

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
	Free Contour Programming	
8	FK Telephone	75103
9	FK Dumbbell	75116
10	FK Hammer basic	75119
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12	FK Comb, basic, uncorrected	75108
13	FK Comb first original, then mirrored in Y	75122



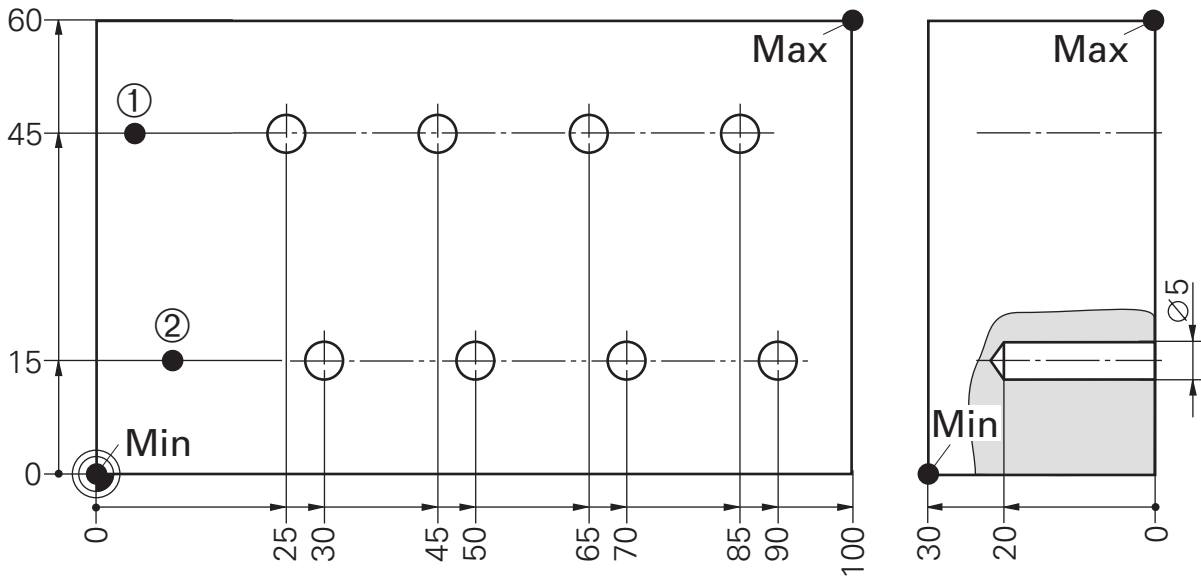
Contents: Advanced course TNC 4xx

No.	Title	PGM-No.
	3D Milling	
14	Toggle joint, 1 tool	761260
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Q-Parameter Programming

No.	Title	PGM-No.
	Milling	
26	Milling a contour with several Z-settings	7285
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29	1 Simple bolt hole circle	7416
30	6 Bolt hole circles, 1 tool	74160
31	6 Bolt hole circles, 3 tools, 3 cycles	74161
32	Linear hole pattern	746910





Program layout:

Conventional preparation

```

    BLK FORM
    TOOL DEF
    TOOL CALL 1 Z S3000

    CYCL DEF 1.0 PECKING

    L X... Y... R0 F9999 M3
    L Z...

    ① CALL LBL 1

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

    ② CALL LBL 1
    
```

Workpiece blank

First tool call

Pecking cycle

Pre-position

Pre-position

Retract tool, end

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

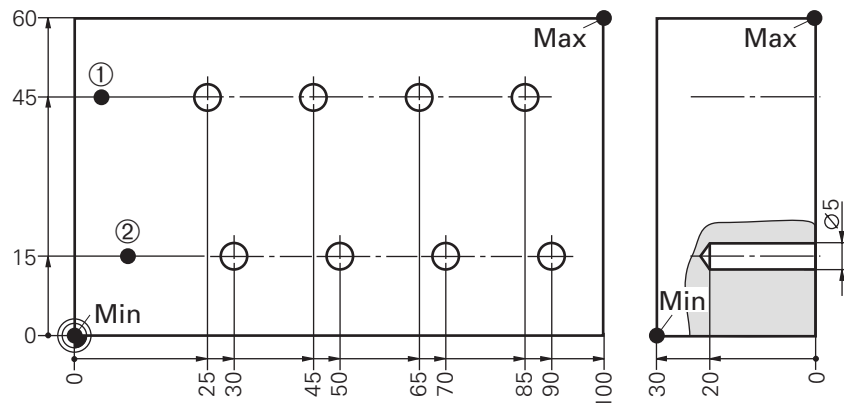
SPGM 1

```

    LBL 1
    L IX+20 M99
    CALL LBL 1 REP 3/3
    LBL 0
    
```

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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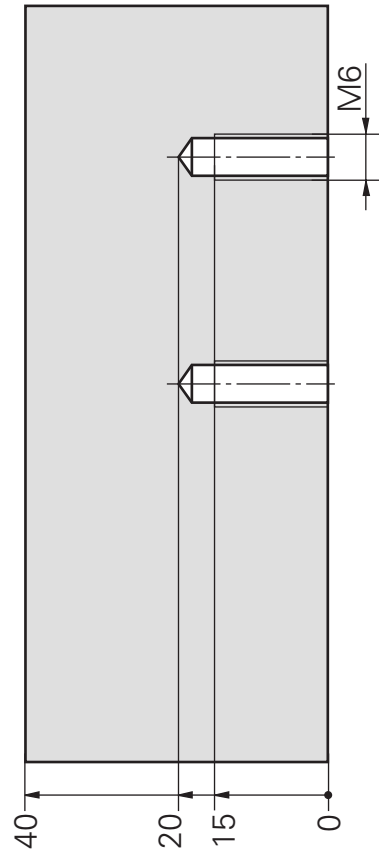
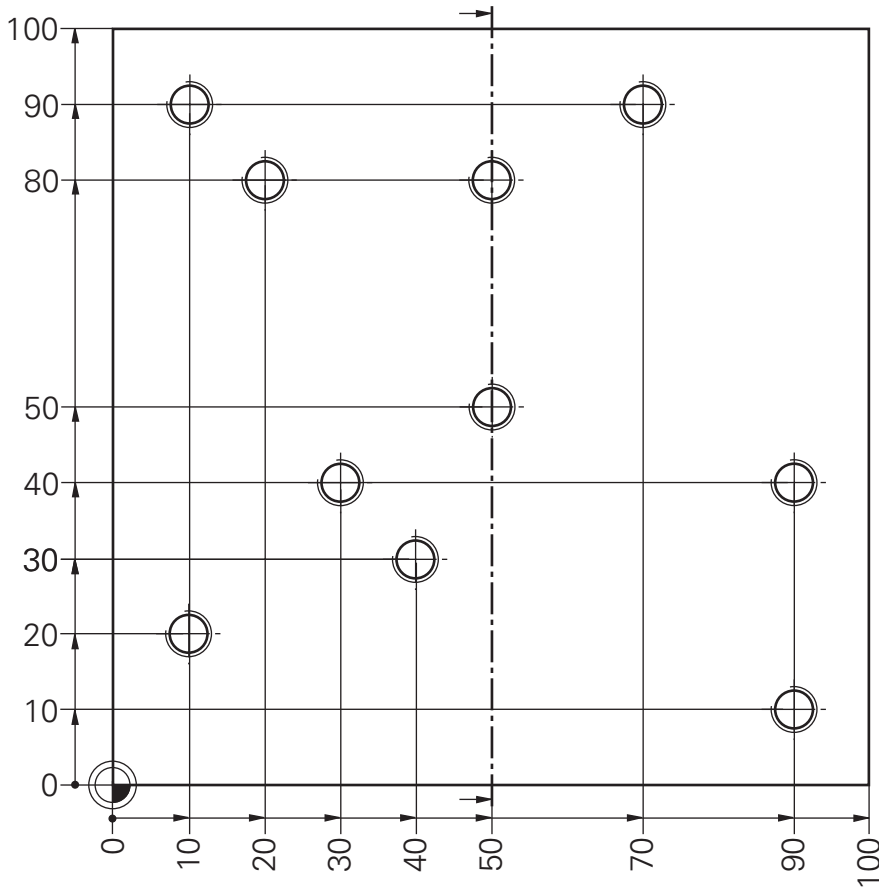
C04



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

Program layout:

Use of Q-parameter for irregular drilling pattern

BLK-FORM

Center

```
TOOL DEF 1 L0 R3,5  
TOOL CALL ...  
Q1 = +2  
Q2 = +3  
  
CYCL DEF ... PECKING  
SET UP -Q1  
DEPTH -Q2 ...
```

Set up
Depth

```
CALL LBL 1
```

Pecking

```
TOOL DEF 2 L0 R2,5  
TOOL CALL ...  
Q2 = 20
```

Cycle type stays the
same!

```
CALL LBL 1
```

Tapping

```
TOOL DEF 3 L0 R3,0  
TOOL CALL ...  
Q1 = 6  
Q2 = 15  
CYCL DEF ... TAPPING  
SET UP -Q1  
DEPTH -Q2 ...
```

```
CALL LBL 1
```

Retract tool, end

```
L Z100 M2
```

Return jump

**Drilling pattern,
SPGM**

```
LBL 1  
  
L X... Y... R0 F9999 M3  
L ZQ1 M89  
L X... Y...  
L X... Y... M99  
L Z50  
  
LBL 0
```



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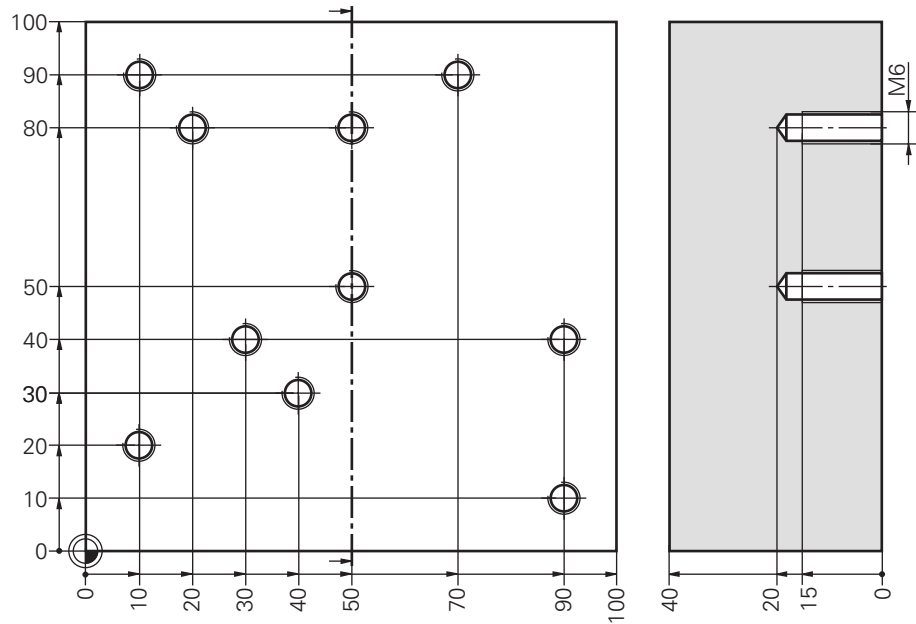
C04



G7

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:

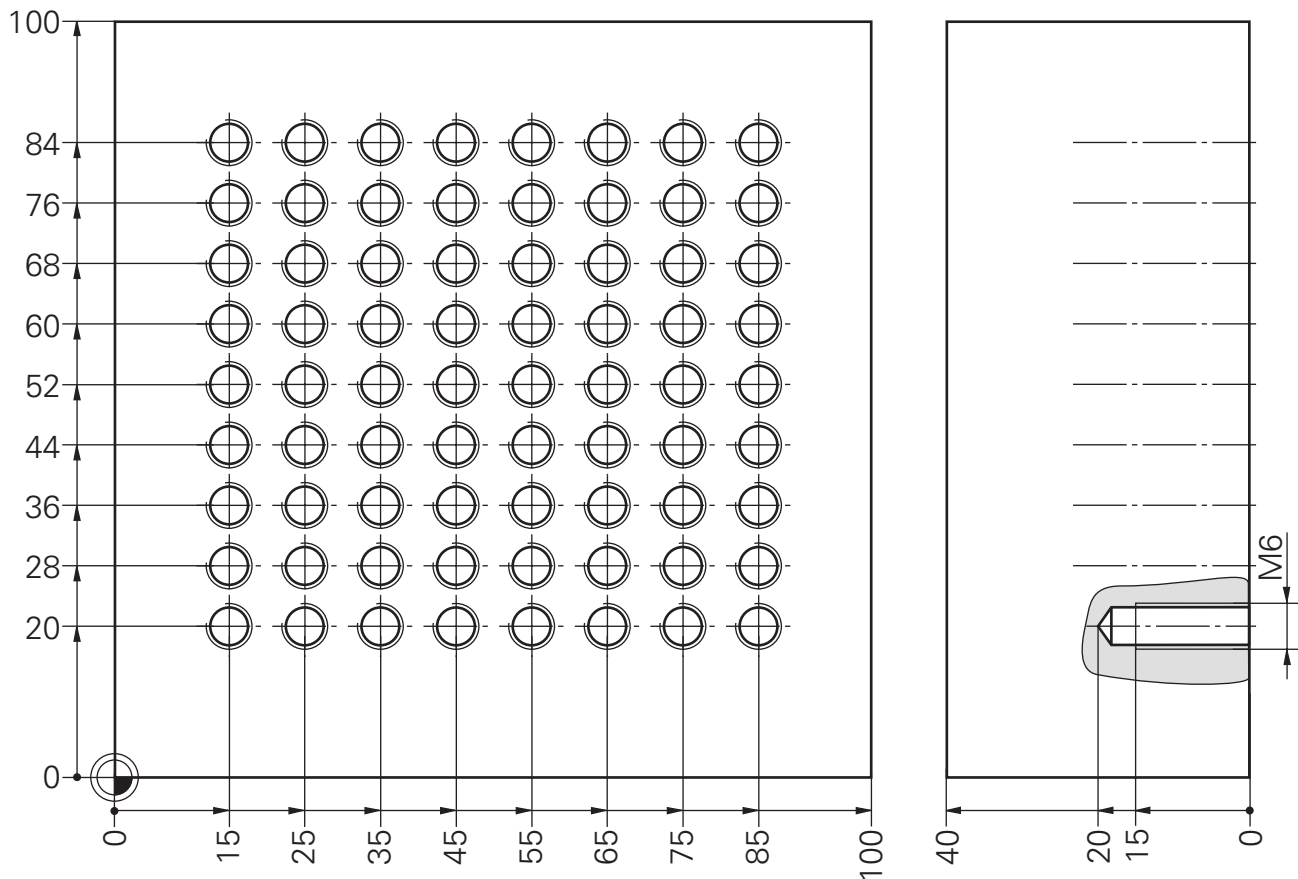
Irregular drilling pattern, with 3 tools and 3 cycles

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
```

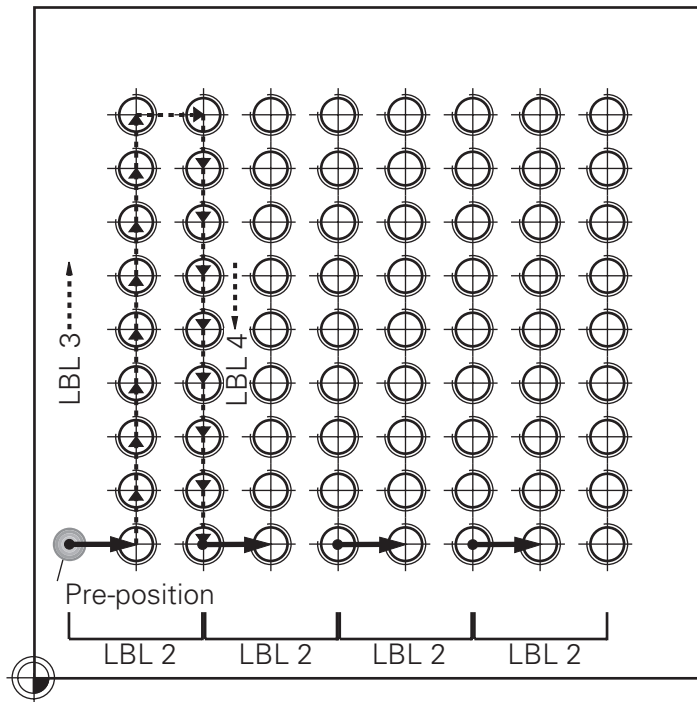
Call drilling pattern

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

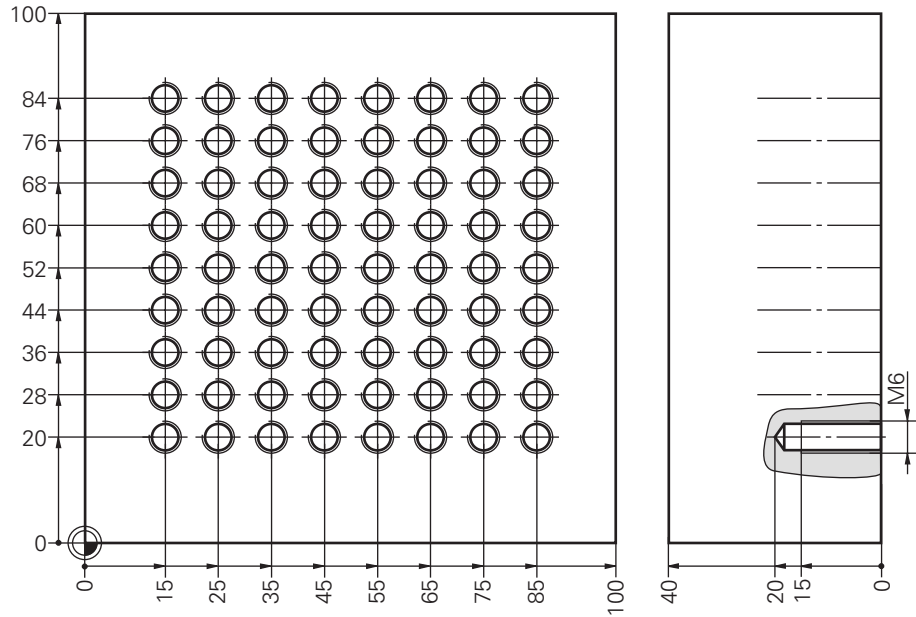
Cross over and drill

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

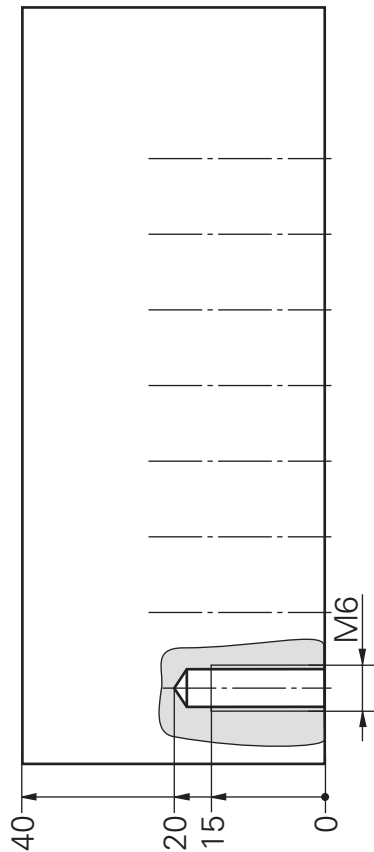
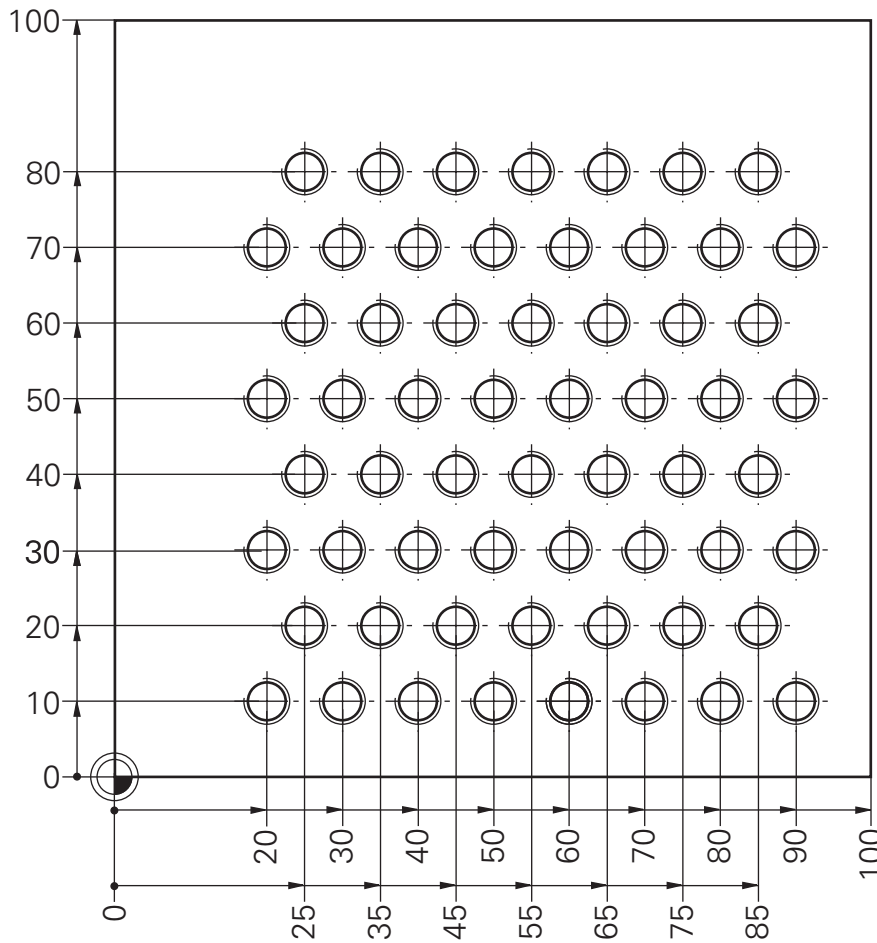
42 LBL 4
43 L IY-8 M99 ..... Y-STEP DOWNWARDS
44 CALL LBL 4 REP 7/7 ..... COLUMN DOWNWARDS

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): _____



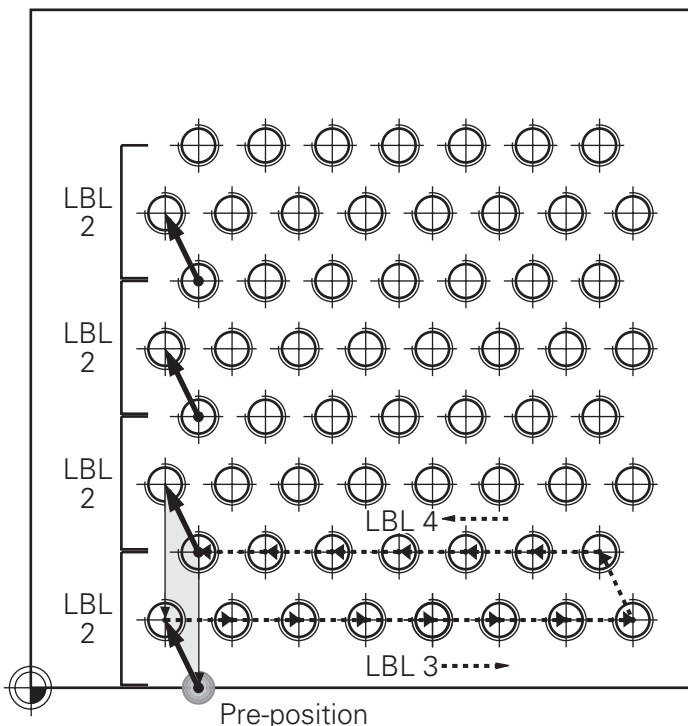
Procedure: • Move back and forth along rows (meandering)

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
```



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C05







7426/2

Program layout:

Linear offset hole pattern, including tapping

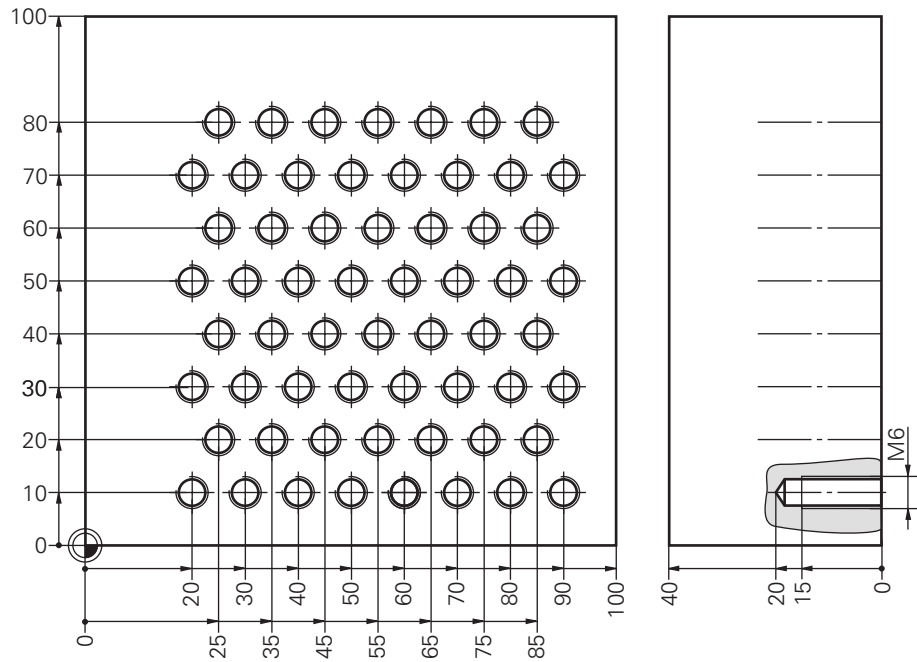
**Drilling pattern,
SPGM 1**

<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

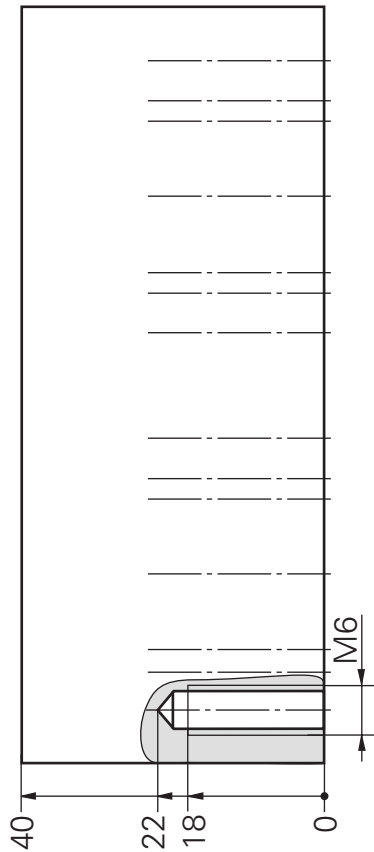
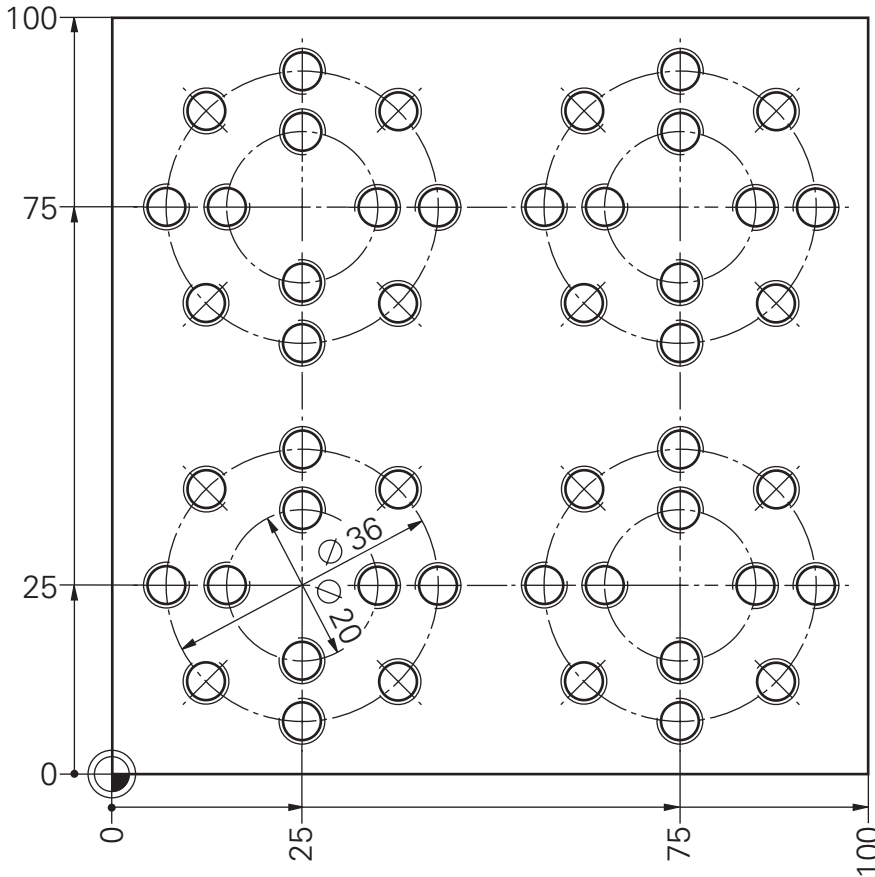
45 CALL LBL 2 REP 3/3 ..... REMAINING ROWS

