Metalworking and milling machines

The operation of milling consists of machining a workpiece that is secured to the machine table by bringing it into contact with a revolving cutting tool. Milling machines, their hazards and recommended safe practices are the topic of this data sheet.

Hazards

2. The majority of milling machine accidents occurs when operators unload or make adjustments. The principal hazard is that of injury to arms, hands or fingers by contact with the cutter or other sharp objects or by pinching. This contact can be due to:

a. lack of essential guarding
b. improper training
c. unsafe work practices
- failure to withdraw the fixture a safe distance from the cutter while loading, unloading, gaging, etc.
- attempting to remove chips by hand
- adjusting coolant flow while cutters are moving
- checking the finished surface of components or calipering and measuring work while cutters are moving
- using wipers or rags near cutters while they are moving
- wearing gloves, loose sleeves, etc., near revolving cutters, spindle ends or other moving parts

d. unsafe workplace conditions
- insufficient or unsuitable lighting or both
- slippery or uneven floors or poor housekeeping around machines
- lack of adequate lifting equipment for heavy jobs or fixtures

e. unsafe machine design
- improper location of machine controls or control push buttons that can be inadvertently activated
- inefficient means of securing jigs, fixtures, etc., that involve pushing levers or spanners toward the cutters
- unguarded pinch points between moving parts and external objects
- lack of adequate access to the job or to the controls on large milling machines.

3. Not wearing proper safety glasses/shields around machines exposes personnel to hazards from flying particles.

The machine

4. The milling machine, like many other machines, is not dangerous to operate if safeguards are installed, the operator is trained and safe operating practices are followed. Have the milling machine anchored to the floor or machine foundation in such a manner as to prevent vibration. Vibration not only results in poor cutter life and job finish, but tends to loosen clamps, bolts and other fasteners. If the workpiece is not watched, it can become loose. If it is necessary to cushion the machine foundation, it can be done by using isolation dampeners between the machine base and the floor.

5. Milling machines come in many sizes and shapes, but can be divided into two main groups, according to whether the cutter spindle is vertical or horizontal. (Some ram type machines have swiveling heads and can be both.) Both types, however, share the same cutting principle and will, therefore, be handled together in this data sheet.

6. The horizontal type can be divided into two classes, the plain and the universal. The main difference between the two is that the table on the plain machine is set permanently at 90 degrees to the center line of the spindle, while on the universal machine, it is set on a swivel and may be swung 45 degrees horizontally to either side of the center line.

Operations

7. The operations performed can be classified either as (a) repetitive work or (b) non-repetitive work, sometimes referred to as jobbing.

a. Repetitive work means the consecutive milling of a number of similar articles when the machining process is fully governed by the requisite initial setting up of the machine on a predetermined method of operation.

b. Non-repetitive work (jobbing) means the milling of any article when the actual cutting process is not entirely governed by the initial set up. The operator controls the cutting action, together with the measuring or gauging necessary to achieve the size and finish required.

8. Special purpose milling machines include a wide range of machines designed for special or specific jobs and special units for production machinery, including attachments to other machines such as lathes, planers and drills.*

9. Machine design has been influenced by the development of the tungsten-carbide-tipped and other high-speed cutting tools. The higher chip load and cutting speed have demanded more speed, power and rigidity from mills; and while today's modern machine can fully exploit these advantages, many of the older machines are not suitable for new technology tools.

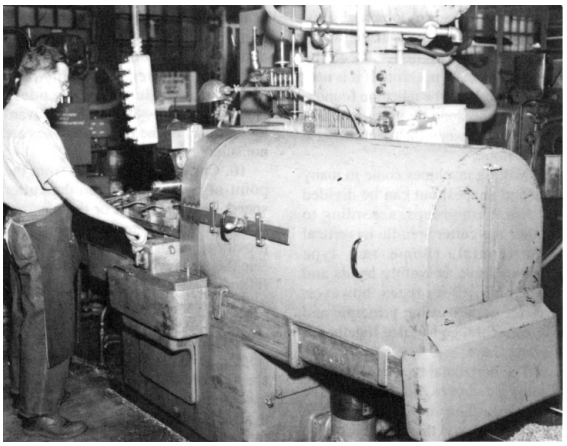

Figure 1. The spindle on this horizontal milling machine is completely guarded, protecting the operator from contact with moving parts and from flying chips. Note the accessibility of the controls.

