



# Hazard Analysis of a Handheld Angle Grinder

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**Abstract.** A safety analysis of a cordless (handheld) angle grinder is presented. The analysis includes a discussion of prior injury data, a preliminary hazard analysis, a fault tree analysis, and a failure modes and effects analysis of the angle grinder. Based upon these various analyses, the most common and the most severe injury modes are identified, as well as the causes of these injury modes. Finally, in each analysis, specific preventive measures, including preventive maintenance is discussed.

**Keywords:** Handheld grinder safety · Hazard analysis

## 1 Introduction

The specific angle grinder analyzed is the Makita Brushless Cordless 7” Paddle Switch Cut-Off/Angle Grinder. Detailed specifications for the grinder are contained in the references [1]. This angle grinder is a handheld power tool used to grind metal to be fit, finished or sanded and may be used in both household and worksite applications; they are also widely used on crash sites to remove passengers from vehicles.

Angle grinders come in different varieties such as pneumatic, electric and battery powered; they also have a large multitude of interchangeable abrasive discs so the user may choose a specific type based on the project, or when the disc wears down. The availability of power sources and wide variety of abrasive discs make the angle grinder a prevailing, dynamic power tool.

The motor drives a geared head at a right-angle propelling the mounted disc into a circular motion. When applied to the surface of an object the abrasive cutting wheel may be used as a sander, employing a sanding disc with a backing pad or disc, grinder or abrasive cutting tool.

The authors chose the angle grinder because the first time the first author used one was quite the experience; they are powerful, aggressive tools and if used improperly could cause serious harm to the user and bystanders. The force of the torque created by the spinning disc is difficult to work against when attempting to turn the tool off which could injure the user. Hazards such as loss of control of the tool resulting in injury, sparks creating fire, electrocution and pain in joints and muscles due to the prolonged handling of the tool.

Most grinders on the market come equipped with a number of safety features such as guards, additional handles and a very thorough user’s manual. As a novice user, the

first author's greatest fear when using the angle grinder was losing control of it and dropping it on the floor, consequently breaking the grinding disc and potentially sending metal shrapnel into the air.

The manufacturer promotes OSHA safety standards and provides additional OSHA safety training. The particular angle grinder models the authors chose may also be equipped with dust gathering attachments. The additional OSHA information available on the website relates to OSHA COMPLIANCE RULE 29 CFR 1926.1153 [2]. OSHA standards pertaining to this grinder can be found under 1926.303 grinding wheels.

The battery powered feature of this grinder eliminates the potential for electrocution should the angle grinder come in to contact with the power cord. Another valuable safety feature of this tool is the vibration absorbing back handle, this reduces the vibration to the operator's hands.

There are many power tool safety warnings for the angle grinder posted right at the beginning of the user manual. The instructions are in English and Spanish and span 48 pages. There are many sections that provide specific instructions on proper use of the power tool. The sections include:

- General handheld power tool safety warnings
- Cordless grinder safety warnings
- Battery care
- Instructions for wireless unit
- The general safety warnings include:
  - Work area safety
  - Electrical safety
  - Personal safety
  - Kickback and related warnings
  - Safety warnings specific for sanding operations
  - Safety warnings specific for wire brushing operations
  - Power tool use and care
  - Battery tool use and care
  - Service.

## 2 Safety Precautions Included in the Manual

The manual also contains a number of useful figures to instruct the user in safe and efficient operation of the grinder. While space limitations do not permit them to be reproduced here, the reader can review these figures in the Makita manual [2].

There are many hazards involved with the use of the angle grinder. Makita engineers went through a considerable amount of effort to develop safety features to protect the user and bystander from injury. Engineers have created safety features such as:

- Tool/battery protection system
- Shaft lock
- Accidental re-start preventive function
- Electronic torque control function

- Soft start feature
- Wheel guard
- Switch action
- Automatic speed change function

Engineers have also identified the following hazards and provided precautions to avoid each of the following hazards:

- Fire and explosion hazards: Power tools create sparks which may ignite the dust or fumes.
- Breathing and air quality hazards
- Electromagnetic field generator hazards: Power tools emit EMF's that may be harmful to users or bystanders with cardiac pacemakers.
- Personal safety hazards caused by inattention or impairment from alcohol or drugs.
- Battery hazards: Use of any other battery packs may create a risk of injury and fire.
- Liquid ejected from the battery may cause irritation or burns.
- Familiarity hazard: A careless action can cause severe injury within a fraction of a second.

