UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

BALLOT VOTE SHEET

DATE: JUN 28 2006

TO: The Commission
Todd A. Stevenson, Secretary

THROUGH: Patricia M. Semple, Executive Director

FROM: Page C. Faulk, General Counsel
Jeffrey R. Williams, Assistant General Counsel for Enforcement and Information
Hyun S. Kim, Attorney, OGC

SUBJECT: Petition CP 03-2, Performance Standards for Table Saws

Ballot Vote Due: JUL - 6 2006

Attached is a briefing memo from the staff concerning a petition from Stephen Gass, David Fanning, and James Fulmer requesting mandatory performance standards to reduce or prevent table saw blade contact injuries. The staff recommends that the Commission grant the petition to the extent it requests the Commission to proceed with a rulemaking process that could result in a mandatory safety standard for table saws to reduce the risk of blade contact injury, and direct the staff to prepare an advance notice of proposed rulemaking (ANPR).

Please indicate your vote on the following options.

I. Grant Petition CP 03-2 and direct staff to draft an ANPR.

____________________ __________
(Signature) (Date)

II. Deny Petition CP 03-2 and direct staff to prepare a letter of denial to the petitioners.

(Signature) (Date)

III. Defer decision on Petition CP 03-2.

(Signature) (Date)

IV. Take other action (please specify):

(Signature) (Date)

Attachment: Briefing memo on Petition CP 03-2.

BRIEFING PACKAGE

PETITION FOR
PERFORMANCE STANDARDS FOR TABLE SAWS

June 2006

For Further Information Contact:

Caroleene Paul
Project Manager
Directorate for Engineering Sciences
301-504-7540

Executive Summary

This briefing package provides the Commission with available information about blade contact injuries associated with table saw use and describes options for the Commission to consider in determining whether a rule may be reasonably necessary to eliminate or reduce the risk of table saw blade contact injury.

On April 15, 2003, Messrs. Gass, Fanning, and Fulmer, et al. petitioned the U.S. Consumer Product Safety Commission (CPSC) to require performance standards for a system to reduce or prevent injuries from contact with the blade of a table saw. The petition asserts that technology is available that can detect contact between a person and a saw blade and then react to stop and retract the blade. This technology was invented and patented by Dr. Stephen Gass, one of the primary petitioners.

The petitioners state that current table saws pose an unacceptable risk of severe injury because they are inherently dangerous and lack an adequate safety system to protect users from accidental contact with the blade. The petitioners also state that virtually all table saws sold in the U.S. meet the current safety standard for table saws, UL 987 *Standard for Stationary and Fixed Electric Tools*. The petitioners maintain that accidents continue to occur in large numbers and thus demonstrate the need for more effective safety standards for table saws.

Based on data from CPSC's National Electronic Injury Surveillance System (NEISS) and a NEISS-based special study on stationary saw-related injuries conducted in 2001, CPSC staff estimates that there were 28,300 emergency room treated injuries caused by operator contact with a table saw blade in 2001. Almost all of the table saw operator blade contact injuries analyzed in the special study were sustained by consumers. Most (94%) of the injuries were sustained to the finger(s), and the majority of the injuries (65%) were lacerations. The second largest type of injury sustained by operators was amputation (15%). The remaining injuries (20%) were fractures, avulsions, and crushings. The rate of hospitalization was 11%, and all these hospitalized injuries were related to fingers.

From the 28,300 emergency room treated operator blade contact injuries, the Commission's Injury Cost Model (ICM)[1] estimates 55,300 total medically treated blade contact injuries in 2001 with associated injury costs of $2.13 billion. The estimates for total medically treated injuries include injuries treated in settings other than the emergency room, such as ambulatory surgery centers, physicians' offices, or clinics. The high societal costs are attributed to the large number of amputations (approximately 15% of the operator blade contact injuries) and the 11% rate of hospitalization, which is more than twice the 4.6% average hospitalization rate for all consumer products in 2001. The societal costs associated with these operator blade contact injuries suggest that an effective remedy could generate net societal benefits over the lifetime of the table saws.

Based on available information from the petitioners and the Power Tool Institute (PTI)[2], the retail price impact of the petitioner's particular request may amount to about $100 per table saw.

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[1] The Injury Cost Model is a computerized analytical tool that uses NEISS data to estimate the total number of medically treated injuries. The ICM also estimates the direct and indirect costs associated with those injuries.

[2] PTI represents the majority of table saw manufacturers and/or importers in the U.S. PTI estimated that costs could be higher than $150 per table saw.

In addition, there are unknown maintenance costs that may be associated with components of such a system if it requires replacement after each activation. Also, according to PTI, the costs associated with the proposal could potentially eliminate some of the least expensive table saws from the market. Staff has issues concerning the appropriate blade-approach speed to be used in evaluating this and other approaches to reduce or eliminate blade contact injuries. Nevertheless, CPSC staff review of the injury data from its special study suggests that a large percentage of operator blade contact injuries on table saws could be addressed by table saw performance requirements.

Many industry representatives believe that modification of consumer behavior through information and education campaigns could best address the hazard. Despite efforts by the table saw industry to educate consumers on the safe use of table saws, severe injuries continue to occur at a high cost to society and the victims.

The voluntary standard for table saws was recently revised to include a safety device that may be more effective at preventing kickback of the material during use of a table saw. CPSC staff supports this new requirement as an improvement to table saw safety but does not believe it will adequately address the blade contact hazard. In addition, in June 2006, the Table Saw Mechanical Guarding Joint Venture submitted for consideration to Underwriters Laboratories Inc. (UL) and the Canadian Standards Association (CSA) proposed requirements that would allow for alternative blade guards. PTI has indicated that, assuming the UL and CSA processes proceed smoothly, it is anticipated that implementation by individual manufacturers could begin in 2007.

The Occupational Safety and Health Administration (OSHA) regulates table saw products and the workplace environment in which the products are used. Current OSHA product requirements on table saws are essentially identical to the requirements in the voluntary standard in terms of providing an adjustable blade guard and some type of spreader (device that prevents the cut material from binding the saw blade). CPSC staff does not believe OSHA regulation will adequately address the blade contact hazard to consumers because:

1) Current OSHA requirements for table saws are identical to existing voluntary standard requirements, and
2) OSHA does not have jurisdiction in the home wood working shop and, therefore, cannot enforce a safe work environment and proper safety training for all users of table saws.

CPSC staff recommends granting the petition to the extent it requests the Commission to proceed with a rulemaking process that could result in a mandatory safety standard for table saws to reduce the risk of blade contact injury. Granting a petition in this manner and beginning a rulemaking proceeding does not mean that the Commission would necessarily issue a rule in the specific form requested in the petition.

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TAB C	Memorandum from William Zamula, EC, to Caroleene Paul, Project Manager, "Petition Requesting Performance Standards for a System To Reduce or Prevent Injuries From Contact With the Blade of a Table Saw (Petition CP03-2)," June 15, 2005
TAB D	Memorandum from Caroleene Paul, ESME to Ronald L. Medford, Office of Hazard Identification and Reduction, "Evaluation of Prototype Tablesaw Safety Device," July 19, 2001

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: JUN 28 2006

TO	:	The Commission Todd A. Stevenson, Secretary
THROUGH	:	Page C. Faulk, General Counsel Patricia M. Semple, Executive Director
FROM	:	Jacqueline Elder, Assistant Executive Director Office of Hazard Identification and Reduction Caroleene Paul, Project Manager, Table Saw Petition Directorate for Engineering Sciences
SUBJECT	:	Petition CP 03-2, Requesting Performance Standards for a System to Reduce or Prevent Injuries from Contact with the Blade of a Table Saw

1. Introduction

The staff of the U.S. Consumer Product Safety Commission (CPSC) prepared this briefing package for use by the Commission in considering Petition No. CP 03-2: Petition for Performance Standards for Table Saws.* This package provides information on table saws, related injuries and deaths, feasibility of the performance requirements requested in the petition to address table saw hazards, voluntary standards activities, and responses to public comments to the petition. This package also provides options for Commission consideration along with staff's conclusion and recommendation.

2. Background

A. Petition for Rulemaking

On April 15, 2003, Messrs. Gass, Fanning, and Fulmer, et al. requested that the Commission issue a rule prescribing performance standards for a system to reduce or prevent injuries from contact with the blade of a table saw. The Office of the General Counsel (OGC) docketed the request as petition number CP 03-2 on June 10, 2003, under provisions of the Consumer Product Safety Act (CPSA) 15 U.S.C. §§ 2051-2084.

* In accordance with 16 C.F.R. § 1031.11(b), the Commission is advised that Caroleene Paul, the principal author of this memorandum, attended voluntary standard meetings held by Underwriters Laboratories, Inc. (UL), participated in discussions regarding table saw safety, and provided data support for the UL working groups.

The petitioners state that current table saws pose an unacceptable risk of severe injuries that include lacerations and amputations. The petitioners maintain that a system to reduce or eliminate the risk of injury associated with table saws must include the following:

1) A detection system capable of detecting contact or dangerous proximity between a person and the saw blade when the saw blade is –
   (a) spinning prior to cutting,
   (b) cutting natural wood with a moisture content of up to 50%,
   (c) cutting glued wood with a moisture content up to 30%, and
   (d) spinning down after turning off the motor;
2) A reaction system to perform some action upon detection of such contact or dangerous proximity, such as stopping or retracting the blade, so that a person will be cut no deeper than 1/8 of an inch when contacting or approaching the blade at any point above the table and from any direction at a rate of one foot per second;
3) A self-diagnostic capability to verify the functionality of key components of the detection and reaction system; and
4) An interlock system so that power cannot be applied to the motor if a fault interfering with the functionality of a key component in the detection or reaction system is detected.

The petitioners cite CPSC staff estimates of 30,000 annual emergency room treated injuries involving table saws, with approximately 90% of the injuries occurring to the fingers and hands and 10% of the injuries resulting in amputation.[3]

The current safety system on table saws sold in the U. S. includes a blade guard to protect the user from accidental contact with the blade. The petitioners state that blade guards are often removed by consumers because they interfere with the operation of the saw (blade guards must be removed for non-through dado or rabbet cuts), they are often difficult to reinstall once they have been removed, they block the view of a cut, and they interfere with narrow cuts.[4]

The petitioners state that virtually all table saws sold in the U.S. meet the current safety standard for table saws established by Underwriters Laboratories (UL) as UL 987 *Standard for Stationary and Fixed Electric Tools*. They also state that the UL Standards Technical Panel responsible for table saws has not taken action to develop new requirements to address blade contact injuries. The petitioners maintain that accidents continue to occur in large numbers and thus demonstrate the need for more effective safety standards for table saws.

B. Table Saw Description

A table saw is a popular power tool used primarily to cut wood. It consists of a circular saw blade mounted on an arbor that is driven by an electric motor. The blade protrudes through the

[3] Adler, P. (February 2002). Data Report. Table Saw Related Injuries And Fatalities (1991-2000). U.S. Consumer Product Safety Commission: Bethesda, MD. Data report was cleared and presented to UL table saw working group on February 6, 2002. (TAB C, Appendix C)

[4] Two alternative guard designs have been developed through a joint venture of five table saw manufacturers (Table Saw Mechanical Guarding Joint Venture), and focus group studies comparing the current guard design with the alternative designs have been conducted. Letter from Power Tool Institute, Inc. to Ms. Patsy Semple, U.S. Consumer Product Safety Commission, Table Saw Guarding, April 17, 2006.

surface of a table, and the table provides support for the material being cut. The amount of the blade that protrudes above the table surface is adjustable and determines the depth of cut that will be made. The operator pushes the material to be cut into the saw blade.
There are three basic table saw categories that comprise the population of table saws used for both consumer and professional use: bench saws, contractor saws, and cabinet saws.[5] Generally, the range of quality and accuracy of a table saw is commensurate with its size, motor horsepower, weight and, indirectly, price.

Bench saws are lightweight, inexpensive saws designed to be easily moved around and temporarily placed on a work bench or stand (see Figure 1). Prices for bench saws range from $100 to $500.[6] They are often the first table saw purchased by the inexperienced wood worker but are also used by contractors who have to transport a saw from job to job for light work.

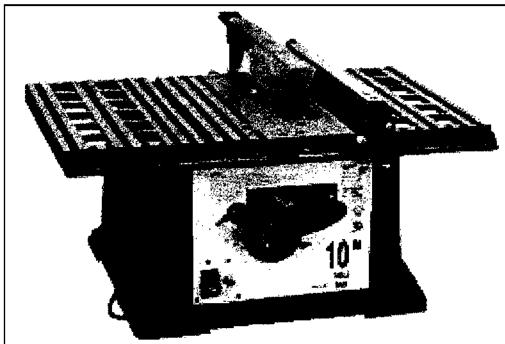	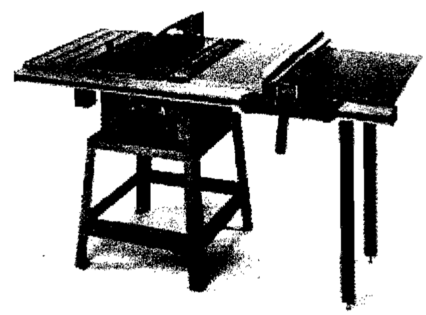
Figure 1. Bench Saw	Figure 2. Contractor Saw

Contractor saws are characterized by a set of light duty legs and bigger table and motor than a bench saw (Figure 2). Prices for a contractor saw range from $150 to $1,000 or more.[7] These saws are generally quieter, more accurate, and able to cut materials up to 2 inches thick. Contractor saws are commonly used by the home wood worker because the saws are capable of high quality work and are commonly found at mass merchandisers. Nevertheless, contractor saws are also accurate enough to be used in professional cabinet shops and transportable enough to be used on construction work sites.[8]

Cabinet saws are heavier than contractor saws because the higher powered motor is enclosed in a solid base (see Figure 3). Prices for cabinet saws range from $1,200 to $3,000. These saws are designed for heavy use and the greater weight minimizes vibration so that cuts are smooth and more accurate. These saws are typically the highest grade saw found in the home wood working shop. The higher end cabinet saws are also capable of some light duty production work in a professional shop.

[5] http://www.woodcraft.com/articleprint.aspx?ArticleID=241
[6] http://www1.pricetool.com/xDN-Tools_and_Hardware-table_saw-~PG-13~S-2~OR-0
[7] http://www.consumersearch.com/www/house_and_home/table-saw-reviews/fullstory.html
[8] http://www.southern-tool.com/store/powermatic_cabinet_table_saws.html

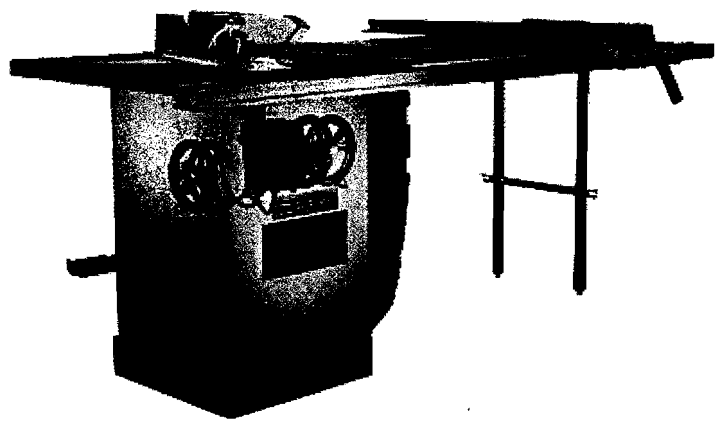

Figure 3. Cabinet Saw

Production table saws are not considered part of the population of table saws used for consumer use. They are typically massive, heavy duty table saws designed with very large working surfaces, 12 inch blades, and 3 phase motors greater than 5 horsepower. Production table saws are used in production facilities, factories, and cabinet shops. They are designed to accommodate power feeds and are robust enough to continuously saw thick wood stock. These saws are not used by consumers in home wood shops.

C. Table Saw Safety Components

Table saws sold in the United States share similar variations of a blade guard assembly that consists of a splitter (also known as a spreader), a blade guard, and an antikickback device (see Figure 4). The splitter is a piece of sheet metal fixed to the top of a table saw and located behind the blade. A splitter prevents the sides of the cut material from pinching or rotating into the saw blade - a situation in which the energy of the spinning blade can be imparted to the material causing it to lift up off the table and eject towards the operator (kickback).

The splitter also serves as the hinged attachment point for the blade guard. The blade guard is typically a rectangular piece of clear plastic that covers the saw blade. The front of the blade guard is tapered so that it lifts over the work piece as it is fed into the blade. A blade guard provides a barrier against inadvertent contact with the saw blade from the back, top, or sides of the blade.

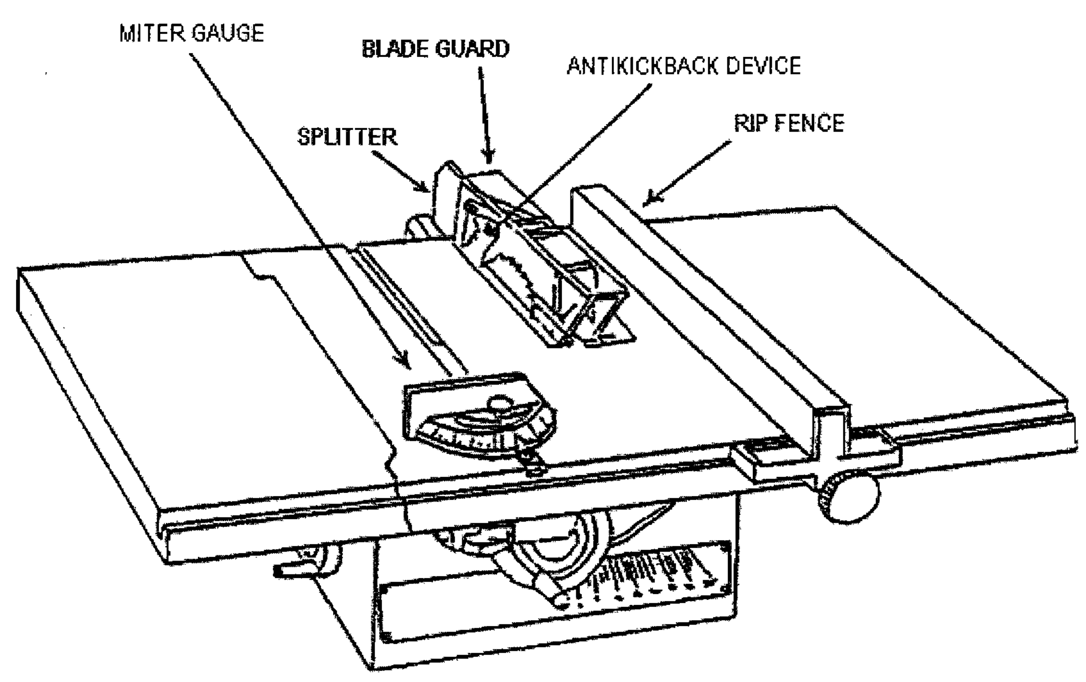

Figure 4. Components of a Table Saw

A typical antikickback device consists of pawls, which have teeth that are designed to grab the work piece if it begins to reverse and prevent it from being thrown back towards the operator. The antikickback pawls are also attached to the splitter (see Figure 4).

Because the splitter is fixed to the table and is set for the highest height of the blade (which means it is often taller than the blade and its distance from the blade varies with the height of the blade), the splitter and attached guard assembly must be removed for cuts that use the top of the saw blade to cut a channel in the material. These "non-through" cuts are common in wood working, and are known as a dado cut (when the channel is cut in the middle of the material) and a rabbet cut (when the channel is cut on the edge of the material). When the splitter and attached guard assembly are removed, there is no protection against blade contact or kickback of the material.

Table saws sold in Europe differ in the type of splitter and blade guard provided with the product (see Figure 5). European table saws use a riving knife, which performs the same function as a splitter. The riving knife is a curved steel plate located a few millimeters behind the saw blade (see Figure 6). Because the riving knife is secured to the same structural member as the saw blade, the riving knife raises and lowers with the blade, maintaining a constant radial distance from the blade. The riving knife does not need to be removed for most non-through cuts because it is located just below the top of the saw blade.

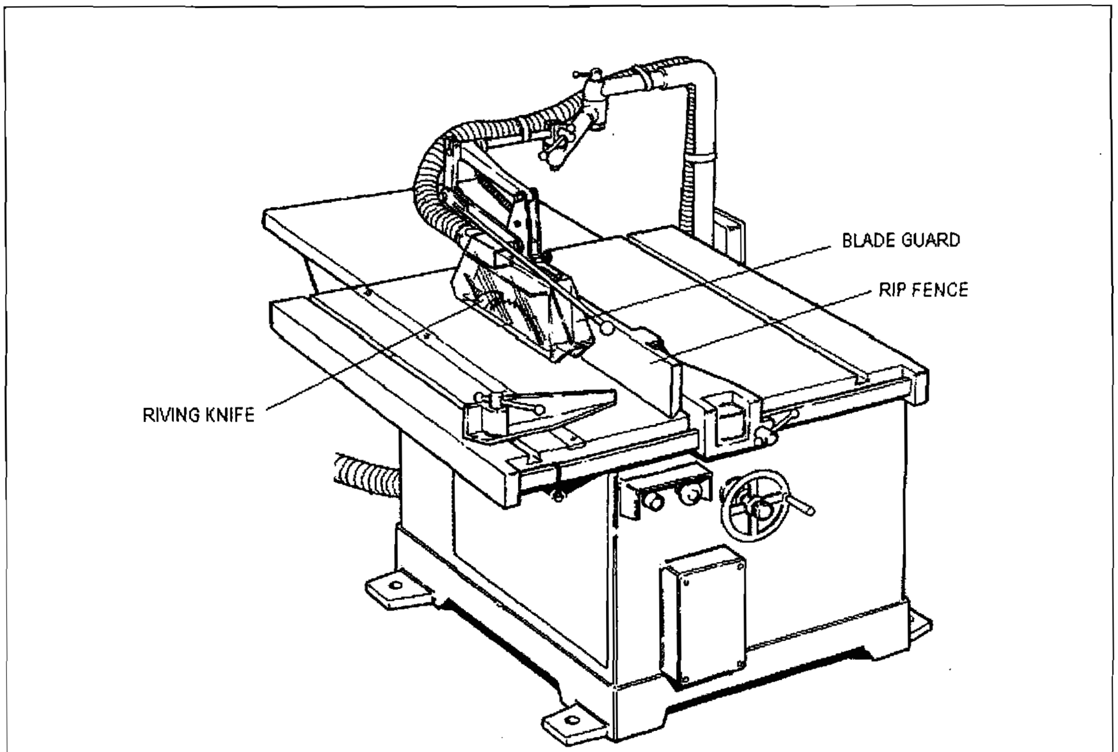

Figure 5. European Table Saw

A blade guard on a European table saw is secured to an arm that is attached to the table top and raises and lowers vertically above the saw blade. This type of blade guard design is available as an aftermarket option to the splitter/guard assembly provided with the typical table saw in the United States and ranges in price from $250 to $500.[9] Aftermarket splitters are also available and range in price from $30 to $150. The aftermarket splitters and blade guards are separate pieces, so if one must be removed, the other device can remain in place.

