Massachusetts Woodworker Dies When Struck By Knife Launched from Overhead Router

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SUMMARY

On June 21, 1995, a 32 year old male woodworker was fatally injured when a steel tool knife was propelled from the overhead pin router he was operating. The victim, a tool grinder and setup man, had just sharpened the tool knives from the router. According to co-workers, the victim, working alone in a room, had fastened the knives into the holder, inserted the tool holder into the router and had just started the machine when they heard a loud noise. The co-workers entered the room to find the victim slouched against the wall approximately 25 feet from the router. A tool knife had launched from the router, perforated the victim's chest and ricocheted around the room. Emergency medical assistance was immediately summoned and the victim was transported to a local hospital emergency room where he died of his injuries shortly after arrival.

To prevent future similar occurrences, the MA FACE Director concluded that employers should:

- ***ensure that tooling for woodworking machines is used on the machinery intended by the tool designers***
- ***ensure that machines are adequately equipped with tool guards wherever possible***
- ***design, develop and implement a comprehensive safety program that includes, but is not limited to conducting periodic hazard analyses for each job classification, and employee training on hazards in the use of high speed woodworking machinery***

Additionally, tool manufacturers should:

- ***ensure that multipart (insert) tool holders are properly designed to hold tool knives securely.***
- ***ensure that tooling for woodworking machines are clearly labeled with their maximum permissible spindle speeds for which designed***

INTRODUCTION

On June 22, 1995, the MA FACE Program was informed through its Occupational Fatality Hotline by a Massachusetts medical examiner and the regional OSHA office that a 32 year old male woodworker had died the previous day of injuries received in a machine-related incident. The next day an investigation was initiated. On June 28, 1995 the FACE Investigator and the FACE Director traveled to the incident site and interviewed the owner, plant manager and co-workers of the victim. Multiple photographs, witness interviews, the death certificate, the police report and OSHA information were obtained during the course of the investigation.

The employer was a architectural moulding producer specializing in small runs milled to customer specifications. The company had been in business for six years and employed nine people, five of whom worked in the shop.. The company did have a designated safety officer, but did not have any written safety rules or procedures in place for the tasks being performed by the victim at the time of the incident.

The victim was the only employee in his job classification, and had received training in the operation of the machine involved in the incident. The victim was considered a highly skilled woodworker and tool grinder, who had worked for the employer for five and one-half years.

INVESTIGATION

The main woodworking shop contained typical woodworking machinery, including planers, shapers, saws, and spindle moulders. A drill press, sanding machines and the overhead router were in another room adjacent to the loading dock. A third room was used for tool grinding and storage.

The company typically received orders from customers for specially designed door and window moulding. The mouldings were produced on the high-speed spindle moulders. A spindle moulder is a specialty machine that cuts a pattern into long pieces of wood, which, in this case, are then used for door and window mouldings. The company custom-designed the cutting knives to match the requested patterns. It was the victim's job to grind these knives to order, and set them up in the machines for production.

Occasionally the company received special orders for rosettes. Rosettes are the decorative wood blocks which join the vertical and horizontal moulding of a doorframe or window. For a number of years the rosettes were made on the drill press, which had a top spindle speed of 5380 RPM. In 1992, the company purchased a used manual overhead router to make the rosettes because they wanted to be able to do more of this work. Approximately two days a month, an employee, usually the victim, would be required to cut rosettes on the router. This was the only job performed using the router.

Overhead routers are machines used to make patterned cuts in wood. A cutting tool is secured into the vertical spindle of the router, which rotates at high speeds, while the wood piece to be cut is secured to the table of the machine. In this case, the cutting tool was fed into the wood piece by use of a pneumatically driven foot pedal.

The cutting tools can be single or multiple piece tools. Cutting may be done by the face and/or

sides of the tool. The pattern can be changed by using different cutting tools or knife shapes. The cutting tool being used during the incident was a multiple part tool with two detachable tool knives specifically designed and ground for this job.

The knife holder, also called a cutting head, was made by a company other than the machine manufacturer. The holder was 4-3/4 inches diameter with a slot for the knives. The two knives, approximately 1-3/8" square, were clamped in the holder by use of shims and Allen head set screws (See attached Figures 1 and 2). The back of each knife was serrated in a horizontal direction matching the serration in the tool holder. The shims were blocks of steel approximately ½ inch thick, the same depth as the tool slot, and the same length as the knife. There were also spring pins pressed into holes at the two outer edges of the slot. The tool holder had no markings on it as to permissible speeds, but there was word-of-mouth information that it was limited to 10,000 RPM.

