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Manufacturing Engineering

MANUFACTURING PART ROUTING Sheet: 1 of 8

TEAM NAME/NUMBER:	
PART :	CRANK DISK
DRAWING :	IME AIR MOTOR CRANK DISK REV B
MATERIAL:	BRASS

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS

OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD FOR COST REPORT	OPERATION TIME (min)
10	CUT STOCK TO ROUGH LENGTH, DEBURR EDGES OF STOCK & INSPECT ROUGH LENGTH CUT	SCOTCHMAN COLD SAW	SAW STOP & PNEUMATIC VISE, FILE, ROUGH LENGTH GO / NO GO GAGE	.600 ± .015 LENGTH & NO BURRS		
20	FACE SIDE #1	LEBLOND ENGINE LATHE #5 or #11	ALUMINUM SOFJAW SET & FACING TOOL	.575 ± .010 LENGTH		
30	FACE SIDE #2 & DRILL CENTER HOLE	LEBLOND ENGINE LATHE #6 or #12	ALUMINUM SOFTJAW SET, FACING TOOL & #4 SPLIT POINT DRILL BIT, & FINAL LENGTH GO / NO GO GAGE	.550 ± .005 & Ø.209 ± .005 THRU HOLE		
40	BROACH D-HOLE	PIONEER HYDRAULIC BROACH	D-SHAPE BROACH & D-HOLE GO/NO GO GAGE	.262 ± .002 D-HEIGHT & Ø.314 ± .002 THRU HOLE		
50	DRILL & REAM HOLE DOWEL PIN HOLE	HAAS CNC MINI MILL #6	CRANK DISK OP50 CNC MILL FIXTURE, 15/64" HSS JOBBER DRILL, Ø8 MM HSS REAMER, DOWEL GO / NO GO	$Ø\ .249\ ^{+.000}_{-.003}$ THRU HOLE		
60	CONTOUR MILL & CHAMFER OUTER COUNTER BALANCE PROFILE	HAAS CNC MINI MILL #5	CHICK ONE LOK VISE, CRANK DISK OP 70 SOFT JAW SET, CRANK DISK MILL FIXTURE, 1/2" 4-FLUTE CARBIDE CC END MILL, CNC PROGRAM #O00060	OUTSIDE DIAMETER Ø1.45 ± .01 PROFILE DEPTH .28 ± .01		
70	COUNTERBORE, DRILL, TAP, DEBURR, CLEAN, INSPECT, AND PLACE IN INVENTORY	HAAS CNC MINI MILL #6	CHICK ONE LOK VISE, CRANK DISK OP 70 SOFT JAW SET, LETTER F JOBBER DRILL, #7 JOBBER DRILL, & 1/4-20 SPIRAL FLUTE TAP & 1/4-20 GO / NO GO GAGE	COUNTERBORE Ø.257 ± .005 ↓ .33 ± .01 THREADED HOLE 1/4-20 UNC 2B		

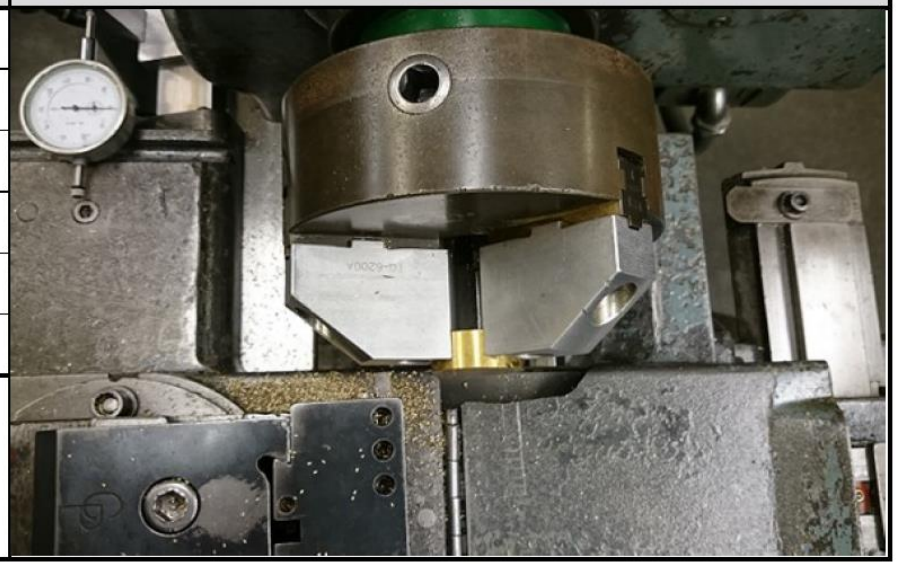
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MANUFACTURING OPERATION SETUP SHEET			Sheet: 3 of 8
OPERATOR:		MACHINE TOOL:	LEBLOND LATHE #5 or #11
PART :	CRANK DISK	DATE:	
DRAWING:	IME AIR MOTOR CRANK DISK REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	BRASS	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE THREE JAW CHUCK WITH SOFT JAWS ON THE LATHE, MAKING SURE SPINDLE NUT IS TIGHT. INSTALL THE OP#20 CRANK DISK (.575") MASTER GAGE IN THE SOFT JAW POCKET AND CLAMP THE JAWS SHUT. SET THE LATHE TO OPERATE AT A SPEED OF 480 RPM, FEED OF .0036 IN/REV, FORWARD GEAR, AND COMPOUND AT 0 PARALLEL WITH THE CROSS SLIDE. INSTALL THE FACING TOOL IN THE LEFT HAND TOOL HOLDER MAKING SURE THE TIP OF THE TOOL IS SET AT THE LATHE'S CENTERLINE OF ROTATION HEIGHT WHEN INSTALLED ON THE TOOL POST. TOUCH THE FACING TOOL OFF ON THE MASTER GAGE'S FRONT FACE AND LOCK THE SADDLE IN THIS POSITION. (*THIS STEP IS ONLY DONE DURING 1ST SETUP OR IF PRODUCING SCRAP PARTS!*) (*LOOSEN THE TOOL HOLDER AND PULL THE TOOL AWAY FROM THE WORKPIECE WHEN RETRACTING THE TOOL OFF OF THE MASTER GAGE OR WHEN THE WORKPIECE IS NOT SPINNING BETWEEN TOOL* INSTALL THE WORKPIECE IN THE SOFT JAW AND MAKE SURE IT IS FULLY SEATED AGAINST THE BACK OF THE JAW. TURN ON THE LATHE AND USE THE AUTOFEED TO FACE THE WORKPIECE. (*DO NOT MOVE CARRIAGE DURING THIS MANUFACTURING OPERATION, IT IS LOCKED DOWN!*) TURN OFF THE LATHE, LOOSEN THE TOOL POST, MOVE THE TOOL AWAY FROM THE WORKPIECE, AND RETRACT THE CROSS SLIDE SO YOU DO NOT MARK UP THE PART! REMOVE THE PART FROM THE SOFT JAWS AND CHECK THE WORKPIECE'S FINAL LENGTH OF .575 ± .010 WITH THE GO /NO-GO GAGE.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	3-Jaw Lathe Chuck	N/A
T2	Crank Disk Lathe Chuck Soft Jaw Set	N/A
T3	Crank Disk Op #20 Master Gage	N/A
T4	ACL-5 Brazed Carbide Insert Left Hand Turning Tool	480 RPM - .0036 in/rev
T5	Facing & Chamfer Tool Holder	N/A
T6	Crank Disk OP #20 Go / No-Go Gage	N/A