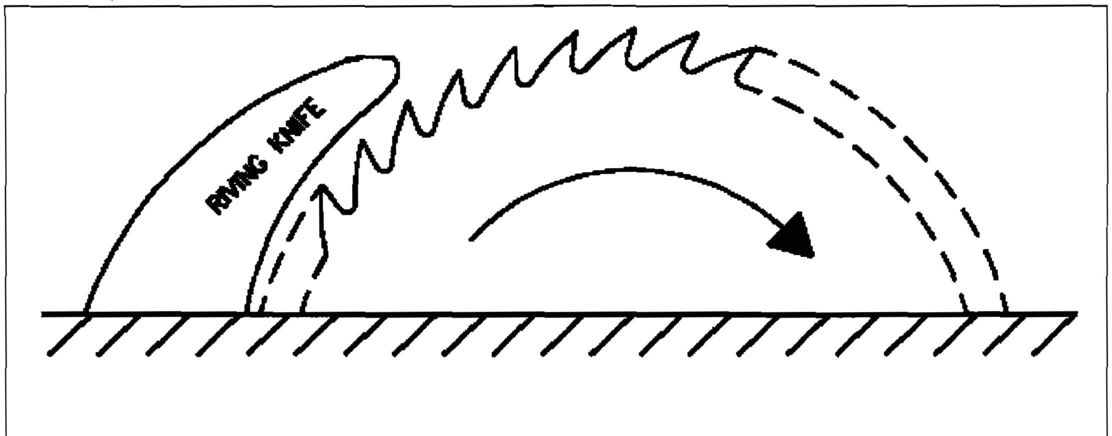

Figure 6. Riving Knife

[9] http://www.taunton.com/finewoodworking/pages/w00130.asp

D. Design of Safety Components

Machine safety features may be classified as active or passive. An active safety device would require the operator to perform some function in order to activate or invoke the safety feature. Users will be more prone to override or somehow deactivate safety features when those features require the operator to perform additional steps, make the operation more difficult or awkward, take more time to do than performing that same operation without the safety device, occlude a clear view of the operation itself, or in any way require more effort. Automobile seat belts are an example of an active safety device.

Safety features that are passive require no active intervention on the part of the user of the device. The operation of the safety feature is invisible to the user and does not impact the speed or ease of performing an operation in any way. An automobile air bag is an example of a passive safety device.

Principles of good safety engineering eliminate hazards from the design of a product whenever possible. If hazards cannot be eliminated from a product, passive safety features should be designed into the product. When this is not possible, active safety features can be designed into the product. Some hazards can only be addressed by warning labels and other materials to alert users to the hazards.

3. Table Saws

A. Consumer Use versus Professional Use of Table Saws (TAB A)

The attributes of each category of table saw lend the tool to both consumer use and professional use. However, the primary function of the table saw in either a work or home setting is to make rip cuts (cutting wood with the grain), cross cuts (cutting wood across the grain), or non-through cuts (cutting a groove into the material). The primary differences between consumers and professional users of table saws are environment and training/experience.

<u>Environment</u>

Professional wood workers are in an environment where Occupational Safety and Health Administration (OSHA) regulations require that table saws have all safety devices installed and in working order. For instance, OSHA regulations specifically state that "[E]mphasis is placed upon the importance of maintaining cleanliness around the woodworking machinery, particularly as regards the effective functioning of guards" [29 CFR § 1910.213 (s)(6)], and require that "[P]ush sticks or push blocks shall be provided at the work place in the several sizes and types suitable for the work to be done" [29 CFR § 1910.213 (s)(9)]. In many production environments where a specific cut is performed continuously, guards and safety cut-off switches are custom designed for that set up. The area is specifically designed to be as safe as possible and safety is a continuous focus through warning/instruction signs and posters that are often displayed throughout the work area. The workplace is subject to spontaneous inspection by OSHA inspectors; therefore, the prospect of being fined for safety violations increases the likelihood that workers or supervisors will ensure safety codes are followed.

The consumer wood worker does not have the same OSHA-regulated protections in the home wood shop. The focus on a safe environment in a consumer setting is dependent on the knowledge and initiative of the home wood worker. Those who are consciously cautious will take the time to verify that the product is in safe working order and that the work area is properly prepared. This primarily involves making sure all the product's safety devices, most notably the blade guard, are intact and working properly. Of additional importance is the need for an uncluttered work area that is well lit and free of distraction. Overall there is no oversight influence to educate and motivate the consumer to prepare as safe an environment as possible.

Training/Experience

Professional wood workers are in an industrial setting where employees often receive training on safety practices and in the proper use of the tool. Professional wood workers will have had training and be experienced in performing any special or complex operations with the saw. Due to their deep experience, they will recognize situations and set-ups that may be dangerous or require extra care and caution.

Amateur wood workers generally have little or no safety training nor training in the proper use of a table saw. They may take wood working classes or obtain a training video, but there is no mechanism to encourage the home wood worker to use a table saw as safely as possible. Home users typically have far less experience than professional wood workers and may discover dangerous or difficult operations only by actually experiencing near incidents or problems.

B. Deaths and Injuries Associated with Table Saws (TAB B)

Deaths

CPSC staff is aware of two deaths involving blade contact on a table saw from 1991 to August 2004. In 1997, a 67-year-old man died from a heart attack after he severed three fingers using a table saw. In 2001, a 52-year-old man died three days after his left hand was amputated while using a table saw.

Injuries

Total Injuries[10]

Based on data from the National Electronic Injury Surveillance System (NEISS), the estimated number of emergency room treated injuries associated with table saws averaged 29,000 per year from 1991 to 2000. This injury trend remained stable during that time period and into 2002. As part of a special study on stationary saw-related injuries, follow-up interviews were conducted on NEISS cases treated between October 1, 2001 and December 31, 2001. The special study identified incidents involving table saws that were formerly coded as "other power saws" or "power saws, not specified." As a result of the follow-up investigations, the injuries involving unspecified saws (43% of the annual stationary saw estimate) were re-distributed among the

[10] The coefficients of variation for injury estimates are provided in TAB C and its appendices.

specified saw categories. The results of the special study allowed more precise injury estimates to be computed for 2001 (38,000 injuries) and 2002 (38,980 injuries).

Since the injury trend associated with table saws has been stable from 1991 to 2002 and the results of the special study represent the most accurate estimates available, the injury statistics for 2001 have been used to summarize blade contact injuries and their associated hazard patterns. Of the 38,000 total emergency room treated injuries associated with table saws in 2001, an estimated 34,000 injuries were sustained by operators of table saws. Of the injuries to table saw operators, an estimated 28,300 injuries (83%) involved blade contact. Virtually all of the table saw operator blade contact-related injuries were sustained by consumers (only 5 cases out of 120 were identified as work-related). However, since both consumers and workers possibly use the same high and low end table saws, potentially in the same manner, work-related injuries were not removed from the injury estimates. The majority of the remaining non-blade contact injuries sustained by table saw operators involved injuries caused by impact with a thrown piece during kickback of the material being cut.

Injuries Due To Blade Contact

Of the estimated 28,300 emergency room treated injuries involving table saw operator blade contact in 2001, the ages of the victims ranged from 15 to 69 years old, but the majority (56%) of the victims were 51 years of age or older. Almost all (94%) of the injuries were sustained to the finger(s). The majority of the blade contact injuries (65%) sustained by table saw operators were lacerations. The second most frequent injury sustained was amputation (15%). The remaining injuries (20%) were fractures, avulsions, and crushings. The rate of hospitalization was 11% (the average rate of hospitalization for all NEISS products in 2001 was about 4.6%), and all of these hospitalized injuries were related to fingers.

C. Hazard Patterns Associated with Table Saws (TAB B)

Of the 28,300 emergency room treated injuries involving table saw operator blade contact in 2001, approximately 9,300 of the injuries occurred as a result of kickback of the material. CPSC staff's review of the investigations from the special study revealed that some victims described a scenario where they were startled by the material being lifted by the blade during kickback, which caused the victim's hand to slide or be "drawn into" the blade. Some victims described pushing a piece of stock with one hand in front of the blade and pulling the stock from behind the blade at the same time. When the stock pinched the blade and kicked back towards the front of the table saw, the hand resting on the stock behind the blade was pulled into the blade. Kickback of material resulted in minor and severe lacerations, amputations, fractures, and avulsions.

Approximately 16,000 of the 28,300 injuries did not occur as a result of kickback of the material. Many of these injuries were caused by a lapse in attention of the operator, such as reaching over the blade to retrieve a cut piece or simply not being aware of the blade during a cut. Non-kickback related incidents resulted in minor and severe lacerations, amputations, fractures, and avulsions. It is not known if kickback caused operator contact with the blade in approximately 3,000 of the 28,300 injuries.

D. Table Saw Market (TAB C)

Manufacturers and/or importers of table saws include Bosch/Skil, Black & Decker/DeWalt, Makita, Ryobi, Delta/Porter-Cable (Pentair Tool Group), Hitachi, Jet/Powermatic (WMH Tool Group), Grizzly, Inca, Jepson, General International, PTS/Rexon/Tradesman, and Emerson Electric/Ridgid. The first seven manufacturers/importers mentioned above probably account for most of the shipments of table saws in the U.S. (The Power Tool Institute comments on the petition state that these seven companies, along with several former members (not specified), account for 95% of all table saws sold in the U.S.)

The Power Tool Institute (PTI), the trade association representing the primary table saw manufacturers, estimates shipments of 725,000 table saws in 2002 (which account for approximately 95% of U.S. table saw sales) and estimates that there are approximately 6 million table saws currently in use in the U.S. PTI also estimates the expected useful life of a table saw to be 10 years. Alternatively, a market study conducted in the 1980s estimated the expected useful life of a table saw to be 15 years. Based on estimated shipments from 1983 to 2002, and assuming the longer 15 year expected useful life, the population of table saws would be approximately 10 million table saw units. Therefore, assuming a 10-15 year expected product life, the product population is probably in the range of 6 to 10 million units.

Retail prices range from about $100 for some consumer-oriented table saws to several thousand dollars for professional quality saws. PTI characterizes the consumer price range as $100 to $800 and the professional price range as $500 to $2,500. Assuming an average retail price of $400 to $500 and sales of 725,000 table saws annually, the annual retail sales are in the range of $300 to $400 million.

4. Annual Costs to Society of Table Saw-Related Injuries/Deaths (TABS B and C)

The Injury Cost Model (ICM) is a computerized analytical tool that uses NEISS data to estimate the total number of medically treated injuries. The ICM also estimates the direct and indirect costs associated with the total estimated injuries. NEISS gathers data on nonfatal injury victims treated in or admitted through hospital emergency departments. However, victims could be treated in other settings such as ambulatory surgery centers, physicians' offices and clinics, or company clinics. The ICM uses empirically derived relationships between emergency department injuries and those treated in other settings to estimate the number of injuries treated outside hospital emergency departments.

The ICM cost estimates consist of four parts: medical costs, work losses, quality of life and pain and suffering costs, and product liability insurance administration and litigation costs. Both the petitioner and comments submitted by PTI in response to the petition mention medical costs; but neither addressed other costs such as time lost from work or other activities, permanent disability, pain, and disfigurement. The ICM is structured to estimate these costs using data from surveys dealing with costs of treatment in different medical settings, databases of work loss estimates, and the Jury Verdicts Research data for pain and suffering estimates.

Based on the 2001 Special Study, there were an estimated 28,300 blade contact related injuries experienced by operators of table saws that were treated in emergency rooms. From these 28,300 injuries, the ICM estimates 55,300 total medically treated blade contact injuries with associated injury costs of approximately $2.13 billion (see Table 1). Since injuries have remained relatively constant over the 1991-2002 time period, the injury costs for 2001 have been used in the cost analyses.

Deaths resulting from blade contact during table saw use are relatively rare and seem to be the result of secondary effects of the injury (e.g., heart attack) rather than the injuries themselves. Deaths have therefore been excluded from the cost analyses.

Table 1: Blade Contact-Related Injuries of Table Saw Operators, 2001

	Estimate	95% Confidence Interval[11]
ER-treated injuries	28,300	(19,900, 36,700) [12]
All medically-treated injuries	55,300	(38,800, 71,800)
Total medically-treated injury costs	$2.13 billion	($1.50 billion, $2.76 billion)

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2001 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

Of the 28,300 table saw operator blade contact-related injuries treated in emergency rooms:

- 9,300 injuries involved blade contact that was caused by kickback of the material. From these 9,300 injuries, the ICM estimates 17,900 total medically treated table saw operator blade contact-related injuries due to kickback of the material, with associated injury costs of $730 million (see Table 2).

- 16,000 injuries involved blade contact that was not caused by kickback of the material. From these 16,000 injuries, the ICM estimates 32,300 total medically treated table saw operator blade contact-related injuries that were not caused by kickback of the material, with associated injury costs of $971 million (see Table 2).

- 3,000 injuries involved blade contact where it is unknown if kickback of the material caused the operator to contact the blade.

[11] The confidence interval for injury costs is derived by applying an average injury cost to the confidence interval for medically treated injuries.
[12] Coefficient of variation = .152

Table 2: Blade Contact-Related Injuries of Table Saw Operators, 2001

	Estimate	95% Confidence Interval[10]
KICKBACK		
ER-treated injuries	9,300	(5,700, 12,900) [1]
All medically-treated injuries	17,900	(11,000, 24,800)
Total medically-treated injury costs	$730 million	($448 million, $1,012 million)
NON-KICKBACK		
ER-treated injuries	16,000	(11,500, 20,400)[2]
All medically-treated injuries	32,300	(23,300, 41,300)
Total medically-treated injury costs	$971 million	($701 million, $1,241 million)

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2001 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

Societal costs per product in use per year range from $213 ($2.13 billion/10 million table saws in use) to $355 ($2.13 billion/6 million table saws in use). Over its 10 to 15 year lifetime, a table saw would generate societal costs of $2,600 to $3,100 at a discount rate of 3%, if all blade contact injuries are included.

In comments submitted in response to the petition, PTI suggests non-kickback injuries are more likely to be addressable than kickback injuries. If only costs from non-kickback injuries are included, the societal costs per product in use per year would range from $97 ($971 million/10 million table saws in use) to $162 ($971 million/6 million table saws in use). Over the 10-15 year product life of a table saw, the present value of the societal costs would be $1,200 to $1,400 per saw.

The societal cost estimates are derived from injury estimates that include a small proportion of occupational injuries. Because of the small sample size (5 cases out of 120 cases), the variance associated with estimates based on occupational injuries alone is large. Estimates of societal costs based on occupational injuries alone also would have a large variance.

For purposes of comparison, if the work-related injuries were removed from the data, the societal costs of all blade contact injuries would be reduced from $2.13 billion for all users to $1.78 billion for consumer users. The societal cost per product in use per year for consumer users would range from $178 (for 10 million total saws in use) to $297 (for 6 million total saws in use), and the present value of societal costs per table saw would be $2,200 and $2,600, respectively. Since all of the occupational injuries in the sample were kickback-related[3], estimates of societal costs for non-kickback injuries for consumer users would be unaffected.

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[1] Coefficient of variation = .191
[2] Coefficient of variation = .142
[3] In this particular sample, all the occupational injuries happen to be kickback-related. It is possible that a larger sample of occupational injuries would contain a mixture of kickback and non-kickback related injuries.

There is no available information that provides an estimate of the number of table saws that are only used for occupational purposes. However, eliminating occupational use table saws from the estimates would reduce the denominator in the cost calculations (6 to 10 million total saws in use) and, therefore, would increase the estimates of societal cost per table saw for consumers. Consequently, assuming all remaining injuries are non-occupational, the present value of the societal costs per table saw for consumers would likely be in excess of $2,200 to $2,600 for all blade contact injuries and in excess of $1,200 to $1,400 for non-kickback injuries.

Whether or not occupational injuries and/or kickback injuries are included, the societal costs suggest that an effective remedy could generate net societal benefits.

5. Voluntary Standard

A. Background

The voluntary standard for table saws is UL 987 *Standard for Stationary and Fixed Electric Tools*, published by Underwriters Laboratories, Inc. (UL) in 1971. In the past, revisions to UL standards were made by UL after conferring with members of the affected industries and interested parties at Industry Advisory Council (IAC) meetings. In June 2000, UL converted to the American National Standards Institute (ANSI) consensus process for review and revision of UL voluntary standards. Under the new system, UL representatives became voting members of Standards Technical Panels (STPs) that were formed for different groups of products to provide consensus forums for all standards activities. The STPs consist of producers, users, and general interests groups, with no category represented by more than 50% of the membership. UL or others may submit proposals to an STP for comment and balloting. Comments are responded to, and proposals are recirculated until a consensus approval is achieved (approval of at least two-thirds of the voting members and approval by a majority of the consensus body). CPSC staff participates as non-voting general interest group members of STPs. Revisions to UL 987 are covered by an STP for electric tools that was formed in June 2002.

B. Past Actions

Table Saw Injuries

In 1998, CPSC staff was concerned that the number of injuries associated with table saws (estimated annual average of approximately 30,000 emergency room treated injuries) outnumbered every other home power tool tracked by the National Electronic Injury Surveillance System (NEISS). A preliminary analysis of the injury data indicated that blade contact was the main hazard pattern and that many incidents involved table saws where the blade guard was removed. CPSC staff presented these concerns to UL in a letter dated April 21, 1998. Subsequently, CPSC staff presented injury data and concerns over blade guarding to industry members at an IAC meeting for stationary electric tools on October 13, 1998.

Industry members responded that product misuse was the primary factor in the incidents and that the current voluntary standard and product guarding system were adequate. The industry members believed an information and education campaign was required to instruct users on the safe operation of a table saw.[16] PTI produced a video on table saw safety for distribution to schools with vocational and technical programs and for interested consumers and users. CPSC staff and UL staff reviewed and made comments to drafts of the PTI video. In addition, CPSC staff continued discussions with UL staff regarding table saw safety. After a meeting in June 2000, it was agreed that UL would encourage the development of performance requirements for increased table saw safety.[17]

Guard Effectiveness

In November 2001, the IAC for stationary electric tools formed a working group to review blade guard requirements and to determine if the continuing blade contact injuries associated with table saws could be better addressed. CPSC staff participated in this working group, which also reviewed and discussed the merits of a detection/reaction technology. CPSC staff provided injury data and hazard analysis support to the working group. Issues discussed by the working group centered on the causes of blade contact injuries, the cause and definition of kickback, the effectiveness of current blade guards, and the merits of alternative systems to reduce blade contact injuries. The discussions regarding a detection/reaction system centered on theoretical and substantiated shortcomings of potential technologies and difficulties associated with a patented technology.[18]

Standards Technical Panel (STP) for Electric Tools

The Standards Technical Panel (STP) for electric tools convened for the first time in February 2003 and was presented with:

1) A proposal by the principals of SawStop™ for a requirement that all table saws have a detection/reaction system, and
2) A proposal by the working group for a requirement that all table saws have a riving knife similar to those required on European table saws.

The proposal for a detection/reaction system was rejected by the STP members due to concerns of reliability, impact of brake forces on small table saws, durability over the lifetime of a table saw, overall feasibility, and the economic benefit to the patent holder of the only technology that would currently meet the proposal. The proposal for a riving knife was discussed and approved.[19]

In addition, in June 2006, the Table Saw Mechanical Guarding Joint Venture submitted for consideration to Underwriters Laboratories Inc. (UL) and the Canadian Standards Association (CSA) proposed requirements that would allow for alternative blade guards. PTI has indicated

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[16] Paul, C. (December 1999). Meeting Log. Table Saws (December 8, 1999). U.S. Consumer Product Safety Commission: Bethesda, MD.
[17] Paul, C. (July 2000). Letter. Table Saws (UL 987). U.S. Consumer Product Safety Commission: Bethesda, MD.
[18] Paul, C. (December 2001). Meeting Log. Meeting of the table saw guarding working group for the standard for stationary and fixed electric tools, UL 987 (November 29, 2001). U. S. Consumer Product Safety Commission: Bethesda, MD.
[19] Paul, C. (February 2003). Meeting Log. Standards Technical Panel meeting for Tools February 10-22, 2003. U.S. Consumer Product Safety Commission: Bethesda, MD.

that, assuming the UL and CSA processes proceed smoothly, it is anticipated that implementation by individual manufacturers could begin in 2007.

C. Requirements Relating To Blade Contact Hazard

Section 40A.1. *General [Requirements for Table Saws]* requires that a table saw have a blade guard that automatically adjusts to the thickness of the work piece and completely encloses the top and sides of the saw blade. Current blade guards that meet this requirement are typically a hinged rectangular piece of clear plastic.

Sections 40A.2 *Riving Knife* and 40A.3 *Riving Knife/Spreader Combination* require that a riving knife or a riving knife/spreader combination unit be installed on the table saw, and section 40A.5 *Antikickback Devices* requires that antikickback devices be provided with a table saw. Section 40A.4 *Spreader* provides requirements for a spreader if the blade guard and/or antikickback devices are mounted to a spreader. All these requirements are intended to reduce kickback of the work piece when the sides of the cut piece bind against the saw blade. This indirectly addresses some blade contact injuries that occur during kickback of the work piece. The riving knife requirements were added in the updated 6^{th} edition of UL 987, which was issued in January 2005. The effective date for these new requirements is January 31, 2014 for currently Listed products and January 31, 2008 for new products submitted for investigation.