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

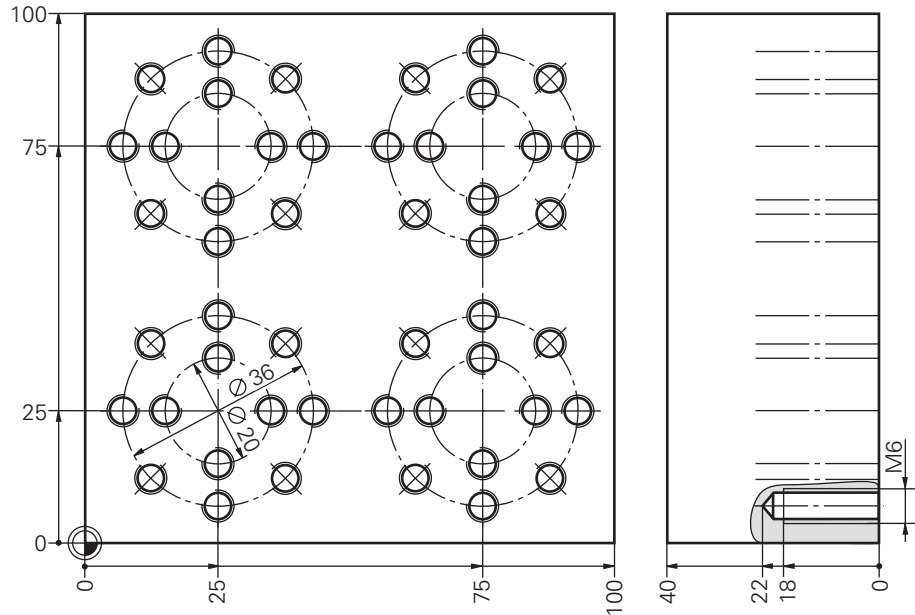
Label

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

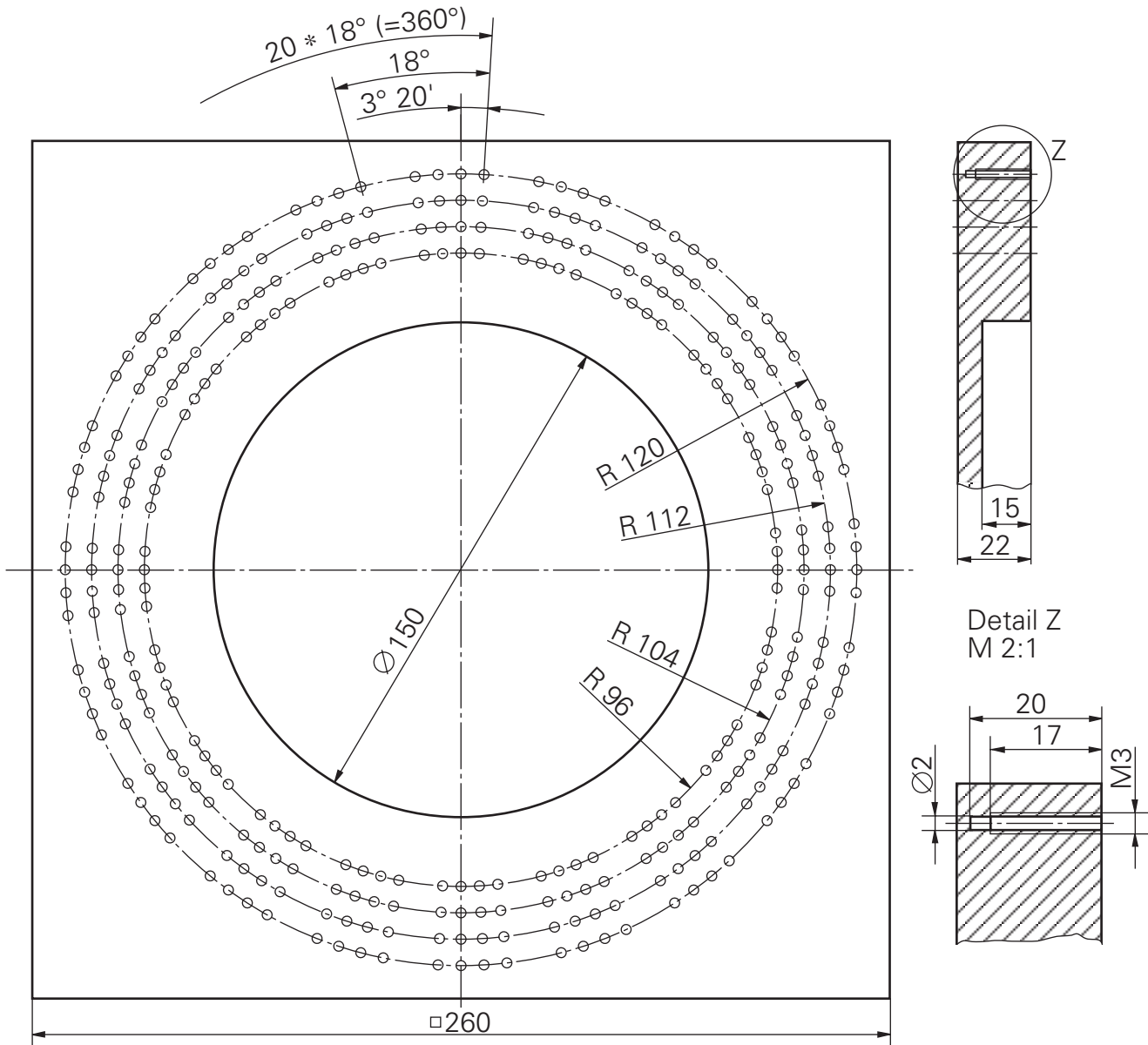
49 LP PR+18 PA+180 M99 OUTER CIRCLE

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

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

Workpiece blank
Tool list if necessary

**Process
Center**

```
TOOL 1... (R 2,0)
CYCL DEF, DEPTH = PECKG
CALL LBL 1
... M6
```

Pecking cycle
Call drilling pattern
Tool change

Pecking

```
TOOL 2... (R 1,0)
CYCL DEF
CALL LBL 1
... M6
```

Pecking cycle
Call drilling pattern
Tool change

Tapping

```
TOOL 3... (R 1,5)
CYCL DEF
CALL LBL 1
... M6
```

Tapping cycle
Call drilling pattern
Tool change

Mill large holes

```
TOOL 4... (R 30)
CYCL DEF
L X... Y...
L Z... M99
```

Circular pocket-cycle
Starting position and
cycle call

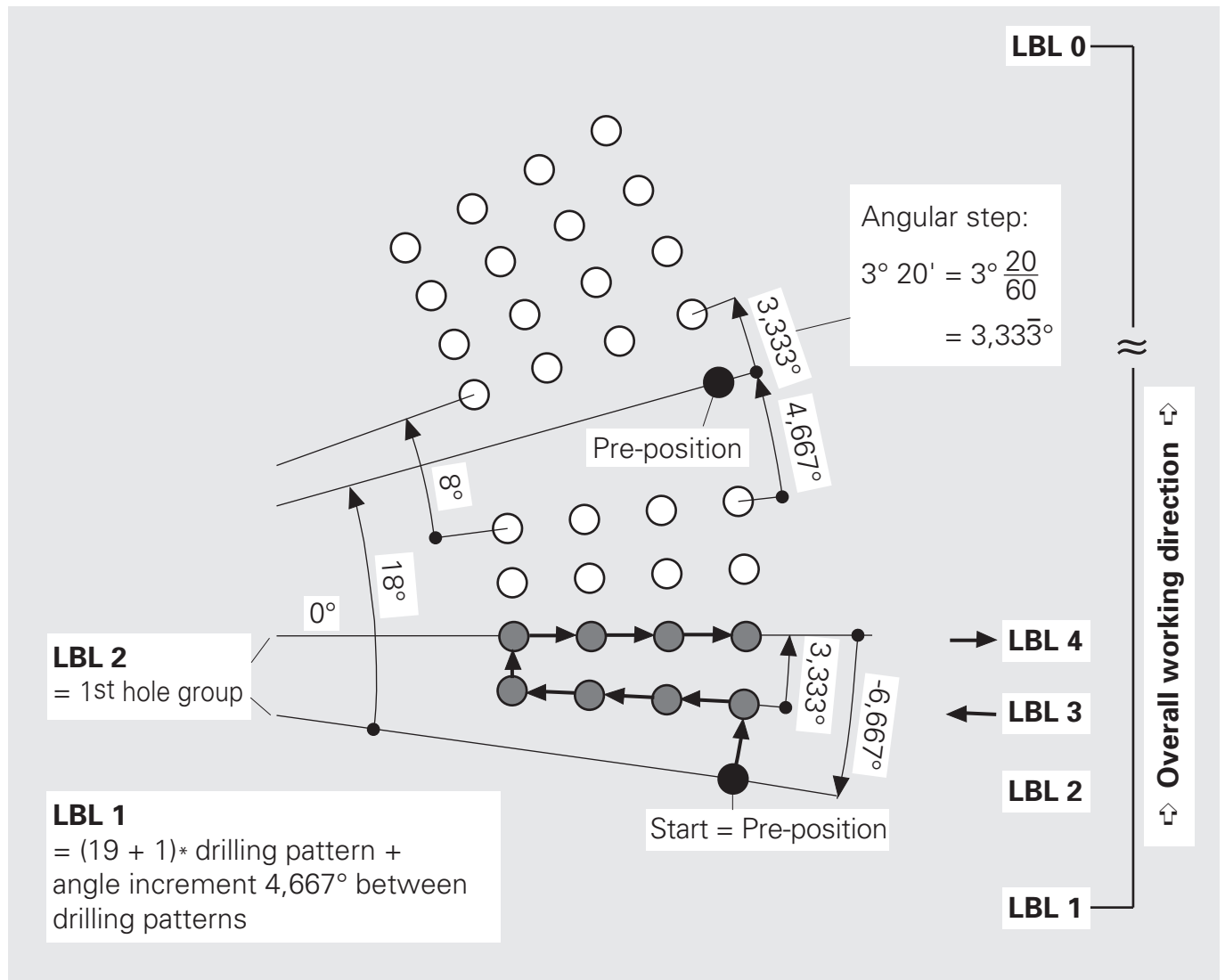
Retract tool, end

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



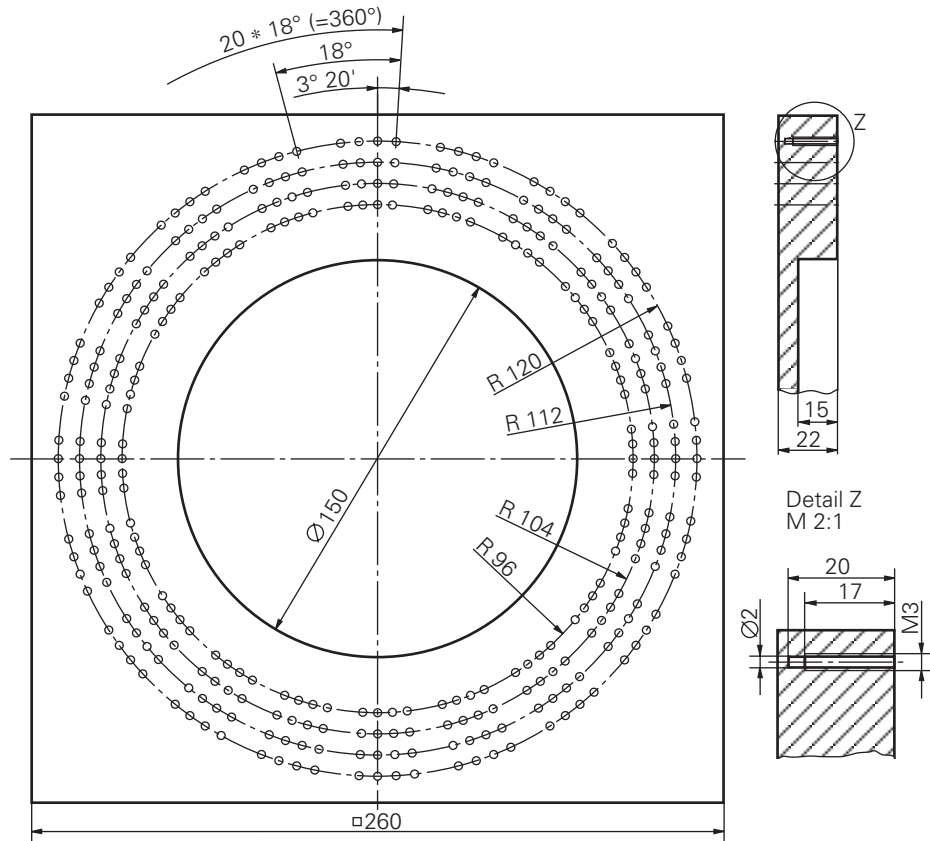
**Drilling pattern,
SPGM 1**

<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

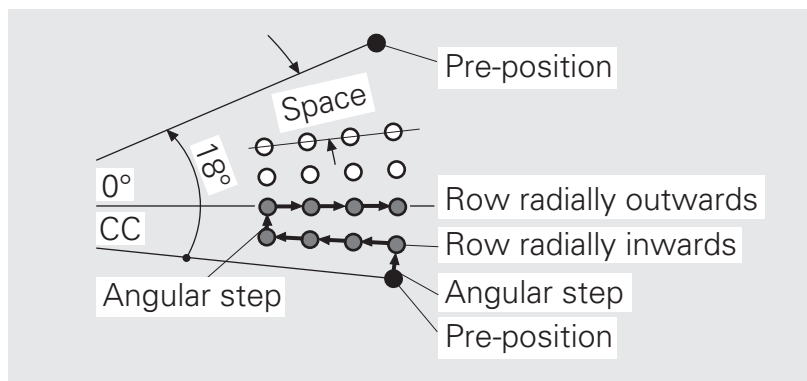
49 LBL 3
50 LP IPR-8 M99
51 CALL LBL 3 REP 2/2 ..... ROW RADIALLY INWARDS

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

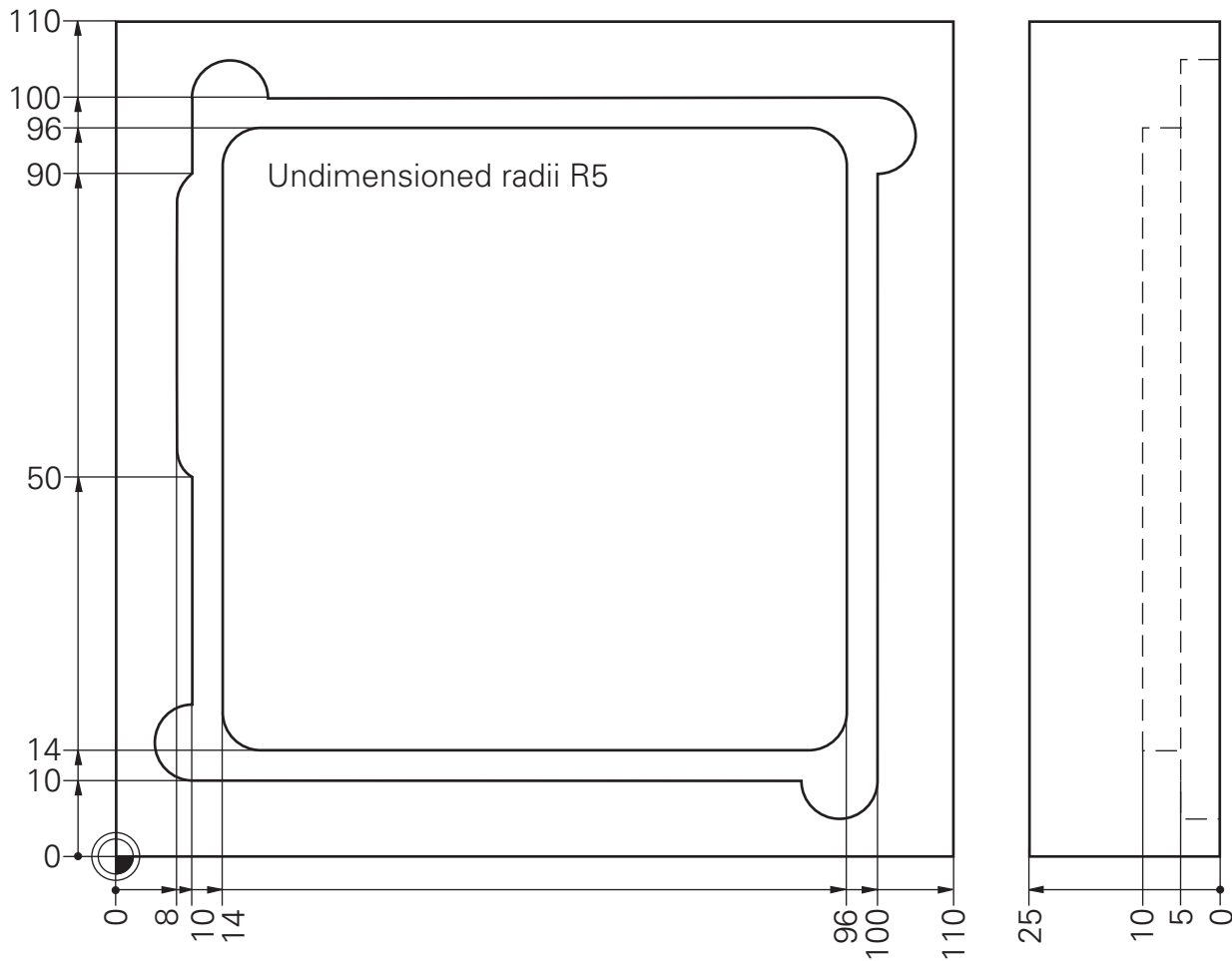
56 CALL LBL 2 REP 1/1 ..... FURTHER DOUBLE ROWS

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



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C04



72810/1

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

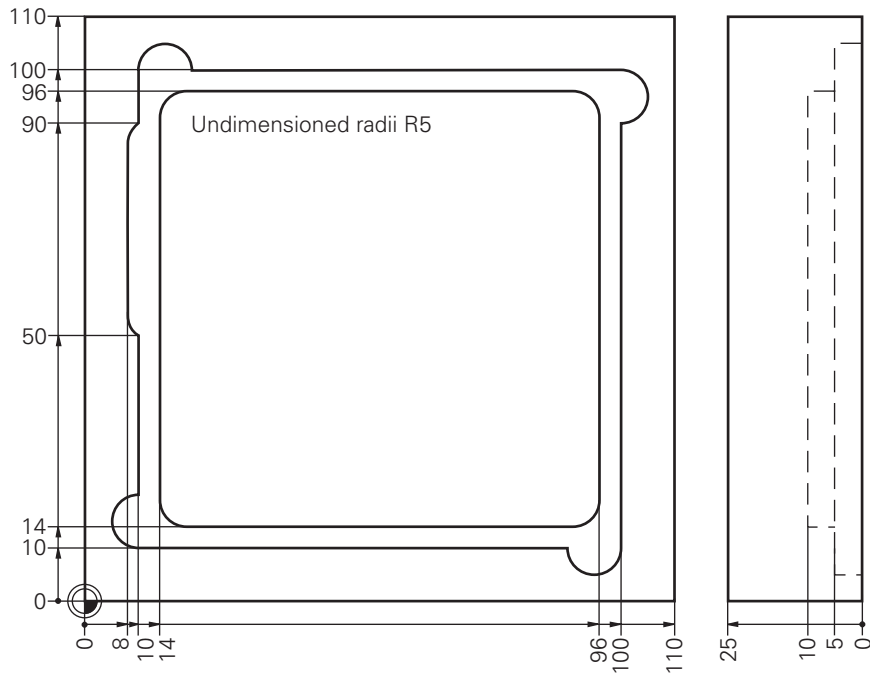
```
L Z... .. M2
```

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
```



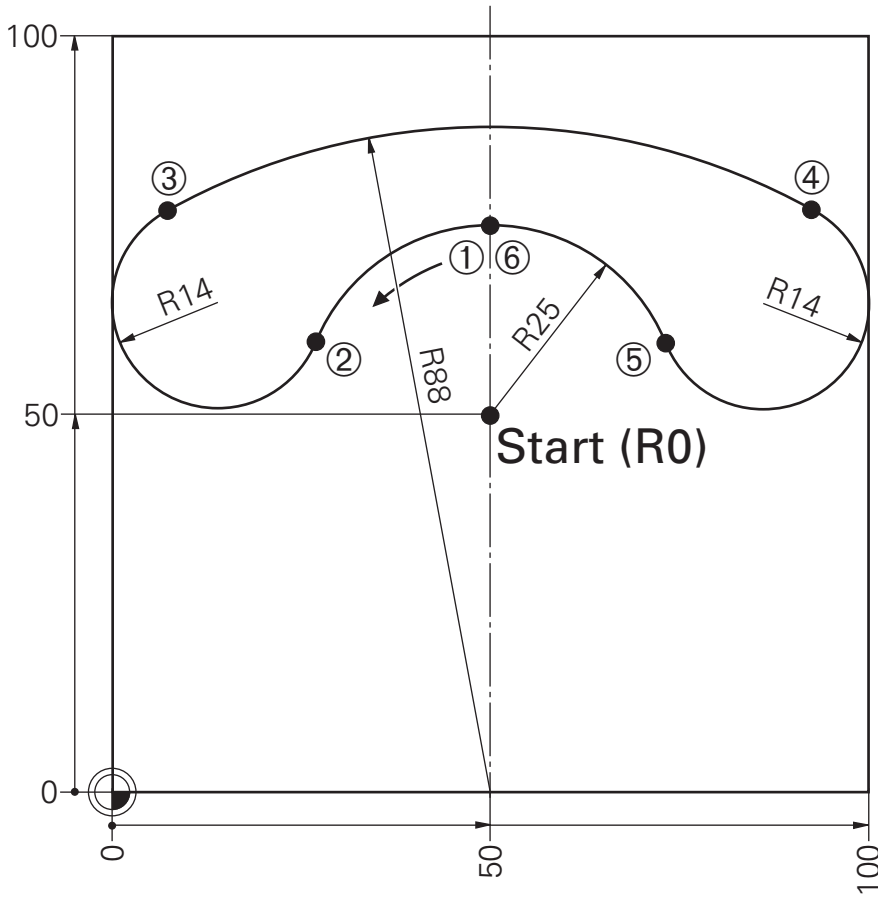
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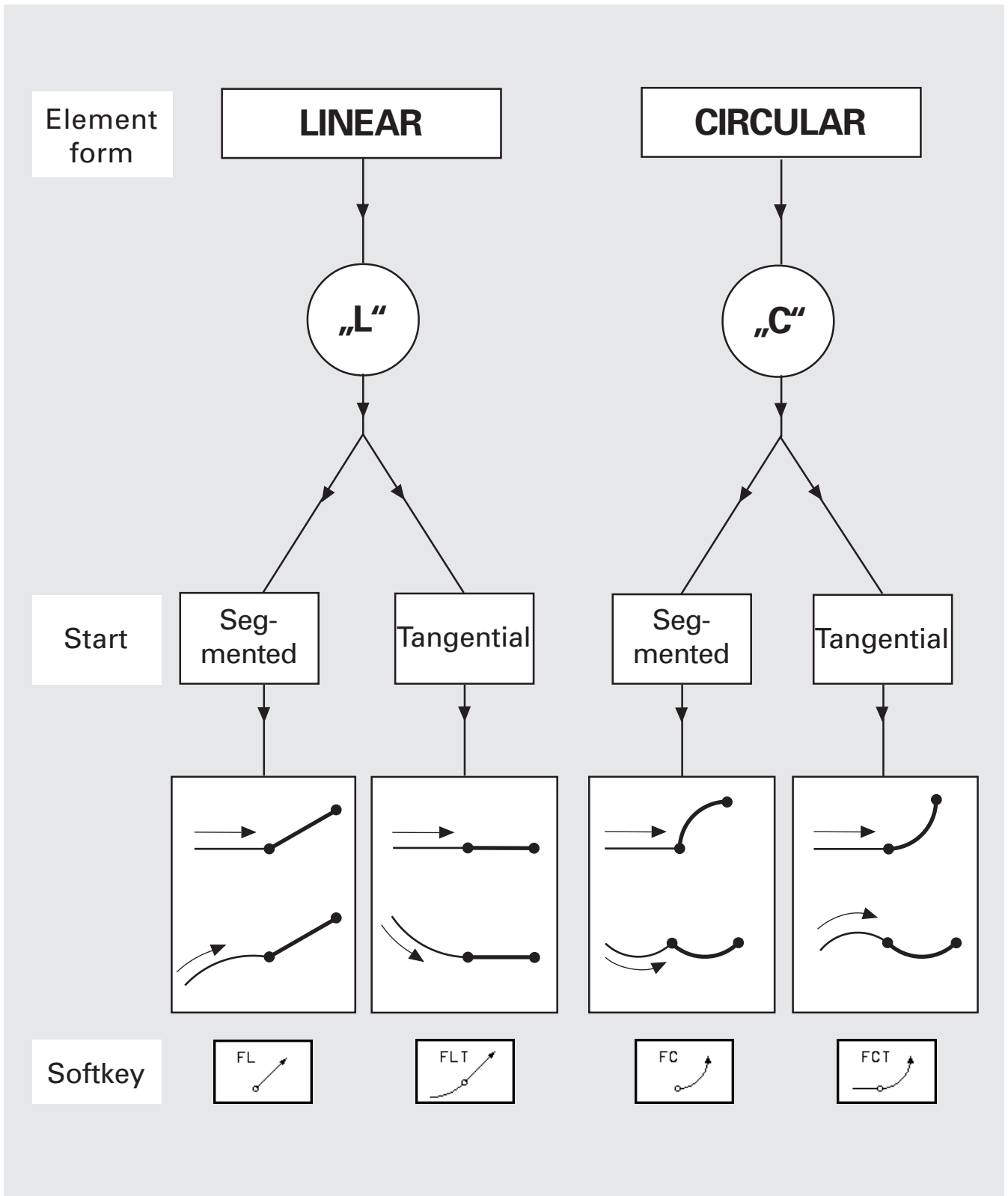
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C01



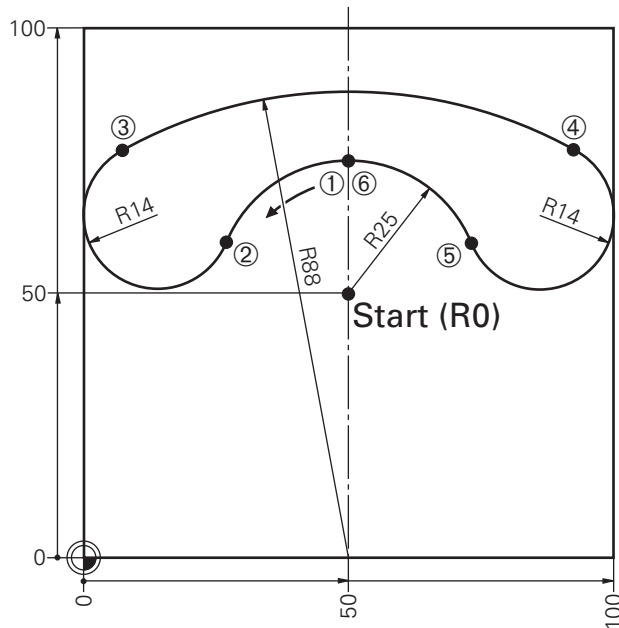
72810/3





Solution:

FK Telephone



FK Program

```

0 BEGIN PGM 75103 MM
1 BLK FORM 0.1 Z X+0 Y+50 Z-20
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+10
4 TOOL CALL 1 Z S2800
5 L X+50 Y+50 R0 F9999 M13
6 L Z-5 F100
7 L X+50 Y+75 RL .....①
8 RND R5 F100

9 FC DR+ R25 CCX+50 CCY+50 F500 .....②
10 FCT DR- R14 .....③
11 FCT DR- R88 CCX+50 CCY+0 .....④
12 FCT DR- R14 .....⑤
13 FCT X+50 Y+75 DR+ R25 CCX+50 CCY+50 .....⑥
14 FSELECT 2

15 RND R5 F100
16 L X+50 Y+50 R0 M9

17 L Z+10
18 END PGM 75103 MM
    
```

Converted Program

```

0 BEGIN PGM BOGEN MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-20
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3
4 TOOL CALL 1 Z S2800
5 L X+50 Y+50 R0 F9999 M13
6 L Z-5 F100
7 L X+50 Y+75 RL
8 RND R5 F100

9 CC X+50 Y+50
10 C X+26,805 Y+59,3269 DR+
11 CC X+13,8158 Y+64,55
12 C X+6,9701 Y+76,7622 DR-
13 CC X+50 Y+0
14 C X+93,0299 Y+76,7622 DR-
15 CC X+86,1842 Y+64,55
16 C X+73,195 Y+59,3269 DR-
17 CC X+50 Y+50
18 C X+50 Y+75 DR+

