INTERNATIONAL STANDARD

ISO 4343

Second edition
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Industrial automation systems — Numerical control of machines — NC processor output — Post processor commands

Systèmes d'automatisation industrielle — Commande numérique des machines — Informations de sortie des processeurs CN — Instructions post-processeur

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 4343 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 1, *Physical device control*.

This second edition cancels and replaces the first edition (ISO 4343:1978), which has been technically revised.

Annexes A and B form a normative part of this International Standard.

Introduction

The output of a general purpose numerical control processor is information used as input to a post processor. This information is called CLDATA, which was originally derived from “cutter location data.”

CLDATA provides a general language to pass manufacturing information from a numerical control processor to a post processor, where the general language is converted to the specific format required by the particular numerical control equipment. The logical and physical structure of CLDATA records are given in ISO 3592.

This International Standard defines a standard post processor vocabulary, in the context of command word and the parameters that can be associated with a command word. This vocabulary is encoded using the 2 000 class (“integer code type post processor command”) and 20 000 class (“literal type post processor command”) CLDATA records given in ISO 3592.

There is a one-to-one correspondence between the elements of the post processor vocabulary and the elements of the post processor command CLDATA records. The integer code numbers given in annex B of this International Standard are the code numbers that are used to represent keywords in the 2 000 class CLDATA records. The keyword names given in annex B of this International Standard are the names that are used to represent keywords in the 20 000 class CLDATA records.

Numerical control is applied to many types of machines, but the language defined in this International Standard has been developed primarily for numerically controlled machine tools – hence the words “tool” and “part” are used in the description of the language to indicate the working element and processed element respectively. Many of the vocabulary words are also derived from metal working terminology.

Industrial automation systems — Numerical control of machines — NC processor output — Post processor commands

1 Scope

This International Standard defines the elements of a set of post processor statements to be used in numerical control software. These statements are encoded on 2 000 class and 20 000 class CLDATA records or their equivalent.

Each processor using one of the ISO numerical control programming languages shall be capable of producing post processor command type CLDATA records as defined in this International Standard.

Each post processor shall be capable of using the post processor command type CLDATA records defined in this international Standard as input.

This International Standard does not prescribe

a) the mechanism by which the statements are processed;

b) the medium on which the input language statements are recorded;

c) the medium and format of output machine control data;

d) the order of statements within a part program.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 841[1)], *Industrial automation systems – Numerical control of machines – Coordinate system and motion nomenclature.*

ISO 3592:2000, *Industrial automation systems – Numerical control of machines – NC processor output – File structure and language format.*

ISO 4342:1985, *Numerical control of machines – NC processor input – Basic part program reference language.*

ISO 6983-1:1982, *Numerical control of machines – Program format and definition of address words – Part 1: Data format for positioning, line motion and contouring control systems.*

1) To be published. (Revision of ISO 841:1974)

3 Co-ordinate system

3.1 Part program reference

ISO 841 is the basis for defining the co-ordinate system of CLDATA.

In the CLDATA, the reference axes of the co-ordinate system are *x*, *y* and *z*. Co-ordinates refer to a reference point on a tool (usually the center of the tip) relative to the part co-ordinate system. CLDATA can define the following location and orientation components:

x	Dimension parallel to X
y	Dimension parallel to Y
z	Dimension parallel to Z
i	X axis component of the tool axis vector
j	Y axis component of the tool axis vector
k	Z axis component of the tool axis vector
l	X axis component of a secondary orientation vector
m	Y axis component of a secondary orientation vector
n	Z axis component of a secondary orientation vector

Unless otherwise specified, post processor command dimensional values refer to the CLDATA co-ordinate system. The following syntax is permitted as replacement for strings of numeric values representing CLDATA co-ordinates, CLDATA tool orientation vectors and CLDATA secondary orientation vectors.

```
XCOORD,x
YCOORD,y
ZCOORD,z
TLVEC,i,j,k
NORMAL,l,m,n
COORD,x,y,z [,i,j,k [,l,m,n ] ]
```

3.2 Machine program reference

ISO 841 is the basis for defining the standard configuration of machine axes.

On the machine, the reference axes of the co-ordinate system are *x*, *y* and *z*. Co-ordinates refer to a reference point on the machine (usually the center face of the tool holding mechanism) relative to the machine co-ordinate system. The origin and alignment of the CLDATA and machine reference systems coincide. Provision is made within this International Standard to define an alternate relationship

between CLDATA and machine reference systems. The following machine axes are recognized:

a angular dimension about the X axis
b angular dimension about the Y axis
c angular dimension about the Z axis
p tertiary dimension parallel to the X axis
q tertiary dimension parallel to the Y axis
r tertiary dimension parallel to the Z axis
u secondary dimension parallel to the X axis
v secondary dimension parallel to the Y axis
w secondary dimension parallel to the Z axis
x primary dimension parallel to the X axis
y primary dimension parallel to the Y axis
z primary dimension parallel to the Z axis

The following syntax is permitted as replacement for strings of numeric values representing machine linear axis co-ordinates:

(**PAXIS** | **QAXIS** | **RAXIS** | **UAXIS** | **VAXIS** | **WAXIS** | **XAXIS** | **YAXIS** | **ZAXIS**), *a*

The following syntax is permitted for numeric values representing machine rotary axis co-ordinates. The initial HEAD or TABLE keyword further qualifies the rotary axis when there are multiple axes providing rotation about a given axis.

([**HEAD** | **TABLE** ,] **AAXIS** | **BAXIS** | **CAXIS** | **DAXIS** | **EAXIS**), *a*

When specifying angles of planes, the positive direction is counterclockwise and the reference axis is as shown in table 1. The positive direction of angle is counterclockwise from the reference axis.

Table 1 - Reference axes

Plane	Reference axis
XY	*x*
YZ	*y*
ZX	*z*

3.3 Units of measure

Angles are expressed in degrees and decimal fractions of a degree.

The linear unit of measure of CLDATA is the millimeter. ISO 3592 has provision to define other units of measure. A change of units is modal and applies to subsequent co-ordinate data until changed again.

Unless otherwise specified, dimensional values appearing in post processor commands are in the same reference units as the CLDATA. Provision is made within this International Standard to define explicit units of measure for simple parameters on post processor commands. Table 2 lists the preferred non dimensional keyword followed by the non preferred dimensional alternates. Only preferred keywords appear in syntax definitions. Non preferred keywords can be substituted, however, their use is not encouraged.

Table 2 – Dimensional keywords

Preferred keyword **Non-preferred alternate**	
PERMIN	CLDATA units per minute
IPM	inches per minute
MMPM	millimeters per minute
PERREV	CLDATA units per revolution of the spindle
IPR	inches per revolution of the spindle
MMPR	millimeters per revolution of the spindle
TPI	the reciprocal of IPR
MXPERM	maximum CLDATA units per minute
MAXIPM	maximum inches per minute
MXMMPM	maximum millimeters per minute
CSS	surface speed in CLDATA units per minute
SFM	surface speed in feet per minute
SMM	surface speed in meters per minute

Unless otherwise specified and providing that the capability exists, dimensional values appearing in the post processor generated machine program shall be in the same reference units as the CLDATA. Where this is impossible due to limitations of the machine, the post processor shall be responsible for converting the CLDATA units to the appropriate units supported by the machine. Provision is made within this International Standard to define explicit output units to be used for the entire machine program irrespective of the CLDATA units.

4 General structure of post processor commands

4.1 NC processor

ISO 4342 defines the syntax and semantics of a standard NC processor input language, including a limited set of post processor vocabulary.

Post processor command names are defined using a Major type post processor keyword. A comma separated parameter list, if present, is separated from the command name using a “/” delimiter.

Parameters can consist of any combination of numeric values, keywords and quote delimited strings, respecting the syntax of the particular post processor command.

4.2 CLDATA

ISO 3592 defines the CLDATA record format for post processor commands. Specifics concerning the command names and command parameters are defined within that International Standard.

2 000 class records carry post processor instructions and are formed of elements as follows:

a) Element 1 (integer) is the CLDATA record sequence number.

b) Element 2 (integer) is 2 000, which identifies the record as an integer code type post processor command.

c) Element 3 (integer) is the integer code of the Major word identifying the post processor command.

d) Element 4 onwards (various) is an optional list of post processor command parameters.

Keywords are represented in element 3 and onwards as integer codes.

20 000 class records also carry post processor instructions and are formed of elements as follows:

a) Element 1 (integer) is the CLDATA record sequence number.

b) Element 2 (integer) is 20 000, which identifies the record as a literal type post processor command.

c) Element 3 (integer) is a code indicating whether the post processor command spans multiple records.

d) Element 4 (keyword) is the text of the Major word identifying the post processor command.

e) Element 5 onwards (various) is an optional list of post processor command parameters.

Keywords are represented in element 4 and onwards as character text.

4.3 Post processor

Each post processor shall support the basic set of commands defined in the general language section (see 5). Each post processor shall also support the additional set of commands defined in one or more machine family sections which follow. Each machine family section defines only those commands which are applicable to the machine type. The general language section and the applicable machine family language sections together provide the whole language for a machine family.

When a machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4) shall be used to designate the machine family being manipulated at any given moment.

Table 3 lists a cross reference of commands and language sections.

Table 3 - Cross reference of commands and language sections

Command	General	Die EDM	Flame	Grinder	Laser	Milling	Punch	Turning	Wire EDM	Probe	Plotting
ADAPTV	5.2										
AIR	5.3										
APPLY	5.4	6.2	7.2	8.2	9.2	10.2	11.2	12.2	13.2	14.2	
ARCSLP						10.3					
ASSIST			7.3		9.3						
AUXFUN	5.5										
BARFED								12.3			
BREAK	5.6										
CALSUB	5.7										
CATCHR								12.4			
CHUCK								12.5			
CLAMP	5.8					10.4	11.3	12.6			
CLDATA	5.9										
CLDIST			7.4		9.4				13.3		
CLEARP						10.5					
COOLNT						10.6		12.7			
COUPLE	5.10							12.8			
CUTCOM	5.11	6.3				10.7		12.9	13.4		
CYCLE					9.5	10.8	11.4		13.5		
DEFCON								12.10			
DEFSUB	5.12										
DELAY	5.13										
DISPLY	5.14										
DRAFT											15.2
DRESS				8.3							
END	5.15										
ENDSUB	5.16										
FEDRAT	5.17										
FLUSH		6.4							13.6		
GENRTR		6.5							13.7		
GOHOME	5.18										
GOPARK	5.19										
HEAD						10.9					
HOMEPT	5.20										
INCLUD	5.21										
INDPOS						10.10					
INSERT	5.22										
LEADER	5.23										
LETTER											15.3
LIMIT	5.24										
LINTOL						10.11					
LOAD		6.6				10.12	11.5	12.11	13.8	14.3	
LOCATE	5.25										
LPRINT	5.26										
MACHIN	5.27										

Table 3 - Cross reference of commands and language sections *(concluded)*

Command	General	Die EDM	Flame	Grinder	Laser	Milling	Punch	Turning	Wire EDM	Probe	Plotting
MATERL	5.28										
MCHFIN	5.29										
MCHTOL	5.30										
MODE	5.31							12.12		14.4	
MOVETO	5.32										
OP		6.7						12.13			
OPSKIP	5.33										
OPSTOP	5.34										
ORIGIN	5.35					10.13			13.9		
OVPLOT											15.4
PARKPT	5.36										
PARTNO	5.37										
PENDWN											15.5
PENUP											15.6
PIERCE			7.5		9.6		11.6				
PITCH								12.14			
PPFUN	5.38										
PPLOT											15.7
PPRINT	5.39										
PPTIME	5.40										
PREFUN	5.41										
PROBE										14.5	
RAPID	5.42										
RESET	5.43										
RETRCT						10.14					
REWIND	5.44										
ROTATE						10.15					
SAFETY								12.15			
SAFPOS	5.45										
SELECT		6.8				10.16	11.7	12.16	13.10	14.6	
SEQNO	5.46										
SPINDL		6.9				10.17		12.17			
STAN								12.18	13.11		
STDYRS								12.19			
STOP	5.47										
SYNCTR	5.48										
TLLIFE	5.49										
TLSTCK								12.20			
TMARK	5.50										
TOOLNO		6.10				10.18	11.8	12.21	13.12	14.7	
TORCH			7.6								
TRANS	5.51										
TURRET								12.22			
UNLOAD		6.11				10.19	11.9	12.23	13.13	14.8	
VERIFY										14.9	

5 General language

5.1 General comments

5.1.1 General semantics

The general language section defines the language that is common to a number of machine families. The general language section and a machine family section together provide the whole language for the machine family. A post processor for the family shall provide recognition and resolution of the entire language set.

5.1.2 Sub-contents

For

1) the ADAPTV command, which controls the use of an adaptive controller, see 5.2;
2) the AIR command, which controls the supply of air, see 5.3;
3) the APPLY command, which defines the selection of machine family, see 5.4;
4) the AUXFUN command, which provides for the insertion of miscellaneous function (M) codes, see 5.5;
5) the BREAK command, which provides for segmentation of a machine program, see 5.6;
6) the CALSUB command, which activates a predefined or machine specific sub program, see 5.7;
7) the CLAMP command, which controls the application of axis clamps, see 5.8;
8) the CLDATA command, which controls the input of part program data, see 5.9;
9) the COUPLE command, which defines the association between part program axes and machine axes, see 5.10;
10) the CUTCOM command, which controls workpiece compensation, see 5.11;
11) the DEFSUB command, which indicates the start of a sub program definition, see 5.12;
12) the DELAY command, which temporarily halts the movement of axes on the machine, see 5.13;
13) the DISPLY command, which controls the display of operator messages at the machine console, see 5.14;
14) the END command, which designates the end of the machine program, see 5.15;
15) the ENDSUB command, which indicates the end of a sub program definition, see 5.16;
16) the FEDRAT command, which controls various functions related to feed velocity, see 5.17;
17) the GOHOME command, which moves the machine to the home position, see 5.18;
18) the GOPARK command, which moves the machine to the secondary home position, see 5.19;
19) the HOMEPT command, which defines the machine home position, see 5.20;
20) the INCLUD command, which specifies a source for additional part program data, see 5.21;
21) the INSERT command, which provides for the insertion of machine program data, see 5.22;
22) the LEADER command, which provides for the insertion of leader spacing, see 5.23;
23) the LIMIT command, which defines travel limits and guard zones, see 5.24;
24) the LOCATE command, which preloads machine reference system axes, see 5.25;
25) the LPRINT command, which provides for control of the post processor listing, see 5.26;
26) the MACHIN command, which defines the post processor, see 5.27;
27) the MATERL command, which defines the workpiece material, see 5.28;
28) the MCHFIN command, which defines the acceptable machining finish, see 5.29;
29) the MCHTOL command, which defines the acceptable machining tolerance, see 5.30;
30) the MODE command, which controls various modal settings, see 5.31;
31) the MOVETO command, which controls the movement of machine axes, see 5.32;
32) the OPSKIP command, which controls the insertion of block delete codes, see 5.33;
33) the OPSTOP command, which designates an optional stopping point in the machine program, see 5.34;
34) the ORIGIN command, which defines the relationship between part and machine reference systems, see 5.35;
35) the PARKPT command, which defines the secondary machine home position, see 5.36;
36) the PARTNO command, which provides a unique identification for the machine program, see 5.37;

37) the PPFUN command, which provides special commands or instructions for the post processor, see 5.38;
38) the PPRINT command, which provides messages in the output data, see 5.39;
39) the PPTIME command, which provides for modification of post processor calculated run time, see 5.40;
40) the PREFUN command, which provides for the insertion of preparatory function (G) codes, see 5.41;
41) the RAPID command, which specifies motion at rapid traverse velocity, see 5.42;
42) the RESET command, which designates a restart point in the machine program, see 5.43;
43) the REWIND command, which rewinds the control tape, see 5.44;
44) the SAFPOS command, which defines the working element change position, see 5.45;
45) the SEQNO command, which controls the numbering of machine program blocks, see 5.46;
46) the STOP command, which designates a required stopping point in the machine program, see 5.47;
47) the SYNCTR command, which controls the synchronization of multiple machine heads, see 5.48;
48) the TLLIFE command, which controls the use of tool life monitoring equipment, see 5.49;
49) the TMARK command, which provides for the insertion of rewind stop codes, see 5.50;
50) the TRANS command, which translates the part program co-ordinates, see 5.51.

5.1.3 Limitations

None.

5.2 The ADAPTV command

Controls the use of an adaptive controller.

ADAPTV / { **ON** | **OFF** }

5.2.1 Semantics

This command is used to engage and disengage the adaptive control unit, which is a control system that adjusts the response from conditions detected during the work.

ON (keyword) turns the adaptive control unit on and gives it control from that point in the machine program until it is turned off.

OFF (keyword) turns the adaptive control unit off and returns control to the machine program.

5.2.2 Examples

None.

5.2.3 Limitations

None.

5.3 The AIR command

Controls the supply of air.

AIR / (**ON** | **THRU**) **[,***a* **]**

AIR / OFF

5.3.1 Semantics

This command controls the supply of air. The air device is operated in a modal fashion if a duration is not specified.

ON (keyword) specifies a general air device.

THRU (keyword) specifies an alternate air device.

a (real) indicates the duration in seconds that the air device is to be active. The duration shall be a non-zero positive value. If the duration is omitted, the air device shall operate continuously.

OFF (keyword) terminates the continuous operation of the air device.

5.3.2 Examples

The following command activates the air device for 6 seconds.

```
AIR/ON,6
```

The following commands activate the air device during a tool change.

```
AIR/THRU
LOAD/TOOL,1
AIR/OFF
```

5.3.3 Limitations

None.

5.4 The APPLY command

Defines the selection of machine family.

```
APPLY / ( DEDM  )
        ( FLAME )
        ( GRIND )
        ( LASER )
        ( MILL  )
        ( PROBE )
        ( PUNCH )
        ( TURN  )
        ( WEDM  )
```

5.4.1 Semantics

This command specifies which machine family to control when the application programming changes to another basic machine family within the same post processor. Subsequent part program data is interpreted using the language defined for the named machine family.

DEDM (keyword) specifies die sinking electrical discharge machining (EDM).

FLAME (keyword) specifies flame, plasma or water jet machining.

GRIND (keyword) specifies grinding.

LASER (keyword) specifies laser machining.

MILL (keyword) specifies milling or drilling.

PROBE (keyword) specifies probing or measuring.

PUNCH (keyword) specifies sheet metal forming.

TURN (keyword) specifies turning.

WEDM (keyword) specifies wire electrical discharge machining (EDM).

5.4.2 Examples

None.

5.4.3 Limitations

None.

5.5 The AUXFUN command

Provides for the insertion of miscellaneous function (M) codes.

AUXFUN / *a* $^{0:n}$[,*a*] [,NOW]

5.5.1 Semantics

This command provides the facility to insert miscellaneous function (M) code numbers in the machine program.

a (real) specifies the miscellaneous function (M) code number to be output. If multiple codes are specified, they shall be inserted into the machine program as though each was specified in a separate AUXFUN command.

NOW (keyword) indicates that a break to a new block shall appear immediately following the output of each (M) code. The default action is to allow the (M) code to be combined with subsequent machine program data if possible.

5.5.2 Examples

The following command will output two (M) codes in the machine program, with each (M) code appearing in a separate block.

```
AUXFUN/5,4,NOW
```

The following commands perform the identical function as the single command described above.

```
AUXFUN/5,NOW
AUXFUN/4,NOW
```

5.5.3 Limitations

This command produces machine program data which may not be portable.

5.6 The BREAK command

Provides for segmentation of a machine program.

BREAK [**/** (**LENGTH,***a* | **TIME,***b* | **NOW**)]

5.6.1 Semantics

This command is used to segment a machine program. Segmentation can be immediate, or deferred based on machine program size or elapsed machine run time.

LENGTH,*a* (keyword,real) specifies the maximum machine program length in part program units before each new machine program segmentation.

TIME,*b* (keyword,real) specifies the machine run time duration in seconds before each new machine program segmentation.

NOW (keyword) specifies that machine program segmentation shall occur immediately.

A BREAK command without parameters shall be treated as a request for immediate segmentation.

5.6.2 Examples

None.

5.6.3 Limitations

None.

5.7 The CALSUB command

Activates a predefined or machine specific sub program.

CALSUB / (*a* | *'b'*) (,CLDATA | SYSTEM) [,ON] [,TIMES,*c*] [,*'d'*]

CALSUB / OFF

5.7.1 Semantics

This command controls the activation of a predefined or machine specific sub program.

a (real) identifies the sub program by a numeric identifier.

b (text) identifies the sub program by a textual identifier.

CLDATA (keyword) specifies that the sub program being called has been previously defined by a DEFSUB command (see 5.12).

SYSTEM (keyword) specifies that the sub program being called is a machine specific sub program which has been preloaded on the machine. Machine specific sub programs are not defined in the part program.

ON (keyword) specifies that the sub program shall be called once for each motion following in the part program until canceled by a CALSUB/OFF command. In the absence of this qualifier, the sub program is called immediately.

OFF (keyword) specifies that modal calling of the sub program shall be terminated.

TIMES,*c* (keyword,real) specifies the number of times to call the sub program. For modal operation, the sub program is called the specified number of times at each motion point in the part program. In the absence of this qualifier the sub program is called once.

d (text) specifies optional machine specific data to be appended to the end of each call sub program block. This provides a rudimentary mechanism for passing parameters to a sub program. The text is treated in the same manner as an INSERT command (see 5.22).

Predefined sub programs are those that have been defined earlier within the part program. A predefined sub program consists of a DEFSUB command naming the sub program, one or more part program instructions defining the body of the sub program, and a terminating ENDSUB (see 5.16) command.

The CALSUB command causes a copy of the part program data within the named sub program to be processed. On machines which do not support sub programs, the post processor shall substitute the part program data within the sub program definition at the point in the machine program where the CALSUB occurs.

The modal CALSUB operation causes the named sub program to be called at each motion point in the part program until canceled by a CALSUB/OFF command. When possible, the post processor shall combine the motion and the sub program call into a single block. When this is not possible, the motion shall be processed first, followed by the sub program call. This provides the capability to perform cyclic operations at a series of points.

5.7.2 Examples

The following example calls a sub program once for each point in a linear pattern.

```
CALSUB/9010,CLDATA,ON
GOTO/4,1,0
GOTO/4,2,0
GOTO/4,3,0
CALSUB/OFF
```

The following example calls a sub program, passing machine specific parameters.

```
CALSUB/8100,SYSTEM,'P01=4.5 P02=2'
```

5.7.3 Limitations

Machine specific parameters shall not be used when the machine does not support sub programs.

The machine specific formats of this command produce machine program data which may not be portable.

5.8 The CLAMP command

Controls the application of axis clamps.

```
CLAMP / ( {mc-axis} ) (,ON   )
        ( ALL       ) ( OFF  )
                      ( AUTO )
```

5.8.1 Semantics

This command controls a clamping operation.

{*mc-axis*} (keyword) specifies a machine axis by name (see 3.2 for a list of machine axis names and associated syntax).

ALL (keyword) specifies all machine axes.

ON (keyword) initiates a clamping operation.

OFF (keyword) terminates a clamping operation.

AUTO (keyword) specifies that the axis shall remain clamped by default. When motion is programmed for the axis, the clamps will be automatically removed before the motion commences and reapplied after the motion completes.

5.8.2 Examples

The following example clamps the rotary A axis table during each drilling motion in a cycle.

```
CYCLE/DRILL,DEPTH,4,PERREV,.012,CLEAR,.1,RETURN,.5
CLAMP/TABLE,AAXIS,AUTO
GOTO/0,0,8,0,0,1
GOTO/0,8,0,0,1,0
GOTO/0,0,-8,0,0,-1
GOTO/0,-8,0,0,-1,0
CLAMP/TABLE,AAXIS,OFF
CYCLE/OFF
```

5.8.3 Limitations

None.

5.9 The CLDATA command

Controls the input of part program data.

```
CLDATA / ( ON  )
         ( OFF )
```

5.9.1 Semantics

This command allows the part programmer to selectively control the part program data input to the manufacturing post processor. This command does not apply to a plotting post processor.

ON (keyword) specifies that all part program data following the command shall be processed by the manufacturing post processor.

OFF (keyword) specifies that all part program data following the command shall be ignored by the manufacturing post processor, with the exception of the CLDATA command.

5.9.2 Examples

None.

5.9.3 Limitations

None.

5.10 The COUPLE command

Defines the association between part program axes and machine axes.

COUPLE / (**XCOORD** / **YCOORD** / **ZCOORD**) **,{*mc-axis*}** **0:n** [**,** (**XCOORD** / **YCOORD** / **ZCOORD**) **,{*mc-axis*}**]

5.10.1 Semantics

This command assigns an axis of motion from the part reference system to a specific axis on the machine. It is used to control machines which have one or more co-linear or co-rotary axes. The assignment is modal until changed.

[*XYZ*]COORD (keyword) specifies one of the three primary co-ordinate axes of the part reference system to be associated with the specified machine axis.

{*mc-axis*} (keyword) specifies a co-linear or co-rotary axis which will be used for subsequent motions (see 3.2 for a list of machine axis names and associated syntax). With co-linear axes, movement along the specified part reference axis will be resolved by moving the named co-linear axis. With co-rotary axes, rotation about the specified part reference axis will be resolved by rotating the named co-rotary axis.

5.10.2 Examples

The following command specifies that X motion in the part reference system is to be coupled to the Z machine axis, that Y motion in the part reference system is to be coupled to the X machine axis, and that Z motion in the part reference system is to be coupled to the Y machine axis. This is a common configuration for horizontal lathe programming.

```
COUPLE/XCOORD,ZAXIS,YCOORD,XAXIS,ZCOORD,YAXIS
```

The following command specifies that Y motion in the part reference system is to be coupled to the Z machine axis and that Z motion in the part reference system is to be coupled to the Y machine axis. This is a common configuration for vertical lathe programming.

```
COUPLE/YCOORD,ZAXIS,ZCOORD,YAXIS
```

The following command specifies that Z motion of the part reference system is to be coupled to the W machine axis (secondary Z axis).

```
COUPLE/ZCOORD,WAXIS
```

The following command resets the Z motion of the part reference system to the Z machine axis.

```
COUPLE/ZCOORD,ZAXIS
```

5.10.3 Limitations

Part/machine axis coupling shall be limited to the set of configurations defined by ISO 841.

5.11 The CUTCOM command

Controls workpiece compensation.

CUTCOM / ON $^{1:n}\left(,\left(\begin{array}{l}\textbf{XCOORD}\\ \textbf{YCOORD}\\ \textbf{ZCOORD}\end{array}\right),\textbf{\textit{a}}\right)$

CUTCOM / OFF $^{1:n}\left(,\begin{array}{l}\textbf{XCOORD}\\ \textbf{YCOORD}\\ \textbf{ZCOORD}\end{array}\right)$

CUTCOM / ON,COORD,*a*

CUTCOM / OFF,COORD

5.11.1 Semantics

This command controls the application and removal of workpiece compensation.

ON (keyword) specifies that workpiece compensation shall be applied.

OFF (keyword) removes workpiece compensation.

[*XYZ*]COORD (keyword) identifies a machine axis for which compensation is to be applied or removed.

COORD (keyword) identifies a general workpiece compensation to be applied to or removed from all axes.

a (real) identifies the offset register on the machine to use for workpiece compensation.

5.11.2 Examples

None.

5.11.3 Limitations

None.

NOTE

The XCOORD, YCOORD and ZCOORD keywords refer to machine axes, contrary to the general guidelines described in section 3.2. This axis specific form of workpiece compensation has been retained in this revision of the International Standard for the purpose of continuity.

5.12 The DEFSUB command

Indicates the start of a sub program definition.

DEFSUB / (***a*** | ***'b'***)

5.12.1 Semantics

This command indicates the start of a predefined sub program.

a (real) identifies the sub program by a numeric identifier.

b (text) identifies the sub program by a textual identifier.

A predefined sub program consists of a DEFSUB command naming the sub program, one or more part program instructions defining the body of the sub program, and a terminating ENDSUB (see 5.16) command. A sub program is called by coding a CALSUB command (see 5.7) with a matching sub program identifier.

The sub program shall be stored by the post processor for subsequent processing by a CALSUB command. On machines which support sub programs, the storage of the sub program shall occur in the machine program in the appropriate format. On machines which do not support sub programs, the post processor shall defer the processing of the sub program until a CALSUB command is encountered.

5.12.2 Examples

Special consideration must be given for sub programs containing cyclic operations to be performed relative to the machine position when the sub program is activated. Sub programs used for this purpose should start and end as follows:

```
DEFSUB/9010
FROM/0,0,0
MODE/INCR
...
...
...
MODE/ABSOL
ENDSUB
```

The FROM statement defines a starting position for the tool corresponding to the tool position when the sub program is called. The co-ordinate used in the FROM command need not be (0,0,0). The MODE/INCR command specifies that subsequent tool positions shall be output as relative motions. The MODE/ABSOL command resets positioning to absolute mode before returning from the sub program. Absolute positioning eliminates the potential for position skew which would occur in incremental mode if the tool position at the end of the sub program is different from the starting position.

5.12.3 Limitations

None.

5.13 The DELAY command

Temporarily halts the movement of axes on the machine.

DELAY / [**DWELL,** | **REV**] ***a***

5.13.1 Semantics

This command halts movement of machine axes for a specified duration, corresponding to the G04 definition in ISO 6983.

DWELL (keyword) specifies that the delay will be timed in seconds.

REV (keyword) specifies that the delay will be timed in revolutions of the spindle.

a (real) indicates the delay duration in the specified units. The duration shall be a non-zero positive value. If neither DWELL or REV are specified, then the duration defaults to seconds.

5.13.2 Examples

None.

5.13.3 Limitations

A delay duration in spindle revolutions is only valid for machines with spindles, and then only when the spindle is rotating.

5.14 The DISPLY command

Controls the display of operator messages at the machine console.

```
DISPLY / ( a    )
         ( 'b'  )
         ( ON   )
         ( OFF  )
```

5.14.1 Semantics

This command controls the output of operator messages at the machine console. Messages can be specified either with the DISPLY command or with subsequent PPRINT commands (see 5.39).

a (real) specifies a console light or display pattern.

b (text) specifies a message to display at the console.

ON (keyword) specifies that subsequent PPRINT commands are to be displayed at the machine console.

OFF (keyword) specifies that subsequent PPRINT commands will no longer be displayed at the machine console.

5.14.2 Examples

The following example outputs a series of messages to the machine console.

```
DISPLY/'Message 1'
DISPLY/'Message 2'
DISPLY/'Message 3'
```

This next example performs the same operation.

```
DISPLY/ON
PPRINT/'Message 1'
PPRINT/'Message 2'
PPRINT/'Message 3'
DISPLY/OFF
```

5.14.3 Limitations

None.

5.15 The END command

Designates the end of the machine program.

```
END
```

5.15.1 Semantics

This command designates the end of the machine program, corresponding to the M02 definition in ISO 6983.

5.15.2 Examples

None.

5.15.3 Limitations

None.

5.16 The ENDSUB command

Indicates the end of a sub program definition.

```
ENDSUB
```

5.16.1 Semantics

This command indicates the end of a predefined sub program.

A predefined sub program consists of a DEFSUB command (see 5.12) naming the sub program, one or more part program instructions defining the body of the sub program, and a terminating ENDSUB command. A sub program is called by coding a CALSUB command (see 5.7) with a matching sub program identifier.

5.16.2 Examples

None.

5.16.3 Limitations

None.

5.17 The FEDRAT command

5.17.1 General comments

Controls one of feed movement velocity, or feed rate override inhibit.

5.17.1.1 Sub-contents

For

1) feed movement velocity specification, see 5.17.2;
2) feed rate override inhibit specification, see 5.17.3.

5.17.1.2 Limitations

None.