SETUP PICTURE



Operator Notes:

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MANUFACTURING OPERATION SETUP SHEET			Sheet: 4 of 8
OPERATOR:		MACHINE TOOL:	LEBLOND LATHE #6 or #12
PART :	CRANK DISK	DATE:	
DRAWING:	IME AIR MOTOR CRANK DISK REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	BRASS	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE THREE JAW CHUCK WITH SOFT JAWS ON THE LATHE, MAKING SURE SPINDLE NUT IS TIGHT. INSTALL THE OP#30 CRANK DISK (.550") MASTER GAGE IN THE SOFT JAW POCKET AND CLAMP THE JAWS SHUT. SET THE LATHE TO OPERATE AT A SPEED OF 480 RPM, FEED OF .0036 IN/REV, FORWARD GEAR, AND COMPOUND AT 0 PARALLEL WITH THE CROSS SLIDE. INSTALL THE FACING TOOL IN THE LEFT HAND TOOL HOLDER MAKING SURE THE TIP OF THE TOOL IS SET AT THE LATHE'S CENTERLINE OF ROTATION HEIGHT WHEN INSTALLED ON THE TOOL POST. TOUCH THE FACING TOOL OFF ON THE MASTER GAGE'S FRONT FACE AND LOCK THE SADDLE IN THIS POSITION. (*THIS STEP IS ONLY DONE DURING 1ST SETUP OR IF PRODUCING SCRAP PARTS!*) (*LOOSEN THE TOOL HOLDER AND PULL THE TOOL AWAY FROM THE WORKPIECE WHEN RETRACTING THE TOOL OFF OF THE MASTER GAGE OR WHEN THE WORKPIECE IS NOT SPINNING BETWEEN TOOL* INSTALL THE #4 HSS JOBBER DRILL IN THE DRILL CHUCK AND INSTALL THE DRILL CHUCK IN THE LATHE'S TAILSTOCK INSTALL THE WORKPIECE IN THE SOFT JAW AND MAKE SURE THE BACK FACE IS FULLY SEATED AGAINST THE BACK FACE IN THE SOFT JAW POCKET. TURN ON THE LATHE AND USE THE AUTOFEED TO FACE THE WORKPIECE. (*DO NOT MOVE CARRIAGE DURING THIS MANUFACTURING OPERATION, IT IS LOCKED DOWN!*) TURN OFF THE LATHE, LOOSEN THE TOOL POST, MOVE THE TOOL AWAY FROM THE WORKPIECE, AND RETRACT THE CROSS SLIDE ALL THE WAY BACK SO THE TAILSTOCK CAN FIT! MOVE THE TAILSTOCK FORWARD UNTIL THE TIP OF THE DRILL BIT IS APROXIMATELY .25" AWAY FROM THE FRONT OF THE WORKPIECE, AND LOCK THE TAILSTOCK IN PLACE. TURN ON THE LATHE, USE THE TAILSTOCK'S HANDWHEEL TO PECK DRILL A HOLE THRU THE WORKPIECE, RETRACT THE QUILL, AND TURN OFF THE LATHE. REPOSITION THE TAILSTOCK TO THE BACK OF THE LATHE, REMOVE THE PART FROM THE SOFT JAWS, AND CHECK THE WORKPIECE'S FINAL LENGTH OF .550 ± .010 WITH THE GO /NO-GO GAGE.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	3-Jaw Lathe Chuck	N/A
T2	Crank Disk Lathe Chuck Soft Jaw Set	N/A
T3	Crank Disk Op #30 Master Gage	N/A
T4	ACL-5 Brazed Carbide Insert Left Hand Turning Tool	480 RPM - .0036 in/rev
T5	Facing & Chamfer Tool Holder	N/A
T6	#4 HSS Jobber Drill	480-RPM & Manual Feed
T7	Drill Chuck With Morse Taper Adapter	N/A
T8	Crank Disk OP #30 Go / No-Go Gage	N/A

SETUP PICTURE



Operator Notes:

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MANUFACTURING OPERATION SETUP SHEET Sheet: 5 of 8