19 RND R5 F100
20 L X+50 Y+50 R0 M9

21 L Z+10
22 END PGM BOGEN MM
    
```



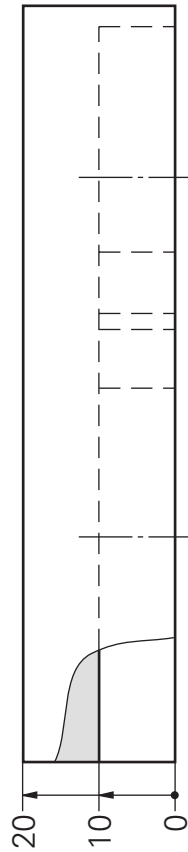
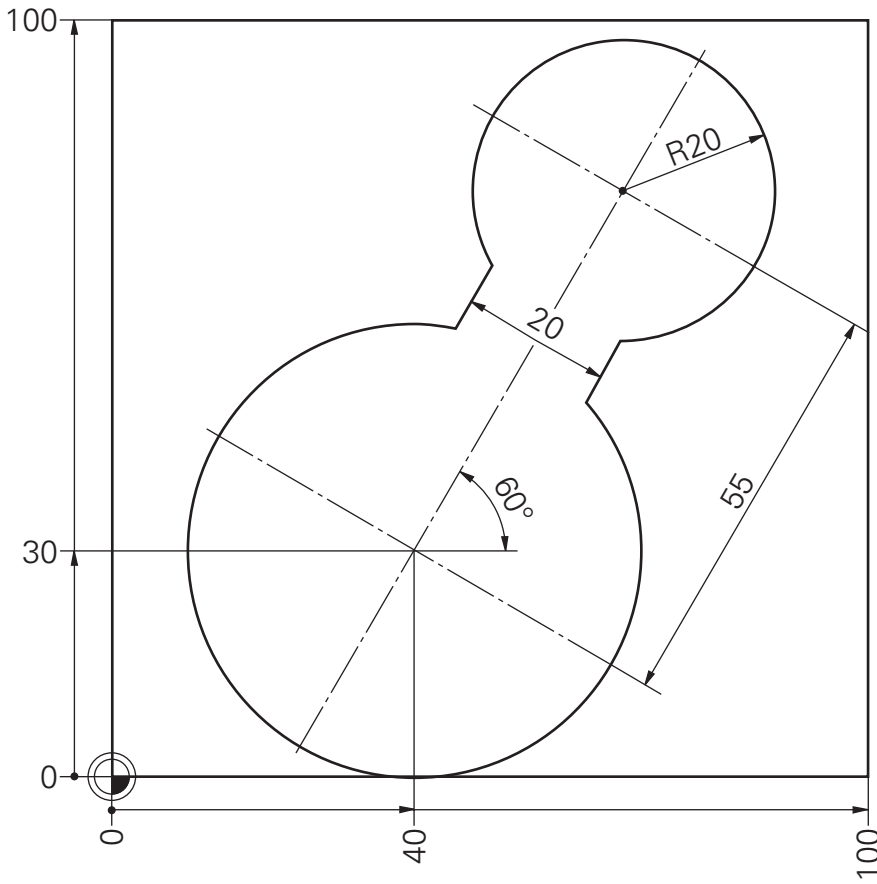
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C01

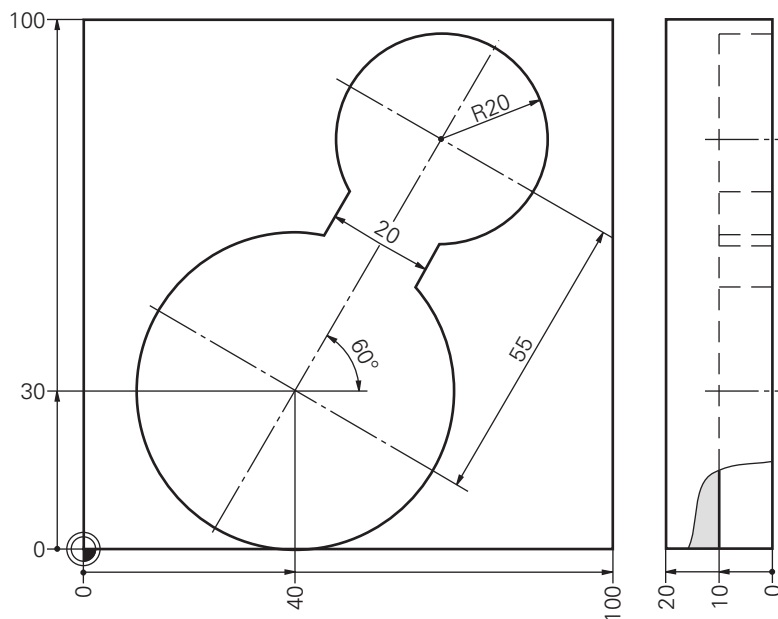


75103/2



Solution:

FK Dumbbell



```
0 BEGIN PGM 75116 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-20
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+4
4 TOOL CALL 1 Z S4000
5 L Z+2 R0 F MAX M3
6 L X+40 Y+30 R0 F2000
7 L Z-10 F100
8 L X+10 Y+30 RR F200
9 FPOL X+40 Y+30
10 FC DR- R30 CCX+40 CCY+30 F500
11 FL AN+60 PDX+40 PDY+30 D10
12 FSELECT 3
13 FC DR- R20 CCPR+55 CCPA+60
14 FSELECT 2
15 FL AN-120 PDX+40 PDY+30 D10
16 FSELECT 3
17 FC X+10 Y+30 DR- R30 CCX+40 CCY+30
18 FSELECT 2
19 L X+40 Y+30 R0
20 L Z+50 R0 F MAX M2
21 END PGM 75116 MM
```



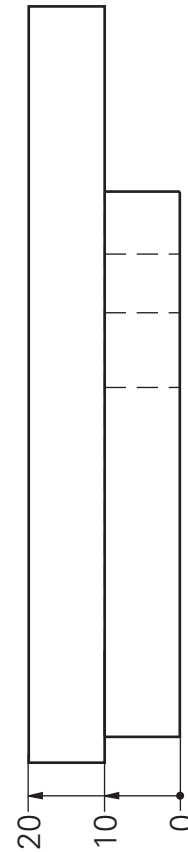
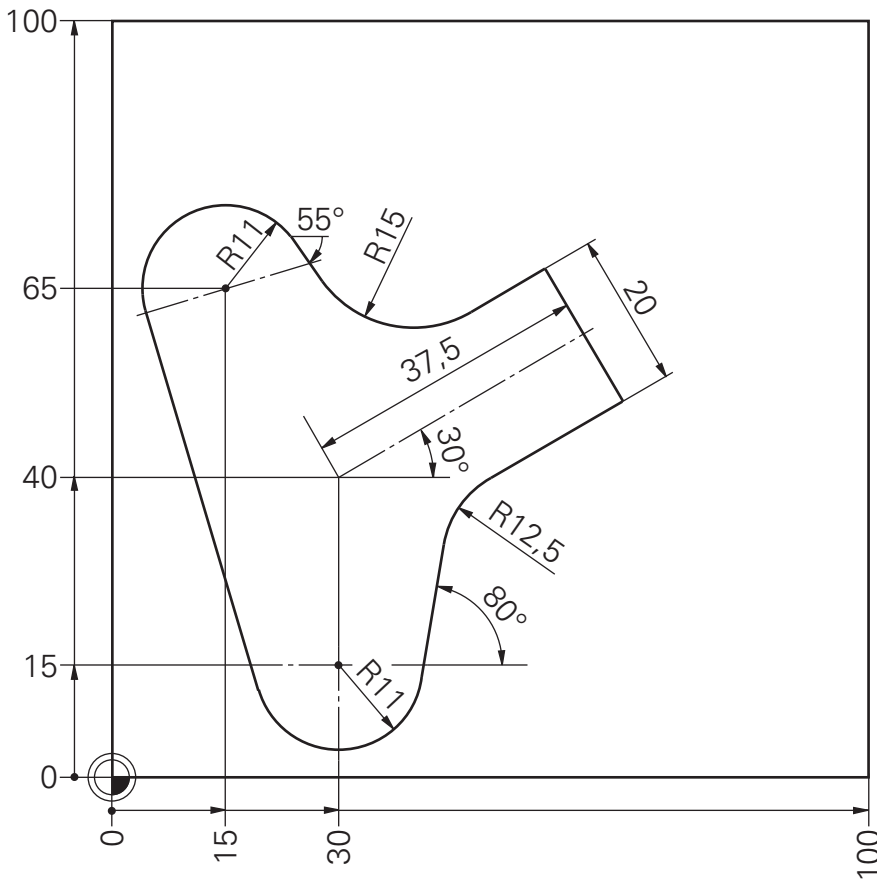
HEIDENHAIN

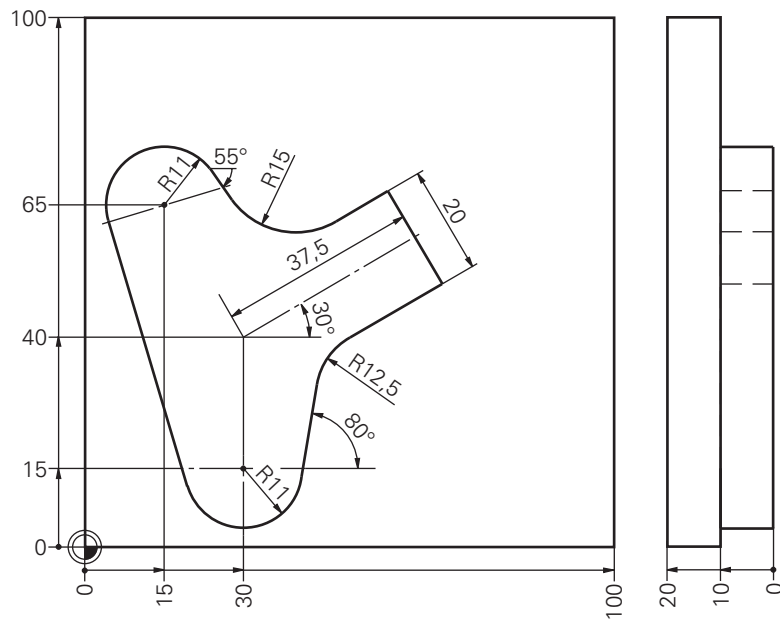
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C01



75116/2

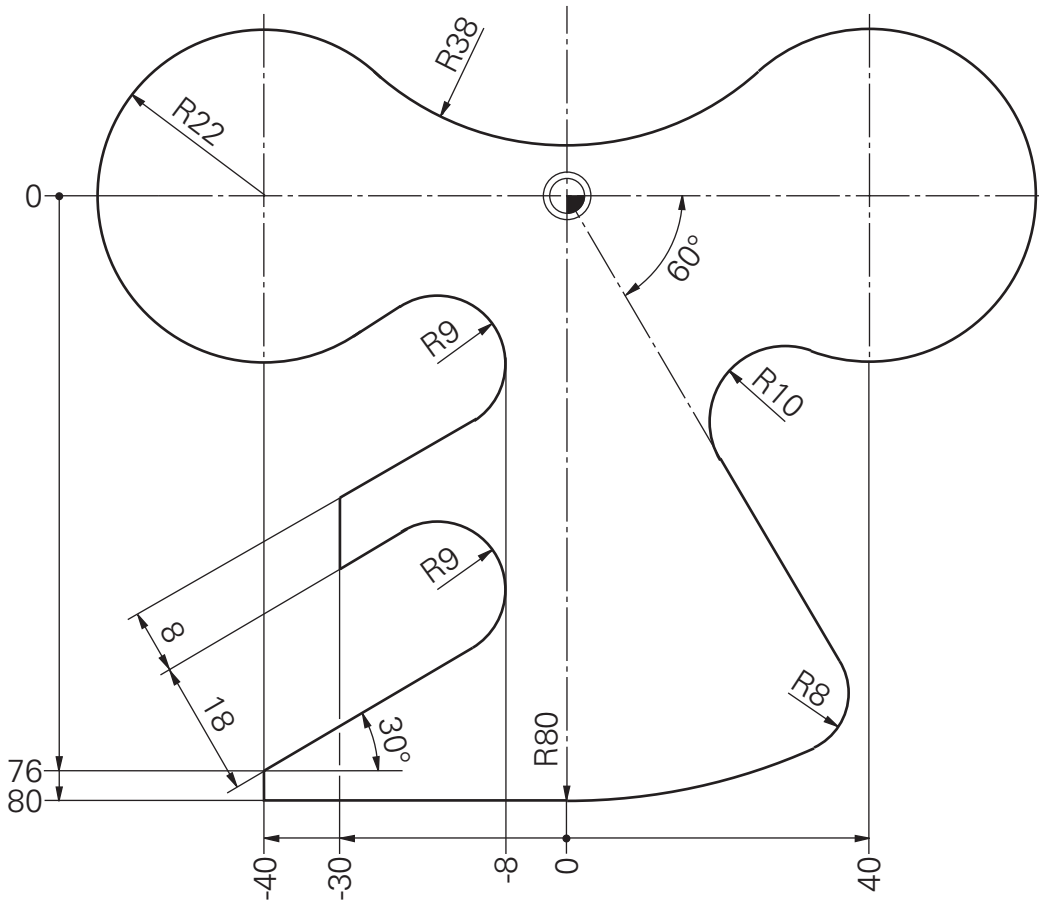




```

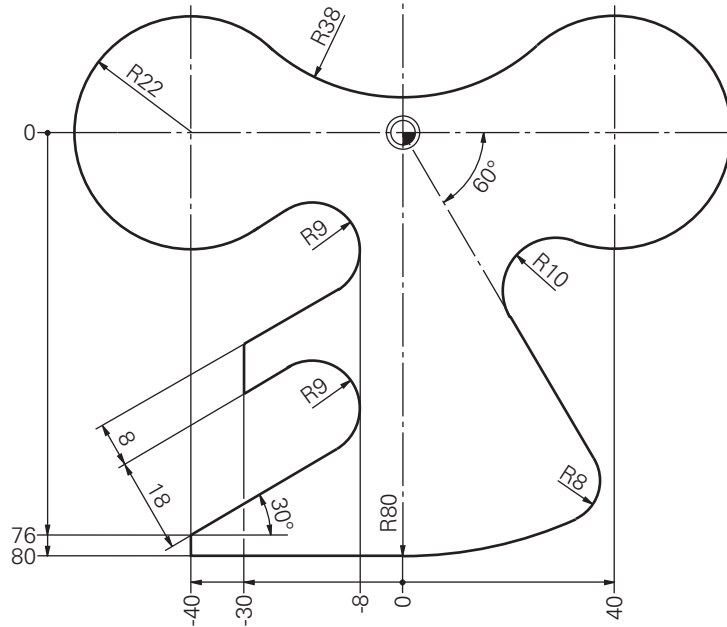
0 BEGIN PGM 75119 MM
1 BLK FORM 0.1 Z X+0 Y+0 Z-20
2 BLK FORM 0.2 X+100 Y+85 Z+0
3 TOOL DEF 1 L+0 R+5
4 TOOL CALL 1 Z S4000
5 L Z+50 R0 F MAX M6
6 L X+80 Y+70 F MAX M3
7 L Z-10 F100
8 CC X+30 Y+40
9 LP PR+37,5 PA+30 RL F500
10 FL LEN10 AN-60
11 FL AN-150
12 FCT DR+ R12,5
13 FLT AN-100
14 FCT DR- R11 CCX+30 CCY+15
15 FLT PDX+15 PDY+65 D11
16 FSELECT 1
17 FCT DR- R11 CCX+15 CCY+65
18 FLT AN-55
19 FCT DR+ R15
20 FPOL X+30 Y+40
21 FLT AN+30 PDX+30 PDY+40 D10
22 FSELECT 2
23 FL PR+37,5 PA+30 IAN+90
24 L X+80 Y+70 R0 F500
25 L Z+50 R0 F MAX M2
26 END PGM 75119 MM

```

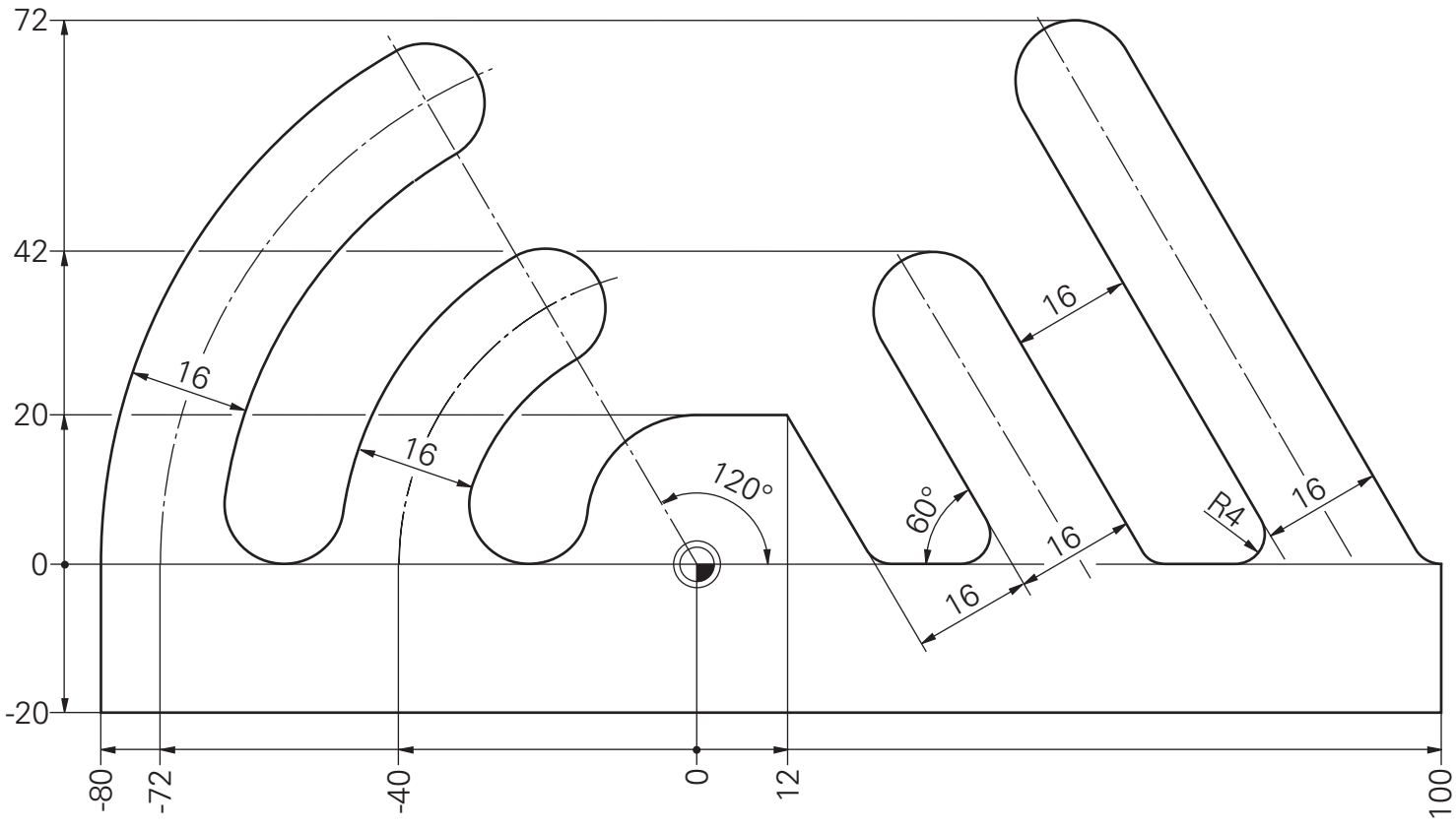


Solution:

FK Mickey Mouse

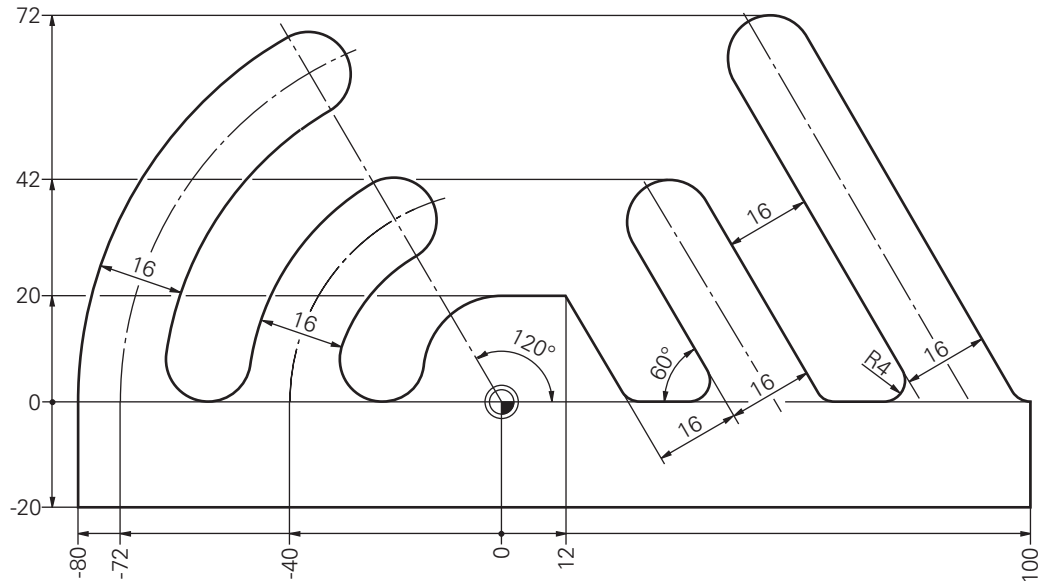


```
0 BEGIN PGM 71750 MM
1 ..... MICKEY
2 BLK FORM 0.1 Z X-70 Y-90 Z-12
3 BLK FORM 0.2 X+70 Y+30 Z+0
4 TOOL DEF 1 L+0 R+5
5 TOOL CALL 1 Z S2500
6 L Z+10 R0 F9999 M3
7 L X-62 Y+0 RL
8 L Z-10 F150
9 FC DR- R22 CLSD+ CCX-40 CCY+0
10 FCT DR+ R38 CCX+0
11 FSELECT 1
12 FCT DR- R22 CCX+40 CCY+0
13 FCT DR+ R10
14 FLT AN-60 PDX+0 PDY+0 D0
15 FSELECT 3
16 FCT DR- R8
17 FCT X+0 Y-80 DR- R80 CCX+0 CCY+0
18 FLT X-40 AN+180
19 FL AN+90
20 FL AN+30
21 FCT DR+ R9 CCX-17
22 FLT X-30 PAR21 DP18
23 FSELECT 2
24 FL AN+90
25 FL PAR23 DP8
26 FSELECT 2
27 FCT DR+ R9 CCX-17
28 FCT X-62 Y+0 DR- R22 CLSD- CCX-40 CCY+0
29 FSELECT 2
30 L Z+10 F9999 M2
31 END PGM 71750 MM
```



Solution:

FK Comb



```
0 BEGIN PGM 75108 MM
1 BLK FORM 0.1 Z X-80 Y-10 Z-20
2 BLK FORM 0.2 X+100 Y+100 Z+0
3 TOOL DEF 1 L+0 R+3,5
4 TOOL CALL 1 Z S1000
5 L X-100 Y+0 R0 F MAX M3
6 L Z-20 F MAX
7 L X-80 Y+0 RL F600
8 FPOL X+0 Y+0
9 FC DR- R80 CCX+0 CCY+0
10 FCT DR- R8 CCPR+72 CCPA+120
11 FCT DR+ R64 CCX+0 CCY+0
12 FCT DR+ R8 CCY+8
13 FSELECT 2
14 FCT DR- R48 CCX+0 CCY+0
15 FCT DR- R8 CCPR+40 CCPA+120
16 FCT DR+ R32 CCX+0 CCY+0
17 FCT DR+ R6 CCY+6
18 FSELECT 2
19 FCT X+0 Y+20 DR- R20 CCX+0 CCY+0
20 FLT X+12 Y+20
21 FL AN-60
22 FCT Y+0 DR+ R4
23 FLT AN+0
24 FCT DR+ R4
25 FLT AN+120 PAR21 DP16
26 FCT DR- R8 CCY+34
27 FLT AN-60 PAR25 DP16
28 FCT Y+0 DR+ R4
29 FLT Y+0 AN+0
30 FCT DR+ R4
31 FLT AN+120 PAR27 DP16
32 FCT DR- R8 CCY+64
33 FLT AN-60 PAR31 DP16
34 FCT X+100 Y+0 DR+ R4
35 FSELECT 2
36 FL X+100 Y-20
37 FL X-80 Y-20
38 FL X-80 Y+0
39 END PGM 75108 MM
```



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C05



75108/2

Program layout: **FK Comb first as island and then mirrored in Y with SL I roughing**

Preparation	<i>BLK FORM</i>	
	<i>TOOL 1...</i>	
Listing	<i>CYCL DEF 14 LABEL 1/2</i>	Part contours
Machining cycle	<i>CYCL DEF 6 ROUGH OUT</i>	
	<i>L X... Y... R0 F9999 M3</i>	
Execution	<i>L Z... M99</i>	Upper half
	<i>CYCL DEF 7 DATUM SHIFT</i>	
	<i>X0 Y-...</i>	
	<i>CYCL DEF 8 MIRROR IMAGE Y</i>	
	<i>CYCL CALL</i>	Y-values mirrored in lower half
Retract tool, end	<i>L Z20 F9999 M2</i>	

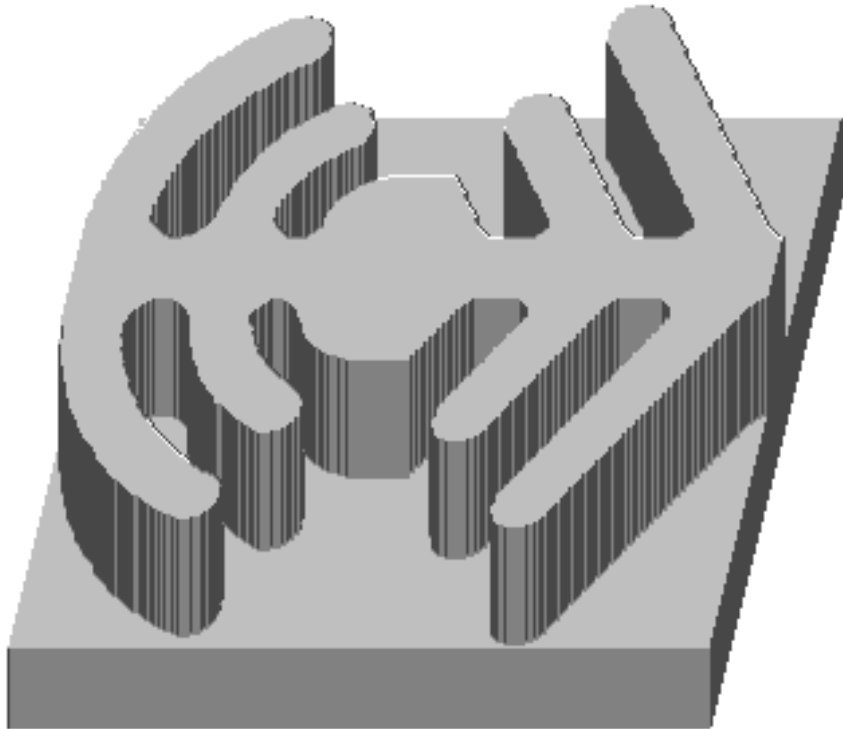
SPGM, part contours	<i>LBL 1</i>	Original island
	<i>L X... Y... RL</i>	
	<i>⋮</i>	
	<i>LBL 0</i>	

<i>LBL 2</i>	Original pocket
<i>L X... Y... RR</i>	
<i>⋮</i>	
<i>LBL 0</i>	



Solution:

FK Comb first as island and then mirrored in Y



Main program

```
0 BEGIN PGM 75122 MM
1 BLK FORM 0.1 Z X-80 Y-95 Z-50
2 BLK FORM 0.2 X+100 Y+75 Z+0
3 TOOL DEF 1 L+0 R+3
4 TOOL CALL 1 Z S200
5 CYCL DEF 14.0 CONTOUR
6 CYCL DEF 14.1 CONTOUR LABEL 1/2
7 CYCL DEF 6.0 ROUGH OUT
8 CYCL DEF 6.1 SET UP -2 DEPTH -30
9 CYCL DEF 6.2 PECKG -10 F100 ALLOW +0
10 CYCL DEF 6.3 ANGLE +0 F200
11 L X-100 Y+0 R0 F MAX M3
12 L Z+2 F9999 M99
13 CYCL DEF 7.0 DATUM SHIFT
14 CYCL DEF 7.1 X+0
15 CYCL DEF 7.2 Y-20
16 CYCL DEF 8.0 MIRROR IMAGE
17 CYCL DEF 8.1 Y
18 CYCL CALL

19 CYCL DEF 8.0 MIRROR IMAGE
20 CYCL DEF 8.1
```

Retract tool, End

```
21 L Z+20 F MAX M2
```



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C01



75122/3

Solution:

FK Comb first as island and then mirrored in Y

SPGM