5.17.2 Feed movement velocity specification

FEDRAT / [**PERMIN,** | **PERREV** | **FPT**] ***a*** **[,MXPERM,*b*]**

5.17.2.1 Semantics

This command specifies the feed movement velocity and optionally establishes an upper limit to the velocity.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute, corresponding to the G94 definition in ISO 6983.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle, corresponding to the G95 definition in ISO 6983.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command. A single tooth (flute) shall be assumed if FLUTES have not been specified.

a (real) specifies the feed movement velocity in the specified or default units. The feed velocity shall be a non-zero positive value. The feed velocity units keyword remains in effect on subsequent FEDRAT commands until explicitly changed. The default feed velocity units at the start of a program is part program units per minute (PERMIN).

MXPERM,*b* (keyword,real) specifies an upper limit to the feed velocity measured in part program units per minute. The feed velocity limit shall be a non-zero positive value. This limit remains in effect until the next feed velocity specification command. If an upper limit is omitted, then feed limitation shall not occur.

5.17.2.2 Examples

The following example specifies a feed velocity of 0,2 part program units per revolution of the spindle, with an upper bound of 56,0 part program units per minute.

```
FEDRAT/PERREV,.2,MXPERM,56
```

5.17.2.3 Limitations

None.

5.17.3 Feed rate override inhibit specification

```
FEDRAT / LOCK,( ON  )
               ( OFF )
```

5.17.3.1 Semantics

This command controls the availability of a feed rate override capability at the machine.

LOCK,ON (keywords) specifies that a lock be placed on the programmed feed velocity, inhibiting any machine based override capability.

LOCK,OFF (keywords) removes the lock on the programmed feed velocity, allowing a machine based override capability.

5.17.3.2 Examples

None.

5.17.3.3 Limitations

None.

5.18 The GOHOME command

Moves the machine to the home position.

GOHOME [/ {*mc-axis*} 0:n[,{*mc-axis*}]]

5.18.1 Semantics

This command moves the machine at a rapid traverse rate to the home position of the machine, or if applicable, to the home position defined by the HOMEPT command (see 5.20).

{*mc-axis*} (keyword) specifies one or more machine axes to move to the home point (see 3.2 for a list of machine axis names and associated syntax). The order of the axes is not important as all named axes will be moved simultaneously. If GOHOME is specified without any machine axis names, all axes having a home position will be moved to the home point if required.

5.18.2 Examples

The following commands will first move the machine Z axis and machine W axis to their home positions, then move all remaining axes to the home position.

```
GOHOME/ZAXIS,WAXIS
GOHOME
```

5.18.3 Limitations

None.

5.19 The GOPARK command

Moves the machine to the secondary home position.

GOPARK [/ {*mc-axis*} 0:n[,{*mc-axis*}]]

5.19.1 Semantics

This command moves the machine at a rapid traverse rate to the secondary home position of the machine, or if applicable, to the home position defined by the PARKPT command (see 5.36). If a secondary home is not defined for the machine, the primary home point will be used (see 5.20).

{*mc-axis*} (keyword) specifies one or more machine axes to move to the secondary home point (see 3.2 for a list of machine axis names and associated syntax). If GOPARK is specified without any machine axis names, all axes having a secondary home position will be moved.

5.19.2 Examples

None.

5.19.3 Limitations

None.

5.20 The HOMEPT command

Defines the machine home position.

HOMEPT / ({*mc-axis*}) , *a* 0:n [, ({*mc-axis*}) , *a*]
({*cl-axis*})

HOMEPT / NOMORE

5.20.1 Semantics

This command defines the location of the machine home position used by the GOHOME command (see 5.18). The HOMEPT command is ignored if the machine has a fixed home position, is used for information purposes only if the machine has a reference home position, and is used to define a home position in all other cases. The default home position is the co-ordinates defined by the first FROM motion in the part program.

{*mc-axis*} (keyword) specifies that a home position is being defined for a machine axis (see 3.2 for a list of machine axis names and associated syntax).

{*cl-axis*} (keyword) specifies that a home position is being defined for a part reference axis (see 3.1 for a list of part program axis names and associated syntax).

a (real) defines a home position for either the named machine axis or for the named part co-ordinate axis.

NOMORE (keyword) cancels the last specified HOMEPT position and resets the machine home position to the co-ordinates defined by the first FROM motion in the part program.

Only those axes mentioned in a HOMEPT command are moved by a GOHOME command. All unreferenced axes remain unchanged.

5.20.2 Examples

None.

5.20.3 Limitations

None.

5.21 The INCLUD command

Specifies a source for additional part program data.

INCLUD / *'a'*

5.21.1 Semantics

This command provides for including secondary part program data into the post processor input stream. This can be useful for loading standard information into the post processor, such as TOOLNO or MATERL specifications.

a (text) specifies the name of the file to be read as a secondary part program before continuing with the primary part program.

The INCLUD command does not cause a permanent transfer of input to occur. When an end-of-file or FINI record is encountered in the secondary part program, processing shall continue with the instruction following the INCLUD record in the primary part program.

Secondary files may contain INCLUD commands.

5.21.2 Examples

None.

5.21.3 Limitations

An INCLUD command shall not recursively reference a part program file.

5.22 The INSERT command

Provides for the insertion of machine program data.

INSERT / *'a'* [,NEXT]

5.22.1 Semantics

This command provides the facility to insert data into the machine program.

a (text) specifies data to insert into the machine program.

NEXT (keyword) specifies that the data shall be appended to the next block. In the absence of this qualifier, the data shall be output immediately.

The post processor will provide sequence number information and end of block character data where appropriate.

5.22.2 Examples

None.

5.22.3 Limitations

This command produces machine program data which may not be portable.

5.23 The LEADER command

Provides for the insertion of leader spacing.

`LEADER / [ LENGTH,]` ***a***

5.23.1 Semantics

This command specifies the amount of leader spacing to insert into the control tape.

LENGTH,*a* (keyword,real) specifies the length of the leader in part reference units. The LENGTH keyword is optional and has no effect on the actions of the LEADER command.

5.23.2 Examples

None.

5.23.3 Limitations

None.

5.24 The LIMIT command

Defines travel limits and guard zones.

LIMIT / *a*,(IN | OUT)$^{1:n}$(,{*mc-axis*},*b*,*c*)

LIMIT / *a*,(ON | OFF)

5.24.1 Semantics

This command defines a region of space that the working element (tool) must remain either entirely in (travel limit) or out (guard zone).

a (real) provides an integer identification of the travel limit zone that will be used by the post processor when reporting violations.

IN (keyword) specifies that the tool must remain within the zone being defined.

OUT (keyword) specifies that the tool must remain outside of the zone being defined.

{*mc-axis*} (keyword) specifies that travel limit checking is required for the named machine axis (see 3.2 for a list of machine axis names and associated syntax).

b*,*c (reals) specify the lower and upper travel limits for the named machine axis. Travel limits are measured in machine units for linear axes and degrees for rotary axes.

ON (keyword) enables limit checking for the specified travel zone. By default limit checking is enabled when a zone is defined.

OFF (keyword) disables limit checking for the specified travel zone.

5.24.2 Examples

The following example establishes a travel limit, identified as zone 1, which limits machine travel in the X axis to the range 0 through 20 and in the Y axis to the range -5 through 5.

```
LIMIT/1,IN,XAXIS,0,20,YAXIS,-5,5
```

This next example establishes a guard zone, identified as zone 2, which restricts X axis travel in the range 15 through 30. The combined effect of zone 1 and zone 2 travel limits checking will limit the X axis to the range 0 through 15.

```
LIMIT/2,OUT,XAXIS,15,30
```

This last example removes the travel restriction imposed by zone 2 in the previous example.

```
LIMIT/2,OFF
```

5.24.3 Limitations

None.

5.25 The LOCATE command

Preloads machine reference system axes.

LOCATE / {*mc-axis*},*a* $^{0:n}$[,{*mc-axis*},*a*]

LOCATE / OFF

5.25.1 Semantics

This command will preload the machine reference system axes to the specified values. A preload operation does not cause a motion to occur. Only those axes referenced in the LOCATE command will be preloaded, all other axes retain their current settings.

{*mc-axis*} (keyword) specifies that a preload operation is required for the named machine axis (see 3.2 for a list of machine axis names and associated syntax).

a (real) specifies the preload value for the named machine axis. Preload values are measured in machine units for linear axes and degrees for rotary axes.

OFF (keyword) resets the machine axes to the initial state, clearing all preload values.

5.25.2 Examples

The following example moves the machine secondary Z axis (W) to a position 20 machine units from the axis origin. The LOCATE command then resets the machine axis origin for this axis to that point.

```
MOVETO/WAXIS,20
LOCATE/WAXIS,0
```

This next example is typical of common programming practice to output a block at the start of the machine program resetting the machine axes to a required starting position. It is the machine operator's responsibility to insure that the machine is correctly positioning before starting the machine program.

```
PARTNO/'SAMPLE'
LOCATE/XAXIS,50,YAXIS,0,ZAXIS,10
FROM/50,0,10
…
…
```

5.25.3 Limitations

None.

5.26 The LPRINT command

Provides for control of the post processor listing.

LPRINT / (**ON** | **OFF**)

5.26.1 Semantics

This command controls the output of information to the post processor listing.

ON (keyword) specifies that all relevant data shall be output to the post processor listing file.

OFF (keyword) suspends the output of data to the post processor listing file.

5.26.2 Examples

None.

5.26.3 Limitations

None.

5.27 The MACHIN command

Defines the post processor.

MACHIN / *a*,*b* [**,INCH** | **MM** | **CM** | **FEET**]

5.27.1 Semantics

This command identifies the post processor for a specific machine and provides parameters for initialization.

a (text) specifies the name of the post processor. The name is an unquoted 1 to 6 character alphanumeric string.

b (real) further identifies the post processor using a unique integer number.

INCH (keyword) specifies that the machine program units shall be inches, corresponding to the G70 definition in ISO 6983.

MM (keyword) specifies that the machine program units shall be millimeters, corresponding to the G71 definition in ISO 6983.

CM (keyword) specifies that the machine program units shall be centimeters.

FEET (keyword) specifies that the machine program units shall be feet.

5.27.2 Examples

The following example requests machine program units of MM for the post processor identified as “TEST” number 7.

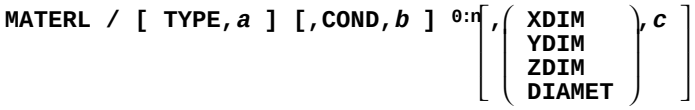
```
MACHIN/TEST,7,MM
```

5.27.3 Limitations

None.

5.28 The MATERL command

Defines the workpiece material.



5.28.1 Semantics

This command defines the workpiece material by type, hardness and size.

TYPE,*a* (keyword,real) specifies the material type by a machine specific code number.

COND,*b* (keyword,real) specifies the material condition with the brinnel hardness number.

[*XYZ*]DIM,*c* (keyword,real) specifies the length of the workpiece when measured along the specified part reference axis. The dimension value is in part reference units.

DIAMET,*c* (keyword,real) specifies the diameter of the workpiece. The dimension value is in part reference units.

5.28.2 Examples

The following command defines a sheet thickness of 3 millimeters for a turret punch machine.

```
MATERL/ZDIM,3
```

5.28.3 Limitations

At least one form of type, hardness or size information must be specified.

The use of machine specific material codes may not be portable.

5.29 The MCHFIN command

Defines the acceptable machining finish.

MCHFIN / (***a*** | **FINE** | **COARSE**)

5.29.1 Semantics

This command defines the acceptable machine finish to be produced by the operations performed on the material.

a (real) specifies the required finish measured in RMS.

FINE (keyword) specifies that a fine finish is required.

COARSE (keyword) specifies that a coarse finish is allowable.

5.29.2 Examples

None.

5.29.3 Limitations

None.

5.30 The MCHTOL command

Defines the acceptable machining tolerance.

```
MCHTOL / ( a                    )
         ( FINE                 )
         ( COARSE               )
         (                      )
         ( TO,b,PAST,c          )
```

5.30.1 Semantics

This command defines the maximum allowable error from true tool path for machine slide dynamics at discontinuities.

a (real) specifies the magnitude of allowable error measured in part reference units.

FINE (keyword) specifies that the allowable error shall be minimized.

COARSE (keyword) specifies that a normal amount of error can be tolerated.

TO,*b* (keyword,real) specifies the magnitude of allowable undershoot measured in part reference units.

PAST,*c* (keyword,real) specifies the magnitude of allowable overshoot measured in part reference units.

5.30.2 Examples

None.

5.30.3 Limitations

None.

5.31 The MODE command

5.31.1 General comments

Controls one of machine positioning mode, curve interpolation mode, or circular interpolation mode specifications.

5.31.1.1 Sub-contents

For

1) machine positioning mode specification, see 5.31.2;
2) curve interpolation mode specification, see 5.31.3;
3) circular interpolation mode specification, see 5.31.4.

5.31.1.2 Limitations

None.

5.31.2 Machine positioning mode specification

```
MODE / ( INCR  )
       ( ABSOL )
```

5.31.2.1 Semantics

This command defines the positioning mode to be used at the machine.

INCR (keyword) specifies that machine program data commanding movement of machine axes shall do so using an incremental format, corresponding to the G91 definition in ISO 6983.

ABSOL (keyword) specifies that machine program data commanding movement of machine axes shall do so using an absolute format, corresponding to the G90 definition in ISO 6983.

5.31.2.2 Examples

None.

5.31.2.3 Limitations

None.

NOTE

The choice of machine positioning mode is an output convention. It has no effect on the interpretation of co-ordinate data in the part program, which is always specified in absolute terms from the part reference system origin.

5.31.3 Curve interpolation mode specification

```
MODE / ( LINEAR )
       ( CIRCUL )
       ( PARAB  )
       ( SPLINE )
```

5.31.3.1 Semantics

This command defines the interpolation mode to be used at the machine between each point contained within a part program multi-point linear motion.

LINEAR (keyword) specifies that straight line interpolation shall be performed between each point in the multi-point linear motion. This is the default.

CIRCUL (keyword) specifies that circular interpolation shall be performed between each point in the multi-point linear motion.

PARAB (keyword) specifies that parabolic interpolation shall be performed between each point in the multi-point linear motion.

SPLINE (keyword) specifies that cubic spline interpolation shall be performed between each point in the multi-point linear motion.

5.31.3.2 Examples

None.

5.31.3.3 Limitations

Straight line interpolation will be used if a requested interpolation mode is not available on the machine.

NOTES

1) Multi-point motions are defined in ISO 3592 CLDATA as two or more sets of co-ordinate data, the whole of which is contained within a class 5 000 record and zero or more class 5 000 subclass 6 continuation records.

2) Multi-point motions are defined in ISO 4342 NC processor source CLDATA output as one or more MOVE commands followed by a terminating GOTO command.

3) Multi-point motions are defined in ISO 4342 NC processor input using any one of the continuous motion statements.

5.31.4 Circular interpolation mode specification

`MODE / LINCIR,ON [,ANGLE,`*`a`*` ]`

`MODE / LINCIR,OFF`

5.31.4.1 Semantics

This command defines the interpolation mode to be used at the machine when processing part program circular interpolation motions.

LINCIR,ON (keywords) specifies that straight line interpolation shall be performed to approximate circular motions within a specified or default tolerance, corresponding to the G01 definition in ISO 6983.

LINCIR,OFF (keywords) specifies that circular interpolation shall be performed, corresponding to the G02 and G03 definitions in ISO 6983. This is the default.

ANGLE,*a* (keyword,real) specifies the maximum angle in degrees between each point output during linear approximation of a circle. If this qualifier is omitted, the original intermediate points from the part program motion will be used. If this qualifier is omitted and the part program motion defines the end point only, then intermediate points will be computed using the larger of the last specified INTOL or OUTTOL part program values.

The tolerance specified by INTOL and OUTTOL records defines, among other things, the maximum chord height between intermediate points on a circular arc. The ANGLE qualifier on the MODE/LINCIR command specifies an angular tolerance between intermediate points on a circular arc. The choice of tolerance method to be used when approximating circles is controlled by the presence or absence of the ANGLE qualifier.

5.31.4.2 Examples

None.

5.31.4.3 Limitations

Linear interpolation will be used to approximate circular motions if circular interpolation mode is not available on the machine.

NOTES

1) Part program circular motions are defined in ISO 3592 CLDATA as a class 3 000 record defining the circle, followed either by a class 15 000 unsegmented motion record or a class 5 000 multi-point motion record. The multi-point motion record consists of two or more sets of co-ordinate data, the whole of which is contained within a class 5 000 record and zero or more class 5 000 subclass 6 continuation records.

2) Part program circular motions are defined in ISO 4342 NC processor source CLDATA output as a MOVARC command defining the circle, followed either by a simple GOTO command or a multi-point motion record. The multi-point motion record consists of one or more MOVE commands followed by a terminating GOTO command.

3) Part program circular motions are defined in ISO 4342 NC processor input using any one of the continuous motion statements while in contact with a cylindrical drive or part surface.

5.32 The MOVETO command

Controls the movement of machine axes.

MOVETO / {*mc-axis*},*a* $^{0:n}$[,{*mc-axis*},*a*]

5.32.1 Semantics

This command will move one or more machine axes to the specified locations. Only those axes referenced in the MOVETO command will be moved, all other axes retain their current positions. The movement is performed at the programmed velocity, either feed velocity or rapid traverse.

{*mc-axis*} (keyword) specifies that a movement is required for the named machine axis (see 3.2 for a list of machine axis names and associated syntax). The order of the axes is not important as all named axes will be moved simultaneously.

a (real) specifies the absolute value of the new position for the named machine axis. Values are measured in machine units for linear axes and degrees for rotary axes.

5.32.2 Examples

The following example moves the machine X and Y axes at rapid traverse to the machine origin, and then plunges the machine Z axis at a controlled feed rate.

```
RAPID
MOVETO/XAXIS,0,YAXIS,0
FEDRAT/PERMIN,250
MOVETO/ZAXIS,-50
```

5.32.3 Limitations

None.

5.33 The OPSKIP command

Controls the insertion of block delete codes.

OPSKIP / (**ON** | **OFF**) [,*a*]

5.33.1 Semantics

This command controls the output of block delete codes in the machine program. The machine operator can then choose, via a switch setting, to process or skip over segments of the machine program.

ON (keyword) defines the start of a region to be optionally skipped. All subsequent blocks will contain the appropriate block delete codes until canceled.

OFF (keyword) defines the end of a region to be optionally skipped.

a (real) identifies the optional skip region by an integer number. It shall be used when multiple regions overlap.

5.33.2 Examples

None.

5.33.3 Limitations

None.

5.34 The OPSTOP command

Designates an optional stopping point in the machine program.

OPSTOP

5.34.1 Semantics

This command designates an optional stopping point in the machine program. The machine operator may choose, via a switch setting, to ignore or process the stop request.

5.34.2 Examples

None.

5.34.3 Limitations

None.

5.35 The ORIGIN command

Defines the relationship between part and machine reference systems.

ORIGIN / [COORD,] *a*,*b* [,*c*]

ORIGIN / (**XCOORD** / **YCOORD** / **ZCOORD**) **,*d*** **0:n** [, (**XCOORD** / **YCOORD** / **ZCOORD**) **,*d***]

5.35.1 Semantics

This command defines the relationship between the part reference system origin and the machine reference system origin.

COORD,*a*,*b*,*c* (keyword,reals) specify the part reference system X,Y,Z co-ordinates of the machine reference system origin. The COORD keyword is optional and has no effect on the ORIGIN command.

[*XYZ*]COORD,*d* (keyword,real) specifies the location of the machine reference system origin measured along the named part co-ordinate axis. The dimension is a signed value in part reference units.

5.35.2 Examples

The following example identifies the part reference co-ordinate (X=0, Y=10, Z=4) as the machine origin point.

```
ORIGIN/0,10,4
```

With this origin in effect, the part reference origin corresponds to machine co-ordinates (X=0, Y=-10, Z=-4) excluding transformations due to units and axis sign inversions.

5.35.3 Limitations

None.

5.36 The PARKPT command

Defines the secondary machine home position.

PARKPT / ({*mc-axis*}), *a* 0:n [, ({*mc-axis*}), *a*]
{*cl-axis*} **{*cl-axis*}**

PARKPT / NOMORE

5.36.1 Semantics

This command defines the location of the machine secondary home position used by the GOPARK command (see 5.19). The PARKPT command is ignored if the machine has a fixed secondary home position, is used for information purposes only if the machine has a reference secondary home position, and is used to define a secondary home position in all other cases. The default secondary home position is the primary home position defined by the HOMEPT command (see 5.20).

{*mc-axis*} (keyword) specifies that a secondary home position is being defined for a machine axis (see 3.2 for a list of machine axis names and associated syntax). The order of the axes is not important as all named axes will be moved simultaneously.

{*cl-axis*} (keyword) specifies that a secondary home position is being defined for a part reference axis (see 3.1 for a list of part program axis names and associated syntax).

a (real) defines a secondary home position for either the named machine axis or for the named part co-ordinate axis.

NOMORE (keyword) cancels the last specified PARKPT position and resets the secondary home position to the co-ordinates defined by the last HOMEPT command.

Only those axes mentioned in a PARKPT command are moved by a GOPARK command. All unreferenced axes remain unchanged.

5.36.2 Examples

None.

5.36.3 Limitations

None.

5.37 The PARTNO command

Provides a unique identification for the machine program.

```
PARTNO / 'a'
```

5.37.1 Semantics

This command provides a unique identification for the machine program.

a (text) specifies the machine program identification.

5.37.2 Examples

None.

5.37.3 Limitations

None.

5.38 The PPFUN command

Provides special commands or instructions for the post processor.

PPFUN / *a* 0:n[,*a*]

5.38.1 Semantics

This command specifies special commands or instructions given by the part programmer for use by the post processor.

a (various) is any combination of text, numbers and keywords as required by the post processor.

5.38.2 Examples

None.

5.38.3 Limitations

This command is not portable.

5.39 The PPRINT command

Provides messages in the output data.

PPRINT / *'a'*

5.39.1 Semantics

This command provides a message to be output in the post processor listing and, depending on the status of the DISPLY command (see 5.14), also at the machine console.

a (text) specifies the message.

5.39.2 Examples

None.

5.39.3 Limitations

None.

5.40 The PPTIME command

Provides for modification of post processor calculated run time.

PPTIME / *a*

5.40.1 Semantics

This command defines an amount of time to be added to the time calculation of the post processor.

a (real) specifies the amount of time in seconds to be added to the time calculations of the post processor.

5.40.2 Examples

None.

5.40.3 Limitations

None.

5.41 The PREFUN command

Provides for the insertion of preparatory function (G) codes.

PREFUN / *a* $^{0:n}$[,*a*] [,NOW]

5.41.1 Semantics

This command provides the facility to insert preparatory function (G) code numbers in the machine program.

a (real) specifies the preparatory function (G) code number to be output. If multiple codes are specified, then they shall be inserted into the machine program as though each was specified in a separate PREFUN command.

NOW (keyword) indicates that a break to a new block shall appear immediately following the output of each (G) code. The default action is to allow the (G) code to be combined with subsequent machine program data if possible.

5.41.2 Examples

None.

5.41.3 Limitations

This command produces machine program data which may not be portable.

5.42 The RAPID command

Specifies motion at rapid traverse velocity.

RAPID

5.42.1 Semantics

This command specifies that the following motion shall be performed at a rapid traverse rate. Subsequent motions revert back to the last specified feed velocity (see 5.17.2).

5.42.2 Examples

None.

5.42.3 Limitations

None.

5.43 The RESET command

Designates a restart point in the machine program.

RESET

5.43.1 Semantics

This command designates a restart point in the machine program. The post processor shall insure that sufficient information is output to allow restarting from this point in the machine program without loss of coordination.

5.43.2 Examples

None.

5.43.3 Limitations

None.

5.44 The REWIND command

Rewinds the control tape.

REWIND [/ *a*]

5.44.1 Semantics

This command rewinds the control tape either to a unique tape mark identification generated with the TMARK command (see 5.50), or to the start of the control tape, corresponding to the M30 definition in ISO 6983.

a (real) specifies the tape mark identification to rewind to. If omitted, the control tape will be rewound to the start.

5.44.2 Examples

None.

5.44.3 Limitations

None.

5.45 The SAFPOS command

Defines the working element change position.

SAFPOS / ({*mc-axis*} | {*cl-axis*}), *a* 0:n [, ({*mc-axis*} | {*cl-axis*}), *a*]

SAFPOS / **NOMORE**

5.45.1 Semantics

This command defines the location of the working element (tool) change position used by application specific LOAD commands. The SAFPOS command is ignored if the machine has a fixed tool change position, is used for information purposes only if the machine has a reference tool change position, and is used to define a tool change position in all other cases. The default tool change position is the primary home position defined by the HOMEPT command (see 5.20).

{*mc-axis*} (keyword) specifies that a tool change position is being defined for a machine axis (see 3.2 for a list of machine axis names and associated syntax).

{*cl-axis*} (keyword) specifies that a tool change position is being defined for a part reference axis (see 3.1 for a list of part program axis names and associated syntax).

a (real) defines a tool change position for either the named machine axis or for the named part co-ordinate axis.

NOMORE (keyword) cancels the last specified SAFPOS position. No motion will occur for subsequent tool changes.

Only those axes mentioned in a SAFPOS command are moved by a LOAD command. All unreferenced axes remain unchanged.

5.45.2 Examples

None.

5.45.3 Limitations

None.

5.46 The SEQNO command

Controls the numbering of machine program blocks.

SEQNO / (**ON** | **OFF** | **AUTO**)

SEQNO / CONST, ***a***

SEQNO / ***b*** **[,INCR,** ***c*** **[,** ***d*** **]]**

SEQNO / [***b*****,] INCR,** ***c*** **[,** ***d*** **]**

5.46.1 Semantics

This command controls the sequence numbering of machine program blocks.

ON (keyword) resumes the output of sequence number information.

OFF (keyword) specifies that sequence number information shall no longer be output.

AUTO (keyword) specifies that sequence numbers shall correspond to the part program instruction number.

CONST,*a* (keyword,real) specifies that each subsequent block be output with the specified sequence number.

b**,INCR,*****c*****,*****d*** (real,keyword,reals) specifies that subsequent blocks be output starting with the number ***b***, and incrementing by ***c*** every ***d*** blocks. If the starting number is omitted then the next block will be ***c*** larger than the last sequence number output. If the increment is omitted an increment of 1 (one) is used. If the skip is omitted, sequence numbers are output on each block.

5.46.2 Examples

The following command will output sequence numbers starting at 100 and incrementing by 2 on each block.

```
SEQNO/100,INCR,2
```

5.46.3 Limitations

None.

5.47 The STOP command

Designates a required stopping point in the machine program.

STOP

5.47.1 Semantics

This command designates a required stopping point in the machine program. Operator intervention will be necessary to restart the machine program.

5.47.2 Examples

None.

5.47.3 Limitations

None.

5.48 The SYNCTR command

Controls the synchronization of multiple machine heads.

SYNCTR / (**ON** | **OFF**)

SYNCTR / {*head-identifier*}

SYNCTR / NEXT [,*a*]

5.48.1 Semantics

This command is used to control the synchronization of two or more heads programmed independently on a single machine.

ON (keyword) begins simultaneous operation of all heads.

OFF (keyword) ends simultaneous operation of all heads and reverts back to sequential operation of a single head.

{*head-identifier*} (keyword) specifies that subsequent part program data shall control the named head.

NEXT (keyword) specifies a synchronization point for the currently active head. A similar command must be coded for all alternate heads.

a (real) specifies an integer identity number for the synchronization point. The identifier is optional, but if specified, corresponding SYNCTR/NEXT for alternate heads must be coded with identical identifier values.

In the absence of any SYNCTR commands, the primary head of the machine shall be controlled. All other heads shall remain inactive.

A specific head is controlled by coding a SYNCTR/{*head identifier*} command. Subsequent part program data shall be processed by the named head. In sequential operation mode (the default) all other heads remain inactive. Coding a new SYNCTR/{*head identifier*} command inactivates the current head and activates the newly specified one.

Simultaneous operation of two or more heads is specified by coding a SYNCTR/ON command. This command shall be followed by two or more sequences of SYNCTR/{*head identifier*} commands followed by their respective part program data. All heads shall begin simultaneous operation and proceed independently. Each head will halt processing when a SYNCTR command is encountered.

A SYNCTR/NEXT command identifies a synchronization point for the head. Corresponding SYNCTR/NEXT commands must be coded for all other heads. When all heads have processed the SYNCTR/NEXT command, simultaneous operation of all heads restarts.

If one of the heads encounters a SYNCTR/OFF command, then simultaneous operation of the heads is ended. The head which encountered the SYNCTR/OFF command shall be the sole head to remain active.

5.48.2 Examples

The following example performs a series of operations on a “main” head, followed by a series of operations on a “side” head.

```
SYNCTR/MAIN
…
…
SYNCTR/SIDE
…
…
```

The following example performs a series of operations simultaneously on both a “main” head and a “side” head.

```
SYNCTR/ON
SYNCTR/MAIN
…
…
SYNCTR/SIDE
…
…
SYNCTR/OFF
```

5.48.3 Limitations

None.

NOTE

The choice of keyword for the head identifier is dependent on the machine family being controlled. For merging lathes, MAIN and SIDE keywords are used. For merging profiles on wire EDMs, UPPER and LOWER keywords are used.

5.49 The TLLIFE command

Controls the use of tool life monitoring equipment.

TLLIFE / (**ON** | **OFF**)

5.49.1 Semantics

This command is used to activate and deactivate tool (working element) life monitoring.

ON (keyword) turns on tool life monitoring. The post processor will provide specific control information to tool life monitoring equipment. This information will indicate when the tool motion is under feed control and when it is in rapid traverse. The tool life monitoring equipment shall compute tool life based on feed rate control times only.

OFF (keyword) turns tool life monitoring off, both in the post processor and at the machine.

5.49.2 Examples

None.

5.49.3 Limitations

None.

5.50 The TMARK command

Provides for the insertion of rewind stop codes.

TMARK / (***a*** | **ON** | **OFF**)

TMARK / AUTO [,*b*]

5.50.1 Semantics

This command controls the output of rewind stop information in the control tape suitable for use by the REWIND command (see 5.44).

a (real) specifies a tape mark identity number to output.

ON (keyword) resumes the automatic output of tape mark information.

OFF (keyword) specifies that automatic tape marks shall no longer be output.

AUTO,*b* (keyword,real) specifies that tape marks will be output automatically every ***b*** blocks. If the block count is omitted, tape marks will be output periodically at the discretion of the post processor.

5.50.2 Examples

None.

5.50.3 Limitations

None.

5.51 The TRANS command

Translates the part program co-ordinates.

TRANS / [COORD,] *a*,*b* [,*c*]

TRANS / (**XCOORD** / **YCOORD** / **ZCOORD**),*d* 0:n [, (**XCOORD** / **YCOORD** / **ZCOORD**),*d*]

5.51.1 Semantics

This command specifies a modal transformation of part program co-ordinates.

COORD,*a*,*b*,*c* (keyword,reals) specify the translation amounts in part reference system X,Y,Z co-ordinates. The COORD keyword is optional and has no effect on the TRANS command.

[*XYZ*]COORD,*d* (keyword,real) specifies an amount to translate along the named part program axis. The dimension is a signed value in part reference units.

Translations are not accumulative. Each TRANS command replaces any translations in effect due to prior TRANS commands.

Translations are applied with respect to the base orientation of the part reference system. Specifically, rotation of the part reference system by machine rotary axes will have no effect on the translation vector.

5.51.2 Examples

The following example translates the part program co-ordinates by X=0, Y=10 and Z=4.

```
TRANS/0,10,4
```

With this translation in effect, the part reference origin corresponds to machine co-ordinates (X=0, Y=10, Z=4) excluding transformations due to units and axis sign inversions.

None.

5.51.3 Limitations

None.