6. Occupational Safety and Health Administration (OSHA) Regulation

A. Background

The Occupational Safety and Health Administration's (OSHA) mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health. Products sold in a commercial setting and used by the public only in the course of employment are outside the CPSC's jurisdiction and are regulated under OSHA. If the product is capable of categorization as both a consumer product and a commercial product, the Commission's jurisdiction to regulate a consumer product is limited by section 31(a) of the Consumer Product Safety Act (CPSA) which provides that "[t]he Commission shall have no authority under this Act to regulate any risk of injury associated with a consumer product if such risk could be eliminated or reduced to a sufficient extent by actions under the Occupational Safety and Health Act." 15 U.S.C. § 2080(a). The Office of the General Counsel (OGC) has determined that if the danger created by the use of table saws in the home is unique from the dangers experienced in the work environment, the Commission may act to eliminate or reduce that risk, because such risk could not be eliminated or reduced to a sufficient extent by OSHA.

B. OSHA Requirements Relating To Blade Contact Hazard

Current OSHA regulations on table saws require that the blades be guarded by a self adjusting blade guard [29 CFR § 1910.213 (c)(1) and (d)(1)] to address point of operation injuries. A spreader [29 CFR § 1910.213 (c)(2)] and antikickback devices [29 CFR § 1910.213 (c)(3)] are required to address the kickback hazard.

The OHSA requirements for blade guard, spreader, and antikickback devices are essentially identical to the requirements in UL 987. The OSHA regulations for table saws do not have a requirement for riving knives.

OSHA regulations do require inspection and maintenance of woodworking machinery. Unsafe saws must be immediately removed from service [29 CFR § 1910.213 (s)(1)], emphasis must be placed on the effective functioning of guards [29 CFR § 1910.213 (s)(6)], and push sticks must be provided at the work place [29 CFR § 1910.213 (s)(9)].

7. Evaluation of Petition for Rulemaking

A. Can Hazard Be Addressed by Requested Action

CPSC staff believes the blade contact hazard associated with table saw use can be addressed by performance requirements. Contact with a spinning blade can cause severe injuries such as amputations, bone and tendon damage, nerve damage, and severe laceration. These injuries result in hospitalization rates more than twice the average rate for all consumer products, and they result in high overall cost of injury.

According to a 2001 NEISS-based special study on stationary power saw-related injuries, there were an estimated 16,000 emergency room treated injuries due to table saw operator blade contact where kickback of the material was not involved. From these 16,000 injuries, the Injury Cost Model (ICM) estimates that there are 32,300 total medically treated operator blade contact injuries where kickback of the material was not involved. CPSC staff review of the survey responses in the special study indicates that many victims described blade contact injury caused by a lapse in attention while performing normal operations at a table saw. Some information suggests that a typical feed rate when cutting wood is 10 to 20 feet per minute, or 2 to 4 inches per second -- which is significantly slower than the petitioners' proposed feed rate of 12 inches per second.[20] Therefore, staff believes that most of these injuries could be addressed by performance requirements (see "Feed Rate" discussion in Section 8 of this memorandum).

There were an estimated 9,300 emergency room treated injuries due to table saw operator blade contact where kickback of the material was involved. CPSC staff review of the survey responses in the special study indicates some victims described being startled by material kickback, which caused a hand to slide or be drawn into the table saw blade. Staff believes that many of these injuries could be addressed or appreciably mitigated by performance requirements similar to those proposed in the petition. In addition, there were an estimated 3,000 emergency room treated injuries where it is not known if kickback of the material caused the operator to make contact with the saw blade. Staff also believes that some of these injuries could be addressed or appreciably mitigated by performance requirements.

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[20] Machacek, J. (August 2003). Comment Letter. Comment CC 03-1-37 on Petition Requesting Performance Standards for a System to Reduce or Prevent Injuries from Contact with the Blade of a Table Saw.

B. Feasibility of Performance Requirements

In July 2001, CPSC staff tested and evaluated a prototype table saw equipped with a detection/reaction technology. The staff noted concerns such as false tripping, proof of viability, and robustness of electrical and mechanical parts, but concluded that a performance based concept was technically feasible.[21] A cabinet saw incorporating detection/reaction technology is now available in the marketplace.

C. Will Compliance to the Voluntary Standard Address the Risk

The current voluntary standard for table saws, UL 987 *Standard for Stationary and Fixed Electric Tools*, includes requirements for a splitter, blade guard, and antikickback device to address the hazard posed by contact with the saw blade. To address concerns raised by CPSC staff and others, the voluntary standards body recently added requirements for a riving knife that may reduce certain kickback conditions that can result in unexpected blade contact. However, a riving knife will not address the blade contact injuries that were not caused by kickback of the material, which accounted for an estimated 32,300 total medically treated injuries in 2001 and approximately $971 million in societal costs.[22]

CPSC staff does not believe compliance with the voluntary standard will adequately reduce the risk of operator blade contact injury because: 1) severe injuries continue to occur on table saws that meet the current voluntary standard and, 2) an addition to the standard of a riving knife requirement will not adequately address the blade contact injuries that are not caused by kickback of the material.

D. Can Consumer Blade Contact Injuries Be Reduced To A Sufficient Extent by OSHA

The current OSHA requirements for table saws are essentially identical to those of the current voluntary standard for table saws in regards to mandatory blade guard, splitter, and antikickback device. The OSHA requirements do not require a riving knife (this requirement was recently added to UL 987).

CPSC staff does not believe compliance with the OSHA requirements will adequately reduce the risk of operator blade contact injury because: 1) the requirements are essentially identical to those in the current voluntary standard for consumer table saws, which do not adequately reduce the risk of operator blade contact injury, and 2) the OSHA requirements that do ensure a safer work environment in the professional setting, such as mandatory use of safety devices, are not applicable in the home wood working environment where OSHA does not have jurisdiction.

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[21] Paul, C. (July 2001). Memorandum. Evaluation of Prototype Tablesaw Safety Device. U.S. Consumer Product Safety Commission: Bethesda, MD. (TAB D)

[22] The societal costs may be higher depending on how many of the unknown blade contact injury cases were also not caused by kickback of the material.

8. Comments Received on Petition

The Commission published a Federal Register (FR) notice (68 FR 40912) on July 9, 2003, soliciting written comments from interested parties on the petition. The comment period was extended to November 7, 2003, at the request of the Power Tool Institute.

The Commission received 69 comments in response to the FR notice. Twenty-six comments expressed support for the petition, with many commenters sharing their personal experiences with blade contact injuries. Forty comments expressed opposition to the petition. The most comprehensive comment in opposition to the petition was from the Power Tool Institute (CC 03-1-62). Three comments provided supplementary information to previous comments.

The issues raised in the comments include the following: the veracity of the information in the petition, the Commission's jurisdiction in accordance with the Consumer Product Safety Act (CPSA), the motives of the petitioners, the cost to benefit ratio of the proposal, the role of the voluntary standards, the creation of a monopoly for the petitioners and their resulting financial gain, specific alleged shortcomings of the petitioners' technology, and the necessity of the performance requirements requested by the petition.

A summary of the CPSC staff's responses to the primary issues is included below. The numbers found in parentheses after a comment refer to the comment number assigned by the Office of the Secretary (OS); copies of the comments are available from OS.

1. NEISS Data

Comment: The Power Tool Institute (PTI) (CC 03-1-62) questions the system and methods used to estimate a national average for injuries. Specifically, PTI states that the average of 30,000 injuries associated with table saws in 2001 was based on only 692 actual injuries. PTI asserts that the experience of its members suggests that the actual number of related table saw injuries per year is far less than the totals extrapolated from the NEISS incident reports. In addition, PTI states that of these 692 injuries, 30% did not involve blade contact.

Response: The NEISS data system is a probability sample of hospital emergency departments in the U.S. and its territories. Data collected by NEISS is weighted to produce national estimates of the number of consumer product-related injuries treated in hospital emergency rooms. NEISS uses well-established statistical methods by which estimates are derived from statistical samples and is recognized as an authoritative source of injury estimates in the U.S. Statistical sampling uncertainties or errors, inherent in all sampling systems, are quantified in terms of a coefficient of variation. The coefficient of variation has been provided for all injury estimates in this briefing package.

Additionally, the NEISS data provide a source for follow-up investigations of product-related injuries. The special study on stationary saws that CPSC staff conducted in 2001 provided the most accurate statistics available because it included table saw incidents that were formerly coded as an unspecified power saw. With the additional information from the special study[23], more precise injury estimates for 2001 were computed. The total table saw related injury estimate was 38,000 emergency room treated injuries, the percentage of amputations was 15%, and the percentage of injuries that involved blade contact was 83%.

2. Proposed Requirements

Comment: Several comments (CC 03-1-56; 61; 62; 63) state that the requirements in the petition are design requirements that mandate the use of a particular technology. Commenters further state that the Consumer Product Safety Commission is prohibited from mandating design requirements pursuant to Section 7 of the Consumer Product Safety Act.

Response: Section 7(a)(1) of the Consumer Product Safety Act (CPSA) requires that safety standards issued thereunder be stated as "requirements expressed in terms of performance requirements." Thus, if a mandatory safety rule were promulgated, it would be expressed in terms of performance requirements that could presumably be met in a number of ways.

3. Technology Proposed by Petition

Comment: Several comments (CC 03-1-44; 45; 46; 47; 48; 56; 62; 63; 69) list shortcomings in the SawStop™ technology (a patented detection/reaction technology) - most notably, lack of proof of viability, false tripping of device, potential degradation of electrical and mechanical components, effects of braking force on components and blades, etc. The general argument is that this technology is too new and unknown to be forced onto manufacturers.

Response: The petition is a request for a performance standard to address table saw injuries and deaths and does not require a particular technology.

4. The Voluntary Standards Process

Comment: Several comments (CC 03-1-59; 61; 62; 63) state a voluntary standard exists for table saws and that the established voluntary standards process should be followed to effect any changes to the product. In particular, commenters expressed concern about a precedent of government regulation that dictates market actions.

Response: The Consumer Product Safety Act prohibits the Commission from promulgating a consumer product safety rule if compliance with an existing voluntary standard is likely to result in elimination or adequate reduction of the risk of injury in question. Available data indicate that severe operator blade contact injuries continue to occur on table saws that meet the current voluntary standard, which suggests that compliance with the voluntary standard may not adequately eliminate or reduce the risk of blade contact injury associated with table saws.

In January 2005, a requirement for a riving knife on table saws was added to the voluntary standard, but this safety feature is primarily intended to address kickback injuries. The

[23] Adler, P. (June 2003). Memorandum. Adjustment for Table Saw, Band Saw, Miter Saw, and Radial Arm Saw Estimates for Future Use. U.S. Consumer Product Safety Commission: Bethesda, MD.

requirement does not become effective until January 31, 2014 for currently Listed products and January 31, 2008 for new products submitted for investigation.

5. Patented Technology

Comment: Several comments (CC 03-1-2; 3-7; 11; 15; 16; 23; 39; 42; 44-26; 68-70) state that issuing a mandatory standard, such as that requested in the petition, would force manufacturers to use a patented technology. As such, the patent holders would have a monopoly and would realize a sizeable financial benefit. Many commenters expressed concern that the petitioners are seeking financial gain.

Response: Section 7(a)(1)) of the CPSA , 15 U.S.C. § 2056(a)(1), requires that any safety standard issued by the Commission be stated as "requirements expressed in terms of performance requirements." If the Commission were to find that a mandatory standard is reasonably necessary to reduce the risk of injury associated with table saw blade contact, it would issue performance requirements to address the hazard and would not favor any particular technology, patented or otherwise.

6. Feed Rate

Comment: Three comments (CC 03-1-37; 48; and 62) question the feed rate criteria of the petition. The PTI comment (CC 03-1-62) states that "injuries occurring as a result of kickback or falling into the blade will not be prevented by the proposal." In particular, PTI states that testing by their members indicates the approach velocity of the hand can be as high as 200 inches per second during kickback and as high as 60 inches per second when slipping or reaching over the table saw blade. Furthermore, PTI concludes that "a significant percentage of known table saw injuries will not be lessened or prevented by the proposed technology" because the NEISS data show slightly more than 50% of incidents involved non-kickback injuries and, of those, "many likely occurred under scenarios where the feed rate was more than 12" per second."

Response: CPSC staff recognizes that further study is needed to estimate the feed rate that would be encountered during actual operation of a table saw and the effect this feed rate would have on the efficacy of a performance standard.

A preliminary review of the available injury data indicates that severe injuries occurred in both kickback and non-kickback situations. The descriptions of the incident scenarios do not provide enough detail to ascertain the approach rate of the victims' hands to the saw blade. However, a review of the responses to the CPSC special study survey indicates that many of the victims experienced a lapse in attention while cutting a piece of wood or reaching over the saw blade. These descriptions suggest that the approach rate of the hand to the saw blade was not as extreme as the figures suggested by PTI. It would be misleading to assume that severe and costly injuries only occur in unique situations where the approach rate of the hand to the blade is extremely high and, therefore, would not be addressed. CPSC staff recommends that this issue be subject to further study and request for comment.

7. Cost of Technology

Comment: Several comments (CC 03-1-9; 11; 36; 62; 63; 67; 70) oppose the costs associated with adding a safety system, with many stating that the costs to implement a patented technology will outweigh the benefits of the system. In particular, PTI estimates that the costs for testing, retooling, and redesigning will range from $2 to $10 million per company. In addition to the cost of modifying existing table saw designs, the SawStop™ system, if used, would require replacement of a brake cartridge and possibly the saw blade once the system has been activated. These costs have been estimated at up to $69 for a brake cartridge and $100 for a new blade. Some comments express concern about these replacement costs.

Response: Further study of all elements of costs associated with a potential table saw performance standard will be necessary if the Commission elects to proceed with rulemaking.

8. Necessity of the Petition

Comment: Several comments (CC 03-1-9; 11; 14; 22; 38; 39) state table saw injuries are low or would not occur if proper safety practices were adopted; therefore, there is no need for a detection/reaction safety system.

Response: An estimated 34,000 injuries to operators of table saws were treated in emergency rooms nationwide in 2001, and approximately 28,300 of those injuries were due to blade contact. Lacerations, amputations, fractures, avulsions and crushings comprised the estimated 55,300 total medically treated injuries at a total societal cost of $2.13 billion. The injury trend associated with table saws has been stable from 1991-2002. Therefore, CPSC staff believes current safety practices are not sufficient to prevent costly injuries.

9. Optional Safety Systems

Comment: Several comments (CC 03-1-10; 41; 67) state that a safety system as requested in the petition should be offered as an option so that consumers may decide whether or not they want to pay the additional costs for such a system. One comment states that the SawStop™ system is already available on the market, which should be sufficient in providing consumers access to this safety system.

Response: Even with the safety system already on the market, substantial injury data leads staff to conclude that further investigation is warranted.

10. Alternative Technology

Comment: PTI has indicated in its comment (CC 03-1-62) that its members intend to enter a joint venture agreement to conduct research into the development of technology for a blade contact injury avoidance system for table saws.

Response: The Department of Justice published a notice in the Federal Register on December 1, 2003 stating that the Power Tool Institute Joint Venture Project had filed notifications, pursuant to section 6(a) of the National Cooperative Research and Production Act of 1993, 15 U.S.C.

4301 *et seq.* (68 FR 67216). The stated nature and objective of the venture are "the research and development of technology for power saw blade contact injury avoidance, including skin sensing systems, blade braking systems, and/or blade guarding systems."

PTI indicated that they intend to develop an enhanced safety system to address blade contact injuries. In June 2006, the Table Saw Mechanical Guarding Joint Venture submitted for consideration to Underwriters Laboratories Inc. (UL) and the Canadian Standards Association (CSA) proposed requirements that would allow for alternative blade guards. PTI has indicated that, assuming the UL and CSA processes proceed smoothly, it is anticipated that implementation by individual manufacturers could begin in 2007.

9. Options Available to the Commission

A. Grant the Petition and Initiate Rulemaking

If the Commission concludes that available information indicates that blade contact injuries on table saws may present an unreasonable risk of injury and that a mandatory rule may be required to address the risk, the Commission may grant the petition and begin the rulemaking process by directing the staff to prepare an Advance Notice of Proposed Rulemaking. Granting a petition in this manner and beginning a rulemaking proceeding does not mean that the Commission would necessarily issue a rule in the specific form requested in the petition.

B. Defer the Petition and Initiate a Project

If the Commission concludes that more information is required before a decision can be made to grant or deny the petition, the Commission may defer a decision and direct the staff to establish a project to collect additional information. This could include participation in voluntary standards activities related to development of requirements that would allow the proposed, alternative blade guards developed by the industry consortium and/or an evaluation of the effectiveness of such guards.

C. Deny the Petition

If the Commission concludes that rulemaking as requested in the petition is not reasonably necessary to eliminate or adequately reduce the risk of injury described in the petition, the Commission could deny the petition. If the Commission denied the petition, it would not be precluded from continuing to consider the matter of table saw blade contact injuries, including by mandatory rulemaking.

10. Staff Conclusion and Recommendation

Injuries on table saws that occur when the operator makes contact with the saw blade accounted for approximately 28,300 emergency room treated injuries in 2001. The injury trend associated with table saws has been stable from 1991-2002. From the 28,300 emergency room treated operator blade contact injuries, the Commission's Injury Cost Model (ICM) estimates 55,300 total medically treated blade contact injuries (this includes injuries treated in settings other than the emergency room such as ambulatory surgery centers, physicians' offices, or clinics) in 2001 with associated injury costs of $2.13 billion. The high societal costs are attributed to the large number of amputations (approximately 15% of the operator blade contact injuries) and the 11% rate of hospitalization, which is more than twice the 4.6% average hospitalization rate for all consumer products in 2001.

Many industry representatives believe that modification of consumer behavior through information and education campaigns could best address the hazard. Despite efforts by the table saw industry to educate consumers on the safe use of table saws, severe injuries continue to occur. Industry representatives have recently revised the voluntary standard for table saws to include a safety device that may be more effective at preventing kickback of the material during use of the table saw. CPSC staff supports this new requirement as an improvement to table saw safety but does not believe it will adequately address the blade contact hazard.

CPSC staff review of the injury data from its special study suggests that a large percentage of the operator blade contact injuries on table saws could be addressed by table saw performance requirements. The societal costs associated with these operator blade contact injuries (estimated at $2.13 billion in 2001) suggest that an effective remedy could generate net societal benefits over the lifetime of the table saws.

The Occupational Safety and Health Administration (OSHA) regulates table saw products and the workplace environment in which the products are used. The current OSHA product requirements on table saws are essentially identical to the requirements in the voluntary standard in terms of providing an adjustable blade guard and some type of spreader (device that prevents the cut material from binding the saw blade). CPSC staff does not believe the OSHA regulation will adequately address the blade contact hazard to consumers because: 1) The current OSHA requirements for table saws are identical to existing voluntary standard requirements, and 2) OSHA does not have jurisdiction in the home wood working shop and, therefore, cannot enforce a safe work environment and proper safety training for all users of table saws.

CPSC staff recommends granting the petition to the extent it requests the Commission to proceed with a rulemaking process that could result in a mandatory safety standard for table saws to reduce the risk of blade contact injury.

TAB A

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: June 26, 2006

To : Caroleene Paul
Project Manager
Petition CP03-02
Power Saw Performance Standard

Through Hugh McLaurin
Assistant Executive Director
Engineering Sciences

From : Robert B. Ochsman, Ph.D., CPE
Director
Human Factors Division

Subject : Petition Requesting Performance Standards for a System to Reduce or Prevent Injuries From Contact With the Blade of a Table Saw (Petition CP03-02)

The objective of this memo is to provide a Human Factors (HF) analysis of table saws related to Petition CP03-02. Specifically, this analysis addresses HF safety-related attributes of table saws, the environment in which table saws are used, and the attributes of typical users of table saws that are relevant to their safe use.

Basic Distinctions between Table Saws

Home table saws may be characterized as either bench top saws, contractor saws, or cabinet saws. However, they are all commonly referred to generically as "table saws."

- ***Bench top saws**:* These are the smallest, lightest, and least expensive type of table saw. They are designed to be easily moved around and temporarily placed on a work bench or stand for use. Bench top saws are often the first table saws purchased by the inexperienced home woodworker but are also used by contractors to haul a saw from job to job for light work.

- ***Contractor saws**:* These saws are characterized by having a set of light duty legs and a bigger table and motor than bench top saws. They are generally quieter, more accurate, and able to cut soft woods up to about two inches thick, hard woods somewhat less. They are still light enough, however, for contractors to haul and set up at job sites. They are commonly used by home wood workers, as these saws are capable of high quality work and are commonly found at mass merchandisers. If these saws are carefully set up and calibrated, they may be used in professional cabinet shops for light duty work.

- ***Cabinet saws:*** Cabinet saws are typically used by the advanced home woodworker. Cabinet saws are heavier than contractor saws, have high quality fences, single phase electric motors, and saw dust ports. They are termed "cabinet" due to the closed structure of the saw base. This construction makes for a more solid and stable saw and is more effective for saw dust collection, as well as minimizing vibration and noise. Also, the saw arbor in a cabinet saw is usually bolted to the cabinet itself facilitating easier and more precise alignment of the arbor as compared to contractor saws in which the arbor is bolted to the saw table. The term "cabinet" does not refer to the type of workplace for which the saw is designed. Cabinet saws in the $1200 to $3000 price range are typically the highest grade saw found in the home woodworking shop. They are capable of performing all table saw operations required by the home woodworker and are capable of some light duty production work in a professional shop.

Production table saws are typically massive, very heavy and not found in the home shop. They are designed with very large extension working surfaces, 12" blades, and heavy duty 3-phase motors greater than 5 horsepower. They are used in production facilities, factories, and cabinet shops. They are designed to accommodate power feeds if needed. They are robust enough to continuously saw very thick wood stock and are designed for continuous operation.

Characteristics of Home Table Saw Users:

The table saw is the one power tool that almost all serious home woodworkers acquire. It is used for more woodworking operations than any other power tool in the home wood shop. Indeed, many home woodworking projects may be completed using only this tool.

