles or safety glasses with side shields.
Skin protection:	Use impermeable gloves and protective clothing as necessary to prevent skin contact. Neoprene gloves. Butyl rubber gloves. Natural rubber gloves.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Color:	Blue
Odor:	Mild
Odor threshold:	Not available
pH:	Not applicable
Vapor pressure:	< 5 mm hg (27 °C (80.6 °F))
Boiling point/range:	> 149 °C (> 300.2 °F)
Melting point/ range:	Not available
Specific gravity:	1.1 at 23.9 °C (75.02 °F)
Vapor density:	Not available
Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Flame projection:	Not applicable
Flammable/Explosive limits - lower:	2.6 % (propylene glycol)
Flammable/Explosive limits - upper:	12.5 % (propylene glycol)
Autoignition temperature:	Not determined
Evaporation rate:	Not available
Solubility in water:	Slight
Partition coefficient (n-octanol/water):	Not available
VOC content:	4.48 %; 49.3 g/l EPA Method 24

10. STABILITY AND REACTIVITY

Stability:	Stable
Hazardous reactions:	Will not occur.
Hazardous decomposition products:	Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapors.
Incompatible materials:	Strong oxidizing agents. Free radical initiators. Strong reducing agents. Alkalis. Oxygen scavengers. Other polymerization initiators. Copper. Iron. Zinc. Aluminum. Rust.
Conditions to avoid:	See "Handling and Storage" (Section 7) and "Incompatibility" (Section 10).

11. TOXICOLOGICAL INFORMATION

Acute oral product toxicity:	LD50 (rat) > 10,000 mg/kg
Acute dermal product toxicity:	LD50 (rabbit) > 5,000 mg/kg

Hazardous components	NTP Carcinogen	IARC Carcinogen	OSHA Carcinogen (Specifically Regulated)
Polyglycol dimethacrylate	No	No	No
Oleic acid 5.5EO	No	No	No
Saccharin	No	No	No
Silica, amorphous, fumed, crystal-free	No	No	No
Cumene hydroperoxide	No	No	No
Propanediol-1,2	No	No	No
Titanium dioxide	No	Group 2B	No

Hazardous components	Health Effects/Target Organs
Polyglycol dimethacrylate	Irritant, Allergen
Oleic acid 5.5EO	Irritant
Saccharin	No Target Organs
Silica, amorphous, fumed, crystal-free	Nuisance dust
Cumene hydroperoxide	Allergen, Central nervous system, Corrosive, Irritant, Mutagen
Propanediol-1,2	Irritant
Titanium dioxide	Irritant, Respiratory, Some evidence of carcinogenicity

12. ECOLOGICAL INFORMATION

Ecological information: Not available

13. DISPOSAL CONSIDERATIONS

Information provided is for unused product only.

Recommended method of disposal: Follow all local, state, federal and provincial regulations for disposal.

Hazardous waste number: Not a RCRA hazardous waste.

14. TRANSPORT INFORMATION

The shipping classifications in this sections are for non-bulk packaging only (unless otherwise specified). Shipping classification may be different for bulk packaging.

U.S. Department of Transportation Ground (49 CFR)

Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

International Air Transportation (ICAO/IATA)

Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

Water Transportation (IMO/IMDG)

Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

15. REGULATORY INFORMATION

United States Regulatory Information

TSCA 8 (b) Inventory Status: All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.

TSCA 12(b) Export Notification: None above reporting de minimus

CERCLA/SARA Section 302 EHS: None above reporting de minimus
 Hydroquinone (CAS# 123-31-9). Ethylene oxide (CAS# 75-21-8).
 Immediate Health, Delayed Health

CERCLA/SARA Section 311/312:
CERCLA/SARA 313: This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Cumene hydroperoxide (CAS# 80-15-9).

This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Saccharin (CAS# 81-07-2). Cumene hydroperoxide (CAS# 80-15-9).

California Proposition 65:

This product contains a chemical known in the State of California to cause cancer. This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Canada Regulatory Information

CEPA DSL/NDSL Status:

All components are listed on or are exempt from listing on the Canadian Domestic Substances List.

WHMIS hazard class:

D.2.A, D.2.B

16. OTHER INFORMATION

This material safety data sheet contains changes from the previous version in sections: New Material Safety Data Sheet format.

