

# Health and Safety Executive OC 633/10

Field Operations Division

To

Factory Inspectors

FCG Specialist Inspectors (Mech, Elec)

## COMPUTER NUMERICALLY CONTROLLED (CNC) PUNCHING AND NIBBLING MACHINES

### Introduction

1 This OC, which replaces NIGM/10/1986/19, concerns CNC punching and nibbling machines, and summarises the information available on hazards, accidents, guarding methods, and noise. It requests that information on safety systems, problems with interlocking and safeguarding methods be sent to the Engineering NIG A.

2 The number of punching and nibbling machines in use which incorporate CNC controls has been rapidly increasing and the Engineering NIG has had many queries about guarding standards. The machines, and consequently the hazards, vary considerably.

3 The machines normally feature a fixed punching head which operates in conjunction with an indexing tool magazine and an arrangement of slides which grip the sheet metal workpiece, and position it by movement along 2 axes. The computer programme selects the correct punch for each blow and causes the corresponding hole position on the workpiece to be presented beneath the punching head. Speed of operation is very fast; punching rates of 500 blows/minute and slide positioning speeds of 50 m/minute are common. Newer machines may have table axis movements of 60-90 m/minute.

4 The machines may be hydraulic or mechanical. It should be remembered that even when the punch incorporates a flywheel and clutch, the machines are exempt from the Power Presses Regulations 1965 by virtue of Certificate of Exemption Number 7.

### HAZARDS

5 Hazards may arise from:

- (1) the workpiece clamps (unless the maximum opening is so small as to prevent finger access);
- (2) the punch tool (unless the gap between the punching tool and the table does not permit access);
- (3) the tool indexing mechanism, and tool change mechanism where fitted;
- (4) transmission machinery;

- (5) traps between the moving table or carriage and walls, control panels etc;
- (6) traps between the moving table or carriage and the machine frame;
- (7) shear traps between the moving sheet and openings in the machine bed;
- (8) shear traps between workpiece with holes and fixed parts of the machine;
- (9) being struck by the table or carriage or a workpiece overlapping the table (eg should an operator approach the machine thinking the cycle was complete);
- (10) being struck by a workpiece ejected from the machine if the grippers release the sheet during carriage movement;
- (11) noise.

6 Hazards 5, 6, 7, 8 and 9 do not exist at all machines and depend upon the individual design and size of sheet used. The retro fitting of sheet handling and positioning devices to existing machines can introduce new hazards for this type of machine.

## ACCIDENTS

7 Between 1985 and 1989 MARCODE revealed 18 accidents investigated on these machines. Of these, 8 occurred at the tools; 4 during tool changing, 2 when cleaning a blockage at the tool, one when removing scrap, and one during fault finding. In 2 cases, a tool changing jig was provided and not used, and the operator held the tool on his fingers, which were clamped by the tool clamps. Accidents during scrap removal show that the turret guard did not prevent access to the tools, and distance fencing or presence sensing was not provided. In one case there was a peripheral photo-electric (PE) device, but the machine was being operated by 2 people, one within the safeguarded area.

8 One accident occurred at the sheet clamps, which are close to the punching position.

9 Two occurred at the turret mechanism, one at the chain and sprocket drive rotating the turret, and one at the rotating turret itself. In both cases the interlocks on the access doors were faulty or badly designed.

10 Two were caused by the moving table or sheet; lacerations can result from sheet edges, and properly located distance fencing or presence sensing devices are important.

11 Two were caused by the moving carriage or table and fixed parts of the machine. These accidents are potentially the most serious, causing loss of a hand or fingers. In some cases fixed guards can be used to fill in slots or holes, but for table gaps the only solution is presence sensing devices or effective distance fencing and trip devices at access points.

## TYPES OF MACHINE

12 There are 3 main types of machine construction, presenting different hazards:

### C Frame Machine

13 C Frame machines can vary from very small to very large. The table may be fixed, or may move with the carriage. There are 3 configurations:

- (1) the carriage is at the back or throat of the machine, and moves forwards and sideways to position the sheet under the punch, with the turret at the open side (see appendix, diagram 1); or,
- (2) the punch and turret are near the throat with the carriage at the open side (see appendix, diagram 2); or,
- (3) the carriage is located to one side of the C frame.

14 There are likely to be traps between the throat and the back of the carriage, or the leading edge of the table, depending on configuration. There may also be traps between the edge of the turret guard and the moving carriage.