This router was capable of running at two spindle speeds believed by the employer to be 9,000 and 18,000 RPM. Manufacturers' literature listed the spindle speeds as 10,000 and 20,000 rpm. The spindle speed was set by removing the top cover, loosening the belt pulleys, moving the belts and tightening the pulleys. There was no indication at which speed the spindle was set without removing the pulley cover.

A Plexiglas shield was secured along the edge of the work table to shield the operator from wood chips and sawdust. This shield had been built by the victim. There was no tool guard on the machine.

On June 21, 1995, the victim had been setting up the spindle moulders as usual. That morning he had also completed an order of rosettes on the router, but was not satisfied with the surface finish on some of them. He informed a co-worker that he had decided to re-grind the tool knives in order to try to get a smoother cut. After regrinding the knives, he entered the room with the overhead router, and assembled the tool holder and knives back into the machine. Two co-workers saw him enter the room where the router was located and heard the machine start up. The co-workers were then alarmed by the sound of something striking the other side of the wall by which they were standing. They ran around the corner and into the room. They did not immediately see the victim, but soon found him on the floor approximately 25 feet from the router. The router was not running at that time.

The victim was gasping but could not speak. He was bleeding from a wound in his lower back. One co-worker ran to call an ambulance, while the other remained with the victim until emergency personnel arrived from the city fire department. The victim was transported to the local city hospital emergency room. Upon arrival the victim had no vital signs and emergency procedures to revive him were performed unsuccessfully. The hospital reported that the victim's heart had been severed by the object that had penetrated his chest.

Upon investigation it was discovered that on startup of the machine, one tool knife and shim flew out of the machine. The knife traveled at high speed through the Plexiglas shield, through the victim, striking a belt sander, and ricocheting off several spots on the walls before landing. The shim followed a different trajectory approximately 90 degrees from that of the knife, striking the concrete wall. It was the sound of the shim striking the wall which alerted

the co-workers.

The investigation also revealed that the spring pin at the edge of the tool had sheared and that the shim showed scrape marks on the side which touched the knife. It was also noted that the spindle belt on the router was set at the higher speed of 18,000 RPM. Employees had been instructed to run the rosette job at the lower spindle speed of 9,000 RPM.

There were no signs of fraying on the belts, nor burn or other marks on the pulleys to indicate that the belt had slipped from the lower to the higher speed. Therefore, the machine had most likely been set at the higher speed. Following the incident it was noted that the spindle of the machine had tilted approximately 1 degree and the shaft of the tool holder had bent approximately 15 degrees. These movements could have occurred as a result of the centrifugal force of the remaining single tool knife in the tool holder. The cutting tool had not yet touched the wood piece on the table of the machine when the knife flew out.

The machine was found in a stopped position. Apparently the victim had started the spindle and then immediately shut it off upon realizing something was wrong.

CAUSE OF DEATH

The medical examiner listed the cause of death as perforating wound of chest.

RECOMMENDATIONS

Recommendation #1: Employers should ensure that tooling for woodworking machines is used on the machinery intended by the tool designers.

Discussion: The tool holder involved in this incident had been designed for a much slower running machine, such as a milling machine or a drill press. When the rosette job was moved to the router, the tool went with it. No maximum permissible spindle speeds were stamped on the tool holder as they should have been, to indicate to users that there was a limit as to how fast this tool could go. When purchasing a tool for a particular machine and application, employers should be sure to receive the tool manufacturer's instructions and recommendations for the tool in writing. These instructions should be made known to all employees as part of their safety and job training. Consider posting instructions at particular workstations to increase employee awareness of the potential seriousness of misuse of tools. If in doubt about tooling applications for particular machines, contact the machine manufacturer for recommendations and follow them.