10. Chips can be thrown from the point-of-operation due to the cutter speed, the type of cut or the material being milled. Where this can happen, provide a guard, hood or shield to confine the chips within the machine area (Figure 1).

11. Never use a paper shim to check the distance from a rotating cutter to the workpiece.

12. Suitable feed direction and speed and the correct combination of cutter speed and table feed for the work material are of paramount importance. They not only increase productivity, they also improve safety by reducing the risk of cutter breakage or job movement. (Information on correct combinations is usually readily available from the manufacturers of the cutters.)

13. The work can be fed to the revolving cutter either against the cutting action (orthodox milling) or with the cutting action (climb milling). Orthodox milling feeds the work against cutter rotation and cutting

* For details, see NSC's *Accident Prevention Manual for Industrial Operations,* and NSC Data Sheets 264 *Engine Lathes* and 335 *Metalworking Drill Presses.*

pressures tend to push the job away from the cutter and allow the table-feed mechanism to take up its slack smoothly.

14. Climb milling, however, feeds the work with the cutter rotation and cutting pressures tend to pull the job down and under the cutter, which tries to climb the work. This tendency is very useful on thin jobs where the pressure holds the work flat against the table with the minimum of clamping. However, without a table-feed backlash eliminator, the cutter will pull the job, violently take up any slack in the feed mechanism and literally bite off more than it can chew.

Safeguards

15. If the machine is motor-driven, be sure stop and start buttons are located within easy reach of the operator, preferably on the frame of the machine. Also make certain that all wiring conforms to the requirements of the *National Electrical Code*.

16. If the machine is motor-driven and a rheostat is provided, enclose the rheostat to prevent accidental contact with the live parts.

17. If the milling machine is belt-driven, be sure the belts and pulleys are enclosed in guards (see ANSI/ASME B15.1). Have the guards constructed so they will permit ready access to the belts and pulleys and also permit easy oiling of the machine. If present, a positive-acting and locking belt shifter is to be within easy reach of the operator. In all cases, make sure power gears, sprocket wheels and chains, telescoping shafts and universal couplings are guarded to prevent injury by accidental contact.

18. Provide a guard over the cutter of a horizontal milling machine to cover the exposed cutter edges where practical (Figure 1). The point of operation where the chips are being generated is not considered a hazard on semi-automatic and automatic machines. However, the rotating cutter, the flying chips and coolant, and the trapping zone between the tool and the work, tooling or machining component can constitute hazards that require safeguarding (see ANSI B11.8-1983).

19. The following guarding methods and control devices are available for use on milling machines:

a. A fixed guard constructed as a whole to enclose the milling cutter or cutters completely and render it impossible to touch any part of a revolving cutter. It can include a composite type of guard in which one or more portions are fastened to a stationary part of the milling machine with other portions secured to a sliding feed table with the whole arrangement completely enclosing the cutter or cutters at all times during operations.

b. An automatic guard that by itself or in conjunction with fixed guards prevents under all conditions any access to the cutter or cutters when they are in motion. The movable portions automatically adjust themselves to the workpiece and are positively actuated in such a way as to be incapable of being displaced by hand.

c. An interlocked guard that, either by its own movement or in conjunction with suitable fixed guards, prevents access to the cutters while they are in motion. The essential characteristic of this type of guard is that it be so interlocked with the driving mechanism or interconnected with the electrical circuit, that the cutters cannot be set in motion until the guard is in the fully closed or safe working position.

