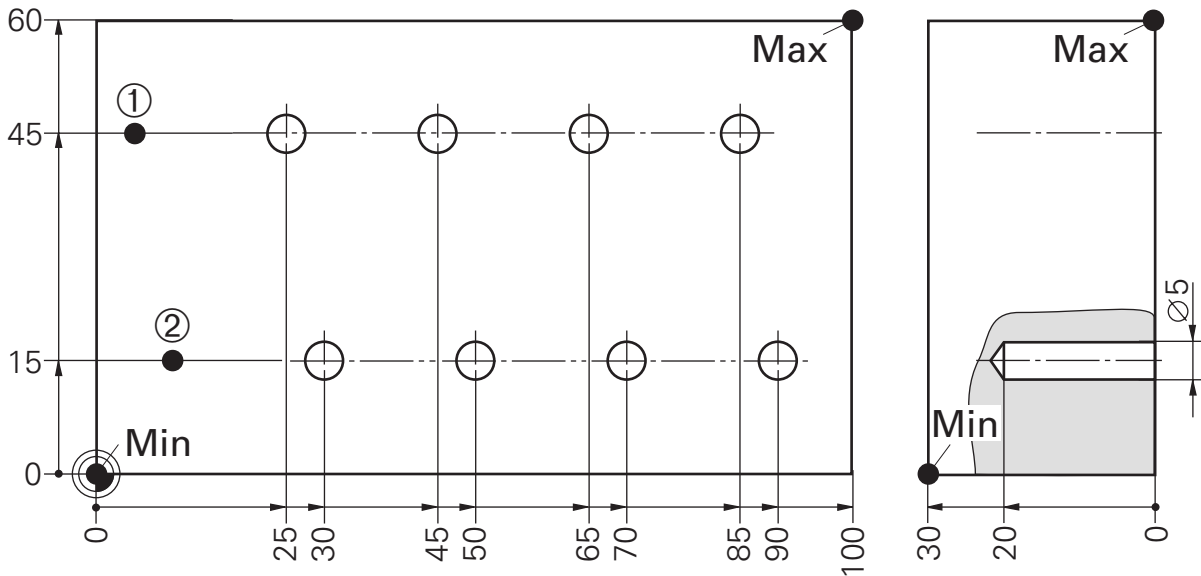


Conventional Programming

No.	Title	PGM-No.
	Drilling	
1	Two rows of holes	7280
2	Irregular drilling pattern, 3 tools	7153
3	Linear hole pattern	7109
4	Linear offset hole pattern	7426
5	Four double bolt hole circles, 3 tools	7139
6	Large drilled plate	7411
	2D Milling	
7	Loading frame	72810
	3D Milling	
8	Hemisphere, external, 3D, vertical, 1 cut	76130
9	Hemisphere, external, 3D, vertical, 2 cuts	76131
10	Threadmilling in three steps, 2 settings	7164





Program layout:

Conventional preparation

	<i>BLK FORM</i>	
	<i>TOOL DEF</i>	
	<i>TOOL CALL 1 Z S3000</i>	
	<i>CYCL DEF 1.0 PECKING</i>	
	<i>L X... Y... R0 F9999 M3</i>	
	<i>L Z...</i>	
①	<i>CALL LBL 1</i>	
	<i>L X... Y...</i>	
	<i>L Z...</i>	
②	<i>CALL LBL 1</i>	

Workpiece blank

First tool call

Pecking cycle

Pre-position

Pre-position

Retract tool, end

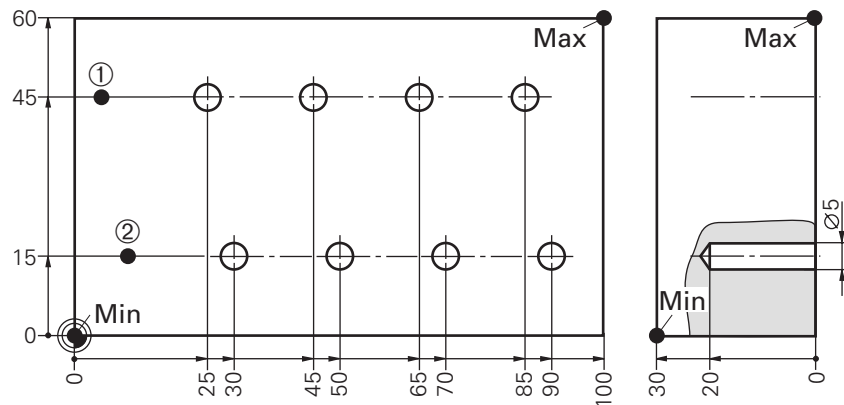
L Z... M2

SPGM 1

<i>LBL 1</i>
<i>L IX+20 M99</i>
<i>CALL LBL 1 REP 3/3</i>
<i>LBL 0</i>

Solution:

Two rows of holes



Main program

```
0 BEGIN PGM 7280 MM
1 ..... TWO ROWS OF HOLES
2 BLK FORM 0.1 Z X+0 Y+0 Z-30
3 BLK FORM 0.2 X+100 Y+60 Z+0
4 TOOL DEF 1 L+0 R+2,5
5 TOOL CALL 1 Z S3000
6 CYCL DEF 1.0 PECKING
7 CYCL DEF 1.1 SET UP -2
8 CYCL DEF 1.2 DEPTH -22
9 CYCL DEF 1.3 PECKG -10
10 CYCL DEF 1.4 DWELL 0
11 CYCL DEF 1.5 F150

12 L X+5 Y+45 R0 F9999 M3
13 L Z+2
14 CALL LBL 1

15 L X+10 Y+15
16 CALL LBL 1

Retract tool, end 17 L Z+20 R0 F9999 M2
```

SPGM 1

```
18 LBL 1
19 L IX+20 F9999 M99
20 CALL LBL 1 REP 3/3
21 LBL 0
22 END PGM 7280 MM
```



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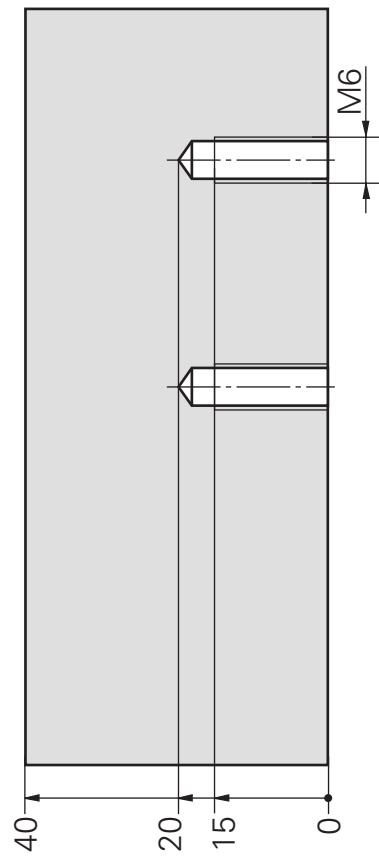
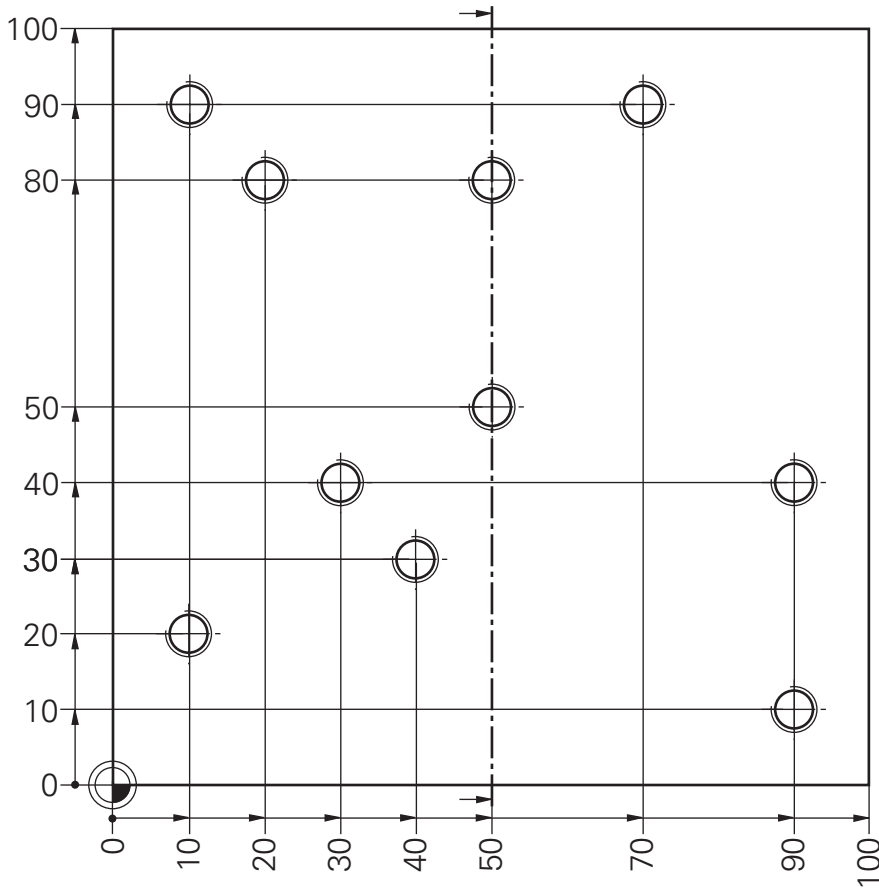
C04



7280/2

Task: **Irregular drilling pattern,
with 3 tools and 3 cycles**

Program(s): _____



- Tools:**
- NC-center drill
 - Twist drill
 - Tap

Program layout: **Irregular drilling pattern,
with 3 tools and 3 cycles**

Preparation

```
BLK FORM
TOOL DEF
TOOL 1...

L Z... M6
```

Workpiece blank
Tool list
First tool call

Tool change

**Process
Center**

```
CYCL DEF, DEPTH = PECKG
CALL LBL 1
STOP M6
```

Pecking cycle

Call drilling pattern

Tool change

Pecking

```
TOOL 2...
CYCL DEF, DEPTH ≠ PECKG
CALL LBL 1
STOP M6
```

Pecking cycle

Call drilling pattern

Tool change

Tapping

```
TOOL 3...
CYCL DEF
CALL LBL 1
```

Tapping cycle

Call drilling pattern

Retract tool, end

```
L Z... M2
```

**Drilling pattern,
SPGM 1**

```
LBL 1
L X... Y...
L Z... M89

L X... Y...

L X... Y... M99

L Z...
L X... Y...

LBL 0
```

1st position lower left
Setup clearance
and modal cycle call

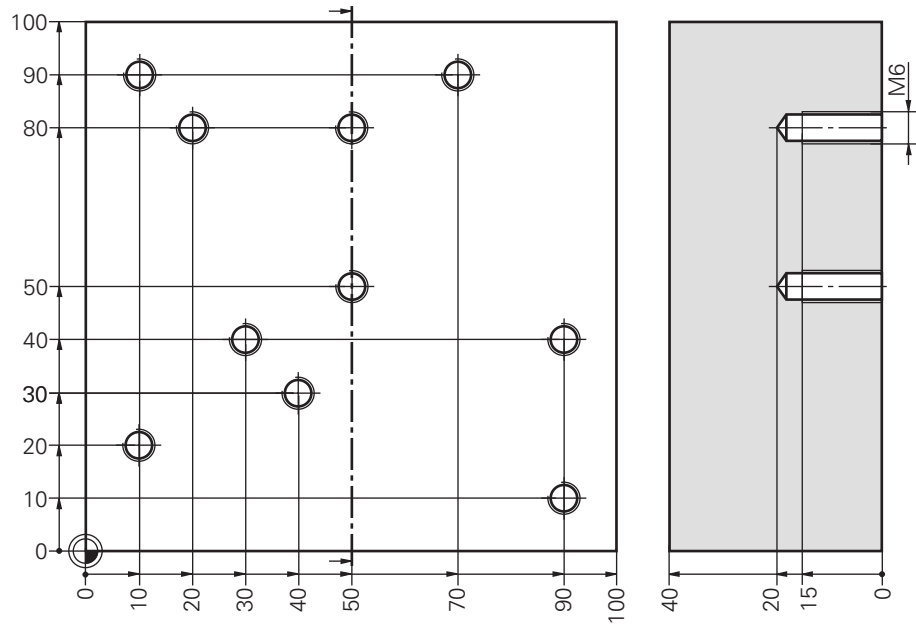
Further hole positions:
automatic

Further hole positions:
Cycle call by block

Tool change position

Solution:

Irregular drilling pattern, with 3 tools and 3 cycles



Main program

```

0 BEGIN PGM 7153 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-40
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3,5 ..... NC-CENTER DRILL
4 TOOL DEF 2 L+0 R+2,5 ..... TWIST DRILL
5 TOOL DEF 3 L+0 R+3 ..... TAP