The angle grinder is a productive, effective and efficient tool. While there are certainly potential hazards associated with its use, adherence to safety precautions specified by the user manual and by OSHA can minimize the risks associated with the use of the tool. OSHA also provides material and extensive training resources. Safety warnings and suggestions from the manufacturer and OSHA include:

- Work area safety: Keep work area clean and well lit
- Electrical safety: Do not expose power tools to rain or wet conditions
- Personal Safety: When using the tool, do not wear cloth work gloves which may be entangled
- Battery care: Do not use a battery pack or tool that is damaged or modified
- Have your power tool serviced by a qualified repair person using only identical replacement parts. This will ensure that the safety of the power tool is maintained.
- Never lay the power tool down until the grinding wheel has come to a complete stop.

This specific angle grinder was chosen for analysis because it is battery operated which would initially be safer due to the elimination of tripping hazards, one of OSHA's first suggestions when operating power tool. A battery-operated power tool also eliminates the risk of electrocution due to the rotating disk coming in to contact with the power cord. The OSHA specifications for angle grinder safety are extremely informative. OSHA provides e-training for proper usage of angle grinder power tools and a detailed list of measures that may be taken to prevent hazards associated with power tools such as:

- Wearing personal protective equipment,
- Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly

All the safety measures will not be listed, but what will be listed are the main topics OSHA associates with angle grinders and power tool safety.

- Guards
  - “The exposed moving parts of power tools need to be safeguarded. Belts, gears, shafts, pulleys, sprockets, spindles, drums, flywheels, chains, or other reciprocating, rotating, or moving parts of equipment must be guarded.”
- Operating Controls and Switches
- Electric Tools
  - “Employees using electric tools must be aware of several dangers. Among the most serious hazards are electrical burns and shocks.”
- Portable Abrasive Wheel Tools
  - “Portable abrasive grinding, cutting, polishing, and wire buffing wheels create special safety problems because they may throw off flying fragments.”

### 3 Discussion of Accident History

Accidents are possible with this type of power tool, there are a number of hazard specifications and safety warnings for a reason. Personal protective equipment must be worn, and safety precautions must be taken seriously to avoid injury. A brief description of potential accidents will be discussed in this portion of the report (Fig. 1).

Accident Report Detail

**Accident: 100050.015 - Employee Incurs Leg Lacerations When Angle Grinder Kicks Back**

Accident: 100050.015 -- Report ID: 0050220 -- Event Date: 10/05/2017						
Inspection	Open Date	SIC	Establishment Name			
1269746.015	10/10/2017		D.L. Denman Construction, Inc.			
At 1:30 p.m. on October 5, 2017, Employee #1, employed by a construction company, was working on his knees inside a water tank. He was operating a Dewart 4011 Angle Grinder, Type 1, 120 V, 50/60 HZ, 12000 RPM with a Pro Star Cut Off Wheel, diameter 4.5, thickness 0.45 inches, max RPM 13300, and cutting off welding tacks inside the water tank. The angle grinder kicked back, and the cut off wheel struck and cut Employee #1's right knee and lower hamstring. Emergency services were called, and Employee #1 was transported to the hospital. He was admitted and treated for lacerations that damaged bone and tendon in his leg and knee.						
<b>Keywords:</b> struck by, construction vehicle, water tank, kick back, grinding wheel, knee, leg, laceration, guard, grinder						
Employee #	Inspection	Age	Sex	Degree	Nature	Occupation
1	1269746.015	27	M	Hospitalized injury	Cut/Laceration	Welders and cutters