6 Die sinking EDM language

6.1 General comments

6.1.1 General semantics

The die sinking EDM language section defines vocabulary specific to the die sinking electrical discharge machine family. Electrical discharge machines are those where a stationary or rotating working element (the electrode) is applied to a stationary workpiece.

The general language (see 5) and the die sinking EDM language together provide the standard vocabulary for a die sinking electrical discharge machine, or that component of a machine which provides this capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 6.2) shall be used to designate the machine family being manipulated at any given moment.

6.1.2 Sub-contents

For

1) the APPLY command, which selects the die sinking EDM capability of the machine, see 6.2;
2) the CUTCOM command, which compensates for differences between programmed and actual electrode dimensions, see 6.3;
3) the FLUSH command, which controls one of tank filling or flushing, see 6.4;
4) the GENRTR command, which controls spark gap generator settings, see 6.5;
5) the LOAD command, which commands the loading of an electrode or workpiece, see 6.6;
6) the OP command, which provides nonmodal application of a preset series of operations, see 6.7;
7) the SELECT command, which commands the selection of an electrode or workpiece, see 6.8;
8) the SPINDL command, which controls various functions related to the spindle, see 6.9;
9) the TOOLNO command, which defines an electrode, see 6.10;
10) the UNLOAD command, which commands the unloading of the electrode or workpiece, see 6.11.

6.1.3 Limitations

None.

6.2 The APPLY command

Selects the die sinking EDM capability of the machine.

APPLY / DEDM

6.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

DEDM (keyword) specifies that subsequent part program data is to be processed using the die sinking EDM capability of the machine.

6.2.2 Examples

None.

6.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

6.3 The CUTCOM command

6.3.1 General comments

Controls the activation and removal of one of electrode length compensation or electrode diameter compensation.

6.3.1.1 Sub-contents

For

1) electrode length compensation, see 6.3.2;
2) electrode diameter compensation, see 6.3.3;

6.3.1.2 Limitations

None.

NOTE

An additional form of the CUTCOM command is defined in general language section 5.11.

6.3.2 Electrode length compensation

```
CUTCOM / ON,LENGTH [,POSX ] [,OSETNO,a ]
                   [,POSY ]
                   [,POSZ ]
                   [,NEGX ]
                   [,NEGY ]
                   [,NEGZ ]

CUTCOM / OFF,LENGTH
```

6.3.2.1 Semantics

This command controls the application and removal of electrode length compensation, corresponding to the G43 and G44 definitions in ISO 6983.

ON,LENGTH (keywords) activates electrode length compensation.

OFF,LENGTH (keywords) terminates electrode length compensation.

POSX (keyword) specifies that electrode length compensation shall be applied along the positive machine X axis.

POSY (keyword) specifies that electrode length compensation shall be applied along the positive machine Y axis.

POSZ (keyword) specifies that electrode length compensation shall be applied along the positive machine Z axis. This is the default direction of compensation for die sinking EDM machines.

NEGX (keyword) specifies that electrode length compensation shall be applied along the negative machine X axis.

NEGY (keyword) specifies that electrode length compensation shall be applied along the negative machine Y axis.

NEGZ (keyword) specifies that electrode length compensation shall be applied along the negative machine Z axis.

OSETNO,*a* (keyword,real) identifies the offset register on the machine to use for electrode length compensation. If the value is omitted, the default register shall be used.

6.3.2.2 Examples

None.

6.3.2.3 Limitations

None.

6.3.3 Electrode diameter compensation

```
CUTCOM / ( ON  )
         ( OFF )

CUTCOM / ( LEFT  ) [,XYPLAN ] [,OSETNO,a ]
         ( RIGHT ) [ YZPLAN ]
                   [ ZXPLAN ]
```

6.3.3.1 Semantics

This command controls the application and removal of electrode diameter compensation.

ON (keyword) reactivates electrode diameter compensation.

OFF (keyword) terminates electrode diameter compensation, corresponding to the G40 definition in ISO 6983.

LEFT (keyword) activates electrode diameter compensation to the left of the workpiece when viewed in the forward direction of motion, corresponding to the G41 definition in ISO 6983.

RIGHT (keyword) activates electrode diameter compensation to the right of the workpiece when viewed in the forward direction of motion, corresponding to the G42 definition in ISO 6983.

XYPLAN (keyword) specifies that compensation shall be applied in the machine reference XY plane. This is the default plane of compensation for a die sinking EDM machine.

YZPLAN (keyword) specifies that compensation shall be applied in the machine reference YZ plane.

ZXPLAN (keyword) specifies that compensation shall be applied in the machine reference ZX plane.

OSETNO,*a* (keyword,real) identifies the offset register on the machine to use for electrode diameter compensation. If omitted, the default register shall be used.

6.3.3.2 Examples

None.

6.3.3.3 Limitations

The ON form of electrode diameter compensation is invalid until either one of the LEFT or RIGHT forms is specified.

6.4 The FLUSH command

6.4.1 General comments

Controls one of tank filling or flushing.

6.4.1.1 Sub-contents

For

1) tank filling specification, see 6.4.2;
2) flushing specification, see 6.4.3.

6.4.1.2 Limitations

None.

6.4.2 Tank filling specification

```
FLUSH / ( IN  )
        ( OUT )
```

6.4.2.1 Semantics

This command controls the level of dielectric fluid surrounding the workpiece.

IN (keyword) specifies that the tank containing the workpiece be filled with dielectric fluid.

OUT (keyword) specifies that the tank containing the workpiece be emptied of dielectric fluid.

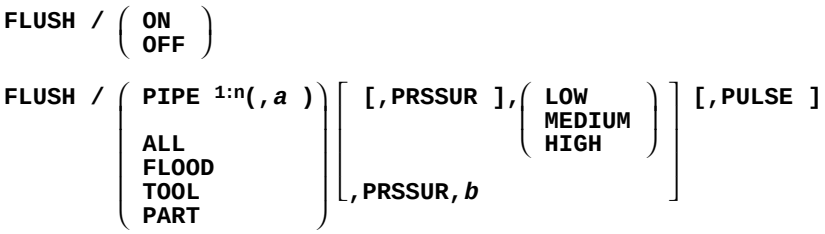
6.4.2.2 Examples

None.

6.4.2.3 Limitations

None.

6.4.3 Flushing specification



6.4.4 Semantics

This command controls the volume and source of dielectric fluid for flushing of eroded material.

ON (keyword) restarts the flow of dielectric fluid. If dielectric fluid has not previously been established, then ON starts a default flow of dielectric fluid.

OFF (keyword) terminates the flow of dielectric fluid.

PIPE,*a* (keyword,real) specifies the identity numbers of one or more machine specific delivery pipes.

ALL (keyword) specifies all available flushing orifices.

FLOOD (keyword) specifies general flooding.

TOOL (keyword) specifies flushing through the electrode.

PART (keyword) specifies flushing through the workpiece.

PRSSUR,LOW (keywords) specifies a low rate of dielectric fluid flow.

PRSSUR,MEDIUM (keywords) specifies a normal rate of dielectric fluid flow.

PRSSUR,HIGH (keywords) specifies a high rate of dielectric fluid flow.

PRSSUR,*b* (keyword,real) specifies the dielectric fluid flow pressure in machine specific units.

PULSE (keyword) specifies a pulsed application of dielectric fluid. In the absence of this keyword, a steady rate of dielectric fluid flow shall be maintained.

6.4.4.1 Examples

None.

6.4.4.2 Limitations

The machine specific format of this command produces output codes which may not be portable.

6.5 The GENRTR command

Controls spark gap generator settings.

GENRTR / *a*

GENRTR / TLLIFE,*b*

GENRTR / FACE,*c* [,SIDE,*d*] [,VOLUME,*e*]

6.5.1 Semantics

This command defines parameters used for the calculation of spark gap generator settings.

a (real) specifies the spark gap generator settings in a machine specific format.

TLLIFE,*b* (keyword,real) specifies the maximum wear (life expectancy) of the electrode as a percentage of the workpiece removal.

FACE,*c* (keyword,real) specifies the frontal area of the electrode measured in part reference units.

SIDE,*d* (keyword,real) specifies the lateral area of the electrode measured in part reference units.

VOLUME,*e* (keyword,real) specifies the total volume of the electrode engaged in the workpiece, measured in part reference units.

6.5.2 Examples

None.

6.5.3 Limitations

The machine specific format of this command produces output codes which may not be portable.

6.6 The LOAD command

Commands the loading of an electrode or workpiece.

LOAD / TOOL,*a* [**,CLW** | **CCLW**] [**,ADJUST,**(**NOW** | **NEXT**)]

LOAD / PART [**,***a* **]** [**,CLW** | **CCLW**] [**,ADJUST,**(**NOW** | **NEXT**)]

6.6.1 Semantics

This command executes a loading sequence. This load sequence shall imply a SELECT operation (see 6.8) if it is necessary to select the new item and it has not already been selected; and an UNLOAD operation (see 6.11) if it is necessary to unload the old item and it has not already been unloaded.

TOOL (keyword) specifies that an electrode defined by a previous TOOLNO command is to be loaded.

PART (keyword) specifies that a workpiece is to be loaded. In the absence of an identity number, a simple workpiece switch operation is assumed.

a (real) identifies the electrode or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the loading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the loading device.

ADJUST,NOW (keywords) specifies that any offset compensation necessary due to the loading operation be immediately output in a separate block.

ADJUST,NEXT (keywords) specifies that any offset compensation necessary due to the loading operation be interpolated with the next motion.

6.6.2 Examples

None.

6.6.3 Limitations

None.

6.7 The OP command

6.7.1 General comments

Nonmodal application of a preset series of operations.

OP / {*type*} 1:n(,{*qualifier*})

6.7.1.1 General semantics

An OP is a nonmodal preset series of operations which direct machine axis movement to complete such actions as plunging, expansion and threading.

{*type*} (keyword) identifies the type of the preset operation.

{*qualifier*} (various) specifies parameters which define and provide for modification of the basic erosion operation. Qualifiers have a consistent meaning where they appear in different operations.

The control point for the operation is defined by the next motion in the part program.

6.7.1.2 Sub-contents

For

1) EXPAND operation specification, which provides for expansion erosion, see 6.7.2;
2) IN operation specification, which provides for plunge erosion, see 6.7.3;
3) THREAD operation specification, which provides for erosion of a thread, see 6.7.4.

6.7.1.3 Limitations

None.

6.7.2 EXPAND erosion specification

OP / EXPAND ,DIAMET,*a* [,RETURN]

6.7.2.1 Semantics

This command activates an expansion erosion operation. The operation starts from the electrode position following the OP command, and expands out to the specified diameter (see figure 1). The expansion occurs in a plane perpendicular to the vector joining the current electrode position with the electrode position defined by the part program motion following the OP command.

EXPAND (keyword) specifies that a spiral expansion erosion operation is to be performed.

DIAMET,*a* (keyword,real) specifies the orbital diameter of the electrode reference point, measured as an unsigned value in part reference units.

RETURN (keyword) specifies that the electrode shall return to the position prior to the OP command at the completion of the operation. If this qualifier is omitted, the electrode shall remain at the position defined by the part program motion following the OP command.

6.7.2.2 Examples

None.

6.7.2.3 Limitations

None.

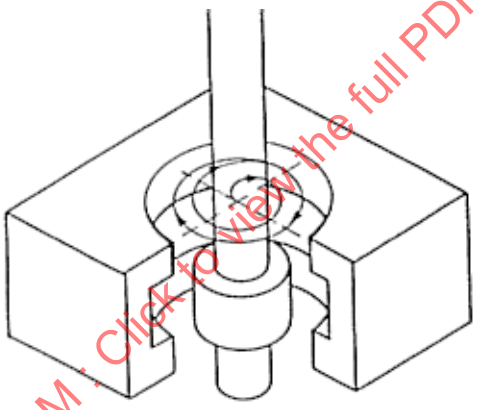


Figure 1 – An EXPAND operation

6.7.3 IN erosion specification

`OP / IN [,DIAMET,`*`a`*` ] [,RETURN ]`

6.7.3.1 Semantics

This command activates a plunge erosion operation. The operation starts from the electrode position prior to the OP command, and ends at the electrode position defined by the following part program motion (see figure 2). The working vector for the plunge operation is determined by the vector joining the two positions.

IN (keyword) specifies that a plunge erosion operation is to be performed.

DIAMET,*a* (keyword,real) specifies the orbital diameter of the electrode reference point at the full depth of operation, measured as an unsigned value in part reference units. The apex of the taper is at the electrode position prior to the OP command. If this qualifier is omitted, or if a diameter of zero is specified, the plunge operation will not contain a lateral component.

RETURN (keyword) specifies that the electrode shall return to the position prior to the OP command at the completion of the operation. If this qualifier is omitted, the electrode shall remain at the position defined by the part program motion following the OP command.

6.7.3.2 Examples

None.

6.7.3.3 Limitations

None.

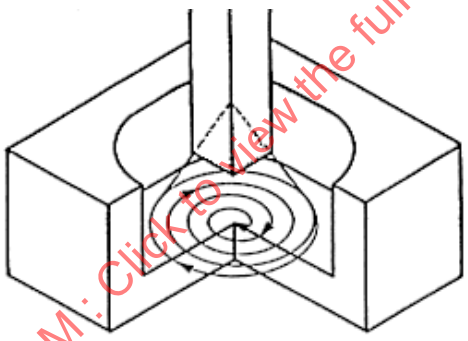


Figure 2 – An IN operation using DIAMET

6.7.4 THREAD erosion specification

OP / THREAD $\left(,\left(\begin{array}{l}\textbf{PERREV}\\ \textbf{LEAD}\end{array}\right),\textit{a}\right)\left(,\begin{array}{l}\textbf{CLW}\\ \textbf{CCLW}\end{array}\right)$ **[,RETURN]**

6.7.4.1 Semantics

This command activates a thread erosion operation. The operation starts from the electrode position prior to the OP command, and ends at the electrode position defined by the following part program motion (see figure 3). The working vector for the thread operation is determined by the vector joining the two positions. The in feed velocity is controlled indirectly by the SPINDL command(see 6.9.3).

THREAD (keyword) specifies that a thread erosion operation is to be performed.

PERREV (keyword) specifies the thread lead in part program units per revolution of the spindle.

LEAD (keyword) specifies the thread lead in number of threads per part program unit.

a (real) specifies thread lead in the specified units.

CLW (keyword) specifies that a clockwise rotation of the spindle shall be used during the plunge portion of the thread operation.

CCLW (keyword) specifies that a counter-clockwise rotation of the spindle shall be used during the plunge portion of the thread operation.

RETURN (keyword) specifies that the electrode shall return to the position prior to the OP command at the completion of the operation. The return operation is performed by reversing the spindle rotation and plunge direction. If this qualifier is omitted, the electrode shall remain at the position defined by the part program motion following the OP command.

6.7.4.2 Examples

None.

6.7.4.3 Limitations

A spindle rotation rate must be set before performing a thread operation.

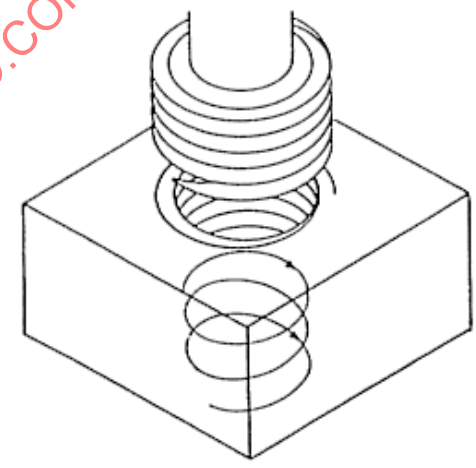


Figure 3 – A THREAD operation

6.8 The SELECT command

Commands the selection of an electrode or workpiece.

SELECT / (**TOOL** | **PART**), *a* [, **CLW** | **CCLW**]

6.8.1 Semantics

This command executes a selection sequence. This places the selected item in a ready state but does not load it.

TOOL (keyword) specifies that an electrode defined by a previous TOOLNO command is to be selected.

PART (keyword) specifies that a workpiece is to be selected.

a (real) identifies the electrode or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the selection device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the selection device.

6.8.2 Examples

None.

6.8.3 Limitations

None.

6.9 The SPINDL command

6.9.1 General comments

Controls one of spindle mode, spindle rotation rate or spindle orientation.

6.9.1.1 Sub-contents

For

1) spindle mode specification, see 6.9.2;
2) spindle rotation rate specification, see 6.9.3;
3) spindle orientation specification, see 6.9.4.

6.9.1.2 Limitations

None.

6.9.2 Spindle mode specification

```
SPINDL / ( ON     )
         ( OFF    )
         ( LOCK   )
         ( NEUTRL )
```

6.9.2.1 Semantics

This command controls the basic operation mode of the spindle.

ON (keyword) restarts the spindle rotation at the last specified rate.

OFF (keyword) stops the spindle rotation.

LOCK (keyword) stops the spindle rotation and locks it.

NEUTRL (keyword) disengages the spindle drive.

6.9.2.2 Examples

None.

6.9.2.3 Limitations

None.

6.9.3 Spindle rotation rate specification

SPINDL / [RPM,] ***a*** [**,CLW** / **CCLW**]

6.9.3.1 Semantics

This command specifies the rotation rate and rotation direction of the spindle.

RPM,*a* (keyword,real) specifies the rotation rate of the spindle in revolutions per minute, corresponding to the G97 definition in ISO 6983. The RPM keyword is optional.

CLW (keyword) specifies clockwise spindle rotation.

CCLW (keyword) specifies counter-clockwise spindle rotation.

6.9.3.2 Examples

None.

6.9.3.3 Limitations

The spindle rotation rate shall be a non-zero positive value.

6.9.4 Spindle orientation specification

SPINDL / ORIENT [,*a*]

6.9.4.1 Semantics

This command indexes the spindle and locks it.

ORIENT,*a* (keyword,real) specifies the orientation angle of the spindle, measured in degrees, from a machine specific reference. If the orientation angle is omitted, a machine specific default angle shall be used.

6.9.4.2 Examples

None.

6.9.4.3 Limitations

None.

6.10 The TOOLNO command

Defines an electrode.

TOOLNO / *a* [**,IN,*b*** | **,MANUAL**] **[,DEDM]** **{*geometry-qualifiers*}** **{*machine-qualifiers*}**

Where {*geometry-qualifiers*} are defined as:

[**,SETOOL,*c*,*d*,*e***] **[,DIAMET,*f*]** **[,TLMATL,*g*]**
[**,LENGTH,*e***]

And where {*machine-qualifiers*} are defined as:

[,OSETNO,*h*] [**,HOLDER,** (**SMALL** | **MEDIUM** | **LARGE**)]

6.10.1 Semantics

This command specifies tool information for a specific electrode which is referenced by the SELECT/TOOL, LOAD/TOOL and UNLOAD/TOOL commands.

a (real) specifies the electrode number.

IN,*b* (keyword,real) specifies the pocket number where the electrode is loaded from.

MANUAL (keyword) specifies that the operator must load the electrode manually.

DEDM (keyword) specifies that the tool being defined applies to that component of a machine which provides a die sinking EDM capability. This is the default when the TOOLNO statement appears within a segment of the part program preceded by an APPLY/DEDM command, or when the machine does not support any manufacturing function other than die sinking EDM.

SETOOL,*c*,*d*,*e* (keyword,reals) specifies the tool setting distance measured in the part co-ordinate X, Y, Z axes, from the electrode tip or reference location to the machine gauge reference point.

LENGTH,*e* (keyword,reals) specifies the tool setting length measured in the part co-ordinate Z axes, from the electrode tip or reference location to the machine gauge reference point.

DIAMET,*f* (keyword,real) specifies the electrode diameter in part reference units.

TLMATL,*g* (keyword,real) specifies the material of the electrode using a code number recognized by the tool life facility.

OSETNO,*h* (keyword,real) specifies a tool correction dial or register to be associated with the electrode.

HOLDER,SMALL (keywords) specifies the electrode is mounted in a small holder.

HOLDER,MEDIUM (keywords) specifies the electrode is mounted in a mid-size holder.

HOLDER,LARGE (keywords) specifies the electrode is mounted in a large holder.

6.10.1.1 Examples

None.

6.10.1.2 Limitations

None.

6.11 The UNLOAD command

Commands the unloading of the electrode or workpiece.

```
UNLOAD / ( TOOL ) [,CLW  ]
         ( PART ) [,CCLW ]
```

6.11.1 Semantics

This command executes an unloading sequence.

TOOL (keyword) specifies that the electrode shall be unloaded. This removes the electrode from the working environment and deposits it in a storage area.

PART (keyword) specifies that the workpiece shall be unloaded. This removes the workpiece from the working environment and deposits it in a storage area.

CLW (keyword) specifies a clockwise indexing direction of the unloading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the unloading device.

6.11.2 Examples

None.

6.11.3 Limitations

None.

7 Flame cutting language

7.1 General comments

7.1.1 General semantics

The flame cutting language section defines vocabulary specific to the flame and plasma-jet cutting machine family. Flame cutting machines are those where a gas, heated to sufficiently high temperature and constricted to a well-collimated jet, is used to erode the part material.

The general language (see 5) and the flame cutting language together provide the standard vocabulary for a flame cutting machine, or that component of a machine which provides a flame cutting capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 7.2) shall be used to designate the machine family being manipulated at any given moment.

7.1.2 Sub-contents

For

1) the APPLY command, which selects the flame cutting capability of the machine, see 7.2;
2) the ASSIST command, which controls the flow of cutting assist gasses, see 7.3;
3) the CLDIST command, which defines the clearance distance between nozzle and part surface, see 7.4;
4) the PIERCE command, which controls the cutting operation, see 7.5;
5) the TORCH command, which ignites or extinguishes the torch, see 7.6.

7.1.3 Limitations

None.

7.2 The APPLY command

Selects the flame cutting capability of the machine.

```
APPLY / FLAME
```

7.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

FLAME (keyword) specifies that subsequent part program data is to be processed using the flame cutting capability of the machine.

7.2.2 Examples

None.

7.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

7.3 The ASSIST command

Controls the flow of cutting assist gasses.

```
ASSIST / ( ON  )
         ( OFF )

ASSIST / ( AIR    ) [ [,PRSSUR ],( LOW    ) ]
         ( OXYGEN )               ( MEDIUM )
                                  ( HIGH   )
                  [ ,PRSSUR,a               ]
```

7.3.1 Semantics

This command controls the type and pressure of cutting assist gasses.

ON (keyword) restarts the flow of cutting assist gas. If cutting assist gas has not previously been established, then ON starts a default flow of cutting assist gas.

OFF (keyword) terminates the flow of cutting assist gas.

AIR (keyword) specifies air for cutting assist.

OXYGEN (keyword) specifies oxygen for cutting assist.

PRSSUR,LOW (keywords) specifies a low rate of gas pressure.

PRSSUR,MEDIUM (keywords) specifies a normal rate of gas pressure.

PRSSUR,HIGH (keywords) specifies a high rate of gas pressure.

PRSSUR,*a* (keyword,real) specifies the gas pressure in machine specific units.

7.3.2 Examples

None.

7.3.3 Limitations

The use of machine specific pressure codes may not be portable.

7.4 The CLDIST command

Defines the clearance distance between nozzle and part surface.

CLDIST / *a*

CLDIST / NOMORE

7.4.1 Semantics

This command defines the clearance distance from the programmed part co-ordinate to the nozzle tip.

a (real) specifies the incremental distance between programmed part co-ordinates and the nozzle tip, as a signed value measured in part reference units along the tool axis. The clearance distance shall take effect on the following motion.

NOMORE (keyword) cancels the CLDIST definition. The nozzle tip shall position to the programmed part co-ordinate values without offset on subsequent moves.

7.4.2 Examples

None.

7.4.3 Limitations

Applies to machines having a programmable head axis.

7.5 The PIERCE command

Controls the cutting operation.

PIERCE / ON [,DWELL,*a*] [,FUEL,*b*] [, (**OXYGEN** / **WATTS**) **[,*c*],*d***]

PIERCE / OFF

7.5.1 Semantics

This command controls the preheating and cutting gas selections of the torch.

Piercing or cutting is activated by some combination of increased cutting jet intensity and/or lowering of the nozzle tip towards the workpiece. When cutting is active, the nozzle tip shall track either the part co-ordinates, or shall maintain a specified clearance distance above the part co-ordinates (see 7.4).

A preheat period can be specified in combination with the cutting operation by the use of two oxygen or power settings. The first setting is applied for the specified delay time as a preheat. The second setting then becomes active for the cutting operation. In the absence of a preheat setting, the delay shall occur after the cutting setting is applied.

Piercing or cutting is disabled by some combination of decreased cutting jet intensity and/or raising of the nozzle tip away from the workpiece to a preset height.

ON (keyword) starts the cutting operation.

OFF (keyword) terminates the cutting operation.

DWELL,*a* (keyword,real) specifies a delay period at the start of the operation, measured in seconds. A delay of zero seconds shall inhibit delays at the start of a cut operation.

FUEL,*b* (keyword,real) specifies the fuel setting in machine specific units. The type of fuel is dependent on the cutting technology and the part material. Common fuels include acetylene for flame cutting and nitrogen or hydrogen for plasma-jet cutting.

OXYGEN,*c,d* (keyword,reals) specifies, for flame cutting, the heating ***c*** and cutting ***d*** oxygen settings in machine specific units. A single setting value is permitted, and specifies the oxygen setting to use without respect to preheating or cutting.

WATTS,*c,d* (keyword,reals) specifies, for plasma-jet cutting, the heating ***c*** and cutting ***d*** power settings in watts. A single setting value is permitted, and specifies the wattage to use without respect to preheating or cutting.

7.5.2 Examples

The following program fragment cuts a series of slots.

```
TORCH/ON
RAPID,GOTO/0,0,0
ASSIST/OXYGEN
PIERCE/ON,DWELL,2
FEDRAT/250,PERMIN
GOTO/1000,0,0
PIERCE/OFF
RAPID,GOTO/1000,100,0
PIERCE/ON
GOTO/0,100,0
PIERCE/OFF
RAPID,GOTO/0,200,0
PIERCE/ON
…
…
```

7.5.3 Limitations

The DWELL qualifier is mandatory for a preheat operation.

The use of machine specific fuel and oxygen setting codes may not be portable.

7.6 The TORCH command

Ignites or extinguishes the torch.

```
TORCH / ( ON  )
        ( OFF )
```

7.6.1 Semantics

This command ignites or extinguishes the torch.

ON (keyword) ignites the torch.

OFF (keyword) extinguishes the torch.

7.6.2 Examples

None.

7.6.3 Limitations

None.

8 Grinding language

8.1 General comments

8.1.1 General semantics

The grinding language section defines vocabulary specific to the grinding machine family. Grinding machines are those where a rotating disk is used to abrade the part material. Grinding is generally a precision finishing process for producing smooth surface finishes with close tolerances.

The general language (see 5) and the grinding language together provide the standard vocabulary for a grinding machine, or that component of a machine which provides a grinding capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 8.2) shall be used to designate the machine family being manipulated at any given moment.

8.1.2 Sub-contents

For

1) the APPLY command, which selects the grinding capability of the machine, see 8.2;
2) the DRESS command, which dresses the grinding wheel, see 8.3.

8.1.3 Limitations

None.

NOTE

The grinding language is incomplete. It has not been revised for this latest revision of the International Standard due to lack of representation on the committee of experts in this field.

8.2 The APPLY command

Selects the grinding capability of the machine.

```
APPLY / GRIND
```

8.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

GRIND (keyword) specifies that subsequent part program data is to be processed using the grinding capability of the machine.

8.2.2 Examples

None.

8.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

8.3 The DRESS command

Provides for dressing of the grinding wheel.

DRESS

8.3.1 Semantics

This command generates a cycle to automatically dress the grinding wheel. Dressing removes the glaze from a dull wheel, removes loaded material from the face and restores the wheel to the original geometry.

8.3.2 Examples

None.

8.3.3 Limitations

None.

9 Laser-beam machining language

9.1 General comments

9.1.1 General semantics

The laser-beam machining language section defines vocabulary specific to the laser-beam machine family. Laser-beam machines are those where light, amplified and emitted as a coherent, highly collimated beam of a single wavelength, is used to ablate the part material.

The general language (see 5) and the laser-beam machining language together provide the standard vocabulary for a laser-beam machine, or that component of a machine which provides a laser-beam capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 9.2) shall be used to designate the machine family being manipulated at any given moment.

9.1.2 Sub-contents

For

1) the APPLY command, which selects the laser-beam machining capability of the machine, see 9.2;
2) the ASSIST command, which controls the flow of cutting assist gasses, see 9.3;
3) the CLDIST command, which defines the clearance distance between nozzle and part surface, see 9.4;
4) the CYCLE command, which provides for modal application of a preset series of operations, see 9.5;
5) the PIERCE command, which controls the cutting operation, see 9.6.

9.1.3 Limitations

None.

9.2 The APPLY command

Selects the laser-beam machining capability of the machine.

APPLY / LASER

9.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

LASER (keyword) specifies that subsequent part program data is to be processed using the laser-beam machining capability of the machine.

9.2.2 Examples

None.

9.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

9.3 The ASSIST command

Controls the flow of cutting assist gasses.

```
ASSIST / ( ON  )
         ( OFF )

ASSIST / ( AIR    ) [ [,PRSSUR ],( LOW    ) ]
         ( ARGON  )              ( MEDIUM )
         ( NITRGN )              ( HIGH   )
         ( OXYGEN )
                  [ ,PRSSUR,a              ]
```

9.3.1 Semantics

This command controls the type and pressure of cutting assist gasses.

ON (keyword) restarts the flow of cutting assist gas. If cutting assist gas has not previously been established, then ON starts a default flow of cutting assist gas.

OFF (keyword) terminates the flow of cutting assist gas.

AIR (keyword) specifies air for cutting assist.

ARGON (keyword) specifies argon for cutting assist.

NITRGN (keyword) specifies nitrogen for cutting assist.

OXYGEN (keyword) specifies oxygen for cutting assist.

PRSSUR,LOW (keywords) specifies a low rate of gas pressure.

PRSSUR,MEDIUM (keywords) specifies a normal rate of gas pressure.

PRSSUR,HIGH (keywords) specifies a high rate of gas pressure.

PRSSUR,*a* (keyword,real) specifies the gas pressure in machine specific units.

9.3.2 Examples

None.

9.3.3 Limitations

The use of machine specific pressure codes may not be portable.

9.4 The CLDIST command

Defines the clearance distance between nozzle and part surface.

CLDIST / *a*

CLDIST / NOMORE

9.4.1 Semantics

This command defines the clearance distance from the programmed part co-ordinate to the nozzle tip.

a (real) specifies the incremental distance between programmed part co-ordinates and the nozzle tip, as a signed value measured in part reference units along the tool axis. The clearance distance shall take effect on the following motion.

NOMORE (keyword) cancels the CLDIST definition. The nozzle tip shall position to the programmed part co-ordinate values without offset on subsequent moves.

9.4.2 Examples

None.

9.4.3 Limitations

Applies to machines having a programmable head axis.

9.5 The CYCLE command

9.5.1 General comments

Provides modal application of a preset series of operations.

CYCLE / {*type*} $^{0:n}$**[,{*qualifier*}]**

$^{1:n}$**({*motions*})**

CYCLE / OFF

9.5.1.1 General semantics

A cycle is a preset series of operations which is applied at one or more control points.

{*type*} (keyword) identifies the type of preset operation to perform.

{*qualifier*} (various) specifies parameters which allow modification of the basic cycle. Qualifiers have a consistent meaning where they appear in different cycles.

{*motion*} (various) defines the control points for the cycle. The preset operation shall be performed at each part program motion point until the cycle is canceled.

OFF (keyword) cancels the cycle operation.

9.5.1.2 Sub-contents

For

1) general activation specification, see 9.5.2;
2) PIERCE cycle specification, see 9.5.3.

9.5.1.3 Limitations

None.

