



# DOOSAN PUMA MX Series

*FANUC Series 31i-Model A5*

## Programming Examples Manual

**DISCLAIMER OF WARRANTY:**

This user manual and the accompanying files are sold or supplied "as is" and without warranties as to performance of merchantability or any other Warranties whether expressed or implied.

While every effort has been made to verify the accuracy of the content provided, it is the responsibility of those programming and operating Doosan MX Series Multi-Tasking CNC Machining Centers to abide by standards of safe programming, setup and operation of any CNC Machine Tool.

Because the various machine configurations, programming methods, individual work pieces and setup/operator skill levels all effect the actual operation of the machine,  
NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS OFFERED.

The user must assume the entire risk of using the information provided in this manual and accompanying files.

Any typographical errors should be brought to the attention of AmTTech immediately.



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## **DOOSAN PUMA MX Series – Standard Turning**

The Doosan Puma MX Series is a powerful Multi-Task Machining Center. Its core is built upon the concepts a standard CNC Turning Center. As such, it handles standard CNC Turning quite well.

The basic differences in programming are not in the tool path motion but in the following:

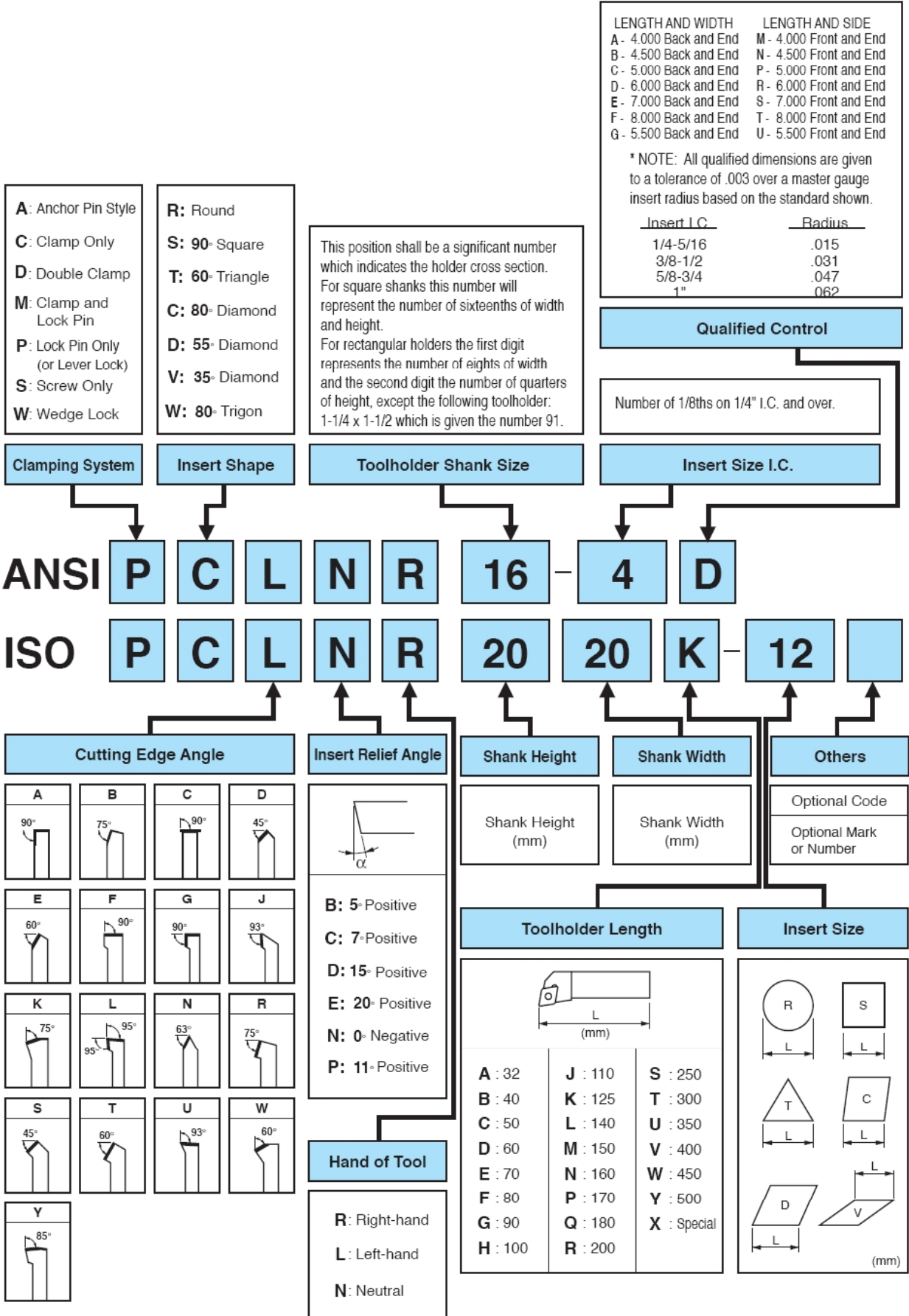
- Preparation and positioning before a Turning Operation
- Tool Changes and Offsets
- End of an Operation/Preparation for the next operation.

By standardizing the NC Code data in these areas, we can come up with a basic skeleton or outline for all machining operations. This standardization will aid in the creation of a Post-Processor for any given CAM system that a user may have for generating NC programs.

As ANSI/ISO Stick Tooling is well established for CNC Turning Operations, the first four examples in this user manual will be using this standard stick tooling along with the proper CAPTO® C6 holder and adapters for that tooling.



















As all Doosan Puma MX Series Multi-Task Machining Center have the common element of the Nutating B-Axis Head, our first standard turning example will be done using the B-Axis Head for all operations. We will then progress to using the Lower Turret independently and then integrate it into synchronized operations using both the Upper B-Axis Head and the Lower Turret.

# External Toolholder Identification System












# Insert Designation Chart

Shape (e.g. "CNMG432" / "CCMT32.51")

Code Letter	Description	Diagram	Nose Angle
A	85° parallelogram		85°
B	82° parallelogram		82°
C	80° diamond		80°
D	55° diamond		55°
E	75° diamond		75°
H	hexagon		120°
K	55° parallelogram		55°
L	rectangle		90°
M	86° diamond		86°
N	55° parallelogram		55°
O	octagon		135°
P	pentagon		108°
R	round		full radius
S	square		90°
T	triangle		60°
V	35° diamond		35°
W	trigon		80°
X	sp. parallelogram		85°

Clearance or Relief Angle (e.g. "CNMG432" / "CCMT32.51")

Code Letter	Angle	Diagram
N	0°	
A	3°	
B	5°	
C	7°	
P	11°	
D	15°	
E	20°	
F	25°	
G	30°	

**Tolerance** (e.g. "CNMG432" / "CCMT32.51")

Code Letter	Cornerpoint (inches)	Thickness (inches)	Inscribed Circle (in)	Cornerpoint (mm)	Thickness (mm)	Inscribed Circle (mm)
A	.0002"	.001"	.001"	.005mm	.025mm	.025mm
C	.0005"	.005"	.001"	.013mm	.025mm	.025mm
E	.001"	.001"	.001"	.025mm	.025mm	.025mm
F	.0002"	.005"	.0005"	.005mm	.025mm	.013mm
G	.001"	.001"	.001"	.025mm	.13mm	.025mm
H	.0005"	.001"	.0005"	.013mm	.025mm	.013mm
J	.002"	.001"	.002-.005"	.005mm	.025mm	.05-.13mm
K	.0005"	.001"	.002-.005"	.013mm	.025mm	.05-.13mm
L	.001"	.001"	.002-.005"	.025mm	.025mm	.05-.13mm
M	.002-.005"	.005"	.002-.005"	.05-.13mm	.13mm	.05-.15mm
U	.005-.012"	.001"	.005-.010"	.06-.25mm	.13mm	.08-.25mm

**Hole / Chipbreaker** (e.g. "CNMG432" / "CCMT32.51")

Code Letter	Diagram	Hole	Hole Shape	Chipbreaker Type
A		Yes	Cylindrical	None
B		Yes	70-90° double countersink	None
D		Yes	Cylindrical	None
E		No		None
F		No		Double-sided
G		Yes	Cylindrical	Double-sided
H		Yes	70-90° single countersink	Single-sided
M		Yes	Cylindrical, or dbl countersink	Single-sided
N		No		None
P		Yes	Cylindrical	Hi-double positive
Q		Yes	40-60° double countersink	None
R		No		Single-sided
S		Yes	Cylindrical	Hi-double positive
T		Yes	40-60° double countersink	Single-sided
U		Yes	40-60° double countersink	Double-sided
W		Yes	40-60° double countersink	None
Z		Yes	Cylindrical	Double-sided hi-double positive

**Size** (e.g. "CNMG432" / "CCMT32.51")

ANSI Code No.	Inscribed Circle Size		ISO Code No. (metric cutting edge length) by shape code letter of insert						
	decimal in.	fractional in.	C	D	R	S	T	V	W
0.5	.0625"	1/16							
1.2	.15625"	5/32							
1.5	.1875"	3/16	04 (4mm)	5mm	04 (4mm)	04 (4mm)	8mm	8mm	S3
1.8	.21875"	7/32							
2	.25"	1/4	06 (6mm)	07 (7mm)	06 (6mm)	06 (6mm)	11 (11mm)	11 (11mm)	04 (4mm)
2.5	.3125"	5/16	08 (8mm)	9mm	07 (7mm)	07 (7mm)	13 (13mm)	13 (13mm)	05 (5mm)
3	.375"	3/8	09 (9mm)	11 (11mm)	09 (9mm)	09 (9mm)	16 (16mm)	16 (16mm)	06 (6mm)
3.5	.4375"	7/16	11mm	13mm	11 (11mm)	11 (11mm)	19 (19mm)	19mm	7mm
4	.5"	1/2	12 (12mm)	15 (15mm)	12 (12mm)	12 (12mm)	22 (22mm)	22 (22mm)	08 (8mm)
4.5	.5625"	9/16	14mm	17mm	14 (14mm)	14 (14mm)	24mm	24mm	9mm
5	.625"	5/8	16 (16mm)	19 (9mm)	15 (15mm)	15 (15mm)	27 (27mm)	27 (27mm)	10 (10mm)
5.5	.6875"	11/16	17mm	21mm	17 (17mm)	17 (17mm)	30mm	30mm	11mm
6	.75"	3/4	19 (19mm)	23 (23mm)	19 (19mm)	19 (19mm)	33 (33mm)	33 (33mm)	13 (13mm)
6.5	.8125"	13/16							
7	.875"	7/8	22mm	27mm	22 (22mm)	22 (22mm)	38mm	38mm	15mm
8	1"	1	25 (25mm)	31 (31mm)	25 (25mm)	25 (25mm)	44 (44mm)	44 (44mm)	17 (17mm)
10	1.25"	1-1/4	32 (32mm)	38mm	31 (31mm)	31 (31mm)	54 (54mm)	54 (54mm)	21 (21mm)
	1.26"				32 (32mm)				

**Thickness** (e.g. "CNMG432" / "CCMT32.51")

ANSI Code No.	ISO Code No.	Decimal Value	Fractional Value	Millimeter Value
1	01	0.0625"	1/16	1.59mm
	T1	0.078"	5/64	1.98mm
1.5	02	0.094"	3/32	2.38mm
	T2	0.109"	7/64	2.78mm
2	03	0.125"	1/8	3.18mm
2.5	T3	0.156"	5/32	3.97mm
3	04	0.187"	3/16	4.76mm
	05	0.219"	7/32	5.56mm
4	06	0.25"	1/4	6.35mm
5	07	0.313"	5/16	7.9mm
6	09	0.375"	3/8	9.53mm
8		0.5"	1/2	12.7mm

**Radius** (e.g. "CNMG432" / "CCMT32.51")

ANSI Code No.	ISO Code No.	Decimal Value	Fractional Value	Millimeter Value
<u>Null</u>	<u>Null</u>	Wiper flat	Wiper flat	Wiper flat
V	M0	0	0	0
0.2	00	0.004"		0.1mm
X		0.004"		0.1mm
0.5		0.008"		0.2mm
0	00	0.008"		0.2mm
Y		0.008"		0.2mm
1	04	0.016"	1/64	0.4mm
	05	0.020"		0.5mm
2	08	0.031"	1/32	0.8mm
	10	0.040"		1.02mm
3	12	0.047"	3/64	1.2mm
4	16	0.062"	1/16	1.6mm
5	20	0.078"	5/64	2mm
6	24	0.094"	3/32	2.4mm
7	29	0.109"	7/64	2.9mm
8	32	0.125"	1/8	3.2mm



**Wiper Lead Angle** (e.g. "SEKN42AFTN")

Code Letter	Angle
A	45°
D	60°
K	60°
E	75°
L	75°
P	0°

**Wiper Clearance Angle** (e.g. "SEKN42AFTN")

Code Letter	Angle
C	7°
D	15°
E	20°
F	25-26°
G	30°
N	0°
P	11°

**Cutting Edge Preparation** (e.g. "SEKN42AFTN")

Code Letter	Edge Preparation
F	sharp
E	honed
T	T-land
S	honed T-land
X	special chamfer

**Cutting Direction** (e.g. "SEKN42AFTN")

Code Letter	Direction
R	right-hand cutting only
L	left-hand cutting only
N	both right-hand and left-hand cutting

# B-Axis Spindle Function - G490

## Automatic Milling Spindle Orientation (G490)

The B-Axis Head Spindle contains a curvic-coupling on the front face.

This allows for the possible indexing of the milling spindle in 30° increments.

The Doosan Puma MX series has two functions in commanding for milling spindle orientation.

The G490 function automatically unclamps the milling spindle and orients to the designated degree of rotation. After orientation, the milling spindle is automatically clamped.

The other function (M279) is needed to command unclamping (M101) for the milling spindle before commanding orientation and to command clamping (M100) after commanding orientation. But this is only for maintenance by an authorized Service Engineer.

### Command Format

**G490 S\_\_\_\_\_**

**G490** : automatic milling spindle orientation command

**S\_\_\_\_\_** : orientation degree of milling spindle

S0 → 0°

S300 → 30°

S1800 → 180°

S3600 → 360°

### Note:

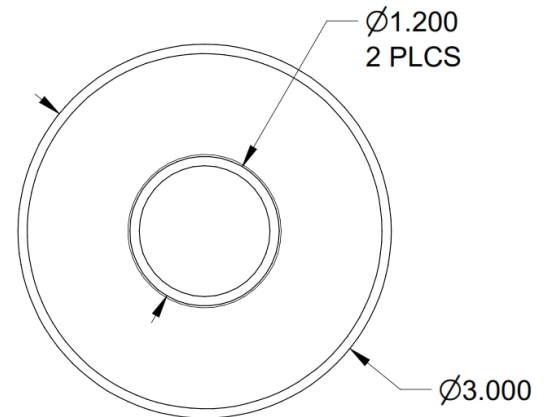
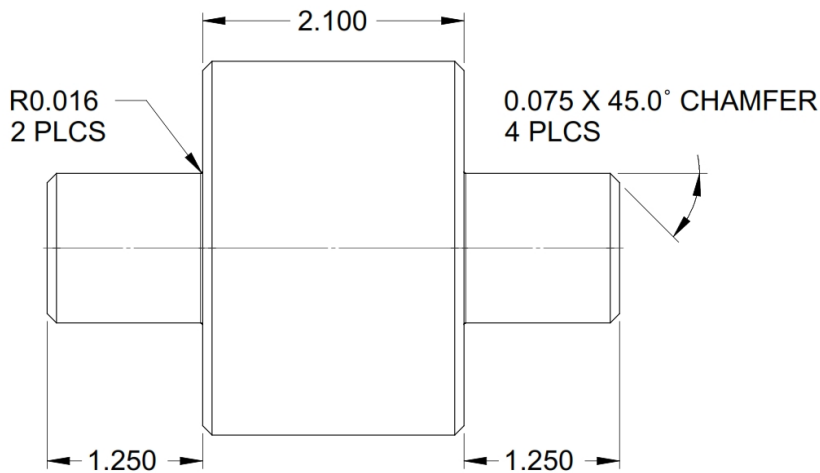
G490 S0 is automatically invoked during a Tool Change Sequence.

It is not required to command G49 S0 prior to a Tool Change Sequence.

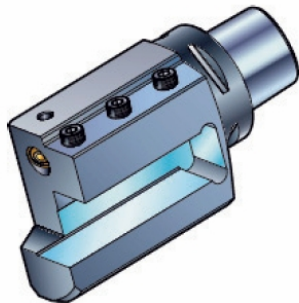
However, all examples using the B-Axis Head will show this commanded explicitly for clarity.

**EXAMPLE #1 - STANDARD TURNING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6-ASHR-38130-16-A (2)  
**HOLDERS** : MCLNR-164D (1), MVJNR-164D (1)  
**INSERTS** : CNMG-432 (1), VNMG-431 (1)  
**SPINDLE** : LEFT MAIN  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : FACE, ROUGH & FINISH TURN HALF OF PART

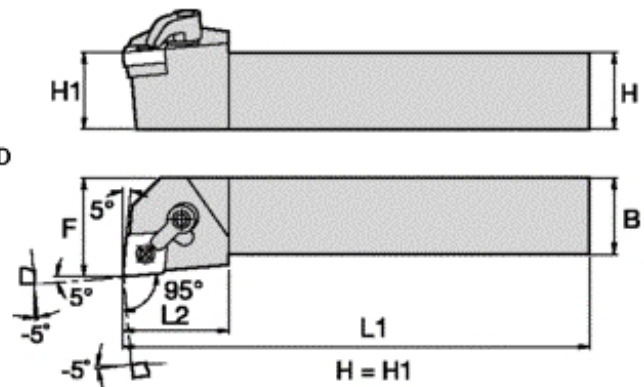


CAPTO® C6 ADAPTER

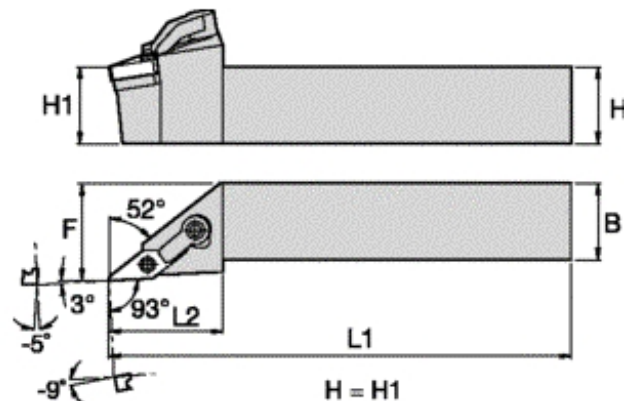


SANDVIK C6-ASHR-38130-16-A

**Tool #1**  
**Holder:** MCLNR-164D  
**Insert:** CNMG432



**Tool #2**  
**Holder:** MVJNR-164D  
**Insert:** VNMG431



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O0001(MX-EXAMPLE #1 - UPPER UNIT ONLY)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T01001 (SANDVIK C6-ASHR-38130-16-A - MCLNR-164D - CNMG432)
N10 T02000 (STAGE NEXT TOOL)
N11 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N17 M261 (SPINDLE WINDING LOW - REPLACES M41)
N18 G50 S2500 (MAXIMUM RPM CAP)
N19 G96 S500 M03 P11 (CONSTANT CUTTING SPEED MODE - 500 FPM - LEFT SPINDLE CLOCKWISE)

(FACE = ROUGH & FINISH)
N20 G00 X3.7 Z0.01
N21 G01 X-0.0625 F0.018
N22 G00 Z0.11
N23 X3.7
N24 Z0.0
N25 G01 X-0.0625 F0.01
N26 G00 Z0.1

(OD CANNED ROUGH)
N27 G00 X3.5
N28 G00 Z0.0615
N29 G71 U0.125 R0.03
N30 G71 P31 Q40 U0.02 W0.01 F0.018
N31 G00 X0.8903
N32 G01 X1.1817 Z-0.0842
N33 G03 X1.2 Z-0.1063 R0.0313
N34 G01 Z-1.125
N35 G01 X2.7875
N36 G03 X2.8317 Z-1.1342 R0.0313
N37 G01 X2.9817 Z-1.2092
N38 G03 X3.0 Z-1.2313 R0.0313
N39 G01 Z-2.225
N40 G01 X3.5
N41 G00 Z0.1

(TOOL CHANGE PREPARATION)
N42 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N43 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N44 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N45 T01000 (CANCEL OFFSET FOR CURRENT TOOL)
N46 M139 (SHOWER BED COOLANT OFF)
N47 M127 (COOLANT THROUGH TOOL OFF)
N48 M05 P11 (LEFT SPINDLE STOP)
N49 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N50 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N51 M01

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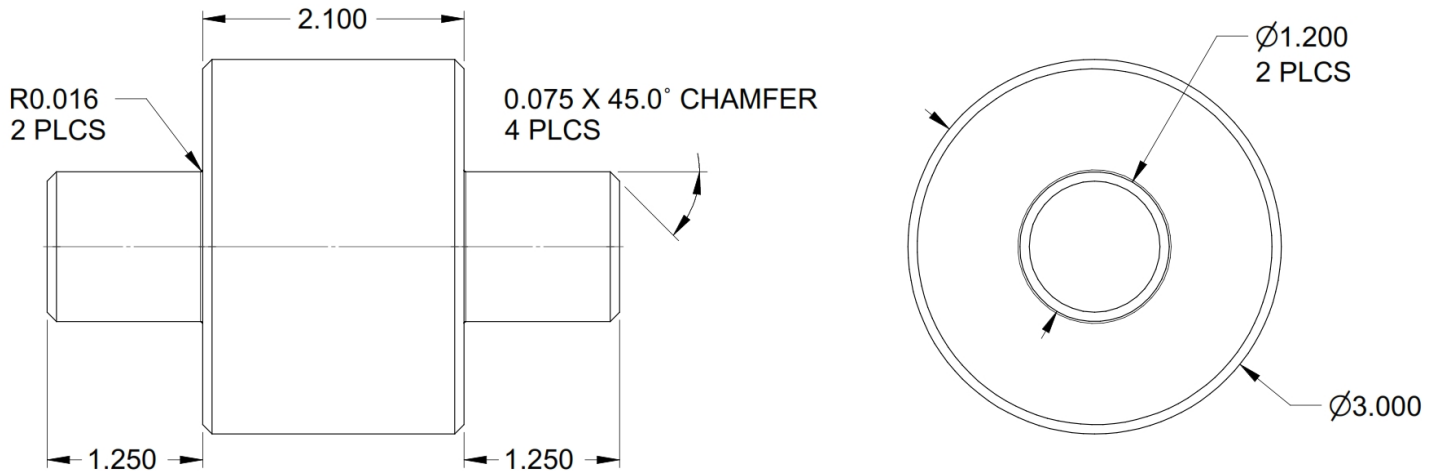
(PREPARATION FOR START OF OPERATION)
N52 G54 (WORK COORDINATE SELECTION)
N53 M06 T02002 (SANDVIK C6-ASHR-38130-16-A - MVJNR-164D - VNMG431)
N54 T01000 (STAGE NEXT TOOL)
N55 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N56 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N57 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N58 M126 (COOLANT THROUGH TOOL ON)
N59 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N60 M262 (SPINDLE WINDING HIGH- REPLACES M42)
N61 G50 S2500 (MAXIMUM RPM CAP)
N62 G96 S600 M03 P11 (CONSTANT CUTTING SPEED MODE - 600 FPM - LEFT SPINDLE CLOCKWISE)