Note: Cutter stop time must be such that the cutter comes to a complete stop when the interlock is open before the operator can reach the cutter.

d. A trip guard or device so placed in relation to a cutter that when it is displaced by any person close to the cutter, it will stop the cutter motion automatically.
e. A distance guard so constructed and positioned in relation to a cutter that is difficult for any person to contact the revolving cutter without some warning of dangerous approach. Where such a guard is provided, supplement it by providing an emergency stop for bringing the cutter rapidly to rest. This stop must be placed within easy reach of any person who could inadvertently contact the cutter.
f. Safety by position can be particularly applied to large milling machines because the cutters are safe by position in relation to the operator's working and controlling positions.

20. All guards and safety devices shall be of sound material, of well engineered construction and properly maintained in good working order at all times. Test interlocks frequently to ensure that they will function as intended in an emergency. Never use them in place of lockout procedures during maintenance.

General

21. Chips give rise to hazards because they are produced in thin, needlelike slivers and because they are often ejected at high temperatures and considerable velocity from fly cutters and other operations. The chip discharge area must be guarded and regularly cleared to prevent a dangerous buildup of these sharp edged hazards either on the machine or on the floor.

22. The wearing of gloves to protect against chip hazards must not be permitted during the operation of the machine because of the risk of becoming entangled with the cutter or spindle. However, gloves may be worn to protect hands during cleanup when the machine is not in operation.

23. Where cutting fluids are used, most companies install an apparatus for filtering and purifying the fluid at regular intervals. Provide adequate splash guards for catching coolant thrown out from the milling operation or running from the table. Obtain Material Safety Data Sheets for the toxic cutting fluids. Where the probability exists for coolant to splash or spray on the operator, provide convenient emergency eye flushing facilities. If mist generation is an issue, provide a mist collection system (for further reference see ANSI B11.TR2-1997 Mist Control Considerations).

24. Machines with automatic table and/or head movement should be located in such a manner that no pinch point will exists between the machine at it's most extreme movement and fixed objects such as other machines, building walls or building support columns.

25. Provide lifting devices where heavy materials or chucks must be handled. Monorail hoists or specially designed portable cranes are frequently employed for this purpose. Visually inspect and document these checks daily.

26. Be sure illumination at the task is free from glare and is adequate to perform the job safely. Light intensity of 50 to 100 footcandles (decalux) is recommended. Provide auxiliary lighting for close work and shades to reduce glare.

27. Maintain floors in good repair, free of all obstructions, and if necessary cover them with a slip-resistant material to prevent an operator from slipping and falling. Open-link rubber mats help reduce operator fatigue and the slipping hazard of hard floors. They also prevent accumulation of dirt on the mat surface.

28. The operation of milling machines by employees not experienced in their use must be prohibited except when an inexpe-

rienced operator is working under the direct instruction and supervision of a trained instructor. Post signs calling attention to such prohibitions in conspicuous places adjacent to the machines. Keep signs clean.

Operating rules

29. Give special attention to training for all milling machine operators.

30. Milling machine operators must not wear gloves, aprons, loose or torn clothing or jewelry of any kind. Long hair is to be confined. If there is metalworking coolant being used breakaway aprons may be considered.

31. Employees operating milling machines must be provided with and be required to wear eye protection with side shields that will prevent chips and other flying particles from entering their eyes (see ANSI Z87.1). Proper foot protection must be worn to protect the feet against possible injury by falling parts, tools or materials.

32. To avoid striking the hands on the cutter while setting up, perform this operation as far away from the cutter as possible. Clamp the job firmly to the table. When clamping the work in place, use only wrenches that properly fit the nut and bolt heads, and take care not to spring the work out of shape.

33. If a vise is used to hold the work, never allow it to be tightened by striking the handle with a hammer. This is likely to spring the vise or break off the end of the screw that carries the handle.

34. Keep bearings in good condition to prevent vibration.

35. When mounting work between centers on the dividing head, have the operator use live centers, and make sure there is no play between them.