NOTE

The {*qualifier*} term has been included in this cycle definition to remain consistent with cycle definitions found elsewhere in this International Standard. The laser-beam machining language at present does not define cycles having optional qualifiers.

9.5.2 General activation specification

CYCLE / OFF

CYCLE / ON $^{0:n}$**[,{*qualifier*}]**

9.5.2.1 Semantics

These commands are used to suspend and reactivate cycles.

OFF (keyword) suspends the active cycle.

ON (keyword) restarts a suspended cycle.

{*qualifier*} (various) modifies selected parameters of the suspended cycle. Parameters of the suspended cycle not referenced retain their original values.

9.5.2.2 Examples

None.

9.5.2.3 Limitations

The ON form is only valid once a cycle has been suspended.

NOTES

1) The keyword NOMORE is a non-preferred alternative for OFF. Either can be used with identical results.

2) The {*qualifier*} term has been included in this cycle definition to remain consistent with cycle definitions found elsewhere in this International Standard. The laser-beam machining language at present does not define cycles having optional qualifiers.

9.5.3 PIERCE cycle specification

CYCLE / PIERCE, (**THRU** | **DWELL,** ***a*** | **PULSE,** ***b***)

9.5.3.1 Semantics

This command initiates a cycle to pierce a vertical hole through the part at each control point in the cycle block.

PIERCE (keyword) specifies a piercing cycle.

THRU (keyword,real) specifies piercing using sensor technology to detect burn-through.

DWELL,*a* (keyword,real) specifies the cutting period in seconds.

PULSE,*b* (keyword,real) specifies the cutting period in pulses.

9.5.3.2 Examples

None.

9.5.3.3 Limitations

None.

9.6 The PIERCE command

Controls the cutting operation.

PIERCE / (**ON** | **OFF**)

PIERCE / [ON,] PULSE [,*a*] [,PERSEC,*b*] [,WATTS,*c*]

PIERCE / [ON,] CONST [,WATTS,*c*]

9.6.1 Semantics

Laser-beam machines control the application of the laser-beam to the workpiece using a shutter or similar beam deflecting technology. The laser-beam itself can be controlled to produce pulses of energy of a specified duration and frequency, or to produce energy at a constant rate.

ON (keyword) starts the cutting operation, generally by opening the lens shutter.

OFF (keyword) terminates the cutting operation, generally by closing the lens shutter.

PULSE (keyword) specifies pulsed laser output.

CONST (keyword) specifies constant wave laser output.

a (real) specifies the width of each pulse, measured in milliseconds. If omitted, the last specified pulse width shall be used.

PERSEC,*b* (keyword,real) specifies the pulse frequency in hertz.

WATTS,*c* (keyword,real) specifies the power setting of the laser in watts.

9.6.2 Examples

The following program fragment uses a pulsed wave power setting to cut a series of slots.

```
RAPID,GOTO/0,0,0
PIERCE/ON,PULSE
FEDRAT/2500,PERMIN
GOTO/100,0,0
PIERCE/OFF
RAPID,GOTO/100,10,0
PIERCE/ON
GOTO/0,10,0
PIERCE/OFF
RAPID,GOTO/0,20,0
PIERCE/ON
…
…
```

9.6.3 Limitations

None.

10 Milling and drilling language

10.1 General comments

10.1.1 General semantics

The milling and drilling language section defines vocabulary specific to the milling and drilling machine family. Milling machines and drilling machines are those where a rotating working element in a spindle is applied to a stationary workpiece.

The general language (see 5) and the milling and drilling language together provide the standard vocabulary for a milling or drilling machine, or that component of a machine which provides a milling or drilling capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 10.2) shall be used to designate the machine family being manipulated at any given moment.

10.1.2 Sub-contents

For

1) the APPLY command, which selects the milling and drilling capability of the machine, see 10.2;
2) the ARCSLP command, which controls the output of helical interpolation, see 10.3;
3) the CLAMP command, which controls the operation of a pallet device, see 10.4;
4) the CLEARP command, which defines the clearance plane used by the RETRCT command, see 10.5;
5) the COOLNT command, which controls the flow of coolant, see 10.6;
6) the CUTCOM command, which compensates for differences between programmed and actual tool dimensions, see 10.7;
7) the CYCLE command, which provides modal application of a preset series of operations, see 10.8;
8) the HEAD command, which defines a removable head, see 10.9;
9) the INDPOS command, which defines a safety position when indexing rotary axes, see 10.10;
10) the LINTOL command, which defines the acceptable straight line deviation, see 10.11;
11) the LOAD command, which commands the loading of various items, see 10.12;
12) the ORIGIN command, which defines the relationship between part and machine reference systems, see 10.13;
13) the RETRCT command, which moves the tool to a clearance plane, see 10.14;
14) the ROTATE command, which moves a rotary axis, see 10.15;
15) the SELECT command, which commands the selection of various items, see 10.16;
16) the SPINDL command, which controls various functions related to the spindle, see 10.17;
17) the TOOLNO command, which defines a tool, see 10.18;
18) the UNLOAD command, which commands the unloading of various items, see 10.19.

10.1.3 Limitations

None.

10.2 The APPLY command

Selects the milling and drilling capability of the machine.

```
APPLY / MILL
```

10.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

MILL (keyword) specifies that subsequent part program data is to be processed using the milling and drilling capability of the machine.

10.2.2 Examples

None.

10.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

10.3 The ARCSLP command

Controls the output of helical interpolation.

ARCSLP / *a*

10.3.1 Semantics

This command indicates that the following circular motion shall be output as a helical arc. This command is not modal.

a (real) specifies a signed helical offset for the complete circular arc.

A positive helical offset is measured in the direction of the circle axis vector. The circle axis vector is defined by the direction of rotation, using the right hand rule.

10.3.2 Examples

The following commands produce a 12 thread helix, having a lead of 0,1 and a diameter of 4.

```
GOTO/2,0,0
ARCSLP/1.2
MOVARC/0,0,0,0,0,-1,2,TIMES,12
GOTO/2,0,0
```

10.3.3 Limitations

None.

10.4 The CLAMP command

Controls the operation of a pallet device.

```
CLAMP / PALLET (,ON
                OFF )
```

10.4.0.1 Semantics

This command controls the clamping of a pallet device. Control is limited to simple activation and deactivation.

PALLET,ON (keywords) specifies that the pallet is to be clamped.

PALLET,OFF (keywords) specifies that the pallet is to be unclamped.

10.4.0.2 Examples

None.

10.4.0.3 Limitations

None.

NOTE

An additional form of the CLAMP command is defined in general language section 5.8.

10.5 The CLEARP command

Defines the clearance plane used by the RETRCT command.

CLEARP / *a,b,c,d*

CLEARP / (**{*mc-axis*}** / **{*cl-axis*}**) **,*e*** **0:n** [**,** (**{*mc-axis*}** / **{*cl-axis*}**) **,*e***]

CLEARP / NOMORE

10.5.1 Semantics

This command defines a clearance location for the tool. A subsequent RETRCT command (see 10.14) shall move the tool along the shortest path to the clearance location.

a*,*b*,*c*,*d (reals) specifies the canonical form of a plane defined in the part reference system. The ***a,b,c*** values define a vector normal to the plane; the ***d*** value defines the offset of the plane from the part origin.

{*mc-axis*} (keyword) indicates that the clearance position is defined in the machine reference system.

{*cl-axis*} (keyword) indicates that the clearance position is defined in the part reference system.

e (real) specifies the machine or part reference system co-ordinate value of the clearance position.

NOMORE (keyword) cancels the CLEARP definition. A subsequent RETRCT command shall return the tool to the default clearance position.

10.5.2 Examples

None.

10.5.3 Limitations

None.

10.6 The COOLNT command

Controls the flow of coolant.

```
COOLNT / ( ON   )
         ( OFF  )

COOLNT / ( FLOOD  ) [,LOW    ] [,PIPE 1:n(,a ) ]
         ( MIST   ) [ MEDIUM ]
         ( TAPKUL ) [ HIGH   ]
         ( THRU   )
```

10.6.1 Semantics

This command controls the type, volume and source of coolant.

ON (keyword) restarts the flow of coolant. If coolant has not previously been established, then ON starts a default flow of coolant.

OFF (keyword) terminates the flow of coolant.

FLOOD (keyword) specifies flood coolant.

MIST (keyword) specifies mist coolant.

TAPKUL (keyword) specifies tapping oil.

THRU (keyword) specifies coolant applied through the working element.

LOW (keyword) specifies a low rate of coolant flow.

MEDIUM (keyword) specifies a normal rate of coolant flow.

HIGH (keyword) specifies a high rate of coolant flow.

PIPE,*a* (keyword,real) specifies the identity numbers of one or more delivery pipes.

10.6.2 Examples

None.

10.6.3 Limitations

None.

10.7 The CUTCOM command

10.7.1 General comments

Controls the activation and removal of cutter length compensation or cutter diameter compensation.

10.7.1.1 Sub-contents

For

1) cutter length compensation, see 10.7.2;
2) cutter diameter compensation, see 10.7.3.

10.7.1.2 Limitations

None.

NOTE

An additional form of the CUTCOM command is defined in general language section 5.11.

10.7.2 Cutter length compensation

```
CUTCOM / ( ON  ) ,LENGTH [,a ] [,POSX ]
         ( OFF )               [ POSY ]
                               [ POSZ ]
                               [ NEGX ]
                               [ NEGY ]
                               [ NEGZ ]
                               [ XYZ  ]
```

10.7.2.1 Semantics

This command controls the application and removal of cutter length compensation, corresponding to the G43 and G44 definitions in ISO 6983.

ON (keyword) specifies that cutter length compensation shall be activated.

OFF (keyword) terminates cutter length compensation.

LENGTH,*a* (keyword,real) identifies the offset register on the machine to use for cutter length compensation. If the value is omitted, the default register shall be used.

POS[*XYZ*] or NEG[*XYZ*] (keyword) specifies the direction of compensation. The keyword identifies both the axis that the compensation shall be applied along, and the sense of positive compensation of the tool. If an orientation is omitted, then POSZ is assumed.

XYZ (keyword) specifies that compensation shall be applied along the tool axis. The axis of compensation shall vary as the tool axis varies.

10.7.2.2 Examples

None.

10.7.2.3 Limitations

None.

10.7.3 Cutter diameter compensation

CUTCOM / (**ON** | **OFF**)

CUTCOM / (**LEFT** | **RIGHT**) [**,XYPLAN** | **YZPLAN** | **ZXPLAN** | **XYZ**] **[,OSETNO,*a*]**

10.7.3.1 Semantics

This command controls the application and removal of cutter diameter compensation.

ON (keyword) reactivates cutter diameter compensation.

OFF (keyword) terminates cutter diameter compensation, corresponding to the G40 definition in ISO 6983.

LEFT (keyword) activates cutter diameter compensation to the left of the workpiece when viewed in the forward direction of motion, corresponding to the G41 definition in ISO 6983.

RIGHT (keyword) activates cutter diameter compensation to the right of the workpiece when viewed in the forward direction of motion, corresponding to the G42 definition in ISO 6983.

XYPLAN (keyword) specifies that compensation shall be applied in the machine reference XY plane.

YZPLAN (keyword) specifies that compensation shall be applied in the machine reference YZ plane.

ZXPLAN (keyword) specifies that compensation shall be applied in the machine reference ZX plane.

XYZ (keyword) specifies that compensation shall be applied in a plane perpendicular to the tool axis. The plane of compensation shall vary as the tool axis varies.

OSETNO,*a* (keyword,real) identifies the offset register on the machine to use for cutter diameter compensation. If omitted, the default register shall be used.

10.7.3.2 Examples

None.

10.7.3.3 Limitations

The ON form of cutter diameter compensation is invalid until either one of the LEFT or RIGHT forms is specified.

10.8 The CYCLE command

10.8.1 General comments

Provides modal application of a preset series of operations.

CYCLE / {*type*} 0:n[,{*qualifier*}]

1:n({*motion*})

CYCLE / OFF

10.8.1.1 General semantics

A cycle is a preset series of operations which direct machine axis movement and/or cause spindle operation to complete such action as boring, drilling, tapping or combinations thereof.

{*type*} (keyword) identifies the type of preset operation to perform.

{*qualifier*} (various) specifies parameters which allow modification of the basic machining cycle. Qualifiers have a consistent meaning where they appear in different cycles.

{*motion*} (various) defines the control points for the cycle. The preset operation shall be performed at each part program motion point until the cycle is canceled.

OFF (keyword) cancels the cycle operation.

The basic sequence of operations is similar for all cycles (see figures 4 and 5).

1) The tool shall position at rapid traverse to a specified clearance distance above the control point. This clearance distance is defined by the CLEAR qualifier and is a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. Tool motion shall be squared during the approach. Squaring shall be implemented such that the tool performs lateral motions at the higher of either the current position or the clearance plane of the approach cycle point.
2) The tool may further plunge at rapid traverse a specified distance below the clearance plane. This plunge distance is defined by the RAPTO qualifier and is an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.
3) Various auxiliary function may occur depending on the cycle type.
4) The tool shall further plunge at the working feed velocity to a specified depth below the control point. This depth is typically defined by the DEPTH qualifier and is a signed value measured in part reference units. The depth is measured along the negative sense of the tool axis. Other provision are available in selected cycles for defining the cycle depth.
5) Various auxiliary functions may occur depending on the cycle type.
6) The tool shall retract at either the working feed velocity or at rapid traverse to one of:
   a) the level defined by the RAPTO qualifier when RAPTO is specified;
   b) or to the level defined by the CLEAR qualifier when RAPTO is not specified.
7) The tool shall further retract at rapid traverse to the retract clearance plane. This plane is defined as one of the following:
   a) A specified retract clearance distance above the control point, defined by the RETURN qualifier as a signed value measured in part reference units. The retract clearance value is measured along the positive sense of the tool axis.
   b) The initial tool plane before the cycle approach motion. This retract clearance specification is obtained by specifying the RETURN qualifier without an associated value.
   c) The approach clearance plane defined by the CLEAR qualifier. This retract clearance specification is obtained by omitting the RETURN qualifier.

10.8.1.2 Sub-contents

For

1) emulation specification, see 10.8.2;
2) general activation specification, see 10.8.3;
3) in-cycle parameter modification, see 10.8.4;
4) in-cycle avoidance specification, see 10.8.5;

5) manual cycle specification, see 10.8.6;
6) BORE cycle specification, see 10.8.7;
7) BRKCHP cycle specification, see 10.8.8;
8) CSINK cycle specification, see 10.8.9;
9) DEEP cycle specification, see 10.8.10;
10) DRILL cycle specification, see 10.8.11;
11) FACE cycle specification, see 10.8.12;
12) MILL cycle specification, see 10.8.13;
13) REAM cycle specification, see 10.8.14;
14) TAP cycle specification, see 10.8.15;
15) THRU cycle specification, see 10.8.16.

10.8.1.3 Limitations

There is no provision within this International Standard to handle squaring of motions when there is a change of tool axis.

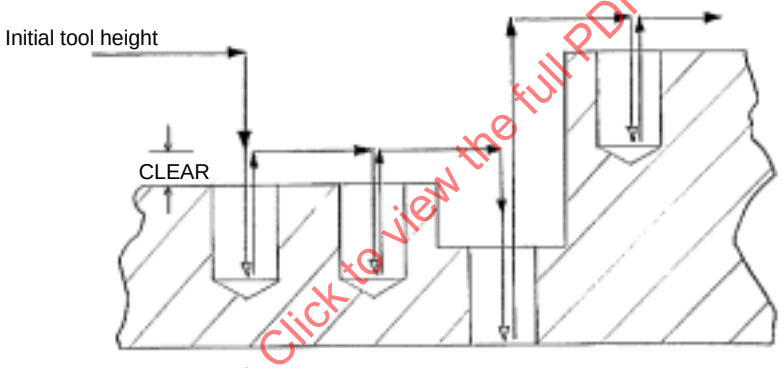


Figure 4 – CYCLE without RETURN option

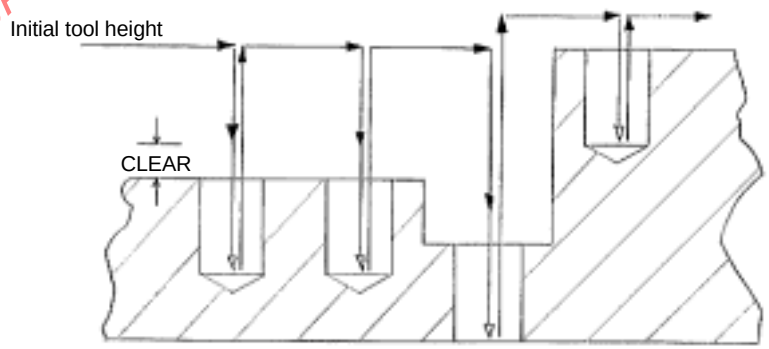


Figure 5 – CYCLE with RETURN option

10.8.2 Emulation specification

Controls the emulation of cycles by the post processor.

```
CYCLE / AUTO,( ON  )
              ( OFF )
```

10.8.2.1 Semantics

AUTO (keyword) identifies an emulation control cycle statement.

ON (keyword) specifies that subsequent cycles shall be output using controller defined hard cycles.

OFF (keyword) specifies that subsequent cycles shall be emulated by the post processor.

10.8.2.2 Examples

None.

10.8.2.3 Limitations

None.

10.8.3 General activation specification

CYCLE / OFF

CYCLE / ON $^{0:n}$**[,{*qualifier*}]**

10.8.3.1 Semantics

These commands are used to suspend and reactivate cycles.

OFF (keyword) suspends the active cycle, corresponding to the G80 definition in ISO 6983.

ON (keyword) restarts a suspended cycle.

{*qualifier*} (various) modifies selected machining parameters of the suspended cycle. Machining parameters of the suspended cycle not referenced retain their original values.

10.8.3.2 Examples

None.

10.8.3.3 Limitations

The ON form is only valid once a cycle has been suspended.

NOTE

The keyword NOMORE is a non-preferred alternative for OFF. Either can be used with identical results.

10.8.4 In-cycle parameter modification

CYCLE / MODIFY $^{1:n}$**(,{*qualifier*})**

10.8.4.1 Semantics

This command is used within a cycle block to modify one or more machining parameters, without having to suspend the cycle and then reactivate as described in section 10.8.3.

MODIFY (keyword) identifies an in-cycle parameter modification cycle statement.

{*qualifier*} (various) modifies selected machining parameters of the active cycle. Machining parameters of the active cycle not referenced retain their original values.

10.8.4.2 Examples

None.

10.8.4.3 Limitations

The MODIFY form is only valid when a cycle is active.

10.8.5 In-cycle avoidance specification

CYCLE / AVOID,*a* [,RETURN]

10.8.5.1 Semantics

This command is used to specify an additional clearance requirement between two points in a cycle block. It is effective only when a cycle is active and only for the cycle control point that immediately follows.

AVOID (keyword) identifies an in-cycle avoidance specification cycle statement.

a (real) specifies a fence height to apply to the positioning moves between two points in a cycle block. The fence height is added to the clearance height at both points, and the highest of the two clearance levels is used for lateral motion between the points.

RETURN (keyword) specifies that the retract clearance plane of each subsequent cycle control point shall be the fence height. If this keyword is omitted then the cycle retract clearance plane remains unchanged.

10.8.5.2 Examples

None.

10.8.5.3 Limitations

The AVOID form is only valid when a cycle is active.

10.8.6 Manual cycle specification

CYCLE / MANUAL $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

CLEAR,*a*

RAPTO,*b*

RETURN [,*c*]

10.8.6.1 Semantics

This command provides the capability to perform a manually generated sequence of events at each point in a cycle block. The cycle consists of a rapid traverse to the clearance position and a machine stop.

MANUAL (keyword) specifies the start of a manual cycle operation.

CLEAR,*a* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the CLEAR qualifier is omitted, an approach clearance distance of zero shall be used.

RAPTO,*b* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*c* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

10.8.6.2 Examples

None.

10.8.6.3 Limitations

None.

10.8.7 BORE cycle specification

CYCLE / BORE, DEPTH,*a* (**,PERMIN** / **PERREV** / **FPT**) **,***b* **,CLEAR,***c* **0:n[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e* **]**

ORIENT [,*f* **] [,NODRAG [,***g* **]]**

(**DWELL** / **REV**) **,***h*

10.8.7.1 Semantics

This command activates a boring cycle corresponding to one of the G86, G87 and G88 canned cycle definitions. The cycle consists of a feed to depth, optional delay, spindle stop, optional spindle orient with or without lateral clearance, rapid retract and spindle restart (see figure 6).

BORE (keyword) specifies the start of a bore cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the bore operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

b (real) specifies the plunge feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

ORIENT,*f* (keyword,real) specifies that the spindle be oriented to the specified angle before retracting from the bore. The angle is measured in degrees relative to a machine dependent reference. If the angle is omitted, the tool shall orient to a default position. If the ORIENT qualifier is omitted, the spindle shall stop at an undefined orientation.

NODRAG,*g* (keyword,real) specifies the lateral clearance of the tool tip from the cylinder wall during the retract portion of an oriented bore cycle. The clearance is specified as an unsigned value measured in part reference units. A clearance of zero will inhibit lateral clearance during the retract. In the absence of this qualifier, the lateral clearance shall be set to a default post processor value.

DWELL,*h* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in seconds. The dwell shall occur before the spindle is stopped or oriented.

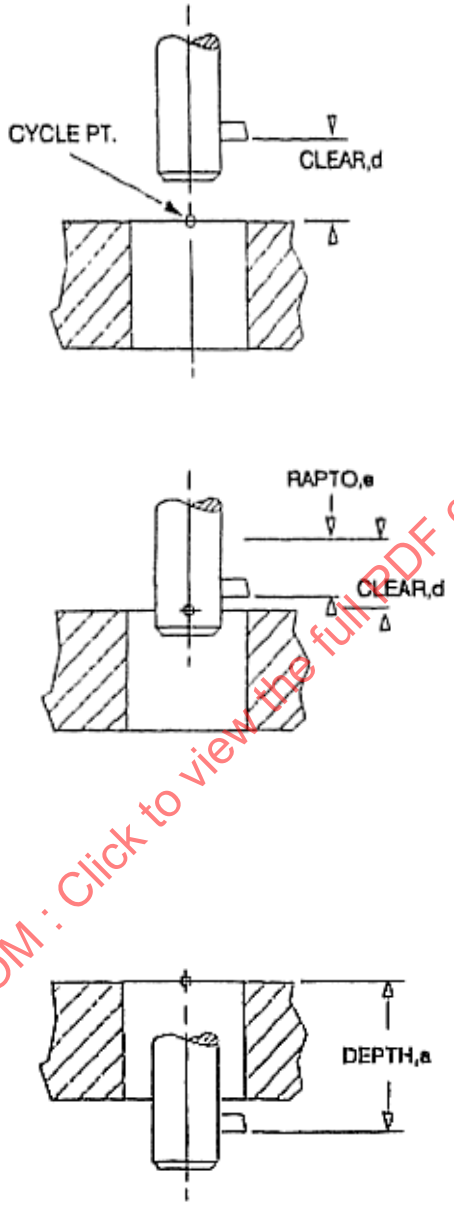
REV,*h* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in revolutions of the spindle. The dwell shall occur before the spindle is stopped or oriented.

10.8.7.2 Examples

None.

10.8.7.3 Limitations

None.



CYCLE/BORE,DEPTH,*a*,PERREV,*c*,CLEAR,*d*,RAPTO,*e*

Figure 6

10.8.8 BRKCHP cycle specification

```
CYCLE / BRKCHP,DEPTH,a 1:n( ,STEP 1:n( ,b ) ( ,PERMIN ,c ) ) ,CLEAR,d [,e ] 0:n[,{qualifier} ]
                                  ( PERREV )
                                  ( FPT    )

CYCLE / BRKCHP 1:n( ,DEPTH 1:n( ,a ) ( ,PERMIN ,c ) ) ,CLEAR,d [,e ] 0:n[,{qualifier} ]
                                     ( PERREV )
                                     ( FPT    )
```

Where {*qualifier*} is defined as zero or more of:

```
RAPTO,f

RETURN [,g ]

( DWELL )
( REV   ) ,h
( BACK  )

TIMES,i
```

10.8.8.1 Semantics

This command activates a chip breaking drill cycle corresponding to the G83 canned cycle definition. The cycle consists of a series of intermittent feeds to depth followed by a rapid retract.

BRKCHP (keyword) specifies the start of a chip breaking drill cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the drill operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis. If multiple depths are specified, then each specifies the depth at which a chip breakage operation is desired and the last depth value specifies the final depth of the drill operation (see figure 7).

STEP,*b* (keyword,real) specifies the intermittent step distance for the drill operation, as an unsigned value measured in part reference units. If multiple steps are specified, then each specifies an incremental feed distance at which a chip breakage operation is desired and the last step value shall be used repeatedly until the full cycle depth is reached (see figure 8).

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

c (real) specifies the plunge feed movement velocity in the specified units. This cycle allows for the definition of multiple feed velocities. All step depths or increments defined immediately preceding a feed velocity qualifier shall be performed at that specified feed.

CLEAR,*d*,*e* (keyword,reals) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value ***d*** is measured along the positive sense of the tool axis. The optional secondary clearance value ***e*** specifies the approach clearance distance when returning following a full retract (see TIMES qualifier), as an unsigned value measured in part reference units. If the secondary clearance is omitted, the post processor shall choose a default value.

RAPTO,*f* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*g* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

DWELL,*h* (keyword,real) specifies a dwell operation at each step in the cycle to allow for chip breakage. The duration is measured in seconds.

REV,*h* (keyword,real) specifies a dwell operation at each step in the cycle to allow for chip breakage. The duration is measured in revolutions of the spindle.

BACK,*h* (keyword,real) specifies a retract operation at each step in the cycle to allow for chip breakage. The retract distance is an unsigned value measured in part reference units.

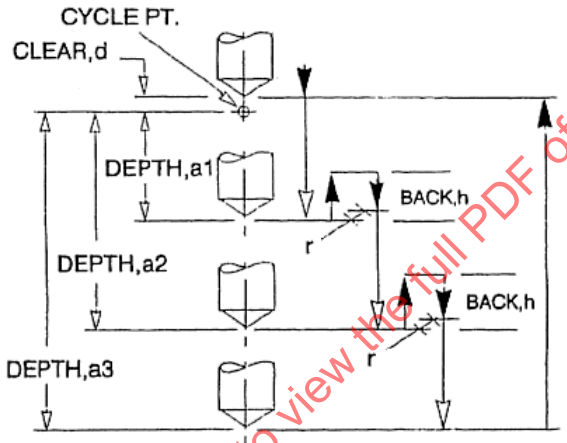
TIMES,*i* (keyword,real) specifies the number of intermittent steps to drill before performing a periodic full retract operation to allow for chip clearance. If the RAPTO qualifier is specified, the retract plane is defined by the RAPTO qualifier, otherwise the retract plane is the approach clearance plane defined by the CLEAR qualifier. Specifying 1 (one) for the TIMES qualifier results in the same operation as a DEEP drill cycle (see 10.8.10).

10.8.8.2 Examples

None.

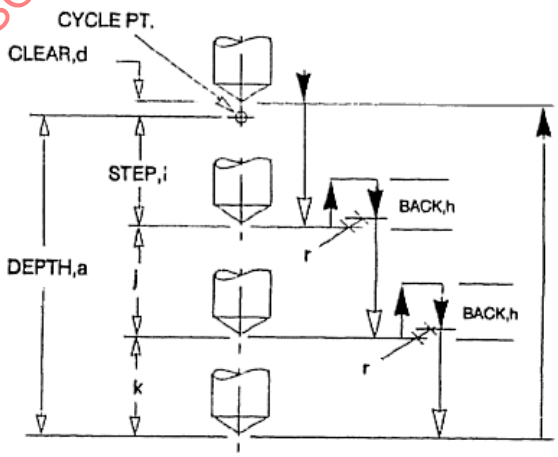
10.8.8.3 Limitations

The STEP qualifier is only valid when a single DEPTH value is specified.



CYCLE/BRKCHP,DEPTH,*a1*,*a2*,*a3*,PERREV,*c*,CLEAR,*d*,*r*,BACK,*h*

Figure 7



CYCLE/BRKCHP,DEPTH,*a*,STEP,*i*,*j*,*k*,PERREV,*c*,CLEAR,*d*,*r*,BACK,*h*

Figure 8

10.8.9 CSINK cycle specification

CYCLE / CSINK, DIAMET,*a*, TLANGL,*b* [,HOLDIA,*c*] (**,PERMIN** / **PERREV** / **FPT**) **,*d* ,CLEAR,*e*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*f*

RETURN [,*g*]

(**DWELL** / **REV**) **,*h***

10.8.9.1 Semantics

This command activates a countersinking cycle corresponding to one of the G81 and G82 canned cycle definitions. The cycle consists of a feed to depth, optional delay and rapid retract (see figure 9). The depth of the cycle is computed from the included angle of the chamfering tool and the finished diameter of the chamfer.

CSINK (keyword) specifies the start of a countersinking cycle operation.

DIAMET,*a* (keyword,real) specifies the final diameter of the countersink at the control point, as an unsigned value measured in part reference units. If RAPTO is specified, the computed depth shall be adjusted downwards by the specified amount.

TLANGL,*b* (keyword,real) specifies the included angle of the countersink tool, as an unsigned value measured in degrees.

HOLDIA,*c* (keyword,real) specifies the internal diameter of the pilot hole at the control point, as an unsigned value measured in part reference units. This shall cause an additional plunge motion at rapid traverse to the point where the tool comes into contact with the workpiece. If RAPTO is specified, the computed secondary clearance shall be adjusted downwards by the specified amount.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

d (real) specifies the plunge feed movement velocity in the specified units.

CLEAR,*e* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*f* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. The computed countersink depth and computed secondary clearance plane shall both be adjusted downwards by the RAPTO amount.

RETURN,*g* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

DWELL,*h* (keyword,real) specifies a dwell operation at full cycle

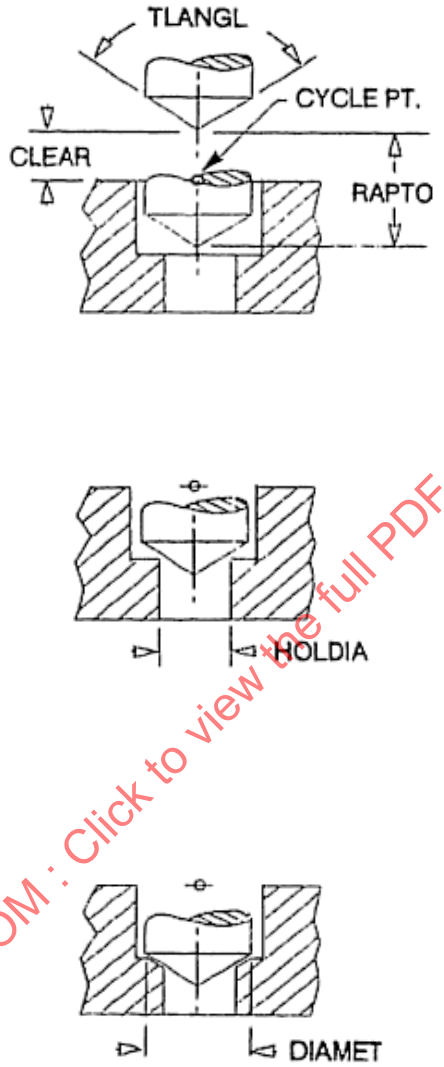
REV,*h* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in revolutions of the spindle.

10.8.9.2 Examples

None.

10.8.9.3 Limitations

None.