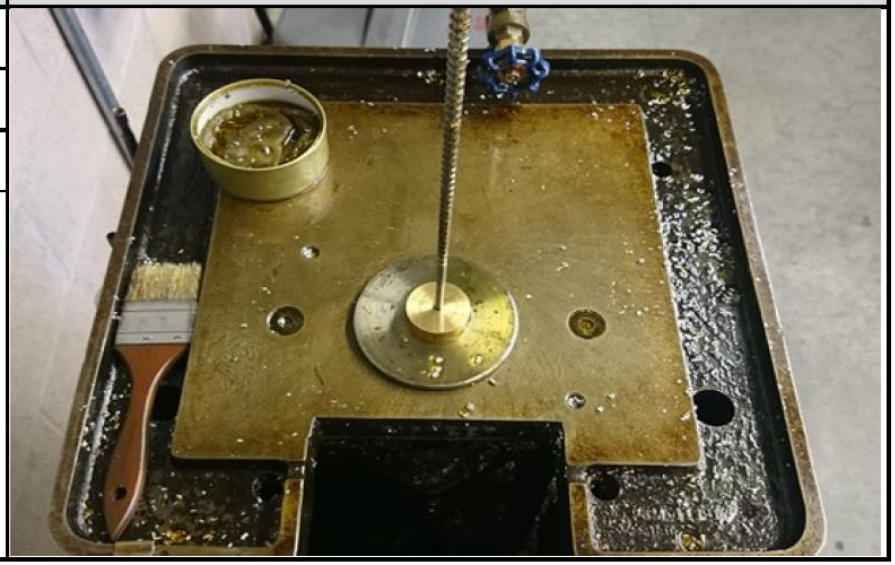
OPERATOR:		**MACHINE TOOL:**	PIONEER HYDRAULIC BROACH	
PART :	CRANK DISK	**DATE:**		
DRAWING:	IME AIR MOTOR CRANK DISK REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	BRASS	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
40	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE "PIN STYLE" BROACHING HEAD ATTACHMENT ON THE BROACH. MAKE SURE ALL CHIPS ARE REMOVED FROM THE TOP OF THE BROACH'S WORKPIECE REST BEFORE INSTALLING THE WORKPIECE ON THE REST. LAY THE WORKPIECE ON TOP OF THE REST, INSERT THE BROACH THROUGH THE HOLE IN THE WORKPIECE, AND SECURE THE BROACH IN TO THE MACHINE TOOL WITH THE PIN DIRECT THE CUTTING FLUID NOZZLE DIRECTLY ON TOP OF THE BROACH (DO NOT ADJUST THE NOZZLE'S VALVE AS YOU WILL GET COVERED IN CUTTING FLUID!). MAKE SURE THE HYDRAULIC LEVER IS SET IN THE UP POSITION, TURN ON THE BROACH AND TURN ON THE CUTTING FLUID PUMP. ONCE THE CUTTING FLUID IS FLOWING OVER THE BROACH, PULL THE LEVER ON THE BROACH DOWN TO ACTIVATE THE HYDRAULIC RAM AND BROACH THE D-SHAPE FEATURE IN THE WORKPIECE. TURN OFF THE CUTTING FLUID, THE MACHINE, AND REMOVE THE WORKPIECE FROM THE BROACH'S REST USING A BLUE RAG. RETURN THE LEVER ON THE BROACH TO THE UPRIGHT POSITION, PULL THE PIN TO RELEASE THE BROACH, REMOVE THE BROACH FROM THE MACHINE, AND CLEAN THE CHIPS FROM THE BROACH. INSPECT THE D-SHAPED HOLE USING THE D-SHAPED GO / NO-GO GAGE.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	D-Shaped Broach	N/A
T2	Blue Rags	N/A
T3	Crank Disk D-Shape Go / No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET Sheet: 6 of 8

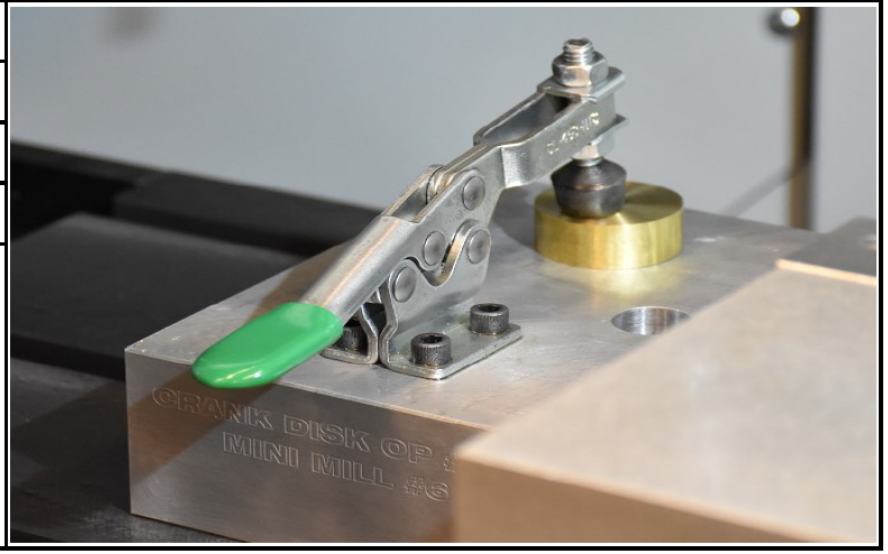
OPERATOR:		**MACHINE TOOL:**	HAAS MINI MILL #6	
PART :	CRANK DISK	**DATE:**		
DRAWING:	IME AIR MOTOR CRANK DISK REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	BRASS	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
50	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE CYLINDER OP50 FIXTURE ON THE MILL'S TABLE AND USE A TEST INDICATOR TO MAKE SURE THE FIXTURE IS ALIGNED PARALLEL TO THE MACHINE'S X-AXIS. LOAD CNC PROGRAM #O00050 (CRANK DISK OP50) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE TOP SURFACE OF THE FIXTURE. SET THE X-ZERO & Y-ZERO LOCATION (G58) IN THE CENTER OF THE CRANK DISK. USING THE AIR NOZZLE, BLOW THE CHIPS OUT OF THE SOFT JAW EVERY TIME A PART IS LOADED & UNLOADED OFF OF THE D-SHAPED PROTRUSION. LOAD THE WORKPIECE ON THE D-SHAPED PIN IN THE FIXTURE AND CLAMP THE CARR-LANE TOGGLE CLAMP TO SECURE THE WORKPIECE TO THE FIXTURE. MAKE SURE WORKPIECE IS LOCATED IN THE FIXTURE CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00050 (CYLINDER OP50). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE FIXTURE, BLOW OFF THE WORKPIECE INSIDE THE ENCLOSURE, AND REMOVE IT FROM THE MACHINING CENTER. INSPECT THE FINISH REAMED THRU HOLE SIZE OF $\varnothing .249\ ^{+.000}_{-.003}$

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Crank Disk OP50 CNC Mill Fixture	N/A
T2	15/64 HSS Jobber Drill (CNC Program = T1 = H21)	4074-RPM & 16-IPM
T3	.2485 Reamer Straight Flute HSS (CNC Program = T2 = H22)	1528-RPM & 9-IPM
T4	Crank Disk Dowel Pin Go / No-Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET Sheet: 7 of 8

OPERATOR:		**MACHINE TOOL:**	HAAS MINI MILL #5	
PART :	CRANK DISK	**DATE:**		
DRAWING:	IME AIR MOTOR CRANK DISK REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	BRASS	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
60	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE CYLINDER OP60 CHICK VISE SOFT JAW SET AND USE A TEST INDICATOR TO MAKE SURE THE JAW IS ALIGNED PARALLEL TO THE MACHINE'S X-AXIS. LOAD THE CRANK DISK OP60 4-POSITION FIXTURE INTO THE SOFT JAW SET. LOAD CNC PROGRAM #O00060 (CRANK DISK OP60) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE CRANK DISK OP 60 FIXTURE'S TOP CIRCULAR PART LOCATING SURFACE. SET THE X-ZERO LOCATION (G58) ON THE LEFT EDGE OF THE FIXTURE AND SET THE Y-ZERO LOCATION ON THE FRONT EDGE OF THE FIXTURE. USING THE AIR NOZZLE, BLOW THE CHIPS OFF OF THE FIXTURE EVERY TIME PARTS ARE LOADED & UNLOADED OFF OF THE D-SHAPED PINS. INSTALL THE D-SHAPED PINS IN THE WORKPIECES, INSTALL THE D-PINS AND WORKPIECES ON THE FIXTURE, USE THE ALLEN WRENCH TO TIGHTEN THE CAP SCREWS AND CLAMP THE WORKPIECES. MAKE SURE THE WORKPIECES ARE TIGHTENED DOWN TO THE FIXTURE VERY TIGHT AND ARE NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00060 (CYLINDER OP60). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNSCREW THE WORKPIECES FROM THE FIXTURE, BLOW OFF THE WORKPIECES INSIDE THE ENCLOSURE, AND REMOVE THEM FROM THE MACHINING CENTER. INSPECT THE MACHINED FINISH ON THE MILLED CONTOURS, THE FINISHED CRANK DISK OUTSIDE Ø1.45 ± .01, AND PROFILE DEPTH OF .28 ± .01