Prepared by: Karim Nasr, Regulatory Affairs Specialist

DISCLAIMER: The data contained herein are furnished for information only and are believed to be reliable. However, Henkel Corporation does not assume responsibility for any results obtained by persons over whose methods Henkel Corporation has no control. It is the user's responsibility to determine the suitability of Henkel's products or any production methods mentioned herein for a particular purpose, and to adopt such precautions as may be advisable for the protection of property and persons against any hazards that may be involved in the handling and use of any of Henkel Corporation's products. In light of the foregoing, Henkel Corporation specifically disclaims all warranties, express or implied, including warranties of merchantability and fitness for a particular purpose, arising from sale or use of Henkel Corporation's products. Henkel Corporation further disclaims any liability for consequential or incidental damages of any kind, including lost profits.

Appendix D:
Material Safety Data Sheet for Loctite Threadlocker Red 271

To access the PDF document for the MSDS for Loctite Threadlocker 271 Red, go to:
<http://www.loctiteproducts.com/techdata-msds.shtml>

Material Safety Data Sheet

Revision Number: 000.0

Issue date: 11/23/2010

1. PRODUCT AND COMPANY IDENTIFICATION

Product name: Loctite Threadlocker Red 271 **IDH number:** 209741
Product type: Anaerobic Sealant

Company address:
 Henkel Corporation
 One Henkel Way
 Rocky Hill, Connecticut 06067

Region: United States
Contact information:
 Telephone: 800.624.7767
 MEDICAL EMERGENCY Phone: Poison Control Center
 1-877-671-4608 (toll free) or 1-303-592-1711
 TRANSPORT EMERGENCY Phone: CHEMTREC
 1-800-424-9300 (toll free) or 1-703-527-3887
 Internet: www.henkeln.com

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

Physical state: Liquid
Color: red
Odor: Mild

HMIS:
HEALTH: *2
FLAMMABILITY: 1
PHYSICAL HAZARD: 1
Personal Protection: See MSDS Section 8

WARNING: CAUSES EYE IRRITATION.
 MAY CAUSE SKIN IRRITATION.
 MAY CAUSE ALLERGIC SKIN REACTION.
 MAY CAUSE RESPIRATORY TRACT IRRITATION.

Relevant routes of exposure: Skin, Inhalation, Eyes

Potential Health Effects

Inhalation: May cause respiratory tract irritation.
Skin contact: May cause allergic skin reaction. May cause skin irritation.
Eye contact: Contact with eyes will cause irritation.
Ingestion: Not expected to be harmful by ingestion.

Existing conditions aggravated by exposure: Eye, skin, and respiratory disorders.

This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous components	CAS NUMBER	%
Polyglycol dimethacrylate	25852-47-5	60 - 100
Bisphenol A fumarate resin	39382-25-7	10 - 30
Saccharin	81-07-2	1-5
Cumene hydroperoxide	80-15-9	1-5

4. FIRST AID MEASURES

Inhalation: Move to fresh air. If symptoms develop and persist, get medical attention.
Skin contact: Remove contaminated clothing and footwear. Wash with soap and water. Wash clothing before reuse. If symptoms develop and persist, get medical attention.

Eye contact:	Flush with copious amounts of water, preferably, lukewarm water for at least 15 minutes, holding eyelids open all the time. Get medical attention.
Ingestion:	Do not induce vomiting. Keep individual calm. Get medical attention.

5. FIRE FIGHTING MEASURES

Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Autoignition temperature:	Not available
Flammable/Explosive limits - lower:	Not available
Flammable/Explosive limits - upper:	Not available
Extinguishing media:	Foam, dry chemical or carbon dioxide.
Special firefighting procedures:	None
Unusual fire or explosion hazards:	None
Hazardous combustion products:	Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapors.

6. ACCIDENTAL RELEASE MEASURES

Use personal protection recommended in Section 8, isolate the hazard area and deny entry to unnecessary and unprotected personnel.

Environmental precautions:	Do not allow product to enter sewer or waterways.
Clean-up methods:	Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Store in a partly filled, closed container until disposal.

7. HANDLING AND STORAGE

Handling:	Prevent contact with eyes, skin and clothing. Do not breathe vapor and mist. Wash thoroughly after handling.
Storage:	For safe storage, store at or below 38 °C (100.4 °F) Keep in a cool, well ventilated area away from heat, sparks and open flame. Keep container tightly closed until ready for use.