```

Center

```

6 TOOL CALL 1 Z S800 ..... NC-CENTER DRILL
7 L Z+100 R0 F9999 M6 ..... TOOL CHANGE
8 CYCL DEF 1.0 PECKING
9 CYCL DEF 1.1 SET UP -2
10 CYCL DEF 1.2 DEPTH -2
11 CYCL DEF 1.3 PECKG -2
12 CYCL DEF 1.4 DWELL 0
13 CYCL DEF 1.5 F200
14 CALL LBL 1 ..... CALL DRILLING PATTERN
15 STOP M6 ..... TOOL CHANGE

```

Pecking

```

16 TOOL CALL 2 Z S500 ..... TWIST DRILL
17 CYCL DEF 1.0 PECKING
18 CYCL DEF 1.1 SET UP -2
19 CYCL DEF 1.2 DEPTH -20
20 CYCL DEF 1.3 PECKG -10
21 CYCL DEF 1.4 DWELL 0
22 CYCL DEF 1.5 F100
23 CALL LBL 1 ..... CALL DRILLING PATTERN
24 STOP M6 ..... TOOL CHANGE

```

Tapping

```

25 TOOL CALL 3 Z S500 ..... TAP
26 CYCL DEF 2.0 TAPPING
27 CYCL DEF 2.1 SET UP -2
28 CYCL DEF 2.2 DEPTH -15
29 CYCL DEF 2.3 DWELL 0
30 CYCL DEF 2.4 F500
31 CALL LBL 1 ..... CALL DRILLING PATTERN

```

Retract tool, end

```

32 L Z+100 M2

```



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C01



7153/3

Solution:

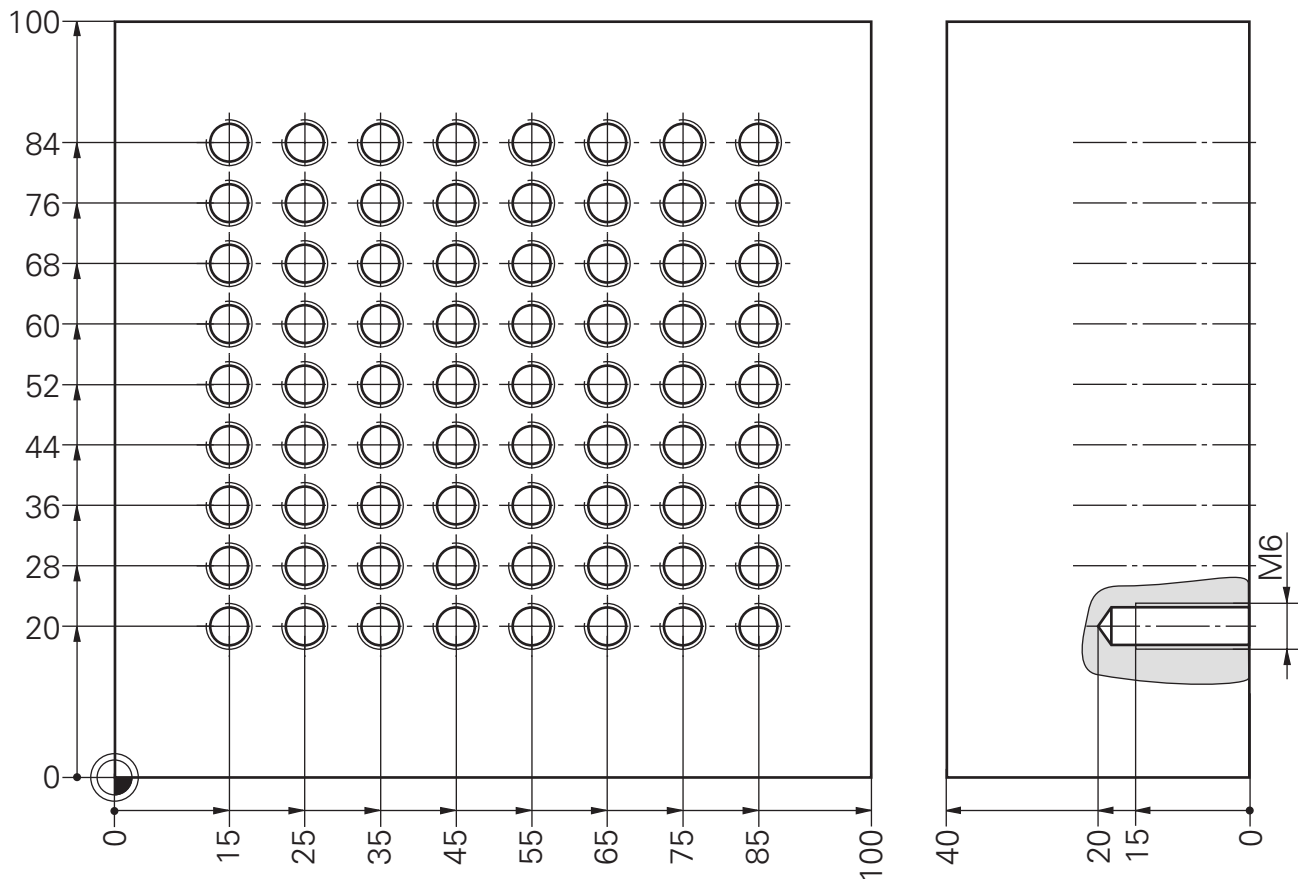
Irregular drilling pattern, with 3 tools and 3 cycles

SPGM 1, Drilling pattern

```
33 LBL 1
34 L X+10 Y+20 R0 F9999 M13
35 L Z+2 M89 ..... FIRST MODAL CYCLE CALL
36 L X+40 Y+30
37 L X+90 Y+10
38 L Y+40
39 L X+50 Y+80
40 L Y+50
41 L X+30 Y+40
42 L X+20 Y+80
43 L X+10 Y+90
44 L X+70 M99 ..... LAST CYCLE CALL BY BLOCK
45 L Z+100 M9 ..... TOOL CHANGE POSITION
46 L X-20 Y-20
47 LBL 0
48 END PGM 7153 MM
```

Task: **Linear hole pattern**

Program(s): _____



Procedure: • Move up and down columns (meandering)

Tools:

- NC-center drill
- Twist drill
- Tap

Program layout: **Linear hole pattern**

Preparation

```
BLK FORM  
TOOL 1.../TOOL 2...
```

Workpiece blank
Tool list if necessary

**Process
Center**

```
TOOL 1...  
CYCL DEF, DEPTH = PECKG
```

Pecking cycle

```
CALL LBL 1
```

Call drilling pattern

```
L Z... M6
```

Tool change

Pecking

```
TOOL 2...  
CYCL DEF, DEPTH ≠ PECKG
```

Pecking cycle

```
CALL LBL 1
```

Call drilling pattern

```
L Z... M6
```

Tool change

Tapping

```
TOOL 3...  
CYCL DEF
```

Tapping cycle

```
CALL LBL 1
```

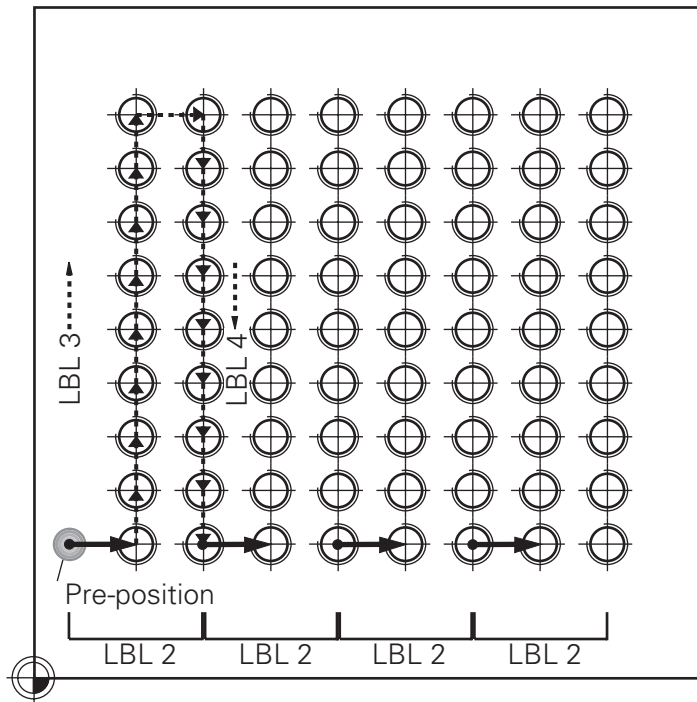
Call drilling pattern

Retract tool, end

```
L Z... M2
```



Meandering movement:



Drilling pattern, SPM 1

<i>LBL 1</i>	
<i>L X... Y... R0 F9999 M3</i> <i>L Z... M8</i>	
<i>LBL 2</i>	
<i>L IX... M99</i>	
<i>LBL 3</i>	
<i>L IY... M99</i>	
<i>CALL LBL 3 REP...</i>	
<i>L IX... M99</i>	
<i>LBL 4</i>	
<i>L IY... M99</i>	
<i>CALL LBL 4 REP...</i>	
<i>CALL LBL 2 REP...</i>	
<i>LBL 0</i>	

Absolute Pre-position
Setup clearance

Label
Define increments
Cross over and drill

Label
Move up column

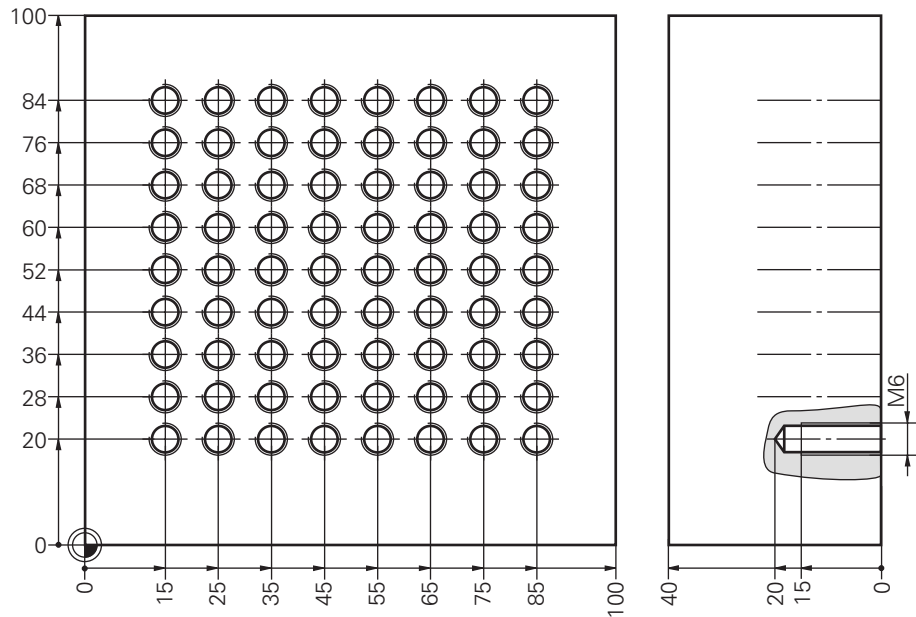
Cross over and drill

Label
Move down column

Remaining columns

Solution:

Linear hole pattern



Main program

```

0 BEGIN PGM 7109 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-40
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3,5 ..... NC-CENTER DRILL
4 TOOL DEF 2 L+0 R+2,5 ..... TWIST DRILL
5 TOOL DEF 3 L+0 R+3 ..... TAP

```

Center

```

6 TOOL CALL 1 Z S2500 ..... NC-CENTER DRILL
7 L Z+100 R0 F9999 M6 ..... TOOL CHANGE
8 CYCL DEF 1.0 PECKING
9 CYCL DEF 1.1 SET UP -2
10 CYCL DEF 1.2 DEPTH -3
11 CYCL DEF 1.3 PECKG -3
12 CYCL DEF 1.4 DWELL 0
13 CYCL DEF 1.5 F100
14 CALL LBL 1 ..... CALL DRILLING PATTERN
15 L Z+100 M6 ..... TOOL CHANGE

```

Pecking

```

16 TOOL CALL 2 Z S1500
17 CYCL DEF 1.0 PECKING
18 CYCL DEF 1.1 SET UP -2
19 CYCL DEF 1.2 DEPTH -20
20 CYCL DEF 1.3 PECKG -20
21 CYCL DEF 1.4 DWELL 0
22 CYCL DEF 1.5 F50
23 CALL LBL 1 ..... CALL DRILLING PATTERN
24 L Z+100 M6 ..... TOOL CHANGE

```

Tapping

```

25 TOOL CALL 3 Z S500
26 CYCL DEF 2.0 TAPPING
27 CYCL DEF 2.1 SET UP -2
28 CYCL DEF 2.2 DEPTH -15
29 CYCL DEF 2.3 DWELL 0
30 CYCL DEF 2.4 F500
31 CALL LBL 1 ..... CALL DRILLING PATTERN