Accident Report Detail

**Accident: 201145810 - Employee Is Injured While Cutting Railing With Angle Grinder**

Accident: 201145810 -- Report ID: 0950631 -- Event Date: 01/21/2004						
Inspection	Open Date	SIC	Establishment Name			
125949156	01/29/2004	1799	T L Fabrications			
At approximately 9:40 a.m. on January 21, 2004, Employee #1 was cutting a metal railing in the garage of a residential home under construction with a Makita angle grinder, Model Number 9524NB, when the 6-inch diameter grinding disc broke. His right hand was struck by the broken disc, lacerating his right wrist. He was hospitalized with his injury. Further investigation revealed that the employee was not familiar with using an abrasive disc grinder as a cutting tool for metal or structural steel.						
<b>Keywords:</b> grinder, portable power tool, metal rail, construction, equipment failure, laceration, struck by, abrasive wheel, wrist						
End Use	Proj Type	Proj Cost	Stories	NonBldgHt	Fatality	
Single family or duplex dwelling	New project or new addition	\$1,000,000 to \$5,000,000	2	18		
Employee #	Inspection	Age	Sex	Degree	Nature	Occupation
1	125949156			Hospitalized injury	Cut/Laceration	Construction laborers
						<b>FailDist</b> <b>FailHt</b> <b>Cause</b> Erecting structural steel <b>FatCause</b> Other

Fig. 1. OSHA accident reports

## 4 Safety Analyses

Three different safety analyses techniques were used to review the safety and hazard controls for this angle grinder. The first was a Preliminary Hazard Analysis, which is shown below.

### 4.1 Preliminary Hazard Analysis

See Table 1.

**Table 1.** Preliminary hazard analysis.

Hazard	Cause	Effect	Corrective or preventative measures
Bodily injury	Loss of control of power tool	The grinder may be spinning so fast and have so much torque that the operator loses control of the grinder. The grinder could hit an object or bounce off the floor and injure the operator or anyone in the near vicinity	Adding side grips to the grinder so the operator may hold the grinder and be less likely to lose control  Wear proper protective equipment
Facial/eye injury	Improper use of grinder: placing grinder in a vice grip	If the grinder is used at an improper angle the abrasive disk can shatter and send shrapnel in to the eye or face of the operator causing serious harm or loss of sight	Follow user operation manual and read all warnings before operating a product  Wear proper protective equipment
Head/face injury	Improper use of grinder: holding grinder in the wrong position and not using side grips	When an angle grinder is applied to a surface at an incorrect angle the angle grinder may have a kickback effect and possibly bounce out of an operator's grip and injure the head or face	Hold angle grinder at the correct position when operating and move it in the appropriate direction when moving along the part  Use side grips when operating angle grinder  Wear proper protective equipment
Fire and spark	Sparks are discharged from the contact of the angle grinder and materials	A fire could potentially be ignited if the surrounding area is not free of oil or combustibles	Ensure the surrounding area is free of combustibles and oil
Charging hazards	Improper charging procedures (not following charging instructions)  Not positioning the battery correctly in the charging unit	Damaging the battery, potentially exposing the operator to toxic chemicals discharged by the battery	Properly position the battery on the charging unit

### 4.2 Fault Tree Analysis

The specific accident scenario selected for the fault tree was damage to the hands and face, caused by oil on the floor (Fig.2).