36. Only use cutters that are correctly dressed and in good condition. When using cutters in a milling machine, care must be taken not to employ too heavy a feed or too heavy a cut. Such a feed or cut is likely to break the cutter, with the possibility of flying particles striking and injuring the operator.

37. Before starting a milling machine, the operator needs to make sure that:

- all guards are in place
- the work is properly secured in place
- any bolts used in holding down the work will clear the tooling
- the tooling and supporting pieces are properly tightened in position
- table stops are secured in proper places
- the handles on the various feed screws are in neutral
- the table is free of stock, tools or other loose material that might fall off and injure the operator.

(See paragraphs 12 through 14 for details of feed direction and speed.)

38. When inserting the arbor or adapters into the spindle, observe the following procedure:

a. Be sure both arbor and spindle holes are clean and free from nicks.
b. Insert the arbor or adapter into the spindle, pushing it firmly into place.
c. Screw in the draw-in bar until it begins to turn hard; be sure the bar is clean, both on the body and threads.
d. Draw the arbor firmly into place by means of the sleeve nut.
e. Securely tighten overhead supporting arm in place.

39. When removing the arbor from the spindle, observe the following procedure:

a. Loosen the overhead arm clamps
b. Remove the sleeve nut.
c. Remove the draw-in bar.
d. Tap the arbor lightly with a composite head hammer.

40. Do not use sprung arbors. If an arbor is sprung, straighten it or obtain a straight arbor before the cutter and spacing collars

are put in place. Do not attempt to take the nut off the machine arbor by applying power to the machine. Do not reach around the cutter to move any control level while the machine is running.

41. Do not remove chips from the table by hand. Use a brush or other tool for that purpose.

42. The operator must stop the cutter before using quick traverse, clearing chips or checking the job. The operator shall not attempt to clean or oil the machine nor make any adjustments to the work while the machine is in motion. The operator must use appropriate lockout procedure when changing tools or performing any maintenance (see ANSI Z244.1-2003).

43. Change the cutting fluid periodically, and clean out the container at regular intervals. If the cutting fluid is used over a long period, it becomes rancid, especially during hot weather, and can cause skin disease.

44. Operators shall not rest their hands on the part being milled, nor shall they lean against the table or any part of the machine while the machine is in motion. They shall never reach within one foot of a rotating cutter to load or unload or for any other reason.

45. Horseplay about a milling machine or distracting the operator's attention while the machine is in motion is unsafe and must not be allowed.

46. When an operator has finished an operation or before leaving the machine for any reason, he or she is to shut off the power and make sure the machine has stopped running.

47. In case of emergency, know how to stop the machine or disengage the clutch promptly. On large machines, where the operator may not be close to the regular control switch, install an emergency stop so the machine can be stopped instantly.

Note: more than one e-stop device may be necessary.

48. Store cutters with care, especially when placed on racks. Contact with the sharp teeth will cause severe cuts and serious injury could result if a cutter were to fall.

49. Whenever an operator observes an unsafe condition in the machine, he or she must report it without delay to the supervisor. An operator is also to report all injuries no matter how minor and get treatment to prevent infection.

Acknowledgment

This data sheet was revised by The Automotive, Metals & Power Press Section of the National Safety Council, 1121 Spring Lake Drive, Itasca, IL 60143-3201.

Sources of information

American National Standards Institute, II West 42nd Street, New York, NY 10036:

Safety Requirements for Manual, Milling Drilling and Boring Machines with or without Automatic Control, ANSI B11.8-2001.

Safety Standard for Mechanical Power Transmission Apparatus, ANSI/ASME B15.1-2001.

Practice for Occupational And Educational Eye and Face Protection, ANSI Z87.1-2003

Control of Hazardous Energy—Lockout/Tagout and Alternate Methods, ANSI Z244.1-2003

The control of hazardous energy (lockout/tagout), OSHA, 29 *CRF* 1910.147.

Mist Control Considerations for the Design, Installation and Use of Machine Tools Using Metalworking Fluids, ANSI B11.TR2-1997

National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, *National Electrical Code*, ANSI/NFPA 70.