CYCLE/CSINK,DIAMET,*a*,TLANGL,*b*,HOLDIA,*c*,CLEAR,*f*,RAPTO,*g*

Figure 9

10.8.10 DEEP cycle specification

```
CYCLE / DEEP ,DEPTH,a 1:n( ,STEP 1:n( ,b ) ( ,PERMIN ,c ) ,CLEAR,d [,e ] 0:n[,{qualifier} ]
                                      ( PERREV
                                      ( FPT

CYCLE / DEEP 1:n( ,DEPTH 1:n( ,a ) ( ,PERMIN ,c ) ,CLEAR,d [,e ] 0:n[,{qualifier} ]
                                    ( PERREV
                                    ( FPT
```

Where {*qualifier*} is defined as zero or more of:

RAPTO,*f*

RETURN [,*g*]

10.8.10.1 Semantics

This command activates a chip clearance drill cycle corresponding to the G83 canned cycle definition. The cycle consists of a series of intermittent feeds each followed by a rapid retract to clear cut material from the hole.

DEEP (keyword) specifies the start of a chip clearance drill cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the drill operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis. If multiple depths are specified, then each specifies the depth at which a chip clearance operation is desired and the last depth value specifies the final depth of the drill operation (see figure 10).

STEP,*b* (keyword,real) specifies the intermittent step distance for the drill operation, as an unsigned value measured in part reference units. If multiple steps are specified, then each specifies an incremental feed distance at which a chip clearance operation is desired and the last step value shall be used repeatedly until the full cycle depth is reached (see figures 11 and 12).

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

c (real) specifies the plunge feed movement velocity in the specified units. This cycle allows for the definition of multiple feed velocities. All step depths or increments defined immediately preceding a feed velocity qualifier shall be performed at that specified feed.

CLEAR,*d*,*e* (keyword,reals) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value ***d*** is measured along the positive sense of the tool axis. The optional secondary clearance value ***e*** specifies the approach clearance distance when returning following a full retract, as an unsigned value measured in part reference units. If the secondary clearance is omitted, the post processor shall choose a default value.

RAPTO,*f* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*g* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

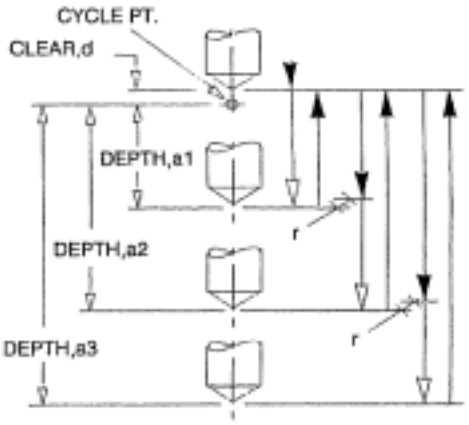
The DEEP cycle performs a full retract at each feed step in the cycle to clear material from the hole. If the RAPTO qualifier is specified, the retract plane is defined by the RAPTO qualifier, otherwise the retract plane is the approach clearance plane defined by the CLEAR qualifier.

10.8.10.2 Examples

None.

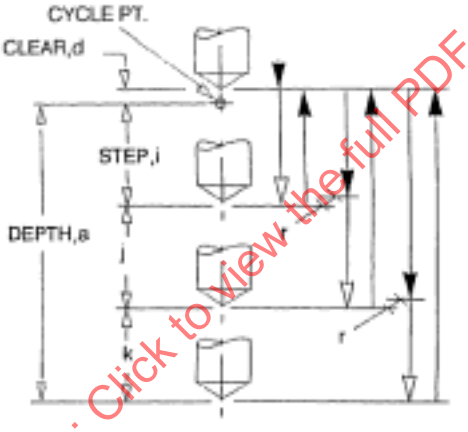
10.8.10.3 Limitations

The STEP qualifier is only valid when a single DEPTH value is specified.



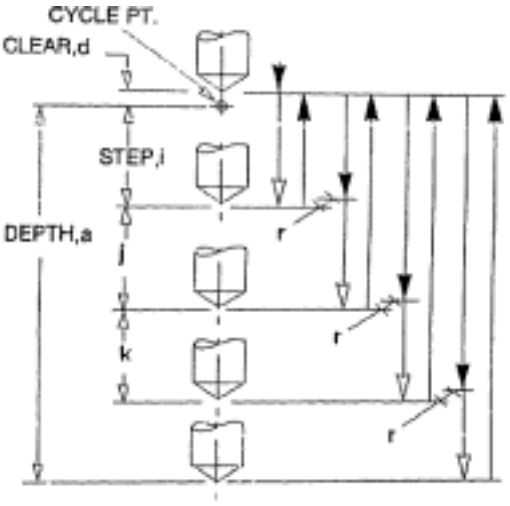
CYCLE/DEEP,DEPTH,*a1*,*a2*,*a3*,PERREV,*c*,CLEAR,*d*,*r*

Figure 10



CYCLE/DEEP,DEPTH,*a*,STEP,*i*,*j*,*k*,PERREV,*c*,CLEAR,*d*,*r*

Figure 11 – *a = i+j+k*



CYCLE/DEEP,DEPTH,*a*,STEP,*i*,*j*,*k*,PERREV,*c*,CLEAR,*d*,*r*

Figure 12 – *a > i+j+k*

10.8.11 DRILL cycle specification

CYCLE / DRILL ,DEPTH,*a* (**,PERMIN** / **PERREV** / **FPT**) **,*b*** **,CLEAR,*c*** **0:n[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e*]

10.8.11.1 Semantics

This command activates a drilling cycle corresponding to the G81 canned cycle definition. The cycle consists of a feed to depth and rapid retract (see figure 13).

DRILL (keyword) specifies the start of a drill cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the drill operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

b (real) specifies the plunge feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

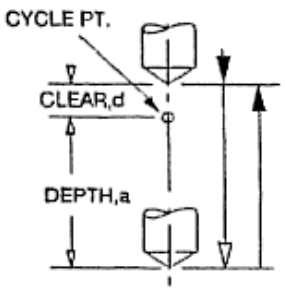
RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

10.8.11.2 Examples

None.

10.8.11.3 Limitations

None.



CYCLE/DRILL,DEPTH,*a*,PERMIN,*b*,CLEAR,*d*

Figure 13

10.8.12 FACE cycle specification

CYCLE / FACE ,DEPTH,*a* (**,PERMIN** | **PERREV** | **FPT**) **,*b* ,CLEAR,*c*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e*]

(**DWELL** | **REV**) **,*f***

10.8.12.1 Semantics

This command activates a spot facing cycle corresponding to the G82 canned cycle definition. The cycle consists of a feed to depth, dwell and rapid retract.

FACE (keyword) specifies the start of a spot facing cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the face operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

b (real) specifies the plunge feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

DWELL,*f* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in seconds.

REV,*f* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in revolutions of the spindle.

10.8.12.2 Examples

None.

10.8.12.3 Limitations

None.

10.8.13 MILL cycle specification

CYCLE / MILL ,DEPTH,*a* (**,PERMIN** / **PERREV** / **FPT**) **,*b* ,CLEAR,*c*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e*]

(**DWELL** / **REV**) **,*f***

10.8.13.1 Semantics

This command activates a constant depth milling cycle. The cycle consists of a feed to depth and spindle lock at the first control point, followed by lateral milling at subsequent control points, followed by a spindle unlock and rapid retract at the end of the cycle (see figure 14). The FEDRAT command (see 5.17.2) can be specified within the cycle block to modify the feed velocity during lateral milling.

MILL (keyword) specifies the start of a constant depth milling cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the mill operation below the first control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

b (real) specifies the plunge feed movement velocity and the lateral feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the first control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the first control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

DWELL,*f* (keyword,real) specifies a dwell operation following the plunge to cycle depth. The duration is measured in seconds.

REV,*f* (keyword,real) specifies a dwell operation following the plunge to cycle depth. The duration is measured in revolutions of the spindle.

A change in depth during the cycle operation is permitted and can be caused either by a MODIFY cycle definition or a change in control point height. In either case the sequence of operations is the same.

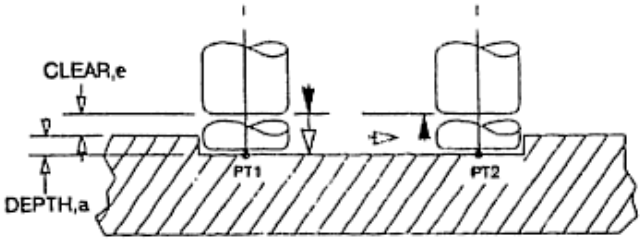
1) Spindle locks will be removed if necessary.
2) If the new cycle depth is higher than the current depth, the tool shall retract at rapid traverse to the new depth.
3) The tool shall traverse at cutting feed without change in depth to a position at or above the new control point.
4) If the new cycle depth is lower than the current depth, the tool shall plunge at the plunge feed rate to the new depth. The lateral feed rate shall be reapplied if necessary.
5) Spindle locks shall be reapplied if necessary.

10.8.13.2 Examples

None.

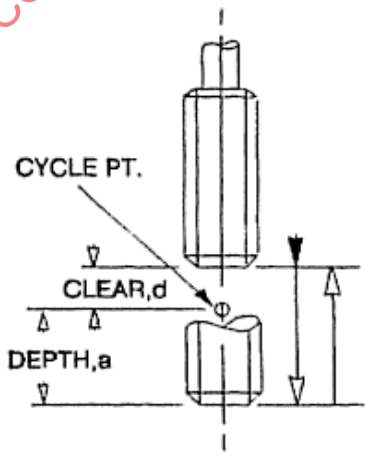
10.8.13.3 Limitations

None.



CYCLE/MILL,DEPTH,*a*,PERMIN,*b*,CLEAR,*e*
GOTO/*pt1*
GOTO/*pt2*
CYCLE/OFF

Figure 14



CYCLE/REAM,DEPTH,*a*,PERMIN,*b*,CLEAR,*d*

Figure 15

10.8.14 REAM cycle specification

CYCLE / REAM ,DEPTH,*a* (**,PERMIN** | **PERREV** | **FPT**) **,***b* **,CLEAR,***c* 0:n**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e* **]**

(**DWELL** | **REV**) **,***f*

10.8.14.1 Semantics

This command activates a reaming cycle corresponding to the G85 and G89 canned cycle definitions. The cycle consists of a feed to depth, optional dwell and feed retract (see figure 15).

REAM (keyword) specifies the start of a reaming cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the ream operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

b (real) specifies the plunge and retract feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

DWELL,*f* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in seconds.

REV,*f* (keyword,real) specifies a dwell operation at full cycle depth. The duration is measured in revolutions of the spindle.

The REAM cycle performs a feed velocity retract at the end of the cycle. If the RAPTO qualifier is specified, the feed retract plane is defined by the RAPTO qualifier, otherwise the feed retract plane is the approach clearance plane defined by the CLEAR qualifier. Any additional retract movement shall be performed at rapid traverse.

10.8.14.2 Examples

None.

10.8.14.3 Limitations

None.

10.8.15 TAP cycle specification

CYCLE / TAP ,DEPTH,*a* (**,PERREV** / **LEAD**) **,*b* ,CLEAR,*c*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*d*

RETURN [,*e*]

(**NOREVR** / **RAPOUT**)

10.8.15.1 Semantics

This command activates a tapping cycle corresponding to the G84 cycle definition. The basic cycle consists of a spindle start, feed to depth, spindle reverse and feed retract. The direction of spindle rotation during the in-feed operation is controlled by the last specified SPINDL command (see 10.17.3).

TAP (keyword) specifies the start of a tapping cycle operation.

DEPTH,*a* (keyword,real) specifies the final depth of the tap operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

LEAD (keyword) specifies the number of threads per part program unit. The reciprocal of this value specifies the velocity measured in part program units per revolution of the spindle.

b (real) specifies the plunge and retract feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*d* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

RETURN,*e* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

NOREVR (keyword) specifies that a non reversing tapping tool shall be used. The basic cycle is modified to retract at feed without a spindle reverse at depth.

RAPOUT (keyword) specifies that a collapsing tapping tool shall be used. The basic cycle is modified to retract at rapid traverse without a spindle reverse at depth.

The basic TAP cycle performs a feed velocity retract at the end of the cycle. If the RAPTO qualifier is specified, the feed retract plane is defined by the RAPTO qualifier, otherwise the feed retract plane is the approach clearance plane defined by the CLEAR qualifier. Any additional retract movement shall be performed at rapid traverse.

10.8.15.2 Examples

None.

10.8.15.3 Limitations

None.

10.8.16 THRU cycle specification

CYCLE / THRU ,DEPTH,*a* $^{0:n}$**[,*b*,*c*]** (**,PERMIN** / **PERREV** / **FPT**) **,*d* ,CLEAR,*e*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

RAPTO,*f*

RETURN [,*g*]

10.8.16.1 Semantics

This command activates a web drilling drill cycle for drilling several walls separated by air spaces. The cycle consists of an alternating sequence of plunge operations at feed velocity and rapid traverse, with the final feed motion followed by a rapid retract (see figure 16).

THRU (keyword) specifies the start of a web drilling cycle operation.

DEPTH,*a* (keyword,real) specifies the first web depth of the drill operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

b*,*c (reals) specifies starting and ending depth information for each additional web. The ***b*** value specifies the distance below the control point of the web upper surface, as measured in part reference units. The tool shall plunge at rapid traverse to the CLEAR distance above this point. The ***c*** value specifies the depth of the drill operation below the control point, as a signed offset value measured in part reference units. The tool shall plunge at feed velocity to this depth.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

FPT (keyword) specifies that the velocity is measured in part program units per tooth per revolution of the spindle. The number of teeth is defined using the FLUTES qualifier of the TOOLNO command (see 10.18). A single tooth (flute) shall be assumed if FLUTES have not been specified.

d (real) specifies the plunge feed movement velocity in the specified units.

CLEAR,*e* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis.

RAPTO,*f* (keyword,real) specifies an additional distance to plunge at rapid traverse below the approach clearance plane, as an unsigned value measured in part reference units. No additional plunge motion shall be made in the absence of a RAPTO qualifier.

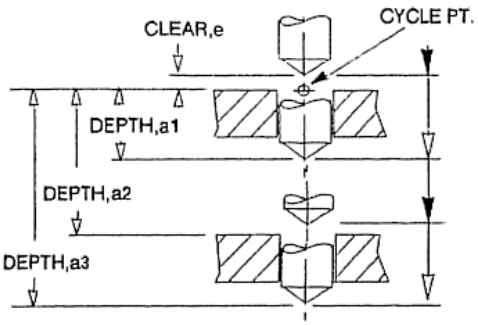
RETURN,*g* (keyword,real) specifies the final retract clearance plane distance above the control point, as a signed value measured in part reference units. The clearance value is measured along the positive sense of the tool axis. If the value is omitted, then the retract clearance plane is defined as the initial tool plane before the start of the cycle. If the RETURN qualifier is omitted, the retract clearance plane defaults to the approach clearance plane.

10.8.16.2 Examples

None.

10.8.16.3 Limitations

None.



CYCLE/THRU,DEPTH,*a1*,*a2*,*a3*,PERMIN,*c*,CLEAR,*e*

Figure 16

10.9 The HEAD command

Defines a removable head.

```
HEAD / a [,POSX          ] [,SETOOL,e,f,g ] [,HIGH ]
         [ POSY          ]                  [ LOW  ]
         [ POSZ          ]
         [ NEGX          ]
         [ NEGY          ]
         [ NEGZ          ]
         [                ]
         [,ATANGL,b,c,d   ]
```

10.9.1 Semantics

This command defines a head when the machine has the capability to use multiple heads. The LOAD command (see 10.12) must be used to load the head onto the machine.

a (real) identifies the head number.

POS[*XYZ*] or **NEG[*XYZ*]** (keyword) specifies the orientation of the tool when the head is loaded on the machine. The keyword identifies both the axis that the tool parallels, and the sense of positive direction of the tool. If an orientation is omitted, then POSZ is assumed.

ATANGL,*b*,*c*,*d* (keyword,reals) specifies the part co-ordinate X, Y, Z components of the tool axis vector when the head is loaded on the machine. If the orientation is omitted, then an alignment of (0,0,1) is assumed.

SETOOL,*e*,*f*,*g* (keyword,reals) specifies the tool setting distance measured in the part co-ordinate X, Y, Z axes, from the attachment tool mounting location to the machine gauge reference point.

HIGH (keyword) specifies that the head is a high speed head.

LOW (keyword) specifies that the head is a low speed head.

10.9.2 Examples

None.

10.9.3 Limitations

None.

10.10 The INDPOS command

Defines a safety position when indexing rotary axes.

INDPOS / (**{*mc-axis*}** | **{*cl-axis*}**) **,*a*** **0:n** [**,** (**{*mc-axis*}** | **{*cl-axis*}**) **,*a***]

INDPOS / NOMORE

10.10.1 Semantics

This command defines the location of a safety position to be used when indexing rotary axes. By default, no special precautions are used when indexing rotary axes.

{*mc-axis*} (keyword) specifies that a safety position is being defined for a machine axis. Only linear machine axes are valid.

{*cl-axis*} (keyword) specifies that a safety position is being defined for a part reference axis.

a (real) defines a safety position for either the named machine axis or for the named part co-ordinate axis.

NOMORE (keyword) cancels the last specified INDPOS position. No special precautions shall be taken for subsequent rotary motions.

Only those axes mentioned in a INDPOS command are moved prior to indexing the rotary axes.

10.10.2 Examples

None.

10.10.3 Limitations

None.

10.11 The LINTOL command

Defines the acceptable straight line deviation.

LINTOL / [FINE,] ***a*** **[,COARSE,*b*]**

LINTOL / (**ON** | **OFF**)

10.11.1 Semantics

This command defines the acceptable deviation from a straight line between tool path points when a combination of linear and rotary motion is producing the actual tool path. Linearization may produce additional tool path motions to maintain the allowable deviation.

FINE,*a* (keyword,real) defines the allowable deviation in part reference units to be used when the tool is moving at feed velocity. The FINE keyword is optional and has no effect on the actions of the LINTOL command.

COARSE,*b* (keyword,real) defines the allowable deviation in part reference units to be used when the tool is positioning under rapid traverse control.

ON (keyword) reactivates the last suspended linearization.

OFF (keyword) suspends linearization.

10.11.2 Examples

None.

10.11.3 Limitations

None.

10.12 The LOAD command

Commands the loading of a tool, removable head, workpiece pallet or workpiece.

LOAD / TOOL,*a* [,CLW | CCLW] [,ORIENT] [,ADJUST,(NOW | NEXT)]

LOAD / HEAD,*a* [,CLW | CCLW] [,ADJUST,(NOW | NEXT)]

LOAD / (PALLET | PART) [,*a*] [,CLW | CCLW] [,ADJUST,(NOW | NEXT)]

10.12.1 Semantics

This command executes a loading sequence. This load sequence shall imply a SELECT operation (see 10.16) if it is necessary to select the new item and it has not already been selected; and an UNLOAD operation (see 10.19) if it is necessary to unload the old item and it has not already been unloaded.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be loaded.

HEAD (keyword) specifies that a head defined by a previous HEAD command is to be loaded.

PALLET (keyword) specifies that a workpiece pallet is to be loaded. In the absence of an identity number, a simple pallet switch operation is assumed.

PART (keyword) specifies that a workpiece is to be loaded. In the absence of an identity number, a simple workpiece switch operation is assumed.

a (real) identifies the tool, head, pallet or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the loading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the loading device.

ORIENT (keyword) specifies, for tool change only, that the tool be oriented to a predefined position to obtain tight tolerances.

ADJUST,NOW (keywords) specifies that any offset compensation necessary due to the loading operation be immediately output in a separate block.

ADJUST,NEXT (keywords) specifies that any offset compensation necessary due to the loading operation be interpolated with the next motion.

10.12.2 Examples

None.

10.12.3 Limitations

None.

10.13 The ORIGIN command

10.13.1 General comments

Provides for the definition of one of the relationship between the part reference system and a machine rotary table, or the length of a machine rotary head pivot.

10.13.1.1 Sub-contents

For

1) relationship between part reference system and machine rotary axis specification, see 10.13.2;
2) rotary head pivot length specification, see 10.13.3.

10.13.1.2 Limitations

None.

NOTE

An additional form of the ORIGIN command is defined in general language section 5.35.

10.13.2 Relationship between part reference system and machine rotary axis specification

ORIGIN / [**TABLE,** | **HEAD**] (**AAXIS** | **BAXIS** | **CAXIS** | **DAXIS** | **EAXIS**) **,COORD,** ***a*****,** ***b*****,** ***c***

10.13.2.1 Semantics

This command defines the relationship between the part reference system origin and a specified machine rotary axis. The post processor will use this information to determine the relationship between part and machine reference systems.

TABLE (keyword) further qualifies the named rotary axis as a rotary table. Used when a head co-rotary axis is also available on the machine.

HEAD (keyword) further qualifies the named rotary axis as a rotary head. Used when a table co-rotary axis is also available on the machine.

[*ABCDE*]AXIS (keyword) specifies the name of the rotary axis used as a reference point for the ORIGIN command.

COORD,*a*,*b*,*c* (keyword,reals) specifies the part reference system X,Y,Z co-ordinates of the rotary table center top face or of the rotary head pivot point.

10.13.2.2 Examples

None.

10.13.2.3 Limitations

None.

10.13.3 Rotary head pivot length specification

```
ORIGIN / [ HEAD,] ( AAXIS ) ,LENGTH,a
                  ( BAXIS )
                  ( CAXIS )
                  ( DAXIS )
                  ( EAXIS )
```

10.13.3.1 Semantics

This command redefines the distance between the spindle gauge reference point and the rotary head pivot centre point. The post processor will use this information in lieu of the predefined pivot length information.

HEAD,[*ABCDE*]AXIS (keywords) specifies the name of the rotary head axis whose pivot length is being redefined. The HEAD keyword is optional.

LENGTH,*a* (keyword,real) specifies the distance between the pivot point and the spindle gauge point, measured parallel to the spindle axis, in part reference system units.

10.13.3.2 Examples

None.

10.13.3.3 Limitations

None.

10.14 The RETRCT command

Moves the tool to a clearance plane.

```
RETRCT
```

10.14.1 Semantics

This command moves the tool tip along the tool axis to the clearance plane defined by the previous CLEARP command (see 10.5). If a clearance plane is not defined, then the tool shall move to the Z level of the primary home position.

10.14.2 Examples

None.

10.14.3 Limitations

None.

10.15 The ROTATE command

Moves a rotary axis.

```
ROTATE / [ TABLE, ] ( AAXIS ) [,ATANGL],a [,CLW  ] [,ROTREF ] [,NOW  ]
         [ HEAD   ] ( BAXIS ) [ INCR   ]  [ CCLW ]             [ NEXT ]
                    ( CAXIS )
                    ( DAXIS )
                    ( EAXIS )
```

10.15.1 Semantics

This command rotates a selected head or table rotary axis to the specified position or through the specified angle. The angle is measured in degrees.

TABLE (keyword) further qualifies the named rotary axis as a rotary table. Used when a head co-rotary axis is also available on the machine.

HEAD (keyword) further qualifies the named rotary axis as a rotary head. Used when a table co-rotary axis is also available on the machine.

[*ABCDE*]AXIS (keyword) specifies the name of the rotary axis to be moved.

ATANGL (keyword) specifies that the angular position of the endpoint of the rotary move is measured as an absolute value from the zero reference position.

INCR (keyword) specifies that the angular position of the endpoint of the rotary move is measured as an incremental displacement from the current position.

a (real) specifies the absolute or incremental endpoint of the rotary move in degrees. ATANGL is assumed if neither ATANGL or INCR is specified.

CLW (keyword) forces rotation to the endpoint to occur in a clockwise direction.

CCLW (keyword) forces rotation to the endpoint to occur in a counter-clockwise direction.

ROTREF (keyword) specifies that the post processor shall account for the effect of the rotation when computing the relationship between the tool and workpiece.

NOW (keyword) specifies that the rotary move shall be output immediately.

NEXT (keyword) specifies that the rotary move shall be interpolated with the next motion.

10.15.2 Examples

None.

10.15.3 Limitations

None.

10.16 The SELECT command

Commands the selection of a tool, removable head, workpiece pallet or workpiece.

SELECT / TOOL, *a* [**,CLW** | **CCLW**] [**,UPPER** | **LOWER**]

SELECT / (**HEAD** | **PALLET** | **PART**) **,** *a* [**,CLW** | **CCLW**]

10.16.1 Semantics

This command executes a selection sequence. This places the selected item in a ready state but does not load it.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be selected.

HEAD (keyword) specifies that a head defined by a previous HEAD command is to be selected.

PALLET (keyword) specifies that a workpiece pallet is to be selected.

PART (keyword) specifies that a workpiece is to be selected.

a (real) identifies the tool, head, pallet or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the selection device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the selection device.

UPPER (keyword) selects the upper tool loading position.

LOWER (keyword) selects the lower tool loading position.

10.16.2 Examples

None.

10.16.3 Limitations

None.

10.17 The SPINDL command

10.17.1 General comments

Controls one of spindle mode, spindle rotation rate or spindle orientation.

10.17.1.1 Sub-contents

For

1) spindle mode specification, see 10.17.2;
2) spindle rotation rate specification, see 10.17.3;
3) spindle orientation specification, see 10.17.4.

10.17.1.2 Limitations

None.

10.17.2 Spindle mode specification

```
SPINDL / ( ON     )
         ( OFF    )
         ( LOCK   )
         ( NEUTRL )
```

10.17.2.1 Semantics

This command controls the basic operation mode of the spindle.

ON (keyword) restarts the spindle rotation at the last specified rate.

OFF (keyword) stops the spindle rotation.

LOCK (keyword) stops the spindle rotation and locks it.

NEUTRL (keyword) disengages the spindle drive.

10.17.2.2 Examples

None.

10.17.2.3 Limitations

None.

10.17.3 Spindle rotation rate specification

SPINDL / [RPM,] *a* [**,CLW** | **CCLW**] [**,RANGE,** (***b*** | **LOW** | **MEDIUM** | **HIGH**)] [**,PRSSUR,** (**LOW** | **MEDIUM** | **HIGH**)]

10.17.3.1 Semantics

This command specifies the rotation rate, rotation direction, gear selection and tapping pressure of the spindle.

RPM,*a* (keyword,real) specifies the rotation rate of the spindle in revolutions per minute, corresponding to the G97 definition in ISO 6983. The RPM keyword is optional.

CLW (keyword) specifies clockwise spindle rotation.

CCLW (keyword) specifies counter-clockwise spindle rotation.

RANGE,*b* (keyword,real) specifies a numbered gear range to use on the machine.

RANGE,LOW (keywords) specifies that the lowest gear range be used.

RANGE,MEDIUM (keywords) specifies that the mid-range gear range be used.

RANGE,HIGH (keywords) specifies that the highest gear range be used.

PRSSUR,LOW (keywords) specifies that a low thread start pressure be used.

PRSSUR,MEDIUM (keywords) specifies that a normal thread start pressure be used.

PRSSUR,HIGH (keywords) specifies that a high thread start pressure be used.

10.17.3.2 Examples

None.

10.17.3.3 Limitations

The spindle rotation rate shall be a non-zero positive value.

10.17.4 Spindle orientation specification

`SPINDL / ORIENT [,a ]`

10.17.4.1 Semantics

This command indexes the spindle and locks it.

ORIENT,*a* (keyword,real) specifies the orientation angle of the spindle, measured in degrees, from a machine specific reference. If the orientation angle is omitted, a machine specific default angle shall be used.

10.17.4.2 Examples

None.

10.17.4.3 Limitations

None.

10.18 The TOOLNO command

Defines a tool.

TOOLNO / *a* [**,IN,*b***] **[,MILL] {*geometry-qualifiers*} {*machine-qualifiers*}**
                 [**,MANUAL**]

Where {*geometry-qualifiers*} are defined as:

[**,SETOOL,*c*,*d*,*e***] **[,DIAMET,*f*] [,FLUTES,*g*] [,TLMATL,*h*]**
[**,LENGTH,*e***   ]

And where {*machine-qualifiers*} are defined as:

[,OSETNO,*i*] [**,HOLDER,**(**SMALL**)]
                  (**MEDIUM**)
                  (**LARGE**)

10.18.1 Semantics

This command specifies tool information for a specific tool which is referenced by the SELECT/TOOL, LOAD/TOOL and UNLOAD/TOOL commands.

a (real) specifies the tool number.

IN,*b* (keyword,real) specifies the pocket number where the tool is loaded from.

MANUAL (keyword) specifies that the operator must load the tool manually.

MILL (keyword) specifies that the tool being defined applies to that component of a machine which provides a milling or drilling capability. This is the default when the TOOLNO statement appears within a segment of the part program preceded by an APPLY/MILL command, or when the machine does not support any manufacturing function other than milling or drilling.

SETOOL,*c*,*d*,*e* (keyword,reals) specifies the tool setting distance measured in the part co-ordinate X, Y, Z axes, from the tool tip location to the machine gauge reference point.

LENGTH,*e* (keyword,real) specifies the tool setting length measured in the part co-ordinate Z axis, from the tool tip location to the machine gauge reference point.

DIAMET,*f* (keyword,real) specifies the tool diameter in part reference units.

FLUTES,*g* (keyword,real) specifies the number of cutting surfaces on the tool.

TLMATL,*h* (keyword,real) specifies the material of the tool using a code number recognized by the tool life facility.

OSETNO,*i* (keyword,real) specifies a tool correction dial or register to be associated with the tool.

HOLDER,SMALL (keywords) specifies that the tool is mounted in a small holder.

HOLDER,MEDIUM (keywords) specifies that the tool is mounted in a mid-size holder.

HOLDER,LARGE (keywords) specifies that the tool is mounted in a large holder.

10.18.2 Examples

None.

10.18.3 Limitations

None.

10.19 The UNLOAD command

Commands the unloading of the tool, removable head, workpiece pallet or workpiece.

```
UNLOAD / ( TOOL   ) [,CLW  ]
         ( HEAD   )  ( CCLW ]
         ( PALLET )
         ( PART   )
```

10.19.1 Semantics

This command executes an unloading sequence. This removes the item from the working environment and deposits it in a storage area.

TOOL (keyword) specifies that the tool shall be unloaded.

HEAD (keyword) specifies that the head shall be unloaded.

PALLET (keyword) specifies that the workpiece pallet shall be unloaded.

PART (keyword) specifies that the workpiece shall be unloaded.

CLW (keyword) specifies a clockwise indexing direction of the unloading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the unloading device.

10.19.2 Examples

None.

10.19.3 Limitations

None.

11 Punching and forming language

11.1 General comments

11.1.1 General semantics

The punching and forming language section defines vocabulary specific to the turret punching machine family. Turret punching machines are those where a stationary working element is driven through a stationary workpiece.

The general language (see 5) and the punching and forming language together provide the standard vocabulary for a turret punching machine, or that component of a machine which provides a turret punching capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 11.2) shall be used to designate the machine family being manipulated at any given moment.

11.1.2 Sub-contents

For

1) the APPLY command, which selects the punching and forming capability of the machine, see 11.2;
2) the CLAMP command, which adjusts the material clamp position, see 11.3;
3) the CYCLE command, which provides for modal application of a preset series of operations, see 11.4;
4) the LOAD command, which commands the loading of various items, see 11.5;
5) the PIERCE command, which controls the rate of punching, see 11.6;
6) the SELECT command, which commands the selection of various items, see 11.7;
7) the TOOLNO command, which defines a tool, see 11.8;
8) the UNLOAD command, which commands the unloading of various items, see 11.9.

11.1.3 Limitations

None.

11.2 The APPLY command

Selects the punching and forming capability of the machine.

```
APPLY / PUNCH
```

11.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

PUNCH (keyword) specifies that subsequent part program data is to be processed using the punching and forming capability of the machine.

11.2.2 Examples

None.

11.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

11.3 The CLAMP command

Adjusts the material clamp position.

CLAMP / MATERL ,XDIST,*a* [,CLEAR,*b*]

11.3.1 Semantics

This command initiates a series of actions to move the material from one clamping position to another. This typically consists of a series of actions including; holding of the material by presser feet, removal of material clamps, movement of material clamps to a new position, reapplication of material clamps and removal of presser feet.