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Chick One Lok Mill Vise & Crank Disk OP60 Soft Jaw Set	N/A
T2	Crank Disk 4-Position Fixture & Allen Wrench 3/16	N/A
T3	1/2" 4-Flute Carbide End Mill (CNC Program = T2 = H22)	3438-RPM & 22-IPM
T4	Rotary Hole Deburring Tool	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET Sheet: 8 of 8

OPERATOR:		**MACHINE TOOL:**	HAAS MINI MILL #6	
PART :	CRANK DISK	**DATE:**		
DRAWING:	IME AIR MOTOR CRANK DISK REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	BRASS	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
70	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE CYLINDER OP70 CHICK VISE SOFT JAW SET AND USE A TEST INDICATOR TO MAKE SURE THE JAW IS ALIGNED PARALLEL TO THE MACHINE'S X-AXIS. LOAD CNC PROGRAM #O00070 (CRANK DISK OP70) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE TOP SURFACE OF THE SETUP CRANK DISK MASTER GAGE. SET THE X-ZERO LOCATION (G58) IN THE CENTER OF THE CRANK DISK (3.000" FROM EDGE OF SOFT JAW) AND SET THE Y-ZERO LOCATION ON THE FRONT EDGE OF THE FIXED SOFT JAW. USING THE AIR NOZZLE, BLOW THE CHIPS OUT OF THE SOFT JAW EVERY TIME A PART IS LOADED & UNLOADED OFF OF THE D-SHAPED PROTRUSION. LOAD THE WORKPIECE ON THE D-SHAPED PIN IN THE SOFT JAW WITH THE UN MILLED SURFACE FACING THE FIXED JAW AND TIGHTEN THE MILLING VISE TO APPROXIMATELY 10 FT-LBS OF TORQUE. MAKE SURE WORKPIECE IS LOCATED IN SOFT JAW CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00070 (CYLINDER OP70). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE SOFT JAW, BLOW OFF THE WORKPIECE INSIDE THE ENCLOSURE, AND REMOVE IT FROM THE MACHINING CENTER. INSPECT THE FINISH CLEARANCE HOLE Ø.257 ± .005 AT A DEPTH OF .33 ± .01 AND THE 1/4-20 UNC 2B HOLE WAS TAPPED CORRECTLY WITH THE 1/4-20 UNC 2B GO / NO-GO GAGE USE THE SMALL FILE TO DEBURR THE FLAT INSIDE THE D-SHAPED HOLE AND USE THE D-SHAPE GO-NO-GO GAGE TO INSURE THE FLAT HAS BEEN FULLY DEBURRED! WASH THE CYLINDER IN SIMPLE GREEN, RINSE IN WARM WATER, DEBURR WITH ROTARY DEBURRING TOOL, AND SEND TO INSPECTION.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Chick One Lok Mill Vise & Crank Disk OP70 Soft Jaw Set	N/A
T2	F HSS Jobber Drill (CNC Program = T8 = H8)	N/A
T3	#7 HSS Jobber Drill (CNC Program = T7 = H7)	N/A
T4	1/4-20 UNC 2B Spiral Flute CNC Tap	200 RPM & 10-IPM
T5	Small File	N/A
T6	1/4-20 UNC 2B Go / No-Go Thread Gage	N/A
T7	D-Shape Go / No-Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING PART ROUTING Sheet: 1 of 5

TEAM NAME/NUMBER:	
PART :	CYLINDER
DRAWING :	IME AIR MOTOR CYLINDER REV B
MATERIAL:	A356 ALUMINUM

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS
OPERATIONS #20 & #30 ARE PARALLEL OPERATIONS THAT CAN BE PERFORMED IN EITHER ORDER

OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD	OPERATION TIME (min)
10	FACE BOTTOM SURFACE, TURN OUTSIDE DIAMETER, CHAMFER OUTSIDE DIAMETER , CENTER DRILL, DRILL, AND REAM PISTON HOLE	HAAS ST-10 CNC LATHE	FILE OR BELT SANDER, CYLINDER LATHE FIXTURE, GO NO/GO LENGTH GAGE, CNMG 432B OD TURN / FACE CARBIDE INSERT TOOL , #8 CENTER DRILL, 47/64 THROUGH SPINDLE COOLANT DRILL, .750" HSS REAMER, CYLINDER BORE GO / NO GO GAGE	NO CASTING FLASH OR BURRS CYLINDER OD Ø1.05 ± .01 CYLINDER BORE Ø.750 ± .002 CYLINDER OD CHAMFER .05 x 45°		
20	FACE MILL TOP, CONTOUR MILL TOP OD, CHAMFER TOP OD, ENGRAVE CP LOGO	HAAS CNC MINI MILL #2	COLLET HOLDER, Ø1-3/64" COLLET, 1/2"4-FLUTE CARBIDE END MILL, 1/2" 45° CHAMFER TOOL, HEIGHT GO / NO GO GAGE	TOP OD Ø1.40 ± .01 DEPTH .38 ± .01 OD CHAMFER .05 x 45°		
30	FACE MILL VALVE FACE, POCKET MILL CYLINDER EXHAUST PORT, CENTER DRILL HOLES, DRILL AIR PORT HOLE, DRILL & TAP 1/4-20 THREAD, CONTOUR MILL FRONT ENGRAVING POCKET, ENGRAVE CAL POLY LOGO	HAAS 4-AXIS CNC MINI MILL	4TH AXIS CNC ROTARY WITH 3 JAW CHUCK AND FIXTURE STOP, 3/8" 3-FLUTE CARBIDE END MILL, #3 CENTER DRILL, 1/4" STUB DRILL, #7 STUB DRILL, 1/4-20 CNC SPIRAL FLUTE TAP, SPLIT POINT ENGRAVING TOOL, AIR PORT GO / NO GO GAGE, 1/4-20 GO / NO GO PLUG GAGE	CLEAN VALVE FACE SURFACE AIR PORT HOLE THRU TO CYLINDER BORE 1/4-20 THREAD CLEAN POCKET MILLED LOGO		
40	MILL SLOT FOR PISTON DOWEL PIN, DEBURR, CLEAN INSPECT, & PLACE IN INVENTORY	HAAS CNC MINI MILL #3	3/8" 3-FLUTE CARBIDE END MILL, EDGE FINDER, CHICK VISE, OP40 SOFT JAW SET, ROTARY DEBURRING TOOL, 3/4" REAMER	SLOT WIDTH .375 ± .005 SLOT LENGTH 1.438 ± .005		