Recommendation #2: Employers should ensure that machines are adequately equipped with tool guards wherever possible

Discussion: Due to high operational speeds and very sharp cutting tools, woodworking machinery is extremely dangerous. Although manufacturers have a responsibility to equip machines with certain safety features, employers who are purchasing machines should familiarize themselves with current OSHA regulations (29 CFR 1910.213 (n)(1)) and industry machine guarding standards. As far as possible, metal or polycarbonate guards should be provided or retrofit that are able to withstand possible forces generated by flying tools. If the dust guard on this machine had been made from a polycarbonate plastic, which is used for bullet-proofing, the knife may have been contained or at least slowed down. Safety training programs should encourage the proper use of guards. Employers should consult with machine manufacturers periodically to learn about advances in machine guarding and current recommended practices or available devices.

Recommendation #3: Employers should design, develop and implement a comprehensive safety program that includes, but is not limited to conducting periodic hazard analyses for each job classification, and employee training on hazards in the use of high speed woodworking machinery

Discussion: Employers, with the participation of employees, should develop, implement, and enforce a comprehensive safety program. The program should begin with an identification and analysis of hazards associated with the specific machinery being used and work being done in the shop. It should also include the identification of the best controls for those hazards and how those controls could be implemented. Regular safety meetings should be held and all employees should be trained in the recognition of hazards and the implementation of controls. These controls can include changes in procedures, changes in equipment or use of personal protective equipment.

In particular, woodworkers should familiarize themselves and their employees with the relationship between tool diameter and spindle speed. To maintain safe cutting speeds, large diameter tools must be run at much slower spindle speeds than small diameter tools. Tool manufacturers provide charts for this purpose and these charts should be read and understood by those working in the trade for the safety of all in the shop.

As part of a safety program, employers should ensure that all tooling should be stamped with its maximum safe spindle speed and that all machinery is marked with the spindle speeds available on that machine. In this case, had all employees been aware of the serious hazards associated with running machines too fast, the incident may not have occurred.

Recommendation #4: Tool manufacturers should ensure that multipart (insert) tool holders are properly designed to hold tool knives securely.

Discussion: In this instance, the friction between the knife and the shim, which was maintained by the pressure of the two set screws was the only mechanism for containing the knife in the tool holder. As it happened, the pressure applied by tightening the set screws was insufficient to keep the knife in the tool holder. The set screws were not connected to the shim, so that the friction force had to hold the shim against the screws as well as the tool knife

against the shim. The centrifugal force for a 4 ¾ inch diameter tool at 18,000 RPM is extremely high. The set screws were also not located at an angle that would counteract this centrifugal force.

As stated in the International Labor Organization "Encyclopedia of Occupational Safety and Health" article on "Routers":

"Removable parts of tool holders must be secured against being ejected" and referring the reader to "Spindle Moulders - Assembled Tool Blocks", it furthers recommends:

> *"The detachable parts of cutter blocks must be secured against flying off. For this reason the parts to be fixed should preferably be held by positively interlocking elements (which are so designed that the shapes of the parts in contact with each other counteract the centrifugal force), and not by tightening friction alone."*

Many commercially made tool holders are designed with positively interlocking elements which prevent tool knives from ejecting. In fact, tools being used at this facility on the high-speed spindle moulders were designed in this way. If woodworking shop owners and managers are not sure if tool holders are properly designed, they should seek the advice of professional engineers or request recommendations from the machine manufacturer. If the tool holder had been better designed to prevent knife ejection, this incident may not have occurred.

Recommendation #5: Tool manufacturers should ensure that tooling for woodworking machines are clearly labeled with their maximum permissible spindle speeds for which designed

Discussion: In this case, the tool holder was not marked with any indication of the maximum permissible safe rotational speed of the tool. Neither was there written information available. The ability of woodworkers to make intelligent decisions about safe work practices depends on having such information immediately available. The ANSI Safety Code for Woodworking Machinery (O1.1-1992, section 4.18) recommends:

> *"Limiting speed for a rotating cutting tool*
>
> *A rotating cutting tool designed to be used on a woodworking machine shall be marked, where possible, by its manufacturer with its maximum safe rotational speed. When the cutting tool or saw is too small to mark legibly, the maximum safe speed shall be marked on its packaging."*

Had this tool holder been stamped with the maximum safe rotational speed, this incident may not have occurred.

REFERENCES

American National Standard Safety Requirements for Woodworking Machinery (ANSI O1.1-1992)

Code of Federal Regulations, Labor, 29 CFR 1910.213, Woodworking machinery, U. S. Government Printing Office.

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