```

Retract tool, end

```

32 L Z+100 M2

```

Solution:

Linear hole pattern

SPGM 1, Drilling pattern

```
33 LBL 1 ..... DRILLING PATTERN
34 L X+5 Y+20 R0 F9999 M3 ..... PRE-POSITION
35 L Z+2 R0 M8

36 LBL 2
37 L IX+10 M99 ..... CROSS OVER

38 LBL 3
39 L IY+8 M99 ..... Y-STEP UPWARDS
40 CALL LBL 3 REP 7/7 ..... COLUMN UPWARDS

41 L IX+10 M99 ..... CROSS OVER

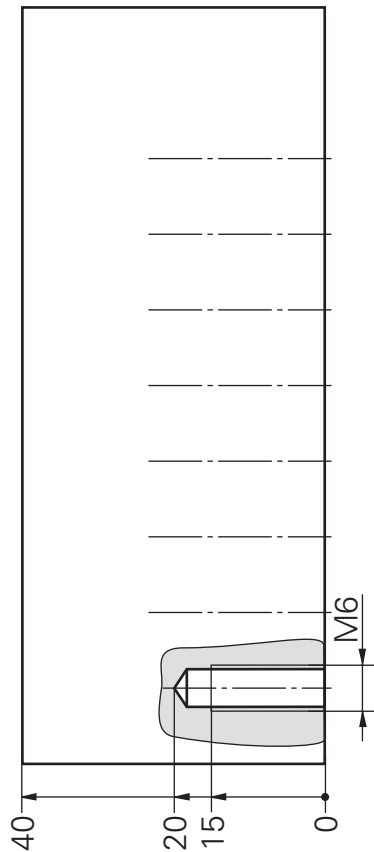
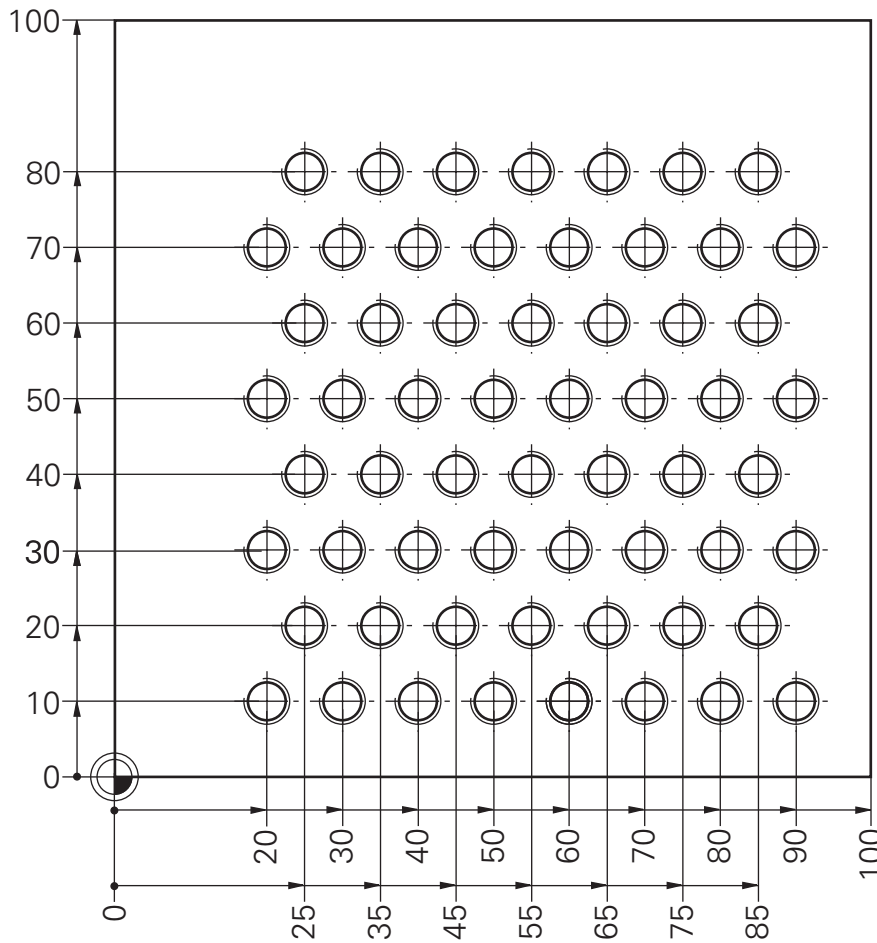
42 LBL 4
43 L IY-8 M99 ..... Y-STEP DOWNWARDS
44 CALL LBL 4 REP 7/7 ..... COLUMN DOWNWARDS

45 CALL LBL 2 REP 3/3 ..... REMAINING COLUMNS

46 LBL 0
47 END PGM 7109 MM
```

Task: **Linear offset hole pattern, including tapping**

Program(s): _____



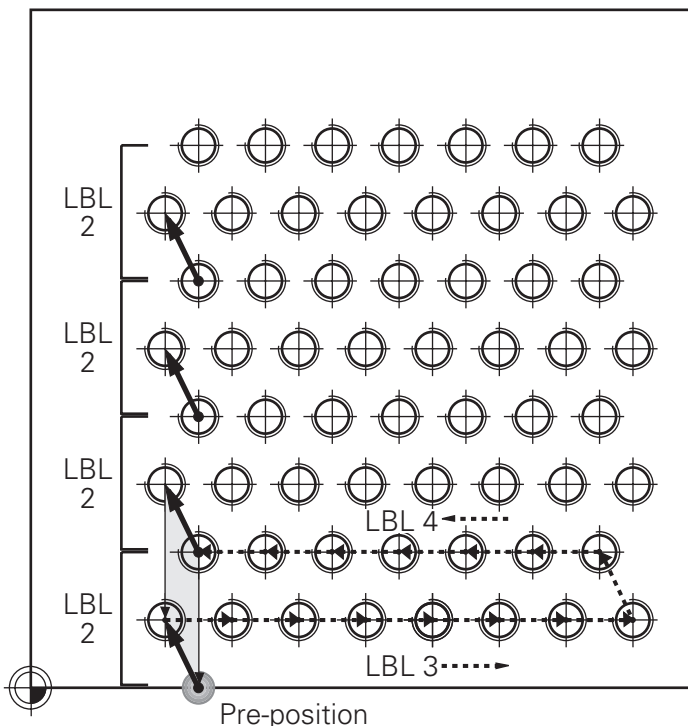
Procedure: • Move back and forth along rows (meandering)

Tools: • NC-center drill
• Twist drill
• Tap

Program layout:

Linear offset hole pattern, including tapping

Meandering movement:



Left end of short row = Pre-position for next row

First pre-position lies under the first long row

Preparation

BLK FORM
TOOL DEF
TOOL 1...

Workpiece blank
Tool list
First tool call

L Z... M6

Tool change

Process Center

CYCL DEF, DEPTH = PECKG

Pecking cycle

CALL LBL 1

Call drilling pattern

STOP M6

Tool change

Pecking

TOOL 2...
CYCL DEF, DEPTH ≠ PECKG

Pecking cycle

CALL LBL 1

Call drilling pattern

STOP M6

Tool change

Tapping

TOOL 3...
CYCL DEF

Tapping cycle

CALL LBL 1

Call drilling pattern





Process end

STOP M2

Program layout:

Linear offset hole pattern, including tapping

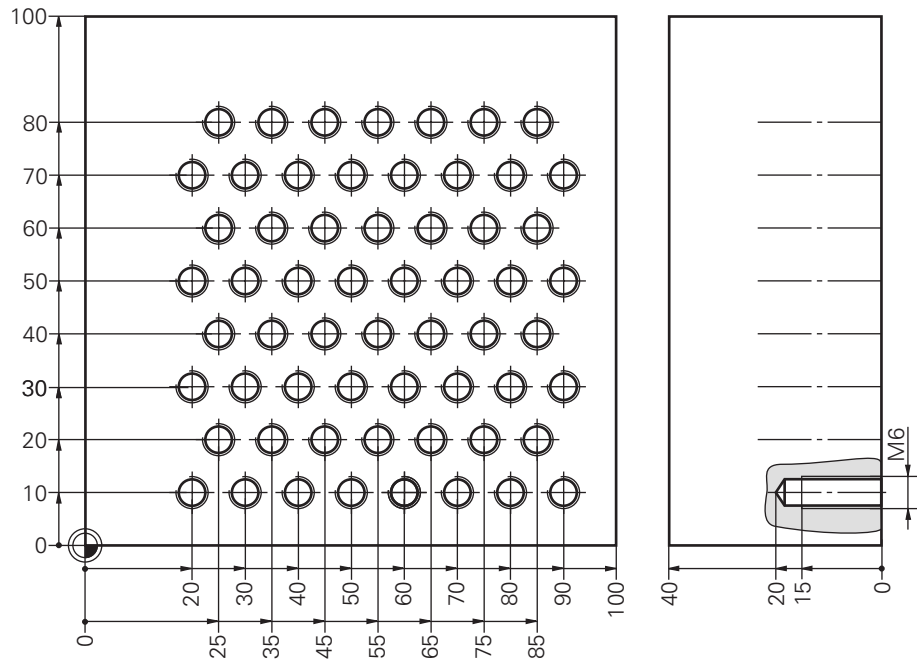
**Drilling pattern,
SPGM 1**

<i>LBL 1</i>		
<i>L X... Y...</i> <i>L Z...</i>		Absolute pre-position Setup clearance
<i>LBL 2</i>		Label
<i>L IX... IY... M99</i>		Define increments Cross over and drill
<i>LBL 3</i>		Label
<i>L IX... M99</i>		Move right
<i>CALL LBL 3 REP...</i>		
<i>L IX... IY... M99</i>		Cross over and drill
<i>LBL 4</i>		Label
<i>L IX... M99</i>		Move left
<i>CALL LBL 4 REP...</i>		
<i>CALL LBL 2 REP...</i>		Remaining rows
<i>L Z...</i> <i>L X... Y... ..</i>		Tool change position
<i>LBL 0</i>		



Solution:

Linear offset hole pattern, including tapping



Main program

```

0 BEGIN PGM 7426 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-40
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3,5 ..... NC-CENTER DRILL
4 TOOL DEF 2 L+0 R+2,5 ..... TWIST DRILL
5 TOOL DEF 3 L+0 R+3 ..... TAP

```

Center

```

6 TOOL CALL 1 Z S800 ..... NC-CENTER DRILL
7 L Z+100 R0 F9999 M6 ..... TOOL CHANGE
8 CYCL DEF 1.0 PECKING
9 CYCL DEF 1.1 SET UP -2
10 CYCL DEF 1.2 DEPTH -2
11 CYCL DEF 1.3 PECKG -2
12 CYCL DEF 1.4 DWELL 0
13 CYCL DEF 1.5 F200
14 CALL LBL 1 ..... CALL DRILLING PATTERN
15 STOP M6 ..... TOOL CHANGE

```

Pecking

```

16 TOOL CALL 2 Z S500 ..... TWIST DRILL
17 CYCL DEF 1.0 PECKING
18 CYCL DEF 1.1 SET UP -2
19 CYCL DEF 1.2 DEPTH -20
20 CYCL DEF 1.3 PECKG -10
21 CYCL DEF 1.4 DWELL 0
22 CYCL DEF 1.5 F100
23 CALL LBL 1 ..... CALL DRILLING PATTERN
24 STOP M6 ..... TOOL CHANGE

```

Tapping

```

25 TOOL CALL 3 Z S500 ..... TAP
26 CYCL DEF 2.0 TAPPING
27 CYCL DEF 2.1 SET UP -2
28 CYCL DEF 2.2 DEPTH -15
29 CYCL DEF 2.3 DWELL 0
30 CYCL DEF 2.4 F500
31 CALL LBL 1 ..... CALL DRILLING PATTERN

```

Retract tool, end

```

32 STOP M2

```


Solution:

Linear offset hole pattern, including tapping

SPGM 1, Drilling pattern

```
33 LBL 1
34 L X+25 Y+0 R0 F9999 M3 ..... PRE-POSITION
35 L Z+2 R0 M8

36 LBL 2 ..... CROSS OVER AND DRILL
37 L IX-5 IY+10 R0 M99

38 LBL 3 ..... RIGHT ALONG ROW
39 L IX+10 R0 M99
40 CALL LBL 3 REP 6/6

41 L IX-5 IY+10 R0 M99 ..... CROSS OVER

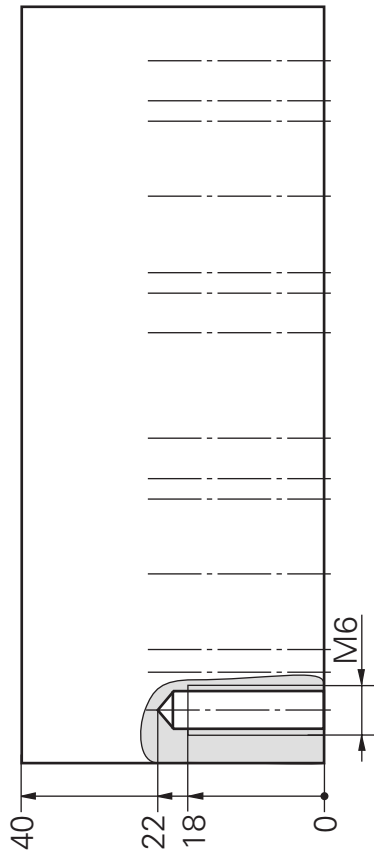
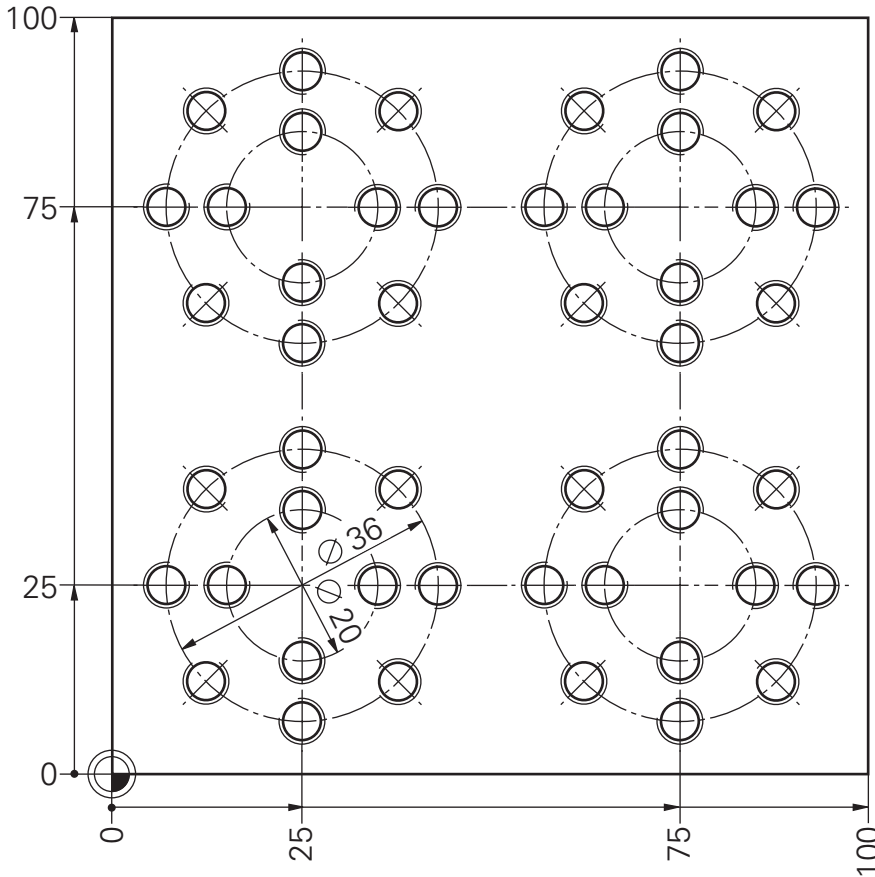
42 LBL 4 ..... LEFT ALONG ROW
43 L IX-10 R0 M99
44 CALL LBL 4 REP 5/5

45 CALL LBL 2 REP 3/3 ..... REMAINING ROWS

46 L Z+100 R0 M9 ..... TOOL CHANGE POSITION
47 L X-20 Y-20 R0
48 LBL 0
49 END PGM 7426 MM
```

Task: **Four double bolt hole circles, with 3 tools, 3 cycles, including tapping**

Program(s): _____



- Tools:**
- NC-center drill
 - Twist drill
 - Tap

BLK-FORM

Center

```
TOOL DEF / TOOL CALL 1 ...
CYCL DEF ...
CALL LBL 1
```

Pecking

```
TOOL DEF / TOOL CALL 2 ...
CYCL DEF ...
CALL LBL 1
```

Tapping

```
TOOL DEF / TOOL CALL 3 ...
CYCL DEF ...
CALL LBL 1
```

Retract tool, end

```
L Z100 M2
```

**SPGM 1,
Circle center and
SPGM call**

```
LBL 1
CC X... Y...
CALL LBL 2
CC X... Y...
CALL LBL 2
CC X... Y...
CALL LBL 2
LBL 0
```

**SPGM 2,
Tool movements
and holes**

```
LBL 2
LP PR... PA... M3
L Z2 M99
LBL 3
•
•
LBL 4
•
•
LBL 0
```

Inner bolt hole circle

Outer bolt hole circle

Program layout: **Four double bolt hole circles,
with 3 tools, 3 cycles,
including tapping**

Preparation

```
BLK FORM
TOOL DEF
TOOL 1...

L Z... M6
```

Workpiece blank
Tool list
First tool call

Tool change

**Process
Center**

```
CYCL DEF, DEPTH = PECKG
CALL LBL 1
L Z... M6
```

Pecking cycle

Call drilling pattern

Tool change

Pecking

```
TOOL 2...
CYCL DEF, DEPTH ≠ PECKG
CALL LBL 1
L Z... M6
```

Pecking cycle

Call drilling pattern

Tool change

Tapping

```
TOOL 3...
CYCL DEF
CALL LBL 1
```

Tapping cycle

Call drilling pattern

Retract tool, end

```
L Z... M2
```

Program layout:

**Four double bolt hole circles,
with 3 tools, 3 cycles,
including tapping**

**Center of circles,
SPGM 1**

<i>LBL 1</i>	
<i>CC X... Y...</i>	
<i>CALL LBL 2</i>	
<i>CC X... Y...</i>	
<i>CALL LBL 2</i>	
<i>...</i>	
<i>LBL 0</i>	

Center lower left

Call bolt hole circle

Remaining centers

Call remaining bolt
hole circles

End SPGM 1

**Drilling pattern,
SPGM 2
Bolt hole circle**

<i>LBL 2</i>	
<i>LP PR... PA... R0 F9999 M13 L Z... M99</i>	
<i>LBL 3</i>	
<i>LP PR... IPA... M99</i>	
<i>CALL LBL 3 REP...</i>	
<i>LP PR... M99</i>	
<i>LBL 4</i>	
<i>LP PR... IPA... M99</i>	
<i>CALL LBL 4 REP...</i>	
<i>LBL 0</i>	

Drill positions

Inner circle
Setup clearance
and first hole
Label

Remaining
drill positions

Outer circle,
first hole

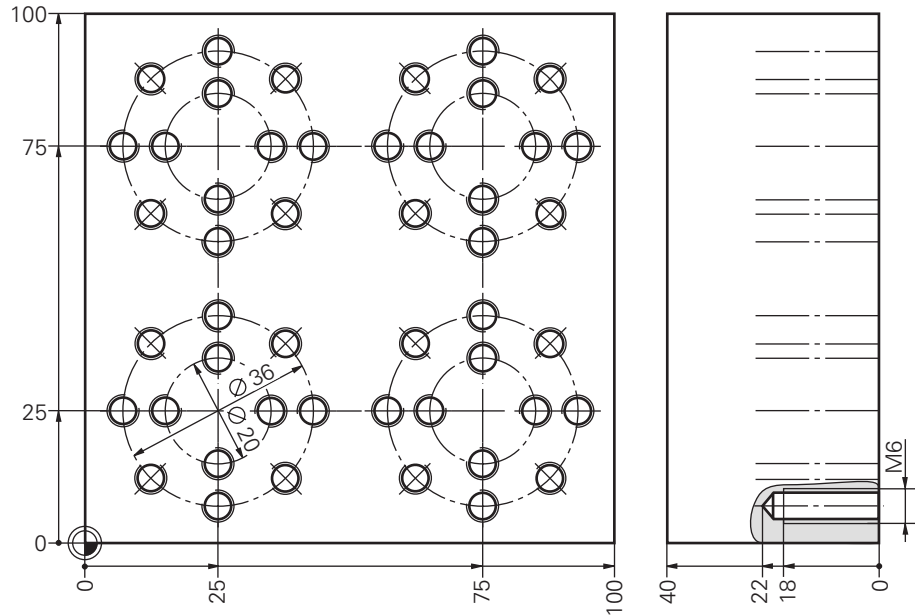
Label

Remaining
drill positions

End SPGM 2

Solution:

Four double bolt hole circles, with 3 tools, 3 cycles, including tapping



Main program

```

0 BEGIN PGM 7139 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-40
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3,5 ..... NC-CENTER DRILL
4 TOOL DEF 2 L+0 R+2,5 ..... TWIST DRILL
5 TOOL DEF 3 L+0 R+3 ..... TAP
6 L Z+100 R0 F9999 M6 ..... TOOL CHANGE

```

Center

```

7 TOOL CALL 1 Z S2500 ..... NC-CENTER DRILL
8 CYCL DEF 1.0 PECKING
9 CYCL DEF 1.1 SET UP -2
10 CYCL DEF 1.2 DEPTH -1,5
11 CYCL DEF 1.3 PECKG -1,5
12 CYCL DEF 1.4 DWELL 0
13 CYCL DEF 1.5 F100
14 CALL LBL 1 ..... CALL DRILLING PATTERN
15 L Z+100 M6 ..... TOOL CHANGE

```

Pecking

```

16 TOOL CALL 2 Z S500
17 CYCL DEF 1.0 PECKING
18 CYCL DEF 1.1 SET UP -2
19 CYCL DEF 1.2 DEPTH -22
20 CYCL DEF 1.3 PECKG -10
21 CYCL DEF 1.4 DWELL 0
22 CYCL DEF 1.5 F100
23 CALL LBL 1 ..... CALL DRILLING PATTERN
24 L Z+100 M6 ..... TOOL CHANGE

```

Tapping

```

25 TOOL CALL 3 Z S250
26 CYCL DEF 2.0 TAPPING
27 CYCL DEF 2.1 SET UP -2
28 CYCL DEF 2.2 DEPTH -18
29 CYCL DEF 2.3 DWELL 0
30 CYCL DEF 2.4 F250
31 CALL LBL 1 ..... CALL DRILLING PATTERN

```

Retract tool, end

```

32 L Z+100 M2

```

Solution:

**Four double bolt hole circles,
with 3 tools, 3 cycles,
including tapping**

**SPGM 1, Center of
circles**

33 LBL 1
34 CC X+25 Y+25 CENTER LOWER LEFT
35 CALL LBL 2 DRILL POSITIONS
36 CC X+75 Y+25 CENTER LOWER RIGHT
37 CALL LBL 2 DRILL POSITIONS
38 CC X+75 Y+75 CENTER UPPER RIGHT
39 CALL LBL 2 DRILL POSITIONS
40 CC X+25 Y+75 CENTER UPPER LEFT
41 CALL LBL 2 DRILL POSITIONS
42 LBL 0