```
22 LBL 1
23 L X-80 Y+0 RL
24 FPOL X+0 Y+0
25 FC DR- R80 CCX+0 CCY+0
26 FCT DR- R8 CCPR+72 CCPA+120
27 FCT DR+ R64 CCX+0 CCY+0
28 FCT DR+ R8 CCY+8
29 FSELECT 2
30 FCT DR- R48 CCX+0 CCY+0
31 FCT DR- R8 CCPR+40 CCPA+120
32 FCT DR+ R32 CCX+0 CCY+0
33 FCT DR+ R6 CCY+6
34 FSELECT 2
35 FCT X+0 Y+20 DR- R20 CCX+0 CCY+0
36 FLT X+12 Y+20
37 FL AN-60
38 FCT Y+0 DR+ R4
39 FLT AN+0
40 FCT DR+ R4
41 FLT AN+120 PAR37 DP16
42 FCT DR- R8 CCY+34
43 FLT AN-60 PAR41 DP16
44 FCT Y+0 DR+ R4
45 FLT Y+0 AN+0
46 FCT DR+ R4
47 FLT AN+120 PAR43 DP16
48 FCT DR- R8 CCY+64
49 FLT AN-60 PAR47 DP16
50 FCT X+100 Y+0 DR+ R4
51 FSELECT 2
52 FL X+100 Y-20
53 FL X-80 Y-20
54 FL X-80 Y+0
55 LBL 0

56 LBL 2
57 L X-90 Y-20 RR
58 L Y+100
59 L X+120
60 L Y-20
61 L X-90
62 LBL 0
63 END PGM 75122 MM
```



HEIDENHAIN

Advanced course TNC 4xx

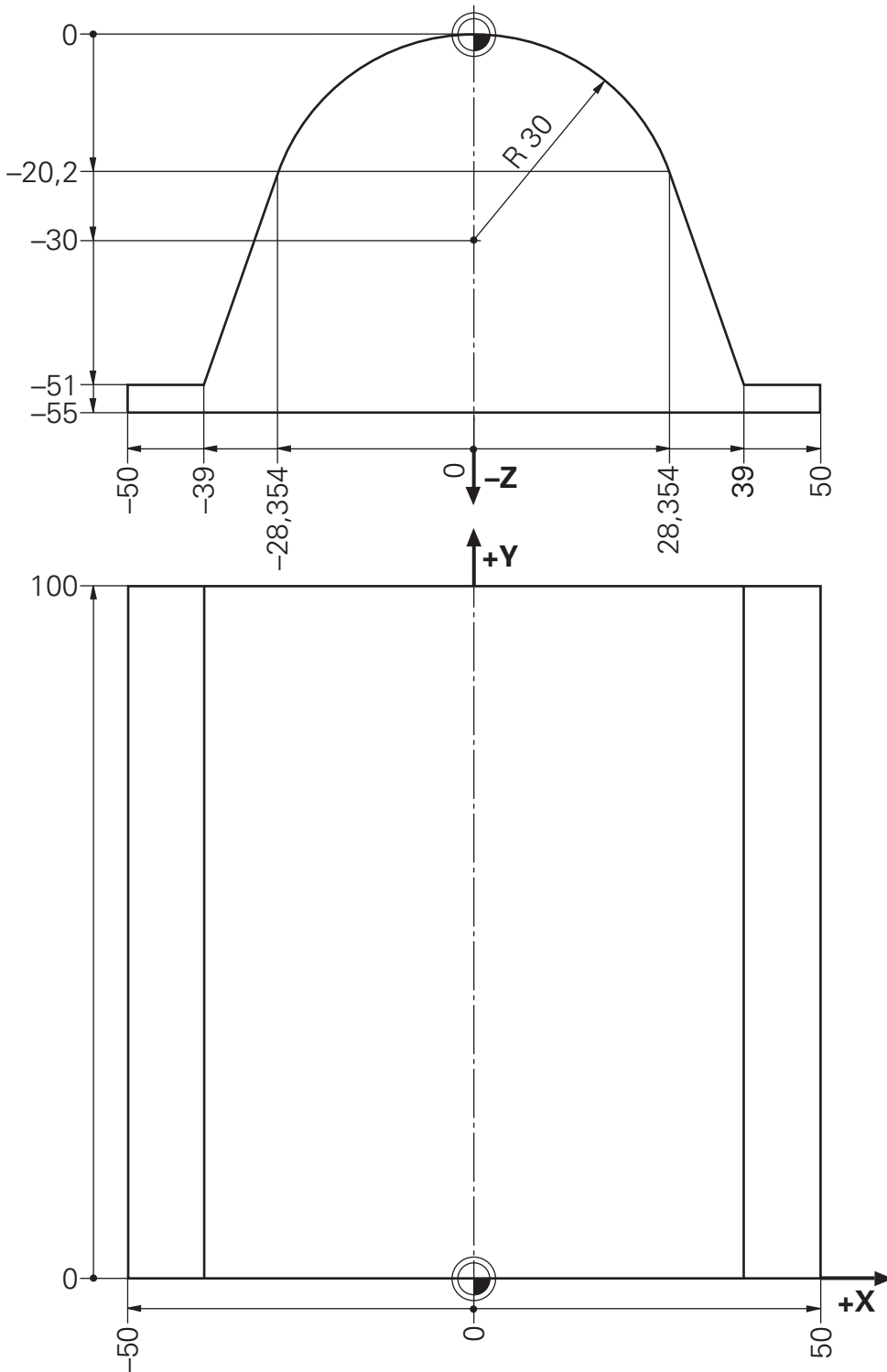
C05



75122/4

Task: **Toggle joint**

Program(s): _____



- Procedure:**
- 2½ D-cut in Z/X
 - Setting in Y

- Tools:**
- End mill R10 for roughing-out
 - End mill R10 for finishing

Program layout:

Toggle joint with 1 tool, constant climb-cut

Preparation

Roughing-out

```
BLK FORM
TOOL DEF ... R10
TOOL 2 ...
L Z50 R0 F ... M3
CYCL DEF 7.0 DATUM SHIFT
CYCL DEF 7.1 X+Q108 Y0 / Z0
```

```
CALL LBL 1
```

Right

```
CYCL DEF 7.0 DATUM SHIFT
CYCL DEF 7.1 X-Q108 Y100 / Z0
CYCL DEF 10.0 ROT180
```

```
CALL LBL 1
```

Left

Retract tool, end

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

Contour Z/X, SPGM

```
LBL 1
```

```
L X+55 Y-4 R0 F ... M3
L Z ...
```

Starting plane
Starting Z

```
LBL 2
```

```
L IY ... F100
L X ... Z ... F250
L X ... Z ...
CT X ... Z ...
L Z ... F9999
L X ... Z ...
L Z ... F ...
```

Y-steps

Tangent
Arc

Retract tool
For further steps

```
CALL LBL 2 REP ...
```

```
L Z+ ...
CYCL DEF 7.0 DATUM SHIFT
CYCL DEF ... X0 Y0 Z0
CYCL DEF 10.0 ROT 0
```

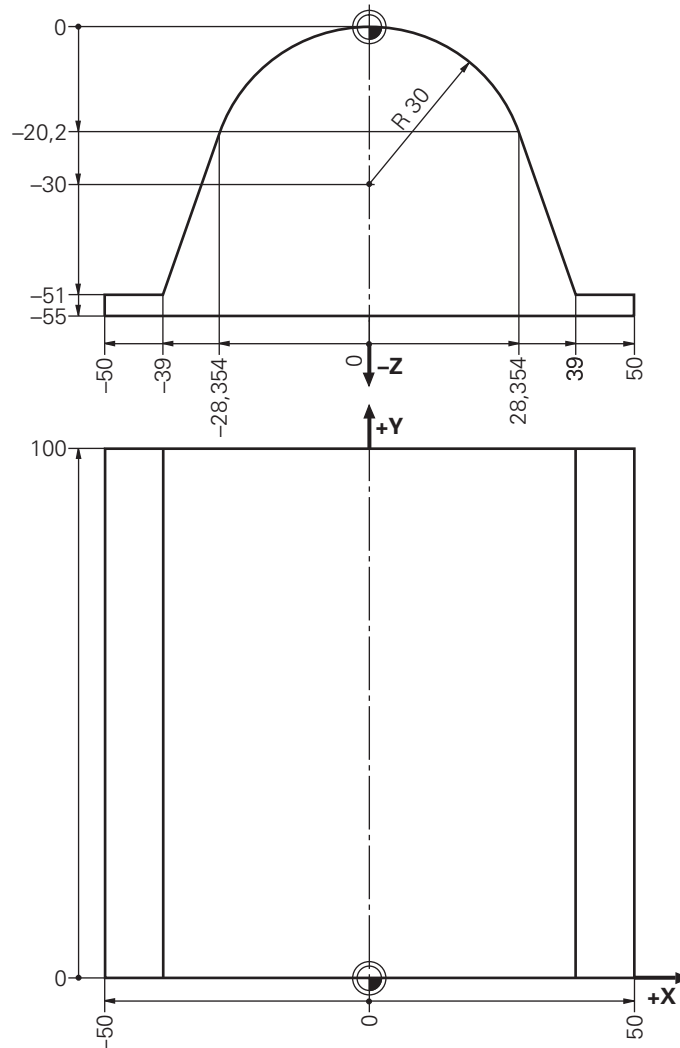
Retract tool
Reset

```
LBL 0
```



Solution:

Toggle joint with 1 tool, constant climb-cut



Main program

```
0 BEGIN PGM 761260 MM
1 BLK FORM 0.1 Z X-50 Y+0 Z-52
2 BLK FORM 0.2 X+50 Y+100 Z+0
3 L Z+50 R0 F9999 M6
4 TOOL DEF 2 L+0 R+10
5 TOOL CALL 2 Z S4000
6 L Z+50 R0 F MAX M3
7 CYCL DEF 7.0 DATUM SHIFT
8 CYCL DEF 7.1 X+Q108
9 CYCL DEF 7.2 Y+0
10 CALL LBL 1 ..... RIGHT

11 CYCL DEF 7.0 DATUM SHIFT
12 CYCL DEF 7.1 X-Q108
13 CYCL DEF 7.2 Y+100
14 CYCL DEF 10.0 ROTATION
15 CYCL DEF 10.1 ROT+180
16 CALL LBL 1 ..... LEFT

Retract tool, end 17 L Z+50 R0 F MAX M2
```



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C01



761260/3

Solution: **Toggle joint with 1 tool,
constant climb-cut**

SPGM, Contour Z/X 18 LBL 1
19 L X+55 Y-4 R0 F9999 M3
20 L Z-51 F1000

21 LBL 2
22 L IY+2 F100
23 L X+39 Z-51 F250
24 L X+28,354 Z-20,2
25 CT X+0 Z+0
26 L Z+5 R0 F9999
27 L X+55 Z+5
28 L Z-51 F1000
29 CALL LBL 2 REP 50/50

30 L Z+5 R0 F MAX
31 CYCL DEF 7.0 DATUM SHIFT
32 CYCL DEF 7.1 X+0
33 CYCL DEF 7.2 Y+0
34 CYCL DEF 7.3 Z+0
35 CYCL DEF 10.0 ROTATION
36 CYCL DEF 10.1 ROT+0
37 LBL 0
38 END PGM 761260 MM



Program layout:

Toggle joint with 2 tools, constant climb-cut expanded roughing

Preparation
Roughing

```
BLK FORM  
TOOL DEF ... R10  
TOOL 1 ...  
FN 1: Q1 = Q108 + 5  
L Z50 R0 F ... M3  
CYCL DEF 7.0 DATUM SHIFT  
CYCL DEF ... X+Q1 Y0 Z+5
```

X > tool radius

```
CALL LBL 1
```

```
CYCL DEF 7.0 DATUM SHIFT  
CYCL DEF ... X-Q1 Y100 Z+5  
CYCL DEF 10.0 ROT180
```

```
CALL LBL 1
```

Completed section
already exists

```
TOOL 2 ...  
•  
•
```

```
CALL LBL 1
```

```
•  
•
```

```
CALL LBL 1
```

Retract tool, end

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

Contour Z/X,
SPGM 1
already exists

```
LBL 1
```

```
•  
•  
•  
•  
•  
•  
•  
•
```

```
LBL 0
```



Solution:

Toggle joint with 2 tools, constant climb-cut

Main program

```
0 BEGIN PGM 761261 MM
1 BLK FORM 0.1 Z X-50 Y+0 Z-52
2 BLK FORM 0.2 X+50 Y+100 Z+0
3 TOOL DEF 1 L+0 R+10
4 TOOL CALL 1 Z S2800
5 FN 1: Q1 = +Q108 + +5
6 L Z+50 R0 F9999 M3
7 CYCL DEF 7.0 DATUM SHIFT
8 CYCL DEF 7.1 X+Q1
9 CYCL DEF 7.2 Y+0
10 CYCL DEF 7.3 Z+5
11 CALL LBL 1 ..... RIGHT
```

Tool 1

```
12 CYCL DEF 7.0 DATUM SHIFT
13 CYCL DEF 7.1 X-Q1
14 CYCL DEF 7.2 Y+100
15 CYCL DEF 7.3 Z+5
16 CYCL DEF 10.0 ROTATION
17 CYCL DEF 10.1 ROT+180
18 CALL LBL 1 ..... LEFT
```

Tool 2

```
19 TOOL DEF 2 L+0 R+10
20 TOOL CALL 2 Z S4000
21 L Z+50 R0 F MAX M6
22 CYCL DEF 7.0 DATUM SHIFT
23 CYCL DEF 7.1 X+Q108
24 CYCL DEF 7.2 Y+0
25 CALL LBL 1 ..... RIGHT
```

```
26 CYCL DEF 7.0 DATUM SHIFT
27 CYCL DEF 7.1 X-Q108
28 CYCL DEF 7.2 Y+100
29 CYCL DEF 10.0 ROTATION
30 CYCL DEF 10.1 ROT+180
31 CALL LBL 1 ..... LEFT
```

Retract tool, end

```
32 L Z+50 R0 F MAX M2
```

SPGM, Contour Z/X

```
33 LBL 1
34 L X+55 Y-4 R0 F9999 M3
35 L Z-51 F1000
```

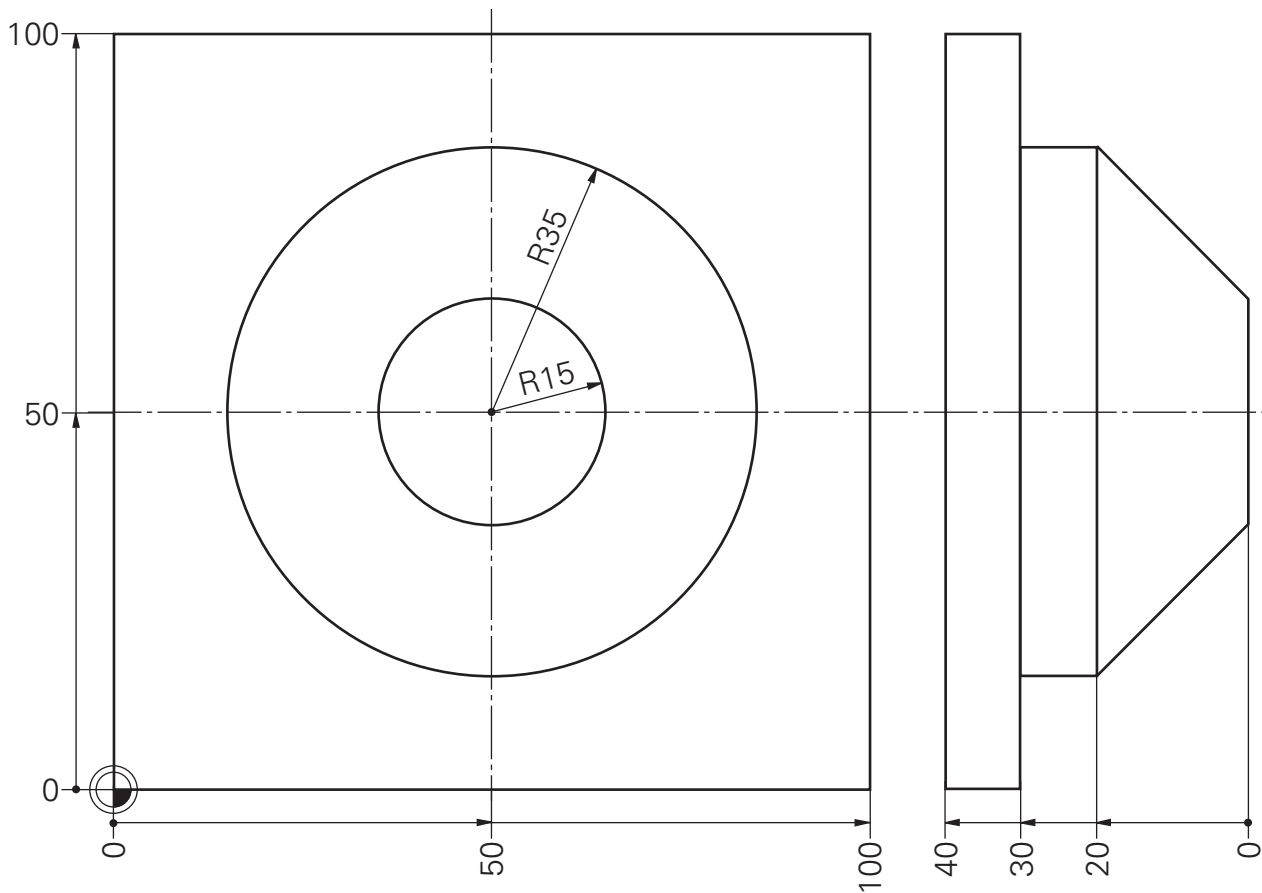
```
36 LBL 2
37 L IY+2 F100
38 L X+39 Z-51 F250
39 L X+28,354 Z-20,2
40 CT X+0 Z+0
41 L Z+5 R0 F9999
42 L X+55 Z+5
43 L X+55 Z-51 F MAX
44 CALL LBL 2 REP 50/50
```

```
45 L Z+5 R0 F MAX
46 CYCL DEF 7.0 DATUM SHIFT
47 CYCL DEF 7.1 X+0
48 CYCL DEF 7.2 Y+0
49 CYCL DEF 7.3 Z+0
50 CYCL DEF 10.0 ROTATION
51 CYCL DEF 10.1 ROT+0
52 LBL 0
53 END PGM 761261 MM
```



Task: **Truncated cone, standing, 2½ D, external**

Program(s): _____

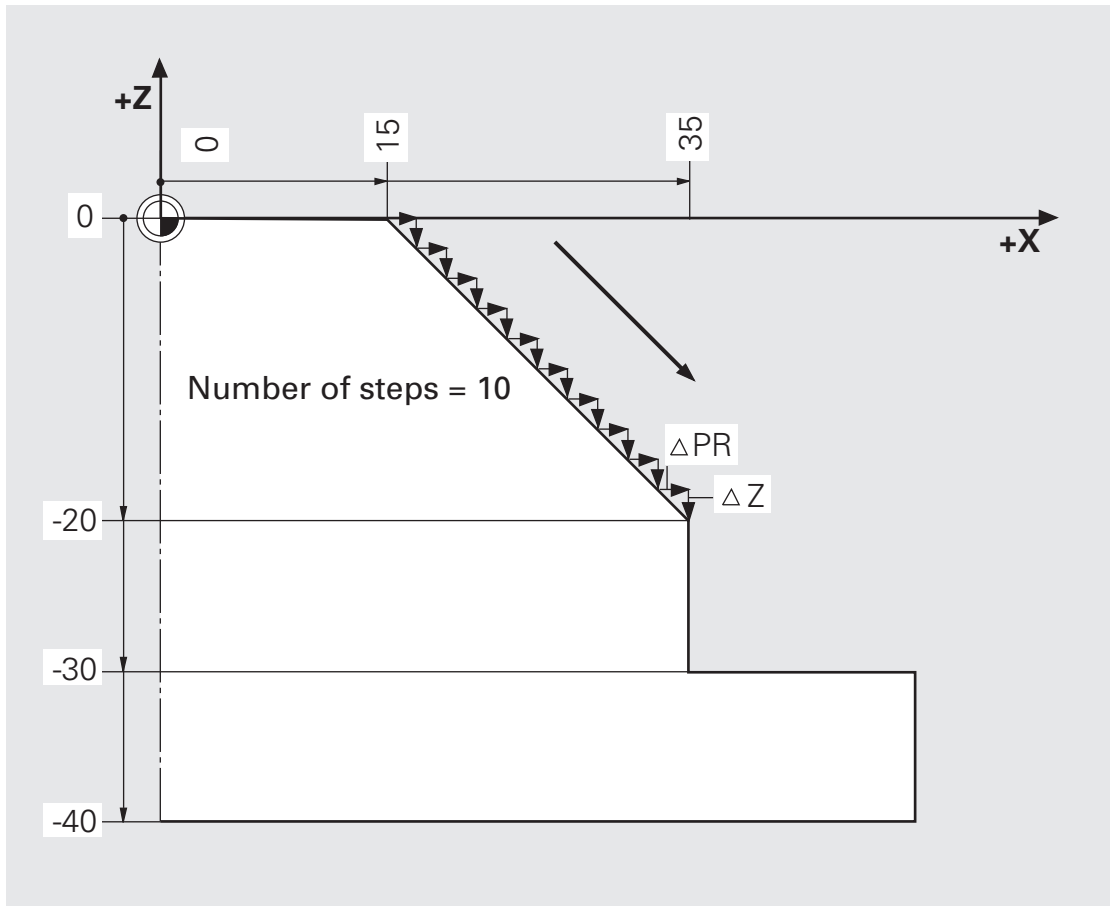


- Procedure:**
- 2½ D cut
 - Vertical position in X/Y
 - Setting in Z

- Tools:**
- End mill



Truncated cone, standing, 2½ D, horizontal, with full circles



Calculation of step width per revolution:

$$\Delta PR = \frac{\text{End radius} - \text{Starting radius}}{\text{Number of steps}}$$

$$\Delta Z = \frac{\text{End height} - \text{Starting height}}{\text{Number of steps}}$$

Example: Number of steps = 10

$$\Delta PR = \frac{35 - 15}{10} = \frac{20}{10} = 2$$

$$\Delta Z = \frac{-20 - 0}{10} = \frac{-20}{10} = -2$$



Program layout:

Truncated cone, standing, external, 2½ D, horizontal

Preparation

Roughing

```
BLK FORM  
TOOL 1... R10  
L Z20 R0 F9999 M3  
CC X... Y...  
LP PR65 PA0 R... F... M...  
L Z+2
```

Z-Clearance

```
LBL 1
```

```
LP IPR-... RL F...  
L Z-30  
CP IPA-360 DR- RL F... M98
```

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

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

Finishing

```
TOOL 2... R10  
L Z+... R0 F... M3  
LP PR15 PA0 R0 F...  
LP IPR+Q108
```

Compensate tool
radius outside
Contact

```
L Z0 F150
```

```
LBL 2
```

```
LP IPR+1  
L IZ-1 F200  
CP IPA-360 DR- F1000
```

} Cone angle 45°
for slope
Full circle in X/Y

```
CALL LBL 2 REP...
```

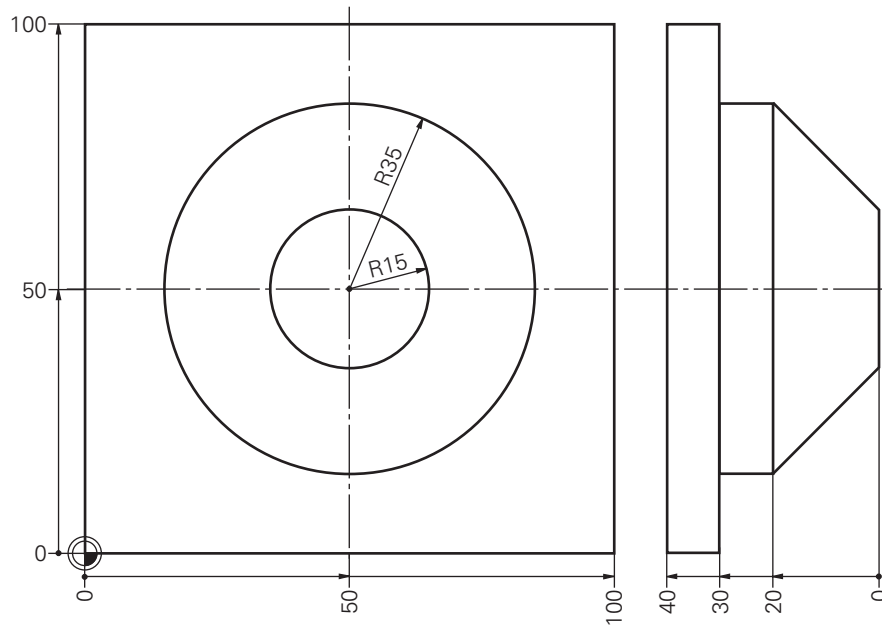
Retract tool, end

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



Solution:

Truncated cone, standing, 2½ D, horizontal, external form with end mill



```
0 BEGIN PGM 7162 MM
1 ..... TRUNCATED CONE STANDING
2 ..... 2½ D, HORIZONTAL, END MILL
3 BLK FORM 0.1 Z X+0 Y+10 Z-31
4 BLK FORM 0.2 X+100 Y+100 Z+0
5 TOOL DEF 1 L+0 R+10
6 TOOL CALL 1 Z S2000
7 CC X+50 Y+50
8 L Z+20 R0 F9999 M3
9 LP PR+65 PA+0
10 L Z+2

11 LBL 1
12 LP IPR-5 RL F200
13 L Z-30
14 CP IPA-360 DR- RL F300 M98
15 CALL LBL 1 REP 5/5
16 L Z+20 R0 F9999 M6

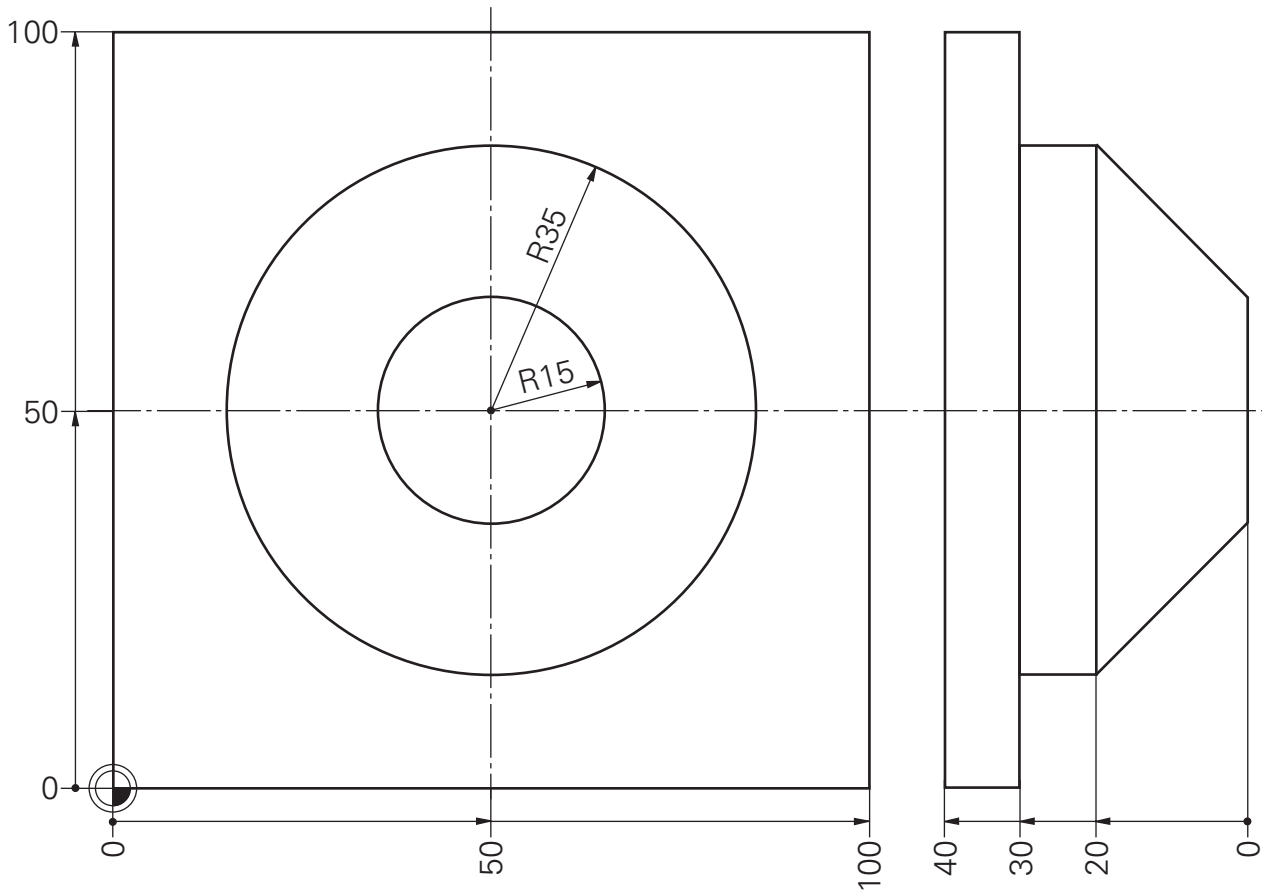
17 TOOL DEF 2 L+0 R+10
18 TOOL CALL 2 Z S2800
19 L Z+20 R0 F9999 M3
20 LP PR+15 PA+0 R0 F9999 M3
21 LP IPR+Q108
22 L Z+2
23 L Z+0 F150