Once a homeowner purchases a table saw, there are no controls on the use of the product and no oversight from that point forward. There are no training or experience requirements.

Table Saw User Experience and Training: This tool is often the first or second large power tool purchased by the amateur woodworker. Some common table saw operations such as cross cuts are not particularly complicated, and the new user will probably learn to do these simple operations very quickly. This will quickly engender confidence in one's ability to safely operate the saw. However, increasingly complicated operations such as ripping, cutting tapers, cutting sheet goods, simple and compound miter cuts and dados require more precise set-up and advanced techniques such as the use of jigs. These operations are well within the capabilities of more advanced amateur woodworkers, but they do require some experience or training to perform safely. Very few hobby woodworkers obtain any kind of formal training in table saw use. The potential dangers of some of the more complicated operations, such as kick-back, may not be apparent to the inexperienced user. Therefore, these hidden potential dangers pose a greater threat to the home user than an experienced or professional user.

***User Performance Attributes**:* Woodworking can be a life-long hobby that is attractive for middle age and more senior amateurs. These older wood workers may have sensory, perceptual, or cognitive deficits that will affect their performance with these machines and, therefore, impact safe operation. Safe table saw operation requires healthy vision and depth perception, well functioning eye-hand coordination, complex decision making, accurate memory, hearing, and, at times, moderate or greater strength.

Frequency of Use: The home table saw may be used infrequently or in spurts. It may only be used on weekends or for the occasional project that requires this tool. The essential point is that the home woodworker is rarely a constant, everyday user of the tool. Therefore, most home woodworkers are frequently going to be "rusty," even if they are experienced. When using the tool again after a few weeks or even months have passed, the operator may have lost some of the mental "precision" needed to operate the saw safely, even though the self-perception is one of confidence.

Professional Saw Users versus Home Hobby Users: All of the personal attributes outlined above (experience, training, personal performance attributes, and frequency of use) tend to sharply differentiate the home hobbyist from the professional. Amateur woodworkers will have little or no safety training nor training in the proper use of the table saw. They will typically have far less experience, may have physical attributes that are not conducive to safe operation of the saw, and may use the saw infrequently.

Inexperienced or untrained home users may not comprehend their lack of knowledge or experience in operating their table saw. They may discover dangerous or difficult operations only by actually experiencing near accidents or problems. They may have no or little knowledge about how to properly set up and operate the saw to perform more complex types of operations. Typically, they will have no training or oversight by experienced woodworkers.

Professional wood workers in an industrial setting will typically have been trained extensively on both safety practices and the proper use of the tool. They will have had training and be experienced in performing any special or complex operations with the saw. Due to their deep experience, they will recognize situations and set-ups that may be dangerous or require extra care and attention. Safety equipment such as safety glasses, gloves and boots will be required and available.

Environmental Attributes

Lighting: Home table saws are commonly placed in basements, garages, or small outbuildings. These are locations for which lighting, temperature, ventilation, saw dust control, and adequate space may be compromised. Perhaps the most critical physical attribute of the workplace is lighting. Inadequate lighting may severely compromise safe use of the table saw. Basements and garages may require supplemental lighting for safe table saw use, and older users or any user with poor vision would require even more lighting. Inadequate lighting may make it more difficult for the user to easily see the spinning blade or may require the user to place the eyes close to the spinning blade while sawing.

Clearance: Given the large space requirements for many table saws and the often limited space available in home basement or garage workshops, the tale saw operator may have to operate the saw in cramped conditions. This may force the operator into introducing wood pieces into the blade in orientations that are unsafe. For safest operations, table saws require a rather large footprint around the tool to enable the woodworker to freely manipulate and orient large or awkward pieces of wood.

Distractions: The home work shop in the basement or garage means that other family members and pets will have access to this shared space. The presence of children or pets may significantly draw the operator's attention away from the machine. Safe operation of the saw requires users to concentrate and be fully focused on sawing operations. A moment's distraction can mean contact with the blade.

Industrial Wood Working Settings: The factors described above are more tightly controlled in a professional wood shop or manufacturing setting due to safety codes, laws/regulations, insurance company inspections and, potentially, Occupational Safety and Health Administration (OSHA) inspections. For example, OSHA regulations specifically require that "[E]mphasis is placed upon the importance of maintaining cleanliness around the woodworking machinery, particularly as regards the effective functioning of guards" [§ 1910.213 (s)(6)], and that [P]ush sticks or push blocks shall be provided at the work place in the several sizes and types suitable for the work to be done." [§ 1910.213 (s)(9)]. In many production environments where a specific cut is performed continuously, guards and safety cut-off switches are custom designed for that set up. The area is specifically designed to be as safe as possible, and safety is a continuous focus through warning/instruction signs. Posters are often displayed throughout the work area.

The workplace environment is subject to spontaneous inspections by OSHA inspectors at any time. Violations of OSHA workplace safety regulations carry a heavy fine. These inspections can take place in permanent establishments, such as a cabinet-making shop, and temporary job sites, such as at residential or commercial construction projects. The prospect of being fined for safety violations increases the likelihood that workers or supervisors will ensure that safety systems, such as blade guards, are left in place.

A professional work setting for a table saw most likely will have adequate lighting directed toward the work surface, marked clearance lines around the saw to ensure that the operator has plenty of space to work safely, minimum distractions, and regular policing of the area to ensure a safe tool use environment.

Table Saw Safety Features

Machine safety features may be classified as active or passive. That is, an active safety device would require the machine operator to actually perform some behavior in order to activate or invoke the safety feature. For example, some machines in a production environment require the user to wear special hand or wrist harnesses to literally pull their hands out of the path of moving blades or punches. If the operator fails to put the harness on, the safety feature is completely overridden. Users will be more prone to override or somehow deactivate machine safety features when those features require the operator to perform additional steps, make the operation more difficult or awkward, take more time to do than performing that same operation without the safety device, occlude a clear view of the operation itself, or in any way make the work more difficult or slower.

Safety features that are passive require no active intervention on the part of the user of the device. Their operation is invisible to the user and doesn't impact the speed or ease of performing an operation in any way. An automobile air bag is an example of passive protection.

Most table saw safety features require intervention by the user. The intervention may only be initial set-up and adjustment for some blade guards. Other guards may require removal and replacement, depending on the saw operation being performed.

Principles of good safety engineering eliminate hazards from the design of a product whenever possible. Passive safety features should be incorporated if hazards are not eliminated from a product. Active safety features are less effective as they are totally dependent upon the user, and even the most diligent and highly motivated user may, from time to time, overlook or forget to use such a safety feature. Some hazards will only be addressed by warning labels, training materials, and instructions to alert users to the hazards.

Most home table saws have active safety features in which design and engineering require more operator time, attention, and "fiddling" than would be necessary with more refined designs. Some saw features which contribute to safety, such as inserts, are often not supplied in a range of sizes. Therefore, the user may make do with only one insert and, therefore, subject himself to unnecessary danger. Blade guards may be poorly constructed and time consuming to remove and replace.

The proper set-up, adjustment, and operation of safety features that are supplied with table saws may not be obvious to the inexperienced home craftsman. Often, careful attention to the instructions is necessary for proper use of the safety features on a table saw. Since the saw may be successfully used repeatedly without knowledge of the proper use of the safety features, the home table saw user may come to devalue the need to use these safety features.

Conclusion:

From a Human Factors safety perspective, the use, user, and environment of table saws are significantly different in the home versus the industrial setting. The professional wood worker is trained and experienced in safe table saw practices and uses the tool in a safe environment which expects and monitors safe tool use. By contrast, the home user lacks the experience and focus on safety and may use the saw in situations that detract from safe practices.

TAB B

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: April 12, 2005

TO : Caroleene Paul, ESME
Directorate for Engineering Sciences

THROUGH: Russell Roegner, PhD, RR
Director, Division of Hazard Analysis
Acting Associate Executive Director, Directorate for Epidemiology

FROM : Natalie Marcy
Division of Hazard Analysis

SUBJECT : Data Analysis for Petition CP 03-2, Table Saw Blade Contact Deaths and Injuries

This memo was prepared in response to the petition, requesting that the CPSC issue performance standards for a system to reduce or prevent injuries from contact with the blade of a table saw. The primary source of data in this analysis is from the 2001 NEISS based special study of stationary power saw-related injuries. Death reports have also been reviewed.

Special Study on Stationary Saws
(October 1, 2001 – December 31, 2001)

This report on stationary saw-related injuries is based on information gathered from NEISS (National Electronic Injury Surveillance System) between October 1, 2001 and December 31, 2001[1]. NEISS cases reported with product codes for table saws; band saws; radial arm saws; powered hack saws; saws, not specified; other power saws; and power saws, not specified were automatically assigned for follow-up investigations. As a result of the follow-up investigations, the injuries involving unspecified saws (43% of the annual stationary saw estimate) were re-distributed among the specified saw categories. After this re-distribution, table saws accounted for 38,000 injuries (73%) out of 52,000 total stationary saw-related injuries treated in U.S. hospital emergency rooms for the calendar year 2001.

An estimated 34,000 injuries were associated with table saw operators in 2001. Of those, 28,300 injuries (83%) involved blade contact, which is the hazard pattern of particular interest to this petition. Virtually all of the table saw operator blade contact-related injuries were sustained by consumers (only 5 cases out of 120 cases were identified as work-related). However, since both consumers and workers possibly use the same high and low end table saws potentially in the same manner, work-related injuries were not removed from the injury estimates. The majority of the remaining injuries sustained by table saw operators involved kickback of the material being cut.

The majority of the table saw operators who sustained blade contact-related injuries (56%) were 51 years of age or older and the ages of the victims ranged from 15 to 69 years old. Almost all (94%) of the injuries were sustained to the finger(s) and the majority (65%) of the injuries were lacerations. Amputations were the second largest type of injury sustained by the operators (15%). The remaining injuries were fractures, avulsions, and crushings. The rate of hospitalization was 11%[2] and all of these hospitalized injuries were related to fingers. Men accounted for 96% of the injuries. The Injury Cost Model (ICM) was used to generate an estimate of the total number of medically treated injuries and the associated cost components[3] for blade contact-related injuries of table saw operators (Table 1).

Table 1: Blade Contact-Related Injuries of Table Saw Operators, 2001

	Estimate	95% Confidence Interval[4]
ER-treated injuries	28,300	(19,900, 36,700)
All medically-treated injuries	55,300	(38,800, 71,800)
Total medically-treated injury costs	$2.13 billion	($1.50 billion, $2.76 billion)[5]

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2002 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

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[1] Some of the discussion of the special study is taken from a Memorandum from Prowpit Adler to Caroleene Paul[1]. Some additional analysis was also performed for this memorandum using the data obtained through the special study. This memorandum is included as Appendix A.

[2] The average rate of hospitalization for all NEISS products in 2001 was about 4.6%.

[3] See the methodology section for more information on how these estimates are derived.

[4] CV = .152 [2]

[5] The confidence interval for injury costs is derived by applying an average injury cost to the confidence interval for medically treated injuries.

Of the 28,300 blade contact-related injuries sustained by table saw operators, 16,000 of the injuries do not involve any type of kickback (Table 2). There were 9,300 blade contact-related injuries that did involve kickback. In the remaining 3,000 injuries, the reason why the operator came into contact with the blade is unknown. Amputations and hospitalizations occurred with both kickback and non-kickback related injuries.

Table 2: Blade Contact-Related Injuries of Table Saw Operators, 2001

	Estimate	95% Confidence Interval[6]
KICKBACK		
ER-treated injuries	9,300	(5,700, 12,900)[7]
All medically-treated injuries	17,900	(11,000, 24,800)
Total medically-treated injury costs	$730 million	($448 million, $1,012 million)
NON-KICKBACK		
ER-treated injuries	16,000	(11,500, 20,400)[8]
All medically-treated injuries	32,300	(23,300, 41,300)
Total medically-treated injury costs	$971 million	($701 million, $1,241 million)

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2002 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

The adjustment factor used to redistribute the unspecified saw-related injuries in 2001 was also used to redistribute the unspecified saw-related injuries in 2002[3]. Thus, the estimated number of table saw-related emergency room-treated injuries in 2002 is 38,980. Both the 2001 and 2002 estimates increased roughly 6,000 injuries from the original NEISS estimate, as a result of the redistribution. The injury trend associated with tables saws has been stable from 1991 – 2000[9]. This trend continues through 2001 and 2002.

[6] The confidence interval for injury costs is derived by applying an average injury cost to the confidence interval for medically treated injuries.

[7] CV = .191 [2]

[8] CV = .142 [2]

[9] The year-to-year comparisons of injury estimates were not statistically significant. [4]

Fatalities

The Commission has received reports of 10 deaths involving a table saw from 1991 to August 2004. Two of them involved blade contact and are relevant to the petition. A 67 year old man died from a massive heart attack after he severed three fingers using an industrial type table saw (8/13/97). A 57 year old man died three days after the incident in which his left hand was traumatically amputated (12/25/01).

Response to Comment Submitted by PTI

The Power Tool Institute, Inc. (PTI) submitted a comment to petition CP 03-2. Within their comment, they cite a number of injury statistics. They state that there are, on average, 30,000 emergency room-treated injuries related to table saws each year. While this is true according to raw NEISS data, more precise injury estimates for 2001 (38,000) and 2002 (38,980) have been computed as a result of the special study. They stated that 10% of the injuries in 2001 are amputations, which is slightly lower than the proportion found through the special study (15%). PTI states that 30% of the table saw-related injuries do not involve blade contact which is almost twice the proportion found through the special study (17%). They also state that in between 73% and 85% of the table saw hand/arm accidents, the blade guard is not in place. It is unclear where this statistic came from because the special study found that in 50% of the injuries to stationary saw operators, the blade guard was damaged, removed, broken off, or the stationary saw never had a blade guard[1]. In 28% of the injuries, the presence of a blade guard is unknown. The rest of the injuries, 22%, involved stationary saws with a blade guard attached. The presence of a blade guard cannot be determined from the raw NEISS data, so the stationary saw special study is the best statistic available. PTI also brings into question the accuracy of the NEISS estimates because of the sample size. The coefficient of variation (CV) on the NEISS estimates takes the sample size into account and can be used to produce a confidence interval on the estimate. The CV for the blade contact-related injuries of table saw operators was computed and the 95% confidence interval has been provided.

Methodology

National Electronic Injury Surveillance System (NEISS)

The Commission operates the National Electronic Injury Surveillance System, a probability sample of about 100 U.S. hospitals with 24-hour emergency rooms (ERs) and more than six beds. These hospitals provide CPSC with data on all consumer product-related injury victims seeking treatment in the hospitals' ERs. Injury and victim characteristics, along with a short description of the incident, are coded at the hospital and sent electronically to CPSC.

Because NEISS is a probability sample, each case collected represents a number of cases (the case's *weight*) of the total estimate of injuries in the U.S. The weight that a case from a particular hospital carries is associated with the number of hospitals in the U.S. of a similar size. NEISS hospitals are stratified by size based on the number of annual emergency-room visits. NEISS comprises small, medium, large and very large hospitals, and includes a special stratum for children's hospitals[5].

The weights from the cases that were successfully contacted during the follow-up investigations were adjusted for the non-responses using the method of raking. The annual estimates of injuries are based on these adjusted weights.

Injury Cost Model (ICM) [6]

The Injury Cost Model (ICM) is a computerized analytical tool that uses NEISS data to estimate the total number of medically treated injuries and measure the direct and indirect costs associated with consumer product-related injuries. NEISS gathers data on nonfatal injury victims (injury survivors) treated in hospital emergency room departments (ERs) or admitted through the ER. Survivors could be treated in many other settings including ambulatory surgery centers, physicians' offices and clinics, or company clinics. In addition, a few injury survivors are admitted to the hospital directly, by-passing the ER (and the NEISS system). These survivors may be transferred from a walk-in clinic or doctor's office, or they may be triaged by emergency medical services to a specialty hospital that lacks an ER but directly admits victims of severe trauma. The ICM estimates the number of injury survivors who were treated in places other than emergency departments and the costs of their injuries.

ICM cost estimates consist of four parts: medical costs, work losses, quality of life and pain and suffering costs, and product liability insurance administration and litigation costs. These estimates are diagnosis specific (meaning they vary by body part injured and nature of injury diagnosis), vary by age and sex of the victim, and also vary depending on the highest level (also called setting) where medical treatment was received. The intangible cost estimates are based on a statistical analysis of jury verdicts.

Fatalities

CPSC purchases death certificates from all 50 states, New York City, the District of Columbia and some territories. Only those certificates in certain E-codes (based on the World Health Organization's International Classification of Diseases ICD-10 or ICD-9 systems) are purchased. These are then examined for product involvement before being entered into CPSC's death certificate database. The result is neither a statistical sample nor a complete count of product-related deaths. The database provides only counts of product-related deaths from a subset of E-codes. For this reason, these counts tend to be underestimates of the actual numbers of product-related deaths.

Injury or Potential Injury Incident Data Base (IPII) is a CPSC database containing reports of deaths, injuries, or potential injuries made to the Commission. These reports come from news clips, consumer complaints received by mail or through CPSC's telephone hotline or web site, Medical Examiners and Coroners Alert Program (MECAP) reports, letters from lawyers, and similar sources. While the IPII database does not constitute a statistical sample, it can provide CPSC staff with guidance or direction in investigating potential hazards.

To obtain a count of reported fatalities, death certificate data and fatalities reported through IPII are combined and the duplicate records are eliminated.

Investigations from the Special Study Used For This Analysis:
Table saw operator blade contact-related injuries

011208HEP2722	kickback
011212HEP6743	kickback
011218HEP6721	kickback
011007HEP5761	kickback
011029HEP2367	kickback
011104HEP5921	kickback
011108HEP8854	kickback
011113HEP5921	kickback
011210HEP7063	kickback
011221HEP5282	kickback
011127HEP6002	kickback
020106HEP5761	kickback
011007HEP5123	kickback
011010HEP1281	kickback
011022HEP8013	kickback
011023HEP0161	kickback
011023HEP3361	kickback
011028HEP8079	kickback
011029HEP6641	kickback
011101HEP4081	kickback
011102HEP8035	kickback
011102HEP8036	kickback
011106HEP7361	kickback
011108HEP2722	kickback
011119HEP8035	kickback
011125HEP8854	kickback
011204HEP6743	kickback
011215HEP5761	kickback
011222HEP2321	kickback
011227HEP1121	kickback
011227HEP3041	kickback
020102HEP6743	kickback
020102HEP7064	kickback
011214HEP1041	kickback
020107HEP1401	kickback
011105HEP7281	kickback
011204HEP6721	kickback

011115HEP0321	non-kickback
011209HEP6641	non-kickback
020109HEP8141	non-kickback
011016HEP5282	non-kickback
011025HEP5761	non-kickback
011106HEP3361	non-kickback
011107HEP6721	non-kickback
011108HEP0401	non-kickback
011113HEP4081	non-kickback
011126HEP0641	non-kickback
011210HEP8013	non-kickback
011211HEP5041	non-kickback
011215HEP5762	non-kickback
020101HEP0401	non-kickback
011012HEP2721	non-kickback
011003HEP5122	non-kickback
011006HEP0481	non-kickback
011025HEP0721	non-kickback
011113HEP1441	non-kickback
011113HEP7064	non-kickback
011115HEP5761	non-kickback
011119HEP6743	non-kickback
011127HEP6721	non-kickback
011209HEP5121	non-kickback
011227HEP4081	non-kickback
020206HEP6401	non-kickback
011114HEP4801	non-kickback
011005HEP5121	non-kickback
011008HEP8767	non-kickback
011011HEP1121	non-kickback
011011HEP5602	non-kickback
011011HEP8141	non-kickback
011012HEP0641	non-kickback
011016HEP6002	non-kickback
011017HEP2402	non-kickback
011018HEP6721	non-kickback
011019HEP1121	non-kickback

011024HEP0481	non-kickback
011026HEP6001	non-kickback
011026HEP6722	non-kickback
011028HEP4084	non-kickback
011028HEP8854	non-kickback
011105HEP8876	non-kickback
011108HEP2721	non-kickback
011108HEP5761	non-kickback
011108HEP8142	non-kickback
011113HEP7063	non-kickback
011114HEP5281	non-kickback
011115HEP5763	non-kickback
011117HEP6002	non-kickback
011118HEP6001	non-kickback
011119HEP1121	non-kickback
011120HEP4081	non-kickback
011123HEP1761	non-kickback
011125HEP5763	non-kickback
011126HEP7063	non-kickback
011129HEP5761	non-kickback
011202HEP6001	non-kickback
011203HEP6983	non-kickback
011205HEP2365	non-kickback
011206HEP7063	non-kickback
011212HEP8013	non-kickback
011218HEP8832	non-kickback
011219HEP6743	non-kickback
011227HEP8898	non-kickback
011228HEP1041	non-kickback
011228HEP6721	non-kickback
020116HEP6401	non-kickback
011109HEP2241	non-kickback
011207HEP4241	non-kickback
011127HEP1042	unknown
011126HEP6001	unknown
011015HEP0402	unknown
011025HEP2161	unknown

011112HEP6722	unknown
020101HEP8079	unknown
020102HEP8722	unknown
011007HEP5601	unknown

011211HEP6401	unknown
011114HEP1841	unknown
011228HEP2241	unknown
011125HEP0961	unknown

011022HEP6743	unknown

References

1. Memorandum from Prowpit Adler to Caroleene Paul, "Injuries Associated with Stationary Power Saws, 2001" May 5, 2003 (Appendix A)

2. The data analysis and CV's for this paper were generated using SAS software, Version 8.02 of the SAS System. Copyright © 1999-2001 SAS Institute Inc. SAS and all other SAS Institute Inc. products or service names are registered trademarks of trademarks of SAS Institute Inc., Cary, NC, USA.