(OD FINISH)
N63 G00 X3.5 Z0.1
N64 X1.0408 Z0.0661
N65 G01 X0.9701 Z0.0308 F0.006
N66 X1.1908 Z-0.0796
N67 G03 X1.2 Z-0.0906 R0.0156
N68 G01 Z-1.125
N69 X2.8187
N70 G03 X2.8408 Z-1.1296 R0.0156
N71 G01 X2.9908 Z-1.2046
N72 G03 X3.0 Z-1.2156 R0.0156
N73 G01 Z-2.205
N74 X3.0707 Z-2.1697
N75 G00 X3.5 Z0.1

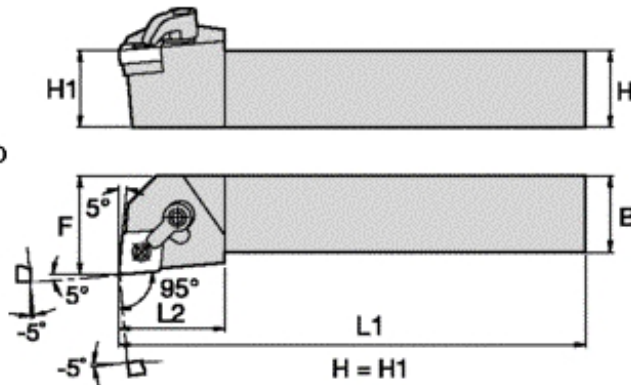
(END PROGRAM/TOOL CHANGE PREPARATION)
N76 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N77 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N78 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N79 T02000 (CANCEL OFFSET FOR CURRENT TOOL)
N80 M139 (SHOWER BED COOLANT OFF)
N81 M127 (COOLANT THROUGH TOOL OFF)
N82 M05 P11 (LEFT SPINDLE STOP)
N83 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N84 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N85 M30
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**EXAMPLE #2 - STANDARD TURNING - LOWER UNIT ONLY**

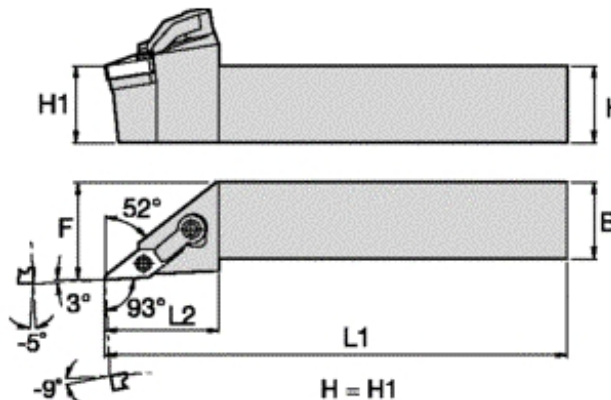
**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : N/A  
**HOLDERS** : MCLNR-164D (1), MVJNR-164D (1)  
**INSERTS** : CNMG-432 (1), VNMG-431 (1)  
**SPINDLE** : LEFT MAIN  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : FACE, ROUGH & FINISH TURN HALF OF PART



**Tool #1**  
**Holder:** MCLNR-164D  
**Insert:** CNMG432



**Tool #2**  
**Holder:** MVJNR-164D  
**Insert:** VNMG431



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O0002 (MX-EXAMPLE #2 - LOWER)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G80 G99
N2 G00 G28 U0.0 (ZERO RETURN X-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)

(PREPARATION FOR START OF OPERATION)
N4 G54 (WORK COORDINATE SELECTION)
N5 T01001 (MCLNR-164D - CNMG432)
N6 M138 (SHOWER BED COOLANT ON)
N7 M08 (COOLANT ON)
N8 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N9 M261 (SPINDLE WINDING LOW - REPLACES M41)
N10 G50 S2500 (MAXIMUM RPM CAP)
N11 G96 S500 M03 P11 (CONSTANT CUTTING SPEED MODE - 500 FPM - LEFT SPINDLE CLOCKWISE)

(FACE = ROUGH & FINISH)
N12 G00 X3.7 Z0.01
N13 G01 X-0.0625 F0.018
N14 G00 Z0.11
N15 X3.7
N16 Z0.
N17 G01 X-0.0625 F0.01
N18 G00 Z0.1

(OD CANNED ROUGH)
N19 G00 X3.5
N20 G00 Z0.0615
N21 G71 U0.125 R0.03
N22 G71 P23 Q32 U0.02 W0.01 F0.018
N23 G00 X0.8903
N24 G01 X1.1817 Z-0.0842
N25 G03 X1.2 Z-0.1063 R0.0313
N26 G01 Z-1.125
N27 G01 X2.7875
N28 G03 X2.8317 Z-1.1342 R0.0313
N29 G01 X2.9817 Z-1.2092
N30 G03 X3.0 Z-1.2313 R0.0313
N31 G01 Z-2.225
N32 G01 X3.5
N33 G00 Z0.1

(TOOL CHANGE PREPARATION)
N34 G00 G28 U0.0 (ZERO RETURN X-AXIS)
N35 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N36 T01000 (CANCEL OFFSET FOR CURRENT TOOL)
N37 M139 (SHOWER BED COOLANT OFF)
N38 M09 (COOLANT THROUGH TOOL OFF)
N39 M05 P11 (LEFT SPINDLE STOP)
N40 M01

(PREPARATION FOR START OF OPERATION)
N41 G54 (WORK COORDINATE SELECTION)
N42 T02002 (MVJNR-164D - VNMG431)
N43 M08 (COOLANT ON)
N44 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N45 M262 (SPINDLE WINDING HIGH- REPLACES M42)
N46 G50 S2500 (MAXIMUM RPM CAP)
N47 G96 S600 M03 P11 (CONSTANT CUTTING SPEED MODE - 600 FPM - LEFT SPINDLE CLOCKWISE)

```

(OD FINISH)

N48 G00 X3.5 Z0.1  
N49 X1.0408 Z0.0661  
N50 G01 X0.9701 Z0.0308 F0.006  
N51 X1.1908 Z-0.0796  
N52 G03 X1.2 Z-0.0906 R0.0156  
N53 G01 Z-1.125  
N54 X2.8187  
N55 G03 X2.8408 Z-1.1296 R0.0156  
N56 G01 X2.9908 Z-1.2046  
N57 G03 X3.0 Z-1.2156 R0.0156  
N58 G01 Z-2.205  
N59 X3.0707 Z-2.1697  
N60 G00 X3.5 Z0.1

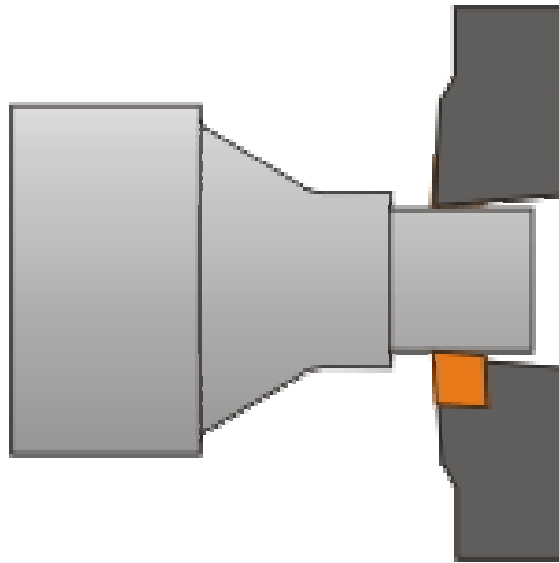
(END PROGRAM/TOOL CHANGE PREPARATION)

N61 G00 G28 U0.0 (ZERO RETURN X-AXIS)  
N62 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N63 T02000 (CANCEL OFFSET FOR CURRENT TOOL)  
N64 M139 (SHOWER BED COOLANT OFF)  
N65 M09 (COOLANT THROUGH TOOL OFF)  
N66 M05 P11 (LEFT SPINDLE STOP)  
N67 T12000 (INDEX TO EMPTY TOOL FOR LOWER TURRET CHUCK CLEARANCE)  
N68 G00 G54 Z0.0 (POSITION LOWER TURRET FOR WORKING ENVELOPE CLEARANCE)  
N69 M30

%



# PINCH TURNING – SYNCHRONIZED UPPER & LOWER



**Pinch Turning** is a way to employ 2 independent and opposing tools on a CNC lathe in order to cut more quickly. When Pinch Turning, one tool follows 180° of spindle rotation behind the other. Each opposing tool is only engaged in the cut for 180° of spindle rotation. The Doosan Puma MX Series T & ST configurations fully support Pinch Turning.

The feed rate that is calculated for each tool is doubled. The tools cut at the same time but are 180° out of phase so that the amount of time needed for the Pinch Turned Operation is 50% less than a standard turning operation.

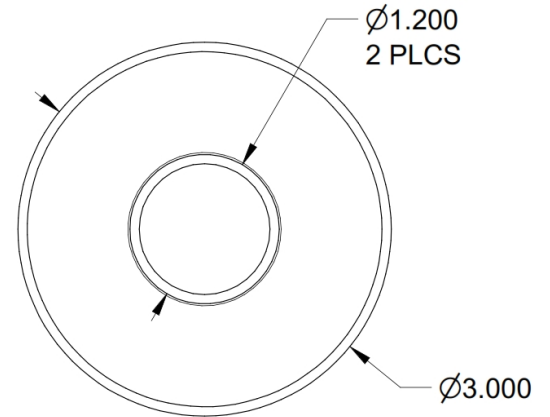
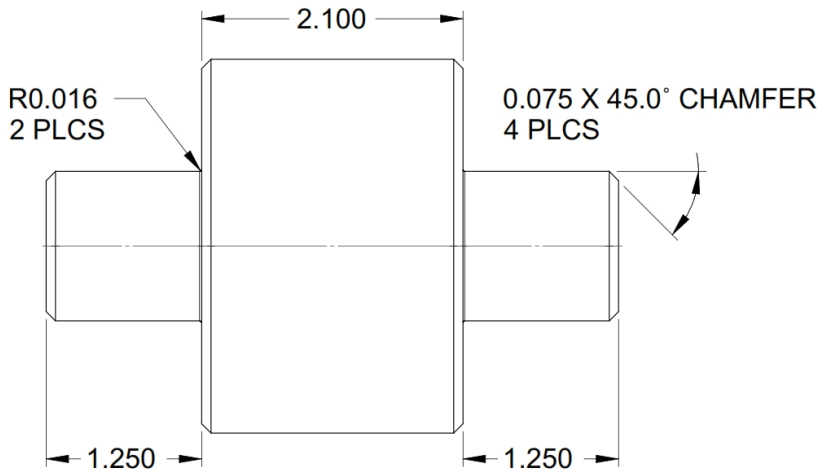
The tools used in Pinch Turning must be identical in configuration. The opposing tools should both share the same orientation (Right or Left Handed), clearance and relief angles, and most importantly, the inserts used must be identical.

Pinch Turning is also referred to as Balanced Turning. It can be used for either roughing or finishing. With Pinch Turning, both the opposing tools use the same programmed path. However, each program is independent and is a separate control system.

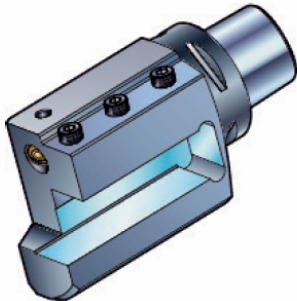
These different control systems are typically classified as Upper & Lower and are synchronized during automatic operation. This synchronization is achieved by the use of Wait Codes (M900-M999) that are placed strategically within the NC code. A Wait Code is included on a line of NC Code where we wish to begin the synchronization. The same wait code is placed at the corresponding point in the NC Code for the opposing tool. When the Upper and Lower Control Systems reach the same point, both Upper and Lower Tools will begin their motion at the same time. If either Control System reaches a Wait Code before the other Control System, that Control System will wait for the other system to “catch up” before beginning synchronized operations.

**EXAMPLE #3 - STANDARD TURNING - SYNCHRONIZED UPPER & LOWER**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6-ASHR-38130-16-A (2)  
**HOLDERS** : MCLNR-164D (2), MVJNR-164D (2)  
**INSERTS** : CNMG-432 (2), VNMG-431 (2)  
**SPINDLE** : LEFT MAIN  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : FACE WITH UPPER, PINCH TURN ROUGH & FINISH TURN HALF OF PART

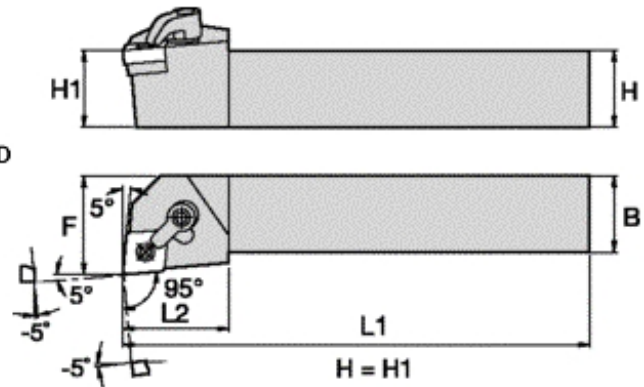


CAPTO® C6 ADAPTER

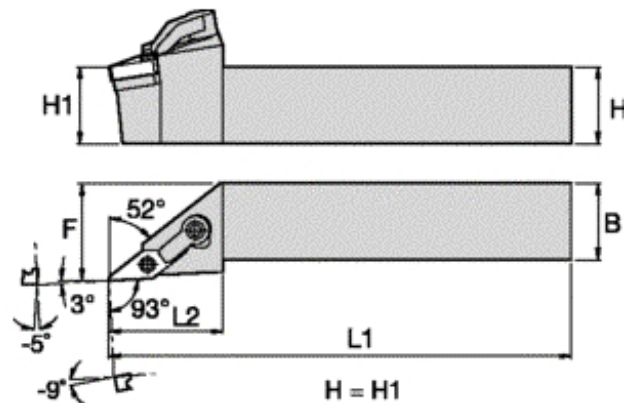


SANDVIK C6-ASHR-38130-16-A

**Tool #1**  
**Holder:** MCLNR-164D  
**Insert:** CNMG432



**Tool #2**  
**Holder:** MVJNR-164D  
**Insert:** VNMG431



```
%
O0003(MX-EXAMPLE #3 - UPPER)
(PINCH TURN SYNCHRONIZED WITH LOWER TURRET)
```

```
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0
N3 G00 G28 W0.0
N4 G00 G28 B0.0
N5 G490 S0
N6 G00 B-90.0
N7 M01
N8 G54
```

```
N9 M06 T01001
N10 T02000
N11 G490 S0
N12 G00 G28 W0.0
N13 G00 G28 B0.0
N14 M138
N15 M126
N16 M34
N17 M261
N18 G50 S2500
N19 G96 S500 M03 P11
```

```
(FACE = ROUGH & FINISH)
```

```
N20 G00 X3.7 Z0.01
N21 G01 X-0.0625 F0.018
N22 G00 Z0.11
N23 X3.7
N24 Z0.
N25 G01 X-0.0625 F0.01
N26 G00 Z0.1
```

```
(OD CANNED ROUGH)
```

```
N27 G00 X3.5 M900 (SYNC POINT)
N28 G00 Z0.0615
N29 G71 U0.125 R0.03
N30 G71 P31 Q40 U0.02 W0.01 F0.036
N31 G00 X0.8903
N32 G01 X1.1817 Z-0.0842
N33 G03 X1.2 Z-0.1063 R0.0313
N34 G01 Z-1.125
N35 G01 X2.7875
N36 G03 X2.8317 Z-1.1342 R0.0313
N37 G01 X2.9817 Z-1.2092
N38 G03 X3.0 Z-1.2313 R0.0313
N39 G01 Z-2.225
N40 G01 X3.5
N41 G00 Z0.1
```

```
N42 G00 G28 U0.0 V0.0
N43 G00 G28 W0.0
N44 G00 G28 B0.0
N45 T01000
N46 M139
N47 M127
N48 M05 P11
N49 G490 S0
N50 G00 B-90.0
N51 M01
```

```
%
O0003(MX-EXAMPLE #3 - LOWER)
(PINCH TURN SYNCHRONIZED WITH B-AXIS HEAD)
```

```
N1 G00 G18 G40 G80 G99
N2 G00 G28 U0.0
N3 G00 G28 W0.0
```

```
N4 G54
N5 T01001
N6 M138
N7 M08
N8 M34
N9 M261
N10 G50 S2500
N11 G96 S500 M03 P11
```

```
(OD CANNED ROUGH)
```

```
N12 G00 X3.5 Z0.1 M900 (SYNC POINT)
N13 G00 Z0.0615
N14 G71 U0.125 R0.03
N15 G71 P16 Q25 U0.02 W0.01 F0.036
N16 G00 X0.8903
N17 G01 X1.1817 Z-0.0842
N18 G03 X1.2 Z-0.1063 R0.0313
N19 G01 Z-1.125
N20 G01 X2.7875
N21 G03 X2.8317 Z-1.1342 R0.0313
N22 G01 X2.9817 Z-1.2092
N23 G03 X3.0 Z-1.2313 R0.0313
N24 G01 Z-2.225
N25 G01 X3.5
N26 G00 Z0.1
```

```
N27 G00 G28 U0.0
N28 G00 G28 W0.0
N29 T01000
N30 M139
N31 M09
N32 M05 P11
N33 M01
```

N52 G54  
N53 M06 T02002  
N54 T01000  
N55 G490 S0  
N56 G00 G28 W0.0  
N57 G00 G28 B0.0  
N58 M126  
N59 M34  
N60 M262  
N61 G50 S2500  
N62 G96 S600 M03 P11

(OD FINISH)

N63 G00 X3.5 Z0.1 M901 (SYNC POINT)  
N64 X1.0408 Z0.0661  
N65 G01 X0.9701 Z0.0308 F0.012  
N66 X1.1908 Z-0.0796  
N67 G03 X1.2 Z-0.0906 R0.0156  
N68 G01 Z-1.125  
N69 X2.8187  
N70 G03 X2.8408 Z-1.1296 R0.0156  
N71 G01 X2.9908 Z-1.2046  
N72 G03 X3.0 Z-1.2156 R0.0156  
N73 G01 Z-2.205  
N74 X3.0707 Z-2.1697  
N75 G00 X3.5 Z0.1

N76 G00 G28 U0.0 V0.0  
N77 G00 G28 W0.0  
N78 G00 G28 B0.0  
N79 T02000  
N80 M139  
N81 M127  
N82 M05 P11  
N83 G490 S0  
N84 G00 B-90.0  
N85 M30  
%

N34 G54  
N35 T02002  
N36 M08  
N37 M34  
N38 M262  
N39 G50 S2500  
N40 G96 S600 M03 P11

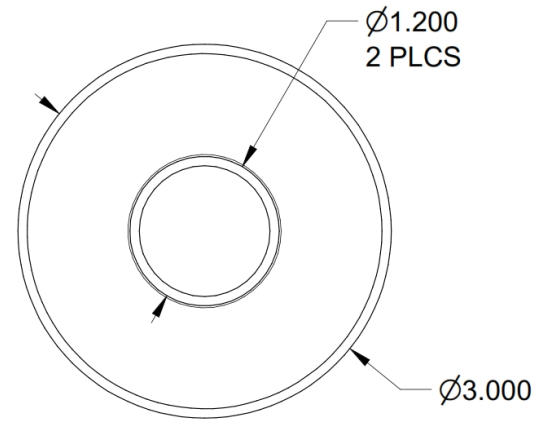
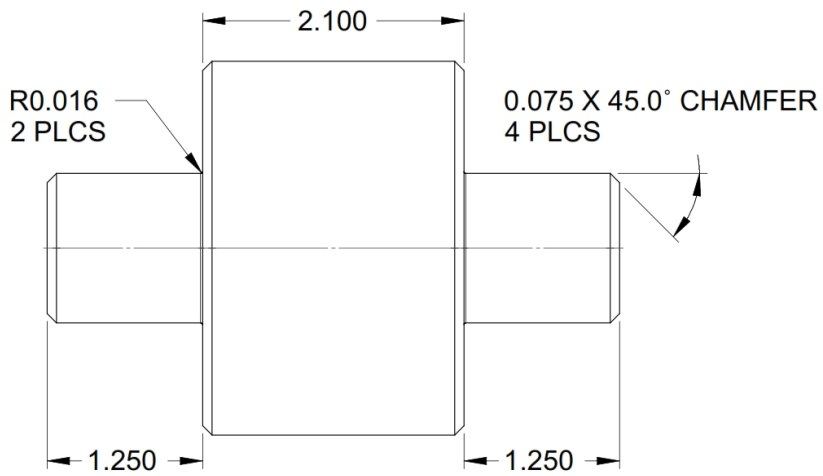
(OD FINISH)

N41 G00 X3.5 Z0.1 M901 (SYNC POINT)  
N42 X1.0408 Z0.0661  
N43 G01 X0.9701 Z0.0308 F0.012  
N44 X1.1908 Z-0.0796  
N45 G03 X1.2 Z-0.0906 R0.0156  
N46 G01 Z-1.125  
N47 X2.8187  
N48 G03 X2.8408 Z-1.1296 R0.0156  
N49 G01 X2.9908 Z-1.2046  
N50 G03 X3.0 Z-1.2156 R0.0156  
N51 G01 Z-2.205  
N52 X3.0707 Z-2.1697  
N53 G00 X3.5 Z0.1

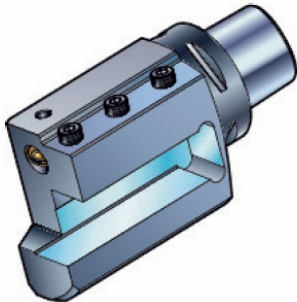
N54 G00 G28 U0.0  
N55 G00 G28 W0.0  
N56 T02000  
N57 M139  
N58 M09  
N59 M05 P11  
N60 T12000  
N61 G00 G54 Z0.0  
N62 M30  
%

**EXAMPLE #4 - STANDARD TURNING  
SIMULTANEOUS UPPER & LOWER OPERATION  
USING LEFT & RIGHT SPINDLES WITH PART TRANSFER**

**MATERIAL : AISI 4140 ALLOY STEEL - 275 HB  
STOCK : 3.5 DIA ROUND BAR X 4.85 LONG  
PROJECTION: 2.5 MINIMUM FROM JAW FACE  
ADAPTERS : SANDVIK C6-ASHR-38130-16-A (2)  
HOLDERS : MCLNR-164D (2), MVJNR-164D (2)  
INSERTS : CNMG-432 (2), VNMG-431 (2)  
SPINDLES : LEFT MAIN W/UPPER, RIGHT MAIN W/LOWER  
WORK COORD: G54=LEFT MAIN W/UPPER, G55=RIGHT MAIN W/LOWER  
ORIGIN : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
PROCESS : FACE, ROUGH & FINISH TURN 1<sup>ST</sup> HALF OF PART - LEFT MAIN w/UPPER  
: FACE, ROUGH & FINISH TURN 2<sup>ND</sup> HALF OF PART - RIGHT MAIN w/LOWER  
: STOP, REMOVE FINISHED PART FROM RIGHT SPINDLE  
: TRANSFER PART FROM LEFT SPINDLE TO RIGHT SPINDLE  
: LOAD NEW STOCK AND CONTINUE SIMULTANEOUS OPERATION**

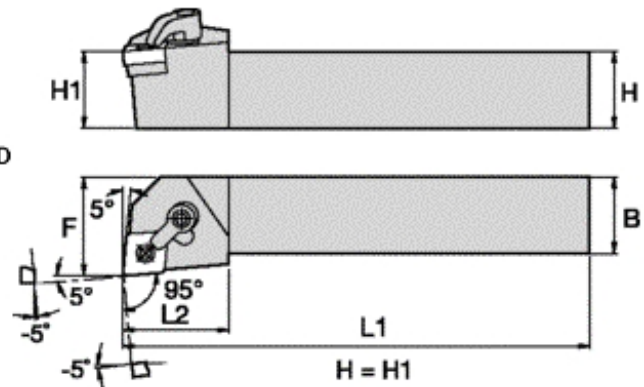


**CAPTO® C6 ADAPTER**

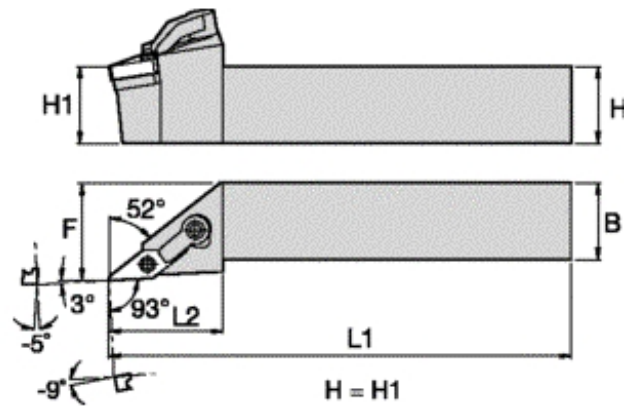


SANDVIK C6-ASHR-38130-16-A

Tool #1  
Holder: MCLNR-164D  
Insert: CNMG432



Tool #2  
Holder: MVJNR-164D  
Insert: VNMG431