24 LBL 2
25 LP IPR+1
26 L IZ-1 F200
27 CP IPA-360 DR- F1000 M98
28 CALL LBL 2 REP 19/19

29 L Z+20 R0 F9999 M2
30 END PGM 7162 MM
```

Task: **Truncated cone, standing, 3D,
external form**

Program(s): _____



Procedure:

- 3D-cut from top to bottom
- Rotation about zero point at center of truncated cone

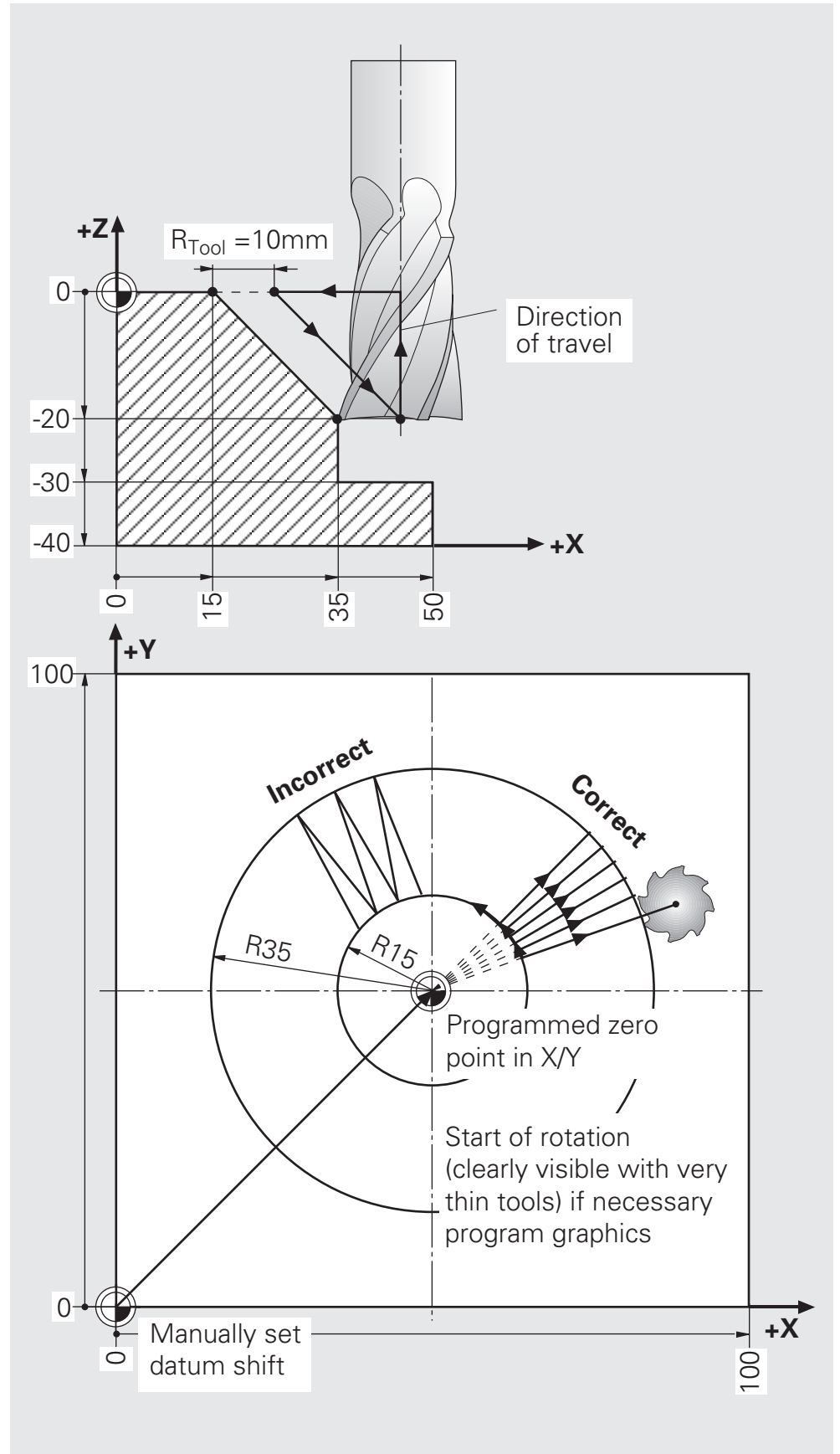
Tools:

- End mill R6



Detail:

Truncated cone, standing, 3D, external form with end mill, radius compensation



Program layout:

Truncated cone, standing, 3D, external form

Preparation

```
BLK FORM  
TOOL ...  
L Z ... M3  
CYCL DEF 7.0 DATUM SHIFT ...  
Q3 = 15 + Q108  
Q4 = 35 + Q108
```

Dat. sh. in center of part
Tool compensation

1 call

```
CALL LBL 1
```

Retract tool, end

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

1 revolution, SPGM

```
LBL 1  
  
L XQ3 Y0 R0 F9999 M3  
  
L Z2  
L Z0 F100  
  
LBL 2  
  
L XQ4 Y0 Z-20  
  
L Z0 F9999  
L XQ3 Y0 F2000  
CYCL DEF 10.0 ROTATION  
CYCL DEF 10.1 IROT-5  
L Y0 F500  
  
CALL LBL 2 REP ...  
  
CYCL DEF 10.0 ROTATION  
CYCL DEF 10.1 ROT+0  
  
LBL 0
```

Approach compensated
X-value in drawing

Contact

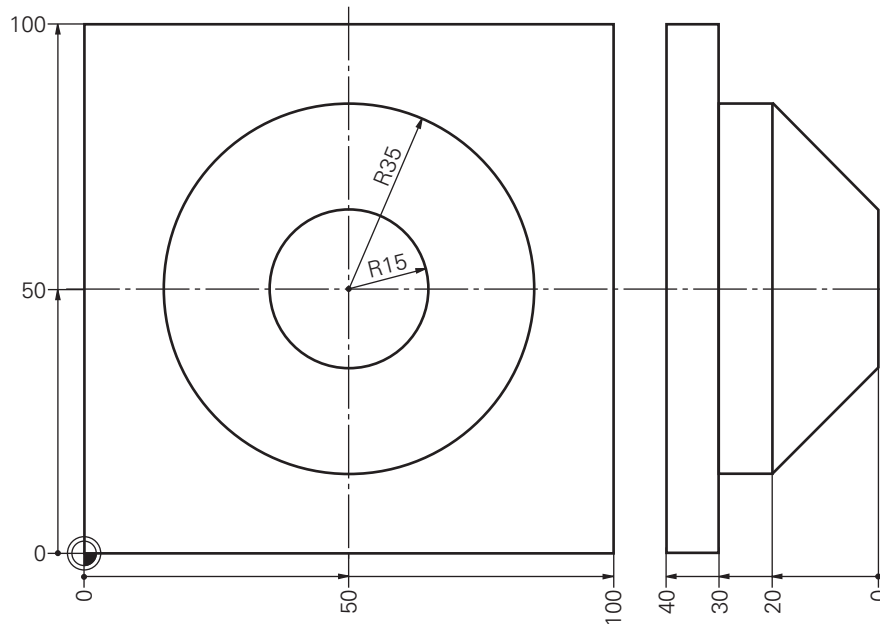
3D-cut, mill stays free!
Feed rate for first cut
=100
Z return

Feed rate for
following cuts



Solution:

Truncated cone, standing, 3D, vertical, external form with end mill, repeatable



Main program

```
0 BEGIN PGM 7282 MM
1 ..... TRUNCATED CONE, STANDING,
2 ..... 3D, VERTICAL, END MILL
3 ..... COMPLETED SECTION
4 BLK FORM 0.1 Z X+10 Y+10 Z-32
5 BLK FORM 0.2 X+90 Y+90 Z+0
6 TOOL DEF 1 L+0 R+10
7 TOOL CALL 1 Z S4000
8 L Z+20 R0 F9999 M3
9 CYCL DEF 7.0 DATUM SHIFT
10 CYCL DEF 7.1 X+50
11 CYCL DEF 7.2 Y+50
12 FN 1: Q3 = +15 + +Q108 ..... X TOP
13 FN 1: Q4 = +35 + +Q108 ..... X BOTTOM
14 CALL LBL 1 ..... FIRST CUT

15 L Z+50 R0 F9999 M2
```

SPGM

```
16 LBL 1
17 L X+Q3 Y+0 R0 F9999 M3 ..... APPROACH TOP
18 L Z+2
19 L Z+0 F100

20 LBL 2
21 L X+Q4 Y+0 Z-20 ..... CUT DOWNWARDS
22 L Z+0 F9999 ..... Z FREE
23 L X+Q3 Y+0 F2000
24 CYCL DEF 10.0 ROTATION
25 CYCL DEF 10.1 IROT-5 ..... FINENESS OF ROTATION
26 L Y+0 F500 ..... CROSS OVER ON TOP
27 L F500
28 CALL LBL 2 REP 71/71 ..... NUMBER OF ROTATION STEPS

29 CYCL DEF 10.0 ROTATION
30 CYCL DEF 10.1 ROT+0
31 LBL 0
32 END PGM 7282 MM
```



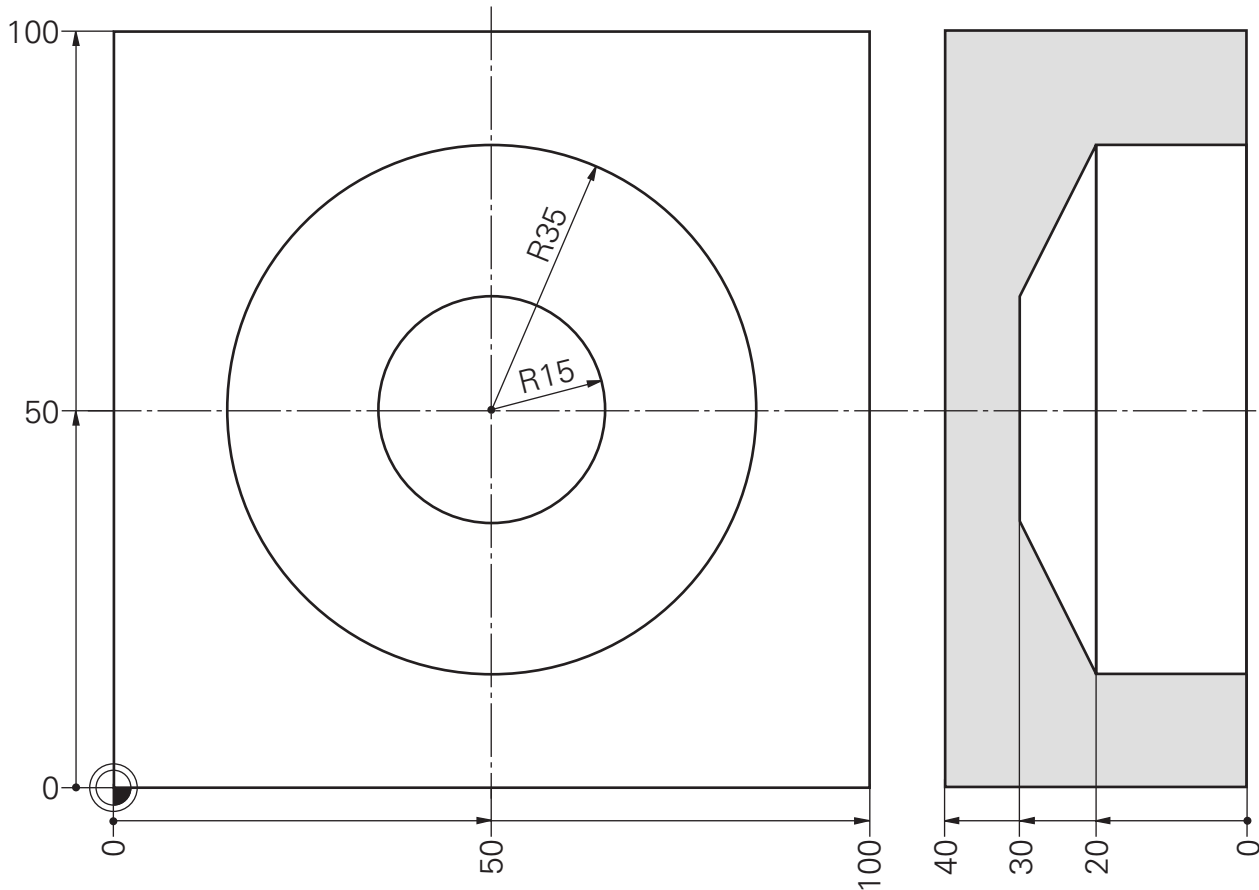
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C05



7282/4

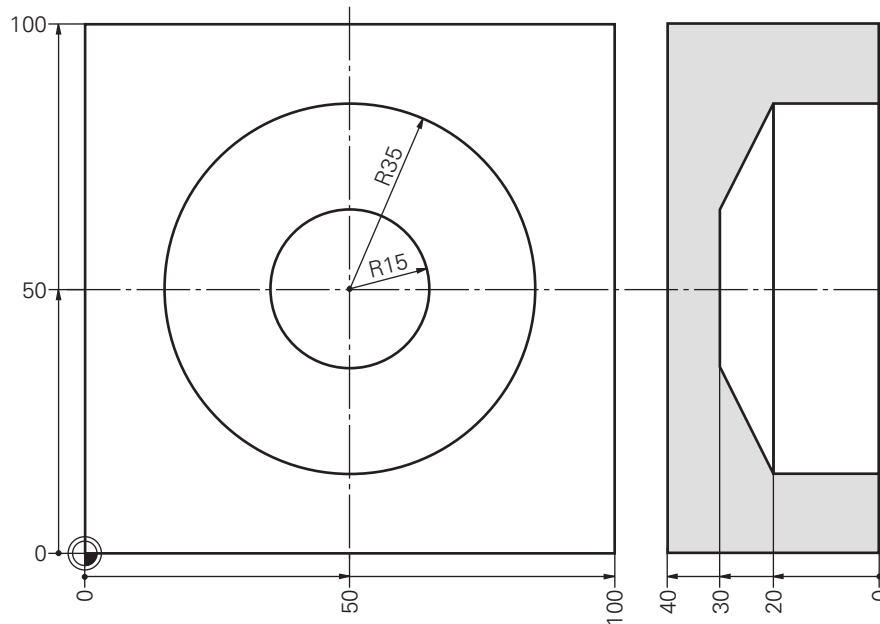


- Procedure:**
- 3 D-cut from bottom to top
 - Pre-machining with 2 circular pockets

- Tools:**
- End mill R6

Solution:

Truncated cone, standing, 3D, vertical, internal form with end mill, upwards



Main program

```
0 BEGIN PGM 7283 MM
1 ..... TRUNCATED CONE, STANDING,
2 ..... 3D, VERTICAL, INTERNAL, END
3 ..... MILL, COMPLETED SECTION, B06
4 BLK FORM 0.1 Z X+0 Y+10 Z-32
5 BLK FORM 0.2 X+100 Y+90 Z+0
6 TOOL DEF 1 L+0 R+10
7 TOOL CALL 1 Z S2800
8 L Z+20 R0 F9999 M3
9 CYCL DEF 7.0 DATUM SHIFT
10 CYCL DEF 7.1 X+50
11 CYCL DEF 7.2 Y+50
12 FN 1: Q3 = +35 + -Q108
13 FN 1: Q4 = +15 + -Q108
14 CALL LBL 1

15 L Z+50 R0 F9999 M2
```

SPGM

```
16 LBL 1 ..... VERY FIRST CUT
17 L X+10 Y+0
18 L Z-20 R0 F400 M3
19 L X+Q3 Y+0

20 LBL 2 ..... FOLLOWING CUTS 3D UPWARDS
21 L X+Q3 Y+0 Z-20 F1000
22 L X+Q4 F9999
23 L Z-30 F2000
24 CYCL DEF 10.0 ROTATION
25 CYCL DEF 10.1 IROT-5
26 CALL LBL 2 REP 71/71

27 CYCL DEF 10.0 ROTATION
28 CYCL DEF 10.1 ROT+0
29 LBL 0
30 END PGM 7283 MM
```



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C01



7283/3

Solution:

Truncated cone, standing, 3D, vertical, internal form with end mill, upwards, with roughing

Main program

```
0 BEGIN PGM 7284 MM
1 ..... TRUNCATED CONE, STANDING,
2 ..... VERTICAL, INTERNAL FORM
3 ..... FROM SOLID BLOCK WITH
4 ..... END MILL
5 BLK FORM 0.1 Z X+0 Y+10 Z-32
6 BLK FORM 0.2 X+100 Y+90 Z+0
7 TOOL DEF 1 L+0 R+10
8 TOOL CALL 1 Z S2800
9 L Z+20 R0 F9999 M3
10 FN 0: Q1 = +20 ..... DEPTH
11 FN 0: Q2 = +35 ..... RADIUS
12 CYCL DEF 5.0 CIRCULAR POCKET
13 CYCL DEF 5.1 SET UP-2
14 CYCL DEF 5.2 DEPTH -Q1
15 CYCL DEF 5.3 PECKG -5 F150
16 CYCL DEF 5.4 RADIUS Q2
17 CYCL DEF 5.5 F500 DR+
18 L X+50 Y+50
19 L Z+2 M99 ..... ROUGHING OUT
20 FN 0: Q1 = +10
21 FN 0: Q2 = +15

22 L Z-18 M99
23 CYCL DEF 7.0 DATUM SHIFT
24 CYCL DEF 7.1 X+50
25 CYCL DEF 7.2 Y+50
26 FN 1: Q3 = +15 + -Q108 ..... XA BOTTOM
27 FN 1: Q4 = +35 + -Q108 ..... XB TOP
28 FN 0: Q5 = -25 ..... Z DEPTH, FIRST CUT

29 CALL LBL 1 ..... ROUGHING OUT SLOPE

30 FN 0: Q5 = -30 ..... Z DEPTH, SECOND CUT

31 CALL LBL 1 ..... FINISHING

32 L Z+50 R0 F9999 M2
```

SPGM, Contour

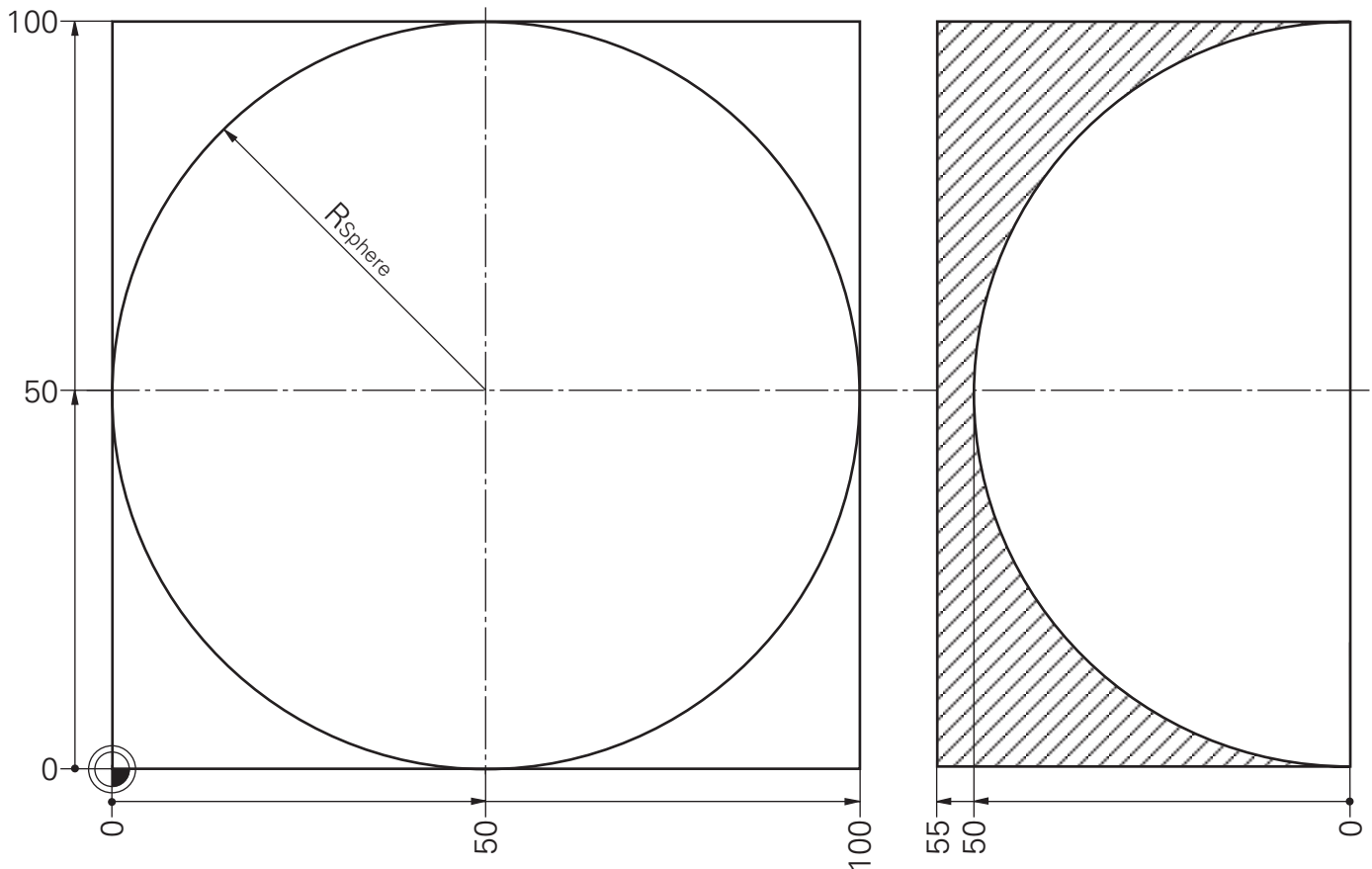
```
33 LBL 1
34 L X+Q3 Y+0 Z+Q5 R0 F400 M3 ..... A
35 L X+Q4 Y+0 Z+0 ..... B

36 LBL 2
37 L X+Q3 Y+0
38 L Z+Q5
39 L X+Q4 Y+0 Z+0 F1000 ..... B
40 L X+Q3 F9999 ..... A
41 L Z+Q5 F2000
42 CYCL DEF 10.0 ROTATION
43 CYCL DEF 10.1 IROT-5
44 CALL LBL 2 REP 71/71
45 CYCL DEF 10.0 ROTATION
46 CYCL DEF 10.1 ROT+0
47 LBL 0
48 END PGM 7284 MM
```



Task: **Hemisphere, internal machining,
2D, horizontal**

Program(s): _____



Procedure:

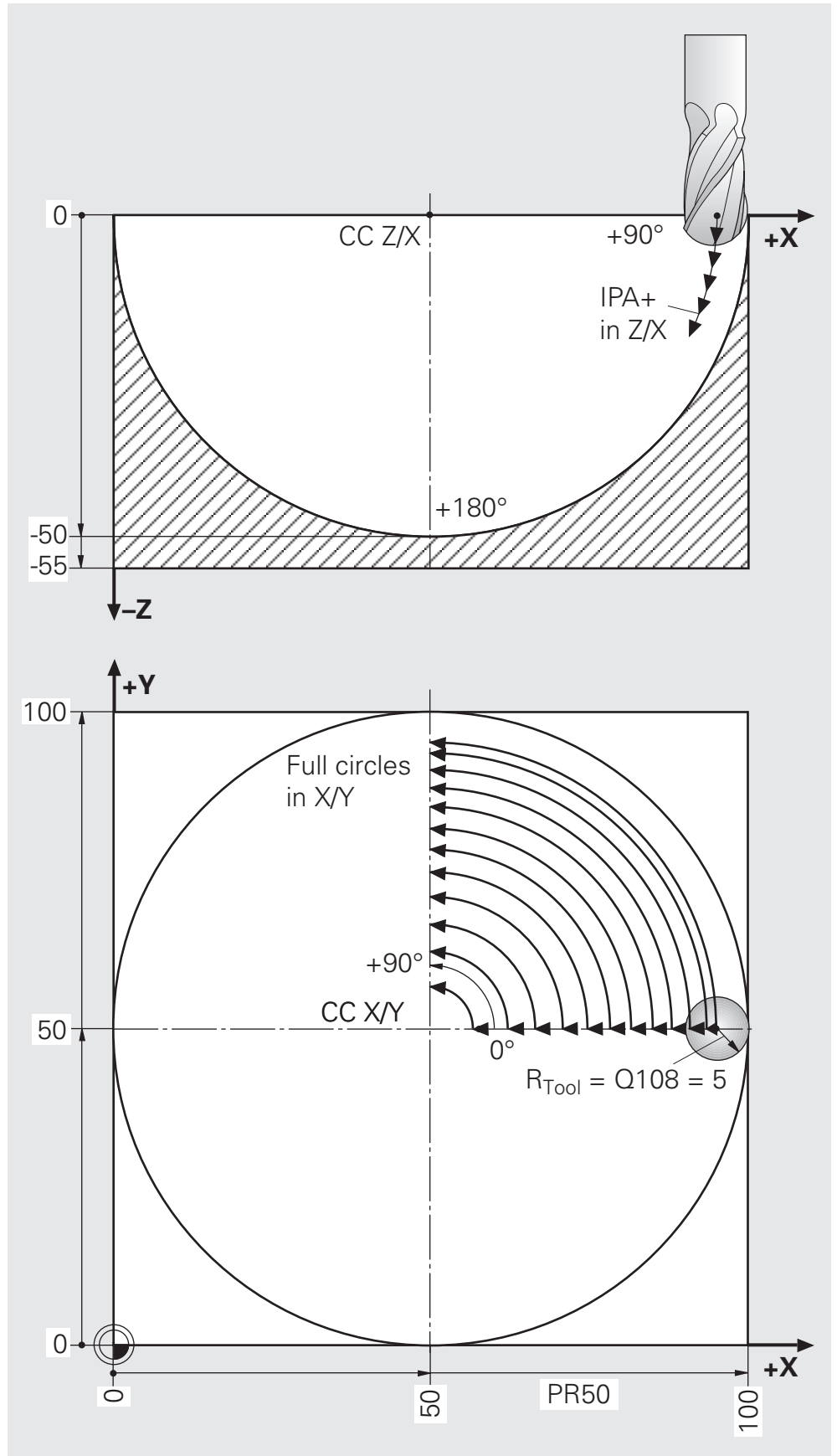
- Full circles (vertical positions) in X/Y
- Pre-machine with 2 circular pockets

Tools:

- Roughing out (circular pockets) with end mill R10
- Machine contour with spherical mill R5

Program layout:

Hemisphere, internal machining with spherical mill conventional with R0, 2D, horizontal



Program layout:

**Hemisphere, internal machining with spherical mill
conventional with R0, 2D, horizontal, working
downwards**

Preparation

```
BLK FORM  
TOOL 1 ... R5  
L Z10 R0 F9999 M3
```

Approach

```
CC X50 Y50  
LP PR50 PA0 R0 F9999  
LP IPR-Q108  
L Z+0 R0 F100
```

Z-clearance

X/Y plane

$PR = R_{\text{Part}} - R_{\text{Tool}}$

Account for tool radius

Plunge