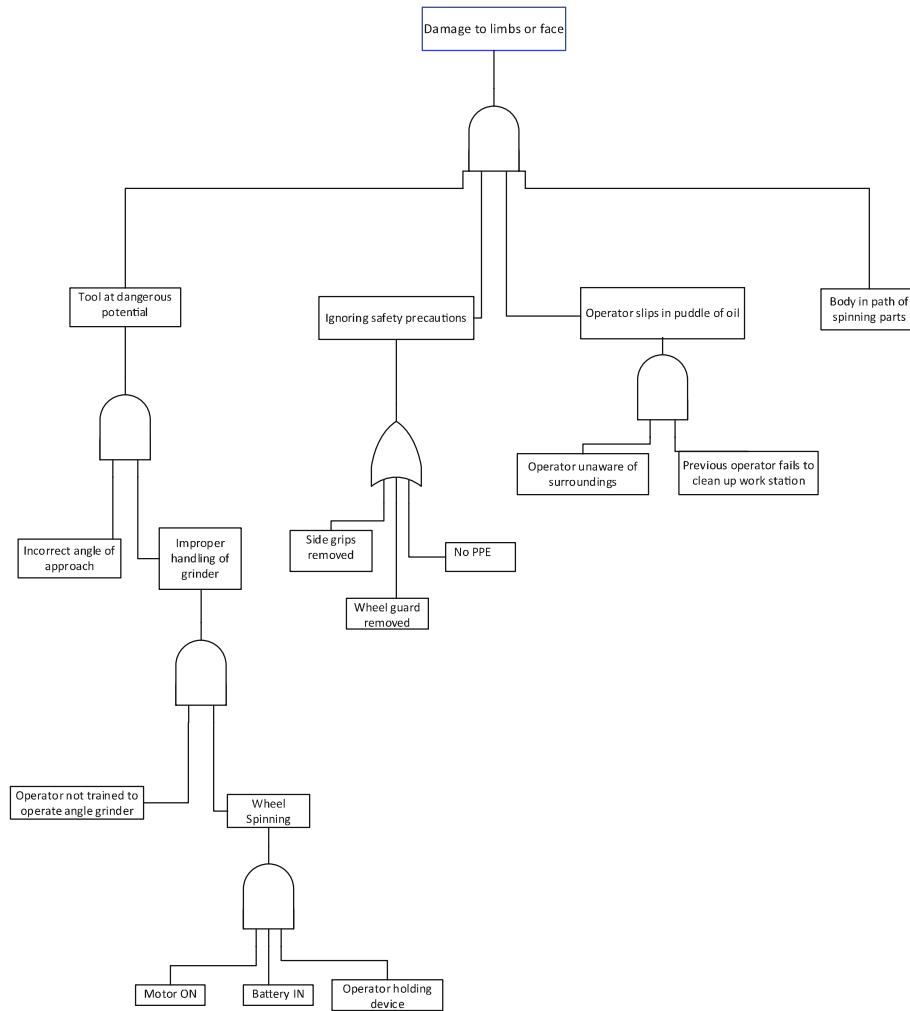


Fig. 2. Fault tree of an injury arising from slipping in oil while using the grinder

FMEA				
Component name	Function	Failure mode and cause	Failure effect on	Corrective action
Lock nut	Keeps the depressed center wheel, and inner flange in place  These components work together to keep the abrasive wheel attached to the power tool	Power ON rotating: a stripped lock nut could come loose during the grinding operation causing the grinding disk to come off and cause injury to operator or surrounding people  Power OFF: the lock nut could be so stripped that it falls off of the angle grinder while not in use; causing malfunction during power up	Abrasive disk	If the lock nut is stripping replace it  Perform preventative maintenance on the wheel components including the lock nut, depressed center and wheel inner flange
Abrasive grinding disc	Grinds metal objects to remove excess material, leave a smooth finish or for cutting metal material	Power ON rotating: grinding disk could be operated at incorrect angle and catch a piece of metal in the wrong way causing the disc to shatter  Power OFF: the grinding disk could deteriorate when exposed to the elements; if the wheel is placed on an angle grinder the disk may shatter	None; Possibly strip the lock nut so the next disk could face the same failure	Operate angle grinder at the appropriate angle and use accordingly  Replace grinding disk if it is showing substantial signs of wear or over usage
Bearing box	Contains bearings that provide a 'cushion' for rotating wheel	Power ON rotating: grinding wheel is pushed too hard against an object, the bearings absorb some of force of the torque in the opposite direction	Rotating disk: the rotating disk can shatter if the bearings are not working correctly because the bearings will not absorb additional torque	Preventative maintenance on the bearing box. Make sure bearings are rotating properly

The preliminary hazard analysis is used to determine what potential hazards the angle grinder may pose to the operator or others standing by. By evaluating the potential hazards, their causes and effects, and then taking correct and preventative measures, user exposure to the hazards involved when using this grinder can be minimized.

The fault tree analysis was a useful tool. Using the AND and OR logic to produce a sequence of events that pose a potential hazard helps clarify those combinations of conditions which can result in the top (adverse) event occurring. The fault tree analysis is a graphical approach to the organization of potential faults and failures that could lead to a larger hazard; it can be easily translated in to layman terms and manipulated if more events are added.

The failure mode effects analysis takes specific components of the device, their function, failure mode and cause, other components the failure could cause failure to (because a piece of equipment is essentially a lot of pieces of equipment combined in to one object) and corrective actions that can be used to prevent failures. When considering safety, identifying equipment failure can save lots of time in replacing equipment and prevent injuries caused by equipment failure.

## References

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