3. Memorandum from Prowpit Adler to The File, "Adjustment for Table Saw, Band Saw, Miter Saw, and Radial Arm Saw Estimates for Future Use." June 4, 2003 (Appendix B)

4. Prowpit Adler, "Table Saw Related Injuries and Fatalities (1991 – 2000)" February 4, 2002 (Appendix C)

5. Kessler, Eileen and Schroeder, Tom. *The NEISS Sample (Design and Implementation). U.S. Consumer Product Safety Commission.* October 1999

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Appendix A:
Injuries Associated with Stationary Power Saws, 2001

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: May 5, 2003

TO : Caroleene Paul, ESME
Directorate for Engineering Sciences

THROUGH: Susan Ahmed, Ph.D., AED RR for SA
Directorate for Epidemiology
Russell H. Roegner, Ph.D., Director RR
Hazard Analysis Division, EP

FROM : Prowpit Adler, EPHA

SUBJECT : Injuries Associated with Stationary Power Saws, 2001

This memorandum transmits a report on injuries associated with table saws, band saws, miter saws, and radial arm saws. The injury data is based on NEISS and its 2001 Special Study.

The Directorate for Epidemiology estimated that about 52,000 people were treated in U.S. hospital emergency rooms for injuries associated with table saws, band saws, miter saws, or radial arm saws in calendar year 2001. About 98 percent of the victims were saw operators. Contact with the saw blade was the major hazard to the operators followed by being hit by stock or cutting material. Almost all of the injuries were lacerations, amputations, fractures, or avulsions. Injuries to fingers accounted for about 83 percent of the total injuries. The rate of hospitalization was 5 percent. An additional 3 percent of injuries required overnight observation or were transferred to another hospital for observation.

1. Introduction

Based on CPSC's National Electronic Injury Surveillance System (NEISS), an estimated 93,880 saw-related injuries were treated in U.S. hospital emergency rooms for the calendar year 2001. About 36,400 injuries (39%) were associated with stationary saws[1]: table saws were predominant, followed by band saws, radial arm saws, and powered hack saws.[2] About 17,240 injuries (18%) were associated with portable or hand-held saws[3]. The remaining 40,240 injuries (43%) were reported to be associated with unspecified saws. Therefore, the number of injuries associated with stationary saws could have been larger if those unspecified saws were identified. In order to obtain the distribution of stationary saws (from the unspecified saws), follow-up investigations of the injuries were conducted between October 1, 2001 and December 31, 2001. The investigations also included injuries reported in NEISS to be associated with table saws, band saws, radial arm saws, and powered hack saws to obtain the nature and probable causes of the injuries which generally are not available from the NEISS reports.

2. Data Description – National Electronic Injury Surveillance System (NEISS)

NEISS is an injury data collection system. It was comprised of a probability sample of about 100 hospitals stratified into 5 strata - small, medium, large, very large, and children's hospitals (where the first four strata were stratified by hospital size) for the calendar year 2001. The system serves the Commission primarily in two ways. First, the NEISS provides national estimates of the number and severity of injuries associated with, but not necessarily caused by, consumer products and treated in hospital emergency departments. Second, the system serves as a means of locating victims so that further information may be gathered concerning the nature and probable cause of the incident. Information gathered from the NEISS and other sources guides the Commission in setting priorities for selecting types of products for further investigation and/or actions that may eventually lead to product modification or development of safety standards.

The report of stationary saw-related injuries is based on information gathered from NEISS between October 1, 2001 and December 31, 2001. Victims with injuries related to the NEISS product codes: 0841 (table saws), 0842 (band saws), 0843 (radial arm saws), 0844 (powered hack saws), 0845 (saws, not specified), 0863 (other power saws), and 0872 (power saws, not specified) were automatically assigned for the follow-up investigations. Of the total 450 assigned cases, 317 cases (70%) were successfully contacted[4]. Based on the results of the follow-up investigations, "stationary saws" in the report are comprised of table saws, band saws, radial arm saws, and miter saws. Powered hack saws were excluded because the investigations indicated that the injuries associated with this product (during the 3-month investigations) were actually associated with portable, electrical hack saws.

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[1] Excludes jigsaws and sabre saws because NEISS does not distinguish between stationary and portable reciprocating saws.
[2] NEISS does not have a product code for "miter saws" which are relatively new compared to other saws. The number of miter saws in the market has recently increased; they are very popular among non-professional users.
[3] Such as circular saws and reciprocating saws (jig or sabre).
[4] About 81 percent of the respondents participated while the remaining 19 percent only partially participated.

The weights from those cases that were successfully contacted during the follow-up investigations were adjusted for the non-responses (failure-to-contact cases) by stratum and product code. The adjusted weights were computed using the method of raking [1] where the NEISS estimated marginal total (for each product code across strata) was fixed. The annual and the 3-month estimates of injuries are based on these raking adjusted weights.

3. Product Definition [2]

A stationary saw is a powered tool that does not move because of its size or because of its type of operation. It is commonly bolted onto/mounted on/rested upon a stand or a base (as opposed to a hand-held, portable powered tool). The work is either fed into the blade (such as a table saw or a band saw) or the blade is moved onto the work (such as a radial arm saw or a miter saw) during the operation. Figure 1 – Figure 4 present a table saw, a band saw, a miter saw, and a radial arm saw, respectively.

Most power tools, especially stationary ones, are equipped with tool guards or safety devices that should be mounted following the manufacturer's instructions and maintained in good working order. The guard that covers the saw blade should be maintained so it lifts easily and allows work to pass while still covering the saw blade. Often, when a tool is designed for more than one job, the manufacturer makes available special guards to be used under particular circumstances. However, the data showed that the operators usually removed the guards when they did special cuts (other than simple cross cuttings or ripping).

A table saw has a saw blade projecting through a table on which the work is rested. The table has a laterally adjustable rip fence and is slotted to equip a wood rest/miter gauge. The wood rest/miter gauge keeps the stock at the proper angle to the blade during a cut. The operator holds the stock against the wood rest/miter gauge and advances both the gauge and the stock past the blade to make a simple crosscut. The rip fence is used in the procedure described as being a cut made parallel to/with the grain of the wood. A basic rip cut is done by placing the stock on the front edge of the table, flat down and snugly against the fence.

The typical band saw for use in a home workshop mostly has a size range of 10 to 14 inches. This dimension indicates the maximum depth of cut. The second capacity factor is the maximum distance between the table and the upper blade guides when they are at their highest point. This is the maximum thickness (height) of cut which, depending on the tool, can be anywhere between 4 and 6 inches. The saw is equipped with a continuous flexible blade or band, held taught around 2 or 3 wheels driven by a motor.

The typical miter saw is very much like a portable circular saw top mounted on its own stand. A pivot arrangement allows the tool to be swung down to saw material that is on the stand's table. That is why it is often called a "chop" saw. It is a tool usually used in miter cutting. It is not uncommon to find it used in industry and on a construction site to do cutoff on long pieces of material. The saw can be set for left-or right-hand cuts and most units have automatic stops for the most commonly used positions. The machine can be used to saw materials other than wood. With the proper blade, it can be used to cut metals or plastics.

The typical radial arm saw is a combination of a large stationary tool with the flexibility of a portable circular saw. With this machine the operator can swing, tilt, raise, lower the blade, and adjust the tool - stock relationship, comparable to hand held saw applications. On the radial arm saw, the work is set on the table against a fence. The saw blade is pulled through the stock to make all cuts.

Figure 1: Table Saw

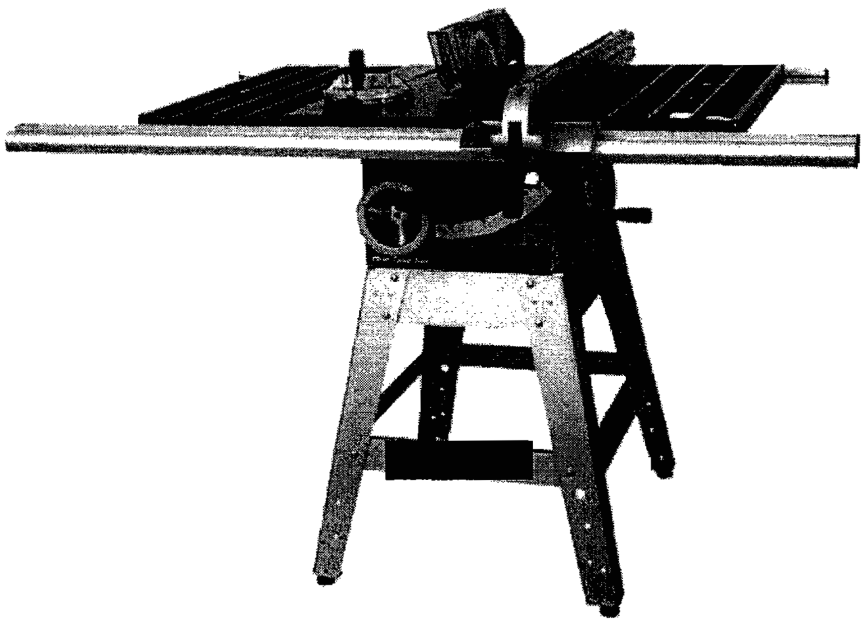


Figure 2: Band Saw

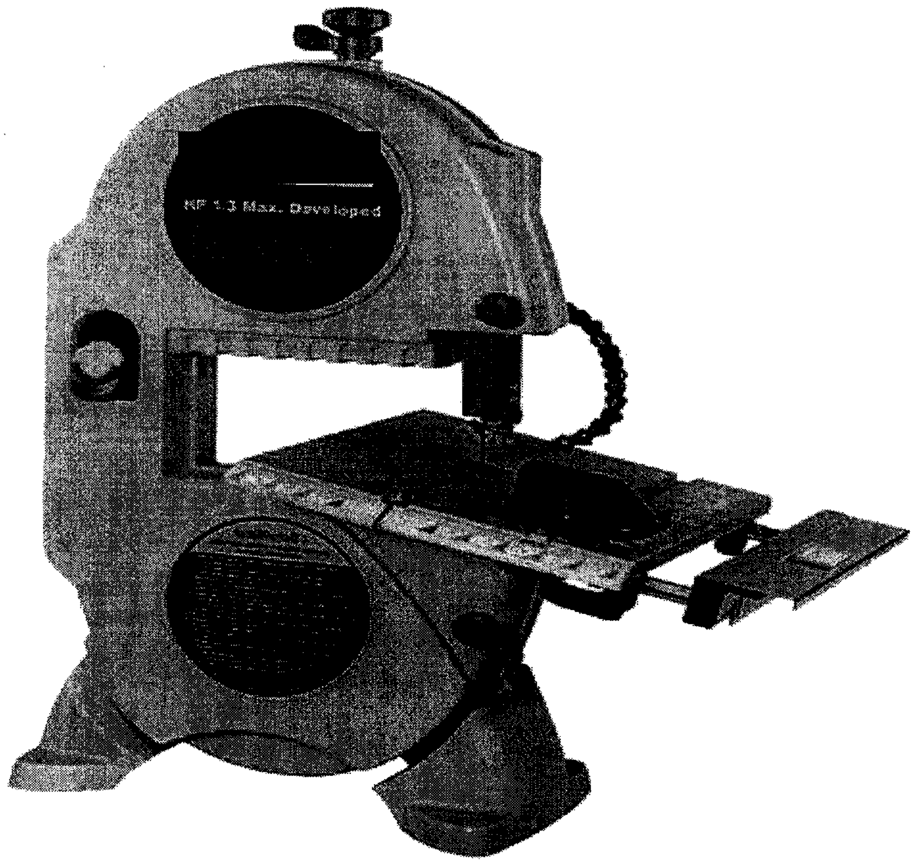


Figure 3: Miter Saw

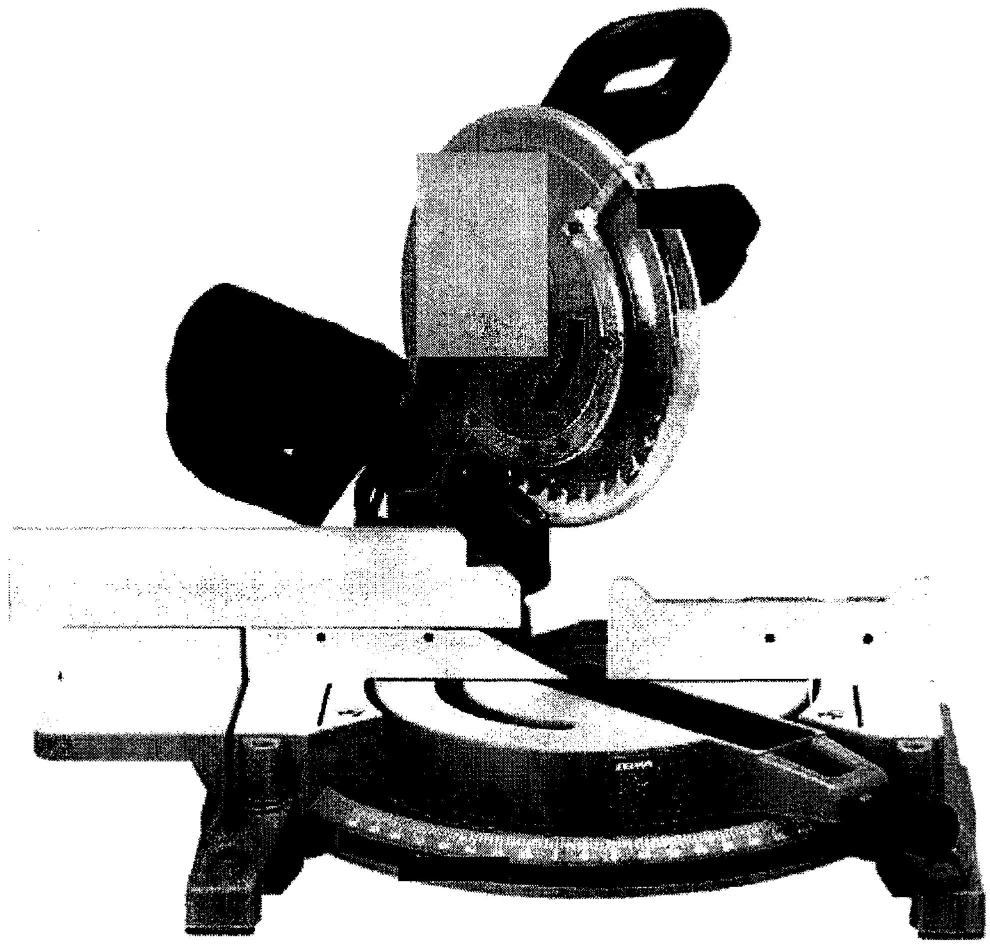
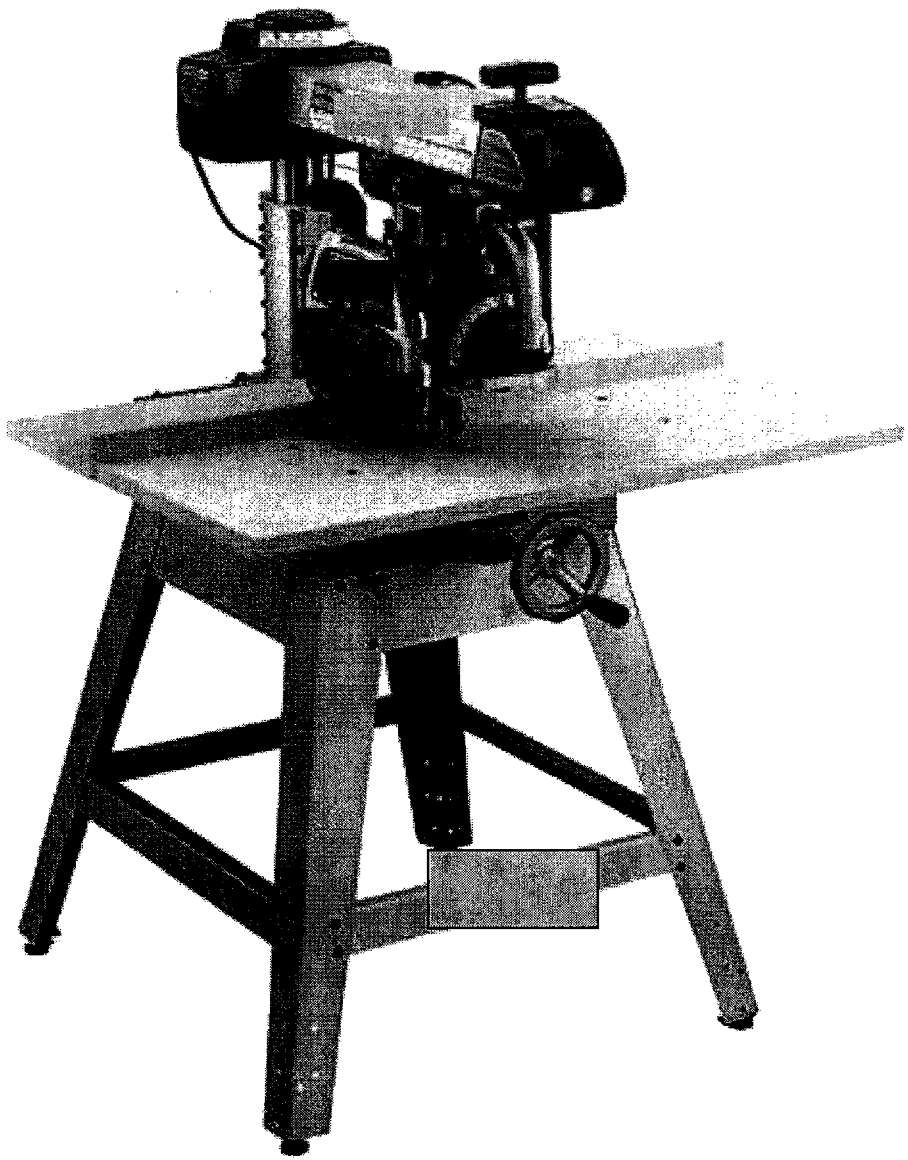


Figure 4: Radial Arm Saw



4. Types of Cuts[2]

A majority of the injuries reported in this study involved crosscutting or ripping; however, there were a few incidents that involved mitering, beveling, and dadoing. With the latter group of incidents, the operator usually took the blade guard off when performing these cuts in order to inspect his/her work closely. A description of the cuts that were performed by the operators (in this report) is presented below.

Crosscutting. A simple crosscut or cutting against the grain of the stock is made by placing the edge of the stock against a miter gauge and moving both the gauge and stock past the saw blade. The operator should be almost directly right behind the miter gauge so he/she will be out of line with the saw blade (as a safety precaution).

Ripping. A rip cut is performed by passing the stock between the blade and rip fence. Often, the procedure is described as being a cut made parallel to or with the grain of the stock. The basic rip cut is performed by placing the stock on the front edge of the saw table snugly against the fence and moving the stock past the saw blade.

Mitering. An angle cut that needs a miter gauge to facilitate the accuracy of the cut, such as cutting the stock for a picture frame. For this type of cut, the miter gauge was usually set at 45^{o} for cutting two matching segments of stock. When two such cuts are matched, the joint is called a miter. The actual cutting may be simple, but a high degree of accuracy is required for a good match.

Beveling. Most bevels are cut using the rip fence as a guide, while the blade (or table) is tilted to the angle required. Sometimes, the miter gauge is used when a cut is performed on a narrow stock because there is a tendency for the stock to move away from the fence.

Dadoing. This is done by setting a regular saw blade to less than the stock thickness and making repeated cuts to widen the normal kerf (channel/cut) and get a U-shaped cut that is a dado when done across the grain, a groove when done with the grain.

5. National Annual Injury Estimates[5]

Based on the investigations of the incidents occurring between October 1, 2001 and December 31, 2001 which allowed for the identification of "unspecified saws", the Directorate for Epidemiology estimated that there were about 52,000 injuries (CV = 0.12, n = 225)[6] treated in U.S. hospital emergency rooms associated with stationary saws for the calendar year 2001. (A data summary of the annual injury estimates and the victims' characteristics are presented in Table 1). About 38,000 injuries (73%) involved table saws, 7,640 injuries (15%) involved miter

[5] The word "injuries" in this report means "injuries treated in U.S. hospital emergency rooms".

[6] The weights from the successfully contacted cases were adjusted for the non-responses (or raked to the fixed marginal totals of the NEISS estimates by product code across strata). SUDAAN (Software for Statistical Analysis of Correlated Data)[3] was used to compute the coefficient of variations (CV).

saws, 4,060 injuries (8%) involved band saws, and 2,300 injuries (4%) involved radial arm saws[7].

Lacerations (68%), amputations (9%), fractures (9%), and avulsions (8%) were predominant and accounted for about 48,880 injuries for the calendar year 2001[8]. Most of the injuries were to fingers which accounted for about 43,160 injuries (83%)[9]. The rate of hospitalization was five percent[10] compared to the average rate of four percent associated with all consumer products reported through the NEISS system.

The average age of the victims was 51 years old with the youngest at 2 and the oldest at 91 years of age. About 7 out of every 10 victims were between 15 and 64 years old. About 1 out of every 4 victims were 65 years or older. Men accounted for about 95 percent of the total injuries. About 51,000 injuries (98%) were associated with the saw operators.

In the following sections, many of the estimates provided for finer characterizations of the data are based on small sample sizes (with asterisk), and therefore have large variability associated with them. However, these estimates provide information which is generally not available from the NEISS reports.

6. Special Study and Specific Information Related to Injuries

Based on the same follow-up investigations (October 1, 2001 – December 31, 2001), an estimated 14,300 injuries (CV = 0.12, n = 225) were treated in U.S. hospital emergency rooms for injuries associated with stationary saws: table saws (74%), miter saws (13%)*, band saws (9%)*, and radial arm saws (4%)* for this 3-month period.

Blade-contact incidents accounted for about 12,300 injuries (86%). The remaining 2,000 injuries (14%) involved incidents such as being hit by the stock/cutting materials (10%), being hit by flying debris (3%)*, and child playing or spurious contacts[11] (1%)*. Within the blade-contact incidents, about 11,800 injuries (96%) occurred while the saws were running, the remaining 500 injuries (4%)* occurred when the saws were just turned on/off or not running. The injuries associated with being hit by the stock/cutting materials or with flying debris occurred while the saws were running. The injuries associated with children playing and with spurious contacts occurred while the saws were not running.