```

%
O0004(MX-EXAMPLE #4 - UPPER)
(TURN ON LEFT MAIN SPINDLE WITH B-AXIS HEAD)
(TURN SIMULTANEOUSLY WITH LOWER TURRET)
(ON RIGHT MAIN SPINDLE)

```

```

N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0
N3 G00 G28 W0.0
N4 G00 G28 B0.0
N5 G490 S0
N6 G00 B-90.0
N7 M01

```

```

N8 G54
N9 M06 T01001
N10 T02000
N11 G490 S0
N12 G00 G28 W0.0
N13 G00 G28 B0.0
N14 M138
N15 M126
N16 M34
N17 M261
N18 G50 S2500
N19 G96 S500 M03 P11

```

```

(FACE = ROUGH & FINISH)
N20 G00 X3.7 Z0.01 M900 (SYNC POINT)
N21 G01 X-0.0625 F0.018
N22 G00 Z0.11
N23 X3.7
N24 Z0.
N25 G01 X-0.0625 F0.01
N26 G00 Z0.1

```

```

(OD CANNED ROUGH)
N27 G00 X3.5 M901 (SYNC POINT)
N28 G00 Z0.0615
N29 G71 U0.125 R0.03
N30 G71 P31 Q40 U0.02 W0.01 F0.036
N31 G00 X0.8903
N32 G01 X1.1817 Z-0.0842
N33 G03 X1.2 Z-0.1063 R0.0313
N34 G01 Z-1.125
N35 G01 X2.7875
N36 G03 X2.8317 Z-1.1342 R0.0313
N37 G01 X2.9817 Z-1.2092
N38 G03 X3.0 Z-1.2313 R0.0313
N39 G01 Z-2.225
N40 G01 X3.5
N41 G00 Z0.1
N42 G00 G28 U0.0 V0.0
N43 G00 G28 W0.0
N44 G00 G28 B0.0
N45 T01000
N46 M139
N47 M127
N48 M05 P11
N49 G490 S0
N50 G00 B-90.0
N51 M01

```

```

%
O0004 (MX-EXAMPLE #4 - LOWER)
(TURN ON RIGHT MAIN SPINDLE WITH LOWER TURRET)
(TURN SIMULTANEOUSLY WITH B-AXIS HEAD)
(ON LEFT MAIN SPINDLE)

```

```

N1 G00 G18 G40 G80 G99
N2 G00 G28 U0.0
N3 G00 G28 W0.0

```

```

N4 G55
N5 T01001
N6 M138
N7 M08
N8 M134
N9 M161
N10 G50 S2500
N11 G96 S500 M03 P21

```

```

(FACE = ROUGH & FINISH)
N12 G00 X3.7 Z-0.01 M900 (SYNC POINT)
N13 G01 X-0.0625 F0.018
N14 G00 Z-0.11
N15 X3.7
N16 Z0.
N17 G01 X-0.0625 F0.01
N18 G00 Z-0.1

```