```
LBL 1
```

Full circles

```
CC X50 Y50  
CP DR+
```

X/Y plane

Setting

```
CC X50 Z0
```

Z/X plane

Angular steps

```
CP IPA2 DR+
```

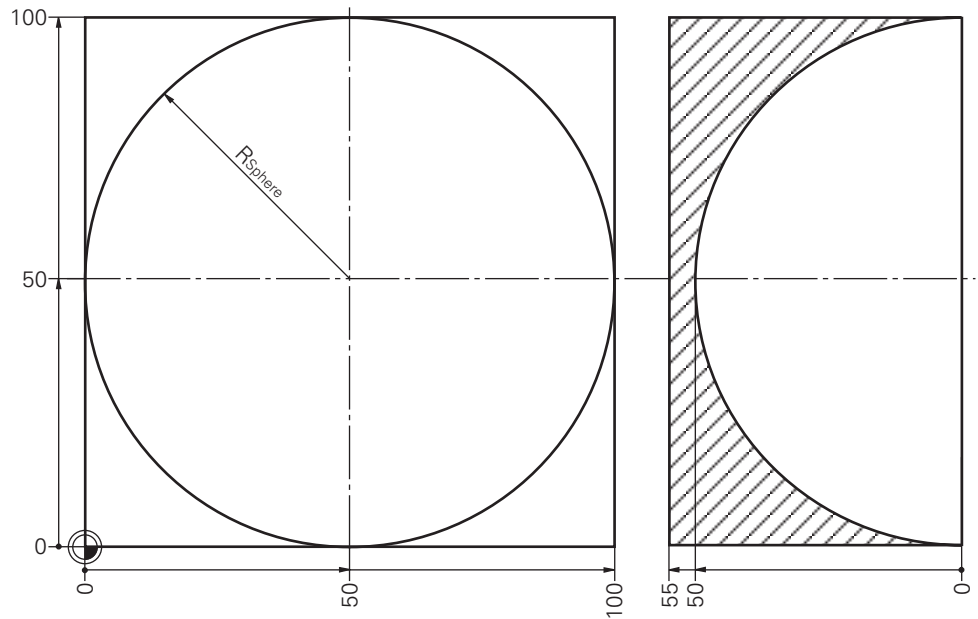
```
CALL LBL 1 REP 44/44
```

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



Solution:

Hemisphere, internal machining with spherical mill conventional with R0, 2D, horizontal



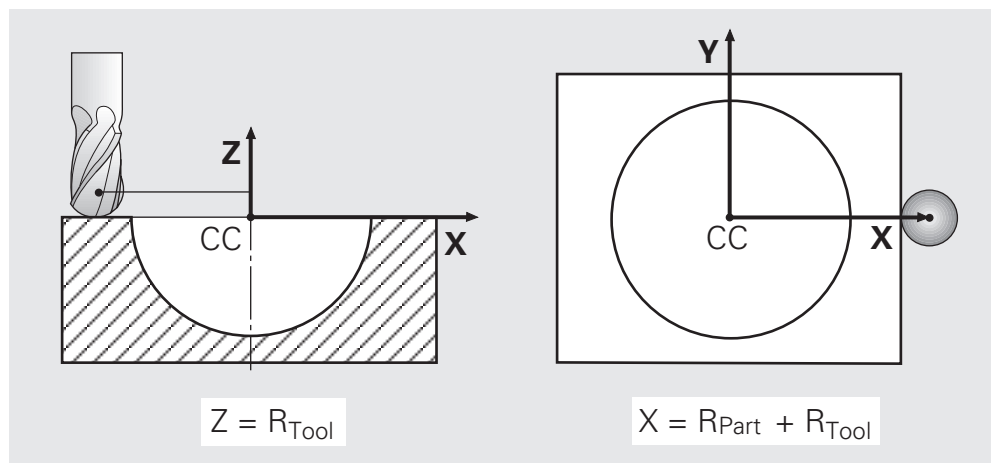
```

0 BEGIN PGM 7322 MM
1 BLK FORM 0.1 Z X-2 Y-2 Z-55
2 BLK FORM 0.2 X+102 Y+102 Z+0
3 TOOL DEF 1 L+0 R+5
4 TOOL CALL 1 Z S4000
5 L Z+70 R0 F9999 M6 ..... Z-CLEARANCE
6 CC X+50 Y+50 ..... CENTER IN X/Y
7 LP PR+50 PA+0 R0 F9999 M3 ..... STARTING POINT
8 LP IPR-Q108 ..... ACCOUNT FOR TOOL RADIUS
9 L Z+0 R0 F100

10 LBL 1
11 CC X+50 Y+50 ..... CENTER IN X/Y
12 CP DR+ F500 ..... CIRCULAR RING
13 CC X+50 Z+0 ..... CENTER IN Z/X
14 CP IPA+2 DR+ F100 ..... MOVE DEEPER (ARC)
15 CALL LBL 1 REP 44/44 ..... FURTHER REVOLUTIONS

16 L Z+70 R0 F9999 M2
17 END PGM 7322 MM
    
```

Set datum



Solution:

Hemisphere, internal machining with end and die sink mill

Main program

```
0 BEGIN PGM 7323 MM
1 BLK FORM 0.1 Z X-2 Y-2 Z-51
2 BLK FORM 0.2 X+102 Y+102 Z+0
```

End mill

```
3 TOOL DEF 1 L+0 R+10
4 TOOL CALL 1 Z S4000
5 FN 0: Q1 = +45 ..... UPPER POCKET RADIUS
6 CALL LBL 1 ..... ROUGHING-OUT
7 L Z+100 R0 F MAX M6 ..... TOOL CHANGE
```

Die sink mill

```
8 TOOL DEF 2 L+0 R+5
9 TOOL CALL 2 Z S4500
10 CALL LBL 2 ..... FINISHING
```

Retract tool, end

```
11 L Z+100 R0 F MAX M2
```

SPGM 1, Roughing out with end mill

```
12 LBL 1
13 CC X+50 Y+50 ..... CENTER IN X/Y
14 LP PR+0 PA+0 R0 F MAX M3
15 CYCL DEF 5.0 CIRCULAR POCKET
16 CYCL DEF 5.1 SET UP -2
17 CYCL DEF 5.2 DEPTH -14
18 CYCL DEF 5.3 PECKG -5 F150
19 CYCL DEF 5.4 RADIUS Q1
20 CYCL DEF 5.5 F500 DR+
21 L Z+2 R0 F MAX M99
22 FN 0: Q1 = +30 ..... LOWER POCKET RADIUS
23 L Z-12 R0 F MAX M99
24 LBL 0
```

SPGM 2, Finishing with die sink mill (spherical form)

```
25 LBL 2
26 LP PR+50 PA+0 R0 F500 M3 ..... STARTING POINT
27 LP IPR-Q108
28 L Z+0 R0 F MAX

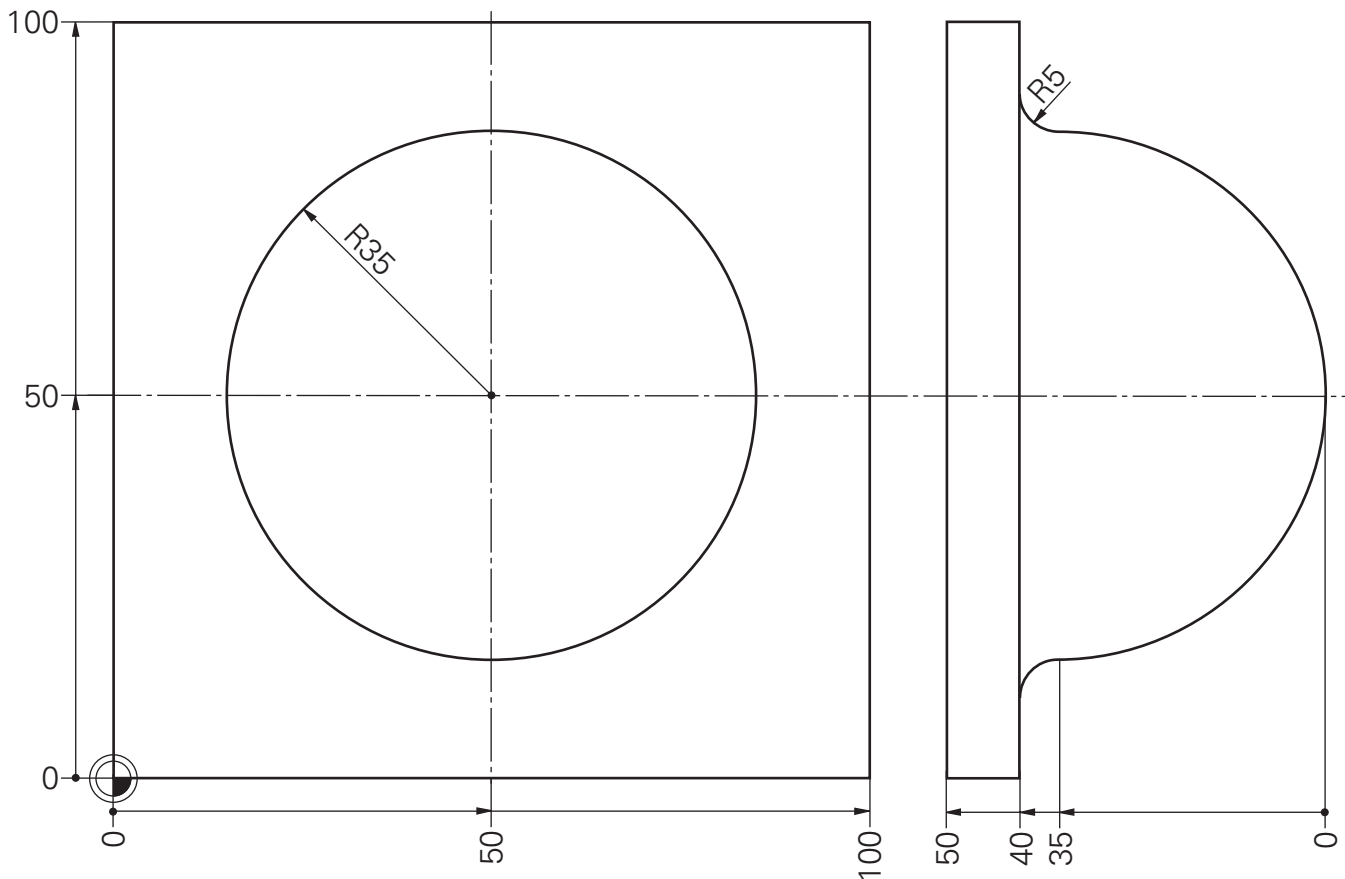
29 LBL 20
30 CC X+50 Y+50 ..... CENTER IN X/Y
31 C DR+ F500 ..... CIRCULAR RING
32 CC X+50 Z+0 ..... CENTER IN Z/X
33 CP IPA+2 DR+ F150 ..... MOVE DEEPER
34 CALL LBL 20 REP 44/44 ..... FURTHER CIRCULAR RINGS

35 LBL 0
36 END PGM 7323 MM
```



Task: **Hemisphere, external machining
with spherical mill, working
downwards, 2½ D, horizontal**

Program(s): _____



Procedure:

- Full circles (vertical positions) in X/Y
- Setting with angular steps in Z/X
- Pre-machining e.g. with contour island or helical interpolation

Tools:

- (Roughing out with end mill R5)
- Finishing with spherical mill R5



Program layout:

**Hemisphere, external machining with spherical mill,
working downwards, 2½ D, horizontal**

Preparation

Finishing

```
BLK FORM  
TOOL 1...R5  
L Z 20 R0 F9999 M3
```

Call

```
CALL LBL 1
```

Retract tool, end

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

SPGM

```
LBL 1
```

```
L X+50 Y+50 R...F...M...  
L Z+Q108 F100
```

Approach center
Account for tool
radius

```
LBL 2
```

```
CC Z-35 X+50  
CP IPA+2 DR+ F100
```

} Setting in Z/X

```
CC X+50 Y+50  
CP DR- F500
```

} Full circle in X/Y

```
CALL LBL 2 REP...
```

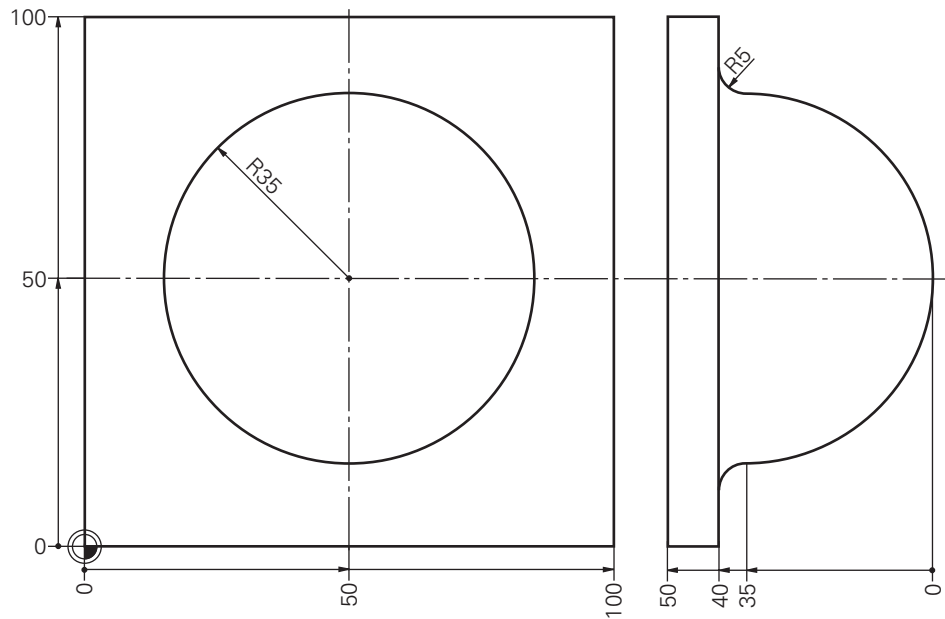
Further cuts

```
LBL 0
```



Solution:

Hemisphere, external machining with spherical mill, working downwards, $2\frac{1}{2} D$, horizontal



Main program

```
0 BEGIN PGM 72841 MM
1 ..... EXTERNAL HEMISPHERE 2D,
2 ..... SPHERICAL MILL,
3 ..... MILLING DOWNWARDS
4 BLK FORM 0.1 Z X+0 Y+10 Z-36
5 BLK FORM 0.2 X+100 Y+90 Z+5
6 TOOL DEF 1 L+0 R+5
7 TOOL CALL 1 Z S2800
8 L Z+20 R0 F9999 M3
9 CALL LBL 1
```

Retract tool, end

```
10 L Z+100 R0 F9999 M2
```

SPGM

```
11 LBL 1
12 L X+50 Y+50 ..... CENTER IN X/Y
13 L Z+Q108 F100 ..... CONTACT WITH TOOL RADIUS

14 LBL 2
15 CC Z-35 X+50
16 CP IPA+2 DR+ F100 ..... SETTING
17 CC X+50 Y+50
18 CP DR- F500 ..... FULL CIRCLE
19 CALL LBL 2 REP 44/44
20 LBL 0
21 END PGM 72841 MM
```



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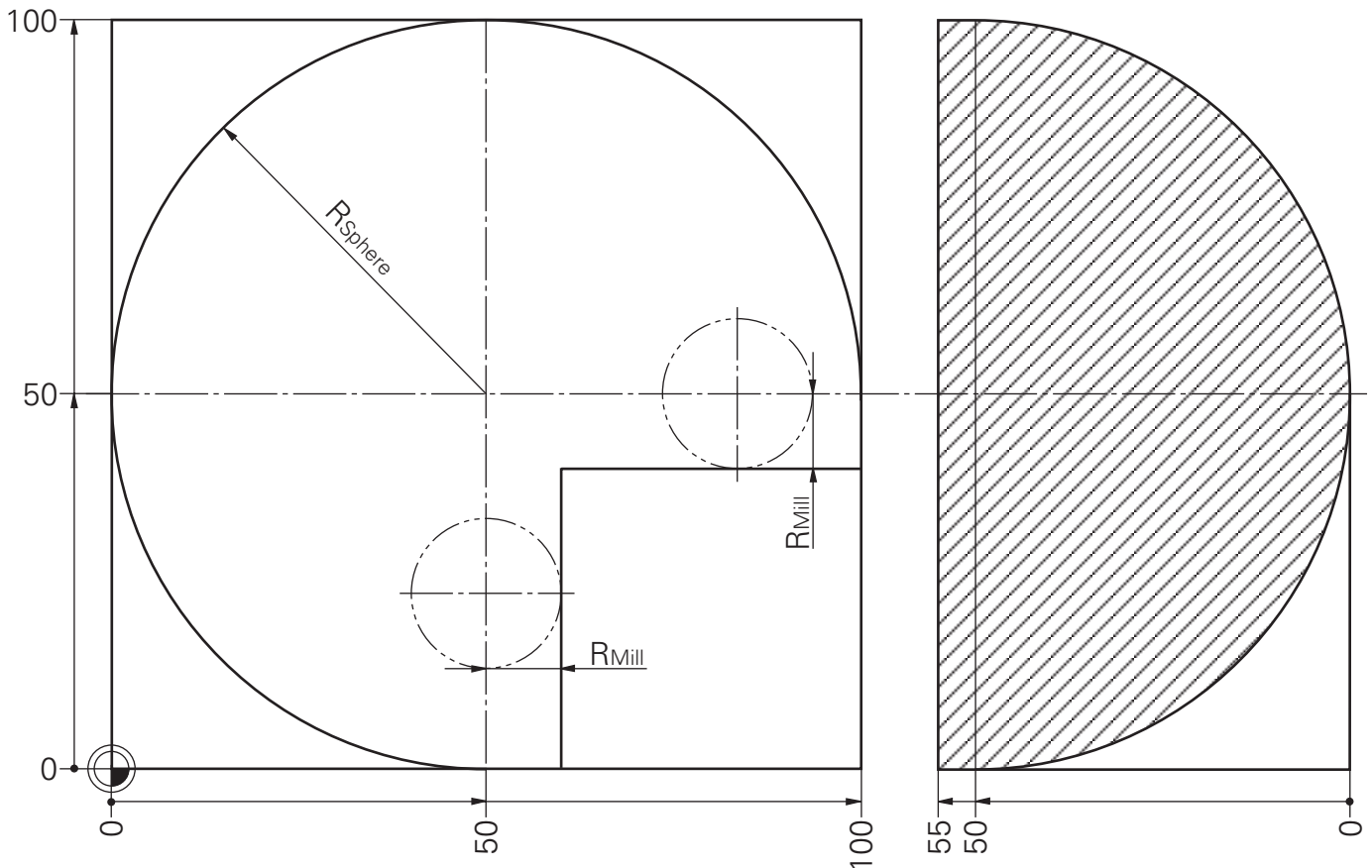
C05



72841/3

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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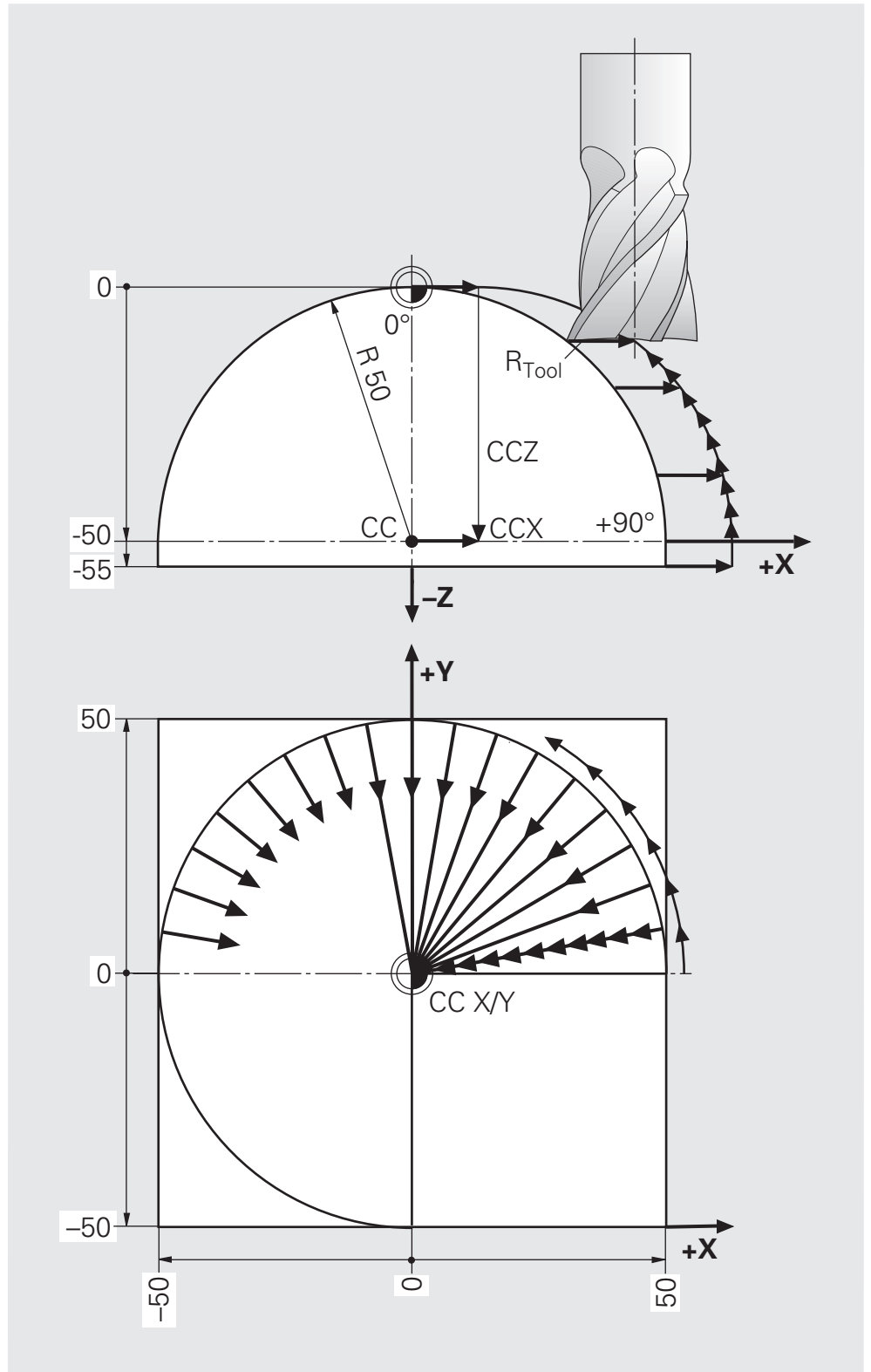
C09



76130/1
76131/1

Program layout:

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



Program layout:

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

Preparation

Pre-position

<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

“Virtual
circular arc”

1 angular step
(angle in space)

Retract tool

1 further arc

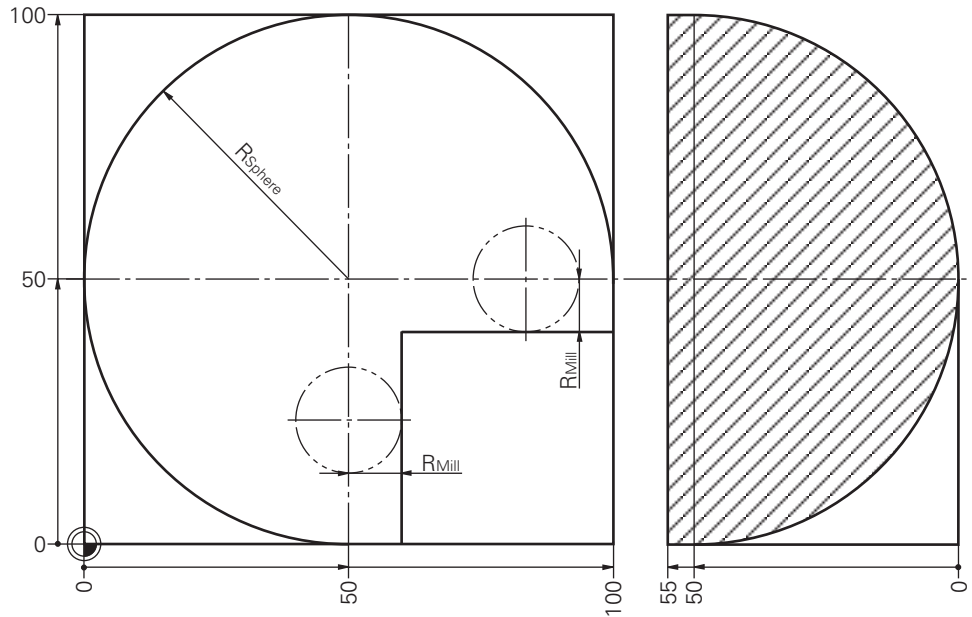
Reset

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
```

```
LP IPA-10 F500
```

1 arc, coarse, not to
largest angle

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

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

Z oversize

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

Additional arcs

```
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
```

```
LP IPA-1 F800
```

1 arc, fine, to largest
angle in space

```
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...
```

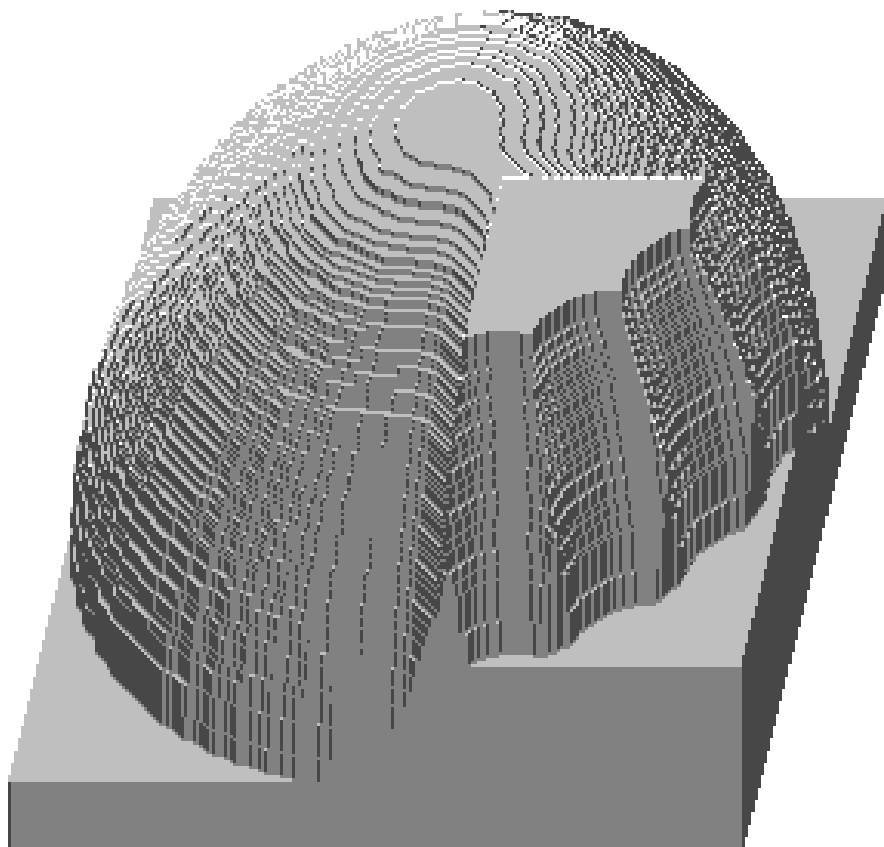
```
CYCL DEF 7 DATUM SHIFT = 0  
CYCL DEF 10 ROTATION = 0
```

Retract tool, end

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

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

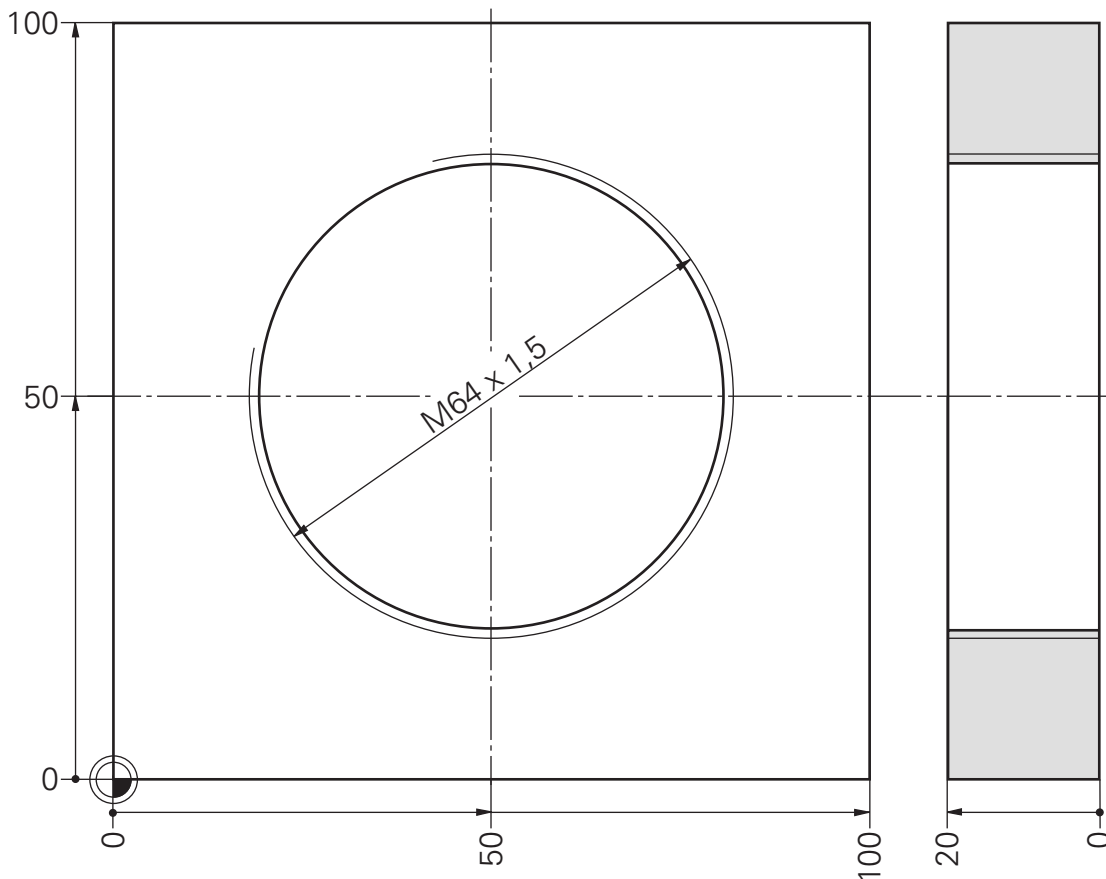
34 L X+50 Y+0 F2000
35 L X+65 Z+0 F1000
36 CYCL DEF 10.0 ROTATION ..... 71 FURTHER ARCS
37 CYCL DEF 10.1 IROT+1
38 CALL LBL 3 REP 359/359