[7] The estimates for band saws and radial arm saws are based on small sample sizes, and therefore have large variability associated with them.
[8] The remaining six percent of injuries were distributed among contusions/abrasions, crushing, internal injuries, and foreign body.
[9] The remaining 8,840 injuries were to the hand, wrist, lower arm, lower trunk, upper leg, lower leg, head, face, eyeball, and neck.
[10] An additional 3 percent of injuries required overnight observation or were treated and then transferred to another hospital for overnight observation.
[11] Such as strains or sprains from using or helping with the saw.
* The asterisks used through out the report indicate that the estimated injuries are based on small sample size and should be used with caution.

Injuries associated with saw operators during the operating sessions accounted for about 12,000 injuries.[12](A data summary of the injuries is presented in Table 2). The following sections examine this group of injuries with respect to hazard patterns and contributing factors, use patterns, the type of saw used at the time of the incidents, the injured body parts, and the diagnoses.

6.1. Operators During the Operating Session (12,000 injuries, n= 191)

An estimated 9,400 injuries (78%) to the operators were associated with table saws, the remaining 2,600 injuries were associated with band saws (9%)*, miter saws (8%)*, and radial arm saws (5%)*. Contact with the saw blade accounted for about 10,300 injuries (86%), being hit by a stock/cutting material accounted for about 1,430 injuries (12%), and injured from flying debris accounted for about 270 injuries (2%)*.

Most of the injuries to the operators were to lower arms, wrists, hands, or fingers and accounted for about 11,400 injuries (95%). Within this group, fingers were the most frequently injured body parts and accounted for about 10,370 injuries (91%). The remaining 600 injuries (5%)* were to heads, faces, eyeballs, lower trunk, upper legs, and lower legs.

The injuries to fingers were lacerations, amputations, fractures, avulsions, crushing, or contusions/abrasions. However, the injuries to lower arms, wrists, or hands were lacerations only. The injuries to the lower trunk, upper legs, or lower legs were lacerations or contusions/abrasions. Finally, the injuries to heads or faces were internal injuries or contusions/abrasions, and to eyeballs were foreign objects. About 1,050 injuries (9%)* were treated and kept overnight for observation, treated and transferred to another hospital, or hospitalized.

The average age of the operators was 51 years old with the youngest at 12 and the oldest at 91 years of age. About 390 operators (3%)* were between 12 and 14 years old, about 8,480 operators (71%) were between 15 and 64 years old, and about 3,130 operators (26%) were 65 years or older. The operators' age distribution was similar to that of all the victims for the calendar year 2001. This is because most of the injuries associated with the saws were to the operators.

The next sections present detailed information on the incidents to the saw operators. This information is available only from the investigations. It is presented in the following order:

6.1.1. Operational activities at the time of the incidents,
6.1.2. Stock/cutting materials,
6.1.3. Characteristics of saws involved, and
6.1.4. Hazard patterns and the contributing factors.

[12] The remaining 2,300 injuries (16%) were to the operators (not in the operating sessions), helpers, or bystanders.
* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

6.1.1.Operational Activities of the Operators

1. The type of cutting operation the operator had been performing prior to/at the time of the incident and the number of injuries.

- The operator had been cutting the length of stock, with the grain (ripping) - 6,170 injuries (51%).
- The operator had been cutting the width of stock, against the grain (cross cutting) - 2,050 injuries (17%).
- The operator had been cutting at a 45 degree angle, cutting at an angle other than 45 degrees, or performing the dado[13] cut - 970 injuries (8%)*.
- The type of cutting operation was *unknown*[14] in the remaining 2,810 injuries (23%)[15].

2. The type of saw blade being used prior to/at the time of the incident.

- Combination blade (cross cutting or ripping) - 3,000 injuries (25%).
- Crosscut blade, carbide-tip blade[16], continuous flexible blade (for band saws), dado blade[17], and other (fine tooth finishing, plane, and hollow grind blade) - 2,710 injuries (23%).
- Rip blade - 2,400 injuries (20%).
- The type of saw blade was *unknown* -3,890 injuries (32%).

3. The operator had been using a different type of blade for a different type of cutting prior to/at the time of the incident[18].

- The operator used a different type of blade for a different cut - 4,440 injuries (37%).
- The operator used the same blade for a different cut - 3,960 injuries (33%).
- *Unknown* if different blade was used - 3,600 injuries (30%)

4. The position of the saw blade, with respect to the stock/cutting material, prior to/at the time of the accident.

- The blade had been positioned for straight up and down cut - 8,640 injuries (72%).
- The blade had been positioned for bevel (tilted) cut - 240 injuries (2%)*.
- The position of the saw blade was *unknown* - 3,120 injuries (26%).

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[13] See footnote # 17.
[14] The respondents (operators or someone else) did not remember, did not know, or refused to answer.
[15] Does not add up to 100 percent because of rounding.
[16] Carbide-tip blade will stay sharp longer than a steel blade. The teeth of the blade cut smoother than steel blade teeth. There is as much variety in carbide-tip blades as in steel blades (combination, crosscutting, ripping, and even some mitering cut).
[17] Dado blades make a u-shaped cut when done across the grain and a groove when done with the grain.
[18] It was recommended that a certain type of blade should be used for a certain type of cut, for example, a crosscut blade is used for cross cutting while a rip blade is for ripping. Only a combination blade could be used for cross cutting or for ripping.
* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

5. The blade motion, with respect to the stock/cutting material, right before/at the time of the incident.

- Blade was inside a cut - 4,080 injuries (34%).
- Blade hit a knot, kicked wood up, or kicked back - 3,360 injuries (28%).
- Other (blade was above/resting against the stock not yet in a cut, caught on glove hand, or caught on hand that slipped off the stock – 1,890 injuries (16%).
- Blade caught/jammed on the stock - 1,320 injuries (11%)*.
- The blade motion was *unknown* - 1,350 injuries (11%).

6. The position of the left hand or right hand, with respect to the stock/cutting material, prior to/at the time of the incidents.

Table Saws and Band Saws (10,480 Injuries)

- Pushing/feeding the stock into the saw blade - 6,810 injuries (65%).
  Within this activity, a free-hand operation accounted for about 3,710 injuries, using a push block accounted for about 2,370 injuries, using a wood rest/miter gauge accounted for about 120 injuries,* the remaining 610 injuries* were unknown (whether a push block, a wood rest/miter gauge, or a free-hand was used when feeding the stock into the blade).
- Holding the stock, reaching across or over the blade, pulling stock, adjusting the blade/table angle, or turning the saw on/off - 1,830 injuries (17%).
- The position of the hand was *unknown* - 1,840 injuries (18%).

Miter Saws and Radial Arm Saws (1,520 Injuries)

- Holding the stock, lifting the saw arm/stock, pushing stock against the fence, or reaching across/over the blade – 1,170 injuries (77%).
- The position of the hand was *unknown* - 350 injuries (23%)*.

7. The status of the cutting operation, with respect to the stock/cutting materials, prior to/at the time of the incident.

- Part way through the cut - 4,190 injuries (35%).
- Stock coming out at the far end of the blade - 3,620 injuries (30%).
- Start cutting, about to cut, or just about finish cutting - 880 injuries (7%)*.
- The status of cutting was *unknown* - 3,310 injuries (28%).

8. The operators had been working at an average of 1 hour and 18 minutes, with a minimum of zero hour (just about to start cutting) and a maximum of eight hours, with the saw that day.

* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

6.1.2.Stock/Cutting Materials

1. The operator had been cutting the stock/material described below prior to/at the time of the accident.

- Wooden board - 8,520 injuries (71%).
- Paneling/siding, block of wood/log, plastic laminate material, wood molding, pipe/metal, bamboo/stick - 980 injuries (8%)*.
- The stock/material was *unknown* - 2,500 injuries (21%)

2. The shape and size (length, width, and thickness) of the stock/cutting material being cut prior to/at the time of the incident.

<u>Shapes</u>

- Rectangular - 7,200 injuries (60%).
- Square, triangular, octagonal, long and thin, round, or curved - 1,690 injuries (14%).
- The shape of the stock/cutting material was *unknown* - 3,110 injuries (26%).

<u>Sizes</u>

- The average length of the stock/cutting materials was about 2 feet
- The average width of the stock/cutting materials was about 6 inches
- The average thickness of the stock/cutting materials was about 1 inch.

3. The condition of the stock/cutting material being cut prior to/at the time of the incident.

- Nothing Unusual - 2,530 injuries (21%)
- Hard wood (mahogany, oak, or walnut) - 2,520 injuries (21%).
- Dry or wet wood - 2,250 injuries (19%).
- Smooth, soft (cedar or pine), knotty wood - 1,610 (13%).
- The condition of stock/cutting material was *unknown* – 3,090 injuries (26%).

4. How the stock/cutting material was supported prior to/at the time of the incident.

- The stock was resting on a table or on a table with an additional support - 8,160 injuries (68%).
- On a saw base, on a saw base with additional support, on the floor/ground, on a saw horse, or held in hand - 600 injuries (5%)*.
- The support of the stock/cutting material was *unknown* - 3,240 (27%).

5. Whether the whole surface of the stock/cutting material fit on the support.

- The whole surface of the stock fit on support – 5,800 injuries (48%).
- The whole surface did not fit on support - 2,770 injuries (23%).
- *Unknown* whether the whole surface of the stock/cutting materials fit - 3,430 injuries (29%).

6. Whether the stock/cutting material or the support was firmly anchored.

- The stock or the support was firmly anchored - 5,550 injuries (46%).
- The stock or support was loosely held or wobbled – 2,720 injuries (23%).
- *Unknown* whether the stock/cutting material or the support was firmly anchored - 3,730 injuries (31%).

* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

6.1.3 Characteristics of Saws Involved

1. Ownership of the saw.
- The operator owned and purchased saw new (74%) or used (26%) - 10,200 injuries (85%).
- The operator used someone else's saw or rented - 1,800 injuries (15%).

2. Saw Age.
- Ten years old or less (one out of every five saws involved were 1 year old or newer) - 5,050 injuries (42%).
- Over 10 years - 3,510 injuries (29%).
- The age of the saw was *unknown* - 3,440 injuries (29%).

3. Whether the saw had been changed or modified in any way since the operator obtained it.
- No, the saw had not been changed or modified - 8,280 injuries (69%).
- Yes, the saw had been changed or modified (mostly by the operators)[19] - 840 injuries (7%)*.
- *Unknown* whether the saw had been changed or modified - 2,880 injuries (24%).

4. Whether the saw was assembled when purchased or the owner assembled it after purchased.
- Assembled when purchased[20] - 6,240 injuries (52%).
- Assembled by owners/relatives - 1,920 injuries (16%).
- *Unknown* whether the saw was assembled when purchased - 3,840 injuries (32%)

5. Whether the blade had a safety switch (removable or stationary) such as a key lock that must be activated, in addition to the starter switch, before the saw could be turned on.
- Did not have a safety switch - 4,680 injuries (39%).
- Had a safety switch (either removable or stationary types) - 4,080 injuries (34%).
- *Unknown* whether the blade had a safety switch - 3,240 injuries (27%).

6. Whether the blade was sharp or dull[21] during the cutting operation.
- The blade was sharp or moderately sharp – 8,060 injuries (67%).
- Dull - 540 injuries (5%)*.
- *Unknown* whether the blade was sharp or dull - 3,400 injuries (28%).

7. Whether the blade guard was attached to the saw prior to/at the time of the incident.
- The blade guard was damaged, removed (including when making special cut such as dado or bevel cut) or guard broken off – 3,860 injuries (32%).
- The blade guard was attached to the saw – 2,600 injuries (22%).
- The saw never had one – 2,180 injuries (18%).
- *Unknown* whether the blade guard was attached to the saw - 3,360 injuries (28%).

[19] For example, blade guards had been removed, motors had been replaced, or rip fences had been added on.
[20] Less than one percent were partially assembled.
[21] Dull blades required more feed pressure, which presents a situation where the operator's hands might slip.
* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

8. Whether the anti-kickback[22] assembly attached to the saw prior to/at the time of the incident.
Table Saws or Band Saws (10,480 injuries)

- Did not come with one – 3,720 injuries (35%).
- Removed or did not put one on – 2,310 injuries (22%).
- Equipped with one - 950 injuries (9%)*.
- *Unknown* whether the anti-kickback assembly attached to the saw – 3,500 injuries (33%)[23].

Miter Saws or Radial Arm Saws (1,520 injuries)

Almost half of the saws had no information on the anti-kickback device. Of the ones with information, some were equipped with a device while others either had a device removed or were not equipped with one.

6.1.4. Hazards and the Contributing Factors

Hazards to the operators associated with stationary saws during the operation were contact with a saw blade (blade contact), being hit by stock/cutting material, or being hit by flying debris. The contributing factors to each of these hazards are presented below. The summary of the hazard patterns and their contributing factors are presented in Table 3.

Blade Contact (10,300 injuries)

The contributing factors to blade contact and the number of injuries are presented below.

- Stock/cutting material, tool, and hand interface[24] - 4,230 (41%).
- The saw or stock/cutting material kicked back[25] causing the hand or finger to come in contact with the blade - 2,580 injuries (25%).
- The saw blade jammed in stock/cutting material[26] (without kickback), hand slipped off stock, or the saw blade hit a knot in the stock - 2,100 injuries (20%).
- The operators reached over the blade and hit the blade - 1,390 (13%)[27].

Being Hit By Stock/Cutting Material (1,430 injuries)

The contributing factors to this hazard were the saw or stock/cutting material kicked back causing the stock to hit the operator or the blade jammed in the stock/cutting material causing the stock to buck/bounce and hit the operator.

Frying Debris (270 injuries)*

The contributing factors to flying debris were stock/cutting material breaking during the operation or the cut off piece caught in the saw teeth and was flung back (incidents in which the stock/cutting material split, broke, or fragmented were seen with all the saws). In most cases, eye injuries were sustained as a small piece of flying debris made contact with the eye. In other

[22] A mechanism that prevents the wood from kicking back.
[23] Does not add up to 100 percent because of rounding.
[24] For example, the operators were using a hand to guide the stock and failed to move the hand as it came into the path of the blade or the operators were trying to remove cut pieces without first turning off the saws.
[25] Kickback of the saw resulting in a blade contact is associated with miter saws or radial arm saws. The blades of these saws are mobile along the arm to which they are connected. The incident occurred when the operator held the stock loosely in his hand and when the saw suddenly kicked back, it threw his hand into the blade.
[26] One fatality is reported in the Commission's Injury or Potential Incident File (IPII) for the calendar year 2001.
[27] Does not add up to 100 percent because of rounding.
* The asterisks indicate that the estimated injuries are based on small sample size and should be used with caution.

cases, injuries to upper leg, upper trunk, face, and head were sustained as large pieces split or broke off and were flung away from the saw onto the operator.

6.2. Discussion

As stated in the introduction, the estimated injuries associated with stationary saws could have been larger if unspecified saws were identified. The follow-up investigation shows that the annual estimated injuries associated with stationary saws increased by 43 percent from about 36,400 injuries (identified by NEISS codes) to about 52,000 injuries (after the unspecified saws were identified) in the calendar year 2001.

Blade contact has been identified as a major hazard related to stationary saw use during this study period. Finger contact with the operating blade occurred most often in different scenarios. With table and band saws, the operator used a hand to guide the stock/cutting material; lacerations and sometimes amputations resulted when he failed to move his hand as it came into the path of the blade. In some incidents, the operator was pushing the stock and got too close to the blade and his/her gloved hand was caught in the blade. With miter and radial arm saws, the operator accidentally engaged the operating switch on the saw arm/handle which automatically started the blade, resulting in blade contact to the hand (which was holding the stock/cutting material). With all types of saws, the operator's hand which was holding the stock and/or guiding the stock slipped into the blade when the blade jammed in the stock. Also the blade contact occurred when the operator was trying to remove cut pieces from the table/base without first turning the saw off. In many of the blade contact cases, there was no blade guard in use at the time of the incident. Often the operator had removed the guard to get a clear view of his work, to do a special cut such as a dado, or to cut a very small piece of stock/cutting material.

Stock kickback was reported with some frequency. In these incidents the blade slowed or stopped momentarily as it bound or caught in the stock such as when it hit a knot or when it was pinched or jammed because the cut began to close behind the blade. This caused the stock to bounce out and hit the operator's hand as he tried to stop the stock from flying up and caused his hand to contact the blade. Some injuries occurred when the stock actually struck the operator as it was kicked out from the saw.

Saw kickback is a hazard which is associated with miter and radial arm saws. Saw kickback cases were similar to those that caused stock kickback, but in these cases the saw blade kicked back because it was mobile. The saw has been reported to bounce out of the cut and contact the users. For example, as the operator of the radial arm saw pulled the radial arm onto the stock too fast it bounced back from the stock and contacted the operator's hand (this is because radial arm saws are mobile along the arm).

A majority of the injuries related to the above hazards occurred when ripping hard boards such as mahogany, walnut, or oak. Other common causes of injuries were free-hand operation when guiding the stock into the blade and reaching across/over the spinning blade to remove cut pieces from the table.

Table 1
Estimated Annual Injuries Associated with Stationary Saws
Treated in U.S. Hospital Emergency Rooms Classified
By Products and Victims' Characteristics
January 1, 2001 – December 31, 2001

Description	Injury Estimate	Sample Size (n)
Type of Saw	**Total=52,000**	**n=225**
Table Saws	38,000	164
Miter Saws	7,640	36
Band Saws	4,060	18*
Radial Arm Saws	2,300	7*
Description of Victim and Injury		
Diagnosis	**Total=52,000**	**n=225**
Lacerations, Amputations, Fractures, Avulsions	48,880	212
Contusions/Abrasions, Crushing, Internal Injuries, Foreign Body	3,120	13*
Body Part	**Total=52,000**	**n=225**
Finger	43,160	186
Hand, Wrist, Lower Arm, Lower Trunk, Upper Leg, Lower Leg, Head, Face, Eyeball, and Neck	8,840	39
Disposition	**Total=52,000**	**n=225**
Hospitalizations	2,600	16*
Overnight Observations or Treated and Transferred	1,560	6*
Treated and Released	47,840	203
Victim (Age)	**Total=52,000**	**n=225**
0 –14	1,200	7*
15 – 64	38,300	161
65 or Older	12,500	57
Users	**Total=52,000**	**n=225**
Operator	51,000	218
Non-operator	1,000	7*
Gender	**Total=52,000**	**n=225**
Male	49,600	214
Female	2,400	11*

Source: CPSC, National Electronic Injury Surveillance System (NEISS) and Special Study of Stationary Saws, October 1, 2001 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

Table 2
Special Study of Stationary Saws
Operators and Activities During Operating Sessions
October 1, 2001 – December 31, 2001

Description	Injury Estimate	Sample Size (n)
Operator		
Age	**Total=12,000**	**n=191**
12 –14	390	5*
15 - 64	8,480	137
65 and Older	3,130	49
Body Part	**Total=12,000**	**n=191**
Lower Arm, Wrist, Hand, and Finger	11,400	181
Head, Face, Eyeball, Lower Trunk, Upper leg, Lower Leg	600	10*
Diagnosis	**Total=12,000**	**n=191**
Laceration, Amputation, Fracture, Avulsion, or Crushing	11,600	183
Contusion/Abrasion, Internal Injury, or Foreign Object	400	8*
Disposition	**Total=12,000**	**n=191**
Hospitalization, Treated and Overnight Stay, or Treated and Transferred to Another Hospital	1,050	18*
Treated and Released	10,950	173
Hazard Patterns[28]	**Total=12,000**	**n=191**
Blade Contact	10,300	162
Being Hit by Stock/Material	1,430	23
Flying Debris	270	6*
Saw Type	**Total=12,000**	**n=191**
Table Saw	9,400	148
Band Saw	1,080	15*[29]
Miter Saw	960	21
Radial Arm Saw	560	7*

* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

[28] Detailed in Table 3

[29] Involved injuries that were treated in small, medium or large hospitals with large sampling weights.

Description	Injury Estimate	Sample Size (n)
Operational Activities		
Type of Cut	**Total=12,000**	**n=191**
Ripping	6,170	91
Crosscutting	2,050	33
Dadoing, Mitering, or Beveling	970	16*
Unknown	2,810	51
Saw Blade	**Total=12,000**	**n=191**
Combination Blade	3,000	47
Rip Blade	2,400	38
Cross Cut, Carbide-Tip, Continuous Flexible, Dado, and Other (fine tooth, hollow grind) Blade	2,710	40
Unknown	3,890	66
Different Type of Blade for Different Type of Cut	**Total=12,000**	**n=191**
Different Type of Blade	4,440	70
Same Blade	3,960	61
Unknown	3,600	60
Position of Saw Blade	**Total=12,000**	**n=191**
Straight Up and Down Cut	8,640	134
Bevel (Tilted) Cut	240	3*
Unknown	3,120	54
Blade Motion	**Total=12,000**	**n=191**
Inside a Cut	4,080	67
Hit a Knot in Stock, Kicked Wood Up, Kicked Back	3,360	56
Other (Above/Resting Against Stock, Caught Gloved Hand, Hand Slipped into Blade, etc.)	1,890	30
Caught/Jammed in Stock,	1,320	18*
Unknown	1,350	20
Position of Operator's Hands	**Total=12,000**	**n=191**
(1) Table and Band Saws	**Subtotal=10,480**	**n=163**
Pushing/Feeding Stock	6,810	103
Holding Stock, Reaching Over Blade/Pulling Stock, or Adjusting Blade Angle	1,830	26
Unknown	1,840	34

* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

Description	Injury Estimate	Sample Size (n)
(2) Miter Saw and Radial Arm Saw	**Subtotal=1,520**	**n=28**
Holding Stock, Lifting the Saw Arm/Stock, Pushing Stock, or Reaching Across/Over Blade	1,170	21
Unknown	350	7*
Status of Cutting Operation	**Total=12,000**	**n=191**
Part Way Through the Cut	4,190	70
Coming Out At the Other End	3,620	56
Start Cutting or Just About to Finish	880	14*
Unknown	3,310	51
Stock/Cutting Material Type	**Total=12,000**	**n=191**
Wooden Board	8,520	130
Paneling/Siding, Block of Wood/Log, Plastic Laminate Material, Wood Molding, Pipe/Metal, Bamboo/ Stick	980	19*
Unknown	2,500	42
Shape	**Total=12,000**	**n=191**
Rectangular	7,200	108
Square, Triangular, Octagonal, Long & Thin, Round, or Curve	1,690	29
Unknown	3,110	54
Condition of Stock/Material	**Total=12,000**	**n=191**
Nothing Unusual	2,530	41
Hard	2,520	36
Dry or Wet	2,250	25
Smooth, Soft, or Knotty	1,610	23
Unknown	3,090	66
Stock Support	**Total=12,000**	**n=191**
Table or Table and Addition	8,160	122
Base, Base and Addition, Floor, Saw Horse, or Held in Hand	600	11*
Unknown	3,240	58
Stock Fit on Support	**Total=12,000**	**n=191**
Fit	5,800	80
Did Not Fit	2,770	47
Unknown	3,430	64
Stock Firmly Anchored	**Total=12,000**	**n=191**
Firmly Anchored	5,550	79
Loosely Held or Wobbled	2,720	48
Unknown	3,730	64

* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

Characteristic of Saw	Injury Estimate	Sample Size (n)
Ownership	**Total=12,000**	**n=191**
Purchased New or Used	10,200	131
Used Someone Else Saw or Rented	1,800	60
Saw Age	**Total=12,000**	**n=191**
10 Years Old or Newer	5,050	81
Over 10 Years	3,510	54
Unknown	3,440	56
Modified or Changed	**Total=12,000**	**n=191**
No	8,280	128
Yes	840	11*
Unknown	2,880	52
Assembled When Purchased	**Total=12,000**	**n=191**
Yes	6,240	92
No	1,920	33
Unknown	3,840	66
Safety Switch	**Total=12,000**	**n=191**
Did Not Have	4,680	68
Have a Safety Switch	4,080	65
Unknown	3,240	58
Sharp or Dull Blade	**Total=12,000**	**n=191**
Sharp or Moderately Sharp	8,060	123
Dull	540	7*
Unknown	3,400	61
Blade Guard	**Total=12,000**	**n=191**
Damaged, Removed, or Broken off	3,860	62
Attached	2,600	43
Never Had One	2,180	28
Unknown	3,360	58
Anti-Kickback	**Total=12,000**	**n=191**
(1) Table and Band Saws	**Subtotal=10,480**	**n=163**
Did Not Come With Saw	3,720	49
Removed/Did Not Put It On	2,310	34
Equipped With One	950	15*
Unknown	3,500	65
2) Miter and Radial Arm Saws	**Subtotal=1,520**	**n=28**
Equipped, Removed/Didn't Put On/Didn't Come With One, or Unknown	1,520	28

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2001 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division.

* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

Table 3
Hazards and Contributing Factors
During the Operating Session
October 1, 2001 – December 31, 2001

Description	Estimated Injuries	Sample Size (n)
Hazards and Contributing Factors	**Total=12,000**	**n=191**
Blade Contact	**Subtotal=10,300**	**n=162**
Stock, Tool, and Hand Interface	4,230	82
Saw or Stock Kicked Back	2,580	32
Blade Jammed in Stock (no kickback), Hand Slipped Off Stock, or Saw Blade Hit a Knot	2,100	24
Reaching Over Blade	1,390	24
Being Hit By Stock	**Subtotal=1,430**	**n=23**
Saw/Stock Kicked Back or Blade Jammed in Stock	1,430	23
Flying Debris	**Subtotal=270**	**n=6***
Piece of Wood or Saw Dust	270	6*

Source: CPSC, National Electronic Injury Surveillance System (NEISS) Special Study of Stationary Saws, October 1, 2001 Through December 31, 2001, Directorate for Epidemiology, Hazard Analysis Division
* Based on small sample size, therefore, the estimate is subject to large sampling variability and should be used with caution.

References:

1. "Statistical Analysis with Missing Data", Little, Roderick J.A. and Rubin, Donald B., Wiley Series in Probability and Mathematical Statistics, pp.58-60.
2. "The Complete Book of Stationary Power Tool Techniques", De Cristoforo, R.J., Published 1988 by Stering Publishing Company, Inc., New York.
3. SUDAAN, Software for Statistical Analysis of Correlated Data, User's Manual, Volume 1, Shah, Babubhai V., Barnwell, Beth G., and Bieler, Gayle S.

Appendix B:
Adjustment for Table Saw, Band Saw, Miter Saw, and Radial Arm Saw Estimates for Future Use

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: June 04, 2003

TO : The File
Directorate for Epidemiology

THROUGH : Susan Ahmed, Ph.D., AED
Directorate for Epidemiology
Russell H. Roegner, Ph.D., Director
Hazard Analysis Division, EP

FROM : Prowpit Adler, EPHA
Division of Hazard Analysis

SUBJECT : Adjustment for Table Saw, Band Saw, Miter Saw, and Radial Arm Saw Estimates for Future Use

This memorandum presents the adjustment method for table saw, band saw, miter saw, and radial arm saw estimates for NEISS CY 2002 and after. The adjustment was based on the results of the follow-up investigation of the incidents that occurred between October 1, 2001 and December 31, 2001 and the raking adjusted weights for non-responses.

Using the adjustment factors based on a follow-up investigation to the annual estimates is desirable when there is a high proportion of the NEISS cases with "Not Specified" product codes involved. This is because without the adjustment factors the estimate for stationary saws (table saws, band saws, radial arm saws, and miter saws) was underestimated by about 43 percent in CY 2001 as shown below.

Code	Name	CY 2001 NEISS Estimate Before Follow Up	CY 2001 NEISS Estimate After Follow Up	Difference
0841	Table Saw	31,900	38,000[1]	+6,100
0842	Band Saw	3,600	4,060[2]	+460
0843	Radial Arm Saws	500	2,300[3]	+1,800
0844	Hack Saw (power)	400	0[4]	-400
0890[5]	Miter Saws	0,000[6]	7,640[7]	+7,640

[1] From NEISS codes 0841 (0.9731), 0842 (0.0221), 0845 (0.2017), 0863 (0.1325), 0872 (0.1388).
[2] From NEISS codes 0842 (0.8622), 0845 (0.0186), 0872 (0.0495).
[3] From NEISS codes 0843 (1.0), 0845 (0.0418), 0863 (0.0562), and 0872 (0.0425).
[4] Follow-up investigation indicated that the saws were portable.
[5] This is a make-up code for miter saws because there is no NEISS code for the saws.
[6] No NEISS cases were reported under this code.
[7] From NEISS codes 0841(0.005), 0842 (0.0221), 0845 (0.1004), 0863 (0.5115), and 0872 (0.2021).

Each of the annual injury estimates corresponding to codes 0841, 0842, 0843, 0844, and 0890 in column # 3 was obtained from the follow-up investigations which allowed for the identification of "unspecified saws" (see Footnotes # 1, 2, 3, 4, and 7). For example, the annual injury estimate of 38,000 which corresponds to table saws (row # 1, column # 3) was obtained from the following NEISS codes:

- About 97 percent (0.9731) of the injuries reported to be associated with code 0841 were actually involved with table saws.
- About 2 percent (0.0221) of the injuries reported to be associated with code 0842 were actually involved with table saws.
- About 20 percent (0.2017) of the injuries reported to be associated with code 0845 (saws, not specified) were actually associated with table saws.
- About 13 percent (0.1325) of the injuries reported to be associated with code 0863 (other power saws) were actually associated with table saws.
- About 14 percent (0.1388) of the injuries reported to be associated with code 0872 (power saws, not specified) were actually associated with table saws.

The annual injury estimates in rows # 2, 3, and 5 in column #3 follow the same principle as the estimate for table saws.

When staff make an adjustment to NEISS estimates of table saw, band saw, miter saw, and radial arm saw injuries (for calendar years 2002 and after) by following the above method, they must consider that the adjusted estimates may have larger variances than those of the original NEISS estimates. This is because each adjusted estimate is calculated from multiple estimates each with a corresponding variance.

If staff are taking adjustments of several different product codes and then adding them together, they must consider the covariances between the product codes. The formula for the adjusted variance for such an estimate is presented below:

$$ADJ\_VAR = \Sigma[(Ratio_i)^2 * Var (NEISS_i)] + 2 \Sigma[(Ratio_i)*(Ratio_j)* Cov (NEISS_i, NEISS_j)] + \Sigma[(NEISS_i)^2 * Var (Ratio_i)] + 2 \Sigma [(Ratio_i)* (NEISS_i)* Cov (Ratio_i , NEISS_i)]$$

where $i = 1, 2, \ldots, n$ and $i<j$.

Assuming that there is no correlation between the adjustment factors[8] ($Ratio_i$) and the corresponding NEISS estimates of the following years, the ADJ_VAR will be

$$= \Sigma[(Ratio_i)^2 * Var (NEISS_i)] + 2 [\Sigma (Ratio_i)*(Ratio_j) * Cov (NEISS_i, NEISS_j)] + \Sigma [(NEISS_i)^2 * Var (Ratio_i)],$$ [9]

where the calculations of the variances and covariances in the above equation are obtained by using SUDAAN software for the statistical analysis of correlated data .

[8] Obtained from the follow-up investigation conducted in CY01.
[9] Schroeder, Thomas J., Division of Hazard & Injury Data Systems, CPSC.

For example, the *adjusted* variance for the *adjusted* annual estimate of 38,980 table saw related injuries in calendar year 2002 is

ADJ_VAR =[(0.9731)^2 * Var (code 0841) + (0.0221)^2 * Var (code 0842) + (0.2017)^2 * Var (code 0845) + (0.1325)^2 * Var (code 0863) + (0.1388)^2 * Var (code 0872)] + **2** [(0.9731) (0.0221) * Cov (code 0841, code 0842) + (0.9731)(0.2017) * Cov (code 0841, code 0845) + (0.9731) (0.1325) * Cov (code 0841, code 0863) + (0.9731) (0.1388) * Cov (code 0841, code 0872) + (0.0221) (0.2017) * Cov (code 0842, code 0845) + (0.0221) (0.1325) * Cov (code 0842, code 0863) + (0.0221) (0.1388) * Cov (code 0842, code 0872) + (0.2017) (0.1325) * (code 0845, code 0863) + (0.2017) (0.1388) * (code 0845, code 0872) + (0.1325) (0.1388) * Cov (code 0863, code 0872)] + [(code 0841.)^2 Var (0.9731) + (code 0842.)^2 Var (0.0221) + (code 0845)^2 Var (0.2017) + (code 0863)^2 Var (0.1325) + (code 0872)^{2}Var (0.1388)]

= 11,863,556.44[10]

CV = 0.088362

Based on the above methodology, the adjusted estimate of injuries associated with table saws, ADJ_VAR and CV for CY 2002 are presented below.

Code	Name	CY 2002 NEISS Estimate	VAR	CV	CY 2002 Adjusted Estimate	ADJ_VAR	CV
0841	Table Saw	33,114	8,850,625	0.09	38,980	11,863,556	0.09

Based on the same methodology, the adjusted variances (ADJ_VARs) for the CY 02, adjusted estimates of injuries associated with band saw, radial arm saw, and miter saw injuries are as follows:

Code	Name	CY2002 NEISS Estimate	VAR	CV	CY 2002 Adjusted Estimate	ADJ_VAR	CV
0842	Band Saw	3,397	219,024	0.14	3,750	612,841	0.21
0843	Radial Arm	617	37,249	0.31	2,290	803,810	0.39
0890	Miter Saw	0	0	0	7,400	2,487,527	0.21

As stated earlier, using the adjustment factors (based on a follow-up investigation) with the annual estimates is desirable when there is a high proportion of NEISS cases with "Not Specified" product codes involved.

[10] A SAS program for the adjusted variance is attached as an Appendix.

Appendix

```
data temp;
 input  Code1 NEISS_1 VNEISS_1 Ratio_1 Sratio_1
         Code2 NEISS_2 VNEISS_2 Ratio_2 Sratio_2
          Code3 NEISS_3 VNEISS_3 Ratio_3 Sratio_3
          Code4 NEISS_4 VNEISS_4 Ratio_4 Sratio_4
          Code5 NEISS_5 VNEISS_5 Ratio_5 Sratio_5
  ;

cards;
 0841 0033114 8850625 00.9731 00.0137
 0842 0003397 0219024 00.0221 00.0214
 0845 0023715 5184729 00.2017 00.0391
 0863 0006315 0720801 00.1325 00.1001
 0872 0007660 0753424 00.1388 00.0583
  ;
Data temp; set temp;
Vratio_1 = Sratio_1**2;
Vratio_2 = Sratio_2**2;
Vratio_3 = Sratio_3**2;
Vratio_4 = Sratio_4**2;
Vratio_5 = Sratio_5**2;
adj_var = ((Ratio_1**2)* VNEISS_1)+ ((Ratio_2**2)* VNEISS_2)+
          ((Ratio_3**2)* VNEISS_3)+((Ratio_4)**2 *
          VNEISS_4)+((Ratio_5**2) *
          VNEISS_5)+2*((Ratio_1*Ratio_2)*(1452049/2))+
          2*((Ratio_1*Ratio_3)*(5391754/2))+2*((Ratio_1*Ratio_4)
          *(1770577/2))+
          2*((Ratio_1*Ratio_5)*(1298125/2))+2*((Ratio_2*Ratio_3)
          *(475353/2))+
          2*((Ratio_2*Ratio_4)*(203661/2))+2*((Ratio_2*Ratio_5)*
          (151612/2))+
          2*((Ratio_3*Ratio_4)*(1209641/2))+2*((Ratio_3*Ratio_5)
          *(1477609/2))+
          2*((ratio_4*Ratio_5)*(248776/2))+(NEISS_1)**2 *
          (Vratio_1)+(NEISS_2)**2 * (Vratio_2)+(NEISS_3)**2 *
          (Vratio_3)+(NEISS_4)**2 * (Vratio_4)+ (NEISS_5)**2 *
          (Vratio_5)
 ;
 proc print; var adj_var;
 run;
```

****

Note: $Var(x-y) = Var(x)+Var(y) - 2\ Cov(x,y)$

$Cov(x,y) = [Var(x) + Var(y) - Var(x-y)]/2$

****

Appendix C:
Table Saw Related Injuries and Fatalities (1991-2000)

Table Saw Related Injuries and Fatalities (1991-2000)

1. Estimated Annual Injuries and Trend

Table 1
Estimated Emergency Room-Treated Injuries
Associated with Table Saws
January 1, 1991 – December 31, 2000

Year	Sample	Estimate	CV[1]	Adjustment Factor	Adjusted Estimate	Adjusted CV
1991	551	30,165	.1194	0.93668	28,255	.1303
1992	676	34,217	.1151	0.92612	31,689	.1306
1993	623	30,743	.1044	0.91557	28,147	.1265
1994	579	30,543	.1014	0.90502	27,642	.1299
1995	604	29,824	.0966	0.89446	26,676	.1329
1996	627	29,040	.0968	0.89446	25,975	.1330
1997[2]	471	23,853	.0854	.	.	.
1998	684	33,590	.0799	.	.	.
1999	683	32,685	.0856	.	.	.
2000	677	32,353	.0839	.	.	.

Source: U.S. Consumer Product Safety Commission (CPSC), National Electronic Injury Surveillance System (NEISS), Directorate for Epidemiology, Hazard Analysis Division.

The adjusted total for table saw-related emergency room-treated injuries for the 10-year period is 290,865. In the same period, the unadjusted total for table saw-related injuries is 307,013. Note that the unadjusted estimates are slightly higher than the adjusted estimates between 1991 and 1996. The injury trend associated with table saws is stable[3] over the past 10 years.

To compute multi-year injury estimates and to compare estimates over time periods with different sampling frames and different samples, CPSC has developed methods to statistically adjust the basic (or historical) NEISS estimates. The adjustments smooth the data across different samples when some discontinuities in the estimates have occurred because of the differences in sampling frames and samples. The adjustment factors were derived from data collected from the overlapping samples of both "old" and "new" hospitals that were in operation in the same period of time[4]. The adjusted estimate is the basic (or historical) estimate multiplied by the adjustment factor. The most recent NEISS update occurred on January 1, 1997. Therefore, all injury estimates prior to this date need adjustments as shown in Table 1, Table 2, and Table 3.

2. Body Parts and Diagnoses

Most of the injuries (95%)[5] associated with table saws were to the wrist, hand, or finger during this period. A majority of these injured body parts (90%)[6] were treated for

---

[1] A relative measure of the variability in the data.
[2] A few new hospitals were late participating with the NEISS system.
[3] Year-to-year comparisons of injury estimates were not statistically significant.
[4] Marker, D, et al (1999). Comparisons of National Estimates from Different Samples and Different Sampling Frames of the National Electronic Injury Surveillance System (NEISS), Rockville, MD: Westat Inc.
[5] Total adjusted estimated 276,445 injuries were to the wrist, hand, or finger.
[6] Total adjusted estimated 249,041 injuries were lacerations, fractures, or amputations to the wrists, hands, or fingers.

lacerations, fractures, or amputations. The annual estimates of injuries associated with the wrists, hands, or fingers are presented in Table 2. The annual estimates of injuries associated with lacerations, fractures, or amputations to the wrists, hands, or fingers are presented in Table 3. The adjustments were made to the estimates prior to January 1, 1997 in both tables. There is no change in the injury trend based on the estimates in Table 2 or in Table 3.

Table 2
Estimated Table Saw-Related Emergency Room Treated Injuries
To Wrists, Hands, or Fingers
January 1, 1991 – December 31, 2000

Year	Sample	Estimate	CV	Adjustment Factor	Adjusted Estimate	Adjusted CV
1991	524	28,577	.1217	0.95099	27,176	.1337
1992	628	31,803	.1146	0.94282	29,985	.1318
1993	579	28,259	.1047	0.93465	26,412	.1287
1994	550	29,058	.1024	0.92648	26,922	.1331
1995	572	28,141	.0975	0.91831	25,842	.1364
1996	581	26,880	.0953	0.91831	24,684	.1349
1997	444	22,373	.0895	.	.	.
1998	640	31,499	.0817	.	.	.
1999	647	30,926	.0873	.	.	.
2000	637	30,626	.0851	.	.	.

Source: U.S. Consumer Product Safety Commission (CPSC), National Electronic Injury Surveillance System (NEISS), Directorate for Epidemiology, Hazard Analysis Division.

Table 3
Estimated Table Saw-Related Emergency Room Treated Injuries
Lacerations, Fractures, or Amputations
To Wrists, Hands, or Fingers
January 1, 1991 – December 31, 2000

Year	Sample	Estimate	CV	Adjustment Factor	Adjusted Estimate	Adjusted CV
1991	467	25,404	.1198	0.96062	24,404	.1329
1992	563	28,264	.1144	0.95406	26,966	.1329
1993	503	24,423	.1061	0.94749	23,141	.1315
1994	493	26,174	.1068	0.94093	24,628	.1384
1995	503	25,323	.1005	0.93436	23,661	.1407
1996	535	24,799	.0974	0.93436	23,171	.1385
1997	403	20,324	.0944	.	.	.
1998	576	28,183	.0848	.	.	.
1999	580	27,703	.0887	.	.	.
2000	561	26,860	.0896	.	.	.

Source: U.S. Consumer Product Safety Commission (CPSC), National Electronic Injury Surveillance System (NEISS), Directorate for Epidemiology, Hazard Analysis Division.

In order to learn more about the involved table saws, incident scenarios and environment, user's characteristics, and use patterns, the Commission is conducting follow-up telephone investigations of the injuries treated in the U.S. hospital emergency departments between October 1, 2001 and December 31, 2001 (see the attached Questionnaire). The analysis of results of the investigations will take place sometime after March 2002.

3. Reported Fatalities

There were 8 fatalities reported to the Commission during this 10-year period. These reported fatalities do not represent all fatalities that may have occurred in the U.S. during this period. Information concerning the stated fatalities is presented below.

Date of Incidents	City	State	Age	Incidents
04/08/91	Hobart	IN	003	Died after being cut underneath table saw while his parent was using the saw.
01/12/92	Gillette	WY	058	Saw blade separated on a large table saw and struck the victim on left side of his head.
07/26/94	Montfort	WI	018	Electrocuted from using ungrounded table saw on a damp floor.
11/17/94	Independence	MO	076	Feeding a piece of pine wood through the cutting blade of table saw, the wood kicked back and struck his abdomen. He died during the surgery.
04/16/97	Grandview	MO	048	A short in table saw had electrified the metal frame and the victim died when he contacted the frame and a ground point.
07/13/97	Easley	SC	040	Electrocuted while using a table saw that was plugged into an extension cord.
08/13/97	Hialleah	FL	067	Died from a massive heart attack after he had severed three fingers and went into cardiac arrest. He was using an industrial type table saw.
09/22/97	Dallas	OR	073	Died after he had collapsed while using a table saw.

Attachment

TAB C

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: June 15, 2005

TO : Caroleene Paul, Project Manager, Petition CP03-02, Power Saw Performance Standard

THROUGH: Gregory B. Rodgers, Ph.D., AED, EC GBR

Deborah V. Aiken, Ph.D., Senior Staff Coordinator, EC

FROM : William W. Zamula, EC

SUBJECT : Petition Requesting Performance Standards for a System to Reduce or Prevent Injuries From Contact With the Blade of a Table Saw (Petition CP03-02)

The Commission received a petition from an inventor and his associates requesting a performance standard to address injuries resulting from contact with the blade of a table saw. This memorandum provides readily available information on annual sales of table saws, the number of manufacturers, the estimated number of products in use, as well as preliminary information on the societal cost of deaths and injuries associated with the hazard pattern.

Market Information

Manufacturers of and/or importers of table saws include Bosch/Skil, Black & Decker/ DeWalt, Makita, Ryobi , Delta/Porter-Cable (Pentair Tool Group), Hitachi, Jet/Powermatic (WMH Tool Group), Grizzly, Inca, Jepson, General International, PTS/Rexon/Tradesman, and Emerson Electric/Ridgid. The first seven manufacturers/importers mentioned above probably account for most of the shipments of table saws in the U.S. [The Power Tool Institute comments on the Petition (PTI, November, 2003) state that these seven companies along with several former members (not specified) account for 95 percent of all table saws sold in the U.S.] Bosch, Black & Decker, Makita, Ryobi, Emerson Electric, and Hitachi are large, diversified international corporations with billions of dollars in sales. Table saws make up a relatively small part of their revenues.