SPGM 1, end

**SPGM 2, Bolt hole
circle itself**

43 LBL 2 DRILL POSITIONS
44 LP PR+10 PA+0 M13 INNER CIRCLE
45 L Z+2 M99 1ST HOLE

46 LBL 3 REMAINING HOLES
47 LP IPA+90 M99
48 CALL LBL 3 REP 2/2

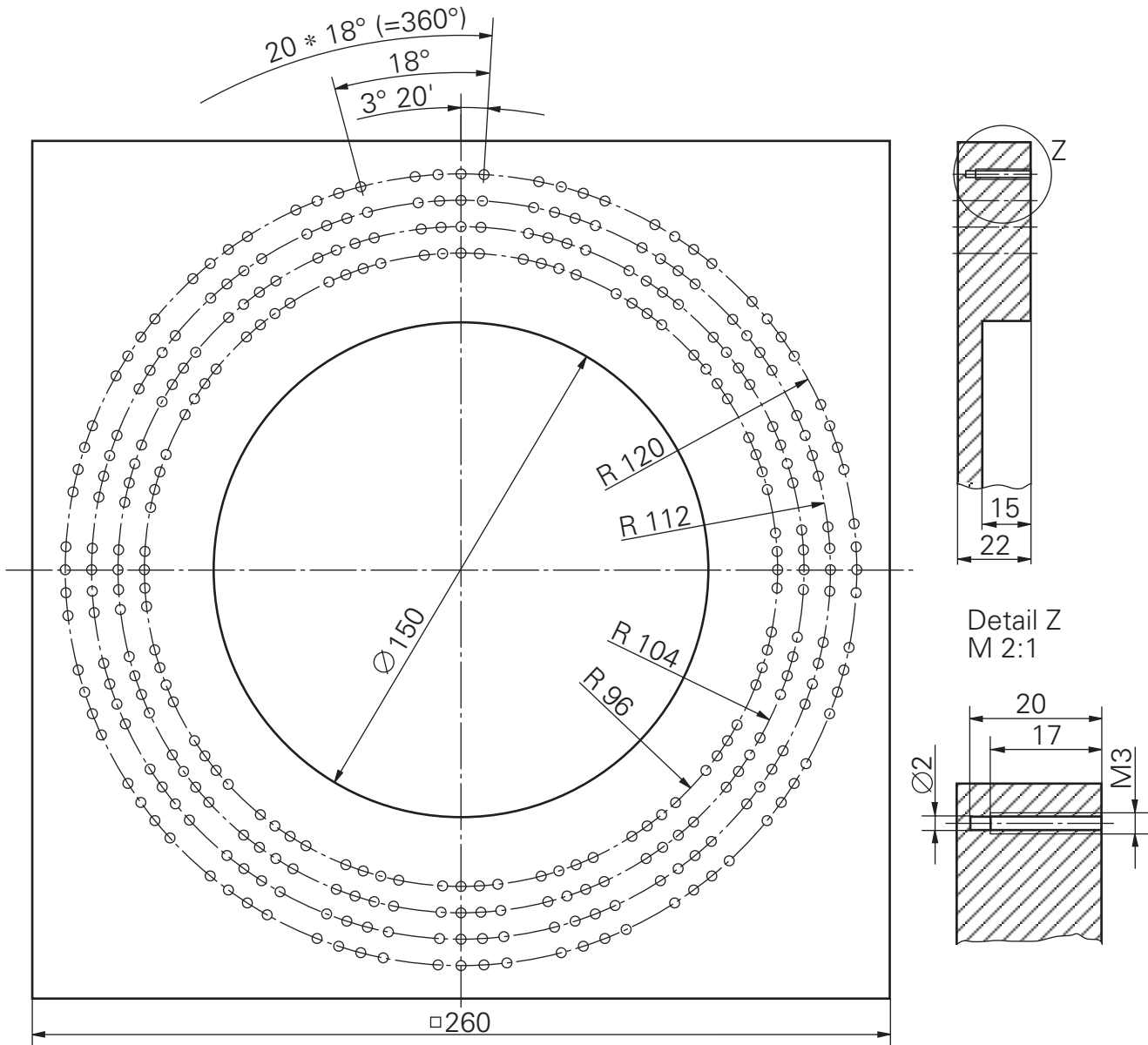
49 LP PR+18 PA+180 M99 OUTER CIRCLE

50 LBL 4 REMAINING HOLES
51 LP IPA+45 M99
52 CALL LBL 4 REP 6/6

SPGM 2, end

53 LBL 0
54 END PGM 7139 MM





- Procedure:**
- Center holes, drill, tap
 - Mill large hole

- Tools:**
- NC-center drill
 - Twist drill
 - Tap
 - Mill R30

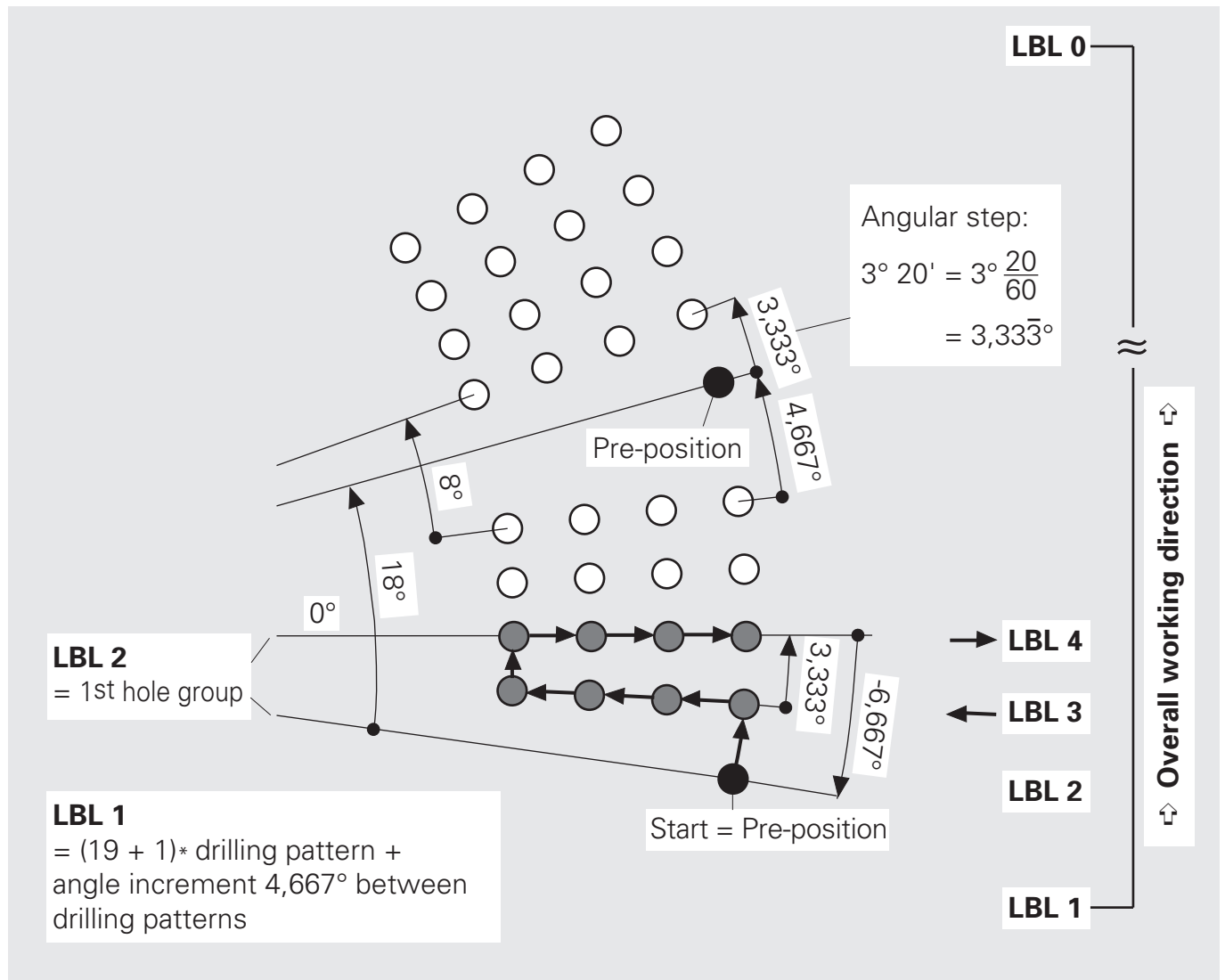
Program layout: **Large drilled plate**

Preparation	<i>BLK FORM</i> <i>TOOL 1.../TOOL 2...</i>	Workpiece blank Tool list if necessary
Process Center	<i>TOOL 1... (R 2,0)</i> <i>CYCL DEF, DEPTH = PECKG</i>	Pecking cycle
	<i>CALL LBL 1</i>	Call drilling pattern
	<i>... M6</i>	Tool change
Pecking	<i>TOOL 2... (R 1,0)</i> <i>CYCL DEF</i>	Pecking cycle
	<i>CALL LBL 1</i>	Call drilling pattern
	<i>... M6</i>	Tool change
Tapping	<i>TOOL 3... (R 1,5)</i> <i>CYCL DEF</i>	Tapping cycle
	<i>CALL LBL 1</i>	Call drilling pattern
	<i>... M6</i>	Tool change
Mill large holes	<i>TOOL 4... (R 30)</i> <i>CYCL DEF</i> <i>L X... Y...</i> <i>L Z... M99</i>	Circular pocket -cycle Starting position and cycle call
Retract tool, end	<i>L Z... M2</i>	



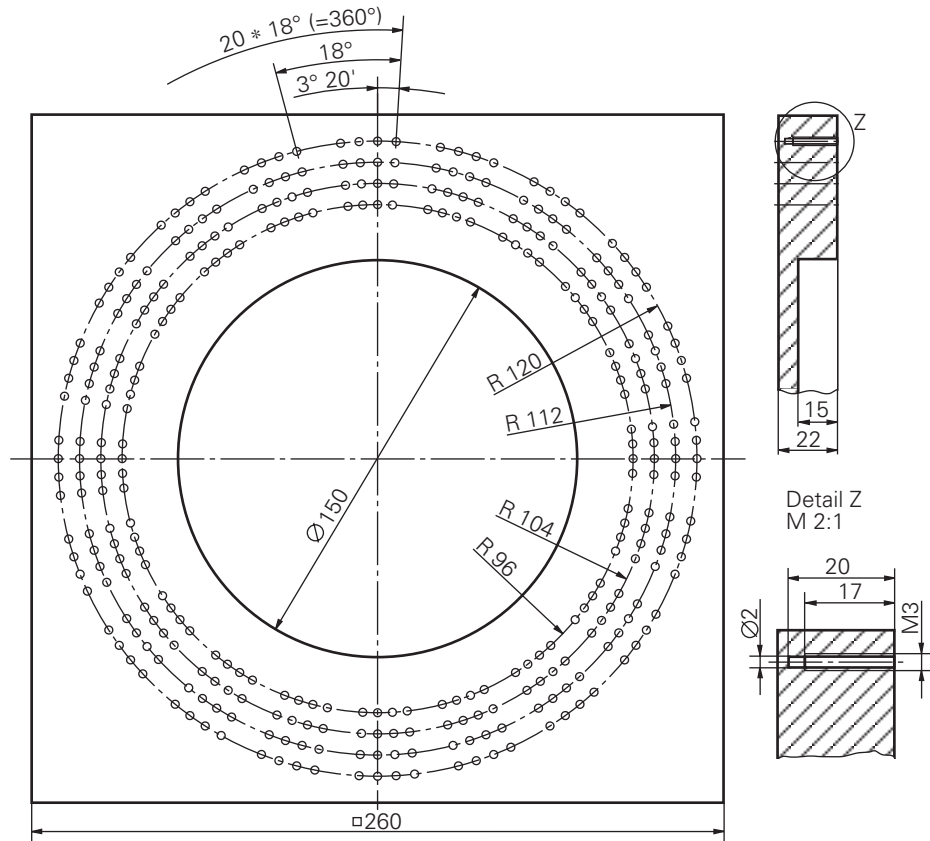
**Drilling pattern,
SPGM 1**

<i>LBL 1</i>	
<i>CC...</i> <i>LP...</i>	Center Absolute pre-position Plane
<i>LZ...</i>	Setup clearance in Z
<i>LBL 2</i>	
<i>LP IPA M99</i>	Angular step (incred.) Drill with M99
<i>LBL 3</i>	
<i>LP IPR M99</i>	Radial step inwards
<i>CALL LBL 3 REP . . .</i>	Further radial steps
<i>LP IPA M99</i>	Angular step
<i>LBL 4</i>	
<i>LP IPR M99</i>	Radial step outwards
<i>CALL LBL 4 REP . . .</i>	Further radial steps
<i>CALL LBL 2 REP . . .</i>	Further double rows
<i>LP IPA</i>	To intermediate pos.
<i>CALL LBL 2 REP . . .</i>	Remaining hole gr.
<i>LZ M99</i> <i>LX . . . Y</i>	Tool change position
<i>LBL 0</i>	



Solution:

Large drilled plate



Main program

```

0 BEGIN PGM 7411 MM
1 BLK FORM 0.1 Z X-125 Y-130 Z-22
2 BLK FORM 0.2 X+125 Y+130 Z+0
3 TOOL DEF 1 L+0 R+2,0 ..... CENTER DRILL
4 TOOL DEF 2 L+0 R+1 ..... TWIST DRILL
5 TOOL DEF 3 L+0 R+1,5 ..... TAP
6 TOOL DEF 4 L+0 R+30 ..... MILL

```

Center

```

7 TOOL CALL 1 Z S3000
8 CYCL DEF 1.0 PECKING
9 CYCL DEF 1.1 SET UP -2
10 CYCL DEF 1.2 DEPTH -2
11 CYCL DEF 1.3 PECKG -2
12 CYCL DEF 1.4 DWELL 0
13 CYCL DEF 1.5 F100
14 CALL LBL 1
15 L Z+20 R0 F9999 M6

```

Pecking

```

16 TOOL CALL 2 Z S3000
17 CYCL DEF 1.0 PECKING
18 CYCL DEF 1.1 SET UP -2
19 CYCL DEF 1.2 DEPTH -20
20 CYCL DEF 1.3 PECKG -20
21 CYCL DEF 1.4 DWELL 0
22 CYCL DEF 1.5 F200
23 CALL LBL 1
24 L Z+20 R0 F9999 M6

```



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C04



7411/5

Solution: Large drilled plate

Tapping

```

25 TOOL CALL 3 Z S500
26 CYCL DEF 2.0 TAPPING
27 CYCL DEF 2.1 SET UP -2
28 CYCL DEF 2.2 DEPTH -17
29 CYCL DEF 2.3 DWELL 0
30 CYCL DEF 2.4 F250
31 CALL LBL 1
32 L Z+20 R0 F9999 M6
  