15 On some machines of type (1) the trap at the throat can be eliminated by attaching a sliding vertical guard parallel to the press frame, to the rear of the carriage (see appendix, diagram 3). Alternatively, presence sensing devices, such as pressure sensitive mats of suitable size, fixed to the floor, should be used.

#### Bridge machines

16 Machines of bridge construction are usually large (see appendix, diagram 4). They may have a fixed or moving table.

17 There may be traps between the rear of the carriage, and the machine frame, between the moving table and machine frame; and between the carriage and turret guard. The trap at the rear of the carriage may be dealt with as for C frame machines. On larger machines with fixed tables, access to traps between carriage and turret may not be possible.

#### Gantry machines

18 Machines of gantry construction have a fixed bed, no moving carriage, and grippers which only move along the bed (X axis) and a punch which moves across the gantry. The tool change mechanism is at one side of the gantry (see appendix, diagram 5). There may be traps at each end of the carriage. Bellows or telescopic guards should be provided. There may be traps between the traversing punch and each end of the gantry, and there are traps between the sideways moving sheet and table gaps at the tool change area and any gaps in the table where persons may need to stand. Presence sensing devices should be provided if the traps cannot be eliminated. It may be possible to fit fixed or interlocked screen guards at each side of the tool change mechanism, to prevent access to table gaps and to the carousel and tool change mechanism.

#### PUNCH HEAD, CLAMPS AND TOOL INDEXING MECHANISM

19 Turret arrangements vary. Access is needed to change tools, to deal with tool jams, and for some cleaning and greasing. There is usually a risk from the turret rotation mechanism, tool clamps and tool change mechanism if fitted, and from the tools.

20 On many presses the paired top and bottom tools are located in 2 turrets, rotated by toothed belts and indexed to come below the punching head, when required. The head descends and strikes the punch, which returns under spring pressure. There is often an air-jet to assist in stripping the scrap off the tool.

21 In other systems, the tools are held in turrets and transferred to the punching section by a tool transfer mechanism. The punch and die are clamped in the punching position and the top tool positively driven down and back up. The tools are then returned to the turret.

22 The turret should be provided with interlocked guards, or a combination of fixed and interlocked guards, which when open only permit turret rotation at slow jog, and prevent punching operations.

23 Transmission machinery, including toothed belts, pulleys and chains and sprockets should have close guarding. Negative mode interlocking switches are not uncommon and should be changed to 2 position switches, working in opposite modes. A separate jog control at the turret or on a handset is usually necessary.

24 On some presses the combination of turret guard and machine table prevents access to the punch tools during operation of the machine. If this is not the case, presence sensing devices, eg pressure sensitive mats will be needed where there is access to the punch head.

25 The workpiece clamps are usually situated on either side of the punching position, and are simply pads driven down by small vertical cylinders. They are sometimes safe by position and sometimes they have insufficient movement to create a trap.

26 On gantry machines, the tool change mechanism may be of the carousel type, situated at one side of the gantry with an open side for the tool change operation allowing ready access to the tool change mechanism and turret. Presence sensing devices will be necessary, unless fixed or interlocked vertical screen guards can be provided along the machine bed adjacent to the carousel. Such safeguards can be arranged to prevent access to the trap between the moving sheet and the gap in the table at the punching area. Where access is required for tool loading, hinged or sliding interlocked guards or suitable presence sensing devices should be provided. Where powered movement of the carousel is necessary with the guards open or presence sensing device overridden, then this should only be done using a hold-to-run slow jog control.

## MACHINE LAYOUT AND CONTROLS

27 Traps between the moving table, or carriage and walls and control panels can be avoided by ensuring a gap of at least 460mm (18") between them. Allowance should be made for large sheets which overhang the edge of the table.

28 Control consoles should be sited in a position which provides a clear view of all access points to the machine. Alternatively, mirrors or video screens can be used. On a large machine there should be stop and lock controls on each console and at conveniently accessible points to anyone entering a danger zone.

29 To prevent the machine being reset inadvertently when a person is within the safeguarded area, stop and lock controls within the safeguarded area, coupled with a final reset on the console, should be provided, or, a 2 stage reset device could be used. This comprises 2 reset buttons, one within the area and one on the console which have to be pressed successively within a set time of one another. On leaving the safeguarded area the operator presses the reset and confirms it at the console.

30 Where electro-sensitive safety devices are used as part of the perimeter fencing, it should not be possible to reach the control console to reset the machine from a position within the protected area.

31 If handsets are provided, they should only be capable of running the machine at inch or crawl speed using hold-to-run controls. There should be an emergency stop button on the handset. When the handset is in use, the main console should not be capable of controlling the machine but its emergency stop should continue to function at all times.