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MANUFACTURING OPERATION SETUP SHEET				Sheet: 2 of 5
OPERATOR:		MACHINE TOOL:	HAAS ST 10 CNC LATHE	
PART :	CYLINDER	DATE:		
DRAWING:	IME AIR MOTOR CYLINDER REV B	QTY MACHINED:		QTY SCRAPED:
MATERIAL:	A-356	MGR APPROVAL:		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
10	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE CYLINDER FIXTURE ON THE LATHE'S SPINDLE AND MAKE SURE IT IS CONCENTRIC WITH THE MACHINE'S AXES. TOOL Z-VALUES ARE TOUCHED ON THE FRONT FACE OF THE FIXTURE & SHIFTED TO THE FRONT FACE OF THE PART USING G54 WHILE X ZERO IS LOCATED ON THE CENTERLINE OF ROTATION TOUCH ALL TOOL Z-ZERO POINTS ON THE FRONT FACE OF THE FIXTURE, USE THE PROBE TO FIND X-CENTERLINE FOR TURNING TOOL, AND USE CENTERLINE OFFSET VALUE FOR DRILLS & REAMERS INSTALL THE SETUP MASTER GAGE IN THE FIXTURE, USE TOOL #1 TO SET THE G54 Z-OFFSET ON THE FRONT FACE OF THE MASTER GAGE. (THIS SHOULD BE A POSITIVE VALUE!) INSTALL THE WORKPIECE IN THE FIXTURE AND USE THE FIXTURE STICK-OUT GAGE TO MAKE SURE THE WORKPIECE IS FULLY SEATED IN THE FIXTURE BEFORE TIGHTENING. CLAMP THE WORKPIECE IN THE FIXTURE BY TIGHTENING THE SET SCREWS USING THE 1/4" T-HANDLE ALLEN WRENCH. (DO NOT FULLY TIGHTEN YET!) USE THE TORQUE WRENCH TO TORQUE THE SET SCREWS TO 125-inlb, MAKING SURE YOU DOUBLE TORQUE THE WORKPIECE IN THE FIXTURE. DOUBLE CHECK THE STICKOUT LENGTH WITH THE LAB INSTRUCTOR BEFORE RUNNING THE PROGRAM ON EVERY SINGLE PART! RUN CNC PROGRAM #O00010 CYLINDER OP10. BLOW OFF THE WORKPIECE USING THE AIR NOZZLE BEFORE UNCLAMPING AND REMOVING IT FROM THE FIXTURE. INSPECT THE CYLINDER'S OD OF Ø1.05 ± .01 AND A .05 x 45° CHAMFER USING A CALIPER ON THE FIRST ARTICLE PART. INSPECT THE CYLINDER BORE FOR AN ID OF Ø.750 ± .002 USING THE GO / NO-GO GAGE ON EVERY PART.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Cylinder Lathe Fixture	N/A
T3	1/4" Allen Socket, T Handle, & Torque Wrench	125-inlb
T4	Cylinder Fixture Stick-Out Gage	N/A
T5	CNMG 432B RH OD Turn & Face Tool	1200-ft/min & .007-in/rev
T6	#8 Center Drill	1000 RPM & .004 in/rev
T7	47/64 Carbide Tip Thru Spindle Coolant Drill	1400 RPM & .010 in/rev
T7	.750" HSS Spiral Flute Reamer	1600 RPM & .010 in/rev
T8	Cylinder Bore Go / No-Go Gage	N/A

SETUP PICTURE



Operator Notes:

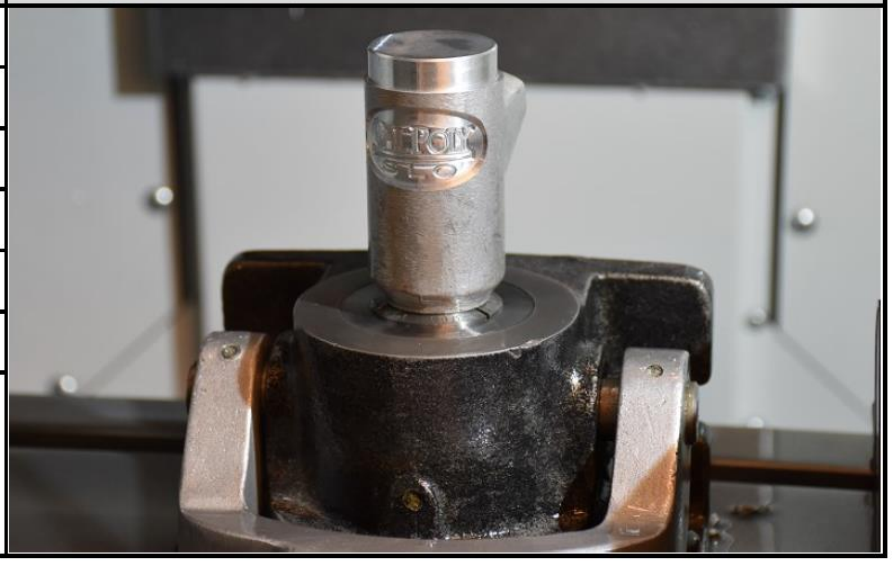
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MANUFACTURING OPERATION SETUP SHEET			Sheet: 2 of 5
OPERATOR:		MACHINE TOOL:	HAAS MINI MILL #2
PART :	CYLINDER	DATE:	
DRAWING:	IME AIR MOTOR CYLINDER REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	A-356	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE 5C COLLET HOLDER ON THE MILL'S TABLE, INDICATE THE COLLET HOLDER PARALLEL TO THE MACHINE'S X-AXIS, AND INSTALL THE 1-3/64" 5C COLLET IN THE COLLET HOLDER LOAD CNC PROGRAM #O00020 (CYLINDER OP#20) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. INSTALL THE CYLINDER OP20 MASTER SETUP GAGE IN THE 5C COLLET AND SET THE Z ZERO HEIGHT (G58) ON THE TOP SURFACE OF THE MASTER GAGE. SET THE X-ZERO AND Y-ZERO LOCATIONS (G58) IN THE CENTER OF THE MASTER SETUP GAGE'S OUTSIDE DIAMETER. USING THE AIR NOZZLE, BLOW THE CHIPS OFF OF THE THE FIXTURE EVERY TIME A PART IS LOADED AND UNLOADED. LOAD THE WORKPIECE IN THE COLLET UNTIL IT BOTTOMS OUT, CHECK THE STICKOUT HEIGHT WITH THE OP20 HEIGHT GO / NO-GO GAGE, AND CLAMP THE PART IN THE COLLET. MAKE SURE WORKPIECE IS ORIENTED IN COLLET CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00020 (CYLINDER OP20). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE COLLET, BLOW OFF THE WORKPIECE INSIDE THE MACHINE BEFORE REMOVING IT FROM THE MACHINING CENTER. INSPECT THE TOP FACE MILLED SURFACE'S FINISH, THE **FINISH MILLED CONTOUR DIAMETER Ø1.40 ± .01 AT A DEPTH OF .38 ± .01 AND A .05 x 45° CHAMFER**.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	5C Collet Holder with 1-3/64" 5C Collet	N/A
T2	Cylinder OP20 Master Setup Gage	N/A
T3	2.0" 4-Flute Carbide Insert Face Mill (CNC Program = T1 = H1)	6000-RPM & 24-IPM
T4	1/2" 4-Flute Carbide End Mill (CNC Program = T2 = H22)	5730-RPM & 36-IPM
T5	5/8" 2-Flute HSS 90° Spot Drill (CNC Program = T5 = H5)	3056-RPM & 18-IPM
T6	Operation Height Go / No-Go Gage	N/A