```

Circular pocket

```

33 TOOL CALL 4 Z S400
34 CYCL DEF 5.0 CIRCULAR POCKET
35 CYCL DEF 5.1 SET UP -2
36 CYCL DEF 5.2 DEPTH -15
37 CYCL DEF 5.3 PECKG -5 F100
38 CYCL DEF 5.4 RADIUS 75
39 CYCL DEF 5.5 F500 DR-
40 L X+0 Y+0 R0 M3
41 L Z+2 M99
  
```

Retract tool, end

```

42 L Z+20 R0 F9999 M2
  
```

SPGM 1, Drilling pattern

```

43 LBL 1
44 CC X+0 Y+0 ..... CENTER
45 LP PR+120 PA-6,666 R0 F9999 M3 ..... PRE-POSITION BY 1ST HOLE
46 L Z+2 R0 M8

47 LBL 2
48 LP IPA+3,333 M99 ..... ANGULAR STEP

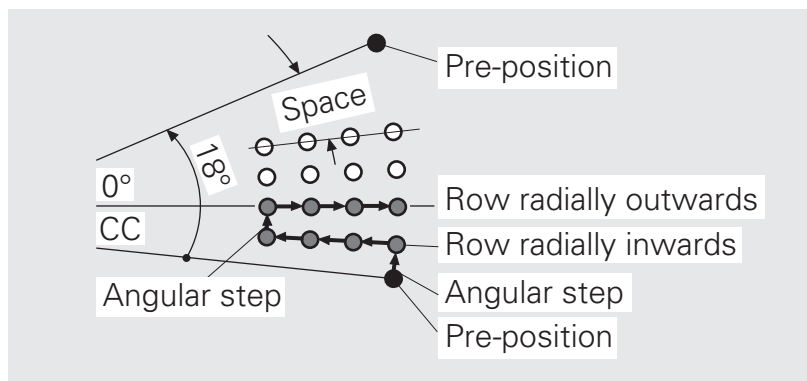
49 LBL 3
50 LP IPR-8 M99
51 CALL LBL 3 REP 2/2 ..... ROW RADIALLY INWARDS

52 LP IPA+3,333 M99 ..... ANGULAR STEP

53 LBL 4
54 LP IPR+8 M99
55 CALL LBL 4 REP 2/2 ..... ROW RADIALLY OUTWARDS

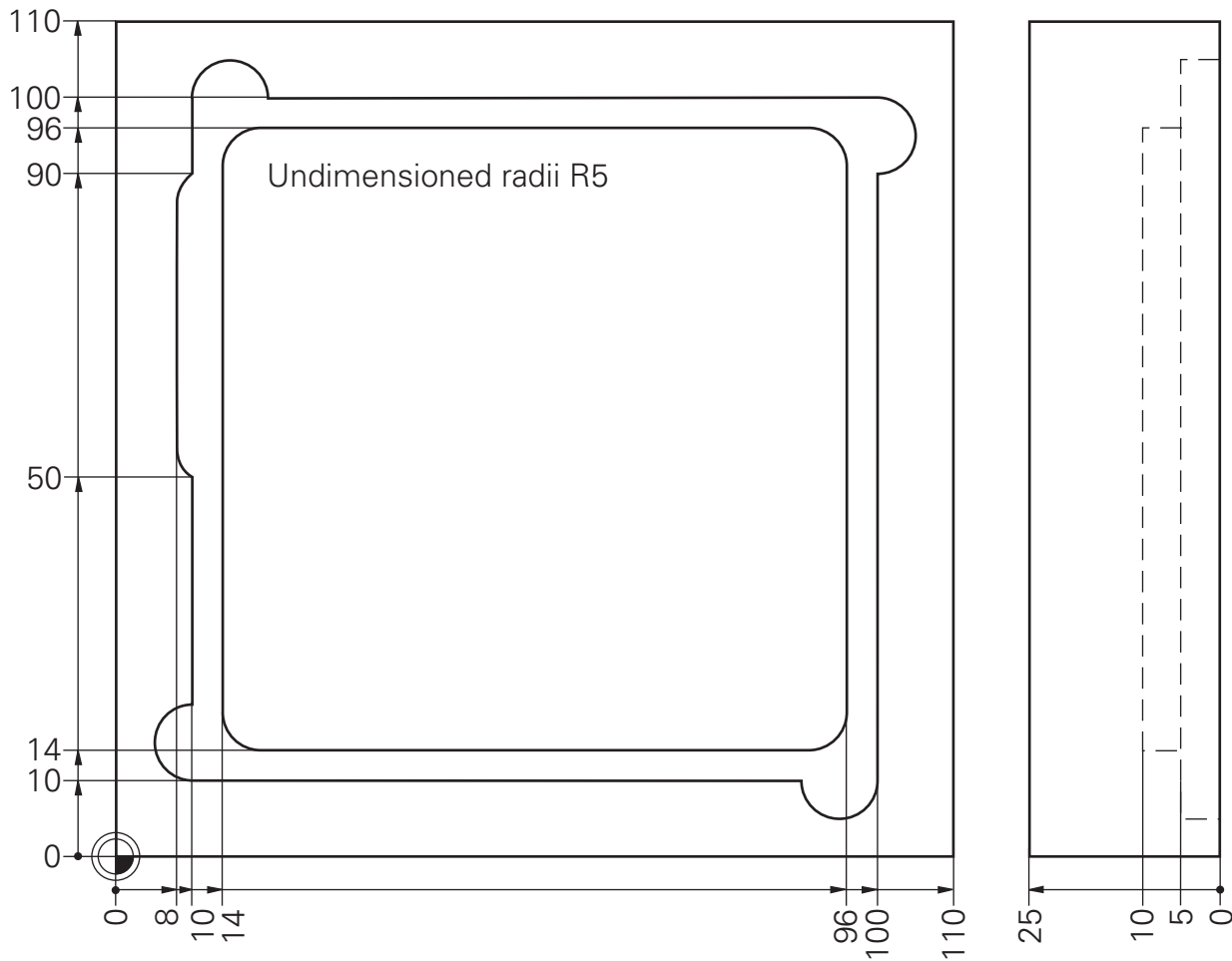
56 CALL LBL 2 REP 1/1 ..... FURTHER DOUBLE ROWS

57 LP IPA+4,666 ..... SPACE
58 CALL LBL 2 REP 19/19 ..... REPEAT FURTHER GROUPS OF 16
59 LBL 0
60 END PGM 7411 MM
  
```



Task: **Loading frame for plate
with M97 and M98**

Program(s): _____



Procedure:

- Rough out inside
- Travel one mill radius farther at the corners of the loading surface
- Small contour step on the side protrusions

Tools:

- Roughing-finishing mill R5

Program layout:

Loading frame for plate with M97 and M98

Preparation

```
BLK FORM  
TOOL DEF  
TOOL 1...  
  
L Z... .. M6
```

Workpiece blank
Tool list
Call tool data
Tool change

Process

Rough out inside

```
CYCL DEF  
L X... Y...  
L Z... .. M99
```

Pocket milling-cycle
Starting position and
cycle call

Loading surface

```
L X... Y... R0  
L Z...  
APPR... X... Y...  
  
L X... M98  
  
L X... Y...  
L Y... M97  
  
L X...  
L Y...  
L X... M97  
  
L Y... M98  
  
L X...  
L X... M98  
  
L X...  
DEP... X... Y...
```

Pre-position
Depth
Contour approach tang. ,
lower center
In corner one tool
radius farther

Small contour step

Protrusion
Protrusion
Reverse contour step

Next corner

Next corner

End of contour
Depart contour tang.

Retract tool, end

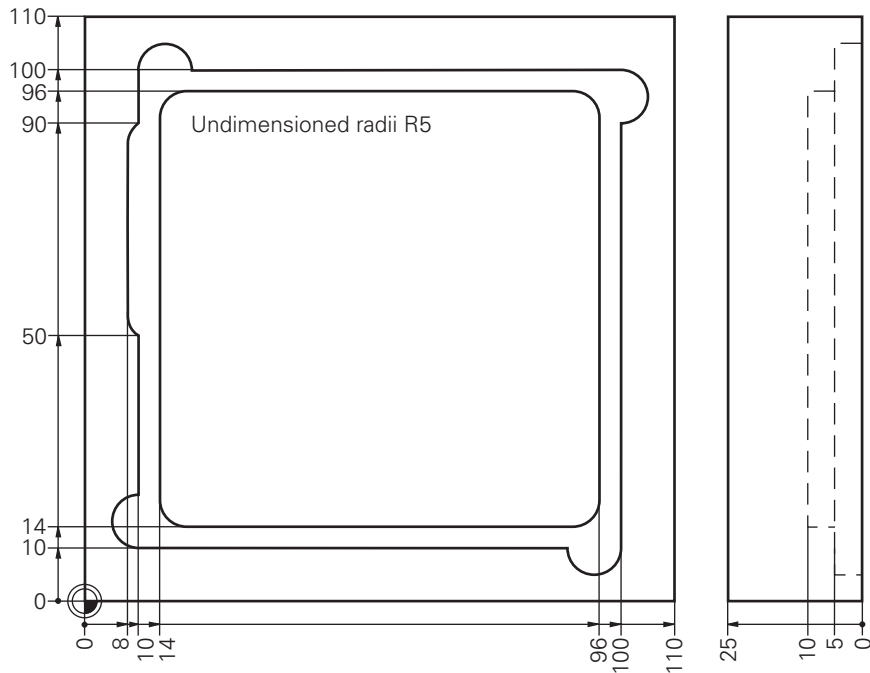
```
L Z... .. M2
```

Tool change position



Solution:

Loading frame for plate with M97 and M98



Roughing out

```
0 BEGIN PGM 72810 MM
1 ..... LOADING FRAME WITH APPR/DEP
2 BLK FORM 0.1 Z X+0 Y+0 Z-25
3 BLK FORM 0.2 X+110 Y+110 Z+0
4 TOOL DEF 1 L+0 R+5
5 TOOL CALL 1 Z S2500
6 L Z+100 R0 F9999 M6
7 CYCL DEF 4.0 POCKET MILLING
8 CYCL DEF 4.1 SET UP -2
9 CYCL DEF 4.2 DEPTH -10
10 CYCL DEF 4.3 PECKG -10 F150
11 CYCL DEF 4.4 X+82
12 CYCL DEF 4.5 Y+82
13 CYCL DEF 4.6 F1000 DR-
14 L X+55 Y+55 R0 M3
15 L Z+2 R0 M99
```

Milling

```
16 L X+30 Y+30
17 L Z-5 R0 F100
18 APPR LCT X+30 Y+10 R5 RR F250
19 L X+10 M98
20 L X+10 Y+15
21 L Y+50 M97
22 L X+8
23 L Y+90
24 L X+10 M97
25 L Y+100 M98
26 L X+15
27 L X+100 M98
28 L Y+95
29 L Y+10 M98
30 L X+95
31 L X+30
32 DEP LCT X+30 Y+30 R5 R0

33 L Z+100 R0 F9999 M2
34 END PGM 72810 MM
```