For information on product shelf life, please review labels on container or check the Technical Data Sheet.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous components	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Polyglycol dimethacrylate	None	None	None	None
Bisphenol A fumarate resin	None	None	None	None
Saccharin	None	None	None	None
Cumene hydroperoxide	None	None	1 ppm (6 mg/m ³) TWA (SKIN)	None

Engineering controls: No specific ventilation requirements noted, but forced ventilation may still be required if concentrations exceed occupational exposure limits.

Respiratory protection:	If airborne concentrations are above the applicable exposure limits, use NIOSH approved respiratory protection. Use a NIOSH approved air-purifying respirator with an organic vapor cartridge.
Eye/face protection:	Safety goggles or safety glasses with side shields.
Skin protection:	Use impermeable gloves and protective clothing as necessary to prevent skin contact. Neoprene gloves. Butyl rubber gloves. Natural rubber gloves.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Color:	red
Odor:	Mild
Odor threshold:	Not available
pH:	Not applicable
Vapor pressure:	< 5 mm hg (27 °C (80.1 °F))
Boiling point/range:	> 148.9 °C (> 300 °F)
Melting point/ range:	Not available
Specific gravity:	1.1
Vapor density:	Not available
Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Flammable/Explosive limits - lower:	Not available
Flammable/Explosive limits - upper:	Not available
Autoignition temperature:	Not available
Evaporation rate:	Not available
Solubility in water:	Slight
Partition coefficient (n-octanol/water):	Not available
VOC content:	0.82 %; 7.81 g/l

10. STABILITY AND REACTIVITY

Stability:	Stable
Hazardous reactions:	Will not occur.
Hazardous decomposition products:	Phenolics. Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapors.
Incompatible materials:	Strong oxidizing agents. Strong reducing agents. Strong acids. Copper Iron. Rust.
Conditions to avoid:	See "Handling and Storage" (Section 7) and "Incompatibility" (Section 10).

11. TOXICOLOGICAL INFORMATION

Acute oral product toxicity:	LD50 (rat) > 10,000 mg/kg
Acute dermal product toxicity:	LD50 (rabbit) > 5,000 mg/kg

Hazardous components	NTP Carcinogen	IARC Carcinogen	OSHA Carcinogen (Specifically Regulated)
Polyglycol dimethacrylate	No	No	No
Bisphenol A fumarate resin	No	No	No
Saccharin	No	No	No
Cumene hydroperoxide	No	No	No

Hazardous components	Health Effects/Target Organs
Polyglycol dimethacrylate	Irritant, Allergen
Bisphenol A fumarate resin	No Target Organs
Saccharin	No Target Organs
Cumene hydroperoxide	Allergen, Central nervous system, Corrosive, Irritant, Mutagen

12. ECOLOGICAL INFORMATION

Ecological information: Not available

13. DISPOSAL CONSIDERATIONS

Information provided is for unused product only.

Recommended method of disposal: Follow all local, state, federal and provincial regulations for disposal.

Hazardous waste number: Not a RCRA hazardous waste.

14. TRANSPORT INFORMATION

The shipping classifications in this sections are for non-bulk packaging only (unless otherwise specified). Shipping classification may be different for bulk packaging.

U.S. Department of Transportation Ground (49 CFR)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

International Air Transportation (ICAO/IATA)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

Water Transportation (IMO/IMDG)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

15. REGULATORY INFORMATION

United States Regulatory Information

TSCA 8 (b) Inventory Status:	All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.
TSCA 12(b) Export Notification:	None above reporting de minimus
CERCLA/SARA Section 302 EHS:	None above reporting de minimus Hydroquinone (CAS# 123-31-9).
CERCLA/SARA Section 311/312:	Immediate Health, Delayed Health
CERCLA/SARA 313:	This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Cumene hydroperoxide (CAS# 80-15-9). This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Saccharin (CAS# 81-07-2). Cumene hydroperoxide (CAS# 80-15-9).
CERCLA Reportable quantity:	Saccharin (CAS# 81-07-2) 100 lbs. (45.4 kg) Cumene hydroperoxide (CAS# 80-15-9) 10 lbs. (4.54 kg)
California Proposition 65:	This product contains a chemical known in the State of California to cause cancer.

Canada Regulatory Information

CEPA DSL/NDSL Status:	All components are listed on or are exempt from listing on the Canadian Domestic Substances List.
WHMIS hazard class:	D.2.B

16. OTHER INFORMATION

This material safety data sheet contains changes from the previous version in sections: 8

Prepared by: Karim Nasr, Regulatory Affairs Specialist

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