MATERL (keyword) specifies a material clamping operation.

XDIST,*a* (keyword,real) specifies the distance to shift the material clamps, as a signed value measured in part reference units along the X axis.

CLEAR,*b* (keyword,real) specifies an additional clearance requirement when shifting the clamps, as an unsigned value measured in part reference units along the Y axis.

11.3.2 Examples

None.

11.3.3 Limitations

None.

NOTE

An additional form of the CLAMP command is defined in general language section 5.8.

11.4 The CYCLE command

11.4.1 General comments

Provides modal application of a preset series of operations.

CYCLE / {*type*} $^{0:n}$**[,{*qualifier*}]**

$^{1:n}$**({*motion*})**

CYCLE / OFF

11.4.1.1 General semantics

A cycle is a preset series of operations which direct machine axis movement and cause punching operations to complete such action as drawing, nibbling, punching and shearing.

{*type*} (keyword) identifies the type of preset operation to perform.

{*qualifier*} (various) specifies parameters which allow modification of the basic cycle. Qualifiers have a consistent meaning where they appear in different cycles.

{*motion*} (various) defines the control points for the cycle. The preset operation will be performed at each part program motion point until the cycle is canceled.

OFF (keyword) cancels the cycle operation.

11.4.1.2 Sub-contents

For

1) general activation specification, see 11.4.2;
2) in-cycle parameter modification, see 11.4.3;
3) BOLTC cycle specification, see 11.4.4;
4) DRAW cycle specification, see 11.4.5;
5) NIBBLE cycle specification, see 11.4.6;
6) RCTNGL cycle specification, see 11.4.7;
7) ROUND cycle specification, see 11.4.8;
8) SHEAR cycle specification, see 11.4.9.

11.4.1.3 Limitations

None.

11.4.2 General activation specification

CYCLE / OFF

CYCLE / ON $^{0:n}$**[,{*qualifier*}]**

11.4.2.1 Semantics

These commands are used to suspend and reactivate cycles.

OFF (keyword) suspends the active cycle.

ON (keyword) restarts a suspended cycle.

{*qualifier*} (various) modifies selected parameters of the suspended cycle. Parameters of the suspended cycle not referenced retain their original values.

11.4.2.2 Examples

None.

11.4.2.3 Limitations

The ON form is only valid once a cycle has been suspended.

NOTE

The keyword NOMORE is a non-preferred alternative for OFF. Either can be used with identical results.

11.4.3 In-cycle parameter modification

CYCLE / MODIFY $^{1:n}$**(,{*qualifier*})**

11.4.3.1 Semantics

This command is used within a cycle block to modify one or more parameters, without having to suspend the cycle and then reactivate as described in section 11.4.2.

MODIFY (keyword) identifies an in-cycle parameter modification cycle statement.

{*qualifier*} (various) modifies selected parameters of the active cycle. Parameters of the active cycle not referenced retain their original values.

11.4.3.2 Examples

None.

11.4.3.3 Limitations

The MODIFY form is only valid when a cycle is active.

11.4.4 BOLTC cycle specification

CYCLE / BOLTC, RADIUS,*a* ,ATANGL,*b* ,TIMES,*c* [**[,STEP,*d*]** ,(**CLW** / **CCLW**)]

11.4.4.1 Semantics

This command initiates a cycle to punch a circular pattern of the specified dimensions at each control point in the cycle block. The cycle control point indicates the centre of the circular arc (see figure 17).

BOLTC (keyword) specifies the start of a circular bolt hole punching operation.

RADIUS,*a* (keyword,real) specifies the radius of the circular pattern, as an unsigned value measured in part reference units. The radius is measured from the cycle control point to the tool control point.

ATANGL,*b* (keyword,real) specifies the angular location in the XY plane of the first hole to punch, as a signed value measured in degrees.

TIMES,*c* (keyword,real) specifies the number of punch hits to perform on the circular arc. In the absence of the STEP parameter, the punch hits are equally spaced over a complete circle.

STEP,*d* (keyword,real) specifies the punch frequency in terms of the angular distance from one punch hit to the next, as an unsigned value measured in degrees.

CLW (keyword) specifies a clockwise punching progression. If CLW and CCLW are both omitted, the progression direction is left to the discretion of the post-processor.

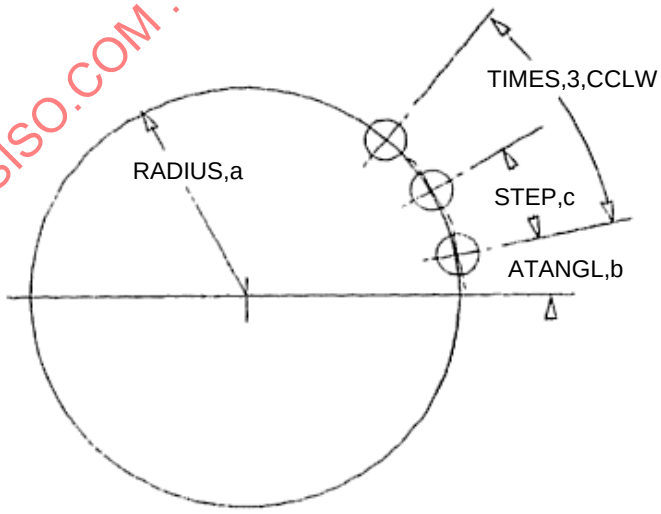
CCLW (keyword) specifies a counter-clockwise punching progression. If CLW and CCLW are both omitted, the progression direction is left to the discretion of the post-processor.

11.4.4.2 Examples

None.

11.4.4.3 Limitations

One of CLW or CCLW must be specified to indicate the progression direction when the STEP qualifier is specified.



CYCLE/BOLTC,RADIUS,*a*,ATANGL,*b*,STEP,*c*,TIMES,3,CCLW

Figure 17

11.4.5 DRAW cycle specification

CYCLE / DRAW ,DEPTH,*a* (**,OVRLAP** / **STEP**) **,***b* **[,INCR,***c* **[,ZIGZAG]]**

11.4.5.1 Semantics

This command initiates a series of punch cycles spaced at the interval specified moving from the first control point to the last control point in the cycle block. The series can be repeated at progressively deeper depths until full depth is reached. This cycle is used to form beading and other shapes that require progressive draw forming.

DRAW (keyword) specifies the start of a progressive draw forming operation.

DEPTH,*a* (keyword,real) specifies the final depth of the draw operation below the control point, as a signed offset value measured in part reference units. A positive depth is measured along the negative sense of the tool axis.

OVRLAP,*b* (keyword,real) specifies the punch frequency in terms of the cutter overlap from one punch hit to the next, as an unsigned value measured in part reference units. The overlap distance shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

STEP,*b* (keyword,real) specifies the punch frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units.

INCR,*c* (keyword,real) specifies the intermittent step distance for the draw operation, as an unsigned value measured in part reference units. If the INCR keyword is omitted, the draw cycle will be performed to full depth on the first pass and not repeated.

ZIGZAG (keyword) specifies that the tool direction shall reverse on alternate depths, proceeding from the last point in the cycle block to the first point. If ZIGZAG is omitted, the tool progression direction shall always be from the first control point to the last control point.

11.4.5.2 Examples

None.

11.4.5.3 Limitations

None.

11.4.6 NIBBLE cycle specification

CYCLE / NIBBLE, (**CUSP** | **OVRLAP** | **STEP**) ***, a***

11.4.6.1 Semantics

This command initiates a nibble cycle to perform a series of punch hits spaced at the interval specified (see figure 18), moving from the first control point to the last control point in the cycle block. This cycle is used to remove material along a contour.

NIBBLE (keyword) specifies the start of a nibble operation.

CUSP,*a* (keyword,real) specifies the nibble frequency in terms of the maximum cusp height that can be left on the programmed profile, as an unsigned value measured in part reference units. The cusp height shall be computed using the RADIUS qualifier of the tool as defined in the TOOLNO specification (see 11.8).

OVRLAP,*a* (keyword,real) specifies the nibble frequency in terms of the cutter overlap from one punch hit to the next, as an unsigned value measured in part reference units. The overlap distance shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

STEP,*a* (keyword,real) specifies the nibble frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units.

11.4.6.2 Examples

None.

11.4.6.3 Limitations

None.

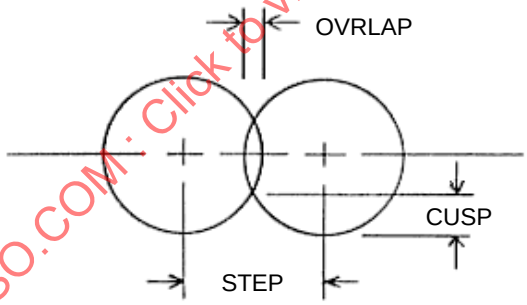


Figure 18 – Punch hit spacing

11.4.7 RCTNGL cycle specification

CYCLE / RCTNGL, XDIM,*a*,YDIM,*b* (**,OVRLAP** / **STEP**) **,*c*** **[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

ATANGL,*d*

CONTUR [**,STOP** / **OPSTOP**]

11.4.7.1 Semantics

This command initiates a cycle to clear a rectangular area of the specified dimensions at each control point in the cycle block (see figure 19). The rectangular area is centred at the cycle control point.

RCTNGL (keyword) specifies the start of a rectangular area clearance operation.

XDIM,*a* (keyword,real) specifies the length of one side of the rectangular area, as an unsigned value measured in part reference units along the X axis. The actual length shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

YDIM,*b* (keyword,real) specifies the length of the second side of the rectangular area, as an unsigned value measured in part reference units along the Y axis. The actual length shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

OVRLAP,*c* (keyword,real) specifies the punch frequency in terms of the cutter overlap from one punch hit to the next, as an unsigned value measured in part reference units. The overlap distance shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

STEP,*c* (keyword,real) specifies the punch frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units.

ATANGL,*d* (keyword,real) specifies rotation of the XDIM and YDIM cutout parameters, as a signed value measured in degrees. The rotation is taken from the cycle control point and is applied in the XY plane.

CONTUR (keyword) specifies that only the contour of the rectangular region shall be punched (see figure 20). If the CONTUR qualifier is omitted, the entire rectangular region is punched.

STOP (keyword) specifies that a required machine stop block shall follow the last punch on the contour, to allow manual removal of the remaining slug of material.

OPSTOP (keyword) specifies that an optional machine stop block shall follow the last punch on the contour, to allow manual removal of the remaining slug of material.

11.4.7.2 Examples

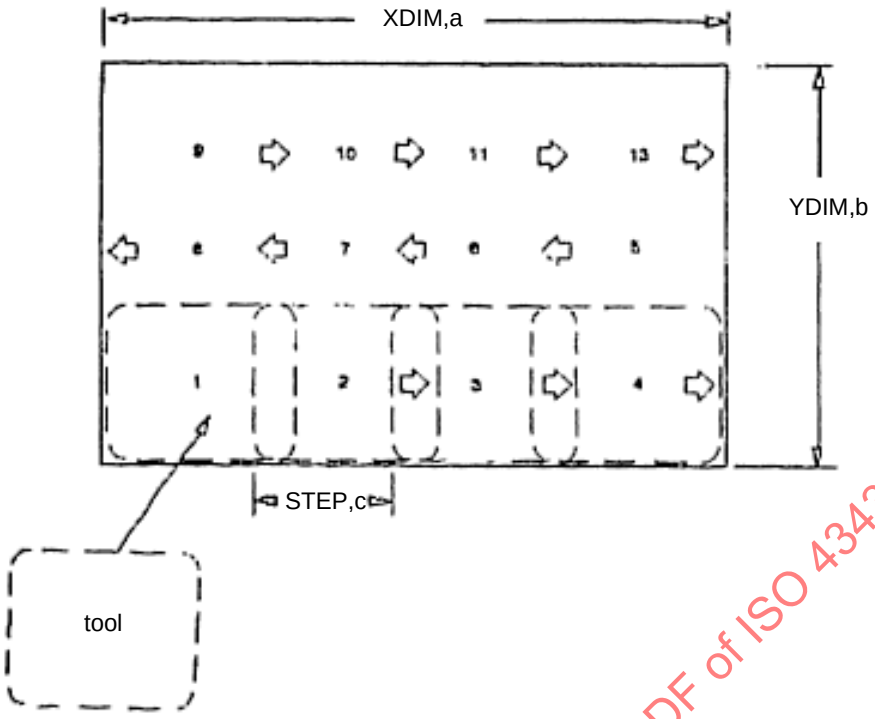
None.

11.4.7.3 Limitations

Both XDIM and YDIM shall be specified on the TOOLNO statement for a tool used in the RCTNGL cycle.

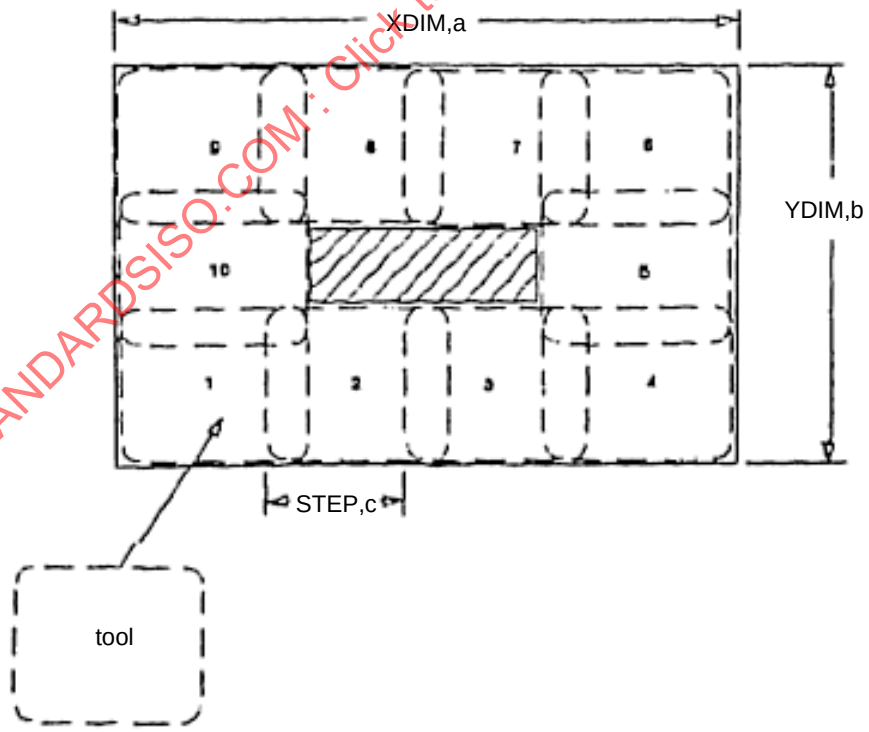
Any difference between the ATANGL qualifiers of the RCTNGL cycle and the TOOLNO statement shall be a multiple of 90 degrees.

The STOP and OPSTOP qualifiers are only valid with the CONTUR qualifier.



CYCLE/RCTNGL,XDIM,*a*,YDIM,*b*,STEP,*c*

Figure 19



CYCLE/RCTNGL,XDIM,*a*,YDIM,*b*,STEP,*c*,CONTUR

Figure 20

11.4.8 ROUND cycle specification

CYCLE / ROUND, DIAMET,*a* (**,CUSP** / **STEP**) **,***b* **[,{***qualifier***}]**

Where {*qualifier*} is defined as zero or more of:

(**CLW** / **CCLW**)

ROUGH,*c*

CONTUR [**,STOP** / **OPSTOP**]

11.4.8.1 Semantics

This command initiates a cycle to clear a circular area of the specified dimensions at each control point in the cycle block (see figure 21). The cycle control point indicates the centre of the circular area.

ROUND (keyword) specifies the start of a circular area clearance operation.

DIAMET,*a* (keyword,real) specifies the diameter of the circular area, as an unsigned value measured in part reference units. The actual length shall be computed using the RADIUS qualifier of the tool as defined in the TOOLNO specification (see 11.8).

CUSP,*b* (keyword,real) specifies the punch frequency in terms of the maximum cusp height that can be left on the programmed profile, as an unsigned value measured in part reference units. The cusp height shall be computed using the RADIUS qualifier of the tool as defined in the TOOLNO specification (see 11.8).

STEP,*b* (keyword,real) specifies the punch frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units.

CLW (keyword) specifies a clockwise punching progression. If CLW and CCLW are both omitted, the progression direction is left to the discretion of the post-processor.

CCLW (keyword) specifies a counter-clockwise punching progression. If CLW and CCLW are both omitted, the progression direction is left to the discretion of the post-processor.

ROUGH,*c* (keyword,real) specifies the roughing punch frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units. If the ROUGH qualifier is omitted, the basic punch frequency will be used for both interior and contour punching.

CONTUR (keyword) specifies that only the contour of the circular region shall be punched (see figure 22). If the CONTUR qualifier is omitted, the entire circular region is punched.

STOP (keyword) specifies that a required machine stop block shall follow the last punch on the contour, to allow manual removal of the remaining slug of material.

OPSTOP (keyword) specifies that an optional machine stop block shall follow the last punch on the contour, to allow manual removal of the remaining slug of material.

11.4.8.2 Examples

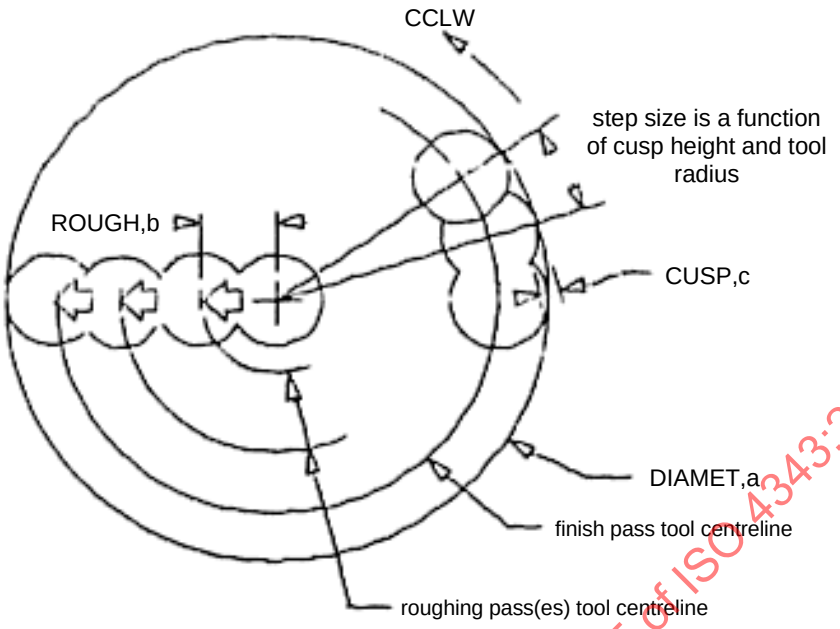
None.

11.4.8.3 Limitations

The RADIUS qualifier shall be specified on the TOOLNO statement for a tool used in the ROUND cycle.

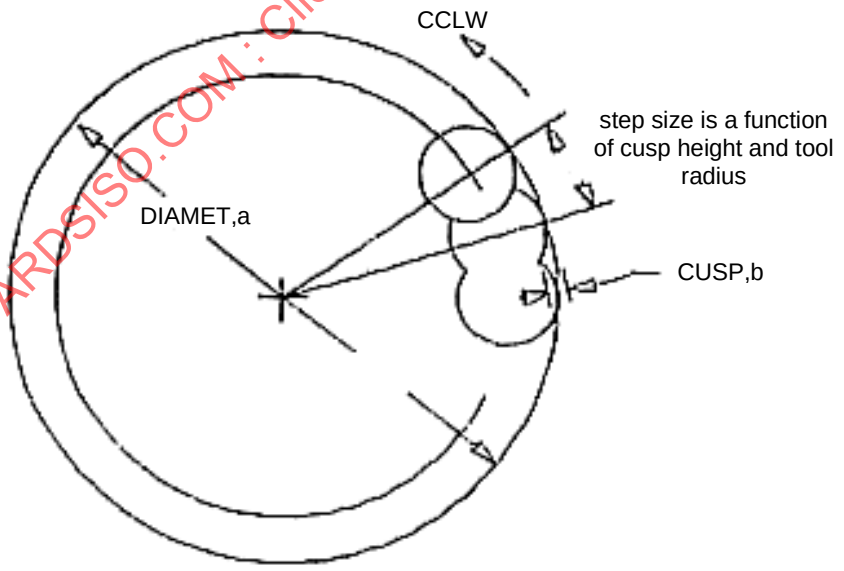
The STOP and OPSTOP qualifiers are only valid with the CONTUR qualifier.

The CONTUR and ROUGH qualifiers are mutually exclusive.



CYCLE/ROUND,DIAMET,a,ROUGH,*b*,CUSP,*c*,CCLW

Figure 21



CYCLE/ROUND,DIAMET,a,CUSP,b,CONTUR,CCLW

Figure 22

11.4.9 SHEAR cycle specification

CYCLE / SHEAR, (**OVRLAP** / **STEP**) ***,a*** **[,ZIGZAG]**

11.4.9.1 Semantics

This command initiates a series of punch cycles spaced at the interval specified moving from the first control point to the last control point in the cycle block. This cycle is used to shear the part material along a specified contour.

SHEAR (keyword) specifies the start of a material shearing operation.

OVRLAP,*a* (keyword,real) specifies the punch frequency in terms of the cutter overlap from one punch hit to the next, as an unsigned value measured in part reference units. The overlap distance shall be computed using the XDIM, YDIM and ATANGL qualifiers of the tool as defined in the TOOLNO specification (see 11.8).

STEP,*a* (keyword,real) specifies the punch frequency in terms of the distance from one punch hit to the next, as an unsigned value measured in part reference units.

ZIGZAG (keyword) specifies that the tool direction shall reverse on alternate punches to equalize the cutting load on the shearing tool. The initial punch will occur at the first control point of the cycle block. Thereafter, punching shall proceed in steps of two ***a*** increments forward and one ***a*** increment backward. If ZIGZAG is omitted, the tool progression direction shall not reverse.

11.4.9.2 Examples

None.

11.4.9.3 Limitations

None.

11.5 The LOAD command

Commands the loading of a tool or workpiece.

LOAD / TOOL,*a* [**,CLW** | **CCLW**] [**,ADJUST,**(**NOW** | **NEXT**)]

LOAD / PART [**,***a* **]** [**,CLW** | **CCLW**] [**,ADJUST,**(**NOW** | **NEXT**)]

11.5.1 Semantics

This command executes a loading sequence. This load sequence shall imply a SELECT operation (see 11.7) if it is necessary to select the new item and it has not already been selected; and an UNLOAD operation (see 11.9) if it is necessary to unload the old item and it has not already been unloaded.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be loaded.

PART (keyword) specifies that a workpiece is to be loaded.

a (real) identifies the tool or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the loading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the loading device.

ADJUST,NOW (keywords) specifies that any offset compensation necessary due to the loading operation be immediately output in a separate block.

ADJUST,NEXT (keywords) specifies that any offset compensation necessary due to the loading operation be interpolated with the next motion.

11.5.2 Examples

None.

11.5.3 Limitations

None.

11.6 The PIERCE command

Controls the rate of punching.

PIERCE / PERMIN,*a*

PIERCE / { **ON** | **OFF** }

11.6.1 Semantics

This command activates or deactivates punch stroke cycling so that punching shall occur or not occur at subsequent motion co-ordinates. This command is also used to set the stroke cycle rate.

PERMIN,*a* (keyword,real) specifies the punch rate as an unsigned value in punches per minute.

ON (keyword) indicates that punching shall occur at subsequent motion co-ordinates.

OFF (keyword) indicates that punching shall not occur at subsequent motion co-ordinates.

11.6.2 Examples

None.

11.6.3 Limitations

None.

11.7 The SELECT command

Commands the selection of a tool or workpiece.

SELECT / TOOL, ***a*** [**,CLW** / **CCLW**]

SELECT / PART [, ***a*** **]** [**,CLW** / **CCLW**]

11.7.1 Semantics

This command executes a selection sequence. This places the selected item in a ready state but does not load it.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be selected.

PART (keyword) specifies that a workpiece is to be selected.

a (real) identifies the tool or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the selecting device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the selecting device.

11.7.2 Examples

None.

11.7.3 Limitations

None.

11.8 The TOOLNO command

Defines a tool.

TOOLNO / *a* [**,IN,*b***
,MANUAL] **[,PUNCH]** **{*geometry-qualifiers*}** **{*machine-qualifiers*}**

Where {*geometry-qualifiers*} are defined as:

[,SETOOL,*c*,*d*] [,XDIM,*e*,YDIM,*f*] [,RADIUS,*g*] [,ATANGL,*h*] [,TLMATL,*i*]

And where {*machine-qualifiers*} are defined as:

[,OSETNO,*j*] [**,HOLDER,**(**SMALL**
MEDIUM
LARGE)]

11.8.1 Semantics

This command specifies tool information for a specific tool which is referenced by the SELECT/TOOL, LOAD/TOOL and UNLOAD/TOOL commands (see figures 23 and 24).

a (real) specifies the tool number.

IN,*b* (keyword,real) specifies the pocket number where the tool is loaded from.

MANUAL (keyword) specifies that the operator must load the tool manually.

PUNCH (keyword) specifies that the tool being defined applies to that component of a machine which provides a turret punching capability. This is the default when the TOOLNO statement appears within a segment of the part program preceded by an APPLY/PUNCH command, or when the machine does not support any manufacturing function other than turret punching.

SETOOL,*c*,*d* (keyword,reals) specifies the tool setting distance measured in the part co-ordinate X and Y axes, from the tool tip location to the machine gauge reference point.

XDIM,*e* (keyword,real) specifies the length of one side of the rectangular tool ignoring corner radius, as an unsigned value measured in part reference units along the X axis.

YDIM,*f* (keyword,real) specifies the length of the second side of the rectangular tool ignoring corner radius, as an unsigned value measured in part reference units along the Y axis.

RADIUS,*g* (keyword,real) specifies the corner radius of the tool, as an unsigned value measured in part reference units.

ATANGL,*h* (keyword,real) specifies rotation of the XDIM and YDIM tool parameters, as a signed value measured in degrees. The rotation is taken from the center of the tool and is applied in the XY plane.

TLMATL,*i* (keyword,real) specifies the material of the tool using a code number recognized by the tool life facility.

OSETNO,*j* (keyword,real) specifies a tool correction dial or register to be associated with the tool.

HOLDER,SMALL (keywords) specifies the tool is mounted in a small holder.

HOLDER,MEDIUM (keywords) specifies the tool is mounted in a mid-size holder.

HOLDER,LARGE (keywords) specifies the tool is mounted in a large holder.

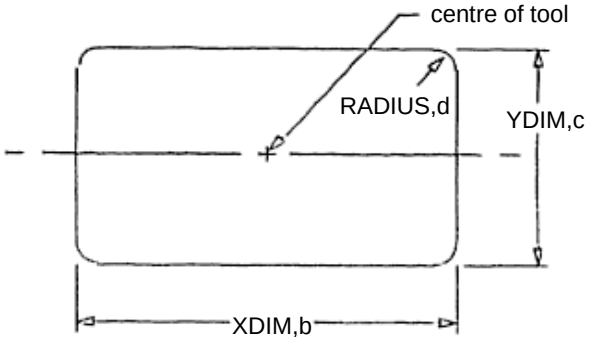
The XDIM, YDIM, RADIUS and ATANGL qualifiers provide basic dimension information used for the calculation of step over and tool offsets within the post-processor. Where these qualifiers are used for this purpose, it will be noted as a limitation.

11.8.2 Examples

None.

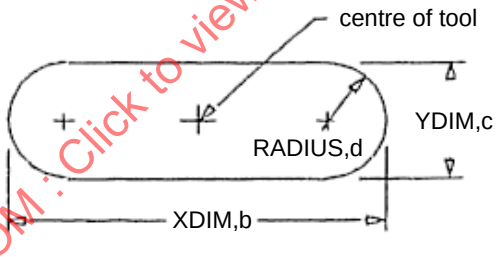
11.8.3 Limitations

Both XDIM and YDIM must be specified if either is used.



TOOLNO/*a*,PUNCH,XDIM,*b*,YDIM,*c*,RADIUS,*d*

Figure 23 – *d* < *c*



TOOLNO/*a*,PUNCH,XDIM,*b*,YDIM,*c*,RADIUS,*d*

Figure 24 – *d* = *c*

11.9 The UNLOAD command

Commands the unloading of the tool or workpiece.

```
UNLOAD / ( TOOL ) [,CLW ]
         ( PART ) [,CCLW]
```

11.9.1 Semantics

This command executes an unloading sequence. This removes the item from the working environment and deposits it in a storage area.

TOOL (keyword) specifies that the tool shall be unloaded.

PART (keyword) specifies that the workpiece shall be unloaded.

CLW (keyword) specifies a clockwise indexing direction of the unloading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the unloading device.

11.9.2 Examples

None.

11.9.3 Limitations

None.

12 Turning language

12.1 General comments

12.1.1 General semantics

The turning language section defines vocabulary specific to the turning machine family. Turning machines are those where a stationary working element is applied to a rotating workpiece held in a spindle.

The general language (see 5) and the turning language together provide the standard vocabulary for a turning machine, or that component of a machine which provides a turning capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 12.2) shall be used to designate the machine family being manipulated at any given moment.

12.1.2 Reference system

Tradition dictates that for horizontal lathes the part reference X axis corresponds to the machine reference Z axis and the part reference Y axis corresponds to the machine reference X axis. For vertical lathes these are inverted, with the part reference Y axis corresponding to the machine reference Z axis and the part reference and machine reference X axes being identical. The intent was to allow programming in the XY plane which is simpler than the ZX plane, and to simplify the visualization of the machining procedure for horizontal and vertical lathes. Notwithstanding tradition, this International Standard dictates that part reference primary linear axes shall correspond to machine reference primary axes. The COUPLE command (see 5.10) shall be used to designate other relationships between part and machine reference axes.

To reduce the potential for confusion, the part reference axis which corresponds to the machine axis parallel to the spindle shall be named the “rail”, and the axis perpendicular to the spindle shall be named the “cross slide”.

12.1.3 Sub-contents

For

1) the APPLY command, which selects the turning capability of the machine, see 12.2;
2) the BARFED command, which controls the feeding of new workpiece material through the holding collet, see 12.3;
3) the CATCHR command, which controls a part catcher, see 12.4;
4) the CHUCK command, which defines a holding device, see 12.5;
5) the CLAMP command, which provides for various clamping operations, see 12.6;
6) the COOLNT command, which controls the flow of coolant, see 12.7;
7) the COUPLE command, which controls synchronization for threading, see 12.8;
8) the CUTCOM command, which controls the activation and removal of cutter diameter compensation, see 12.9;
9) the DEFCON command, which defines a contour used in subsequent turning operations, see 12.10;
10) the LOAD command, which commands the loading of various items, see 12.11;
11) the MODE command, which controls the application of constant surface speed, see 12.12;
12) the OP command, which provides nonmodal application of a preset series of operations, see 12.13;
13) the PITCH command, which provides for thread pitch specification, see 12.14;
14) the SAFETY command, which specifies a retract pull out direction for emergency stops, see 12.15;
15) the SELECT command, which commands the selection of various items, see 12.16;
16) the SPINDL command, which controls various functions related to the spindle, see 12.17.
17) the STAN command, which specifies the setting angle of the tool, see 12.18;
18) the STDYRS command, which controls the positioning of steady rests, see 12.19;
19) the TLSTCK command, which controls the positioning of the tailstock and tailstock quill, see 12.20;
20) the TOOLNO command, which defines a tool, see 12.21;
21) the TURRET command, which controls the indexing of the turret, see 12.22;
22) the UNLOAD command, which commands the unloading of various items, see 12.23.