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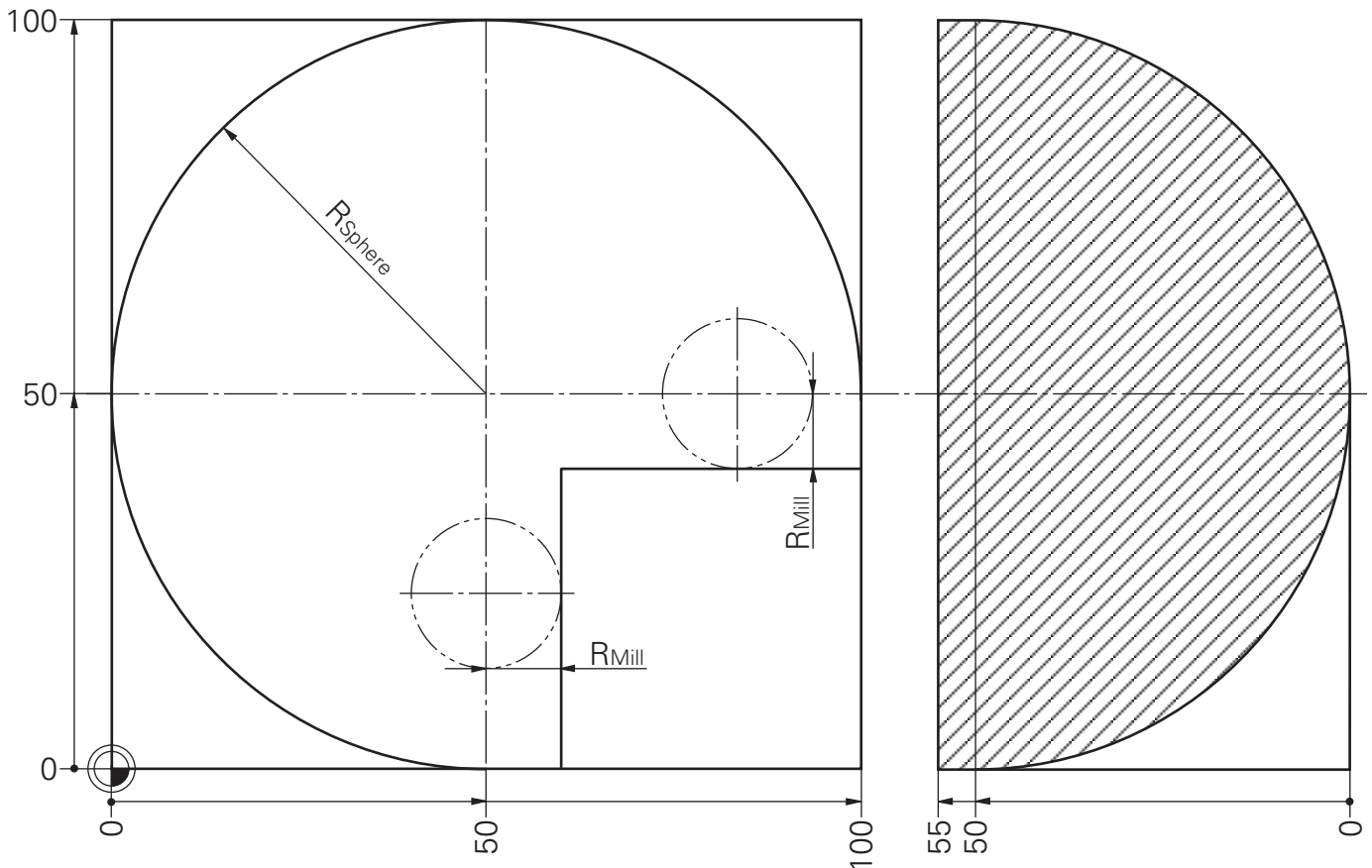
C01



72810/3

Task: **Hemisphere, external machining
with spherical mill, only from
below, 3D**

Program(s): _____



- Procedure:**
- 3D-cut vertical
 - Always from below

- Tools:**
- End mill R10



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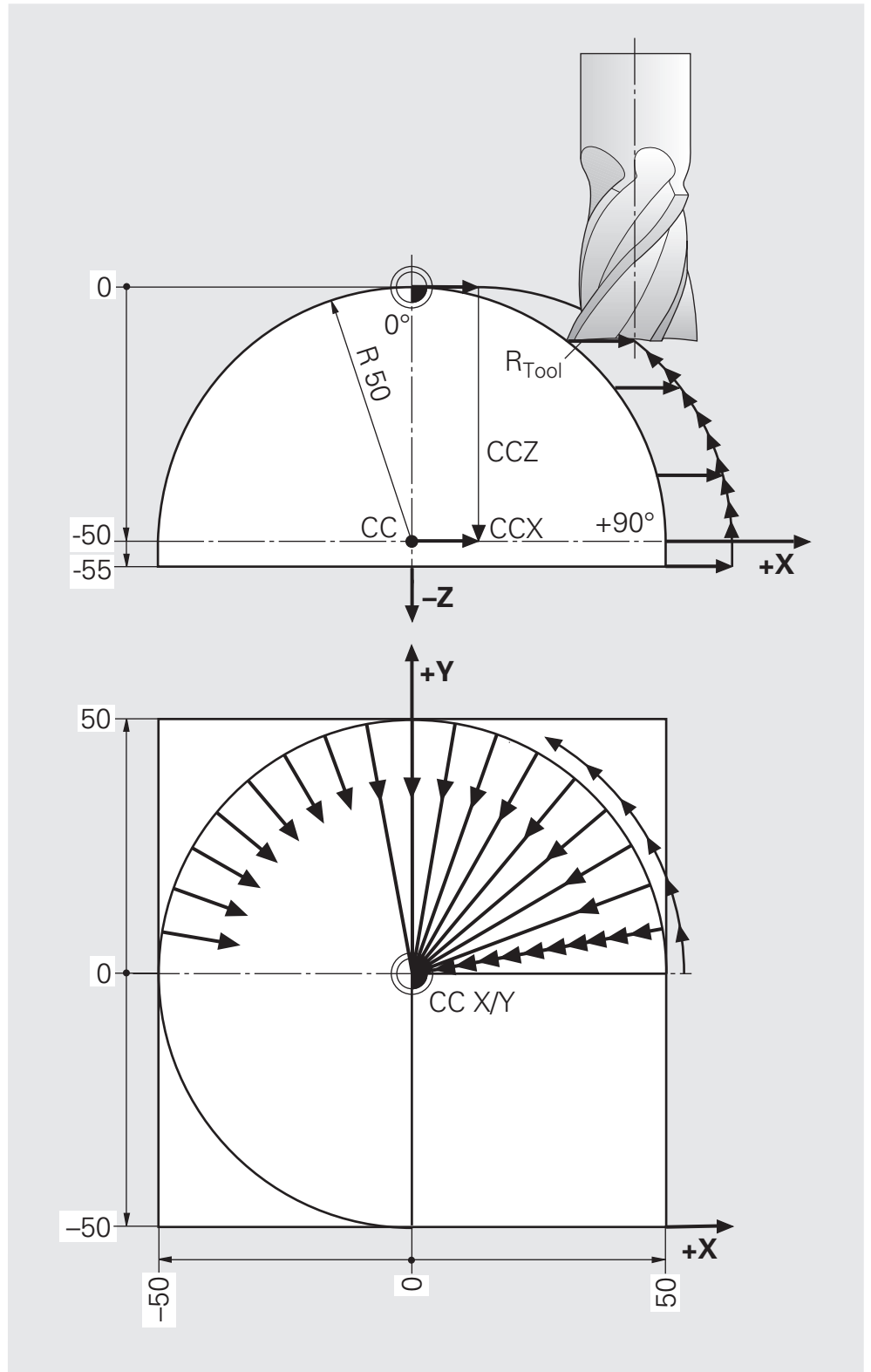
C09



76130/1
76131/1

Program layout:

Hemisphere, external machining with spherical mill, only from below, 3D, 1 cut



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C01



76130/2

Program layout:

**Hemisphere, external machining with spherical mill,
only from below, 3D, 1 cut**

Preparation

Pre-position

“Virtual
circular arc”

<i>BLK FORM</i>	
<i>TOOL 1 . . .</i>	
<i>L Z50 R0 F MAX M6</i>	
<i>L X120 Y50 R0 F MAX M3</i>	
<i>CYCL DEF 7.0 DATUM SHIFT</i>	
<i>X50 Y+50 Z-50</i>	
<i>L Y0 Z0 R0 F MAX</i>	
<i>LBL 2</i>	
<i>CC Z . . . X . . .</i>	
<i>L Y0 . . .</i>	
<i>LP PR50 PA90 R0 . . .</i>	
<i>LBL 3</i>	
<i>LP IPA-5</i>	
<i>CALL LBL 3 REP 17/17</i>	
<i>L X50 . . .</i>	
<i>L X65 Z0 . . .</i>	
<i>CYCL DEF 10.0 ROTATION</i>	
<i>CYCL DEF 10.1 IROT+5</i>	
<i>CALL LBL 2 REP 53/53</i>	
<i>CYCL DEF 7.0 DATUM SHIFT = 0</i>	
<i>CYCL DEF 10.0 ROTATION = 0</i>	
<i>L Z10 R0 F9999</i>	

Zero point in center
of sphere

Compensate circle ctr.

Contour values

1 angular step
(angle in space)

Retract tool

1 further arc

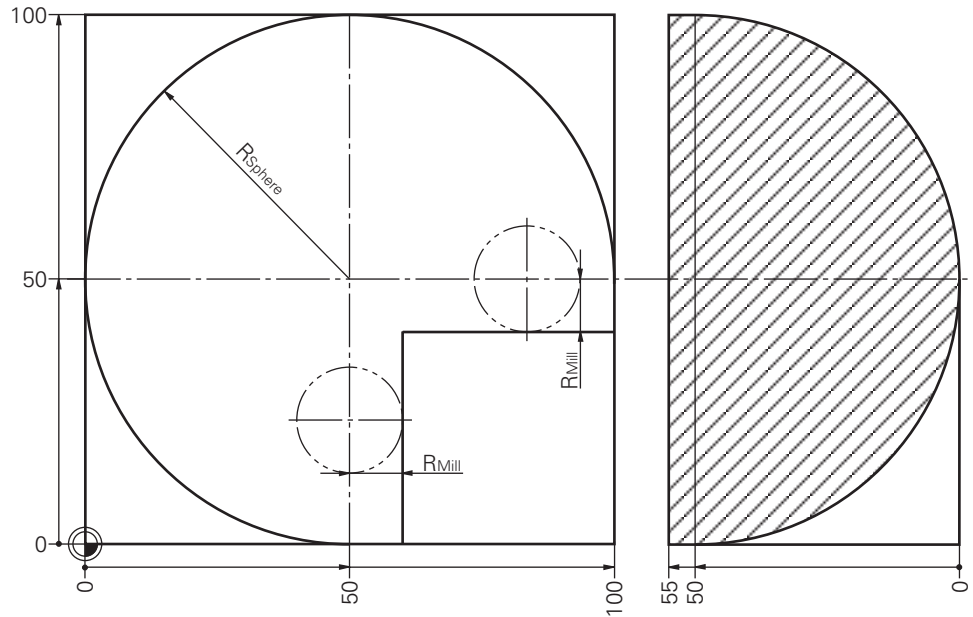
Reset

Retract tool



Solution:

Hemisphere, external machining with spherical mill, only from below, 3D, 1 cut



```

0 BEGIN PGM 76130 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-55
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+10
4 TOOL CALL 1 Z S4000
5 L Z+50 R0 F MAX M6
6 L X+120 Y+50 R0 F MAX M3
7 CYCL DEF 7.0 DATUM SHIFT
8 CYCL DEF 7.1 X+50
9 CYCL DEF 7.2 Y+50
10 CYCL DEF 7.3 Z-50
11 L Y+0 Z+0 R0 F MAX ..... END OF DEPTH
                                (CENTER OF SPHERE)

12 LBL 2
13 CC Z+0 X+Q108 ..... SYSTEMATIC SHIFT IN X
14 L Y+0 F200
15 LP PR+50 PA+90 R0 F200 ..... SPHERE RADIUS

16 LBL 3
17 LP IPA-5 ..... 1 ANGULAR STEP
                                (ANGLE IN SPACE)

18 CALL LBL 3 REP 17/17

19 L X+50 Y+0 R0 F2000
20 L X+65 Z+0 F1000
21 CYCL DEF 10.0 ROTATION ..... 1 FURTHER ARC
22 CYCL DEF 10.1 IROT+5
23 CALL LBL 2 REP 53/53

24 CYCL DEF 7.0 DATUM SHIFT
25 CYCL DEF 7.1 X+0
26 CYCL DEF 7.2 Y+0
27 CYCL DEF 7.3 Z+0
28 CYCL DEF 10.0 ROTATION
29 CYCL DEF 10.1 ROT+0
30 L Z+20 R0 F MAX
31 END PGM 76130 MM

```

Program layout:

**Hemisphere, external machining with spherical mill,
only from below, 3D, 2 cuts**

Preparation

```
BLK FORM.../TOOL 1...R 10  
L X... Y... R0 F9999 M3  
CYCL DEF 7.0 DATUM SHIFT  
                  X50 Y50 Z-50  
L Y0 Z15...
```

External pre-positioning

Center of sphere

Roughing

```
LBL 1
```

```
CC Z15 XQ108  
L Y0 F200  
LP PR50 PA90...
```

Z oversize

Tilt plane

Contour values

```
LBL 2
```

1 arc, coarse, not to
largest angle

```
LP IPA-10 F500
```

```
CALL LBL 2 REP 3/3
```

```
L X50 Y0 F MAX  
L X65 Z15 F1000  
CYCL DEF 10 ROTATION IROT+18
```

Z oversize

Additional arcs

```
CALL LBL 1 REP...
```

```
CYCL DEF 10 ROTATION ROT+0  
L Y0 Z0 F...
```

Finishing

```
LBL 3
```

```
CC Z0 XQ108  
L Y0  
LP PR50 PA90 F200
```

Z specified size

```
LBL 4
```

1 arc, fine, to largest
angle in space

```
LP IPA-1 F800
```

```
CALL LBL 4 REP 89/89
```

Return

```
L X+50 Y+0...  
L X+65 Z+0 F1000  
CYCL DEF 10 ROTATION IROT+1
```

```
CALL LBL 3 REP...
```

```
CYCL DEF 7 DATUM SHIFT = 0  
CYCL DEF 10 ROTATION = 0
```