SETUP PICTURE

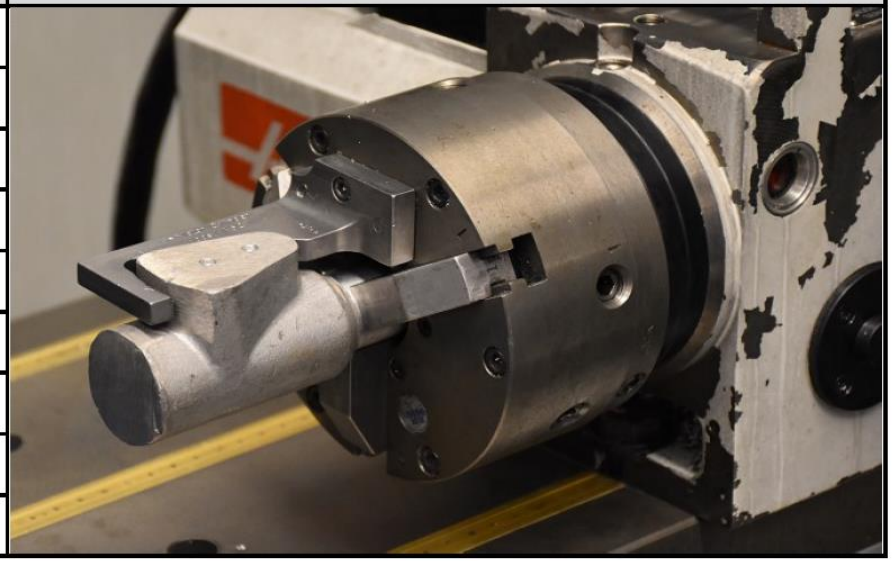


Operation Notes:

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MANUFACTURING OPERATION SETUP SHEET			Sheet: 2 of 5
OPERATOR:		MACHINE TOOL:	HAAS 4-AXIS MINI MILL
PART :	CYLINDER	DATE:	
DRAWING:	IME AIR MOTOR CYLINDER REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	A-356	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE 4TH-AXIS ROTARTY TABLE ON THE HAAS MILL TABLE, INDICATE THE ROTARY TABLE PARALLEL TO THE MACHINE'S Y AXIS, AND INSTALL THE 3-JAW CHUCK WITH STOP AND SOFT JAWS. LOAD CNC PROGRAM #O00811 (CYLINDER 4-AXIS) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 4.0" GAGE HEIGHT (CENTER LINE OF ROTARY AXIS) ABOVE THE MACHINE'S TABLE USING THE 4" TOOL SETTING GAGE. INSTALL THE CYLINDER OP20 MASTER SETUP GAGE IN THE 5C COLLET AND SET THE Z ZERO HEIGHT (G56) AT THE CENTERLINE OF THE ROTARY'S AXIS. SET THE X-ZERO AT THE FRONT FACE OF THE MASTER SETUP GAGE AND THE Y-ZERO LOCATION (G56) AT THE CENTERLINE OF THE ROTARY AXIS. USING THE AIR NOZZLE, BLOW THE CHIPS OFF OF THE THE WORKPIECE AND JAWS EVERY TIME A PART IS LOADED AND UNLOADED. LOAD THE WORKPIECE IN THE 3-JAW CHUCK, LOCATING IT ON THE FIXTURE STOP'S LEFT EDGE AND AGAINST THE BACK EDGE OF THE FIXTURE STOP, AND SNUG THE PART WITH THE CHUCK KEY USE BOTH HANDS ON THE CHUCK KEY TO TIGHTEN THE WORKPIECE IN THE CHUCK (*FAILURE TO DO SO WILL RESULT IN THE PART ROTATING IN THE CHUCK WHEN MACHINING!*). MAKE SURE WORKPIECE IS 4TH AXIS ROTARY CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00811 (CYLINDER 4-AXIS). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE CHUCK, BLOW OFF THE WORKPIECE INSIDE THE MACHINE BEFORE REMOVING IT FROM THE MACHINING CENTER. INSPECT THE TOP VALVE FACE, 4-AXIS MILLED CAL POLY ENGRAVING ON THE FRONT FACE, AND MILLED POCKET'S SURFACE FINISHES. INSPECT THE AIR PORT HOLE AND THREADED HOLE USING THE GO / NO-GO GAGES.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS	SETUP PICTURE
T1	3-Jaw Chuck & Cylinder OP30 Locating Fixture With Soft Jaw Set	N/A	
T2	Cylinder OP30 Master Setup Gage	N/A	
T3	3/8 3-Flute Carbide End Mill (CNC Program = T1 = H1)	6000-RPM & 36-IPM	
T4	#3 Center Drill (CNC Program = T6 = H6)	5500-RPM & 15-IPM	
T5	#1 HSS Jobber Drill (CNC Program = T2 = H2)	5500-RPM & 18-IPM	
T6	1/4-20 UNC Roll Form Tap (CNC Program = T3 = H3)	1360-RPM & 68-IPM	
T7	.605 Flat Insert Mill (CNC Program = T4 = H4)	6000-RPM & 22.5-IPM	
T8	.125 Conical Split Point Carbide Engraving Tool (CNC Program = T5 = H5)	4000-RPM & 40-IPM	
T9	Cylinde Air Port Go / No-Go Gage & Cylinder Thread Plug Gage	N/A	