12.1.4 Limitations

None.

NOTES

1) A turning machine can be used to perform drilling type operations along the centreline of the spindle. The CYCLE vocabulary from the milling and drilling language (see 10.8) applies in this special case. References to these cycles are made within the turning language section.

2) A turning machine with live tooling can also be used to perform drilling operations without specific limitations. The milling and drilling language APPLY command (see 10.2) must be specified to access this capability.

12.2 The APPLY command

Selects the turning capability of the machine.

APPLY / TURN

12.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

TURN (keyword) specifies that subsequent part program data is to be processed using the turning capability of the machine.

12.2.2 Examples

None.

12.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

12.3 The BARFED command

Controls the feeding of new workpiece material through the holding collet.

BARFED / ***a***,**TO**,***b***

12.3.1 Semantics

This command controls the feeding of workpiece material through the holding collet. The BARFED command shall perform all activities necessary to perform this task, including initial unclamping of the collet, feeding of stock and reapplication of clamps.

a (real) specifies the initial position of the end of the bar stock at the start of the bar feed operation, as a signed value measured in part reference units along the rail.

TO,*b* (keyword,real) specifies the final position of the end of the bar stock at the end of the bar feed operation, as a signed value measured in part reference units along the rail.

12.3.2 Examples

None.

12.3.3 Limitations

None.

12.4 The CATCHR command

Controls a part catcher.

```
CATCHR / ( IN  )
         ( OUT )
```

12.4.1 Semantics

This command controls the operation of a part catcher which retrieves the finished workpiece after a cutoff operation or a chuck release operation.

IN (keyword) specifies that the part catcher shall be placed in a position to retrieve or catch the workpiece.

OUT (keyword) specifies that the part catcher shall be withdrawn.

12.4.2 Examples

None.

12.4.3 Limitations

None.

12.5 The CHUCK command

Defines a holding device.

CHUCK / *a*,AT,*b* [,DIAMET,*c*] [,FACE,*d*] [,(**IN** / **OUT**),*e*] [,(**DEPTH** / **LENGTH**),*f*]

12.5.1 Semantics

This command defines a chuck to be selected and loaded at a later point in the part program (see figure 25). The LOAD command (see 12.11) shall be used to load the chuck onto the machine.

a (real) specifies the identity number of the chuck.

AT,*b* (keyword,real) specifies the distance from the machine origin to the part locating face on the front of the chuck, as a signed value measured in part reference units measured along the rail.

DIAMET,*c* (keyword,real) specifies the outside diameter of the chuck housing, as an unsigned value in part reference units. This information is used for collision avoidance purposes.

FACE,*d* (keyword,real) specifies the distance from the part locating face on the front of the chuck to the front face of the chuck, as a signed value in part reference units measured along the rail. This information is used for collision avoidance purposes.

IN,*e* (keyword,real) indicates that the jaws are in the arbor position (see figure 26) and specifies the outward clamping diameter, as an unsigned value in part reference units.

OUT,*e* (keyword,real) indicates that the jaws are in the chuck position (see figure 27) and specifies the inward clamping diameter, as an unsigned value in part reference units.

DEPTH,*f* (keyword,real) specifies the depth of the external clamping diameter in a direction opposite that specified by the AT qualifier, as an unsigned value in part reference units measured along the cross slide.

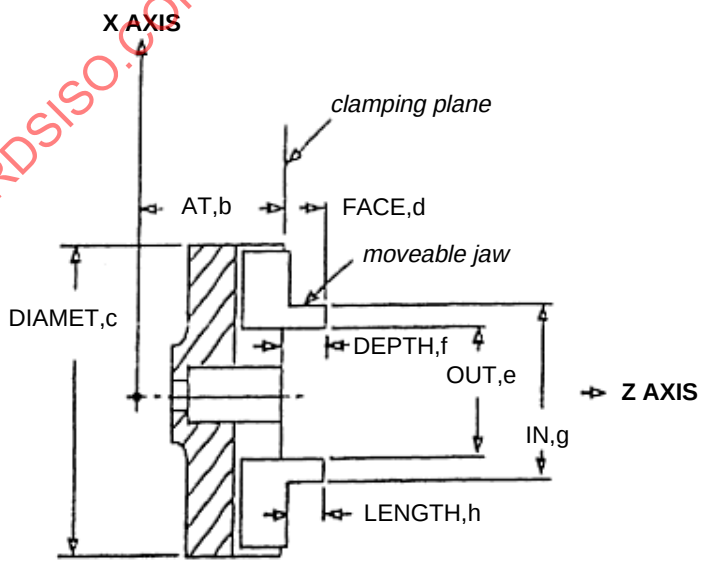
LENGTH,*f* (keyword,real) specifies the length of the internal mounting arbor in the same direction as that specified by the AT qualifier, as an unsigned value in part reference units measured along the rail.

12.5.2 Examples

None.

12.5.3 Limitations

None.



CHUCK/*a*,AT,*b*,DIAMET,*c*,FACE,*d*,OUT,*e*,DEPTH,*f*
or
CHUCK/*a*,AT,*b*,DIAMET,*c*,FACE,*d*,IN,*g*,LENGTH,*h*

Figure 25

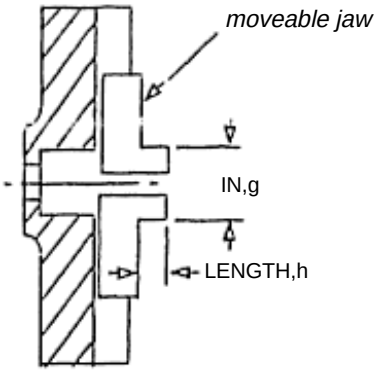


Figure 26 – Jaw dimensions for arbor (IN) position

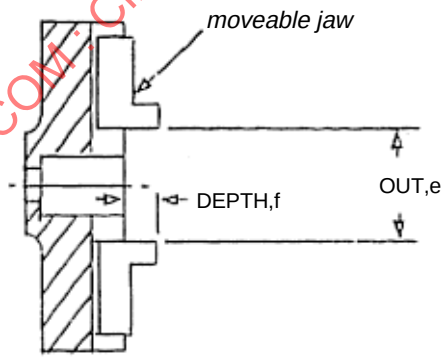


Figure 27 – Jaw dimensions for chuck (OUT) position

12.6 The CLAMP command

12.6.1 General semantics

Controls one of the application of axes clamps, the operation of a holding device or the operation of the tailstock.

12.6.1.1 Sub-contents

For

1) operation of a holding device, see 12.6.2;
2) operation of the tailstock, see 12.6.3.

12.6.1.2 Limitations

None.

NOTE

An additional form of the CLAMP command is defined in general language section 5.8.

12.6.2 Operation of a holding device

```
CLAMP / ( CHUCK  ) [,ON  ] [,XCOORD,a [,INVERS ] ] [ [,PRSSUR ],( LOW    ) ]
        ( ARBOR  ) [,OFF ]                         [            ( MEDIUM )  ]
        ( COLLET )                                 [            ( HIGH   )  ]
                                                   [,PRSSUR,b               ]
```

12.6.2.1 Semantics

This command controls the operation of the workpiece holding device.

CHUCK (keyword) specifies that the device is to be operated as a chuck (see figure 28), where the clamping force is applied from the exterior to the interior.

ARBOR (keyword) specifies that the device is to be operated as an arbor (see figure 29), where the clamping force is applied from the interior to the exterior.

COLLET (keyword) specifies that the device is to be operated as a collet, where a pull-bar applies the clamping force from the exterior to the interior.

ON (keyword) specifies that the device is to be activated, thereby applying a clamping force on the workpiece.

OFF (keyword) specifies that the device is to be deactivated, thereby removing the clamping force on the workpiece.

XCOORD,*a* (keyword,real) specifies the location of the clamping plane, measured in part reference co-ordinates along the rail. The clamping plane shall be aligned by the post processor with the chuck clamping plane defined using the AT qualifier of the CHUCK command (see 12.5).

INVERS (keyword) specifies that the part reference system shall be rotated 180 degrees by the post processor. If this qualifier is omitted, no rotation of the part reference system shall take place.

PRSSUR,LOW (keywords) specifies that a low clamping pressure shall be applied when multiple clamping forces are available.

PRSSUR,MEDIUM (keywords) specifies that a medium or normal clamping pressure shall be applied when multiple clamping forces are available.

PRSSUR,HIGH (keywords) specifies that a high clamping pressure shall be applied when multiple clamping forces are available.

PRSSUR,*b* (keyword,real) specifies the clamping pressure in machine specific units.

12.6.2.2 Examples

None.

12.6.2.3 Limitations

The XCOORD and INVERS qualifiers replace machine reference information defined by the ORIGIN command (see 5.35). Similarly, the ORIGIN command will override information on the CLAMP command of it is encountered subsequent to a CLAMP command.

The machine specific format of this command produces output codes which may not be portable.

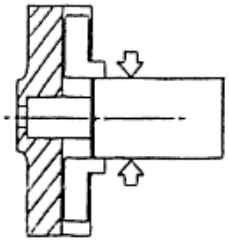


Figure 28 – CLAMP/CHUCK,ON

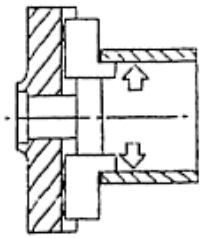


Figure 29 – CLAMP/ARBOR,ON

12.6.3 Operation of the tailstock

CLAMP / TLSTCK (**,ON** / **OFF**)

12.6.3.1 Semantics

This command controls the operation of the tailstock. Control is limited to simple activation and deactivation. The active and inactive state locations of the tailstock shall be set at the machine under operator control.

TLSTCK,ON (keyword) specifies that the tailstock is to be activated, thereby engaging and supporting the workpiece.

TLSTCK,OFF (keyword) specifies that the tailstock is to be deactivated.

12.6.3.2 Examples

None.

12.6.3.3 Limitations

None.

12.7 The COOLNT command

Controls the flow of coolant.

```
COOLNT / ( ON  )
         ( OFF )

COOLNT / ( FLOOD  ) [,LOW    ] 0:n[,a     ]
         ( MIST   ) [,MEDIUM ]    [,FRONT  ]
         ( TAPKUL ) [,HIGH   ]    [,REAR   ]
         ( THRU   )               [,SADDLE ]
```

12.7.1 Semantics

This command controls the type, volume and source of coolant.

ON (keyword) restarts the flow of coolant. If coolant has not previously been established, then ON starts a default flow of coolant.

OFF (keyword) terminates the flow of coolant.

FLOOD (keyword) specifies flood coolant.

MIST (keyword) specifies mist coolant.

TAPKUL (keyword) specifies tapping oil.

THRU (keyword) specifies coolant applied through the working element.

LOW (keyword) specifies a low rate of coolant flow.

MEDIUM (keyword) specifies a normal rate of coolant flow.

HIGH (keyword) specifies a high rate of coolant flow.

a (real) specifies the identity number of a machine specific delivery pipe.

FRONT (keyword) specifies that the coolant shall be activated or deactivated for the front turret.

REAR (keyword) specifies that the coolant shall be activated or deactivated for the rear turret.

SADDLE (keyword) specifies that the coolant shall be activated or deactivated on the saddle.

12.7.2 Examples

None.

12.7.3 Limitations

The machine specific format of this command produces output codes which may not be portable.

12.8 The COUPLE command

Controls synchronization for threading.

COUPLE / (**ON** | **OFF**)

12.8.1 Semantics

This command controls the synchronization of the feed rate and the spindle speed for threading operations. The feed velocity shall be determined by the PITCH command (see 12.14) when synchronization is active and shall revert back to normal feed velocity as defined by the FEDRAT command (see 5.17.2) when synchronization is inactive.

ON (keyword) specifies that synchronization of feed velocity and spindle speed is to be activated, thereby providing a thread turning capability.

OFF (keyword) specifies that synchronization of feed velocity and spindle speed is to be deactivated.

Increasing and decreasing thread lead as defined by the PITCH command shall be taken from the current position when synchronization is activated.

12.8.2 Examples

None.

12.8.3 Limitations

A PITCH command shall be specified at some point prior to the start of synchronization to define the feed velocity during synchronization.

NOTES

1) The OP/THREAD command (see 12.13.5) provides a more complete thread definition.

2) An additional form of the COUPLE command is defined in general language section 5.10.

12.9 The CUTCOM command

Controls the activation and removal of cutter diameter compensation.

CUTCOM / (**ON** | **OFF**)

CUTCOM / (**LEFT** | **RIGHT**) **[,ZXPLAN] [,OSETNO,*a*]**

12.9.1 Semantics

This command controls the application and removal of cutter diameter compensation.

ON (keyword) reactivates cutter diameter compensation.

OFF (keyword) terminates cutter diameter compensation, corresponding to the G40 definition in ISO 6983.

LEFT (keyword) activates cutter diameter compensation to the left of the workpiece when viewed in the forward direction of motion, corresponding to the G41 definition in ISO 6983.

RIGHT (keyword) activates cutter diameter compensation to the right of the workpiece when viewed in the forward direction of motion, corresponding to the G42 definition in ISO 6983.

ZXPLAN (keyword) specifies that compensation shall be applied in the machine reference ZX plane. This is the default plane of compensation for turning applications.

OSETNO,*a* (keyword,real) identifies the offset register on the machine to use for cutter diameter compensation. If omitted, the default register will be used.

12.9.2 Examples

None.

12.9.3 Limitations

The ON form of cutter diameter compensation is invalid until either one of the LEFT or RIGHT forms is specified.

12.9.3.1 Limitations

None.

NOTE

An additional form of the CUTCOM command is defined in general language section 5.11.

12.10 The DEFCON command

Defines a contour used in subsequent turning operations.

DEFCON / *a*

1:n({*motion*})

DEFCON / [*b*,] NOMORE

12.10.1 Semantics

This command assigns an identity number to a series of motions that comprise a contour (see figure 30). No turning occurs during the contour definition. The contour is referenced as a boundary condition in subsequent contouring and profiling OP commands (see 12.13).

a (real) identifies the contour by an identity number.

b*,NOMORE** (real,keyword) indicates the end of the contour. The contour identifier ***b is optional, but if specified it must match the contour identifier ***a*** specified on the initial DEFCON command.

Part program data between the initial DEFCON command and the terminating DEFCON/NOMORE command shall be stored by the post processor for subsequent use in OP/CONTUR and OP/PROFIL commands. Part program data other than motions may appear within the contour definition providing they are acceptable to the OP command referencing the contour.

12.10.2 Examples

None.

12.10.3 Limitations

The original contour and any offset contour generated during turning must not self intersect nor be closed.

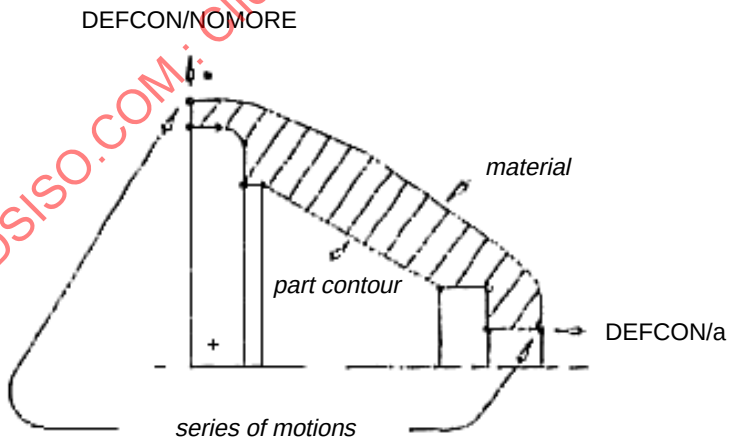


Figure 30

12.11 The LOAD command

Commands the loading of a tool, chuck or workpiece.

```
LOAD / TOOL,a [,CLW ] [,ID ] [,ADJUST,( NOW )]
              [,CCLW] [,OD ] [       ( NEXT)]

LOAD / CHUCK,a [,CLW ] [,ADJUST,( NOW )]
               [,CCLW] [       ( NEXT)]

LOAD / PART [,a ] [,CLW ] [,ADJUST,( NOW )]
                  [,CCLW] [       ( NEXT)]
```

12.11.1 Semantics

This command executes a loading sequence. This load sequence shall imply a SELECT operation (see 12.16) if it is necessary to select the new item and it has not already been selected; and an UNLOAD operation (see 12.23) if it is necessary to unload the old item and it has not already been unloaded.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be loaded.

CHUCK (keyword) specifies that a chuck defined by a previous CHUCK command is to be loaded.

PART (keyword) specifies that a workpiece is to be loaded.

a (real) identifies the tool, chuck or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the loading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the loading device.

ID (keyword) specifies that the tool shall be loaded into the turret that performs inside diameter work.

OD (keyword) specifies that the tool shall be loaded into the turret that performs outside diameter work.

ADJUST,NOW (keywords) specifies that any offset compensation necessary due to the loading operation be immediately output in a separate block.

ADJUST,NEXT (keywords) specifies that any offset compensation necessary due to the loading operation be interpolated with the next motion.

12.11.2 Examples

None.

12.11.3 Limitations

None.

12.12 The MODE command

Controls the application of constant surface speed.

MODE / CSS (**,ON** / **OFF**)

12.12.1 Semantics

This command is used to enable and disable constant surface speed spindle control defined in a previous SPINDL command (see 12.17).

CSS,ON (keywords) enables constant surface speed spindle control, corresponding to the G96 definition in ISO 6983. The spindle rotation rate will be a function of the tool cross slide position.

CSS,OFF (keywords) disables constant surface speed spindle control, corresponding to the G97 definition in ISO 6983. The spindle rotation rate will be fixed at the rate in effect when this command is encountered.

12.12.2 Examples

None.

12.12.3 Limitations

The spindle must be rotating in constant surface speed mode for the MODE command to have any effect.

NOTE

Additional forms of the MODE command are defined in general language section 5.31.

12.13 The OP command

12.13.1 General comments

Provides nonmodal application of a preset series of operations.

OP / {*type*} 1:n(,{*qualifier*})

12.13.1.1 General semantics

An OP is a nonmodal preset series of operations which direct machine axis movement to complete such actions as contouring, facing, grooving, profiling, threading and turning.

{*type*} (keyword) identifies the type of the preset operation.

{*qualifier*} (various) specifies parameters which define and provide for modification of the basic turning operation. Qualifiers have a consistent meaning where they appear in different operations.

12.13.1.2 Sub-contents

For

1) CONTUR operation specification, which provides for turning parallel to a contour, see 12.13.2;
2) GROOVE operation specification, which provides for turning of a groove, see 12.13.3;
3) PROFIL operation specification, which provides for turning to a contour, see 12.13.4;
4) THREAD operation specification, which provides for turning of a thread, see 12.13.5;
5) TURN operation specification, which provides for turning or facing of a rectangular region, see 12.13.6.

12.13.1.3 Limitations

None.

12.13.2 CONTUR operation specification

Rough contour operation:

OP / CONTUR,*a* ,DEPTH,*b* ,STEP,*c* (,PERMIN / PERREV),*d* 0:n[,{*qualifier*}]

Finish contour operation:

OP / CONTUR,*a*

Where {*qualifier*} is defined as zero or more of:

CUTANG,*e*

THICKD,*f*

THICKF,*g*

FINCUT,*h*

12.13.2.1 Semantics

This command performs a controller defined or software simulated operation to turn a contour (see figure 31). The contour shall have been defined by a prior DEFCON command (see 12.10). The operation provides for multiple passes offset from the contour, in the direction defined by the motions comprising the contour, at progressively deeper depths.

CONTUR,*a* (keyword,real) specifies that a contouring operation is to be performed parallel to the contour defined by a prior DEFCON command.

DEPTH,*b* (keyword,real) specifies the depth of the contour operation, as an unsigned offset value measured in part reference units opposite the in-feed direction.

STEP,*c* (keyword,real) specifies the maximum depth of a roughing cut, as an unsigned value measured in part reference units.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

d (real) specifies the working feed movement velocity in the specified units.

CUTANG,*e* (keyword,real) specifies an optional in-feed angle, as a signed value measured in degrees in the machine ZX plane. If the in-feed angle is not specified, then the direction will be taken from the tool position prior to the OP/CONTUR command to the first point on the contour.

THICKD,*f* (keyword,real) specifies an optional amount of stock to be left on the diameter for the finish cut, as a signed offset value measured in part reference units along the cross slide. The stock is applied by translating all cross slide positions by ***f***.

THICKF,*g* (keyword,real) specifies an optional amount of stock to be left on the face for the finish cut, as a signed offset value measured in part reference units along the rail. The stock is applied by translating all rail positions by ***g***.

FINCUT,*h* (keyword,real) specifies the depth of the last cut, as an unsigned value measured in part reference units.

For a rough contour operation, the first cut pass will be performed at a distance ***b-c*** from the contour measured opposite the in-feed angle ***e***. If an in-feed angle is not specified, the in-feed shall occur along a vector connecting the tool position prior to the OP/CONTUR command (*P1*) to the first motion point in the contour (*P2*). Subsequent passes will be performed at successively closer distances to the contour where the step over between each pass shall not exceed the maximum specified by ***c***. The last step depth can be controlled by ***h***. All co-ordinates shall be translated by the amounts specified by ***f*** and ***g***. This provides for stock removal during a finish contour operation. The feed rate specified by ***d*** shall be applied for all roughing cuts. Positioning motions between cutting passes shall be performed at rapid and pass through *P1*. The tool will be at *P1* at the end of the rough contouring operation.

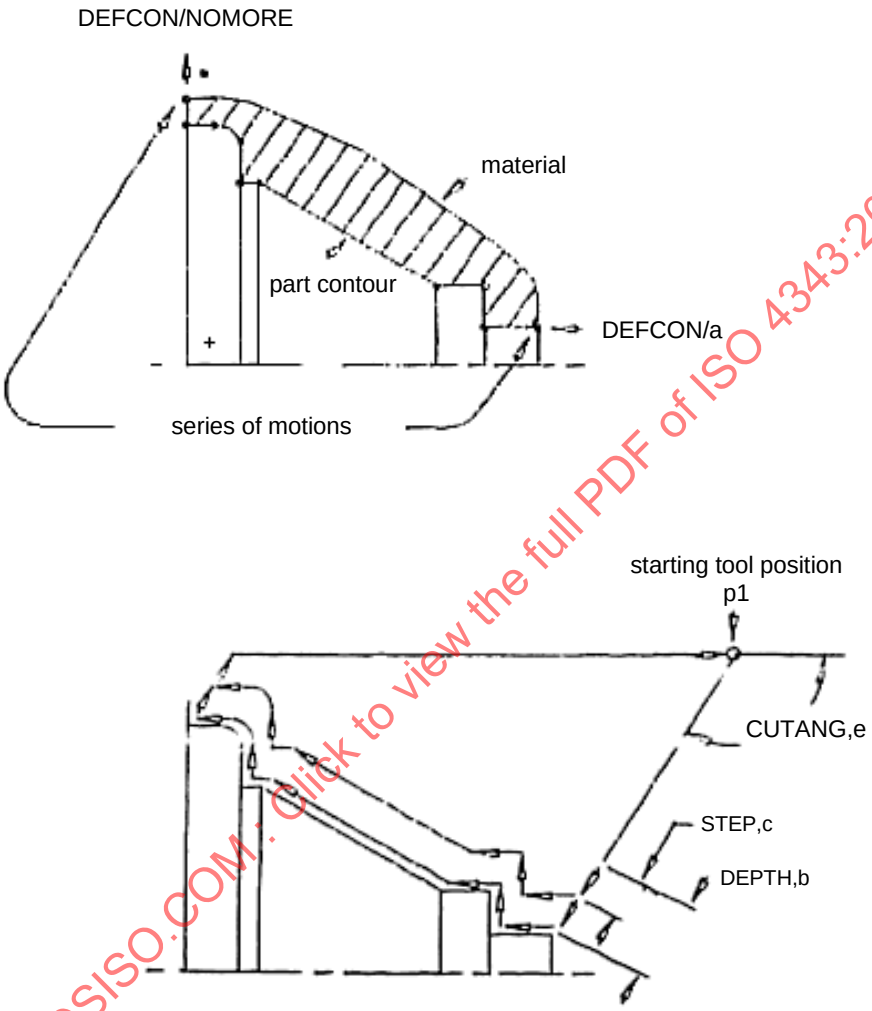
For a finishing contour operation, all part program data comprising the contour definition shall be processed as though the part program data were coded in replacement for the OP/CONTUR command. In the absence of a FEDRAT command (see 5.17.2) at the start of the contour, the tool shall in-feed at the last specified feed rate. The in-feed shall start at *P1* and end at *P2*. The tool position following a finishing contour operation shall be at the last motion point of the contour.

12.13.2.2 Examples

None.

12.13.2.3 Limitations

None.



OP/CONTUR,*a*,DEPTH,*b*,STEP,*c*,PERREV,*d*,CUTANG,*e*

Figure 31

12.13.3 GROOVE operation specification

OP / GROOVE (**,FACE** / **DIA**) **,DEPTH,***a* **,DIST,***b* (**,PERMIN** / **PERREV**) **,***c* **,CLEAR,***d* **,CUTS,***e* **0:n[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

AVOID,*f*

STEP,*g*

FINCUT,*h*

12.13.3.1 Semantics

This command performs a controller defined or software emulated operation to turn a groove (see figure 32). The groove can be turned in one of four directions: along the rail or along the cross slide, in both positive and negative directions. The operation consists of a series of cuts to depth, advancing the tool by a specified amount between each cut. The operation also provides for an optional finish pass.

GROOVE (keyword) specifies that a groove turning operation is to be performed.

FACE (keyword) specifies that the groove will be cut on the face with the depth of the groove measured parallel to the rail and the width of the groove measured along the cross slide.

DIA (keyword) specifies that the groove will be cut on the diameter with the depth of the groove measured parallel to the cross slide and the width of the groove measured along the rail.

DEPTH,*a* (keyword,real) specifies the final depth of the groove operation below the control point, as a signed offset value measured in part reference units.

When grooving with FACE and the value of ***a*** is positive, the groove will be on the back side toward the head stock. If the value ***a*** is negative, the groove will be on the front side toward the tail stock

When grooving with DIA and the value of ***a*** is positive, the groove will be on the inside with the depth measured out away from the turning axis. If the value ***a*** is negative, the groove will be on the outside with the depth measured in towards the turning axis.

DIST,*b* (keyword,real) specifies the length of the groove (see figure 33)as a signed offset value measured in part reference units from the control point.

When grooving with FACE and the value of ***b*** is positive, the length will be measured out away from the turning axis. If the value ***b*** is negative, the length will be measured in toward the turning axis.

When grooving with DIA and the value of ***b*** is positive, the length will be measured towards the tail stock. If the value ***b*** is negative, the length will be measured towards the head stock.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

c (real) specifies the working feed movement velocity in the specified units.

CLEAR,*d* (keyword,real) specifies the initial approach clearance distance above the control point, as a signed value measured in part reference units. The clearance value is measured opposite that of the depth.

CUTS,*e* (keyword,real) specifies the step over along the length between each plunging cut of the groove, as an unsigned value measured in part reference units.

AVOID,*f* (keyword,real) specifies the distance ***f*** to clear the sides of the groove when retracting the tool from the last depth to the clearance level.

STEP,*g* (keyword,real) specifies the depth ***g*** of the plunging cut steps for the cut-retract, cut-retract type plunge cutting and chip breaking operation.

FINCUT,*h* (keyword,real) specifies a finish cut ***h*** deep to the final depth along the floor of the groove moving back to the beginning side of the groove.

12.13.3.2 Examples

None.

12.13.3.3 Limitations

None.

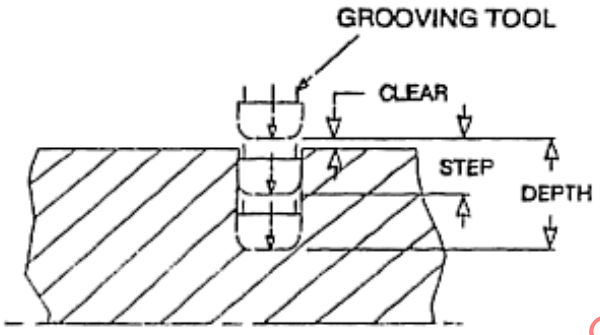


Figure 32 – Simple GROOVE operation

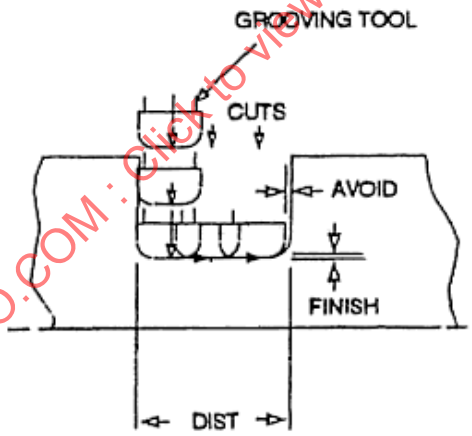


Figure 33 – GROOVE using DIST qualifier

12.13.4 PROFIL operation specification

OP / PROFIL,*a* (**,FACE** / **DIA**) **,STEP,***b* (**,PERMIN** / **PERREV**) **,***c* **,CLEAR,***d* **0:n[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

THICKD,*e*

THICKF,*f*

12.13.4.1 Semantics

This command performs a controller defined or software simulated operation to turn bar stock to a contour. The contour shall have been defined by a prior DEFCON command (see 12.10). The operation provides for multiple passes parallel to the cross slide or rail, intersecting with the contour.

PROFIL,*a* (keyword,real) specifies that a contouring operation is to be performed to the contour defined by a prior DEFCON command (see 12.10).

FACE (keyword) specifies that the profile will be cut by passes parallel to the cross slide (see figure 34), with the step over between each pass measured along the rail. The finish depth of the profile shall be the rail position of the final point on the contour.

DIA (keyword) specifies that the profile will be cut by passes parallel to the rail (see figure 35), with the step over between each pass measured along the cross slide. The finish depth of the profile shall be the cross slide position of the final point on the contour.

STEP,*b* (keyword,real) specifies the maximum depth of a roughing cut, as an unsigned value measured in part reference units.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

c (real) specifies the working feed movement velocity in the specified units.

CLEAR,*d* (keyword,real) specifies a retract clearance distance to apply when traversing back between each cut, as an unsigned value measured in part reference units.

THICKD,*e* (keyword,real) specifies an optional amount of stock to be left on the diameter for the finish cut, as a signed offset value measured in part reference units along the cross slide. The stock is applied by translating all cross slide positions by ***e***.

THICKF,*f* (keyword,real) specifies an optional amount of stock to be left on the face for the finish cut, as a signed offset value measured in part reference units along the rail. The stock is applied by translating all rail positions by ***f***.

The tool position prior to the OP/PROFIL command defines the boundaries of the profiling operation. The profiling direction is controlled by the choice of **FACE** or **DIA** qualifiers.

When **FACE** is chosen, the cutting direction shall be from the initial tool position, parallel to the cross slide, ending at the intersection of the profile. The tool shall advance by an amount specified by ***b*** in the direction of the end point whose rail position is farthest from the start point. The last pass shall end at the intersection of a line passing through the start point parallel to the rail and the profile.

When **DIA** is chosen, the cutting direction shall be from the initial tool position, parallel to the rail, ending at the intersection of the profile. The tool shall advance by an amount specified by ***b*** in the direction of the end point whose cross slide position is farthest from the start point. The last pass shall end at the intersection of a line passing through the start point parallel to the cross slide and the profile.

All co-ordinates shall be translated by the amounts specified by ***e*** and ***f***. This provides for stock removal during an OP/CONTUR finish contouring operation (see 12.13.2).