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

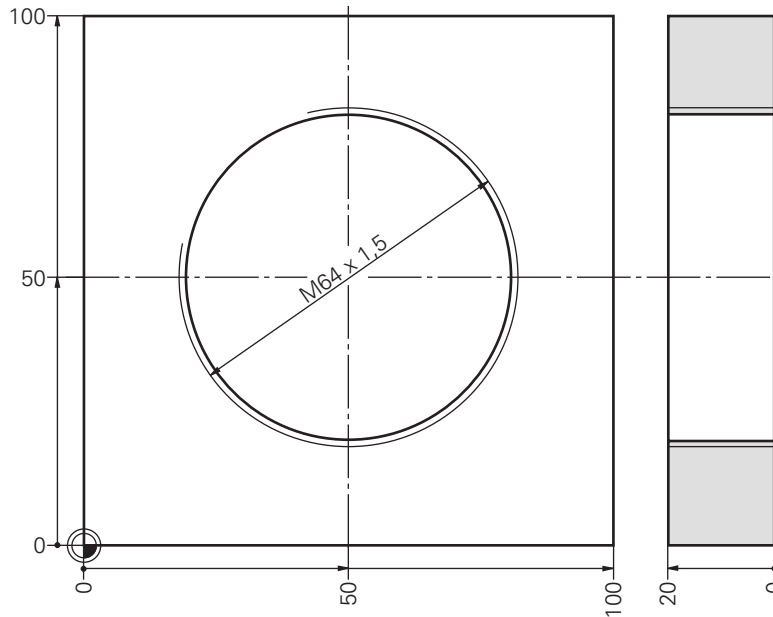
Retract tool, end

```
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°

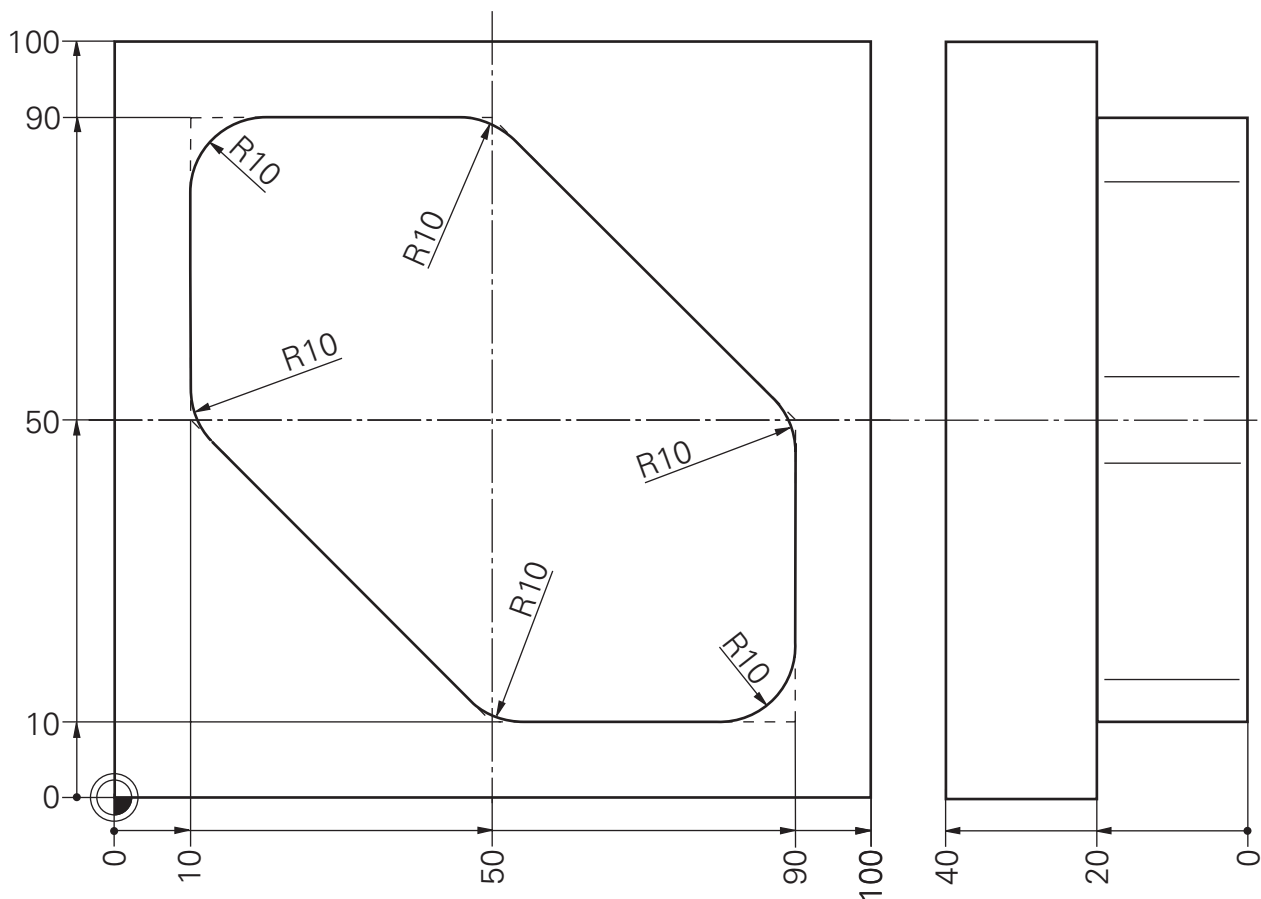
```
22 CYCL DEF 10.1 IROT+120
23 CALL LBL 1 REP 2/2
```

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



Task: **Milling a contour with several settings**

Program(s): _____



Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

Conventional preparation
Load data

```
BLK FORM

FN 0: Q1 = ...
FN 0: Q2 = ...
FN 0: Q3 = ...
FN 0: Q4 = ...
FN 0: Q5 = ...
FN 0: Q6 = ...

TOOL 1 ... R5
L Z+ ... R0 F9999 M3

CALL LBL 1
```

Feed rate Z
Feed rate plane
Start Z
End Z
Number of cuts
Rounding

Execute

Retract tool, end

```
L Z100 ... M2
```

SPGM

Starting values

Starting position

End position

```
LBL 1

FN 2: Q12 = Q4 - Q3
FN 4: Q12 = Q12 DIV Q5
FN 0: Q13 = Q3
L X-10 Y+70 R0 F9999 M3

LBL 2

L ZQ13 FQ1
L X+10 Y+70 RL FQ2
RND ...
L ... / RND ... / L ...
L X ... Y ... RL
RND ...
L X- ... Y ... R0 ...

FN 1: Q13 = Q13 + Q12

FN 11: IF Q13 GT Q4
        GOTO LBL 2

FN 9: IF Q13 EQU Q4
        GOTO LBL 2

L Z2 F9999

LBL 0
```

Setting range Z
Setting step Z
Z-start = Z-current
Uncorrected!

Move deeper
Move to first contour pt.
Approach tangentially

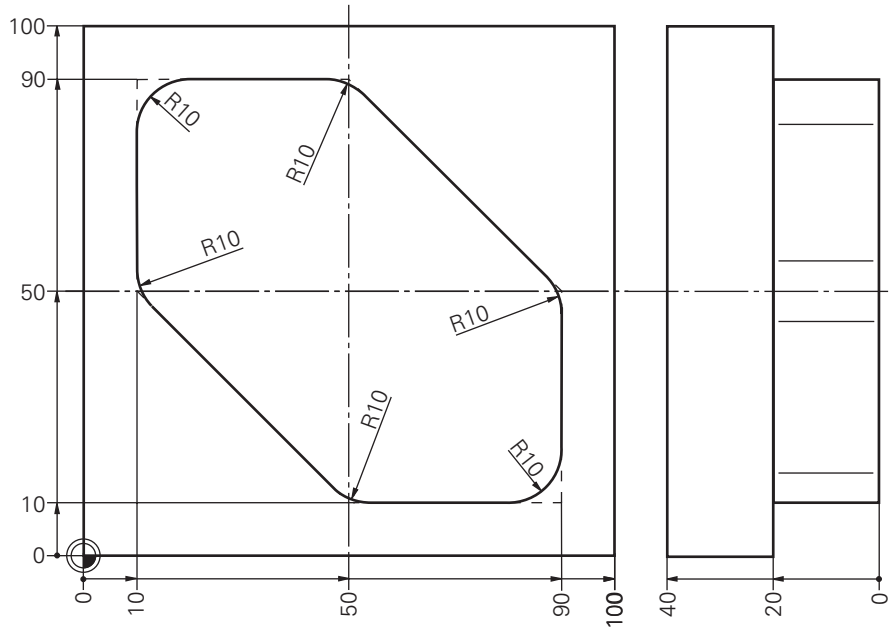
First/last contour point
Depart tangentially
Depart , uncorrected

Calculate Z setting

} Return jump /
further cuts, if the
final depth has not
yet been milled

Solution:

Milling a contour with several settings



Main program

```
0 BEGIN PGM 7285 MM
1 ..... MILLING A CONTOUR WITH
SEVERAL SETTINGS

2 BLK FORM 0.1 Z X-10 Y+0 Z-40
3 BLK FORM 0.2 X+100 Y+100 Z+0
4 FN 0: Q1 = +100 ..... FEED RATE Z
5 FN 0: Q2 = +500 ..... FEED RATE PLANE
6 FN 0: Q3 = -2 ..... START Z
7 FN 0: Q4 = -20 ..... END Z
8 FN 0: Q5 = +4 ..... NUMBER OF CUTS
9 FN 0: Q6 = +10 ..... ROUNDING
10 TOOL DEF 1 L+0 R+5
11 TOOL CALL 1 Z S2800
12 L Z+10 R0 F9998 M3
13 CALL LBL 1

Retract tool, end
14 L Z+100 R0 F9998 M2
```



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7285/3

Solution:

Milling a contour with several settings

SPGM

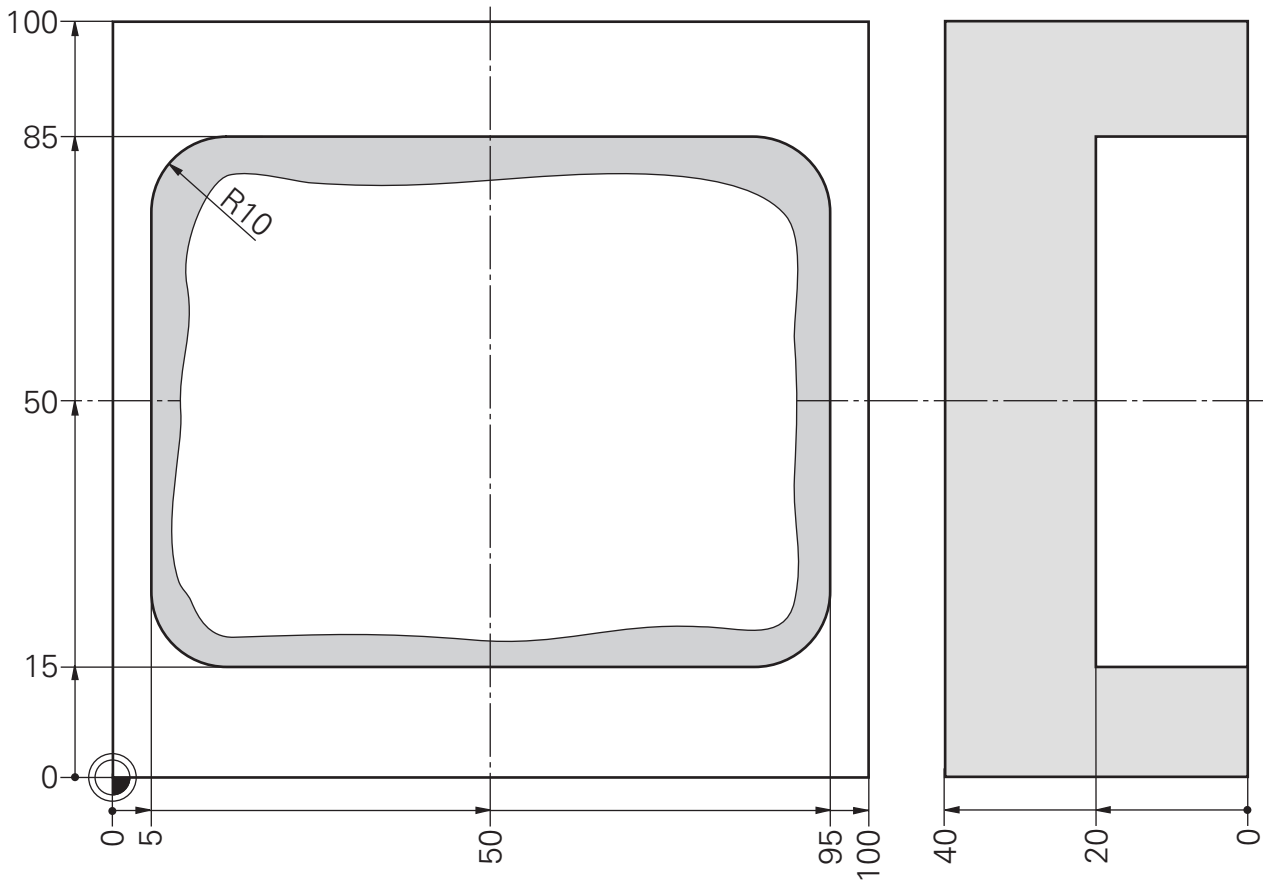
```
15 LBL 1
16 FN 2: Q12 = +Q4 - +Q3
17 FN 4: Q12 = +Q12 DIV +Q5 ..... Z SETTING
18 FN 0: Q13 = +Q3 ..... CURRENT Z
19 L X-10 Y+70 R0 F9998 M3

20 LBL 2
21 L Z+Q13 FQ1
22 L X+10 Y+70 RL FQ2
23 RND R2
24 L Y+90
25 RND RQ6
26 L X+50
27 RND RQ6
28 L X+90 Y+50
29 RND RQ6
30 L Y+10
31 RND RQ6
32 L X+50
33 RND RQ6
34 L X+10 Y+50
35 RND RQ6
36 L Y+70
37 RND R2
38 L X-10 Y+70 R0 F9998
39 FN 1: Q13 = +Q13 + +Q12
40 FN 11: IF +Q13 GT +Q4 GOTO LBL 2
41 FN 9: IF +Q13 EQU +Q4 GOTO LBL 2
42 L Z+2 F9998
43 LBL 0
44 END PGM 7285 MM
```



Task: **Finish milling rectangular pocket**

Program(s): _____



Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

Load data

```

•
•
FN 0: Q1 = ... Q9 = ...
BLK FORM
TOOL 1 ... R5
L Z10 R0 F9999 M3
CALL LBL 1
    
```

Retract tool, end

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

SPGM

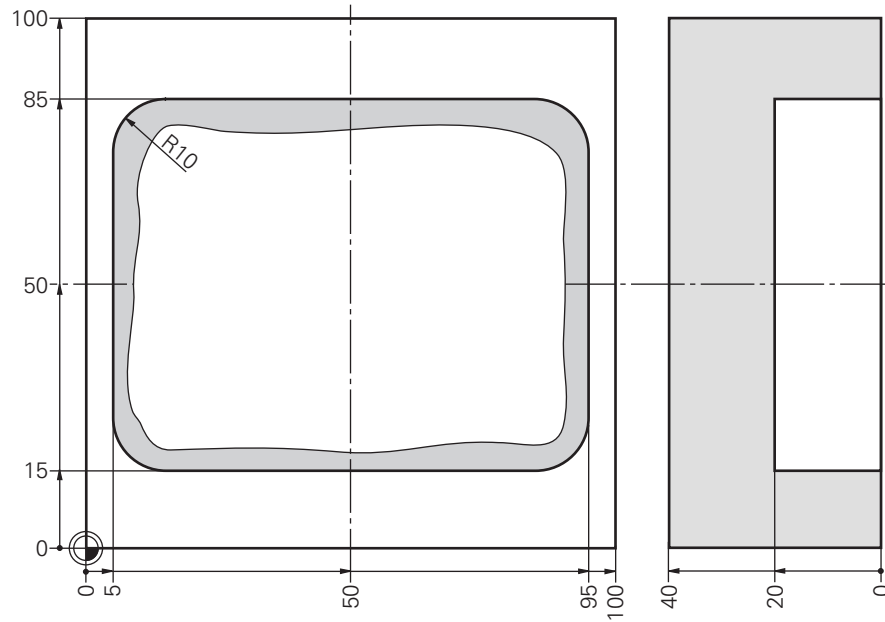
```

LBL 1
FN 4: Q13 = Q3 DIV 2
FN 4: Q14 = Q4 DIV 2
FN 4: Q16 = Q108 DIV 4
FN 4: Q17 = Q7 DIV 2
L X+Q1 Y+Q2 R0 F9999 M3
L Z+Q9
L Z-Q5 FQ7
L IXQ13 YQ2 RL
RND RQ ... FQ ...
L IY ...
•
•
L IX0 IYQ14
RND RQ ... FQ ...
L XQ1 YQ2 R0 F9999
L Z+Q9
LBL 0
    
```

- X/2
- Y/2
- Approach radius (*RND*)
- Appr. feed rate (*RND*)
- Approach center
- Z-clearance
- Z-depth
- First contour point
- Last contour point
- Move to center
- Retract tool in Z

Solution:

Finish milling rectangular pocket



Main program

```
0 BEGIN PGM 7286 MM
1 FN 0: Q1 = +50 ..... X-CENTER
2 FN 0: Q2 = +50 ..... Y-CENTER
3 FN 0: Q3 = +90 ..... LENGTH X
4 FN 0: Q4 = +70 ..... WIDTH Y
5 FN 0: Q5 = +20 ..... DEPTH Z
6 FN 0: Q6 = +10 ..... ROUNDING
7 FN 0: Q7 = +1000 ..... FEED RATE Z
8 FN 0: Q8 = +300 ..... FEED RATE PLANE
9 FN 0: Q9 = +2 ..... Z-CLEARANCE
10 BLK FORM 0.1 Z X+0 Y+10 Z-40
11 BLK FORM 0.2 X+100 Y+90 Z+0
12 TOOL DEF 1 L+0 R+5
13 TOOL CALL 1 Z S2800
14 L Z+10 R0 F9998 M3
15 CALL LBL 1
```

Retract tool, end

```
16 L Z+50 R0 M2
```



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C01



7286/3

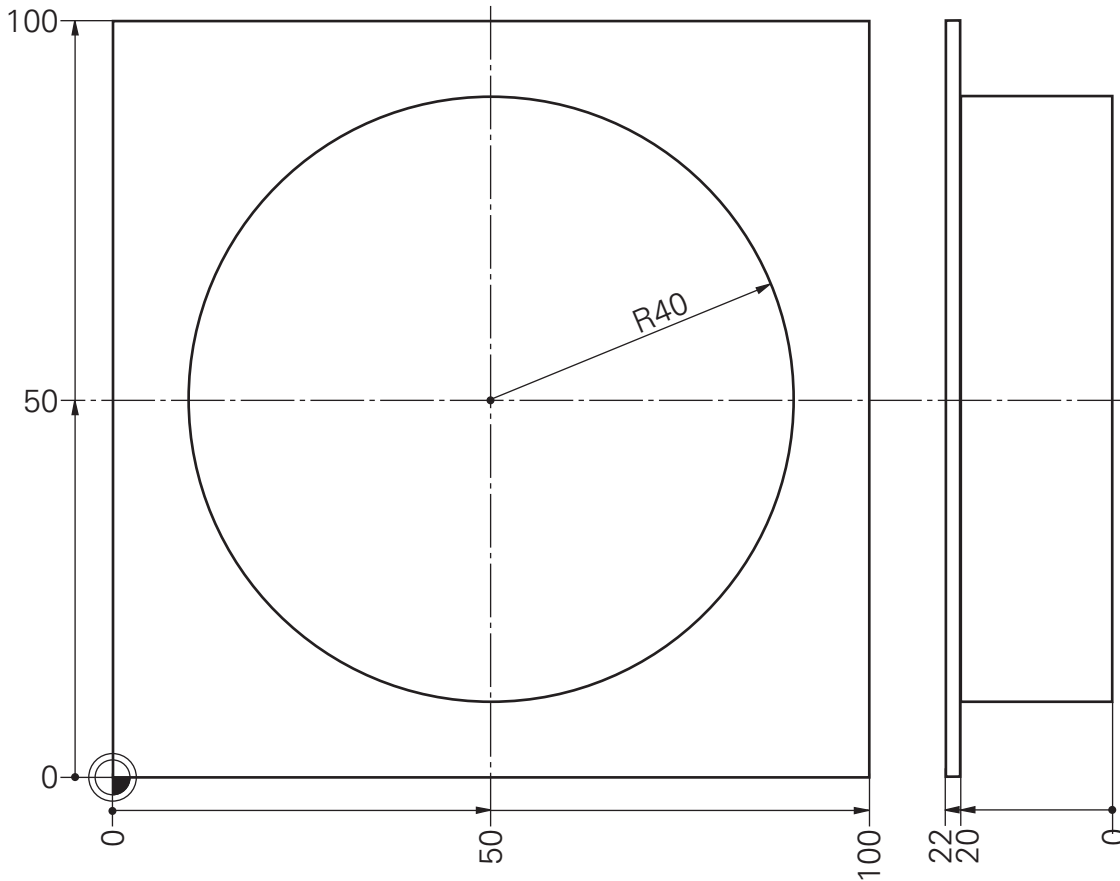
Solution:

Finish milling rectangle pocket

SPGM

```
17 LBL 1
18 FN 4: Q13 = +Q3 DIV +2
19 FN 4: Q14 = +Q4 DIV +2
20 FN 4: Q16 = +Q6 DIV +4
21 FN 4: Q17 = +Q7 DIV +2
22 L X+Q1 Y+Q2 R0 F9998 M3
23 L Z+Q9
24 L Z-Q5 FQ7
25 L IX+Q13 Y+Q2 RL
26 RND RQ16 FQ17
27 L IY+Q14 IX+0 FQ8
28 RND RQ6 FQ17
29 L IX-Q3 IY+0
30 RND RQ6 FQ17
31 L IY-Q4 IX+0
32 RND RQ6 FQ17
33 L IX+Q3 IY+0
34 RND RQ6 FQ17
35 L IY+Q14 IX+0
36 RND RQ16 FQ17
37 L X+Q1 Y+Q2 R0 F9998
38 L Z+Q9
39 LBL 0
40 END PGM 7286 MM
```

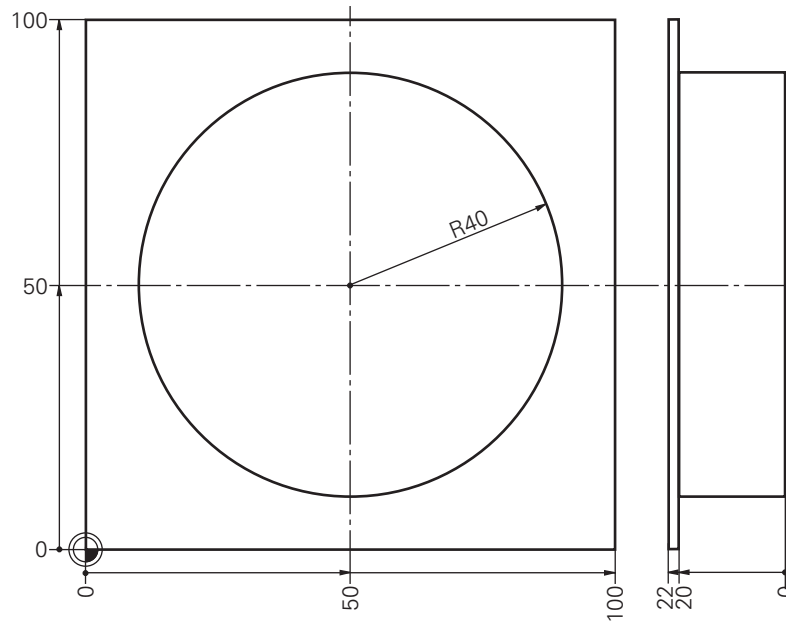




Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

Solution:

Milling cylindrical pins



Main program

```
0 BEGIN PGM 7288 MM
1 ..... MILLING CYLINDRICAL PINS
2 ..... WITH 2 CUTS AND
   ..... RADIAL SETTING

3 FN 0: Q1 = +50 ..... X-CENTER
4 FN 0: Q2 = +50 ..... Y-CENTER
5 FN 0: Q3 = +0 ..... Z-UPPER EDGE
6 FN 0: Q4 = +80 ..... DIAMETER
7 FN 0: Q5 = +1 ..... OVERSIZE RADIUS
8 FN 0: Q6 = +20 ..... MILL DEPTH
9 FN 0: Q7 = +200 ..... MILL FEED RATE
10 BLK FORM 0.1 Z X+0 Y+10 Z-22
11 BLK FORM 0.2 X+100 Y+90 Z+0
12 TOOL DEF 1 L+0 R+10
13 TOOL CALL 1 Z S4000
14 L Z+10 R0 F9999 M3
15 CALL LBL 1

Retract tool, end      16 L Z+50 M2
```



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C01



7288/3

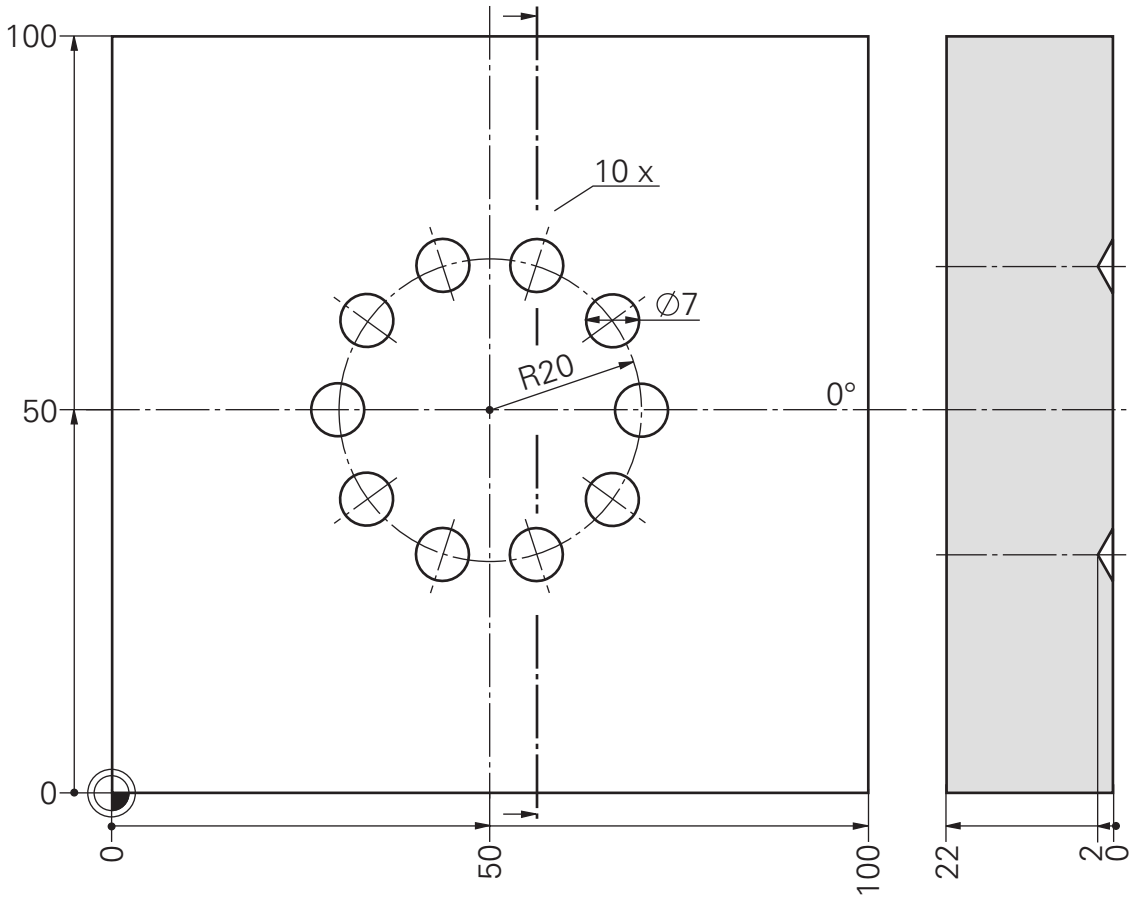
SPGM

17	LBL 1	
18	FN 1: Q23 = +Q3 + +2	Z-HEIGHT OF MOVEMENT (CLEARANCE)
19	FN 4: Q24 = +Q4 DIV +2	RADIUS
20	FN 1: Q25 = +Q24 + +Q5	RADIUS + OVERSIZE
21	FN 1: Q34 = +Q25 + +Q108	RADIUS + OVERS. + TOOL RADIUS
22	FN 1: Q35 = +Q34 + +Q5	RAD. + 2 * OVERS. + TOOL RADIUS
23	FN 4: Q28 = +Q5 DIV +2	ONE HALF OVERSIZE
24	FN 4: Q27 = +Q7 DIV +2	ONE HALF FEED RATE
25	FN 3: Q29 = +Q7 * +2	DOUBLE FEED RATE
26	CC X+Q1 Y+Q2	
27	LP PR+Q35 PA+0 R0 F9999	UNCORRECTED STARTING POINT
28	L Z+Q23	GO TO SETUP CLEARANCE
29	L Z-Q6 FQ27	PLUNGE
30	LP PR+Q25 PA+0 RL FQ7	MOVE TO WITH OVERSIZE
31	RND RQ28 FQ27	APPROACH TANG. WITH OVERS.
32	CP PA+0 DR- FQ7	CIRCLE WITH OVERSIZE
33	RND RQ28 FQ27	DEPART WITH OVERSIZE
34	LP PR+Q35 PA+0 R0 FQ29	
35	LP PR+Q24 PA+0 RL FQ29	FINISH CUT
36	RND RQ28 FQ27	
37	CP DR- FQ7	
38	RND RQ28 FQ27	
39	LP PR+Q35 PA+0 R0 FQ29	RETRACT TOOL
40	L Z+Q23 R0 F9999	
41	LBL 0	
42	END PGM 7288 MM	



Task: **1 Bolt hole circle (parametric),
1 tool, 1 cycle (center)**

Program(s): _____



Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

SPGM 1

Starting values
Preparation

First hole

Start grinding

SPGM 1, end

<i>LBL 1</i>
<i>FN 0: Q24 = 1</i> <i>FN 0: Q25 = Q5</i> <i>FN 4: Q26 = 360 DIV Q4</i> <i>CC XQ1 YQ2</i> <i>LP PRQ3 PAQ5 R0 F9999 M3</i> <i>L Z+Q6 M99</i>
<i>LBL 2</i>
<i>FN 1: Q24 = Q24 +1</i> <i>FN 1: Q25 = Q25 +Q26</i> <i>LP PRQ3 PAQ25 M99</i> <i>FN 12: IF Q24 LT Q4 GOTO LBL 2</i>
<i>LBL 0</i>

Counter
Current angle
Angular step

Pole
Move to

Count
Calculate/update

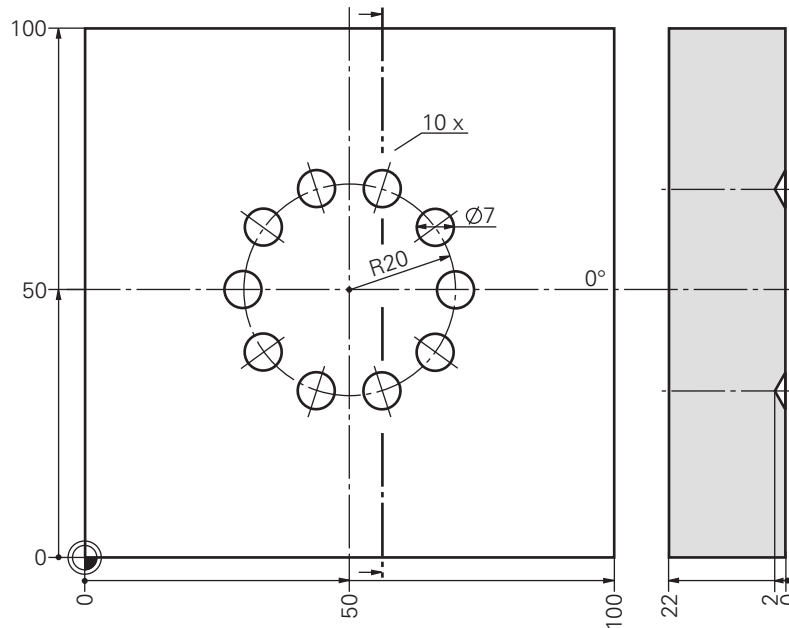
Next holes

Check with
return jump



Solution:

1 Bolt hole circle (parametric), 1 tool, 1 cycle (center)



Main program

Center

Geometry values

Retract tool, end