```

(OD CANNED ROUGH)
N19 G00 X3.5 Z-0.1 M901 (SYNC POINT)
N20 G00 Z-0.0615
N21 G71 U0.125 R0.03
N22 G71 P23 Q33 U0.02 W-0.01 F0.036
N23 G00 X0.8903
N24 G01 X1.1817 Z0.0842
N25 G02 X1.2 Z0.1063 R0.0313
N26 G01 Z1.125
N27 G01 X2.7875
N28 G02 X2.8317 Z1.1342 R0.0313
N29 G01 X2.9817 Z1.2092
N30 G02 X3.0 Z1.2313 R0.0313
N31 G01 Z2.225
N32 G01 X3.5
N33 G00 Z-0.1
N34 G00 G28 U0.0
N35 G00 G28 W0.0
N36 T01000
N37 M139
N38 M09
N39 M05 P21
N40 M01

```

N52 G54  
 N53 M06 T02002  
 N54 T01000  
 N55 G490 S0  
 N56 G00 G28 W0.0  
 N57 G00 G28 B0.0  
 N58 M126  
 N59 M34  
 N60 M262  
 N61 G50 S2500  
 N62 G96 S600 M03 P11

N41 G55  
 N42 T02002  
 N43 M08  
 N44 M134  
 N45 M162  
 N46 G50 S2500  
 N47 G96 S600 M03 P21

(OD FINISH)

N63 G00 X3.5 Z0.1 M902 (SYNC POINT)  
 N64 X1.0408 Z0.0661  
 N65 G01 X0.9701 Z0.0308 F0.012  
 N66 X1.1908 Z-0.0796  
 N67 G03 X1.2 Z-0.0906 R0.0156  
 N68 G01 Z-1.125  
 N69 X2.8187  
 N70 G03 X2.8408 Z-1.1296 R0.0156  
 N71 G01 X2.9908 Z-1.2046  
 N72 G03 X3.0 Z-1.2156 R0.0156  
 N73 G01 Z-2.205  
 N74 X3.0707 Z-2.1697  
 N75 G00 X3.5 Z0.1

(OD FINISH)

N48 G00 X3.5 Z-0.1 M902 (SYNC POINT)  
 N49 X1.0408 Z-0.0661  
 N50 G01 X0.9701 Z-0.0308 F0.012  
 N51 X1.1908 Z0.0796  
 N52 G02 X1.2 Z0.0906 R0.0156  
 N53 G01 Z1.125  
 N54 X2.8187  
 N55 G02 X2.8408 Z1.1296 R0.0156  
 N56 G01 X2.9908 Z1.2046  
 N57 G02 X3.0 Z1.2156 R0.0156  
 N58 G01 Z2.205  
 N59 X3.0707 Z2.1697  
 N60 G00 X3.5 Z-0.1

N76 G00 G28 U0.0 V0.0  
 N77 G00 G28 W0.0  
 N78 G00 G28 B0.0  
 N79 T02000  
 N80 M139  
 N81 M127  
 N82 M05 P11  
 N83 G490 S0  
 N84 G00 B-90.0  
 N85 M903 (SYNC POINT)  
 N86 M30

N61 G00 G28 U0.0  
 N62 G00 G28 W0.0  
 N63 T02000  
 N64 M139  
 N65 M09  
 N66 M05 P21  
 N67 T12000 (EMPTY TOOL STATION)  
 N68 G00 G54 Z0.0  
 N69 M903 (SYNC POINT)

M00

(PROGRAM STOP BEFORE PART TRANSFER)  
 (LEFT & RIGHT SPINDLE MUST BE STOPPED)  
 (PRIOR TO THIS TRANSFER)

(\*\* OPEN JAWS ON RIGHT SPINDLE AND REMOVE \*\*)  
 (\*\* FINISHED PART FROM RIGHT SPINDLE \*\*)

(\*\* BLOW OUT JAWS TO PREPARE FOR TRANSFER \*\*)  
 (\*\* MANUALLY CLOSE JAWS ON RIGHT SPINDLE \*\*)

(\*\* PRESS CYCLE START TO BEGIN TRANSFER \*\*)  
 (\*\* FROM LEFT SPINDLE TO RIGHT SPINDLE \*\*)

%



(\*\* BEGIN PART TRANSFER \*\*)

G97 (ENTER RPM MODE)  
M34 (C-AXIS MODE OFF - LEFT SPINDLE)  
M134 (C-AXIS MODE OFF - RIGHT SPINDLE)  
M19 (ORIENT THE LEFT)  
M119 (ORIENT THE RIGHT)  
M131 (ALLOW THE RIGHT TO OPEN)  
M169 (OPEN RIGHT JAWS)  
G04 U1.0 (WAIT A SECOND)  
G54 G98 G00 A0.5 (RAPID TO 0.5 AWAY)  
M86 (TORQUE SKIP)  
G31 P99 A-2.3 F50.0 (FEED ONTO THE PART)  
(MODIFY A-AXIS VALUE PER PART/JAWS)  
M87 (TORQUE SKIP CANCEL)  
M168 (CLOSE RIGHT JAWS)  
G04 U1.0 (WAIT A SECOND)  
M31 (ALLOW THE LEFT TO OPEN)  
M69 (OPEN LEFT JAWS)  
G04 U1.0 (WAIT A SECOND)  
G00 G28 G53 A0.0 (GO HOME)  
M05 P21 (PREVENT ALARM)  
M05 P11 (PREVENT ALARM)

(\*\* END PART TRANSFER \*\*)

N70 M00

(\*\* BLOW OUT LEFT SPINDLE JAWS \*\*)

(\*\* LOAD STOCK FOR NEXT PART \*\*)

(\*\* IN LEFT SPINDLE \*\*)

N71 M30

%

## **DOOSAN PUMA MX Series – Advanced Turning**

With all of our previous examples we have focused on standard ANSI/ISO Stick Tooling. On a standard CNC Turning Center, stick tooling is designed to be used in a specific orientation.

Multi-Task CNC Machining Centers, like the Doosan Puma MX Series, allow users to create efficient CNC Operations by orienting tooling to positions previously impossible to achieve with Standard CNC Turning Centers.

Specific Tooling Adapters have been designed to support Multi-Task CNC Machining Centers. These tools provide the user with the ability to be used as either Right Handed or Left Handed as well as tilting them to provide optimal chip clearance.

Example #5 is a modified version of Example #1.

Example #5 will use two CAPTO® C6 Holder/Adapters specifically designed for Multi-Task CNC Machining Centers. Additionally, we will now use a new programming code that allows us to use the Nutating B-Axis Head to tilt to an angle that provides for the most efficient machining operation.

# B-Axis Spindle Tilt Function - G400

## Command format

T□□ ●●●

G400 B\_ J\_ R\_ K\_ W\_

□□ : current tool no. in milling spindle.

●●● : geometry tool offset no. measured at B-axis 0°

B : B-axis degree

J : clamped status of Milling spindle and orientation degree

J0 → Milling spindle becomes unclamped.

J1 → Milling spindle becomes oriented to 0° and clamped.

J2 → Milling spindle becomes oriented to 180° and clamped.

J11 → current degree ( $\omega^\circ$ ) of milling spindle for Mini-turret

J12 → current degree ( $\omega^\circ$ )+180° of Milling spindle for Mini-turret

$\omega^\circ$  means current degree of Milling spindle

R : the no. of cutting quadrant (1~4)

K : imaginary tool nose no. (0~9)

W : wear offset no.

Note 1) J11 and J12 are for mini-turret tool and before commanding J11 (J12), milling spindle orientation (G490S\_) must be commanded. In case of not commanding G490S\_, milling spindle will be oriented S0.

G490S1200

G400 B\_ J11. R\_ W\_

.....

G400 B\_ J12. R\_ W\_

.....

G490S1200

G400 B\_ J11. R\_ W\_

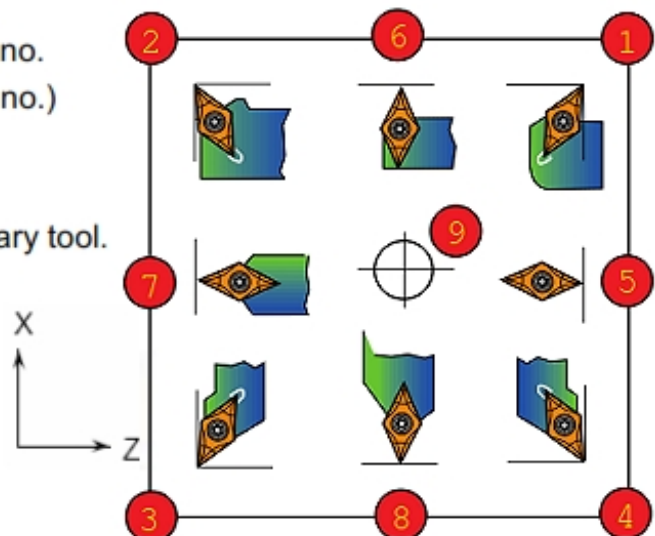
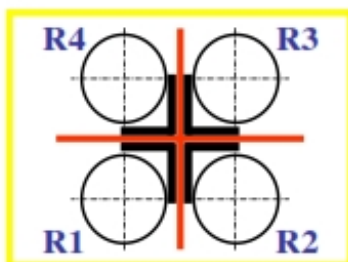
Note 2) After command G400, new tool offset no.

is T□□399. (□□ marks means Tool no.)

Note 3) after command G400 In milling tool,

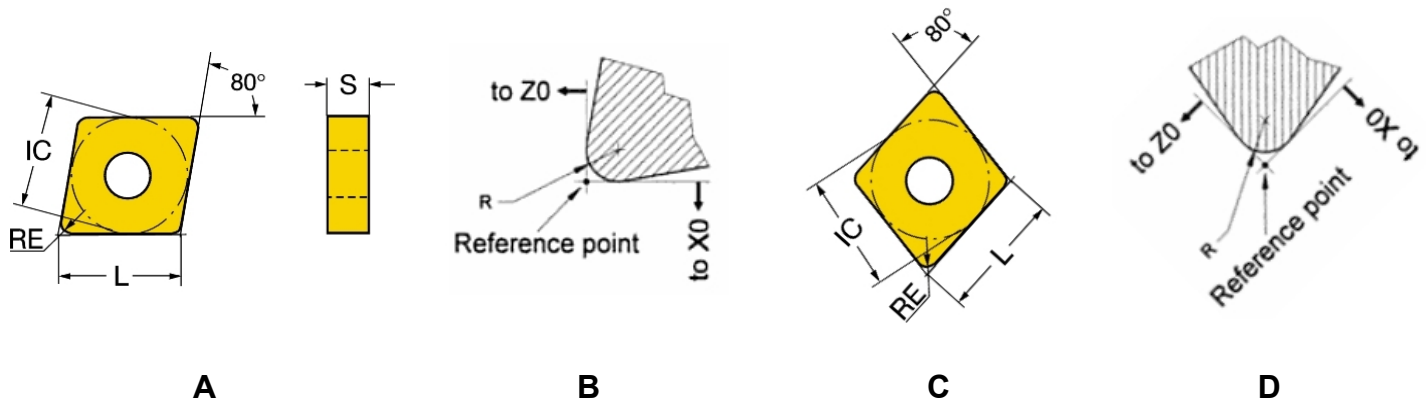
command M101 (spindle unclamp)

Note 4) R,K and W value are omissible for rotary tool.



# B-Axis Spindle Tilt Function - G400

## IMPORTANT NOTE:



When a tool is touched off in a manner that is normal to its cutting position as shown in figures A & B, the tool length is measured by the Q-Setter, including any tool nose radius built into the insert. A high degree of accuracy can be achieved without issue with this method because the reference point shown in figure B is included in the X and Z measurement.

When a tool is touched off in a manner that is *NOT* normal to its cutting position (Figures C & D), The calculations from within G400 project the theoretical position of the tool based on the information defining the tool. ***This definition includes the measured tool length of X and the described R value in the tool offset register.***

A higher degree of accuracy will be achieved with G400 if the radius of the tool is known. For example, A 0.0313 radius cannot be assumed with a CNMG432 insert. Typically, tool manufacturers use a +0 -.005 tolerance band for radii. It is common for the actual radii to be -0.003.

***When using G400 with a turning tool, it is best to start with a radius of minus (-) 0.003 of the published radius in R of the offset page.***

## EXAMPLE:

An ID Boring Bar or Grooving Tool is only used at B-90.0.  
Simply touch off the tool in the orientation it will be cutting.  
The program should have an explicit command for positioning the B-Axis Angle.

However, if you choose to use G400 in such a case, there are some facts users should be aware of. It is permissible to touch off ID Boring and Grooving Tools at B0.

***However, the Tool Nose Radius at the Touch-Off point MUST be entered in the Offset R-Field.***

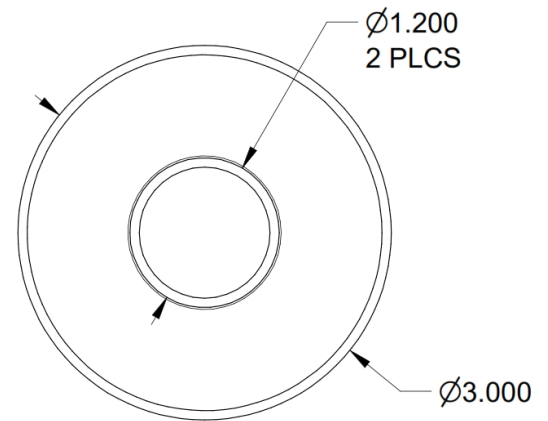
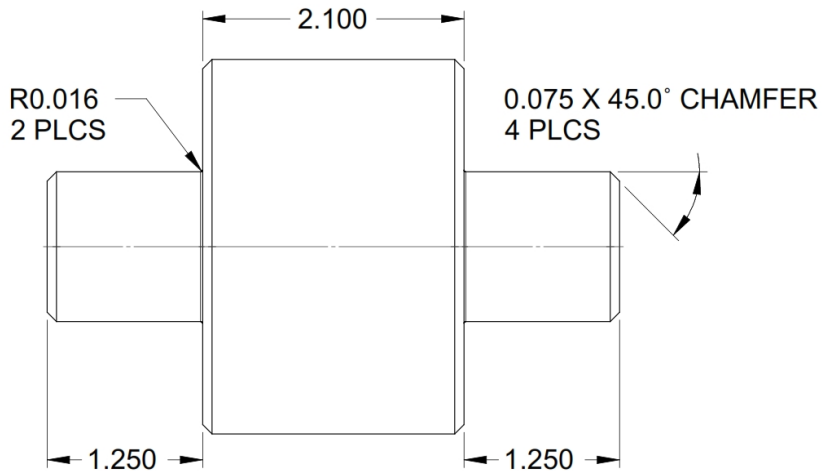
Also, using J11 or J12 on a G400 command line requires a G490 S\_\_\_\_ command PRIOR to the G400 line in order for compensation applied to be accurate. Using G490 S\_\_\_\_ AFTER the G400 line will orient the spindle but your compensation will NOT be accurate.

Please reference the Doosan Programming Manual page 14-4.

Due to the added complexity involved in touching off at B0 for ID tooling that is only used at B-90.0 , The use of G400 is discouraged in favor of the traditional method of touching off at the B-Axis Angle used in the operation.

**EXAMPLE #5 - ADVANCED TURNING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6-DCMNN-00115-12 (1), SANDVIK C6-DDMNL-0013-1504 (1)  
**INSERTS** : CNMG-432 (1), DNMG-431 (1)  
**SPINDLE** : LEFT MAIN  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : FACE, ROUGH & FINISH TURN HALF OF PART  
**Q-SETTER** : TOUCH OFF BOTH TOOLS IN X ONLY AT B0.0

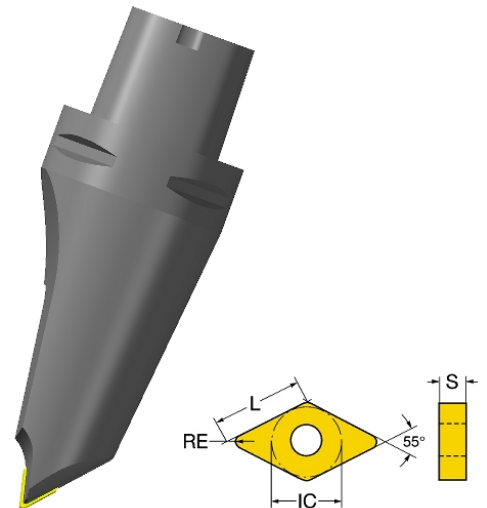
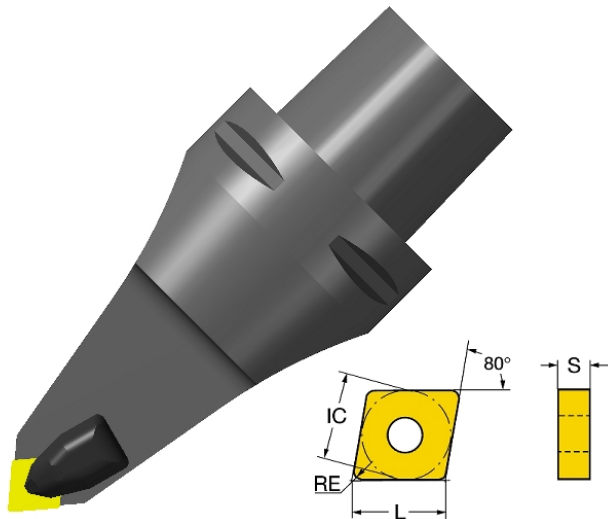


**TOOL #3**

**ADAPTER** : C6-DCMNN-00115-12  
**INSERT** : CNMG432  
**ORIENTATION** : G490 S1800  
**B-AXIS TILT** : -45.0

**TOOL #4**

**ADAPTER** : C6-DDMNL-0013-1504  
**INSERT** : DNMG431  
**ORIENTATION** : G490 S1800  
**B-AXIS TILT** : -20.0



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O0005(MX-EXAMPLE #5 - UPPER - G400)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T03003 (SANDVIK C6-DCMNN-00115-12 - CNMG432)
N10 T04000 (STAGE NEXT TOOL)
N11 G490 S1800 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N17 M261 (SPINDLE WINDING LOW - REPLACES M41)

N18 G400 B-45.0 J2.0 R3.0 K3.0 W3.0 (ENGAGE G400 TOOL POINT CONTROL)
(B-45.0 = ANGLE OF HEAD TILT)
(J2.0 = ORIENTATION AND LOCK B-AXIS SPINDLE AT 180.0 DEGREES & LOCKED)
(R3.0 = CUTTING QUADRANT #3)
(K3.0 = IMAGINARY TOOL NOSE ORIENTATION #3)
(W3.0 = TOOL OFFSET REGISTER #3)

N19 G50 S2500 (MAXIMUM RPM CAP)
N20 G96 S500 M04 P11 (CONSTANT CUTTING SPEED MODE - 500 FPM - LEFT SPINDLE COUNTER-CLOCKWISE)

(FACE = ROUGH & FINISH)
N21 G00 X3.7 Z0.01
N22 G01 X-0.0625 F0.018
N23 G00 Z0.11
N24 X3.7
N25 Z0.
N26 G01 X-0.0625 F0.01
N27 G00 Z0.1

(OD CANNED ROUGH)
N28 G00 X3.5
N29 G00 Z0.0615
N30 G71 U0.125 R0.03
N31 G71 P32 Q41 U0.02 W0.01 F0.018
N32 G00 X0.8903
N33 G01 X1.1817 Z-0.0842
N34 G03 X1.2 Z-0.1063 R0.0313
N35 G01 Z-1.125
N36 G01 X2.7875
N37 G03 X2.8317 Z-1.1342 R0.0313
N38 G01 X2.9817 Z-1.2092
N39 G03 X3.0 Z-1.2313 R0.0313
N40 G01 Z-2.225
N41 G01 X3.5
N42 G00 Z0.1

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(TOOL CHANGE PREPARATION)

N43 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)  
N44 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N45 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N46 T03000 (CANCEL OFFSET #399 FOR CURRENT TOOL USING G400)  
N47 M139 (SHOWER BED COOLANT OFF)  
N48 M127 (COOLANT THROUGH TOOL OFF)  
N49 M05 P11 (LEFT SPINDLE STOP)  
N50 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)  
N51 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)  
N52 M01

(PREPARATION FOR START OF OPERATION)

N53 G54 (WORK COORDINATE SELECTION)  
N54 M06 T04004 (SANDVIK C6-DDMNL-0013-1504 - DNMG431)  
N55 T03000 (STAGE NEXT TOOL)  
N56 G490 S1800 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)  
N57 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N58 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N59 M126 (COOLANT THROUGH TOOL ON)  
N60 M34 (LEFT SPINDLE C-AXIS MODE OFF)  
N61 M262 (SPINDLE WINDING HIGH- REPLACES M42)

N62 G400 B-20.0 J2. R3. K3. W4. (ENGAGE G400 TOOL POINT CONTROL)

(B-20.0 = ANGLE OF HEAD TILT)

(J2.0 = ORIENTATION AND LOCK B-AXIS SPINDLE AT 180.0 DEGREES & LOCKED)

(R3.0 = CUTTING QUADRANT #3)

(K3.0 = IMAGINARY TOOL NOSE ORIENTATION #3)

(W4.0 = TOOL OFFSET REGISTER #4)

N63 G50 S2500 (MAXIMUM RPM CAP)

N64 G96 S600 M03 P11 (CONSTANT CUTTING SPEED MODE - 600 FPM - LEFT SPINDLE CLOCKWISE)

(OD FINISH)

N65 G00 X3.5 Z0.1  
N66 X1.0408 Z0.0661  
N67 G01 X0.9701 Z0.0308 F0.006  
N68 X1.1908 Z-0.0796  
N69 G03 X1.2 Z-0.0906 R0.0156  
N70 G01 Z-1.125  
N71 X2.8187  
N72 G03 X2.8408 Z-1.1296 R0.0156  
N73 G01 X2.9908 Z-1.2046  
N74 G03 X3.0 Z-1.2156 R0.0156  
N75 G01 Z-2.205  
N76 X3.0707 Z-2.1697  
N77 G00 X3.5 Z0.1

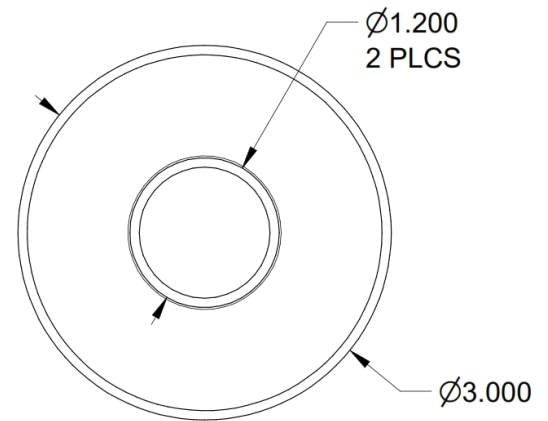
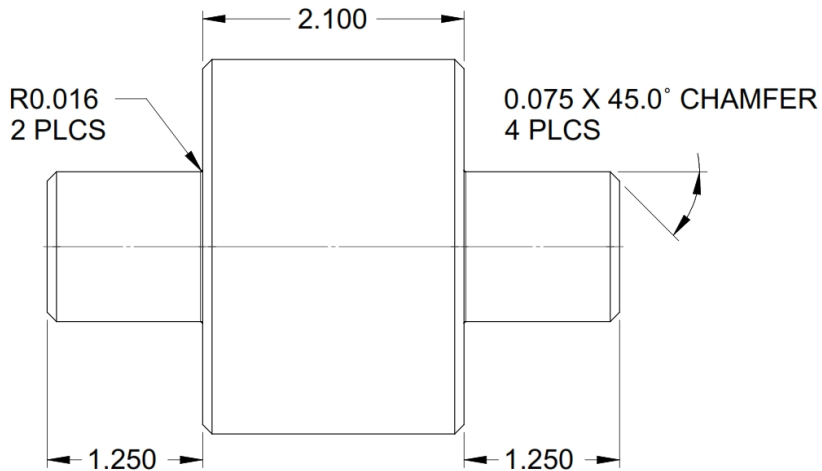
(END PROGRAM/TOOL CHANGE PREPARATION)

N78 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)  
N79 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N80 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N81 T04000 (CANCEL OFFSET #399 FOR CURRENT TOOL USING G400)  
N82 M139 (SHOWER BED COOLANT OFF)  
N83 M127 (COOLANT THROUGH TOOL OFF)  
N84 M05 P11 (LEFT SPINDLE STOP)  
N85 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)  
N86 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)  
N87 M30

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**EXAMPLE #6 - ADVANCED TURNING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6-DCMNN-00115-12 (1), SANDVIK C6-DDMNL-0013-1504 (1)  
**INSERTS** : CNMG-432 (1), DNMG-431 (1)  
**SPINDLE** : RIGHT MAIN  
**WORK COORD**: G55  
**ORIGIN** : X0.0 = SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : FACE, ROUGH & FINISH TURN HALF OF PART  
**Q-SETTER** : TOUCH OFF BOTH TOOLS IN X ONLY AT B0.0

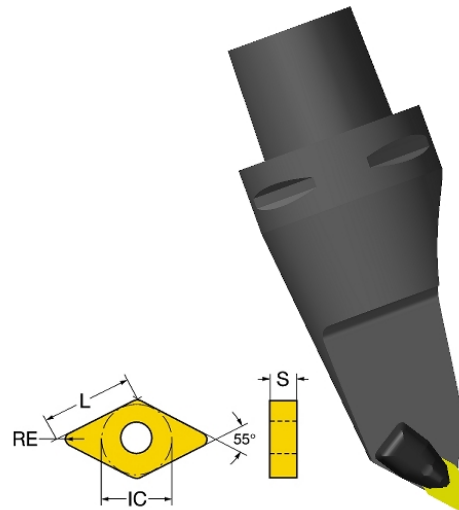
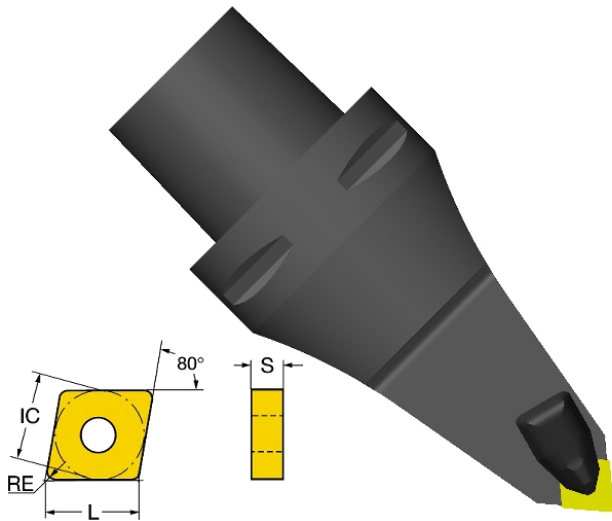


**TOOL #3**

**ADAPTER** : C6-DCMNN-00115-12  
**INSERT** : CNMG432  
**ORIENTATION** : G490 S1800  
**B-AXIS TILT** : 45.0

**TOOL #4**

**ADAPTER** : C6-DDMNL-0013-1504  
**INSERT** : DNMG431  
**ORIENTATION** : G490 S0  
**B-AXIS TILT** : 20.0





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O0006(MX-EXAMPLE #6 - UPPER - G400)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G55 (WORK COORDINATE SELECTION)
N9 M06 T03003 (SANDVIK C6-DCMNN-00115-12 - CNMG432)
N10 T04000 (STAGE NEXT TOOL)
N11 G490 S1800 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M134 (RIGHT SPINDLE C-AXIS MODE OFF)
N17 M161 (SPINDLE WINDING LOW - REPLACES M41)

N18 G400 B45.0 J2.0 R4.0 K4.0 W3.0 (ENGAGE G400 TOOL POINT CONTROL)
(B45.0 = ANGLE OF HEAD TILT)
(J2.0 = ORIENTATION AND LOCK B-AXIS SPINDLE AT 180.0 DEGREES & LOCKED)
(R4.0 = CUTTING QUADRANT #4)
(K4.0 = IMAGINARY TOOL NOSE ORIENTATION #4)
(W3.0 = TOOL OFFSET REGISTER #3)

N19 G50 S2500 (MAXIMUM RPM CAP)
N20 G96 S500 M03 P21 (CONSTANT CUTTING SPEED MODE - 500 FPM - RIGHT SPINDLE CLOCKWISE)

(FACE = ROUGH & FINISH)
N21 G00 X3.7 Z-0.01
N22 G01 X-0.0625 F0.018
N23 G00 Z-0.11
N24 X3.7
N25 Z0.
N26 G01 X-0.0625 F0.01
N27 G00 Z-0.1

(OD CANNED ROUGH)
N28 G00 X3.5
N29 G00 Z-0.0615
N30 G71 U0.125 R0.03
N31 G71 P32 Q41 U0.02 W-0.01 F0.018
N32 G00 X0.8903
N33 G01 X1.1817 Z0.0842
N34 G02 X1.2 Z0.1063 R0.0313
N35 G01 Z1.125
N36 G01 X2.7875
N37 G02 X2.8317 Z1.1342 R0.0313
N38 G01 X2.9817 Z1.2092
N39 G02 X3.0 Z1.2313 R0.0313
N40 G01 Z2.225
N41 G01 X3.5
N42 G00 Z-0.1

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(TOOL CHANGE PREPARATION)

N43 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)  
N44 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N45 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N46 T03000 (CANCEL OFFSET #399 FOR CURRENT TOOL USING G400)  
N47 M139 (SHOWER BED COOLANT OFF)  
N48 M127 (COOLANT THROUGH TOOL OFF)  
N49 M05 P11 (LEFT SPINDLE STOP)  
N50 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)  
N51 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)  
N52 M01

(PREPARATION FOR START OF OPERATION)

N53 G55 (WORK COORDINATE SELECTION)  
N54 M06 T04004 (SANDVIK C6-DDMNL-0013-1504 - DNMG431)  
N55 T03000 (STAGE NEXT TOOL)  
N56 G490 S1800 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)  
N57 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N58 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N59 M126 (COOLANT THROUGH TOOL ON)  
N60 M134 (RIGHT SPINDLE C-AXIS MODE OFF)  
N61 M162 (SPINDLE WINDING HIGH- REPLACES M42)

N62 G400 B20.0 J1. R4. K4. W4. (ENGAGE G400 TOOL POINT CONTROL)

(B20.0 = ANGLE OF HEAD TILT)

(J1.0 = ORIENTATION AND LOCK B-AXIS SPINDLE AT 0.0 DEGREES & LOCKED)

(R4.0 = CUTTING QUADRANT #4)

(K4.0 = IMAGINARY TOOL NOSE ORIENTATION #4)

(W4.0 = TOOL OFFSET REGISTER #4)

N63 G50 S2500 (MAXIMUM RPM CAP)

N64 G96 S600 M03 P21 (CONSTANT CUTTING SPEED MODE - 600 FPM - RIGHT SPINDLE CLOCKWISE)

(OD FINISH)

N65 G00 X3.5 Z-0.1  
N66 X1.0408 Z-0.0661  
N67 G01 X0.9701 Z-0.0308 F0.006  
N68 X1.1908 Z0.0796  
N69 G02 X1.2 Z0.0906 R0.0156  
N70 G01 Z1.125  
N71 X2.8187  
N72 G02 X2.8408 Z1.1296 R0.0156  
N73 G01 X2.9908 Z1.2046  
N74 G02 X3.0 Z1.2156 R0.0156  
N75 G01 Z2.205  
N76 X3.0707 Z2.1697  
N77 G00 X3.5 Z-0.1

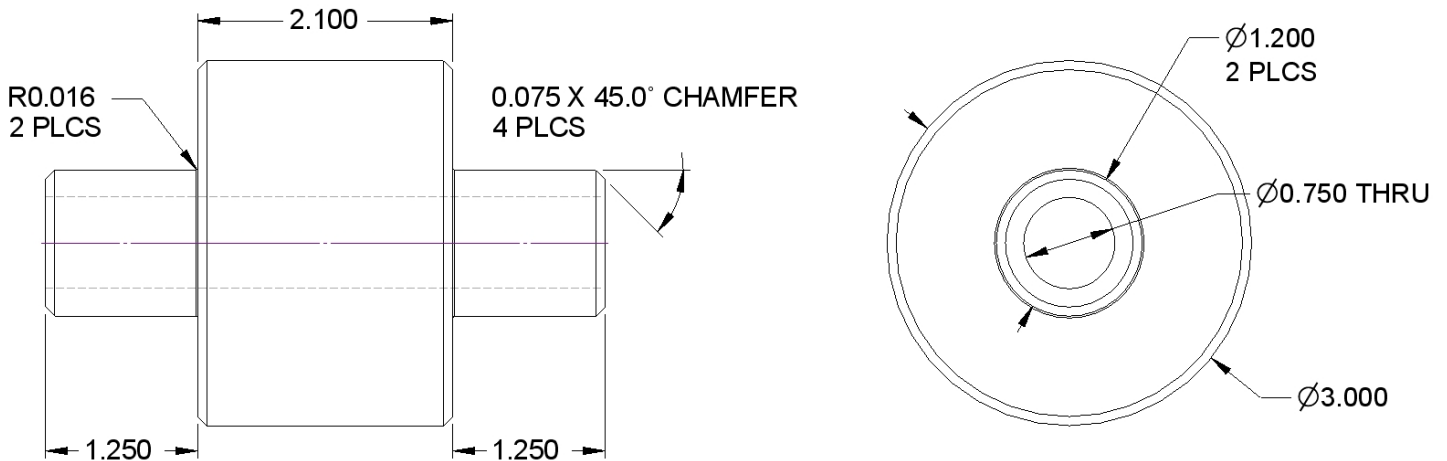
(END PROGRAM/TOOL CHANGE PREPARATION)

N78 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)  
N79 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N80 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N81 T04000 (CANCEL OFFSET #399 FOR CURRENT TOOL USING G400)  
N82 M139 (SHOWER BED COOLANT OFF)  
N83 M127 (COOLANT THROUGH TOOL OFF)  
N84 M05 P11 (LEFT SPINDLE STOP)  
N85 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)  
N86 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)  
N87 M30

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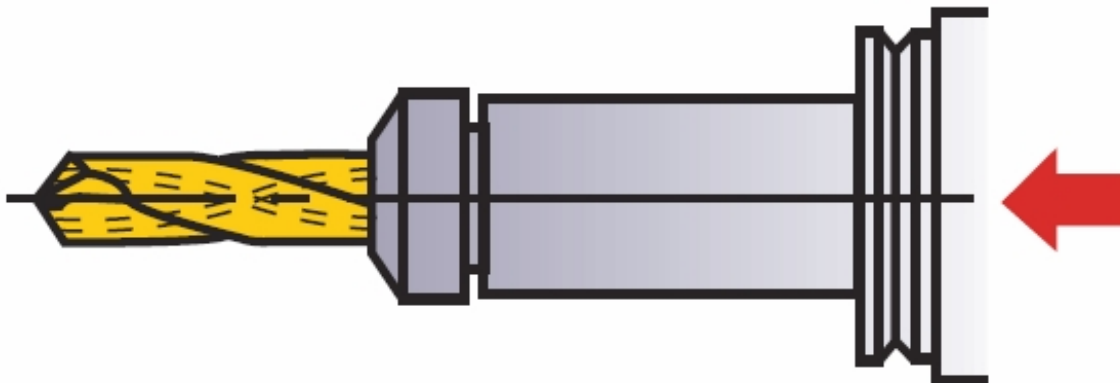
**EXAMPLE #7 - ADVANCED DRILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**SPINDLE** : LEFT MAIN  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : DRILL THRU HOLE  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #5**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**ORIENTATION** : G490 S0  
**B-AXIS TILT** : -90.0



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O0007(MX-EXAMPLE #7 - UPPER - G400 STD DRILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T05005 (SANDVIK C6 ER32 COLLET HOLDER - 0.75 SOLID CARBIDE THRU COOLANT DRILL)
N10 T06000 (STAGE NEXT TOOL)
N11 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 M138 (SHOWER BED COOLANT ON)
N14 M126 (COOLANT THROUGH TOOL ON)
N15 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N16 M261 (SPINDLE WINDING LOW - REPLACES M41)

N17 G400 B-90.0 J1.0 (ENGAGE G400 TOOL POINT CONTROL)
(B-90.0 = ANGLE OF HEAD TILT)
(J1.0 = ORIENTATION AND LOCK B-AXIS SPINDLE AT 0.0 DEGREES & LOCKED)

N18 G50 S2500 (MAXIMUM RPM CAP)
N19 G97 S500 M03 P11 (DIRECT RPM MODE - 500 RPM - LEFT SPINDLE CLOCKWISE)

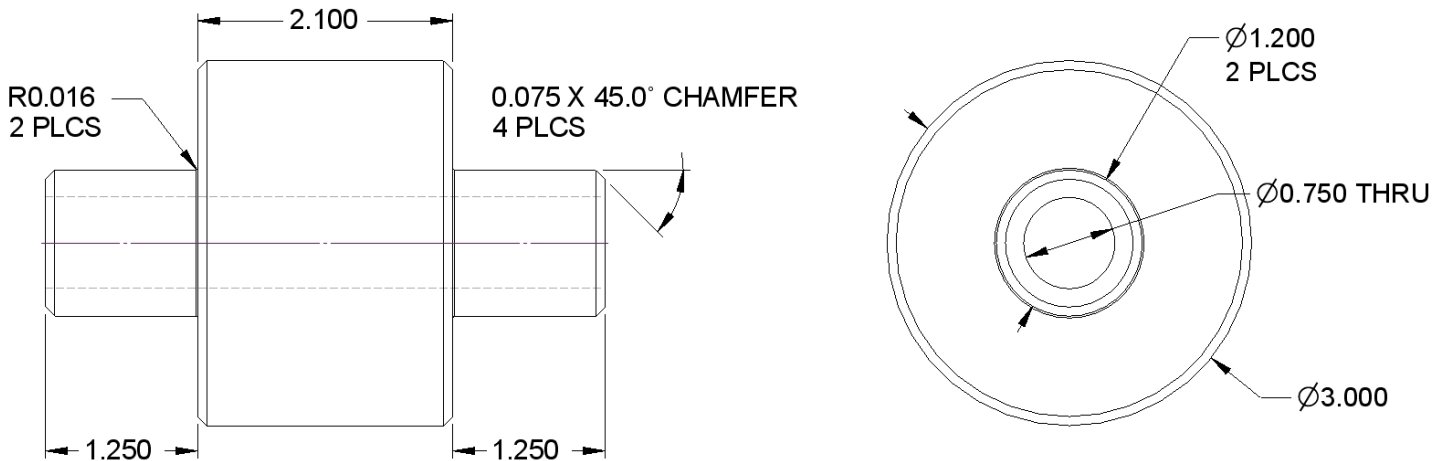
(ID CENTERLINE DRILL)
N20 G00 Z4.0
N21 X0.0
N22 Z0.1
N23 G01 Z-4.8 F0.006
N24 G00 Z4.0

(END PROGRAM/TOOL CHANGE PREPARATION)
N25 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N26 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N27 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N28 T05000 (CANCEL OFFSET FOR CURRENT TOOL)
N29 M139 (SHOWER BED COOLANT OFF)
N30 M127 (COOLANT THROUGH TOOL OFF)
N31 M05 P11 (LEFT SPINDLE STOP)
N32 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N33 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N34 M30
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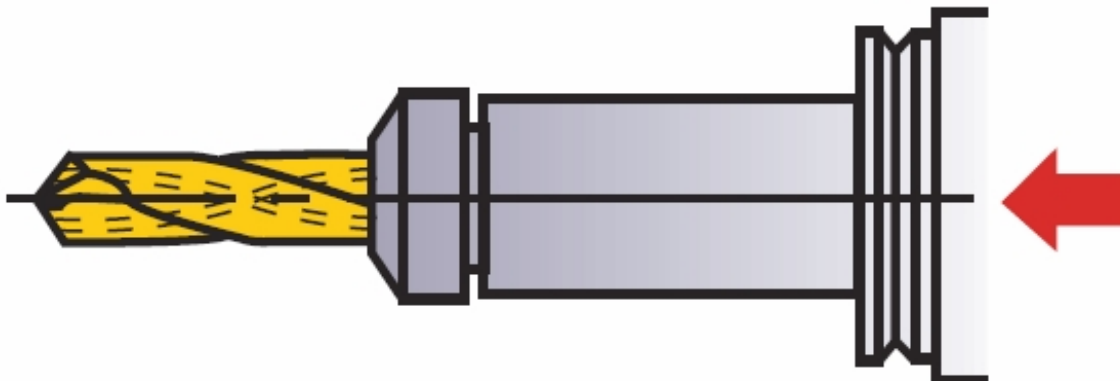
**EXAMPLE #8 - ADVANCED DRILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 DIA ROUND BAR X 4.85 LONG  
**PROJECTION**: 2.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : DRILL THRU HOLE  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #5**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**ORIENTATION** : G490 S0  
**B-AXIS TILT** : -90.0



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O0008(MX-EXAMPLE #8 - UPPER - G400 LIVE DRILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T05005 (SANDVIK C6 ER32 COLLET HOLDER - 0.75 SOLID CARBIDE THRU COOLANT DRILL)