## PERIMETER FENCING

32 It may not be possible to eliminate all traps by design, or to provide local guarding for all hazards.

One solution is to use a combination of perimeter distance fencing, taking care to avoid additional traps, and a presence sensing device to detect when the operator approaches a hazardous area to load a component or free a blocked tool.

Note: A presence sensing device signifies a trip device which maintains the machine in a safe state during the time a person is in the danger area, such as a pressure sensitive mat, or horizontal or diagonal format PE device which extends over the relevant working area. Vertical format PE devices or pressure sensitive mats at the entrance to a danger area, and which once crossed do not continue to register the presence of a person in that area, are trip devices which do not have presence sensing capabilities.

33 On machines where there is good visibility of all parts of the machine from the control console, a perimeter fence comprising handrail or chain with presence sensing device at access points would be adequate. On a large machine where sight of certain areas is obscured, full height perimeter fencing (1800mm) or additional presence sensing devices should be provided.

34 The perimeter fence should be sited to allow at least 460mm (18") space between it and the extreme positions of the table, carriage or workpiece, and should take account of large sheets which may overhang the table. The supplier should stipulate what, if any, sheet overhang is permissible, and find out from the user what the maximum sheet size is likely to be, and design the guard layout accordingly.

#### Electrosensitive devices

35 Electrosensitive safety devices may be used instead of perimeter fencing. Additional presence sensing devices may still be required for particular hazards outside the operator's field of vision which cannot be guarded by other means, and to prevent persons standing between the beam and the machine, without being detected.

36 PE devices at the perimeter should comprise at least 2 discrete beams, at waist and knee height (400mm and 900mm). The location of the PE devices will depend on table/carriage movement and sheet overhang (see para 34): it should not be possible to reach through the curtain to dangerous parts, or to step through it and be struck by the moving table or sheet.

37 GN PM 41 "Application of photo-electric safety systems to machinery" (file 227), particularly paras 103 (angled approach curtains) and 99 (parallel approach curtains for trip or pressure sensing) give information on distance and beam spacing which can be used as a guide: a distance of 1050mm from the nearest position of the table would apply to horizontal or diagonal format curtains and could be used for vertical curtains.

Note: Para 99 states that if the horizontal curtain is positioned higher than 1200mm above the standing position of the operator, the curtain object detection capability can be reduced to 300mm. This requires interpretation; for this application it would be too easy to step under a 1200mm high curtain, and hence a diagonal format curtain with the outer beam at 1200mm and the inner beam at, eg 400mm would be appropriate. At least 3 beams would be required (see appendix, diagrams 6 and 7).

38 Alternatively a vertical format curtain plus additional sensing beams, or pressure sensitive mats at key points, would be appropriate, using 1050mm separation distance. CEN TC 114/WG 5 are working on a standard for the determination of the position of safety devices. The BSI panel shadowing this Working Group have recommended that for vertical discrete beams, the following distances should be used. It should be noted though, that these distances have not yet been agreed across Europe.

<b>No of Beams</b>	<b>Vertical Height from Floor</b>	<b>Distance from Hazard</b>
2.00	400mm	1.2m
	900mm	
3.00	300mm	1.2m
	700mm	
	1100mm	

### INTERLOCKING ARRANGEMENTS, SAFETY DEVICES

39 The level of risk is such that a single channel control interlocking system, as described in BS 5304: 1988 "Code of practice for safety of machinery", clause 9.3.7 should be acceptable.

40 The machine should be classed as category 2 within the terms of GN PM 41 and that guidance adapted accordingly (but see paragraphs 32-37 above for perimeter fencing). Paragraphs 42-47 of GN PM 41 concern integration of the PE device into the electrical circuitry, and paragraph 79 concerns hydraulic circuitry.

41 Pressure sensitive mats should be of a standard suitable for safety purposes, and arranged in accordance with BS 5304 paragraph 8.1.4.

42 In all cases, the system should be arranged so that after a safety device has been actuated, the machine cannot be restarted until the device has been restored to its normal state and the controls reset at the console.

43 The interlocking arrangements on some machines are software based, ie the signal from the safety device is routed via the programmable controller, rather than acting directly on the machine actuators. This is to prevent the interruption to work in progress caused if a hard wired system requires the machine to be re-referenced to a datum point every time a safety device is operated.