Data on shipments, exports, and imports of table saws are typically aggregated with a variety of other types of saws, such as reciprocating, saber, and jig saws, making it impossible to derive an estimate of the number of or dollar value of table saw shipments. However, based on a comment on the Petition, the Power Tool Institute (PTI) estimates shipments of 725,000 table saw units in 2002 and an estimated population of 6 million units in use. It also estimates the expected useful life of a table saw at 10 years. This estimate may be low: a market research report on the power tool industry (Marcom, 1983) estimates an expected useful life of 15 years. Based on estimated shipments from 1983-2002 and a 15 year expected useful life, the product population model estimates a population of about 10 million. Consequently, based on the PTI and Product Population Model estimates, the product population is probably in the range of 6 to 10 million. With an expected useful life of 10-15 years, the benefits of any potential safety improvement for table saws would accrue gradually over a long period of time.

Retail prices vary widely from about $100 for some consumer-oriented table saws to several thousand dollars for large, professional quality saws. PTI characterizes the consumer price range as $100 to $800 and the professional price range as $500 to $2,500. With the PTI estimate of 725,000 units shipped, retail sales are probably in the range of $300-$400 million, assuming an average retail price of $400 -$500.

Consumers vs. Professionals

Distinctions between consumer-oriented table saws and saws oriented towards commercial and industrial users are difficult to make. Inexpensive table saws tend to be lightweight and portable, which makes it easier for a carpenter or other craftsman to transport them to a job site. Consequently, substantial numbers of inexpensive bench and table saws may end up being used by professionals. By the same token, some consumers purchase expensive "cabinet" saws to make their own cabinets. Rental centers may offer some professional or "contractor" table saws to consumers, but probably only the portable models. Cabinet saws are heavy and extremely bulky, and are unsuitable for rentals. While some lines of table saws are designated as "professional," such designations are not always meaningful. It may be difficult or impossible to determine the proportion being sold to consumers versus professionals for most table saws, since both are often purchased through the same retail outlets. Generally, we would not expect a consumer to use a table saw with a blade of 12 inches or more, with more than 5 horsepower, or with a 3 phase power supply. Price is not the best criterion for making a distinction, since there is overlap between consumer and professional purchases even in the $2,000-$3,000 range.

Preliminary Societal Cost Estimates of Table Saw Injuries and Deaths

Based on a 2001 Special Study, Epidemiology staff estimate that almost 28,300 emergency room treated blade contact injuries were experienced by operators of table and bench saws in 2001. According to Epidemiology, virtually all of these blade contact injuries involved consumers. From these 28,300 injuries, the Commission's Injury Cost Model projects 55,300 medically treated injuries with associated injury costs of $2.13 billion. Since injuries have remained relatively constant from 1991-2002, we will use injury costs for 2001 throughout this memo. Deaths resulting from blade contact from table saws are relatively rare and seem to be the result of secondary effects of the injuries (e.g., heart attack) rather than the injuries themselves. We have therefore excluded them from the costs.

The high societal costs are accounted for by the high valuation of amputations by the Injury Cost Model and the relatively high hospitalization rate for table saw blade contact injuries. The hospitalization rate for blade contact reported in the Epidemiology memorandum (April 12, 2005) is 11%: this is more than double the average hospitalization rate for all consumer products (4.6 percent in 2001). Furthermore, amputations make up 15 percent of the blade contact injuries.

The societal costs per product in use per year range from $210 ($2.13 billion/10 million table saws in use) to $355 ($2.13 billion/6 million table saws in use). Over the 10-15 year lifetime of a table saw it would generate societal costs of $2,600 to $3,100 at a discount rate of 3 percent, if all blade contact injuries are included.

The PTI comments suggest non-kickback injuries are more likely to be addressable than kickback injuries. If we only include costs from non-kickback injuries, the societal costs per product in use per year would range from $97 ($971 million/10 million table saws in use) to $162 ($971 million/6 million table saws in use). Over the 10-15 year product life of a table saw, the present value of the societal costs would be $1,200 to $1,400 per saw. In either case (i.e., whether or not kickback injuries are included) the societal costs suggest that an effective remedy could generate net societal benefits.

Because of the small sample size for the occupational injuries, the variance associated with these estimates is large. This large variance also applies to the societal cost estimates based on these injuries. Removal of these injuries from the societal costs of all blade contact injuries reduces the societal costs from $2.13 billion for all users to $1.78 billion for consumers. This reduces the societal cost per product in use per year to $178 (for 10 million saws in use) to $297 (for 6 million saws in use), and the present value of societal costs per table saw to $2,200 and $2,600, respectively. Since all of the occupational injuries are kickback-related[1], estimates of societal costs for non-kickback injuries are unaffected.

It would also be appropriate to remove occupational users from estimates of saw users. However, we have no information that would enable us to estimate the number of table saws in use for occupational users. Eliminating occupational users would reduce the denominator (six million and ten million) in our estimates of costs per saw (for both all blade contact and non-kickback categories) and therefore increase the estimates of cost per saw for consumers. Consequently, assuming all remaining injuries are non-occupational, the present value of the societal costs for consumers would likely be in excess of the $2,200 to $2,600 noted above for blade contact injuries and in excess of $1,200 to $1,400 for non-kickback injuries.

Potential Costs to Manufacturers and Consumers

PTI cites a number of potential costs to manufacturers and consumers for the technical remedy proposed by the petitioner. First, there are the capital costs for tooling changes, which it estimates at $2 million to $10 million per company, depending on the number of models involved, or about $70 million in aggregate for all manufacturers (based on the number of manufacturers listed above and an average tooling cost of $5 million). Capital costs are usually amortized over ten or more years of production. Assuming a $70 million cost amortized over ten years production, the capital costs per unit would amount to about $10-12 per saw, depending on

[1] In this particular sample, all the occupational injuries happen to be kickback-related. It is possible that a larger sample of occupational injuries would contain a mixture of kickback and non-kickback related injuries.

sales. These types of costs tend to bear more heavily on smaller companies with fewer resources and smaller sales volume to support these costs.

The next category of costs is the per-unit cost of the remedy, including the electrical and braking hardware and the licensing fee of the petitioner (if their technology is used). The petitioner estimates a retail price impact of $50-100 per saw (including the capital costs mentioned above), while PTI states the retail price increase may be high as $150. If we assume that the retail price impact is $100 per unit (inclusive of the capital costs), then the retail price impact on a year's worth of sales might be approximately $60 million (600,000 units x $100 per unit), assuming a reduction in sales resulting from the price increase. This may be a reasonable estimate of the reduction in sales considering that an increase of $100 would effectively double the price of a $100 bench saw and increase the price of a $400 saw by 25 percent.

Finally, there is the issue of increased costs to use and maintain the saws over the life of the product, either because of false tripping or the need to purchase additional cartridges for special cuts. However, not enough is known about the durability of the safety device or the probability of false tripping to make any projection of costs. According to PTI, a single trip would require replacement of the brake cartridge and probably the blade. A replacement cartridge might cost $60, while the cost of the blades vary greatly from $25-$100. If the user wishes to use a different size blade or make a different cut than the saw is originally equipped for, then the user might have to purchase a new cartridge, at the cost noted above. However, it may be possible, in some instances, for the user to adjust the saw rather than purchase a new cartridge.

Over the lifetime of the product, the additional cost of the proposed remedy and the replacement of brake cartridges and blades might increase the costs of ownership of the product substantially. However, given the high societal costs associated with table saw injuries, an effective method of preventing blade contact injuries might be sufficient to offset these costs to the consumer.

What is less clear is the impact of the proposed remedy on businesses. The costs to businesses would rise if firms have to purchase the blade stop mechanisms. However, there would also be benefits from reduced injuries and reduced worker's compensation costs. Due to differences in training, working conditions, and exposure to saw hazards, the distribution of benefits and costs to employers and workers using table saws is likely to be different than for consumers.

TAB D

UNITED STATES
CONSUMER PRODUCT SAFETY COMMISSION
WASHINGTON, DC 20207

Memorandum

Date: July 19, 2001

TO : Ronald L. Medford, Assistant Executive Director
Office of Hazard Identification and Reduction

THROUGH: Hugh M. McLaurin, Associate Executive Director
Directorate for Engineering Sciences

FROM : Caroleene Paul, Division of Mechanical Engineering
Roy W. Deppa, Division of Mechanical Engineering
Dean LaRue, Division of Electrical Engineering

SUBJECT: Evaluation of Prototype Tablesaw Safety Device

INTRODUCTION: The Directorate for Engineering Sciences received a sample of a prototype tablesaw safety device, as well as a detailed demonstration from its inventor, on July 11, 2001 to evaluate its potential to address injury. The inventor also provided an information package that combines the extensive technical information of the 26 different patents obtained in designing the safety system. The device consists of a modified commercial consumer-grade tablesaw, including an electrical blade contact detection circuit, logic circuit, and electromechanical device that stops blade rotation and lowers the blade below the table surface upon contact with a human body part. This system is under development and was demonstrated by SawStop LLC. of Wilsonville, OR.

BACKGROUND: Tablesaws account for approximately 30,000 injuries to the hand or finger per year, with approximately 10% of these injuries involving amputation. Tablesaw blades are typically 10 in. in diameter and rotate at about 4,000 rpm. A typical 40-tooth blade's teeth cut at a rate of about 2,700 cuts per second; these saw teeth are travelling at about 120 mph. Resulting injuries are usually severe.

Review of In-Depth Investigations shows that typical incident scenarios involve inadvertent contact with the blade. The operator allows his hand to contact the blade while sawing due to inattention, or the workpiece slips or moves suddenly and the operator reaches, falls, or slips and contacts the blade from the top or rear of the blade. In some cases the work piece is kicked back by the blade and draws the operator's hand into the blade.

Safety engineering on a systematic basis takes a tiered approach to address hazards:

1. The most effective measures are those that design the hazard out of the product. This has not been possible with tablesaws; the operational requirements of tablesaws seem to preclude the possibility of removing the hazard.
2. The second most effective measures are those that guard or shield against the hazard. This is the approach that has been applied to tablesaws, but it has not been effective because the guards are optional and they do not work very well.
3. When design and shielding approaches do not work, the next most effective method is to introduce an intervention strategy in the development of the hazard. That is, allow the events that lead to injury to begin, but introduce some element that stops or diverts the process before the injury occurs, or at least before the injury becomes very severe. This is the philosophical basis for the SawStop. The operator's hand actually contacts the spinning blade, but the device senses this contact and stops the blade and moves it before severe injury occurs. This approach is sophisticated and potentially vulnerable. Timing is everything; the blade begins to cut into the operator's finger before the system can work, and it must work reliably and very quickly to limit the injury.

The SawStop demonstration model is a prototype, therefore issues of reliability and robustness over the life of the product cannot be evaluated. These issues will be dependent upon choices made in the development and manufacture of production products, and they are likely to differ significantly between manufacturers. While the ability of the product to function properly under different conditions, or incident scenarios, can be addressed with a prototype, these factors may differ depending upon the manufacturing design. Consideration of details that are dependent upon design and manufacturing must be evaluated on production products, or may be considered in establishing standards of performance.

What can be evaluated at the prototype stage is whether the basic concept of the device addresses the known hazard pattern in an effective way, and thus can establish whether the device demonstrates the feasibility of eliminating or reducing the hazard. The basic concept of the SawStop is to electrically sense when contact with a body part has been made, and to mechanically remove the cutting hazard before severe injury can occur. In the next three sections, the electrical operation, the mechanical operation, and the testing will be discussed.

Electrical Operation

The theory of operation is based upon the electrical capacitive nature of the human body, or the ability of the human body to store electrical charge. A small electrical field is placed by the SawStop circuitry onto the saw blade by a supply electrode, and a sensing electrode senses the electrical field coming from the saw blade. If a person touches the saw blade, some of the electrical field is redirected into the person's body rather than into the sensing electrode. When the field measured by the sensing electrode drops below a pre-determined percentage of the normal value, the stopping mechanism is activated.

The electrodes are not actually in contact with the saw blade. They are a small distance away from the blade. This is what is called capacitive coupling. Two conductive materials with a dielectric material (in this case air) between them creates a capacitor. Essentially, there is a capacitor created by the supply electrode to the saw blade in series with another capacitor created by the saw blade to the sensing electrode. Electrical energy can therefore flow between the supply electrode to the saw blade and from the saw blade to the sensing electrode.

In the prototype received for evaluation, the supply and sensing electrodes are capacitively coupled to the arbor shaft. In most cases, this is not a problem because the saw blade is electrically connected to the arbor shaft. However, a few saw blades used in the evaluation had plastic hubs. The safety mechanism will not work with these blades because the plastic hub insulates the metal part of the blade from the arbor shaft. In this particular implementation, there is no means to determine whether an appropriate saw blade is attached to the arbor shaft or that the blade is actually coupled to the circuit. This is an issue that will need to be addressed in the development of manufactured products, to ensure that a user knows when they are protected. This does not affect the evaluation of the basic safety mechanisms and principles of this device.

The remainder of the circuitry is designed to detect and react to a person touching the saw blade. The circuitry is controlled by a microcontroller. The microcontroller reads various inputs and makes a decision to activate the saw brake or to allow the saw to keep running. Using the example of the 40-tooth blade operating at 4,000 rpm, one tooth goes by a point every 370 μs. The circuit samples the status and makes a decision every 18 μs, which is more than 20 times per tooth. The circuitry reacts quickly enough to minimize the damage to a person's hand should it come in contact with the saw blade.

The microcontroller is programmed to react quickly to a person touching the saw blade while adjusting itself for scenarios involving wood that may be slightly conductive. Wet green wood or wet pressure treated wood can be conductive and could make the saw brake trip without any danger. Logic has been built into the program to monitor not only the magnitude of the signal but also the rate at which it changes. Conductive wood would cause a slow change in the signal magnitude where a person would generate a quick change in the signal magnitude. If the controller detects a slow change in the signal magnitude, it changes the supply voltage to maintain a relatively constant sensing voltage. However, it is designed so that it cannot change the supply voltage fast enough to miss an actual human event. This is designed to reduce nuisance trips without reducing the protection to people.

There are several self-tests designed into the circuitry to ensure that the safety mechanism will work if needed. If any of these self-tests fail, the saw will either stop if running or will not start if not running. The self-tests are:

1. Watchdog error – this is monitoring the status of the microcontroller.
2. Saw brake triggered or trigger circuit open – this will sense if the saw brake has already been spent or if the electrical connection to the saw brake is missing.
3. Supplies out of regulation – this senses the voltage on the power supply to ensure that it is adequate to operate the circuitry.
4. Capacitor over voltage – this senses the voltage on the capacitor to ensure that the capacitor is working properly.
5. Hall sensor defective – the Hall sensor detects motion of the saw blade. This is used to allow protection during a shut down of the saw. The electronics is capable of activating the saw brake as long as the saw blade is rotating, even after the saw is turned off.
6. Capacitor not charging – senses to see if the capacitor is charging to prevent a misfire.
7. Capacitor under value (discharges too fast) – the system is measuring the time constant during operation to ensure that the capacitor is properly charged.
8. Sense calibration circuit error – the microcontroller monitors the sensing portion of the circuit to verify adequate signal.
9. Sense circuit error – the microcontroller monitors the sensing portion of the circuit to verify it is receiving the signal it expects.

Mechanical Operation

The mechanical theory of operation uses the potential energy stored in a spring to force a plastic brake into the teeth of the rotating saw blade, and the angular momentum of the rotating blade to retract the blade below the surface of the table saw. A brake cartridge consisting of a spring loaded plastic pawl and controller circuitry is positioned on a shaft directly behind the blade arbor. Once a saw blade has been installed, care must be taken to adjust the pawl side of the brake cartridge as closely to the blade as possible without interfering with the blade's free movement. An electrical lead from the microcontroller attaches to the brake cartridge. When the microcontroller determines that a person has touched the saw blade, it sends a signal to discharge a capacitor in the brake cartridge. The capacitor is discharged through a thin wire whose function is to suppress a 100 lb spring against the plastic pawl. When the current from the capacitor goes through the wire, the wire melts and releases the spring. The plastic pawl is then forced into the teeth of the saw blade. The plastic pawl begins to stop the saw blade rotation within milliseconds of when the detection circuitry senses human contact.

The saw blade is raised and lowered by way of a worm screw, keyed to a shaft that is manually rotated by the operator. The worm screw slides freely on this shaft until a U-pin on the worm screw locks into a groove on the shaft. When the worm screw is locked into place, rotation of the worm screw drives the saw blade up and down. The sudden braking of a rotating blade creates so much momentum that the worm screw is knocked loose from its locked position on the shaft. With the worm screw now free to slide on the shaft, the angular momentum of the blade carries the blade straight down below the table saw surface. As with the blade braking, the blade retraction occurs in the time frame of milliseconds.

SawStop Prototype Testing

A table saw is among the most diverse of power tools. A variety of blades can be installed to make straight thru cuts, angled bevel and mitre cuts, or non-thru dado and rabet cuts. The SawStop was tested using a variety of blades to make common cuts. Contact between the saw blade and a finger was simulated using a hot dog in lieu of a finger. The signal change (detected by the SawStop circuitry) caused by contact with a human finger is comparable to the signal change caused by contact with a hot dog that is in contact with a human body. The inventor verified this similarity in signal changes by measuring the signal of a human finger as it was cut on a saw blade and measuring the same on a hot dog as it was cut on a saw blade. The following table summarizes the testing performed on the SawStop.

Trial	Blade		Type Cut	Blade Stop	Hot Dog Damage	Comments
	Type	Teeth				
1	10" carbide	40	straight cut	6 ms	no	slow feed, hot dog on wood piece
2	10" carbide	40	straight cut	4 ms	no	fast feed, hot dog on wood piece
3	10" plywood	250	straight cut	24 ms	no	blade retract prevented injury
4	10" rip	12	straight cut	___	no	blade retracted before stop and prevented injury
5	10" rip	12	straight cut	___	no	blade retracted before stop and prevented injury
6	10" carbide	40	35 deg bevel 60 deg mitre	4 ms	no	average feed, hot dog on wood piece
7	10" carbide	40	kick back into rear of blade	4 ms	no	contact to rear of blade simulated kick back
8	10" carbide	40	contact during coast to stop	1 ms	no	blade stopped immediately contact made approximately 4 seconds after shut off
9	10" carbide	40	straight cut with glove	4 ms	no	cut thru glove, activation upon hot dog contact
10*	7" dado with plastic hub	24	NA	NA	NA	no reaction, blade insulated from arbor
11*	7" dado with plastic hub	8	NA	NA	NA	no reaction, blade insulated from arbor

* These tests were performed with the drive belt removed from the blade and a specialized test box in place of the brake cartridge. The test box simulates braking by cutting power to the motor.

The reaction time of the SawStop system is too fast for the human eye to detect. Each test trial was recorded using a high speed camera at 1000 frames per second. The slowest replay of events possible is 1 frame per second. A typical SawStop reaction to contact with a hot dog resulted in almost immediate retraction of the blade and cessation of the blade rotation within 4 milliseconds. Time for the blade to retract below the surface of the table saw depends on the blade height set for the cut. An important factor is the fact that however long it takes for the blade to stop rotating, the hazardous cutting edge of the blade is already moving away from the contact point.

A 40 tooth, 10" carbide blade stopped in approximately 4 milliseconds. This was true whether it was contact made during a straight cut, during a compound cut, from the rear of the blade, or through a glove. A straight cut made with a 250 tooth, 10" plywood blade resulted in a longer blade stop time of 24 milliseconds. However, despite the longer blade stop reaction time, minimal damage to the hot dog occurred because the blade still retracted from the point of contact almost immediately. Similarly, cuts made with a 12 tooth, 10" rip blade resulted in a blade stop time of approximately 35 milliseconds (the blade retracted below the table saw surface before blade stop), but minimal damage to the hot dog occurred because of the immediate blade retraction.

As stated before, because the prototype design capacitively couples the arbor, conductivity between the blade and the arbor is necessary in order for the system to react to contact between the blade and a body part. Two different blades with plastic hubs were tested and resulted in operation of the table saw in an unsafe condition -- if contact were made, the system would not have worked. The blades were specialized dado blades; however, their use is not uncommon among serious woodworkers.

The limited amount of time allotted for evaluation did not allow for electrical interference testing. Electrical interference transmitted through the electrical supply line or the air could potentially cause nuisance tripping or possibly prevent the circuitry from detecting someone touching the saw blade. If any of these types of interference should cause problems with the circuitry, the problems could likely be remedied by minor changes to the circuitry or how they are shielded from outside interference. Testing for the effects of electrical interference should be conducted in future evaluations of this product.

CONCLUSION

Based upon the evaluation reported here, it appears that the SawStop concept is valid and the prototype impressively demonstrates its feasibility. The electrical and mechanical components operated without failure in a time frame that would greatly reduce blade contact injury. The design concept is very flexible and can be modified to address foreseeable areas of concern.

The device that was evaluated is a prototype, with handmade, non-production components. Production products will include modifications due to design and manufacturing decisions that may result in different performance. In addition, the robustness and life-cycle details of production units will be different from those of the the prototype. The evaluations that were performed therefore concentrated on the validity of the concept and the performance of the components used in the prototype system. A significant amount of further development work may be required before this device could be incorporated into production saws, both because of the need to adapt the concept to mass production, and to address some issues that still require refinement.

Of highest concern are those areas where the SawStop may not perform, and more importantly, may not indicate to the user that it will not perform. As discussed earlier, the device is dependent upon electrical conductivity from the hand through the blade to the saw arbor and thence to the circuitry. There are tablesaw blades that have plastic or other non-conductive hubs or centers, and even a painted or coated metal blade may not make electrical contact with the arbor. In this event, the saw may be operated, but the SawStop will not work as presently configured. This failure may likely be addressed through further design refinement.

Of secondary concern are those areas where the SawStop system may be perceived as a nuisance and therefore a candidate for bypassing by the user. The prototype SawStop uses a brake cartridge that may only be used with a 10 inch blade. The cartridge location does not accommodate smaller diameter blades or thicker specialty blades. In addition, specialized blades such as molding sets, which only have one to three teeth, may not work with the current brake configuration. As stated before, these areas of concern would need to be addressed during production design of each specific table saw.