N10 T06000 (STAGE NEXT TOOL)
N11 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 M138 (SHOWER BED COOLANT ON)
N14 M126 (COOLANT THROUGH TOOL ON)
N15 M35 (LEFT SPINDLE C-AXIS MODE ON)
N16 M89 (C-AXIS CLAMP)

N17 G400 B-90.0 J0.0 (ENGAGE G400 TOOL POINT CONTROL)
(B-90.0 = ANGLE OF HEAD TILT)
(J0.0 = B-AXIS SPINDLE UNLOCKED)

N18 M101
N19 G50 S500 (MAXIMUM RPM CAP)
N20 G97 S500 M03 P12 (DIRECT RPM MODE - 500 RPM - B-AXIS SPINDLE CLOCKWISE)

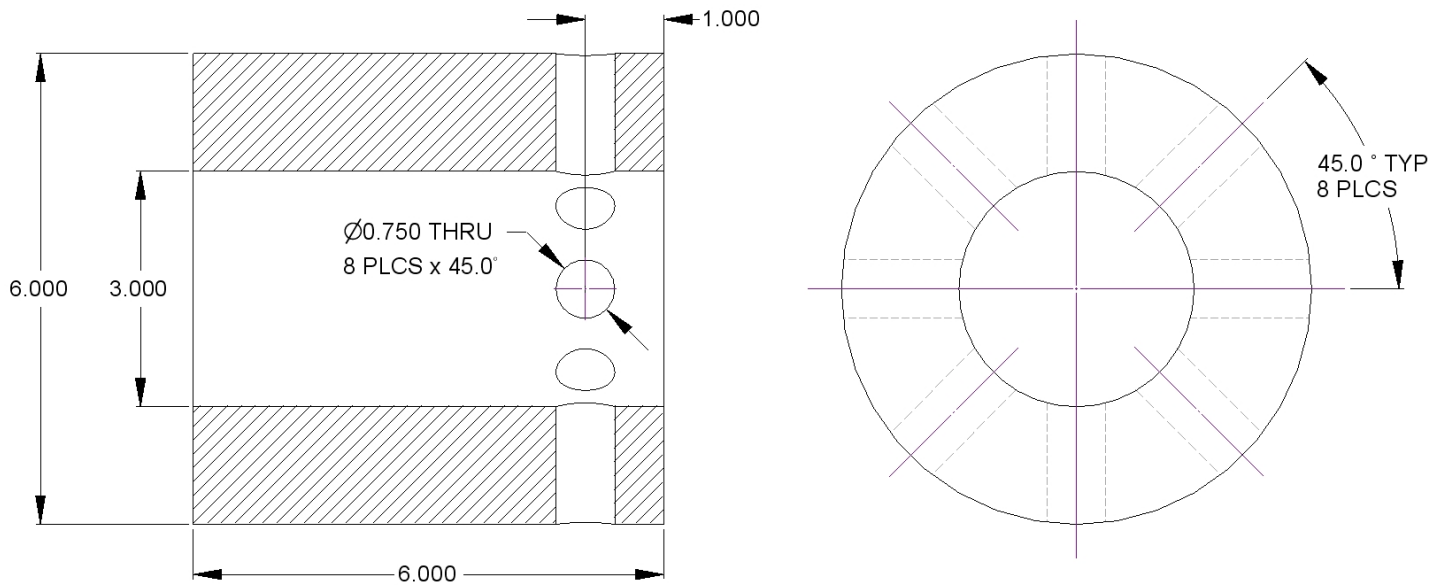
(ID CENTERLINE DRILL)
N21 G00 Z4.0
N22 X0.0
N23 Z0.1
N24 G01 Z-4.8 F0.006
N25 G00 Z4.0

(END PROGRAM/TOOL CHANGE PREPARATION)
N26 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N27 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N28 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N29 T05000 (CANCEL OFFSET FOR CURRENT TOOL)
N30 M139 (SHOWER BED COOLANT OFF)
N31 M127 (COOLANT THROUGH TOOL OFF)
N32 M05 P12 (B-AXIS SPINDLE STOP)
N33 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N34 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N35 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N36 M30
%

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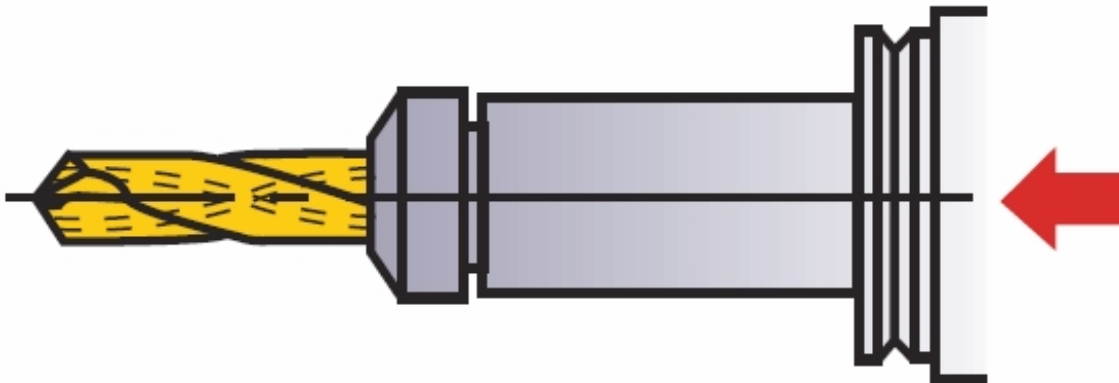
**EXAMPLE #9 - ADVANCED DRILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 6.0 OD X 3.0 ID X 6.0 LONG  
**PROJECTION**: 3.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : DRILL OD HOLE PATTERN  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #5**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**ORIENTATION** : LIVE TOOL - M101 (UNCLAMPED)  
**B-AXIS TILT** : 0.0



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O0009(MX-EXAMPLE #9 - UPPER - LIVE DRILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T05005 (SANDVIK C6 ER32 COLLET HOLDER - 0.75 SOLID CARBIDE THRU COOLANT DRILL)
N10 T06000 (STAGE NEXT TOOL)
N11 M101 (LIVE B-AXIS SPINDLE - UNCLAMPED)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M35 (LEFT SPINDLE C-AXIS MODE ON)
N17 G00 G28 H0.0 (ZERO RETURN C-AXIS)

N18 G97 S500 M03 P12 (DIRECT RPM MODE - 500 RPM - B-AXIS SPINDLE CLOCKWISE)

(OD DRILL HOLE PATTERN)
N19 G00 C0.0
N20 G00 X8.0 Z1.0
N21 Z-1.0
N22 X6.2 (POSITION TO R-PLANE FOR PECK CYCLE)
N23 G87 X2.675 R0.0 Q625 F0.006 M89 (OD PECK DRILL START W/C-AXIS CLAMP - 0.0625 PECK)
N24 C45.0 Q625 M89 (INDEX TO C45.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N25 C90.0 Q625 M89 (INDEX TO C90.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N26 C135.0 Q625 M89 (INDEX TO C135.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N27 C180.0 Q625 M89 (INDEX TO C180.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N28 C225.0 Q625 M89 (INDEX TO C225.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N29 C270.0 Q625 M89 (INDEX TO C270.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N30 C315.0 Q625 M89 (INDEX TO C315.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N31 G80 M90 (PECK CYCLE CANCEL - UNCLAMP C-AXIS)
N32 G00 X8.0
N33 G00 Z1.0

(END PROGRAM/TOOL CHANGE PREPARATION)
N34 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N35 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N36 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N37 T05000 (CANCEL OFFSET FOR CURRENT TOOL)
N38 M139 (SHOWER BED COOLANT OFF)
N39 M127 (COOLANT THROUGH TOOL OFF)
N40 M05 P12 (B-AXIS SPINDLE STOP)
N41 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N42 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N43 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N44 M30
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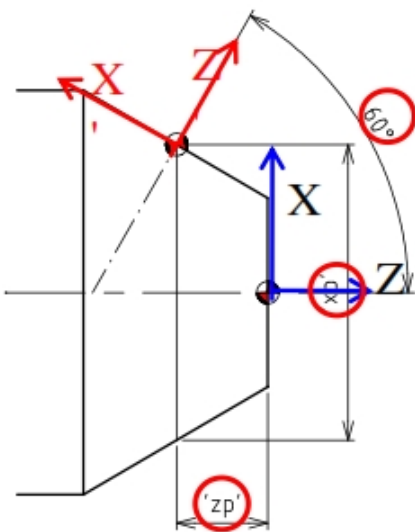


# B-Axis Spindle Tilt Function – G368/G369

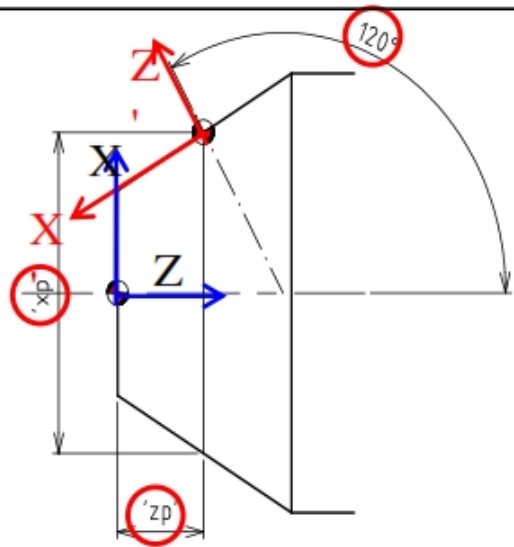
## Command format

**G368** X\_ Z\_ D\_ B\_  
 .....  
**G369**

X\_ Z\_ : center of rotation(absolute coordinates) on the X and Z axis or parallel axes  
 D\_ : direction of feed axis.  
 D0 → Z-axis direction / D1 → X-axis direction  
 B\_ : rotation angle of actual B-axis  
 G369 : 3D coordinate conversion cancel



G368XxpZzpD0.B-30.0



G368XxpZzpD0B30.0

## (2) Format example

**T01001** (Tool offset Call)

M101

**M3S3000P12**

**G368** X95.0Z29.689 D0.B30.0 (3D-mode Act)

G00X0.0Y0.0Z50.0 (Approach Processing)

....

**M5P12**

**G369** (3D-mode Cancel)

Note 1) G368 includes G400 function according to the D0/D1 with G68.1

G369 includes G28 and Tool offset cancel function with G69.1

ex) G369 => G69.1; G28 U0 W0 V0 M101;

G369 includes Live tool rotation stop and G490S0

Note 2) Tool offset conversion

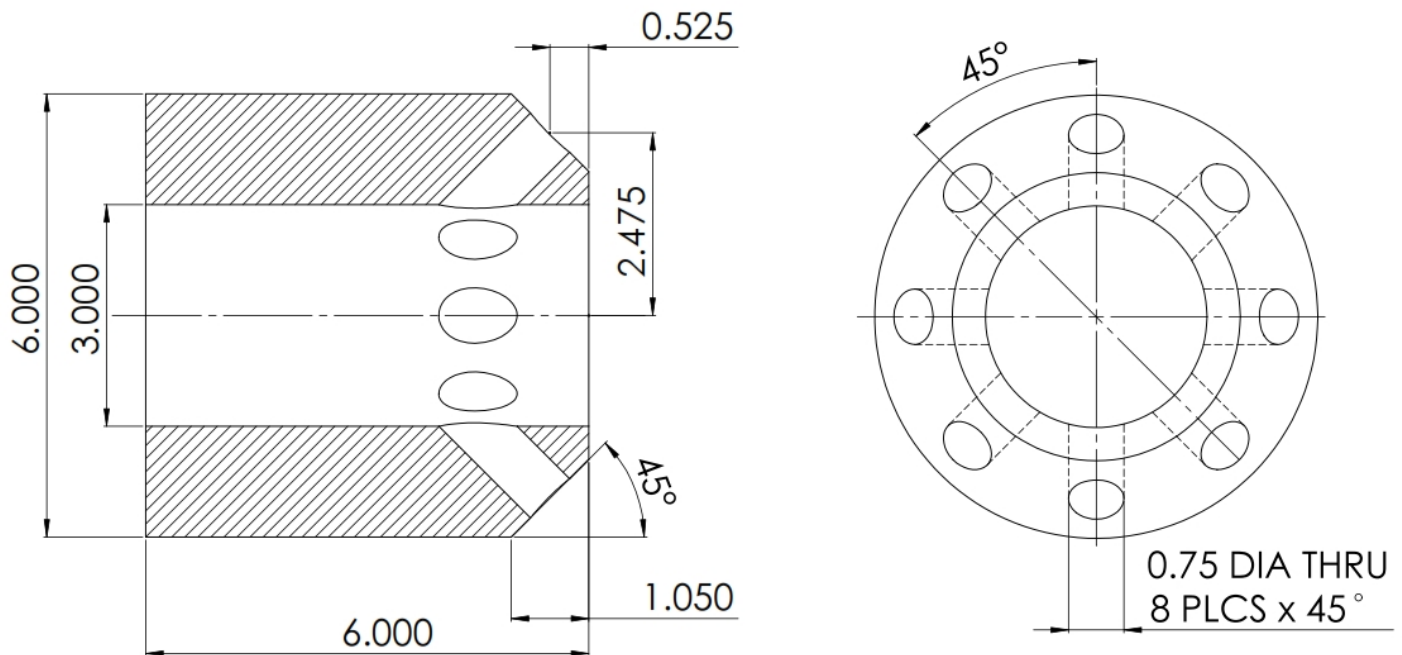
G400 ⇒ Geometry offset 399 / G368 ⇒ Geometry offset 400

Note 3) G368 checks G28 position comparing with Macro value (#550,#551).

G21(metric system) : Macro #550(X) = 1050000, #551(Z) = 670000

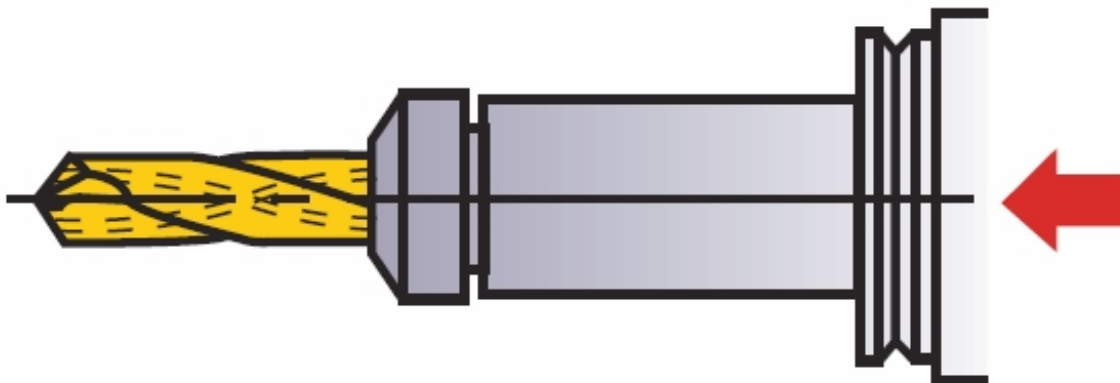
**EXAMPLE #10 - ADVANCED DRILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 6.0 OD X 3.0 ID X 6.0 LONG  
**PROJECTION**: 3.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : DRILL OD HOLE PATTERN  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #5**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER  
**TOOL** : 0.75 SOLID CARBIDE THRU COOLANT DRILL  
**ORIENTATION** : LIVE TOOL - M101 (UNCLAMPED)  
**B-AXIS TILT** : -45.0



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O0010(MX-EXAMPLE #10 - UPPER - LIVE DRILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T05005 (SANDVIK C6 ER32 COLLET HOLDER - 0.75 SOLID CARBIDE THRU COOLANT DRILL)
N10 T06000 (STAGE NEXT TOOL)
N11 M101 (LIVE B-AXIS SPINDLE - UNCLAMPED)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M35 (LEFT SPINDLE C-AXIS MODE ON)
N17 G00 G28 H0.0 (ZERO RETURN C-AXIS)

N18 G97 S500 M03 P12 (DIRECT RPM MODE - 500 RPM - B-AXIS SPINDLE CLOCKWISE)

N19 G00 C0.0
N20 G00 X8.0 Z4.0 (POSITION TO SAFE CLEARANCE)
N21 G368 X4.95 Z-0.525 D0 B-45.0 (ESTABLISH NEW WORKPLANE FOR B-AXIS SPINDLE)
N22 G00 X0.0 Y0.0 Z0.7425 (POSITION TO NEW X0,Y0 POINT ON TILTED PLANE - 0.7425 ABOVE POINT)
(CURRENT POSITION IS THE THEORETICAL PART CORNER)

N23 Z0.1 (POSITION TO R-PLANE FOR PECK CYCLE)

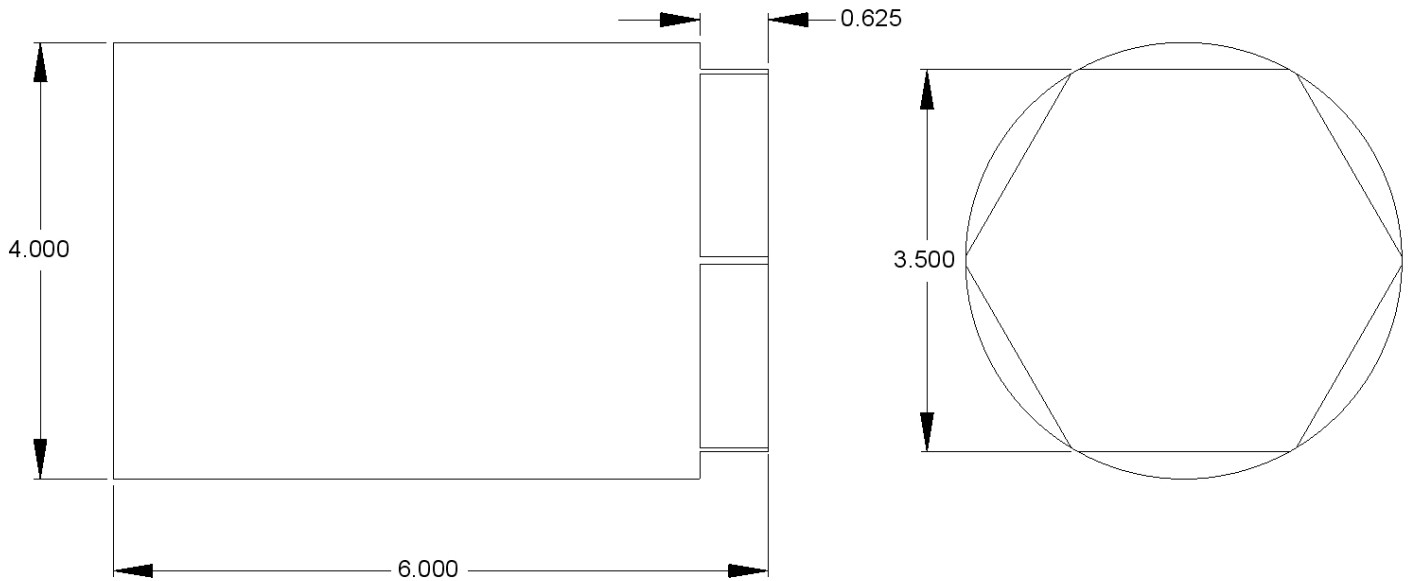
(OD DRILL HOLE PATTERN)
N24 G83 Z-2.0 R0.0 Q625 F0.006 M89 (TILTED OD PECK DRILL START W/C-AXIS CLAMP - 0.0625 PECK)
N25 C45.0 Q625 M89 (INDEX TO C45.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N26 C90.0 Q625 M89 (INDEX TO C90.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N27 C135.0 Q625 M89 (INDEX TO C135.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N28 C180.0 Q625 M89 (INDEX TO C180.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N29 C225.0 Q625 M89 (INDEX TO C225.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N30 C270.0 Q625 M89 (INDEX TO C270.0 - PECK DRILL W/C-AXIS CLAMP - 0.0625 PECK)
N31 C315.0 Q625 M89 (INDEX TO C315.0 - PECK DRILL W/C-AXIS CLAMP- 0.0625 PECK)
N32 G80 M90 (PECK CYCLE CANCEL - UNCLAMP C-AXIS)
N33 G00 Z10.0 (POSITION TO SAFE CLEARANCE ON G368 WORKPLANE)
N34 G369 (G368 PLANE ROTATION CANCEL)

(END PROGRAM/TOOL CHANGE PREPARATION)
N35 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N36 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N37 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N38 T05000 (CANCEL OFFSET FOR CURRENT TOOL)
N39 M139 (SHOWER BED COOLANT OFF)
N40 M127 (COOLANT THROUGH TOOL OFF)
N41 M05 P12 (B-AXIS SPINDLE STOP)
N42 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N43 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N44 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N45 M30
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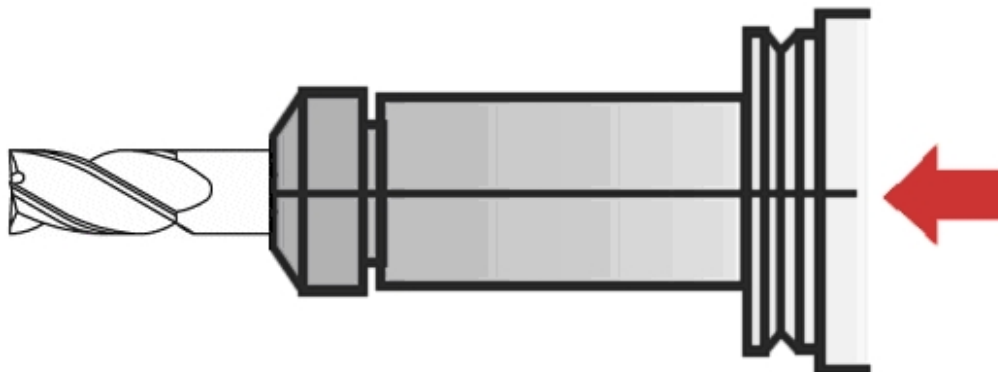
**EXAMPLE #11 - ADVANCED C-AXIS/Y-AXIS MILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 4.0 OD X 6.0 LONG  
**PROJECTION**: 3.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : MILL HEX FLATS WITH BOTTOM OF TOOL  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #6**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER - THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**ORIENTATION** : LIVE TOOL - M101 (UNCLAMPED)  
**B-AXIS TILT** : 0.0



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O0011(MX-EXAMPLE #11 - UPPER - LIVE MILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T06006 (SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT - 0.75 SOLID CARBIDE END MILL)
N10 T07000 (STAGE NEXT TOOL)
N11 M101 (LIVE B-AXIS SPINDLE - UNCLAMPED)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N14 M138 (SHOWER BED COOLANT ON)
N15 M126 (COOLANT THROUGH TOOL ON)
N16 M35 (LEFT SPINDLE C-AXIS MODE ON)
N17 G00 G28 H0.0 (ZERO RETURN C-AXIS)

N18 G97 S1500 M03 P12 (DIRECT RPM MODE - 500 RPM - B-AXIS SPINDLE CLOCKWISE)

N19 G00 C0.0
N20 G00 X8.0 Z4.0 (POSITION TO SAFE CLEARANCE)

N21 M89 (C-AXIS CLAMP)
N22 G00 Z1.0

(PPOSITION TO START POINT)
N23 X6.0
N24 Z-0.25
N25 Y-2.5

(MILL HEX FLAT AT C0.0)
N26 G01 X3.5 F0.0075
N27 Y2.5
N28 G00 X6.0
N29 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C45.0)
N30 G00 C45.0
N31 M89 (C-AXIS CLAMP)
N32 Y-2.5
N33 G01 X3.5 F0.0075
N34 Y2.5
N35 G00 X6.0
N36 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C90.0)
N37 G00 C90.0
N38 M89 (C-AXIS CLAMP)
N39 Y-2.5
N40 G01 X3.5 F0.0075
N41 Y2.5
N42 G00 X6.0
N43 M90 (C-AXIS UNCLAMP)

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(MILL HEX FLAT AT C135.0)

N44 G00 C135.0  
N45 M89 (C-AXIS CLAMP)  
N46 Y-2.5  
N47 G01 X3.5 F0.0075  
N48 Y2.5  
N49 G00 X6.0  
N50 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C180.0)

N51 G00 C180.0  
N52 M89 (C-AXIS CLAMP)  
N53 Y-2.5  
N54 G01 X3.5 F0.0075  
N55 Y2.5  
N56 G00 X6.0  
N57 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C225.0)

N58 G00 C225.0  
N59 M89 (C-AXIS CLAMP)  
N60 Y-2.5  
N61 G01 X3.5 F0.0075  
N62 Y2.5  
N63 G00 X6.0  
N64 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C270.0)

N65 G00 C270.0  
N66 M89 (C-AXIS CLAMP)  
N67 Y-2.5  
N68 G01 X3.5 F0.0075  
N69 Y2.5  
N70 G00 X6.0  
N71 M90 (C-AXIS UNCLAMP)

(MILL HEX FLAT AT C315.0)

N72 G00 C315.0  
N73 M89 (C-AXIS CLAMP)  
N74 Y-2.5  
N75 G01 X3.5 F0.0075  
N76 Y2.5  
N77 G00 X6.0  
N78 M90 (C-AXIS UNCLAMP)

(POSITION TO SAFE CLEARANCE)

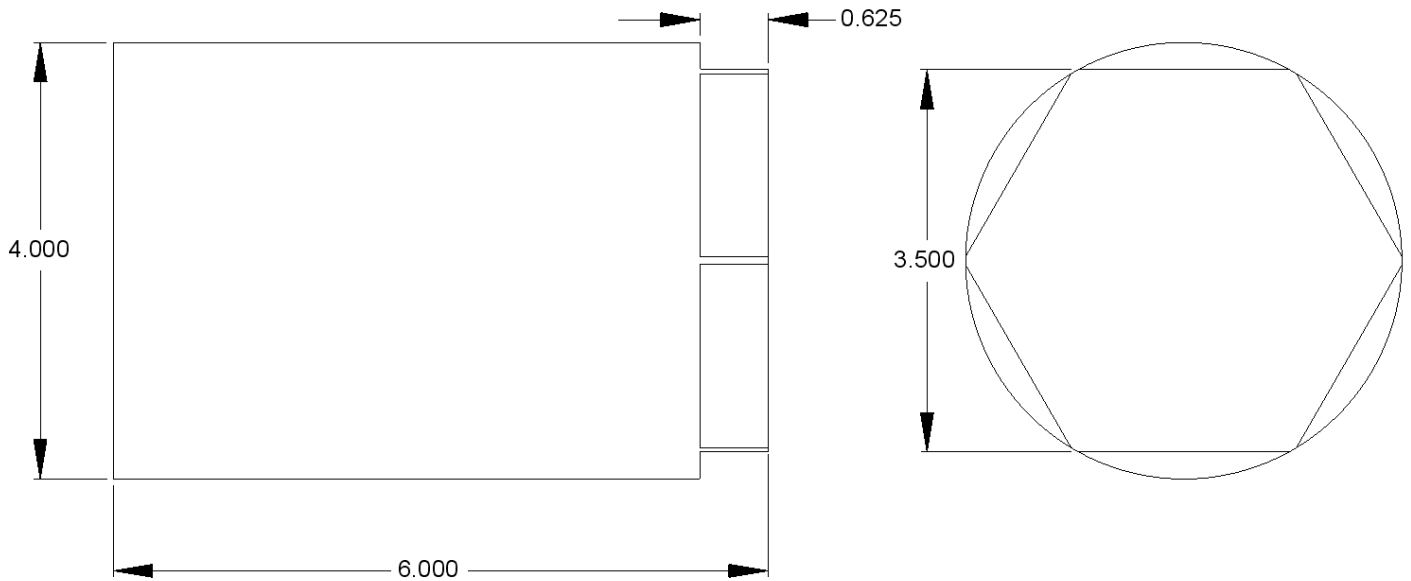
N79 G00 Z4.0  
N80 G00 Y0.0

(END PROGRAM/TOOL CHANGE PREPARATION)

N81 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)  
N82 G00 G28 W0.0 (ZERO RETURN Z-AXIS)  
N83 G00 G28 B0.0 (ZERO RETURN B-AXIS)  
N84 T06000 (CANCEL OFFSET FOR CURRENT TOOL)  
N85 M139 (SHOWER BED COOLANT OFF)  
N86 M127 (COOLANT THROUGH TOOL OFF)  
N87 M05 P12 (B-AXIS SPINDLE STOP)  
N88 M34 (LEFT SPINDLE C-AXIS MODE OFF)  
N89 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)  
N90 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)  
N91 M30  
%

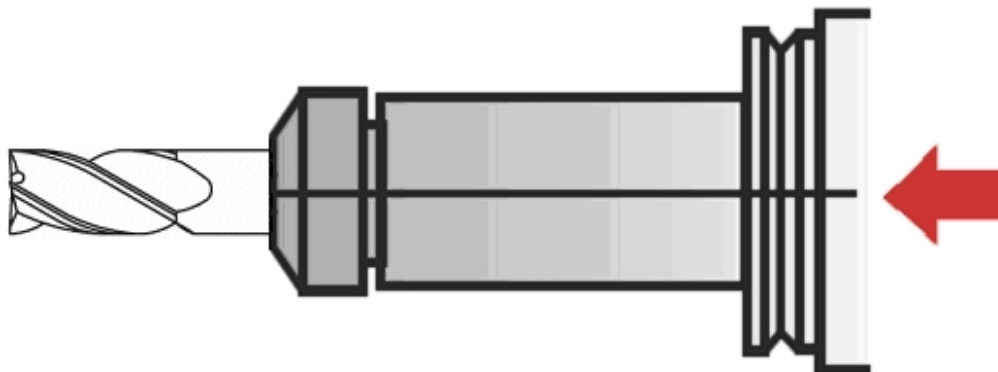
**EXAMPLE #12 - ADVANCED C-AXIS MILLING - UPPER UNIT ONLY**

**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 4.0 OD X 6.0 LONG  
**PROJECTION**: 3.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : MILL HEX FLATS WITH SIDE OF TOOL - C-AXIS POLAR INTERPOLATION  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



**TOOL #6**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER - THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**ORIENTATION** : LIVE TOOL - M101 (UNCLAMPED)  
**B-AXIS TILT** : -90.0



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O0012(MX-EXAMPLE #12 - UPPER - G400 LIVE MILL)

(PREPARATION FOR START OF PROGRAM)

(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)

N1 G00 G18 G40 G49 G80 G99

N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)

N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)

N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)

N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)

N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)

N7 M01

(PREPARATION FOR START OF OPERATION)

N8 G54 (WORK COORDINATE SELECTION)

N9 M06 T06006 (SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT - 0.75 SOLID CARBIDE END MILL)

N10 T07000 (STAGE NEXT TOOL)

N11 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)

N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)

N13 M138 (SHOWER BED COOLANT ON)

N14 M126 (COOLANT THROUGH TOOL ON)

N15 M35 (LEFT SPINDLE C-AXIS MODE ON)

N16 G00 G28 H0.0 (ZERO RETURN C-AXIS)

N17 G00 C0.0

N18 G400 B-90.0 J0.0 (ENGAGE G400 TOOL POINT CONTROL)

(B-90.0 = ANGLE OF HEAD TILT)

(J0.0 = B-AXIS SPINDLE UNLOCKED)

N19 G00 X8.0 Z4.0 (POSITION TO SAFE CLEARANCE POINT)

N20 M101

N21 G97 S1500 M03 P12 (DIRECT RPM MODE - 1500 RPM - B-AXIS SPINDLE CLOCKWISE)

N22 G00 X5.0 Z1.0 (POSITION TO CLEARANCE POINT)

(MILL HEX WITH HELICAL CLIMB MILL CONTOUR WITH CUTTER RADIUS COMPENSATION)

N23 G12.1 (POLAR COORDINATE INTERPOLATION MODE ON)

N24 G98 (UNIT PER MINUTE FEED)

N25 G01 X3.3198 C2.125 F100.0

N26 Z0.1

N27 G01 Z0. F30.0

N28 G41 X2.5762 C2.0761

N29 G03 X2.6702 C1.9375 R0.375

N30 G01 X4.6910 C0.1875 Z-0.0087

N31 G02 X4.7914 C0. Z-0.0095 R0.375

N32 X4.6910 C-0.1875 Z-0.0104 R0.375

N33 G01 X2.6702 C-1.9375 Z-0.0191

N34 G02 X2.0208 C-2.125 Z-0.0208 R0.375

N35 G01 X-2.0208 Z-0.0296

N36 G02 X-2.6702 C-1.9375 Z-0.0313 R0.375

N37 G01 X-4.6910 C-0.1875 Z-0.04

N38 G02 X-4.7914 C0. Z-0.0408 R0.375

N39 X-4.6910 C0.1875 Z-0.0417 R0.375

N40 G01 X-2.6702 C1.9375 Z-0.0504

N41 G02 X-2.0208 C2.125 Z-0.0521 R0.375

N42 G01 X2.0208 Z-0.0608

N43 G02 X2.6702 C1.9375 Z-0.0625 R0.375

N44 G01 X4.6910 C0.1875 Z-0.0712

N45 G02 X4.7914 C0. Z-0.072 R0.375

N46 X4.6910 C-0.1875 Z-0.0729 R0.375

N47 G01 X2.6702 C-1.9375 Z-0.0816

N48 G02 X2.0208 C-2.125 Z-0.0833 R0.375

N49 G01 X-2.0208 Z-0.0921

N50 G02 X-2.6702 C-1.9375 Z-0.0938 R0.375

N51 G01 X-4.6910 C-0.1875 Z-0.1025



N52 G02 X-4.7914 C0. Z-0.1033 R0.375  
N53 X-4.6910 C0.1875 Z-0.1042 R0.375  
N54 G01 X-2.6702 C1.9375 Z-0.1129  
N55 G02 X-2.0208 C2.125 Z-0.1146 R0.375  
N56 G01 X2.0208 Z-0.1233  
N57 G02 X2.6702 C1.9375 Z-0.125 R0.375  
N58 G01 X4.6910 C0.1875 Z-0.1337  
N59 G02 X4.7914 C0. Z-0.1345 R0.375  
N60 X4.6910 C-0.1875 Z-0.1354 R0.375  
N61 G01 X2.6702 C-1.9375 Z-0.1441  
N62 G02 X2.0208 C-2.125 Z-0.1458 R0.375  
N63 G01 X-2.0208 Z-0.1546  
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N65 G01 X-4.6910 C-0.1875 Z-0.165  
N66 G02 X-4.7914 C0. Z-0.1658 R0.375  
N67 X-4.6910 C0.1875 Z-0.1667 R0.375  
N68 G01 X-2.6702 C1.9375 Z-0.1754  
N69 G02 X-2.0208 C2.125 Z-0.1771 R0.375  
N70 G01 X2.0208 Z-0.1858  
N71 G02 X2.6702 C1.9375 Z-0.1875 R0.375  
N72 G01 X4.6910 C0.1875 Z-0.1962  
N73 G02 X4.7914 C0. Z-0.197 R0.375  
N74 X4.6910 C-0.1875 Z-0.1979 R0.375  
N75 G01 X2.6702 C-1.9375 Z-0.2066  
N76 G02 X2.0208 C-2.125 Z-0.2083 R0.375  
N77 G01 X-2.0208 Z-0.2171  
N78 G02 X-2.6702 C-1.9375 Z-0.2188 R0.375  
N79 G01 X-4.6910 C-0.1875 Z-0.2275  
N80 G02 X-4.7914 C0. Z-0.2283 R0.375  
N81 X-4.6910 C0.1875 Z-0.2292 R0.375  
N82 G01 X-2.6702 C1.9375 Z-0.2379  
N83 G02 X-2.0208 C2.125 Z-0.2396 R0.375  
N84 G01 X2.0208 Z-0.2483  
N85 G02 X2.6702 C1.9375 Z-0.25 R0.375  
N86 G01 X4.6910 C0.1875 Z-0.2587  
N87 G02 X4.7914 C0. Z-0.2595 R0.375  
N88 X4.6910 C-0.1875 Z-0.2604 R0.375  
N89 G01 X2.6702 C-1.9375 Z-0.2691  
N90 G02 X2.0208 C-2.125 Z-0.2708 R0.375  
N91 G01 X-2.0208 Z-0.2796  
N92 G02 X-2.6702 C-1.9375 Z-0.2813 R0.375  
N93 G01 X-4.6910 C-0.1875 Z-0.29  
N94 G02 X-4.7914 C0. Z-0.2908 R0.375  
N95 X-4.6910 C0.1875 Z-0.2917 R0.375  
N96 G01 X-2.6702 C1.9375 Z-0.3004  
N97 G02 X-2.0208 C2.125 Z-0.3021 R0.375  
N98 G01 X2.0208 Z-0.3108  
N99 G02 X2.6702 C1.9375 Z-0.3125 R0.375  
N100 G01 X4.6910 C0.1875 Z-0.3212  
N101 G02 X4.7914 C0. Z-0.322 R0.375  
N102 X4.6910 C-0.1875 Z-0.3229 R0.375  
N103 G01 X2.6702 C-1.9375 Z-0.3316  
N104 G02 X2.0208 C-2.125 Z-0.3333 R0.375  
N105 G01 X-2.0208 Z-0.3421  
N106 G02 X-2.6702 C-1.9375 Z-0.3438 R0.375  
N107 G01 X-4.6910 C-0.1875 Z-0.3525  
N108 G02 X-4.7914 C0. Z-0.3533 R0.375  
N109 X-4.6910 C0.1875 Z-0.3542 R0.375  
N110 G01 X-2.6702 C1.9375 Z-0.3629  
N111 G02 X-2.0208 C2.125 Z-0.3646 R0.375  
N112 G01 X2.0208 Z-0.3733  
N113 G02 X2.6702 C1.9375 Z-0.375 R0.375  
N114 G01 X4.6910 C0.1875 Z-0.3837  
N115 G02 X4.7914 C0. Z-0.3845 R0.375  
N116 X4.6910 C-0.1875 Z-0.3854 R0.375  
N117 G01 X2.6702 C-1.9375 Z-0.3941

N118 G02 X2.0208 C-2.125 Z-0.3958 R0.375  
N119 G01 X-2.0208 Z-0.4046  
N120 G02 X-2.6702 C-1.9375 Z-0.4063 R0.375  
N121 G01 X-4.6910 C-0.1875 Z-0.415  
N122 G02 X-4.7914 C0. Z-0.4158 R0.375  
N123 X-4.6910 C0.1875 Z-0.4167 R0.375  
N124 G01 X-2.6702 C1.9375 Z-0.4254  
N125 G02 X-2.0208 C2.125 Z-0.4271 R0.375  
N126 G01 X2.0208 Z-0.4358  
N127 G02 X2.6702 C1.9375 Z-0.4375 R0.375  
N128 G01 X4.6910 C0.1875 Z-0.4462  
N129 G02 X4.7914 C0. Z-0.447 R0.375  
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N131 G01 X2.6702 C-1.9375 Z-0.4566  
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N133 G01 X-2.0208 Z-0.4671  
N134 G02 X-2.6702 C-1.9375 Z-0.4688 R0.375  
N135 G01 X-4.6910 C-0.1875 Z-0.4775  
N136 G02 X-4.7914 C0. Z-0.4783 R0.375  
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N138 G01 X-2.6702 C1.9375 Z-0.4879  
N139 G02 X-2.0208 C2.125 Z-0.4896 R0.375  
N140 G01 X2.0208 Z-0.4983  
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N142 G01 X4.6910 C0.1875 Z-0.5087  
N143 G02 X4.7914 C0. Z-0.5095 R0.375  
N144 X4.6910 C-0.1875 Z-0.5104 R0.375  
N145 G01 X2.6702 C-1.9375 Z-0.5191  
N146 G02 X2.0208 C-2.125 Z-0.5208 R0.375  
N147 G01 X-2.0208 Z-0.5296  
N148 G02 X-2.6702 C-1.9375 Z-0.5313 R0.375  
N149 G01 X-4.6910 C-0.1875 Z-0.54  
N150 G02 X-4.7914 C0. Z-0.5408 R0.375  
N151 X-4.6910 C0.1875 Z-0.5417 R0.375  
N152 G01 X-2.6702 C1.9375 Z-0.5504  
N153 G02 X-2.0208 C2.125 Z-0.5521 R0.375  
N154 G01 X2.0208 Z-0.5608  
N155 G02 X2.6702 C1.9375 Z-0.5625 R0.375  
N156 G01 X4.6910 C0.1875 Z-0.5712  
N157 G02 X4.7914 C0. Z-0.572 R0.375  
N158 X4.6910 C-0.1875 Z-0.5729 R0.375  
N159 G01 X2.6702 C-1.9375 Z-0.5816  
N160 G02 X2.0208 C-2.125 Z-0.5833 R0.375  
N161 G01 X-2.0208 Z-0.5921  
N162 G02 X-2.6702 C-1.9375 Z-0.5938 R0.375  
N163 G01 X-4.6910 C-0.1875 Z-0.6025  
N164 G02 X-4.7914 C0. Z-0.6033 R0.375  
N165 X-4.6910 C0.1875 Z-0.6042 R0.375  
N166 G01 X-2.6702 C1.9375 Z-0.6129  
N167 G02 X-2.0208 C2.125 Z-0.6146 R0.375  
N168 G01 X2.0208 Z-0.6233  
N169 G02 X2.6702 C1.9375 Z-0.625 R0.375  
N170 G01 X4.6910 C0.1875  
N171 G02 X4.7914 C0. R0.375  
N172 X4.6910 C-0.1875 R0.375  
N173 G01 X2.6702 C-1.9375  
N174 G02 X2.0208 C-2.125 R0.375  
N175 G01 X-2.0208  
N176 G02 X-2.6702 C-1.9375 R0.375  
N177 G01 X-4.6910 C-0.1875  
N178 G02 X-4.7914 C0. R0.375  
N179 X-4.6910 C0.1875 R0.375  
N180 G01 X-2.6702 C1.9375  
N181 G02 X-2.0208 C2.125 R0.375  
N182 G01 X2.0208  
N183 G02 X2.6702 C1.9375 R0.375