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MANUFACTURING OPERATION SETUP SHEET — Sheet: 2 of 5

OPERATOR:		**MACHINE TOOL:**	HAAS CNC MILL #3
PART :	CYLINDER	**DATE:**	
DRAWING:	IME AIR MOTOR CYLINDER REV B	**QTY MACHINED:**	**QTY SCRAPED:**
MATERIAL:	A-356	**MGR APPROVAL:**	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
40	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE CYLINDER OP40 CHICK VISE SOFT JAW SET AND USE A TEST INDICATOR TO MAKE SURE THE JAW IS ALIGNED PARALLEL TO THE MACHINE'S X-AXIS. LOAD CNC PROGRAM #O00040 (CYLINDER OP40) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE BOTTOM SURFACE OF THE CHICK VISE JAW PLATE. SET THE X-ZERO LOCATION (G58) ON THE LEFT SIDE OF DOWEL PIN IN THE SOFT JAW AND THE Y-ZERO LOCATION IN THE CENTER OF THE CASTING. USING THE AIR NOZZLE, BLOW THE CHIPS OUT OF THE SOFT JAW EVERY TIME A PART IS LOADED & UNLOADED. LOAD THE WORKPIECE AGAINST THE PIN IN THE SOFT JAW AND TIGHTEN THE MILLING VISE TO APPROXIMATELY 10 FT-LBS OF TORQUE. MAKE SURE WORKPIECE IS LOCATED IN SOFT JAW CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00040 (CYLINDER OP40). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE SOFT JAW, BLOW OFF THE WORKPIECE INSIDE THE ENCLOSURE, AND REMOVE IT FROM THE MACHINING CENTER. INSPECT THE MILLED SLOT AND CHAMFER MAKING SURE THE MILLED SURFACES HAVE A GOOD SURFACE FINISH AND **FINISHED SLOT WIDTH OF .375 ± .005 AND LENGTH OF 1.438 ± .005.** USE THE Ø.750 REAMER TO HAND REAM THE INSIDE OF THE CYLINDER IN ORDER TO DEBURR CNC OP30 AND OP40 DRILLING AND SLOTTING OPERATIONS. WASH THE CYLINDER IN SIMPLE GREEN, RINSE IN WARM WATER, DEBURR WITH ROTARY DEBURRING TOOL, AND SEND TO INSPECTION.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Chick One Lok Milling Vise & Cylinder OP40 Soft Jaw Set	N/A
T2	3/8 3-Flute Carbide End Mill (CNC Program = T3 = H23)	N/A
T3	5/8" 2-Flute HSS 90° Spot Drill (CNC Program = T5 = H5)	N/A
T4	3/4" HSS Reamer	N/A
T5	Rotary Deburring Tool	N/A

SETUP PICTURE



Operator Notes:

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MANUFACTURING PART ROUTING Sheet: 1 of 5

TEAM NAME/NUMBER:	
PART :	FLYWHEEL
DRAWING :	IME AIR MOTOR FLYWHEEL
MATERIAL:	ZA-8 ZINC

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS

OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD FOR COST REPORT	OPERATION TIME (min)
10	DEBURR CASTING FLASH & REAM CENTER HOLE	MANUAL DRILL PRESS #1	ROTARY DEBURRING TOOL, FILE, FLYWHEEL DRILL FIXTURE, .3115 HSS REAMER FLYWHEEL CENTER HOLE GO / NO GO GAGE	NO BURRS & CENTER HOLE Ø .3115 $^{+.0000}_{-.0005}$		
20	TURN OUTSIDE DIAMETER	ENGINE LATHE #2 & #7	ROTARY DEBURRING TOOL, FLYWHEEL 4 JAW CHUCK FIXTURE, 4-JAW CHUCK, 1/8" ALLEN WRENCH, TURNING TOOL. FLYWHEEL FINISH OD GO / NO GO GAGE	OUTSIDE DIAMETER Ø2.65 ± .01		
30	FACE RIM WITH HUB, CHAMFER OUTSIDE DIAMETER, & DEBURR HUB HOLE	ENGINE LATHE #3 & #8	FLYWHEEL 4 JAW CHUCK FIXTURE, 4-JAW CHUCK, 1/8" ALLEN WRENCH, FACING TOOL , 45° CHAMFER TOOL, ROTARY DEBURRING TOOL	PART LENGTH .95 ± .01 CHAMFER .03 X 45°		
40	FACE RIM ONLY, CHAMFER OUTSIDE DIAMETER, DEBURR, WASH, INSPECT, & PLACE IN INVENTORY	ENGINE LATHE #4 & #9	FLYWHEEL 4 JAW CHUCK FIXTURE, 4-JAW CHUCK, SKIL TWIST ELECTRIC SCREWDRIVER WITH 1/8" HEX DRIVE BIT, FACING TOOL , 45° CHAMFER TOOL, ROTARY DEBURRING TOOL	PART LENGTH .90 ± .01 CHAMFER .03 X 45°		