```
0 BEGIN PGM 7416 MM
1 ..... 1 BOLT HOLE CIRCLE
2 BLK FORM 0.1 Z X+0 Y+10 Z-22
3 BLK FORM 0.2 X+100 Y+90 Z+0
4 TOOL DEF 1 L+0 R+3,5
5 TOOL CALL 1 Z S1000
6 L Z+10 R0 F9999 M3
7 CYCL DEF 1.0 PECKING ..... CYCLE TYPE AND CYCLE VALUES
8 CYCL DEF 1.1 SET UP -Q6
9 CYCL DEF 1.2 DEPTH -2
10 CYCL DEF 1.3 PECKG -2
11 CYCL DEF 1.4 DWELL 0
12 CYCL DEF 1.5 F100
13 FN 0: Q1 = +50 ..... X-CENTER
14 FN 0: Q2 = +50 ..... Y-CENTER
15 FN 0: Q3 = +20 ..... RADIUS
16 FN 0: Q4 = +10 ..... NUMBER
17 FN 0: Q5 = +0 ..... STARTING ANGLE
18 FN 0: Q6 = +2 ..... Z-SETUP CLEARANCE
19 CALL LBL 1
20 L Z+20 R0 F9998 M2 ..... RETURN JUMP
```

SPGM, Bolt hole circle

```
21 LBL 1
22 FN 0: Q25 = +Q5
23 FN 0: Q24 = +1
24 CC X+Q1 Y+Q2
25 FN 4: Q26 = +360 DIV +Q4
26 LP PR+Q3 PA+Q5 R0
27 L Z+Q6 M99

28 LBL 2
29 FN 1: Q25 = +Q25 + +Q26
30 FN 1: Q24 = +Q24 + +1
31 LP PR+Q3 PA+Q25 M99
32 FN 12: IF +Q24 LT +Q4 GOTO LBL 2
33 LBL 0
34 END PGM 7416 MM
```



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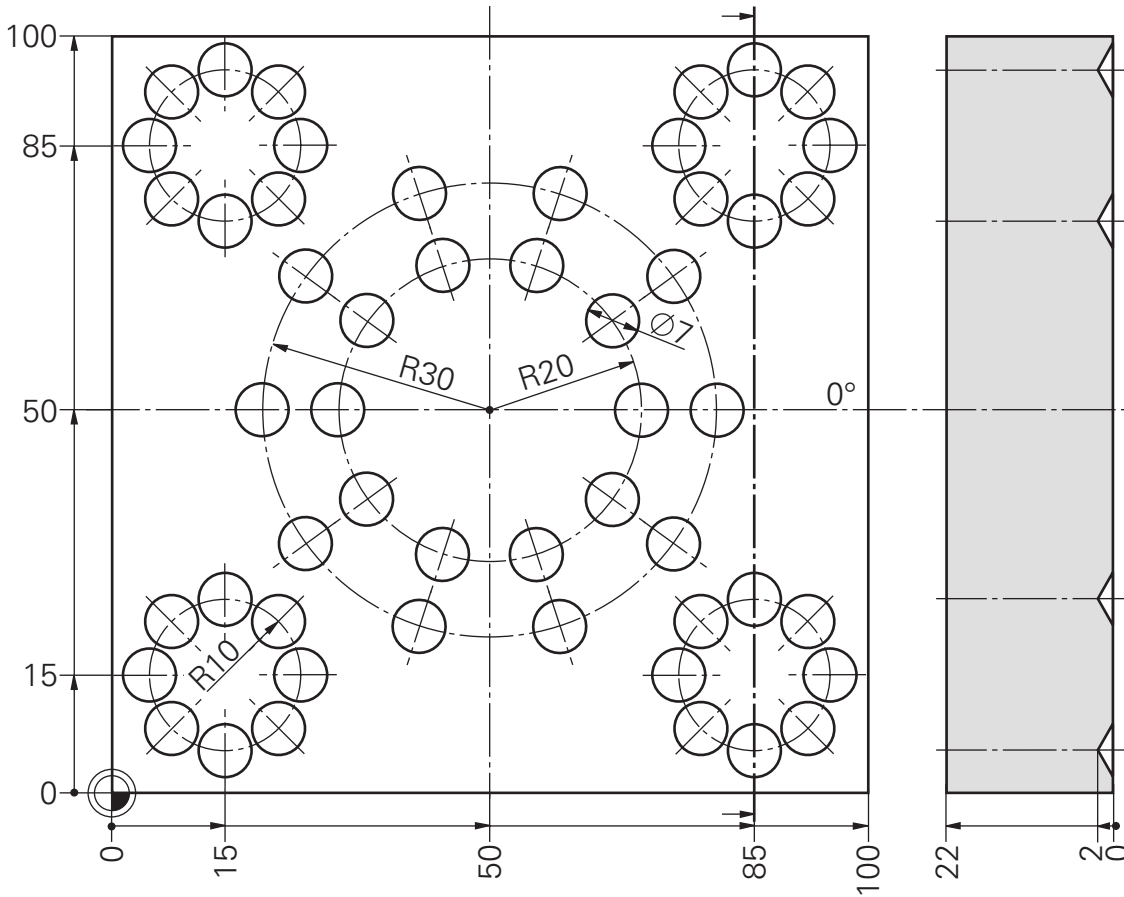
C05



7416/3

Task: **6 Bolt hole circles (parametrisch)**

Program(s): _____



Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

Program layout:
Intermediate step

**6 Bolt hole circles with 1 tool,
1 cycle, 1 clearance height**

**Structure for 1 tool /
1 cycle**

```
TOOL DEF 1 L0 R3,5
TOOL CALL ...
```

```
Q6 = +2      Set up
Q7 = +2      Depth
```

```
PECKING
SET UP -Q6
DEPTH -Q7
```

**Preparation for several
tools / cycles**

```
TOOL DEF 1 L0 R3,5
TOOL CALL ...
```

```
Q6 = +2      Set up
Q7 = +2      Depth
```

```
PECKING
SET UP -Q6
DEPTH -Q7
```

```
CALL LBL 10
```

Further steps / cycles

```
L Z100 F9999 M2
```

Geometry

1st bolt hole circle

```
Q1 = ... // Q5 = ...
```

```
CALL LBL 1
```

```
Q3 = ... /
```

2nd bolt hole circle

```
CALL LBL 1
```

```
Q... = / Q... =
```

3rd bolt hole circle

```
CALL LBL 1
```

```
⋮
```

6th bolt hole circle

```
CALL LBL 1
```

```
L Z100 M2
```

```
LBL 1
```

```
⋮
```

```
LP ... M3
```

```
L Z ... M99
```

```
LBL 3
```

```
⋮
```

```
LP PA M99
```

```
LBL 0
```

```
LBL 10
```

```
Q1 = ... // Q5 = ...
```

```
CALL LBL 1
```

```
Q3 = ... /
```

```
CALL LBL 1
```

```
Q... = / Q... =
```

```
CALL LBL 1
```

```
⋮
```

```
CALL LBL 1
```

```
LBL 0
```

```
LBL 1
```

```
⋮
```

```
LP ... M3
```

```
L Z ... M99
```

```
LBL 3
```

```
⋮
```

```
LP PA M99
```

```
LBL 0
```



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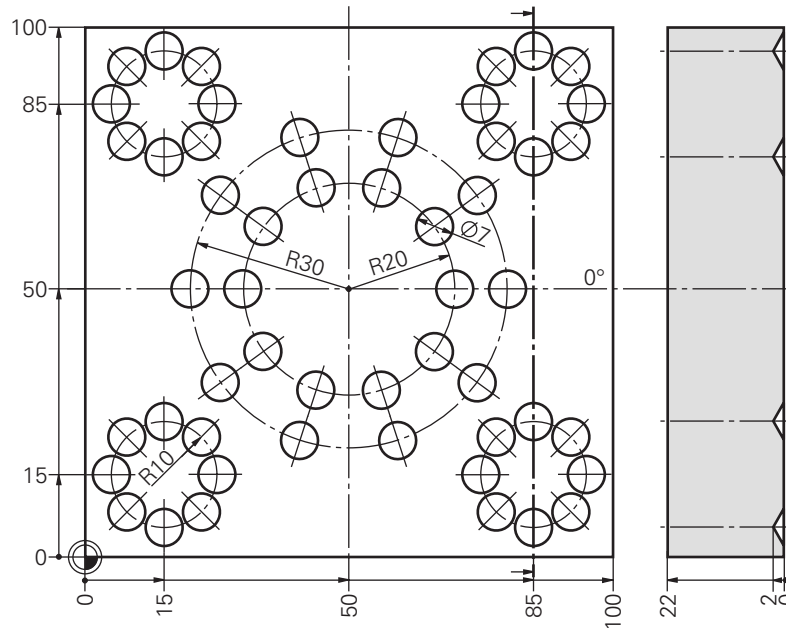
C01



74160/2

Solution:

6 Bolt hole circles with 1 tool, 1 cycle



Main program

```
0 BEGIN PGM 74160 MM
1 ..... 6 BOLT HOLE CIRCLES
2 BLK FORM 0.1 Z X+0 Y+0 Z-22
3 BLK FORM 0.2 X+100 Y+100 Z+0
4 TOOL DEF 1 L+0 R+3,5
5 TOOL CALL 1 Z S1000
6 L Z+10 R0 F9999 M3
7 FN 0: Q6 = +2
8 FN 0: Q7 = +2
9 CYCL DEF 1.0 PECKING
10 CYCL DEF 1.1 SET UP -Q6
11 CYCL DEF 1.2 DEPTH -Q7
12 CYCL DEF 1.3 PECKG -2
13 CYCL DEF 1.4 DWELL 0
14 CYCL DEF 1.5 F100
15 CALL LBL 10

Retract tool, end
16 L Z+50 R0 F MAX M2
```



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C05



74160/3

Solution:

6 Bolt hole circles with 1 tool, 1 cycle

SPGM, Bolt hole circle geometry

```
17 LBL 10
18 FN 0: Q1 = +50 ..... X-CENTER
19 FN 0: Q2 = +50 ..... Y-CENTER
20 FN 0: Q3 = +20 ..... RADIUS
21 FN 0: Q4 = +10 ..... NUMBER
22 FN 0: Q5 = +0 ..... STARTING ANGLE
23 CALL LBL 1 ..... 1st BOLT HOLE CIRCLE

24 FN 0: Q3 = +30
25 CALL LBL 1 ..... 2nd BOLT HOLE CIRCLE

26 FN 0: Q1 = +15
27 FN 0: Q2 = +15
28 FN 0: Q3 = +10
29 FN 0: Q4 = +8
30 CALL LBL 1 ..... 3rd BOLT HOLE CIRCLE

31 FN 0: Q1 = +85
32 CALL LBL 1 ..... 4th BOLT HOLE CIRCLE

33 FN 0: Q2 = +85
34 CALL LBL 1 ..... 5th BOLT HOLE CIRCLE

35 FN 0: Q1 = +15
36 CALL LBL 1 ..... 6th BOLT HOLE CIRCLE
37 LBL 0
```

SPGM, Bolt hole circle itself

```
38 LBL 1 ..... EXECUTION
39 FN 0: Q25 = +Q5
40 FN 0: Q24 = +1
41 CC X+Q1 Y+Q2
42 FN 4: Q26 = +360 DIV +Q4
43 LP PR+Q3 PA+Q5 R0
44 L Z+Q6 M99

45 LBL 2
46 FN 1: Q25 = +Q25 + +Q26
47 FN 1: Q24 = +Q24 + +1
48 LP PR+Q3 PA+Q25 M99
49 FN 12: IF +Q24 LT +Q4 GOTO LBL 2

50 LBL 0
51 END PGM 74160 MM
```



Program layout: **6 Bolt hole circles with 3 tools,
3 cycles, 2 clearance heights**

Preparation: *BLK- FORM*

Center

```
TOOL DEF 1 L0 R3,5
TOOL CALL ...
Q6 = +2
Q7 = +2
Q8 = +2
PECKING
SET UP -Q ...
DEPTH -Q ...
PECKG -Q ...

CALL LBL 10
```

Individual values:
SET UP
DEPTH
PLUNGING DEPTH
Cycle definition 1

SPGM–Aufruf

Pecking

```
TOOL DEF 2 L0 R2,5
TOOL CALL ...
Q7 = +20
Q8 = +10

CALL LBL 10
```

Individual values:
DEPTH
PLUNGING DEPTH

SPGM call

Tapping

```
TOOL DEF 3 L0 R3,0
TOOL CALL ...
Q... = +5
Q... = +15

TAPPING
SET UP -Q ...
DEPTH -Q ...

CALL LBL 10
```

Individual values:
SET UP
DEPTH

Cycle definition 2

SPGM call

Return jump *L Z100 M2*

Subprograms

```
LBL 10
Q1 = ... // Q5 = ...
CALL LBL 1
Q3 = ... // Q5 = ...
CALL LBL 1
:
LBL 0
```

```
LBL 1
:
LP ... M3
L Z... M99
LBL 3
:
LP PA M99
LBL 0
```

Solution:

6 Bolt hole circles with 3 tools, 3 cycles

```
0 BEGIN PGM 74161 MM
1 ..... 6 BOLT H. C., 3 TOOLS, 3 CYCLES
2 BLK FORM 0.1 Z X+0 Y+0 Z-22
3 BLK FORM 0.2 X+100 Y+100 Z+0
Center 4 TOOL DEF 1 L+0 R+3,5
5 TOOL CALL 1 Z S1000
6 FN 0: Q6 = +2 ..... SET UP
7 FN 0: Q7 = +2 ..... DEPTH
8 FN 0: Q8 = +2 ..... PLUNGING DEPTH
9 L Z+10 R0 F9999 M3
10 CYCL DEF 1.0 PECKING
11 CYCL DEF 1.1 SET UP -Q6
12 CYCL DEF 1.2 DEPTH -Q7
13 CYCL DEF 1.3 PECKG -Q8
14 CYCL DEF 1.4 DWELL 0
15 CYCL DEF 1.5 F100
16 CALL LBL 10
17 STOP M6

Pecking 18 TOOL DEF 2 L+0 R+2,5
19 TOOL CALL 2 Z S3150
20 FN 0: Q7 = +20
21 FN 0: Q8 = +10
22 L Z+10 R0 F MAX M3
23 CALL LBL 10
24 STOP M6

Tapping 25 TOOL DEF 3 L+0 R+3
26 TOOL CALL 3 Z S400
27 FN 0: Q6 = +5 ..... SET UP
28 CYCL DEF 2.0 TAPPING
29 CYCL DEF 2.1 SET UP -Q6
30 CYCL DEF 2.2 DEPTH -15
31 CYCL DEF 2.3 DWELL 0
32 CYCL DEF 2.4 F400
33 L Z+10 R0 F MAX M3
34 CALL LBL 10
35 L M30
```



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C01



74161/3

Solution:

6 Bolt hole circles with 3 tools, 3 cycles

Individual dimensions of bolt hole circles

36 LBL 10
37 FN 0: Q1 = +50 X-CENTER
38 FN 0: Q2 = +50 Y-CENTER
39 FN 0: Q3 = +20 RADIUS
40 FN 0: Q4 = +10 NUMBER
41 FN 0: Q5 = +0 STARTING ANGLE
42 CALL LBL 1

43 FN 0: Q3 = +30
44 CALL LBL 1

45 FN 0: Q1 = +15
46 FN 0: Q2 = +15
47 FN 0: Q3 = +10
48 FN 0: Q4 = +8
49 CALL LBL 1

50 FN 0: Q1 = +85
51 CALL LBL 1

52 FN 0: Q2 = +85
53 CALL LBL 1
54 FN 0: Q1 = +15
55 CALL LBL 1

56 L Z+50 R0 F MAX M5
57 LBL 0

Bolt hole circles

58 LBL 1
59 FN 0: Q25 = +Q5
60 FN 0: Q24 = +1
61 CC X+Q1 Y+Q2
62 FN 4: Q26 = +360 DIV +Q4
63 LP PR+Q3 PA+Q5 R0
64 L Z+Q6 M99

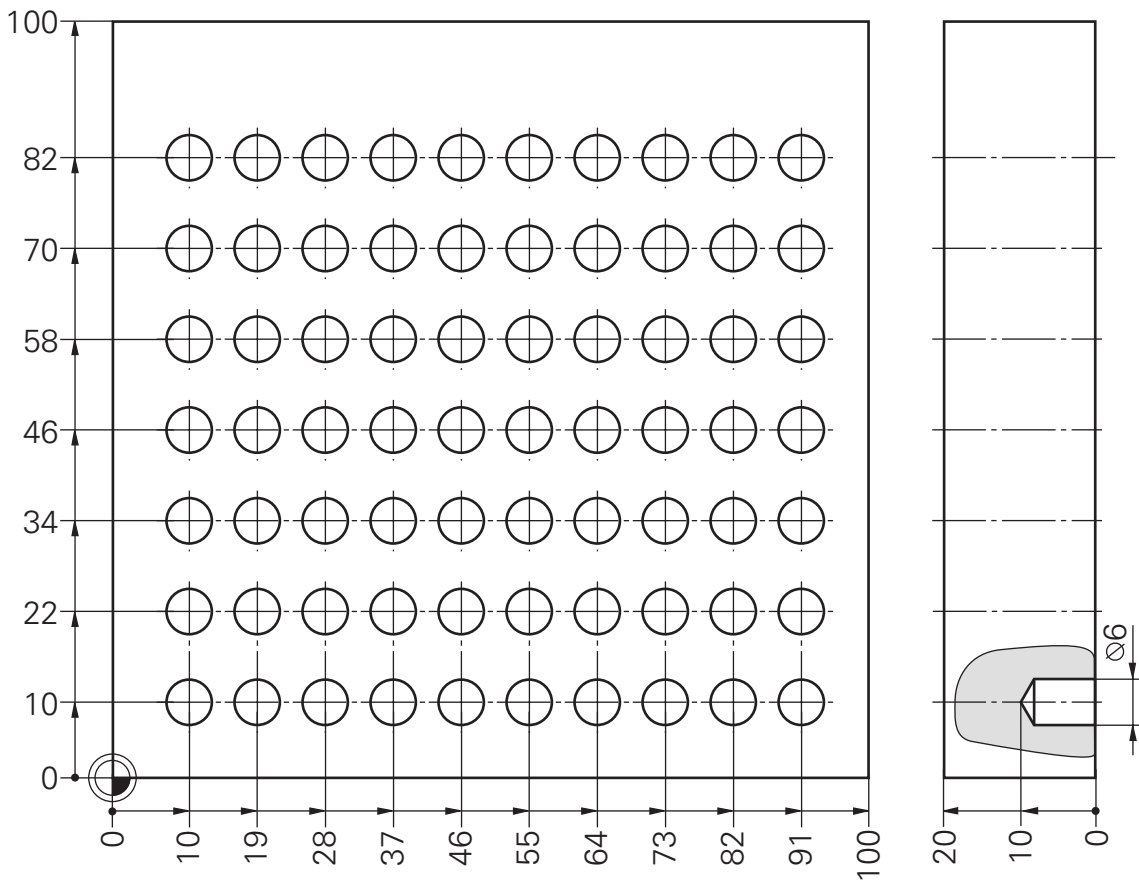
65 LBL 2
66 FN 1: Q25 = +Q25 + +Q26
67 FN 1: Q24 = +Q24 + +1
68 LP PR+Q3 PA+Q25 M99
69 FN 12: IF +Q24 LT +Q4 GOTO LBL 2

70 LBL 0
71 END PGM 74161 MM



Task: Linear hole pattern

Program(s): _____



Q	Meaning	Value	Comment
1	_____	_____	_____
2	_____	_____	_____
3	_____	_____	_____
4	_____	_____	_____
5	_____	_____	_____
6	_____	_____	_____
7	_____	_____	_____
8	_____	_____	_____
9	_____	_____	_____
10	_____	_____	_____
11	_____	_____	_____
12	_____	_____	_____
13	_____	_____	_____
14	_____	_____	_____
15	_____	_____	_____

Preparation

BLK FORM

Load data

FN 0: Q1 = 10

FN 0: Q2 = 10

FN 0: Q3 = 9

FN 0: Q4 = 12

FN 0: Q5 = 10

FN 0: Q6 = 7

FN 0: Q7 = 2

TOOL 1.../CYCL1... SET UP-Q7

CALL LBL 1

X start

Y start

X spacing

Y spacing

Num. of columns ||

Number of rows =

Z clearance

Retract tool, end

L Z50... M2

SPGM

LBL 1

Starting values

FN 0: Q21 = Q1

FN 0: Q22 = Q2

FN 0: Q25 = 0

FN 0: Q26 = 0

FN 0: Q23 = Q3

X current

Y current

Current column ||

Current row =

Copy X steps

Start grinding

LBL 2

Position

L XQ21 YQ22 R0 F... M...

L Z+Q7 M99

FN 1: Q21 = Q21 + Q23

FN 1: Q25 = Q25 + 1

FN 12: IF Q25 LT Q5 GOTO LBL 2

Pecking

X step

Count column

New row

FN 0: Q25 = 0

FN 1: Q26 = Q26 + 1

FN 0: Q23 = -Q23

FN 1: Q21 = Q21 + Q23

FN 1: Q22 = Q22 + Q4

FN 12: IF Q26 LT Q6 GOTO LBL 2

Reset column counter

Count row

Reverse X step

Compensation

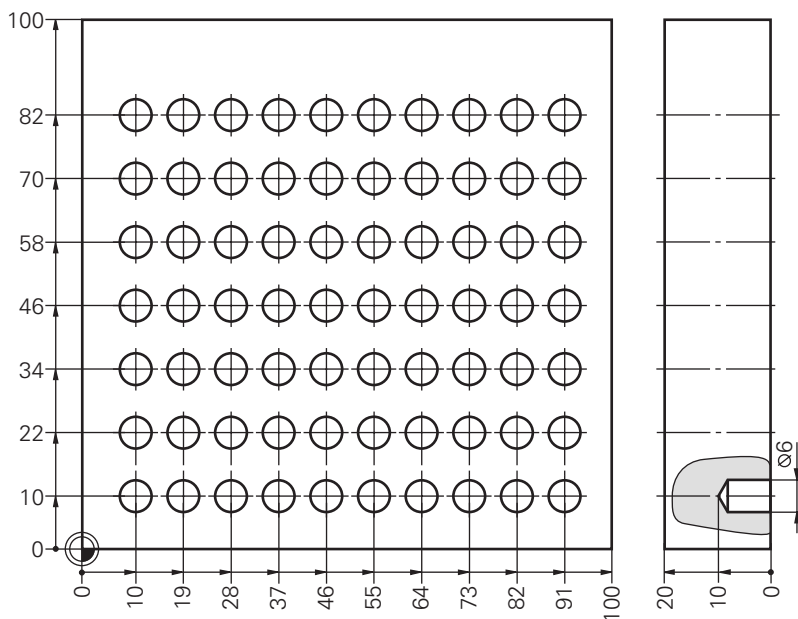
Y step

LBL 0



Solution:

Linear hole pattern with Q-parameters



Main program

```
0 BEGIN PGM 746910 MM
1 ..... LINEAR HOLE PATTERN
2 ..... WITH Q-PARAMETERS
3 BLK FORM 0.1 Z X+0 Y+0 Z-20
4 BLK FORM 0.2 X+100 Y+100 Z+0
5 FN 0: Q1 = +10 ..... X START
6 FN 0: Q2 = +10 ..... Y START
7 FN 0: Q3 = +9 ..... X SPACING
8 FN 0: Q4 = +12 ..... Y SPACING
9 FN 0: Q5 = +10 ..... NUMBER OF COLUMNS
10 FN 0: Q6 = +7 ..... NUMBER OF ROWS
11 FN 0: Q7 = +2 ..... Z CLEARANCE
12 TOOL DEF 1 L+0 R+3
13 TOOL CALL 1 Z S1400
14 L Z+50 R0 F MAX M3
15 CYCL DEF 1.0 PECKING
16 CYCL DEF 1.1 SET UP -Q7
17 CYCL DEF 1.2 DEPTH -10
18 CYCL DEF 1.3 PECKG -5
19 CYCL DEF 1.4 DWELL 0
20 CYCL DEF 1.5 F500
21 CALL LBL 1
```

Retract tool, end

```
22 L Z+50 R0 F MAX M2
```



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C05



746910/3

Solution:

Linear hole pattern with Q-parameters

SPGM

24 LBL 1 PREPARATIONS
25 FN 0: Q21 = +Q1 X
26 FN 0: Q22 = +Q2 Y
27 FN 0: Q25 = +0 COLUMN
28 FN 0: Q26 = +0 ROW
29 FN 0: Q23 = +Q3 X STEP

Start grinding

30 LBL 2
31 L X+Q21 Y+Q22 R0 F9999 POSITION
32 L Z+Q7 R0 F9999 M99 PECKING
33 FN 1: Q21 = +Q21 + +Q23 X STEP
34 FN 1: Q25 = +Q25 + +1 COLUMN
35 FN 12: IF +Q25 LT +Q5 GOTO LBL 2

Return jump

36 FN 0: Q25 = +0 COLUMN COUNTER
37 FN 1: Q26 = +Q26 + +1 ROW
38 FN 0: Q23 = -Q23 REVERSE X-DIRECTION
39 FN 1: Q21 = +Q21 + +Q23 COMPENSATION
40 FN 1: Q22 = +Q22 + +Q4 Y STEP
41 FN 12: IF +Q26 LT +Q6 GOTO LBL 2 NOT COMPLETE?
42 LBL 0
43 END PGM 746910 MM



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746910/4