```

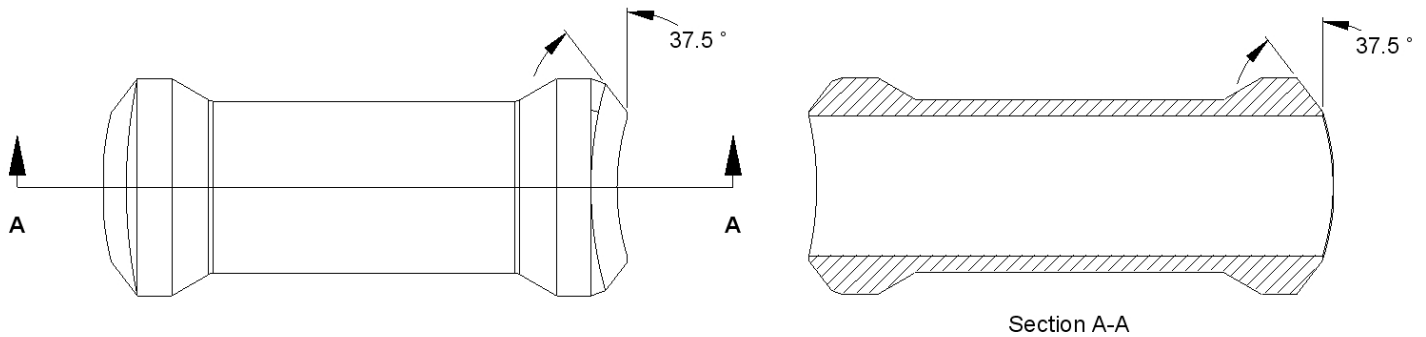
N184 G03 X2.8632 C1.8275 R0.375
N185 G01 G40 X3.3198 C2.125
N186 Z0.1
N187 Z2.0 F100.0
N188 G13.1 (POLAR COORDINATE INTERPOLATION MODE OFF)

N189 G99 (UNIT PER REVOLUTION FEED)
N190 G00 X8.0 Z4.0 (POSITION TO SAFE CLEARANCE POINT)
N191 C0.0

(END PROGRAM/TOOL CHANGE PREPARATION)
N192 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N193 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N194 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N195 T06000 (CANCEL OFFSET FOR CURRENT TOOL)
N196 M139 (SHOWER BED COOLANT OFF)
N197 M127 (COOLANT THROUGH TOOL OFF)
N198 M05 P12 (B-AXIS SPINDLE STOP)
N199 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N200 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N201 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N202 M30
%
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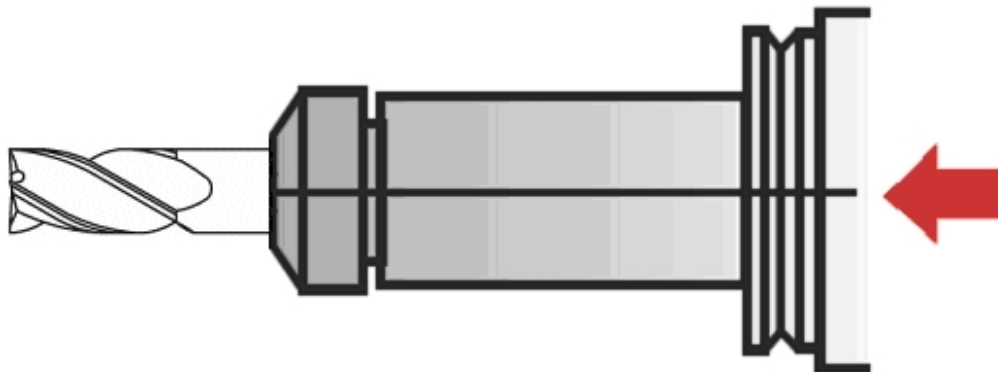
**EXAMPLE #13 - ADVANCED 5-AXIS OPERATIONS - UPPER UNIT ONLY**

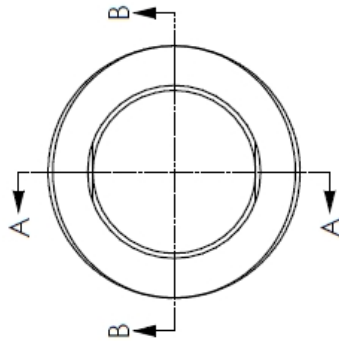
**MATERIAL** : AISI 4140 ALLOY STEEL - 275 HB  
**STOCK** : 3.5 OD X 7.75 LONG FORGING  
**3D MODEL** : PARASOLID FILE O0013.X\_T  
**PROJECTION**: 3.5 MINIMUM FROM JAW FACE  
**ADAPTERS** : SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**SPINDLE** : B-AXIS HEAD  
**WORK COORD**: G54  
**ORIGIN** : X0.0 = LEFT MAIN SPINDLE CENTERLINE, Z0.0 = FINISHED FACE  
**PROCESS** : MILL 37.5° FACE FEATURES WITH SIDE OF TOOL - 5-AXIS CONTINUOUS  
**Q-SETTER** : TOUCH OFF TOOL IN X ONLY AT B0.0