Retract tool, end

```
L Z20... M2
```



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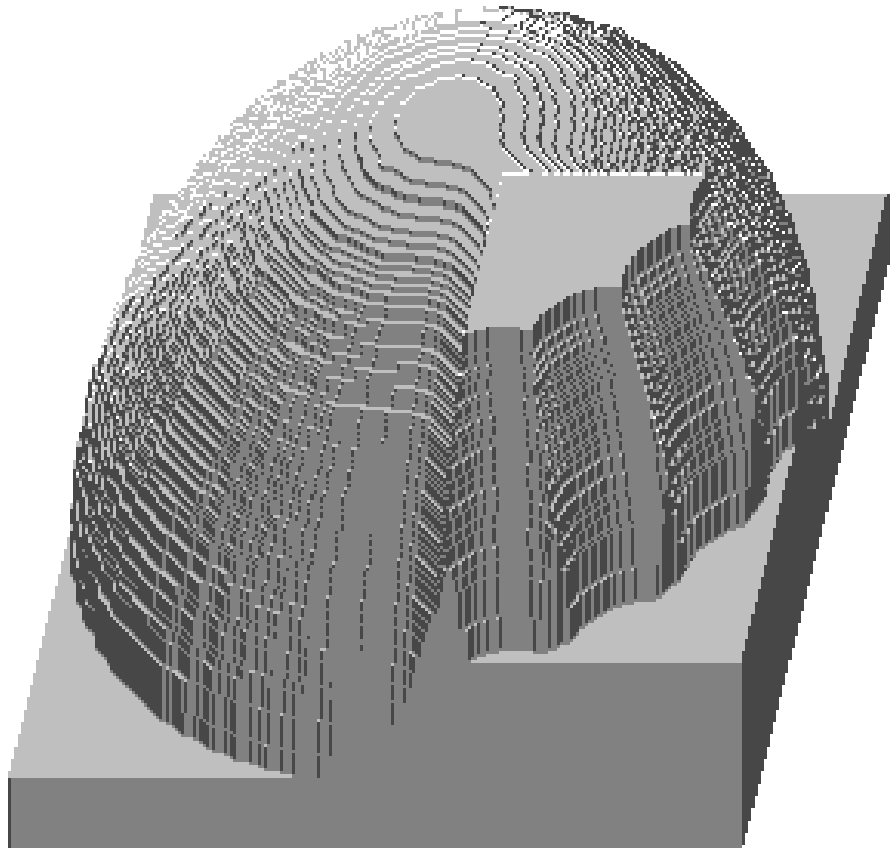
C05



76131/2

Solution:

Hemisphere, external machining with spherical mill, only from below, 3D, 2 cuts



Roughing

```
0 BEGIN PGM 76131 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-60
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+10
4 TOOL CALL 1 Z S4000
5 L Z+50 R0 F MAX M6
6 L X+120 Y+50 R0 F MAX M3
7 CYCL DEF 7.0 DATUM SHIFT
8 CYCL DEF 7.1 X+50
9 CYCL DEF 7.2 Y+50
10 CYCL DEF 7.3 Z-50
11 L Y+0 Z+15 R0 F MAX ..... Z OVERSIZE

12 LBL 1
13 CC Z+15 X+Q108 ..... Z OVERSIZE
14 L Y+0 F200
15 LP PR+50 PA+90 R0 F200 ..... SPHERE RADIUS

16 LBL 2 ..... 1 ARC COARSE
17 LP IPA-10 R0 F500
18 CALL LBL 2 REP 3/3

19 L X+50 Y+0 R0 F MAX
20 L X+65 Z+15 R0 F1000
21 CYCL DEF 10.0 ROTATION ..... 19 FURTHER ARCS
22 CYCL DEF 10.1 IROT+18
23 CALL LBL 1 REP 19/19

24 CYCL DEF 10.0 ROTATION
25 CYCL DEF 10.1 ROT+0
```



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C01



76131/3

Solution:

Hemisphere, external machining with spherical mill, only from below, 3D, 2 cuts

Finishing

```
26 L Y+0 Z+0 R0 ..... Z SPECIFIED SIZE
27 LBL 3
28 CC Z+0 X+Q108 ..... Z SPECIFIED SIZE
29 L Y+0
30 LP PR+50 PA+90 F200 ..... SPHERE RADIUS

31 LBL 4 ..... 1 ARC FINE
32 LP IPA-1 F800
33 CALL LBL 4 REP 89/89

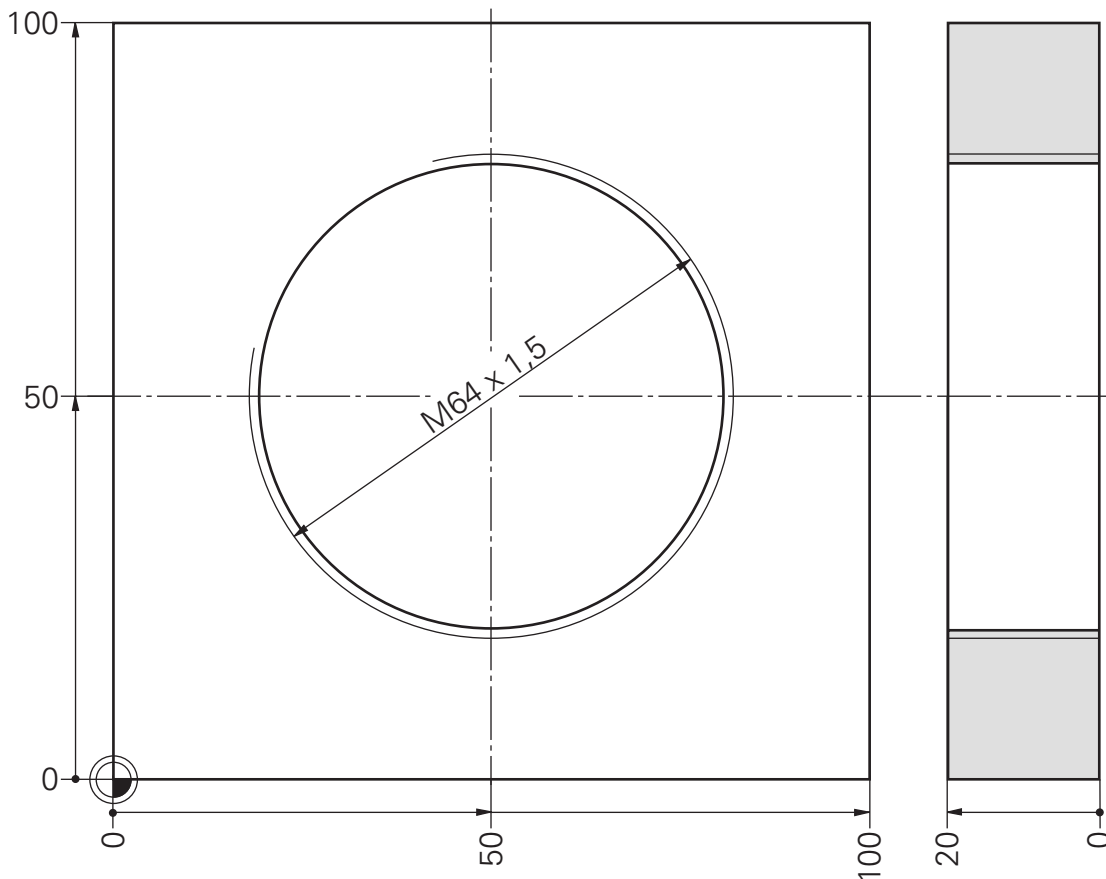
34 L X+50 Y+0 F2000
35 L X+65 Z+0 F1000
36 CYCL DEF 10.0 ROTATION ..... 71 FURTHER ARCS
37 CYCL DEF 10.1 IROT+1
38 CALL LBL 3 REP 359/359

39 CYCL DEF 7.0 DATUM SHIFT
40 CYCL DEF 7.1 X+0
41 CYCL DEF 7.2 Y+0
42 CYCL DEF 7.3 Z+0
43 CYCL DEF 10.0 ROTATION
44 CYCL DEF 10.1 ROT+0
45 L Z+20 R0 F MAX
46 END PGM 76131 MM
```



Task: **Thread milling, in three steps
M64 x 1,5 inside, 2 settings**

Program(s): _____



Precondition: • Center must be free!

Procedure: • Helical interpolation in X/Y plane with simultaneous Z motion
• Working direction downwards

Tools: • Threading mill with cutting edge corresponding to thread profile



Program layout:

Thread milling, in three steps M64 x 1,5 inside, 2 settings

Preparation

```
BLK FORM  
TOOL 1 . . .  
L Z+20 R0 F9999 M3  
L X+50 Y+50 . . .  
CC
```

Retract tool
Approach center
Auto. take over of pole

First cut with oversize

```
LBL 1  
L Z+0 . . . F500  
LP PR+31 PA0 RR F150
```

Contact in Z
Radius oversize

```
LBL 2  
CP IPA-360 IZ-4,5 DR- F500  
CALL LBL 2 REP 4/4
```

Helix

```
LP PR0 PA0 R0 F9999  
L Z+0
```

Second cut to final size

```
LP PR+32 PA0 RR F150
```

Final size, re-contact

```
LBL 3  
CP IPA-360 IZ-4,5 DR- F500  
CALL LBL 3 REP 4/4
```

Helix

```
LP PR0 PA0 R0 F9999  
CYCL DEF 10.0 ROTATION  
CYCL DEF 10.1 IROT+120
```

Center

```
CALL LBL 1 REP 2/2
```

Further threads

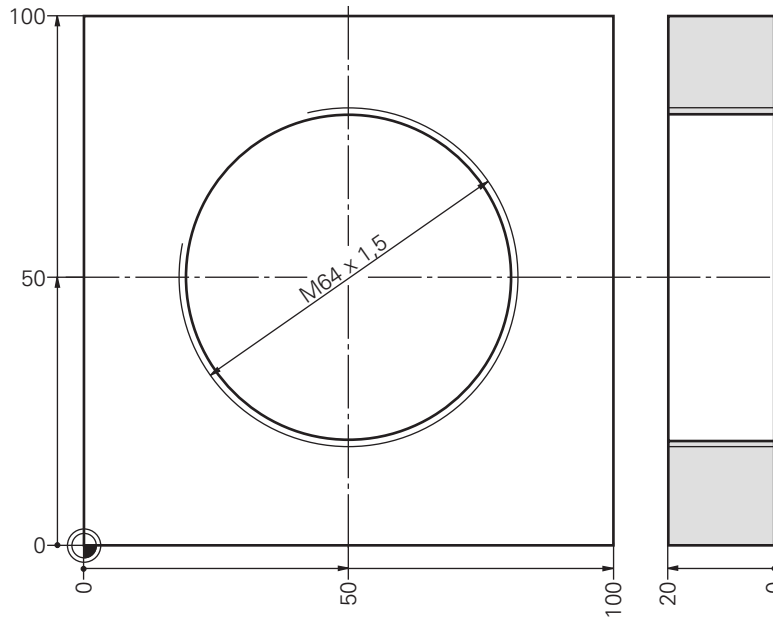
Retract tool, end

```
L Z20 . . . M2
```



Solution:

Thread milling, in three steps M64 x 1,5 inside, 2 settings



```
0 BEGIN PGM 7164 MM
1 BLK FORM 0.1 Z X+0 Y+10 Z-20
2 BLK FORM 0.2 X+100 Y+90 Z+0
3 TOOL CALL 1 Z S2000
4 TOOL DEF 1 L+0 R+20
5 L Z+20 R0 F9999 M3
6 L X+50 Y+50 R0 F9999 M3
7 CC
```

First step, beginning at 0°

```
8 LBL 1
9 L Z+0 R0 F9999
```

First cut, diameter 62

```
10 LP PR+31 PA+0 RR F500 ..... APPROACH WALL
```

```
11 LBL 2
12 CP IPA-360 IZ-4,5 DR- F500 ..... HELIX
13 CALL LBL 2 REP 4/4
```

```
14 LP PR+0 PA+0 R0 F9999 ..... APPROACH CENTER
15 L Z+0
```

Final cut, diameter 64

```
16 LP PR+32 PA+0 RR F500 ..... APPROACH WALL
```

```
17 LBL 3
18 CP IPA-360 IZ-4,5 DR- ..... HELIX
19 CALL LBL 3 REP 4/4
```

```
20 LP PR+0 PA+0 R0 F9999 ..... APPROACH CENTER
21 CYCL DEF 10.0 ROTATION ..... ROTATION
```

Second and third steps, each offset by 120°

```
22 CYCL DEF 10.1 IROT+120
23 CALL LBL 1 REP 2/2
```

```
24 L Z+20 R0 M2
25 END PGM 7164 MM
```