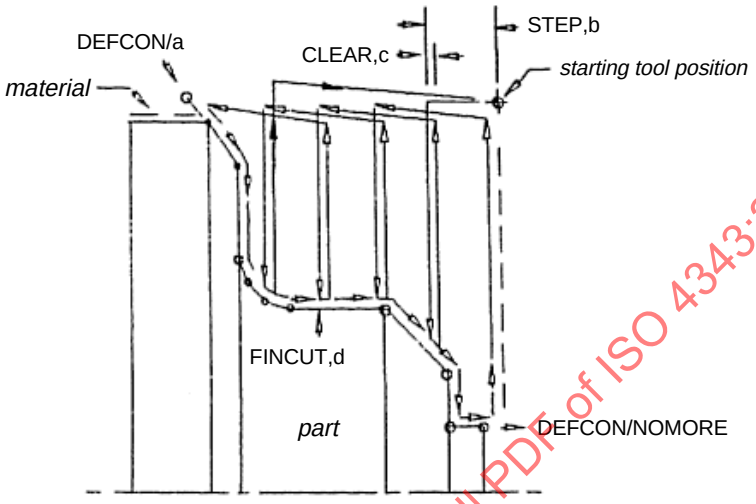
Positioning motions between cutting passes shall be performed at rapid. The tool will retract clear of the surface by an amount specified by ***d*** at the start of the positioning move. The feed rate specified by ***c*** shall be applied for all other cuts.

12.13.4.2 Examples

None.

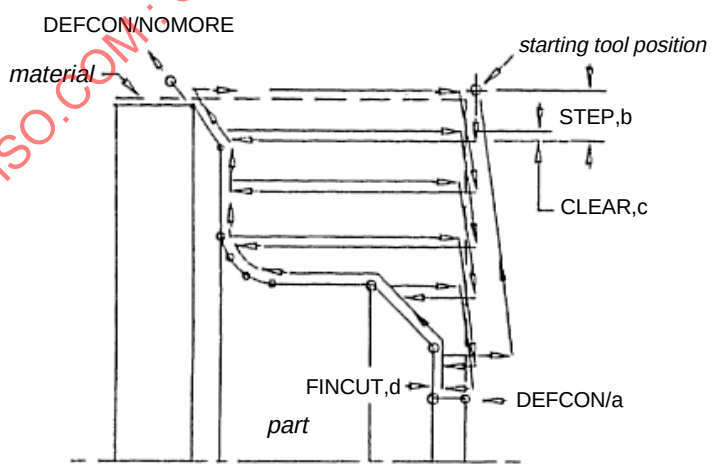
12.13.4.3 Limitations

None.



OP/PROFIL,*a*,FACE,STEP,*b*,CLEAR,*c*,FINCUT,*d*

Figure 34



OP/PROFIL,*a*,DIA,STEP,*b*,CLEAR,*c*,FINCUT,*d*

Figure 35

12.13.5 THREAD operation specification

OP / THREAD (**,FACE** / **TURN** / **TAPER**) **,DEPTH,*a* ,CUTANG,*b*** $^{0:n}$**[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

PERREV,*c*

(**INCR** / **DECR**)**,*d***

MULTRD,*e*

CUTS,*f* [,STEP $^{1:n}$**(,*g*)]**

FINCUT,*h*

OSETNO,*i*,*j*

12.13.5.1 Semantics

This command performs a controller defined or software simulated operation to turn a constant depth or tapered thread across the diameter or face of the workpiece. The baseline for the thread operation is created through the part program motion points preceding and following the OP/THREAD command.

THREAD (keyword) specifies that a thread turning operation is to be performed.

FACE (keyword) specifies a face threading operation with the direction of cut moving parallel to the cross slide. This qualifier is informational since the geometry of the thread is defined by the control points that follow.

TURN (keyword) specifies a diameter threading operation with the direction of cut moving parallel to the rail. This qualifier is informational since the geometry of the thread is defined by the control points that follow.

TAPER (keyword) specifies a tapered threading operation with the direction of cut at an angle to the principle axes of the machine. This qualifier is informational since the geometry of the thread is defined by the control points that follow.

DEPTH,*a* (keyword,real) specifies the depth of the threading operation relative to a baseline intersecting the control points, as an unsigned value measured in part reference units. The depth is measured along the in-feed direction.

CUTANG,*b* (keyword,real) specifies the in-feed angle, as a signed value in degrees measured in the machine ZX plane.

PERREV,*c* (keyword,real) specifies the threading velocity measured in part program units per revolution of the spindle.

INCR,*d* (keyword,real) specifies the amount to increase the thread lead on each revolution of the spindle, as an unsigned value measured in part reference units.

DECR,*d* (keyword,real) specifies the amount to decrease the thread lead on each revolution of the spindle, as an unsigned value measured in part reference units.

MULTRD,*e* (keyword,real) specifies the number of starts for a multiple start thread.

CUTS,*f* (keyword,real) specifies the number of cutting passes required to produce the thread. In the absence of this qualifier, a single cut at full thread depth will be made.

STEP,*g* (keyword,real) specifies one or more initial cut depths, as unsigned values measured in part reference units. In the absence of step data, the post processor shall assume a reasonable step progression for remaining cuts.

FINCUT,*h* (keyword,real) specifies the number of additional finishing cuts to be made at the full thread depth.

OSETNO,*i*,*j* (keyword,reals) specifies two correction dial offset numbers activated alternately for each threading cut.

The start of the thread (*P1*) is defined by the tool position prior to the OP/THREAD command (see figure 36). The end of the thread (*P2*) is defined by the first part program motion following the OP/THREAD command. A line connecting these two points (*P1* and *P2*) defines the thread baseline. The thread depth ***a*** and steps ***g*** are measured from the baseline along the in-feed direction ***b***.

For each threading pass,

1) the tool in-feeds from the initial tool position (*P1*) to a step depth relative to the baseline;
2) threads parallel to the baseline;
3) retracts at rapid traverse to *P2*;
4) and rapid traverses back to *P1*.

12.13.5.2 Examples

None.

12.13.5.3 Limitations

None.

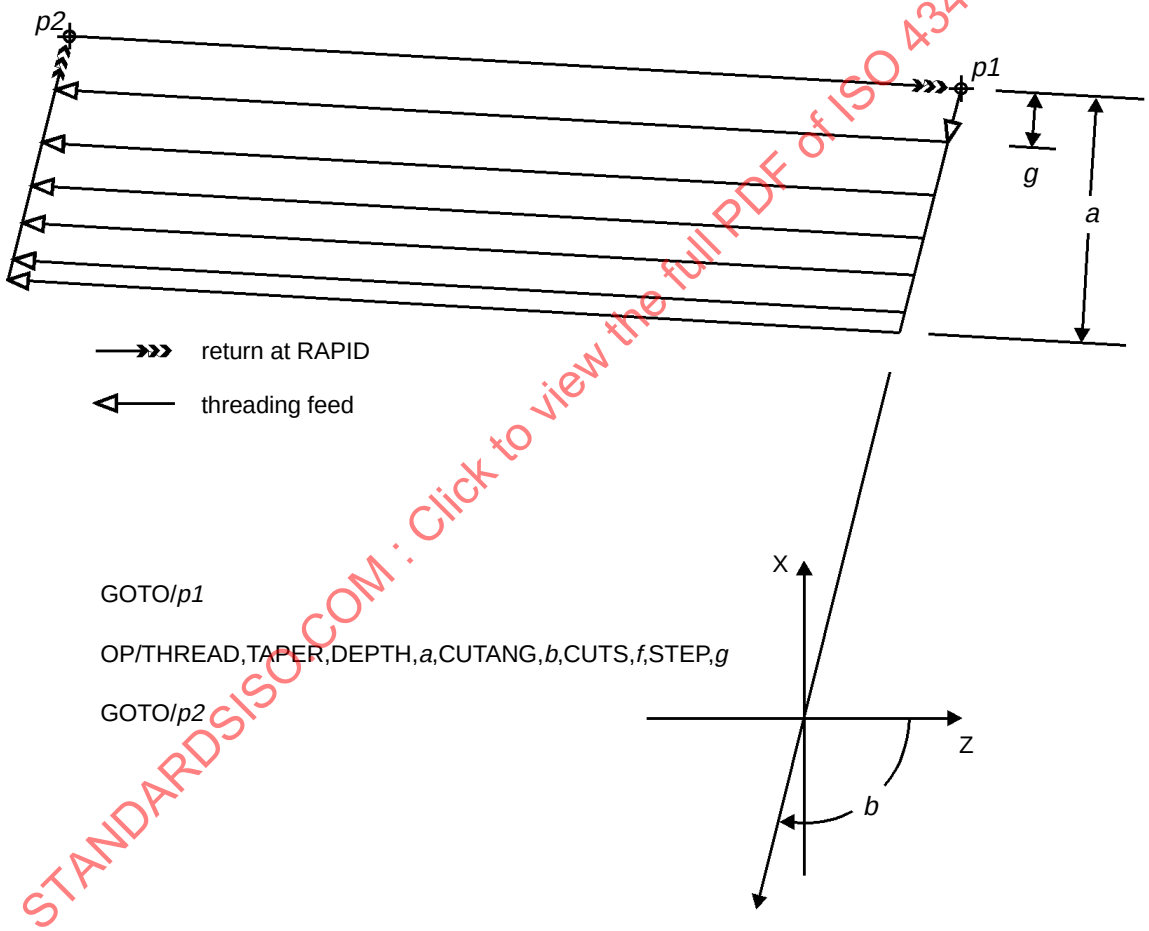


Figure 36

12.13.6 TURN operation specification

OP / TURN, DEPTH,*a* (**,PERMIN** / **PERREV**) **,*b*** **,CLEAR,*c*** **0:n[,{*qualifier*}]**

Where {*qualifier*} is defined as zero or more of:

STEP,*d* **[,FINCUT,*e*** **]**

12.13.6.1 Semantics

This command performs a controller defined or software simulated operation to turn a constant depth across a diameter or face of a turned part. The baseline for the turning operation is created through the first two part program motion points following the OP/TURN command.

TURN (keyword) specifies that a turning operation is to be performed.

DEPTH,*a* (keyword,real) specifies the depth of the turning operation relative to the control point, as an unsigned value measured in part reference units. The depth is measured opposite the in-feed direction, towards the initial tool position.

PERMIN (keyword) specifies that the velocity is measured in part program units per minute.

PERREV (keyword) specifies that the velocity is measured in part program units per revolution of the spindle.

b (real) specifies the working feed movement velocity in the specified units.

CLEAR,*c* (keyword,real) specifies a retract clearance distance to apply when traversing back between each cut, as an unsigned value measured in part reference units.

STEP,*d* (keyword,real) specifies the maximum depth of a roughing cut, as an unsigned value measured in part reference units. The absence of this qualifier indicates that no roughing cuts shall be made.

FINCUT,*e* (keyword,real) specifies the depth of an optional finish pass, as an unsigned value measured in part reference units.

The tool position prior to the OP/TURN command defines the starting point (*P1*) of the turning operation. The two part program motions (*P2* and *P3*) following the OP/TURN command define the baseline for the turning operation, which shall parallel either the machine X or Z axis. The in-feed direction is perpendicular to the baseline, starting on the *P1* side, towards *P2*. The cutting direction is from *P2* to *P3*.

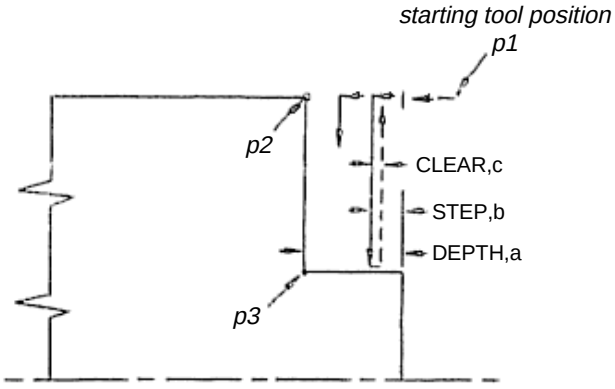
If an optional step value is specified, the turning operation shall be performed as a series of cuts, with the step over between each cut not to exceed ***d***. If an optional finish pass is specified, the last or only roughing pass shall be offset from the baseline by ***e***. Positioning motions between cutting passes shall be performed at rapid. The tool will retract clear of the surface by an amount specified by ***c*** at the start of the positioning move.

12.13.6.2 Examples

None.

12.13.6.3 Limitations

None.



OP/TURN,DEPTH,*a*,STEP,*b*,CLEAR,*c*,PERMIN,*d*

Figure 37

12.14 The PITCH command

Thread pitch specification.

PITCH / *a* [(**,INCR** / **DECR**) **,*b***] **[,MULTRD,*c*]**

12.14.1 Semantics

This command specifies modal parameters for subsequent OP/THREAD (see 12.13.5) and COUPLE/ON (see 12.8) commands.

a (real) specifies the thread pitch as a function of one (1) divided by ***a***, where ***a*** is measured in part reference units.

INCR,*b* (keyword,real) specifies the amount to increase the thread lead on each revolution of the spindle, as an unsigned value measured in part reference units. The absence of the INCR or DECR qualifier implies a constant lead thread.

DECR,*b* (keyword,real) specifies the amount to decrease the thread lead on each revolution of the spindle, as an unsigned value measured in part reference units. The absence of the INCR or DECR qualifier implies a constant lead thread.

MULTRD,*c* (keyword,real) specifies the number of starts for a multiple start thread. The absence of this qualifier implies a single start thread.

12.14.2 Examples

None.

12.14.3 Limitations

None.

12.15 The SAFETY command

Specifies a retract pull out direction for emergency stops.

SAFETY / (**BORE** | **FACE** | **TURN** | **ATANGL,*a***) **[,DIST,*b*]**

SAFETY / OFF

12.15.1 Semantics

This command defines a retract clearance direction and distance to move the tool when the operator activates an emergency stop or emergency pull-out feature of the machine.

BORE (keyword) specifies that the tool shall retract towards the centreline of the spindle.

FACE (keyword) specifies that the tool shall retract towards the tailstock of the machine.

TURN (keyword) specifies that the tool shall retract away from the centreline of the spindle.

ATANGL,*a* (keyword,real) specifies the direction to retract the tool, measured in degrees in the ZX plane of the machine.

DIST,*b* (keyword,real) specifies the distance to retract the tool, as an unsigned value measured in part reference units. In the absence of this qualifier, a machine or post processor defined default shall be used.

OFF (keyword) disables the retract feature during emergency stops. No retraction of the tool shall be made when an emergency stop occurs.

12.15.2 Examples

None.

12.15.3 Limitations

None.

12.16 The SELECT command

Commands the selection of a tool, chuck or workpiece.

```
SELECT / TOOL,a [,CLW  ] [,ID ]
                [,CCLW ] [,OD ]

SELECT / CHUCK,a [,CLW  ]
                 [,CCLW ]

SELECT / PART [,a ] [,CLW  ]
                    [,CCLW ]
```

12.16.1 Semantics

This command executes a selection sequence. This places the selected item in a ready state but does not load it.

TOOL (keyword) specifies that a tool defined by a previous TOOLNO command is to be selected.

CHUCK (keyword) specifies that a chuck defined by a previous CHUCK command is to be selected.

PART (keyword) specifies that a workpiece is to be selected.

a (real) identifies the tool, chuck or workpiece by an identity number.

CLW (keyword) specifies a clockwise indexing direction of the selection device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the selection device.

ID (keyword) specifies that the tool shall be selected for use on the turret that performs inside diameter work.

OD (keyword) specifies that the tool shall be selected for use on the turret that performs outside diameter work.

12.16.2 Examples

None.

12.16.3 Limitations

None.

12.17 The SPINDL command

12.17.1 General comments

Controls one of spindle mode, spindle rotation rate or spindle orientation.

12.17.1.1 Sub-contents

For

1) spindle mode specification, see 12.17.2;
2) spindle rotation rate specification, see 12.17.3;
3) spindle orientation specification, see 12.17.4.

12.17.1.2 Limitations

None.

12.17.2 Spindle mode specification

```
SPINDL / ( ON     )
         ( OFF    )
         ( LOCK   )
         ( NEUTRL )
```

12.17.2.1 Semantics

This command controls the basic operation mode of the spindle.

ON (keyword) restarts the spindle rotation at the last specified rate.

OFF (keyword) stops the spindle rotation.

LOCK (keyword) stops the spindle rotation and locks it.

NEUTRL (keyword) disengages the spindle drive.

12.17.2.2 Examples

None.

12.17.2.3 Limitations

None.

12.17.3 Spindle rotation rate specification

SPINDL / [RPM,] *a* {*qualifiers*}

SPINDL / [CSS,] *a* [,(MAXRPM / MXPERM),*b*] [,RADIUS,*c*] {*qualifiers*}

Where {*qualifiers*} is defined as:

[,CLW / CCLW / NRMTRN / REVTRN] [,RANGE,(*d* / LOW / MEDIUM / HIGH)]

12.17.3.1 Semantics

This command specifies the rotation rate, rotation direction, gear selection and maximum rotation rate of the spindle.

RPM (keyword) specifies the rotation rate of the spindle in revolutions per minute, corresponding to the G97 definition in ISO 6983. The RPM keyword is modal.

CSS (keyword) specifies the rotation rate of the spindle as a constant surface speed (CSS) measured in part program units per minute, corresponding to the G96 definition in ISO 6983. With CSS, the rotation speed is a function of the cross slide position and is dynamically adjusted by the machine when a change in cross slide position is made. The rotation speed in revolutions per minute is computed as (a/2*pi*b), where *a* is the surface speed measured in part program units per minute and *b* is the radial distance from the centreline to the controlling position. The CSS keyword is modal.

a (real) specifies the spindle rotation velocity in the specified units.

MAXRPM (keyword) specifies that the upper limit to the spindle rotation velocity is measured in revolutions per minute.

MXPERM (keyword) specifies that the upper limit to the spindle rotation velocity is indirectly defined by the feed velocity measured in part program units per minute. The spindle rotation rate shall be limited such that the units per revolution feed velocity shall not exceed the specified maximum.

b (real) specifies an upper limit to the spindle rotation velocity in the specified units. This limit remains in effect until the next spindle velocity specification command. If an upper limit is omitted, then spindle limitation shall not occur.

RADIUS,*c* (keyword,real) specifies the radial distance from the centreline of the spindle to the CSS controlling position measured in part program units. When this qualifier is omitted, the default radial distance is measured from the centreline to the tool tip.

CLW (keyword) specifies clockwise spindle rotation.

CCLW (keyword) specifies counter-clockwise spindle rotation.

NRMTRN (keyword) specifies the normal turning direction.

REVTRN (keyword) specifies the reverse of the normal turning direction.

RANGE,*d* (keyword,real) specifies a numbered gear range to use on the machine.

RANGE,LOW (keywords) specifies that the lowest gear range be used.

RANGE,MEDIUM (keywords) specifies that the mid-range gear range be used.

RANGE,HIGH (keywords) specifies that the highest gear range be used.

12.17.3.2 Examples

None.

12.17.3.3 Limitations

The spindle rotation rate shall be a non-zero positive value.

The upper limit rotation specification and radial distance specification are valid only when in CSS mode.

12.17.4 Spindle orientation specification

`SPINDL / ORIENT [,`*`a`*` ]`

12.17.4.1 Semantics

This command indexes the spindle and locks it.

ORIENT,*a* (keyword,real) specifies the orientation angle of the spindle, measured in degrees, from a machine specific reference. If the orientation angle is omitted, a machine specific default angle shall be used.

12.17.4.2 Examples

None.

12.17.4.3 Limitations

None.

12.18 The STAN command

Specifies the setting angle of the tool.

STAN / *a*

12.18.1 Semantics

This command specifies the setting angle of the turning tool.

a (real) specifies the setting angle of the turning tool, as a signed value measured in degrees in the machine ZX plane.

12.18.2 Examples

None.

12.18.3 Limitations

None.

12.19 The STDYRS command

Controls the positioning of steady rests.

STDYRS / (**IN** | **OUT**) **0:n[,** ***a*** **]**

12.19.1 Semantics

This command controls the positioning of steady rests.

IN (keyword) specifies that steady rests shall be engaged.

OUT (keyword) specifies that steady rests shall be disengaged.

a (real) specifies by identifier number, one or more steady rests to be engaged or disengaged. If identifiers are not specified, then all steady rests will be repositioned.

12.19.2 Examples

None.

12.19.3 Limitations

None.

12.20 The TLSTCK command

Controls the positioning of the tailstock and tailstock quill.

```
TLSTCK / [ QUILL,] ( IN  )
                   ( OUT )
```

12.20.1 Semantics

This command controls the positioning of the tailstock and the tailstock quill.

QUILL (keyword) specifies that the tailstock quill is to be positioned. If this qualifier is omitted, the entire tailstock is positioned.

IN (keyword) specifies that device shall be engaged.

OUT (keyword) specifies that device shall be disengaged.

12.20.2 Examples

None.

12.20.3 Limitations

None.

12.21 The TOOLNO command

Defines a tool.

TOOLNO / *a* [**,IN,*b***] **[,TURN] {*geometry-qualifiers*} {*machine-qualifiers*}**
                 [**,MANUAL**]

Where {*geometry-qualifiers*} are defined as:

[,SETOOL,*c*,*d*,*e*] [,DIAMET,*f*] [,TLMATL,*g*]

And where {*machine-qualifiers*} are defined as:

[,OSETNO,*h* [,*i*]] [**,FRONT**] [**,ID**] [**,HOLDER,**(**SMALL**)]
                          [**,REAR**] [**,OD**]   (**MEDIUM**)
                                                              (**LARGE**)

12.21.1 Semantics

This command specifies tool information for a specific tool which is referenced by the SELECTTOOL, LOAD/TOOL and UNLOAD/TOOL commands.

a (real) specifies the tool number.

IN,*b* (keyword,real) specifies the pocket number where the tool is loaded from.

MANUAL (keyword) specifies that the operator must load the tool manually.

TURN (keyword) specifies that the tool being defined applies to that component of a machine which provides a turning capability. This is the default when the TOOLNO statement appears within a segment of the part program preceded by an APPLY/TURN command, or when the machine does not support any manufacturing function other than turning.

SETOOL,*c*,*d*,*e* (keyword,reals) specifies the tool setting distance measured in the part co-ordinate X, Y, Z axes, from the tool tip location to the machine gauge reference point.

DIAMET,*f* (keyword,real) specifies the tool diameter in part reference units.

TLMATL,*g* (keyword,real) specifies the material of the tool using a code number recognized by the tool life facility.

OSETNO,*h*,*i* (keyword,reals) specifies one or two tool correction dials or registers to be associated with the tool.

FRONT (keyword) specifies that the tool is used by the frontal or main turret on a dual turret lathe.

REAR (keyword) specifies that the tool is used by the rear or secondary turret on a dual turret lathe.

ID (keyword) specifies that the tool is used by the inside diameter tooling station on the turret.

OD (keyword) specifies that the tool is used by the outside diameter tooling station on the turret.

HOLDER,SMALL (keywords) specifies that the tool is mounted in a small holder.

HOLDER,MEDIUM (keywords) specifies that the tool is mounted in a mid-size holder.

HOLDER,LARGE (keywords) specifies that the tool is mounted in a large holder.

12.21.2 Examples

None.

12.21.3 Limitations

None.

12.22 The TURRET command

Controls the indexing of the turret.

TURRET / *a* [,*b* [,*c*,*d*]] (**,FRONT** / **REAR** / **SIDE** / **RAIL** / **SADDLE**) (**,CLW** / **CCLW**) (**,NOW** / **NEXT**)

12.22.1 Semantics

This command controls the indexing of the turret.

a (real) specifies the position of the turret index by number.

b (real) specifies the correction dial number.

c*,*d (reals) specifies the distances in X and Y from the reference point of the tool to the reference point of the turret, measured as signed values in part reference units.

FRONT (keyword) specifies indexing of the front turret.

REAR (keyword) specifies indexing of the rear turret.

SIDE (keyword) specifies indexing of the side turret.

RAIL (keyword) specifies indexing of the rail turret.

SADDLE (keyword) specifies indexing of the saddle turret.

CLW (keyword) specifies a clockwise indexing direction of the turret.

CCLW (keyword) specifies a counter-clockwise indexing direction of the turret.

NOW (keyword) specifies that the corrective action for the new tool offsets be output in a block before processing further moves.

NEXT (keyword) specifies that the corrective action for the new tool offsets be incorporated in subsequent moves.

12.22.2 Examples

None.

12.22.3 Limitations

None.

NOTE

The TURRET command is a non-preferred alternative for LOAD/TOOL. The TURRET command has been retained in this revision of the International Standard for the purpose of continuity. The TURRET command syntax has not been revised for this revision.

12.23 The UNLOAD command

Commands the unloading of the tool, chuck or workpiece.

```
UNLOAD / ( TOOL  ) [ ,CLW  ]
         ( CHUCK )   ( CCLW )
         ( PART  )
```

12.23.1 Semantics

This command executes an unloading sequence. This removes the item from the working environment and deposits it in a storage area.

TOOL (keyword) specifies that the tool shall be unloaded.

CHUCK (keyword) specifies that the chuck shall be unloaded.

PART (keyword) specifies that the workpiece shall be unloaded.

CLW (keyword) specifies a clockwise indexing direction of the unloading device.

CCLW (keyword) specifies a counter-clockwise indexing direction of the unloading device.

12.23.2 Examples

None.

12.23.3 Limitations

None.

13 Wire EDM language

13.1 General comments

13.1.1 General semantics

The wire EDM language section defines vocabulary specific to the wire electrical discharge machine family. Electrical discharge machines are those where a stationary working element (the wire) is applied to a stationary workpiece.

The general language (see 5) and the wire EDM language together provide the standard vocabulary for a wire electrical discharge machine, or that component of a machine which provides this capability.

When a single machine supports capabilities of multiple machine families defined within this International Standard, the APPLY command (see 5.4 and 13.2) shall be used to designate the machine family being manipulated at any given moment.

13.1.2 Sub-contents

For

1) the APPLY command, which selects the wire EDM capability of the machine, see 13.2;
2) the CLDIST command, which defines the clearance distance for the upper wire guide, see 13.3;
3) the CUTCOM command, which controls the activation and removal of wire diameter compensation, see 13.4;
4) the CYCLE command, which provides for modal application of a preset series of operations, see 13.5;
5) the FLUSH command, which controls one of tank filling or flushing, see 13.6;
6) the GENRTR command, which controls spark gap generator settings, see 13.7;
7) the LOAD command, which commands the loading of various items, see 13.8;
8) the ORIGIN command, which defines the wire guide reference positions, see 13.9;
9) the SELECT command, which commands the selection of various items, see 13.10;
10) the STAN command, which controls the wire angle, see 13.11;
11) the TOOLNO command, which defines a wire, see 13.12;
12) the UNLOAD command, which commands the unloading of various items, see 13.13.

13.1.3 Limitations

None.

13.2 The APPLY command

Selects the wire EDM capability of the machine.

APPLY / WEDM

13.2.1 Semantics

This command selects a machine family for subsequent processing when a machine provides capabilities found in multiple machine families as defined in this International Standard.

WEDM (keyword) specifies that subsequent part program data is to be processed using the wire EDM capability of the machine.

13.2.2 Examples

None.

13.2.3 Limitations

None.

NOTE

The complete APPLY command definition can be found in general language section 5.4.

13.3 The CLDIST command

Defines the clearance distance for the upper wire guide.

CLDIST / *a*

CLDIST / NOMORE

13.3.1 Semantics

This command defines the clearance distance from the programmed Z co-ordinate to the upper wire guide position.

a (real) specifies the incremental distance between the programmed Z co-ordinate and the upper wire guide position, as a signed value measured in part reference units. The clearance distance shall take effect on the following motion.

NOMORE (keyword) cancels the CLDIST definition. The upper wire guide position shall retain its current position on subsequent motions.

13.3.2 Examples

None.

13.3.3 Limitations

Applies to wire EDM machines having a programmable head axis.

13.4 The CUTCOM command

Controls the activation and removal of wire diameter compensation.

CUTCOM / (**ON** | **OFF**)

CUTCOM / (**LEFT** | **RIGHT**) **[,XYPLAN] [,OSETNO,*a*] [,ROUND,*b*]**

13.4.1 Semantics

This command controls the application and removal of wire diameter compensation.

ON (keyword) reactivates wire diameter compensation.

OFF (keyword) terminates wire diameter compensation, corresponding to the G40 definition in ISO 6983.

LEFT (keyword) activates wire diameter compensation to the left of the workpiece when viewed in the forward direction of motion, corresponding to the G41 definition in ISO 6983.

RIGHT (keyword) activates wire diameter compensation to the right of the workpiece when viewed in the forward direction of motion, corresponding to the G42 definition in ISO 6983.

XYPLAN (keyword) specifies that compensation shall be applied in the machine reference XY plane. This is the default plane of compensation for wire EDM applications.

OSETNO,*a* (keyword,real) identifies the offset register on the machine to use for wire diameter compensation. If omitted, the default register will be used.

ROUND,*b* (keyword,real) specifies that all sharp corners shall be replaced by fillets. The radius of the fillet is measured as an unsigned value in part reference units. A radius of zero will produce sharp corners at intersections.

13.4.2 Examples

None.

13.4.3 Limitations

The ON form of wire diameter compensation is invalid until either one of the LEFT or RIGHT forms is specified.

NOTE

An additional form of the CUTCOM command is defined in general language section 5.11.

13.5 The CYCLE command

13.5.1 General comments

Provides modal application of a preset series of operations.

CYCLE / {*type*} $^{0:n}$**[,{*qualifier*}]**

$^{1:n}$**({*motions*})**

CYCLE / OFF

13.5.1.1 General semantics

A cycle is a preset series of operations which is applied at one or more control points.

{*type*} (keyword) identifies the type of preset operation to perform.

{*qualifier*} (various) specifies parameters which allow modification of the basic cycle. Qualifiers have a consistent meaning where they appear in different cycles.

{*motion*} (various) defines the control points for the cycle. The preset operation shall be performed at each part program motion point until the cycle is canceled.

OFF (keyword) cancels the cycle operation.

13.5.1.2 Sub-contents

For

1) general activation specification, see 13.5.2;
2) PIERCE cycle specification, see 13.5.3.

13.5.1.3 Limitations

None.

NOTE

The {*qualifier*} term has been included in this cycle definition to remain consistent with cycle definitions found elsewhere in this International Standard. The wire EDM language at present does not define cycles having optional qualifiers.

13.5.2 General activation specification

CYCLE / OFF

CYCLE / ON $^{0:n}$**[,{*qualifier*}]**

13.5.2.1 Semantics

These commands are used to suspend and reactivate cycles.

OFF (keyword) suspends the active cycle.

ON (keyword) restarts a suspended cycle.

{*qualifier*} (various) modifies selected parameters of the suspended cycle. Parameters of the suspended cycle not referenced retain their original values.

13.5.2.2 Examples

None.

13.5.2.3 Limitations

The ON form is only valid once a cycle has been suspended.

NOTES

1) The keyword NOMORE is a non-preferred alternative for OFF. Either can be used with identical results.

2) The {*qualifier*} term has been included in this cycle definition to remain consistent with cycle definitions found elsewhere in this International Standard. The wire EDM language at present does not define cycles having optional qualifiers.

13.5.3 PIERCE cycle specification

`CYCLE / PIERCE, DEPTH,`*`a`*

13.5.3.1 Semantics

This command initiates a cycle to pierce a vertical hole through the part at each control point in the cycle block. The piercing operation is generally performed using an electrode attachment which burns a hole through the material in preparation for threading the wire.

PIERCE (keyword) specifies a piercing cycle.

DEPTH,*a* (keyword,real) specifies the final depth of the pierce operation below the control point, as a signed offset value measured in part reference units. The depth is measured along the negative sense of the tool axis.

13.5.3.2 Examples

None.

13.5.3.3 Limitations

None.

13.6 The FLUSH command

13.6.1 General comments

Controls one of tank filling or flushing.

13.6.1.1 Sub-contents

For

1) tank filling specification, see 13.6.2;
2) flushing specification, see 13.6.3.

13.6.1.2 Limitations

None.