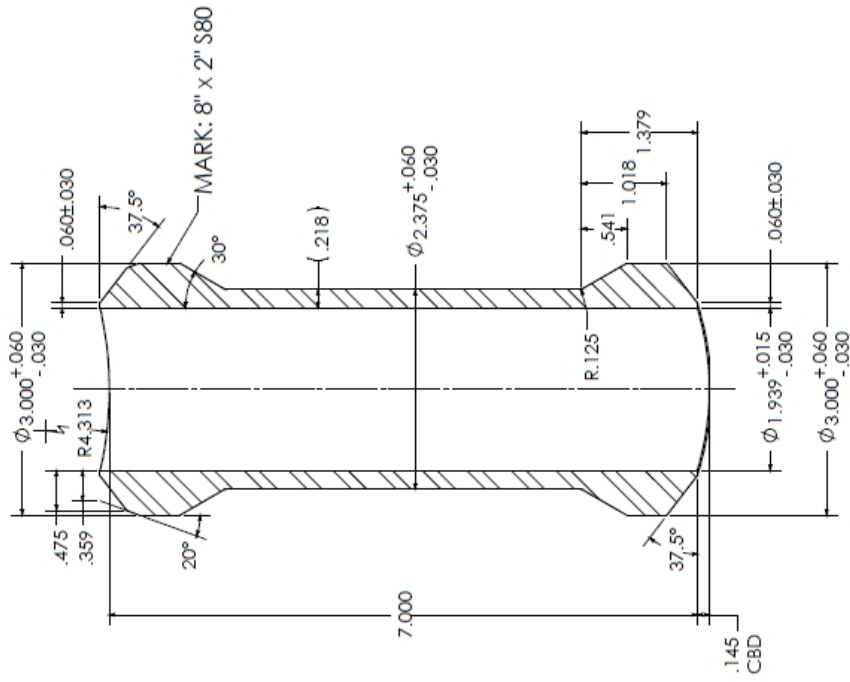
**TOOL #6**

**ADAPTER** : SANDVIK C6 ER32 COLLET HOLDER - THRU COOLANT  
**TOOL** : 0.75 SOLID CARBIDE END MILL  
**ORIENTATION** : LIVE TOOL - M101 (UNCLAMPED)  
**B-AXIS TILT** : CONTINUOUS 5-AXIS WITH TCP MODE (G700)

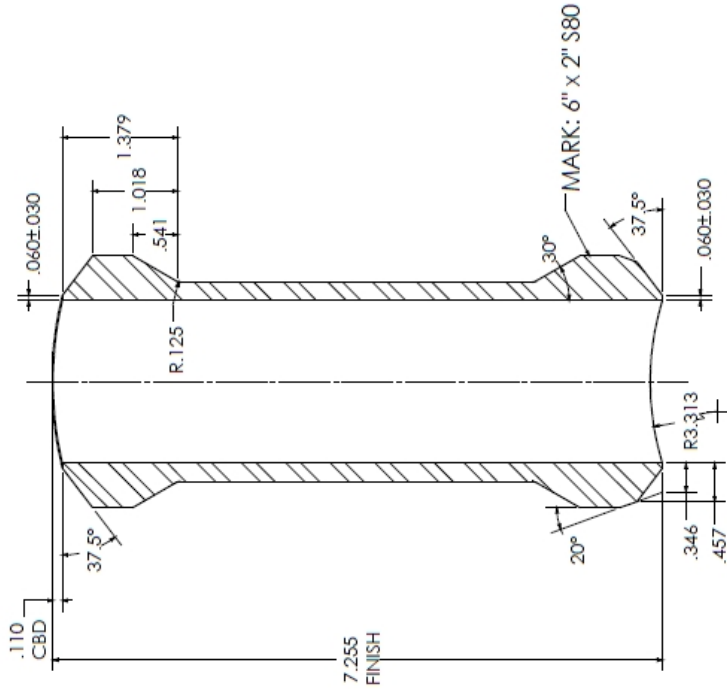




**THIS END  
TO FIT 8" HEADER**



**THIS END  
TO FIT 6" HEADER**

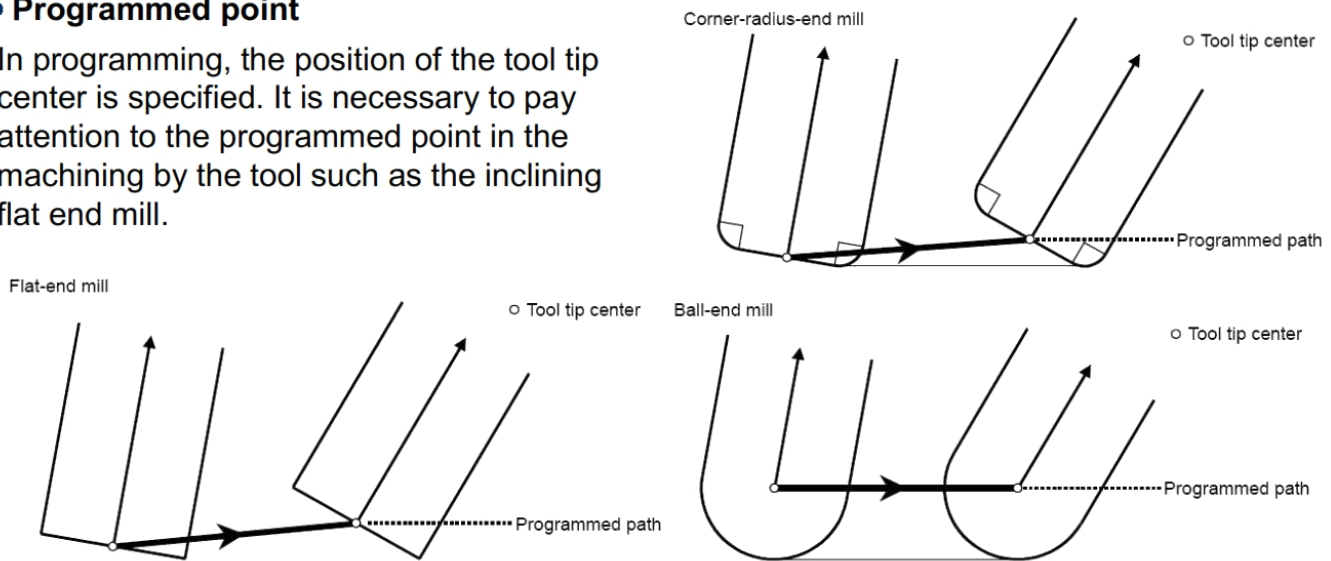


# Advanced 5-Axis Operations:

## Doosan TCP Mode for 5-Axis Machining - G700/G701

### ● Programmed point

In programming, the position of the tool tip center is specified. It is necessary to pay attention to the programmed point in the machining by the tool such as the inclining flat end mill.



The MX-Series has both a Nutating (Articulating) head and a Rotary Axis (C1 Left Main Spindle ,C2 Right Main Spindle). The C-Axis(C1 & C2) is mechanically independent of the B-Axis head.

If we do not use TCP (Tool Center Point) mode then we are required to use the traditional method of calculating X, Y, Z, C and B. In a CAM system, the part will remain static and the system will create 5-axis toolpath vectors around the desired geometry. These vectors represent the centerline axis of the cutting tool and are used to calculate the required position and angles.

The tip of the tool will have XYZ positions based relative to the origin of the part in the CAM system.

On a machine like the MX-Series, the C axis angle would be calculated first.

This is necessary to align a tool vector to the ZX plane as the B-Axis only rotates in this plane.

Once that angle of rotation is known, the CAM system then calculates the X,Y positions required based on the C axis rotation. Since the Z-axis is the centerline of the C axis rotation, the Z axis position isn't effected by the C axis rotation. We now have the new X, Y, Z and C known within the CAM system.

The CAM system next calculates the B-Axis angle based on the toolpath vectors.

Since all tools have differing lengths, the position of the B-Axis head needs to be adjusted based on those tools lengths and B-Axis angle. The only coordinates effected by the length of the tool and the B-Axis rotation are X & Z. Our next step is to calculate new X & Z coordinates based on the distance from the tip of the tool to the center of rotation of the B-axis head. This process would need to be repeated for every toolpath point.

All of these calculations are typically handled within the Post-Processor of the CAM system.

The Post-Processor is the last step in the process as it formats any work done in a CAM system to a useable NC Code file that will operate a CNC Machine Tool.

As one can plainly see, this is a complicated process.

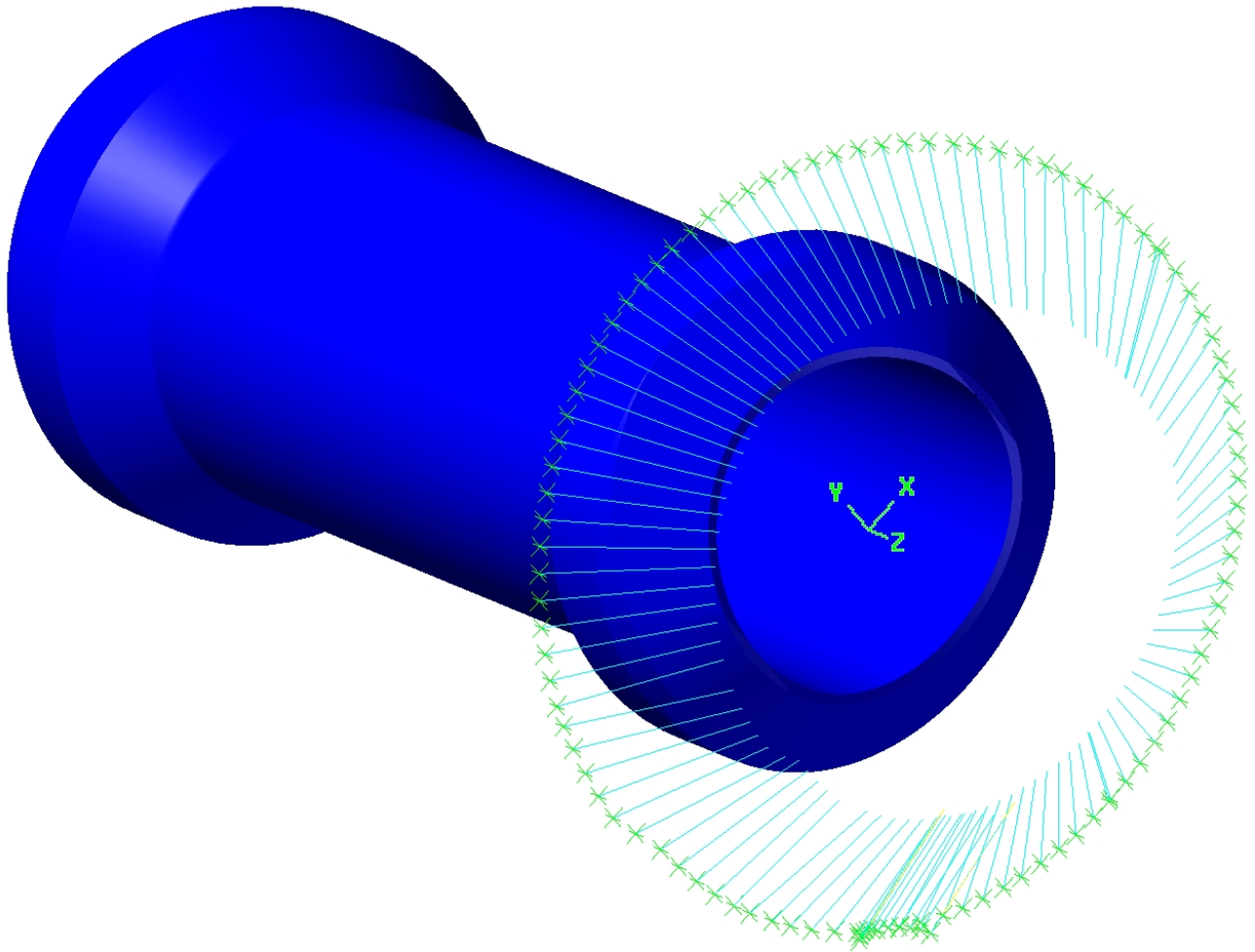
Fanuc TCP Mode is designed for Nutating (Articulating) heads to simplify multi-axis programming by having the machine itself control the position of the tip of the tool during based on the specific tool gage length. Using the Q-Setter, with the B-Axis at 0.0 and touching off in the X-axis only, establishes that gage length. With TCP mode, the relationship between the tool center point (control point) and the workpiece stays constant,

Doosan has further enhanced the TCP functionality of the MX-Series by also applying it to the C-Axis Rotary Axis. This results in simplified programming and a more efficient toolpath motion kinematically by the CNC Machine Tool. The X,Y, Z values in the NC Code are the STATIC Cutter Tip Locations (X,Y,Z Points) in the CAM system, BEFORE the rotation of the C-Axis. The CAM system only needs to calculate the proper C-Axis Rotary Angle and B-Axis Tilt Angle. The Post-Processor should also convert X-Values to Diameter.

Doosan TCP Mode only supports G00 (Rapid Traverse), G01 (Linear Interpolation) and G49 (Tool Length Compensation Cancel). It is engaged with a G700 Command followed by a D-Word containing the appropriate Tool Offset Number (G700 D\_\_). Doosan TCP Mode requires that any active Tool Offset is cancelled prior to engaging TCP Mode. Doosan TCP mode is cancelled by the use of G49 and G701 commands.

Please refer to the Doosan MX-Series Programming Manual for detailed documentation of Doosan TCP Mode. (Sections 15-11, 17-6)

## Advanced 5-Axis Operations: CAM System Post-Processor Information



- X,Y,Z Points are all **STATIC** Cutter Tip Locations **BEFORE** rotation of C-Axis.
- Doosan G700 TCP Mode will recalculate & reposition X,Y based on C-Axis Angle.
- X-Values should be converted to Diameter.
- M296 (Dynamic Radius/Diameter Convert On) will **NOT** be used.



# Advanced 5-Axis Operations:

## APT Cutter Location File Generated by CAM System

PARTNO0013

PPRINT MX-EXAMPLE #13 - UPPER - G700 5-AXIS LIVE MILL

TRACUT/ 1.00000, 0.00000, 0.00000, 0.000,\$  
0.00000, 1.00000, 0.00000, 0.000,\$  
0.00000, 0.00000, 1.00000, 0.000

TMARK / 100

SEQNO/1,INCR,1

LOADTL/6,LENGTH, 0.00000,DIAMTR,0.7500

SPINDL/2000,CLW

MULTAX/OFF

CUTCOM/LENGTH,ON, OSETNO, 6

COOLNT/ON

RAPID

GOTO / 1.08510, 0.30188, 2.56715, 0.00000, 0.00000, 1.00000

MULTAX/ON

GOTO / 1.08510, 0.30188, 2.56715, 0.55266, 0.56272, 0.61474

GOTO / -0.98738,-1.80832, 0.26186, 0.55266, 0.56272, 0.61474

FEDRAT/IPM,10.0

GOTO / -1.07028,-1.89273, 0.16965, 0.55266, 0.56272, 0.61474

GOTO / -1.04851,-1.85913, 0.11793, 0.55266, 0.56272, 0.61474

GOTO / -1.03436,-1.82129, 0.06643, 0.55266, 0.56272, 0.61474

GOTO / -1.02808,-1.77988, 0.01603, 0.55266, 0.56272, 0.61474

GOTO / -1.02977,-1.73558,-0.03241, 0.55266, 0.56272, 0.61474

GOTO / -1.03940,-1.68917,-0.07806, 0.55266, 0.56272, 0.61474

GOTO / -1.05682,-1.64143,-0.12013, 0.55266, 0.56272, 0.61474

GOTO / -1.08171,-1.59319,-0.15791, 0.55266, 0.56272, 0.61474

GOTO / -1.11366,-1.54527,-0.19075, 0.55266, 0.56272, 0.61474

GOTO / -1.15212,-1.49848,-0.21808, 0.55266, 0.56272, 0.61474

GOTO / -1.19643,-1.45363,-0.23945, 0.55266, 0.56272, 0.61474

GOTO / -1.24583,-1.41149,-0.25448, 0.55266, 0.56272, 0.61474

GOTO / -1.29947,-1.37278,-0.26292, 0.55266, 0.56272, 0.61474

FEDRAT/IPM,25.0

GOTO / -1.34208,-1.32787,-0.25671, 0.57134, 0.54314, 0.61528

GOTO / -1.38299,-1.28200,-0.25067, 0.58914, 0.52292, 0.61601

GOTO / -1.42477,-1.23223,-0.24455, 0.60647, 0.50169, 0.61685

GOTO / -1.46268,-1.18273,-0.23896, 0.62361, 0.47877, 0.61797

GOTO / -1.49610,-1.13714,-0.23332, 0.63490, 0.46229, 0.61902

GOTO / -1.53535,-1.07984,-0.22759, 0.65033, 0.43860, 0.62024

GOTO / -1.56445,-1.03350,-0.22223, 0.66230, 0.41945, 0.62082

GOTO / -1.60126,-0.97244,-0.21668, 0.67941, 0.38997, 0.62155

GOTO / -1.62894,-0.92095,-0.21200, 0.68888, 0.37056, 0.62300

GOTO / -1.65643,-0.86720,-0.20708, 0.69804, 0.35136, 0.62393

GOTO / -1.68633,-0.80416,-0.20228, 0.71214, 0.32069, 0.62451

GOTO / -1.70983,-0.74842,-0.19831, 0.72007, 0.29974, 0.62582

GOTO / -1.73183,-0.69237,-0.19434, 0.72698, 0.28027, 0.62685

GOTO / -1.74987,-0.64034,-0.18966, 0.72054, 0.29726, 0.62647

GOTO / -1.76810,-0.58198,-0.18413, 0.73068, 0.27908, 0.62308

GOTO / -1.78641,-0.51741,-0.17907, 0.74418, 0.24814, 0.62018

GOTO / -1.80154,-0.45546,-0.17468, 0.75485, 0.22061, 0.61768

GOTO / -1.81541,-0.39095,-0.17081, 0.76550, 0.18752, 0.61551

GOTO / -1.82688,-0.32698,-0.16749, 0.77295, 0.16166, 0.61353

GOTO / -1.83585,-0.26415,-0.16450, 0.77984, 0.13328, 0.61162

GOTO / -1.84370,-0.19628,-0.16219, 0.78666, 0.09335, 0.61028

GOTO / -1.84879,-0.13242,-0.16068, 0.78984, 0.06832, 0.60949

GOTO / -1.85200,-0.06555,-0.15953, 0.79281, 0.03315, 0.60857

GOTO / -1.85337,-0.00176,-0.15948, 0.79341,-0.00748, 0.60864

GOTO / -1.89141, 0.00082,-0.18868, 0.79339,-0.00421, 0.60870

GOTO / -1.92944, 0.00341,-0.21788, 0.79336,-0.00148, 0.60875

GOTO / -1.92831, 0.06418,-0.21810, 0.79269,-0.02850, 0.60896  
GOTO / -1.92485, 0.13014,-0.21869, 0.79073,-0.05727, 0.60948  
GOTO / -1.91909, 0.19496,-0.21971, 0.78746,-0.08579, 0.61037  
GOTO / -1.91105, 0.25948,-0.22112, 0.78292,-0.11391, 0.61160  
GOTO / -1.90076, 0.32359,-0.22290, 0.77711,-0.14189, 0.61316  
GOTO / -1.88823, 0.38723,-0.22505, 0.77006,-0.16951, 0.61504  
GOTO / -1.87344, 0.45053,-0.22757, 0.76168,-0.19713, 0.61724  
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GOTO / 0.35186, 0.96427, 2.62001, 0.55266, 0.56272, 0.61474

FINI

# Advanced 5-Axis Operations:

## NC Code File Created from APT-CL by CAM Post-Processor

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O0013(MX-EXAMPLE #13 - UPPER - G700 5-AXIS LIVE MILL)

(PREPARATION FOR START OF PROGRAM)
(INITIALIZE - RAPID, ZX PLANE, TNR COMP CANCEL, TLO CANCEL, CYCLE CANCEL, UPR FEED)
N1 G00 G18 G40 G49 G80 G99
N2 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N3 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N4 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N5 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL CHANGE)
N6 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N7 M01

(PREPARATION FOR START OF OPERATION)
N8 G54 (WORK COORDINATE SELECTION)
N9 M06 T06006 (SANDVIK C6 ER32 COLLET HOLDER THRU COOLANT- 0.75 SOLID CARBIDE END MILL)
N10 T07000 (STAGE NEXT TOOL)
N11 G490 S0 (EXPLICIT B-AXIS SPINDLE ORIENTATION FOR TOOL)
N12 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N13 M138 (SHOWER BED COOLANT ON)
N14 M126 (COOLANT THROUGH TOOL ON)
N15 M35 (LEFT SPINDLE C-AXIS MODE ON)
N16 G00 G28 H0.0 (ZERO RETURN C-AXIS)
N17 G00 C0.0
N18 M90 (C-AXIS CLAMP OFF)
N19 M101 (UNCLAMP B-AXIS SPINDLE)
N20 M110 (INTERFERENCE CHECK OFF)
N21 M272 (Y-AXIS REFERENCE INTERLOCK RELEASE)

N22 G97 S2000 M03 P12 (DIRECT RPM MODE - 2000 RPM - B-AXIS SPINDLE CLOCKWISE)
N23 G17 (EXPLICIT X-Y PLANE SELECTION)

N24 G00 X8.0 Z15.0 (POSITION TO SAFE CLEARANCE POINT)

N25 G00 X0.0 Y0.0 B-37.933 C45.517 (POSITION TO ORIGIN WITH INITIAL ROTATION & TILT)

N26 T06000 (EXPLICITLY CANCEL ACTIVE TOOL OFFSET PRIOR TO TCP MODE)