44 For example, PE devices on one make of machines operate via the programmable system, although there is also a hard wired emergency stop which, if operated, requires that the machine be referenced to a datum point before it can be restarted. However the interlock switch on the turret guard is hard wired, if the turret door is open relays break the supply to the motor governing punching and turret rotation and the clutch is disengaged. It is important to establish to what degree the safety of the machine relies solely on the correct operation of such a programmable system and the consequences to the operator or others if it should fail.

45 It is difficult to insist on a hard wired system when there are technical problems in providing one, and where the risk of injury is low. In such cases software based safety systems should be accepted, provided the supplier can demonstrate that they achieve a level of safety equivalent to a non-programmable system. It is possible, in the majority of cases, to provide a hard wired system for parts such as turrets, punching heads, transmission machinery, to which access is not required mid-cycle. These parts normally have hinged or removable interlocked guards. If necessary, the interlocking system can be arranged to send a signal to the controller. This allows, for example, monitoring of guard position by the controller. Engineering NIG A is interested in the types of safety

systems, their effectiveness, and in any problems with them.

#### Override facilities

46 Facilities to override the interlocking devices may be provided on some machines, to permit setting or tool changing. For example, it may be possible to revolve the turret with the guard open, but this should only be at slow speed, with a hold-to-run control, and punching should not be possible. Close guarding of chains and sprockets etc may be necessary. See also paragraph 23 and 31 concerning use of handsets.

47 It should not be possible under any circumstances to override the emergency stop.

#### NOISE

48 Noise levels vary, according to the thickness of sheet and type of material and the nature of the holes being punched. Suppliers should be able to provide examples of noise readings taken at their machines when operating on a variety of typical materials. Some will also undertake noise surveys at users' premises after installation.

49 Noise levels can be reduced, though not necessarily below 90 dB(A), by:

(1) using cushioned or anti-vibration mountings. At least one supplier provides this as a standard fitting, and it also cuts down on installation costs because less bed preparation is needed. It may not be suitable for all machines.


(2) tool design: ensuring a proper shear angle on the tools is maintained removes the hammering effect;

(3) clamp design: one supplier uses cushioned neoprene clamps.

50 The machines should be sited away from other, quieter, machines. Depending on layout, there may be scope for noise segregation, eg using plastic strip curtains, and operators may need to wear hearing protection. Noise enclosures can be provided. They should incorporate guarding features, including interlocks at access doors. Prices for a 7m by 5m installation would vary from £10-£12,000 installed, to £15,000 depending on number of access doors, need for automated access doors, etc. Engineering NIG A would be interested to receive information on noise control measures, especially noise enclosures.

#### PROVISION OF INFORMATION

51 Suppliers should provide users with information on the safe operation of the machine and on

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and maintenance procedures. This should include the function and method of operation of safety devices. They should also be able to provide information on noise (see above).

#### TRAINING AND SYSTEMS OR WORK

52 Training in the use of the particular punching machine should be given to operators, setters and maintenance staff. The machine manual should provide guidance on safety procedures, particularly for tool changing and clearing blockages, during which many of the accidents at these machines have occurred.

53 For some machines there are special tool holding jigs for tool changing and these should be kept available and the operator trained to use them.

54 Safe working procedures, based on the machine manual, should be drawn up for maintenance and fault finding and safe working positions identified. Work should not be done within the perimeter fence when the machine is operating on automatic cycle or under manual control. If safe working procedures alone do not effectively prevent it, further safety measures will be required, such as presence sensing devices.

## NEW MACHINES

55 Some suppliers have not been providing guards as a standard fitting, but as an optional extra. They may argue that each installation varies so much that it is not possible to give a standard quote. This is only partly true, and the suppliers will only have discharged their duty if they comply fully with s.6(8) and get a written undertaking from the user that they will take specific steps to safeguard the machine.

56 The main suppliers have had considerable advice on safeguarding methods as outlined in this OC and a serious view should be taken of the supply of machines with inadequate safeguards.

## EXISTING MACHINES

57 In some cases it will be possible to fit the standard of safeguards provided for new machines to existing machines. With the older or obsolete models this may not be practicable, and a combination of safeguards will need to be selected on an individual basis, chosen from those described in this OC.

# Action by inspectors

58 Engineering NIG A would be interested to receive information about safeguarding systems on these machines particularly about software and hard wired safety features, and about any problems in applying the guidance.


6 November 1990

(1372/FOD/1990)


Disc No:FOD1C/Editors/J74/9.7.90/DH/DS

(NEW DISC REF: J:\EDITORS\CA1\J74JL90.SAM)

# ASI headings

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numerical control: nibbling machines: punching: sheet metal.

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APPEN

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