N27 G700 D006 (ENGAGE DOOSAN TCP MODE WITH TOOL OFFSET #6)
N28 G00 X2.1702 Y0.3019 Z2.5672 B-37.933 C45.517
N29 X-1.9748 Y-1.8083 Z0.2619 B-37.933 C45.517
N30 G01 G98 X-2.1406 Y-1.8927 Z0.1697 B-37.933 C45.517 F10.0
N31 X-2.0970 Y-1.8591 Z0.1179 B-37.933 C45.517
N32 X-2.0687 Y-1.8213 Z0.0664 B-37.933 C45.517
N33 X-2.0562 Y-1.7799 Z0.0160 B-37.933 C45.517
N34 X-2.0595 Y-1.7356 Z-0.0324 B-37.933 C45.517
N35 X-2.0788 Y-1.6892 Z-0.0781 B-37.933 C45.517
N36 X-2.1136 Y-1.6414 Z-0.1201 B-37.933 C45.517
N37 X-2.1634 Y-1.5932 Z-0.1579 B-37.933 C45.517
N38 X-2.2273 Y-1.5453 Z-0.1908 B-37.933 C45.517
N39 X-2.3042 Y-1.4985 Z-0.2181 B-37.933 C45.517
N40 X-2.3929 Y-1.4536 Z-0.2395 B-37.933 C45.517
N41 X-2.4917 Y-1.4115 Z-0.2545 B-37.933 C45.517
N42 X-2.5989 Y-1.3728 Z-0.2629 B-37.933 C45.517
N43 X-2.6842 Y-1.3279 Z-0.2567 B-37.972 C43.551 F25.0
N44 X-2.7660 Y-1.2820 Z-0.2507 B-38.025 C41.592
N45 X-2.8495 Y-1.2322 Z-0.2446 B-38.086 C39.599
N46 X-2.9254 Y-1.1827 Z-0.2390 B-38.168 C37.515
N47 X-2.9922 Y-1.1371 Z-0.2333 B-38.245 C36.060
N48 X-3.0707 Y-1.0798 Z-0.2276 B-38.334 C33.997
N49 X-3.1289 Y-1.0335 Z-0.2222 B-38.376 C32.347
N50 X-3.2025 Y-0.9724 Z-0.2167 B-38.429 C29.855
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N51 X-3.2579 Y-0.9210 Z-0.2120 B-38.536 C28.277  
 N52 X-3.3129 Y-0.8672 Z-0.2071 B-38.604 C26.719  
 N53 X-3.3727 Y-0.8042 Z-0.2023 B-38.646 C24.243  
 N54 X-3.4197 Y-0.7484 Z-0.1983 B-38.743 C22.600  
 N55 X-3.4637 Y-0.6924 Z-0.1943 B-38.818 C21.083  
 N56 X-3.4997 Y-0.6403 Z-0.1897 B-38.790 C22.419  
 N57 X-3.5362 Y-0.5820 Z-0.1841 B-38.541 C20.904  
 N58 X-3.5728 Y-0.5174 Z-0.1791 B-38.329 C18.440  
 N59 X-3.6031 Y-0.4555 Z-0.1747 B-38.147 C16.291  
 N60 X-3.6308 Y-0.3910 Z-0.1708 B-37.989 C13.764  
 N61 X-3.6538 Y-0.3270 Z-0.1675 B-37.845 C11.813  
 N62 X-3.6717 Y-0.2642 Z-0.1645 B-37.707 C9.699  
 N63 X-3.6874 Y-0.1963 Z-0.1622 B-37.610 C6.767  
 N64 X-3.6976 Y-0.1324 Z-0.1607 B-37.553 C4.944  
 N65 X-3.7040 Y-0.0656 Z-0.1595 B-37.486 C2.394  
 N66 X-3.7067 Y-0.0018 Z-0.1595 B-37.491 C-0.540  
 N67 X-3.7828 Y0.0008 Z-0.1887 B-37.496 C-0.304  
 N68 X-3.8589 Y0.0034 Z-0.2179 B-37.499 C-0.107  
 N69 X-3.8566 Y0.0642 Z-0.2181 B-37.514 C-2.059  
 N70 X-3.8497 Y0.1301 Z-0.2187 B-37.552 C-4.143  
 N71 X-3.8382 Y0.1950 Z-0.2197 B-37.616 C-6.218  
 N72 X-3.8221 Y0.2595 Z-0.2211 B-37.705 C-8.278  
 N73 X-3.8015 Y0.3236 Z-0.2229 B-37.818 C-10.347  
 N74 X-3.7765 Y0.3872 Z-0.2251 B-37.955 C-12.414  
 N75 X-3.7469 Y0.4505 Z-0.2276 B-38.115 C-14.510  
 N76 X-3.7129 Y0.5130 Z-0.2304 B-38.299 C-16.550  
 N77 X-3.6745 Y0.5751 Z-0.2336 B-38.500 C-18.737  
 N78 X-3.6347 Y0.6328 Z-0.2371 B-38.734 C-20.118  
 N79 X-3.5999 Y0.6818 Z-0.2402 B-38.737 C-19.196  
 N80 X-3.5564 Y0.7380 Z-0.2428 B-38.599 C-20.026  
 N81 X-3.5061 Y0.7968 Z-0.2458 B-38.535 C-22.017  
 N82 X-3.4527 Y0.8539 Z-0.2489 B-38.449 C-23.746  
 N83 X-3.3951 Y0.9106 Z-0.2523 B-38.372 C-25.590  
 N84 X-3.3341 Y0.9659 Z-0.2558 B-38.295 C-27.411  
 N85 X-3.2697 Y1.0202 Z-0.2595 B-38.219 C-29.234  
 N86 X-3.2019 Y1.0732 Z-0.2634 B-38.143 C-31.053  
 N87 X-3.1308 Y1.1250 Z-0.2673 B-38.069 C-32.887  
 N88 X-3.0563 Y1.1756 Z-0.2714 B-37.998 C-34.743  
 N89 X-2.9785 Y1.2249 Z-0.2756 B-37.933 C-36.618  
 N90 X-2.8975 Y1.2730 Z-0.2800 B-37.873 C-38.513  
 N91 X-2.8133 Y1.3197 Z-0.2844 B-37.820 C-40.424  
 N92 X-2.7264 Y1.3648 Z-0.2888 B-37.774 C-42.331  
 N93 X-2.6369 Y1.4083 Z-0.2934 B-37.732 C-44.234  
 N94 X-2.5448 Y1.4502 Z-0.2979 B-37.693 C-46.131  
 N95 X-2.4504 Y1.4905 Z-0.3024 B-37.657 C-48.025  
 N96 X-2.3535 Y1.5292 Z-0.3069 B-37.622 C-49.916  
 N97 X-2.2543 Y1.5663 Z-0.3113 B-37.592 C-51.823  
 N98 X-2.1527 Y1.6017 Z-0.3156 B-37.566 C-53.747  
 N99 X-2.0489 Y1.6355 Z-0.3199 B-37.547 C-55.686  
 N100 X-1.9432 Y1.6674 Z-0.3241 B-37.532 C-57.625  
 N101 X-1.8358 Y1.6976 Z-0.3282 B-37.519 C-59.561  
 N102 X-1.7267 Y1.7259 Z-0.3321 B-37.511 C-61.496  
 N103 X-1.6162 Y1.7524 Z-0.3358 B-37.503 C-63.429  
 N104 X-1.5042 Y1.7772 Z-0.3394 B-37.498 C-65.362  
 N105 X-1.3909 Y1.8001 Z-0.3427 B-37.493 C-67.294  
 N106 X-1.2762 Y1.8212 Z-0.3459 B-37.489 C-69.229  
 N107 X-1.1602 Y1.8405 Z-0.3488 B-37.488 C-71.183  
 N108 X-1.0431 Y1.8579 Z-0.3515 B-37.489 C-73.143  
 N109 X-0.9252 Y1.8734 Z-0.3539 B-37.491 C-75.098  
 N110 X-0.8066 Y1.8870 Z-0.3561 B-37.494 C-77.049  
 N111 X-0.6873 Y1.8987 Z-0.3579 B-37.497 C-78.996  
 N112 X-0.5675 Y1.9085 Z-0.3595 B-37.500 C-80.939  
 N113 X-0.4473 Y1.9165 Z-0.3608 B-37.501 C-82.878  
 N114 X-0.3266 Y1.9226 Z-0.3618 B-37.502 C-84.819  
 N115 X-0.2059 Y1.9267 Z-0.3625 B-37.501 C-86.729  
 N116 X-0.0837 Y1.9290 Z-0.3629 B-37.499 C-88.720

N117	X0.0098	Y1.9280	Z-0.3619	B-37.501	C-90.131
N118	X0.0884	Y1.9258	Z-0.3606	B-37.513	C-91.444
N119	X0.1730	Y1.9242	Z-0.3603	B-37.515	C-92.613
N120	X0.2581	Y1.9217	Z-0.3597	B-37.510	C-93.873
N121	X0.3467	Y1.9180	Z-0.3589	B-37.503	C-95.341
N122	X0.4377	Y1.9129	Z-0.3579	B-37.508	C-96.906
N123	X0.5220	Y1.9069	Z-0.3567	B-37.525	C-98.094
N124	X0.6052	Y1.9001	Z-0.3552	B-37.531	C-99.272
N125	X0.6897	Y1.8923	Z-0.3535	B-37.529	C-100.573
N126	X0.7756	Y1.8834	Z-0.3516	B-37.525	C-101.948
N127	X0.8633	Y1.8730	Z-0.3494	B-37.523	C-103.435
N128	X0.9488	Y1.8616	Z-0.3472	B-37.533	C-104.853
N129	X1.0289	Y1.8499	Z-0.3447	B-37.549	C-106.019
N130	X1.1103	Y1.8371	Z-0.3421	B-37.556	C-107.176
N131	X1.1964	Y1.8226	Z-0.3391	B-37.543	C-108.737
N132	X1.2836	Y1.8064	Z-0.3361	B-37.544	C-110.536
N133	X1.3556	Y1.7917	Z-0.3332	B-37.604	C-111.148
N134	X1.4347	Y1.7751	Z-0.3298	B-37.593	C-112.368
N135	X1.5220	Y1.7557	Z-0.3261	B-37.564	C-114.326
N136	X1.5989	Y1.7369	Z-0.3226	B-37.599	C-115.459
N137	X1.6757	Y1.7172	Z-0.3188	B-37.616	C-116.671
N138	X1.7545	Y1.6959	Z-0.3149	B-37.616	C-118.157
N139	X1.8334	Y1.6732	Z-0.3109	B-37.623	C-119.722
N140	X1.9083	Y1.6502	Z-0.3069	B-37.665	C-120.929
N141	X1.9800	Y1.6270	Z-0.3028	B-37.697	C-122.085
N142	X2.0512	Y1.6029	Z-0.2985	B-37.700	C-123.490
N143	X2.1254	Y1.5769	Z-0.2941	B-37.705	C-125.001
N144	X2.1976	Y1.5501	Z-0.2897	B-37.735	C-126.349
N145	X2.2674	Y1.5227	Z-0.2853	B-37.768	C-127.613
N146	X2.3390	Y1.4934	Z-0.2807	B-37.773	C-129.300
N147	X2.4071	Y1.4639	Z-0.2764	B-37.807	C-130.829
N148	X2.4704	Y1.4350	Z-0.2721	B-37.874	C-131.963
N149	X2.5311	Y1.4061	Z-0.2678	B-37.945	C-132.802
N150	X2.5993	Y1.3726	Z-0.2630	B-37.951	C-134.381
N151	X2.6643	Y1.3386	Z-0.2584	B-37.971	C-136.070
N152	X2.7185	Y1.3084	Z-0.2542	B-38.022	C-137.173
N153	X2.7792	Y1.2741	Z-0.2496	B-38.053	C-138.539
N154	X2.8402	Y1.2379	Z-0.2452	B-38.076	C-140.160
N155	X2.8977	Y1.2017	Z-0.2409	B-38.108	C-141.799
N156	X2.9537	Y1.1644	Z-0.2368	B-38.199	C-142.995
N157	X3.0039	Y1.1287	Z-0.2328	B-38.258	C-144.290
N158	X3.0520	Y1.0936	Z-0.2288	B-38.290	C-145.726
N159	X3.1041	Y1.0541	Z-0.2247	B-38.361	C-146.965
N160	X3.1532	Y1.0142	Z-0.2208	B-38.412	C-148.382
N161	X3.1978	Y0.9759	Z-0.2171	B-38.459	C-149.770
N162	X3.2395	Y0.9383	Z-0.2134	B-38.508	C-150.939
N163	X3.2877	Y0.8933	Z-0.2095	B-38.523	C-152.848
N164	X3.3292	Y0.8510	Z-0.2063	B-38.597	C-154.363
N165	X3.3617	Y0.8153	Z-0.2033	B-38.684	C-155.059
N166	X3.4030	Y0.7692	Z-0.1998	B-38.709	C-156.713
N167	X3.4383	Y0.7258	Z-0.1968	B-38.760	C-158.241
N168	X3.4659	Y0.6889	Z-0.1941	B-38.839	C-158.731
N169	X3.4929	Y0.6507	Z-0.1906	B-38.825	C-157.713
N170	X3.5202	Y0.6086	Z-0.1865	B-38.637	C-158.152
N171	X3.5473	Y0.5635	Z-0.1827	B-38.483	C-159.890
N172	X3.5725	Y0.5177	Z-0.1791	B-38.334	C-161.506
N173	X3.5953	Y0.4721	Z-0.1759	B-38.203	C-163.224
N174	X3.6163	Y0.4262	Z-0.1730	B-38.083	C-164.915
N175	X3.6352	Y0.3797	Z-0.1703	B-37.968	C-166.458
N176	X3.6512	Y0.3341	Z-0.1678	B-37.858	C-167.945
N177	X3.6658	Y0.2871	Z-0.1655	B-37.755	C-169.619
N178	X3.6783	Y0.2387	Z-0.1636	B-37.675	C-171.473
N179	X3.6883	Y0.1920	Z-0.1621	B-37.612	C-173.187
N180	X3.6969	Y0.1415	Z-0.1610	B-37.566	C-175.136
N181	X3.7024	Y0.0912	Z-0.1605	B-37.559	C-176.970
N182	X3.7049	Y0.0498	Z-0.1601	B-37.546	C-178.012



N183 X3.7066 Y0.0098 Z-0.1596 B-37.504 C-179.281  
 N184 X3.7067 Y-0.0005 Z-0.1595 B-37.483 C-179.126  
 N185 X3.7038 Y-0.0690 Z-0.1595 B-37.472 C177.371  
 N186 X3.6968 Y-0.1384 Z-0.1609 B-37.562 C174.953  
 N187 X3.6857 Y-0.2041 Z-0.1624 B-37.608 C173.004  
 N188 X3.6692 Y-0.2747 Z-0.1648 B-37.707 C169.811  
 N189 X3.6488 Y-0.3420 Z-0.1682 B-37.870 C167.611  
 N190 X3.6239 Y-0.4079 Z-0.1718 B-38.034 C165.526  
 N191 X3.5941 Y-0.4748 Z-0.1761 B-38.208 C163.032  
 N192 X3.5608 Y-0.5397 Z-0.1810 B-38.418 C160.787  
 N193 X3.5223 Y-0.6048 Z-0.1862 B-38.626 C158.284  
 N194 X3.4859 Y-0.6617 Z-0.1920 B-38.864 C158.344  
 N195 X3.4443 Y-0.7185 Z-0.1960 B-38.743 C158.470  
 N196 X3.3936 Y-0.7798 Z-0.2005 B-38.703 C156.336  
 N197 X3.3383 Y-0.8409 Z-0.2052 B-38.628 C154.334  
 N198 X3.2846 Y-0.8958 Z-0.2100 B-38.549 C152.745  
 N199 X3.2187 Y-0.9580 Z-0.2150 B-38.466 C150.236  
 N200 X3.1524 Y-1.0144 Z-0.2209 B-38.444 C148.364  
 N201 X3.0863 Y-1.0682 Z-0.2260 B-38.299 C146.731  
 N202 X3.0106 Y-1.1237 Z-0.2322 B-38.286 C144.379  
 N203 X2.9399 Y-1.1740 Z-0.2378 B-38.171 C142.722  
 N204 X2.8547 Y-1.2286 Z-0.2441 B-38.135 C140.318  
 N205 X2.7753 Y-1.2767 Z-0.2502 B-38.035 C138.814  
 N206 X2.6886 Y-1.3255 Z-0.2564 B-37.970 C136.609  
 N207 X2.5995 Y-1.3726 Z-0.2629 B-37.929 C134.609  
 N208 X2.5070 Y-1.4180 Z-0.2693 B-37.865 C132.565  
 N209 X2.4133 Y-1.4613 Z-0.2759 B-37.830 C130.678  
 N210 X2.3142 Y-1.5035 Z-0.2822 B-37.779 C128.565  
 N211 X2.2123 Y-1.5441 Z-0.2890 B-37.814 C126.226  
 N212 X2.1149 Y-1.5807 Z-0.2951 B-37.738 C124.839  
 N213 X2.0110 Y-1.6170 Z-0.3012 B-37.700 C122.868  
 N214 X1.9027 Y-1.6520 Z-0.3072 B-37.672 C120.824  
 N215 X1.7956 Y-1.6841 Z-0.3129 B-37.631 C119.062  
 N216 X1.6843 Y-1.7149 Z-0.3184 B-37.610 C116.917  
 N217 X1.5715 Y-1.7437 Z-0.3239 B-37.601 C114.998  
 N218 X1.4597 Y-1.7699 Z-0.3288 B-37.560 C113.219  
 N219 X1.3394 Y-1.7955 Z-0.3338 B-37.570 C110.917  
 N220 X1.2211 Y-1.8178 Z-0.3383 B-37.576 C109.031  
 N221 X1.1107 Y-1.8372 Z-0.3422 B-37.544 C107.557  
 N222 X0.9871 Y-1.8565 Z-0.3459 B-37.512 C105.454  
 N223 X0.8612 Y-1.8730 Z-0.3494 B-37.540 C103.141  
 N224 X0.7450 Y-1.8866 Z-0.3524 B-37.534 C101.538  
 N225 X0.6228 Y-1.8989 Z-0.3549 B-37.516 C99.684  
 N226 X0.4963 Y-1.9090 Z-0.3570 B-37.516 C97.593  
 N227 X0.3727 Y-1.9164 Z-0.3587 B-37.521 C95.715  
 N228 X0.2503 Y-1.9219 Z-0.3598 B-37.516 C93.883  
 N229 X0.1253 Y-1.9253 Z-0.3605 B-37.511 C91.977  
 N230 X0.0005 Y-1.9267 Z-0.3608 B-37.496 C90.187  
 N231 X-0.1188 Y-1.9254 Z-0.3604 B-37.485 C88.133  
 N232 X-0.2390 Y-1.9226 Z-0.3599 B-37.499 C86.236  
 N233 X-0.3587 Y-1.9174 Z-0.3587 B-37.494 C84.601  
 N234 X-0.4800 Y-1.9100 Z-0.3572 B-37.504 C82.366  
 N235 X-0.5938 Y-1.9011 Z-0.3554 B-37.521 C80.928  
 N236 X-0.7117 Y-1.8903 Z-0.3530 B-37.513 C78.949  
 N237 X-0.8325 Y-1.8768 Z-0.3503 B-37.527 C77.091  
 N238 X-0.9448 Y-1.8620 Z-0.3471 B-37.537 C75.504  
 N239 X-1.0587 Y-1.8454 Z-0.3436 B-37.522 C73.474  
 N240 X-1.1787 Y-1.8257 Z-0.3398 B-37.533 C71.467  
 N241 X-1.2888 Y-1.8051 Z-0.3357 B-37.558 C69.707  
 N242 X-1.3958 Y-1.7835 Z-0.3314 B-37.570 C68.022  
 N243 X-1.5093 Y-1.7586 Z-0.3266 B-37.573 C66.123  
 N244 X-1.6196 Y-1.7319 Z-0.3215 B-37.579 C64.092  
 N245 X-1.7269 Y-1.7035 Z-0.3163 B-37.611 C62.287  
 N246 X-1.8323 Y-1.6733 Z-0.3109 B-37.639 C60.424  
 N247 X-1.9348 Y-1.6416 Z-0.3053 B-37.676 C58.666  
 N248 X-2.0326 Y-1.6093 Z-0.2995 B-37.686 C56.729

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N249 X-2.1356 Y-1.5734 Z-0.2936 B-37.730 C54.989
N250 X-2.2343 Y-1.5358 Z-0.2874 B-37.734 C52.765
N251 X-2.3284 Y-1.4977 Z-0.2815 B-37.793 C50.916
N252 X-2.4190 Y-1.4584 Z-0.2755 B-37.868 C49.408
N253 X-2.5099 Y-1.4166 Z-0.2692 B-37.892 C47.471
N254 X-2.5989 Y-1.3728 Z-0.2629 B-37.933 C45.517
N255 X-2.6849 Y-1.3242 Z-0.2475 B-37.933 C45.517
N256 X-2.7759 Y-1.2806 Z-0.2256 B-37.933 C45.517
N257 X-2.8702 Y-1.2429 Z-0.1977 B-37.933 C45.517
N258 X-2.9662 Y-1.2115 Z-0.1641 B-37.933 C45.517
N259 X-3.0624 Y-1.1872 Z-0.1255 B-37.933 C45.517
N260 X-3.1570 Y-1.1702 Z-0.0825 B-37.933 C45.517
N261 X-3.2484 Y-1.1609 Z-0.0359 B-37.933 C45.517
N262 X-3.3352 Y-1.1594 Z0.0136 B-37.933 C45.517
N263 X-3.4157 Y-1.1658 Z0.0650 B-37.933 C45.517
N264 X-3.4887 Y-1.1799 Z0.1176 B-37.933 C45.517
N265 X-3.5528 Y-1.2016 Z0.1704 B-37.933 C45.517
N266 X-3.6070 Y-1.2303 Z0.2225 B-37.933 C45.517
N267 X0.7037 Y0.9643 Z2.6200 B-37.933 C45.517
N268 G49 (TOOL LENGTH COMPENSATION CANCEL)
N269 G701 (DOOSAN TCP MODE CANCEL)

N270 G00 Y0.0
N271 C0.0
N272 M273 (Y-AXIS REFERENCE INTERLOCK RELEASE CANCEL)
N273 M111 (INTERFERENCE CHECK ON)
N274 G99 (UNIT PER REVOLUTION FEED)

(END PROGRAM/TOOL CHANGE PREPARATION)
N275 G00 G28 U0.0 V0.0 (ZERO RETURN X-AXIS & Y-AXIS)
N276 G00 G28 W0.0 (ZERO RETURN Z-AXIS)
N277 G00 G28 B0.0 (ZERO RETURN B-AXIS)
N278 T06000 (CANCEL OFFSET FOR CURRENT TOOL)
N279 M139 (SHOWER BED COOLANT OFF)
N280 M127 (COOLANT THROUGH TOOL OFF)
N281 M05 P12 (B-AXIS SPINDLE STOP)
N282 M34 (LEFT SPINDLE C-AXIS MODE OFF)
N283 G490 S0 (EXPLICIT SPINDLE ORIENTATION FOR TOOL CHANGE)
N284 G00 B-90.0 (EXPLICIT B-AXIS POSITIONING FOR TOOL CHANGE)
N285 M30
%
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# Servo Driven Tail Stock

```
%  
O8997 (SUB - ENGAGE SERVO DRIVEN TAILSTOCK)  
G54  
G98  
G01 A1.0 F100.0 (POSITION TAILSTOCK IN TRAVERSE MODE - THRUST OFF)  
G300 B-600.0 (ENGAGE TAILSTOCK TOWARD CHUCK WITH THRUST OF 600KGF)  
G99  
M99  
%
```

```
%  
O8998 (SUB - RETRACT SERVO DRIVEN TAILSTOCK)  
G54  
G98  
G301 (DISENGAGE THRUST)  
G01 A2.0 F100.0 (POSITION TAILSTOCK IN TRAVERSE MODE - THRUST OFF)  
G00 G28 G53 A0.0 (SEND TAILSTOCK HOME)  
G99  
M99  
%
```

# Macro-B OD Jaw Program

```
%  
O8999 (BORE JAWS - !!!DO NOT ERASE!!!)  
(***** DEFINE JAW DATA *****)  
#100=5.5 (STARTING DIA X)  
#101=6.5 (FINAL DIA X)  
#102=0.1 (DIA DEPTH PER PASS)  
#103=-3.5 (FINAL DEPTH Z)  
(*****)  
G18 G40 G80 G99  
G00 G28 U0.0 V0.0  
G00 G28 W0.0  
G54  
G00 B-90.0  
M06 T20020 (SANDVIK ID BAR LEFT HANDED - DNMG432)  
G490 S1800 (ORIENT TO LEFT HAND)  
G00 B-90.0  
G00 Z5.0  
M126  
M34  
M261  
G50 S600  
G96 S500 M04 P11  
G00 Z0.1  
G00 X[#100]  
G01 Z[#103+0.01]F0.012  
G01 X[#100-0.1]  
G00 Z0.1  
#104=[#100+#102]  
GOTO2  
N1  
#104=[#104+#102]  
N2  
IF[#104GT#101]GOTO99  
G00 X[#104-0.02]  
G01 Z[#103+0.01]F0.012  
G01 X[#104-0.15]  
G00 Z0.1  
GOTO1  
N99
```

```
G00 X[#101]
G01 Z[#103]F0.008
G01 X[#100-0.15]
G00 Z0.1
G00 X[#101]
G01 Z[#103]F0.008
G01 U0.0625 W-0.0313
G04 U1.0
G01 U-0.0625 W0.0313
G01 X[#100-0.15]
G00 Z0.1
Z1.0
X10.0
G00 Z10.0
G00 G28 U0.0 V0.0
G00 G28 W0.0
T20000
M09
M127
M05 P11
(***** CLEAR ALL JAW DATA *****)
#100=0
#101=0
#102=0
#103=0
#104=0
(*****)
M30
%
```