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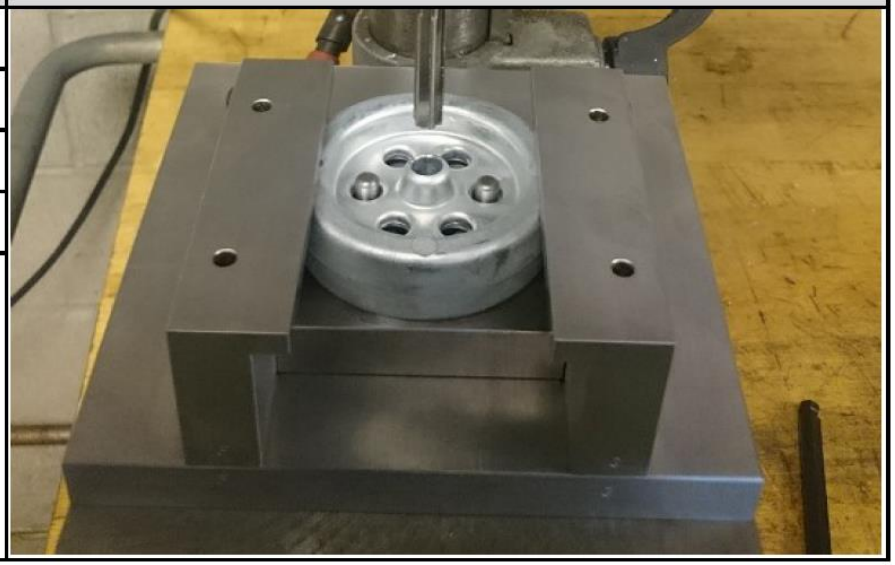
MANUFACTURING OPERATION SETUP SHEET				Sheet: 2 of 5
OPERATOR:		MACHINE TOOL:	DRILL PRESS #1	
PART :	FLYWHEEL	DATE:		
DRAWING:	IME AIR MOTOR FLYWHEEL REV B	QTY MACHINED:		QTY SCRAPED:
MATERIAL:	ZA-8 ZINC	MGR APPROVAL:		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
10	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE FLYWHEEL DRILL PRESS FIXTURE ALONG WITH THE REAMER ON THE DRILL PRESS MAKING SURE THE QUILL HEIGHT IS SET TO RETRACT ABOVE AND REAM THRU THE WORKPIECE. REMOVE FLASH FROM PARTING LINE, EJECTOR PIN MARKS, SPOKE, & SHAFT HOLES WITH ROTARY DEBURRING TOOL. (*IF THE WORKPIECE IS NOT DEBURRED IT WILL NOT FIT INTO THE FIXTURE!*) PLACE THE WORKPIECE ON THE MOVABLE FIXTURE PLATE WITH THE EJECTOR PIN MARKS FACING UPWARDS AND THE SPOKE HOLES ALINGED WITH THE DOWEL PINS. SLIDE THE FIXTURE PLATE INTO THE MAIN FIXTURE ON THE DRILL PRESS AND CONCENTRICALLY ALIGN THE HOLE IN THE WORKPIECE UP WITH THE REAMER. *(MAKE SURE THE FIXTURE AND WORKPIECE ARE WIPED CLEAN OF ALL CHIPS & DEBRIS BEFORE & AFTER EACH REAMING OPERATION OR THE HOLE MAY BE REAMED OVERSIZE!)* VERIFY THE DRILL PRESS IS SET TO 840 RPM, TURN ON THE DRILL PRESS. USE ONE HAND TO ALIGN THE WORKPIECE UP WITH THE REAMER AND THE OTHER HAND ON THE QUILL LEVER TO FEED THE REAMER SLOWLY THRU THE WORKPIECE. BACK THE REAMER OUT, TURN OFF THE DRILL PRESS, AND USE THE FLYWHEEL HOLE GO / NO GO GAGE TO DETERMINE IF THE PART MEASURES WITHIN THE **FINAL DIAMETER OF** **Ø .3115** $^{+.0000}_{-.0005}$

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Flywheel Drill Press Fixture (2 pc)	N/A
T2	.3115 HSS Straight Flute Reamer	840 RPM - Manual Feed
T3	Rotary Deburring Tool	N/A
T4	Flywheel Hole Go / No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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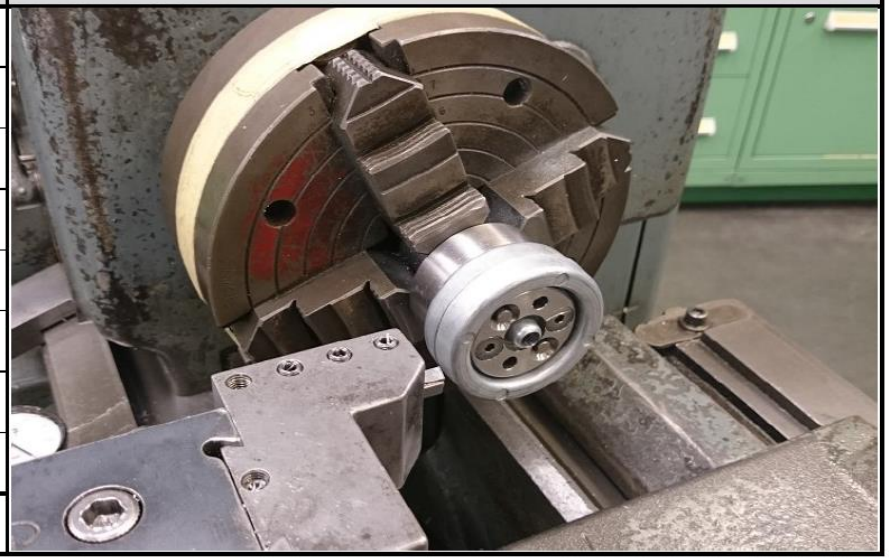
MANUFACTURING OPERATION SETUP SHEET — Sheet: 3 of 5

OPERATOR:		**MACHINE TOOL:**	ENGINE LATHE #2 or #7
PART :	FLYWHEEL	**DATE:**	
DRAWING:	IME AIR MOTOR FLYWHEEL REV B	**QTY MACHINED:**	**QTY SCRAPED:**
MATERIAL:	ZA-8 ZINC	**MGR APPROVAL:**	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE FOUR JAW CHUCK ON THE LATHE, MAKING SURE SPINDLE NUT IS TIGHT. INDICATE THE FIXTURE CONCENTRIC WITH THE 4-JAW CHUCK AND PLACE MASKING TAPE OVER THE CHUCK SO THE FIXTURE CANNOT BE ADJUSTED BY THE OPERATOR DURING PRODUCTION. INSTALL THE OP#20 MASTER GAGE ON THE FIXTURE AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. SET THE LATHE TO OPERATE AT A SPEED OF 360 RPM, FEED OF .008 IN/REV, FORWARD GEAR, AND COMPOUND AT 0 PARALLEL WITH THE CROSS SLIDE. INSTALL THE TURNING TOOL IN THE RIGHT HAND TOOL HOLDER MAKING SURE THE TIP OF THE TOOL IS SET AT THE LATHE'S CENTERLINE OF ROTATION HEIGHT WHEN INSTALLED ON THE TOOL POST. ZERO OUT THE CROSS SLIDE ON THE MASTER GAGE'S OD. (*THIS STEP IS ONLY DONE DURING 1ST SETUP OR IF PROCESS IS PRODUCING SCRAP PARTS!*) INSTALL THE WORKPIECE ON THE FIXTURE WITH THE EJECTOR PIN MARKS POINTING OUTWARDS AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. TURN ON THE LATHE, POSITION THE CUTTING TOOL TO MAKE A 0.035" ROUGING DEPTH OF CUT (*70 ON THE CROSS SLIDE!*) AND USE THE AUTOFEED TO ROUGH TURN THE WORKPIECE'S OD. RE-POSITION THE CUTTING TOOL TO MAKE A 0.015" FINISH DEPTH OF CUT (*100 ON THE CROSS SLIDE!*) AND USE THE AUTOFEED TO FINISH TURN THE WORKPIECE'S OD. REMOVE THE PART FROM THE FIXTURE USING THE 1/8" ALLEN WRENCH AND USE THE FLYWHEEL OD GO / NO GO GAGE TO INSPECT THE WORKPIECE'S **FINAL OUTSIDE DIAMETER OF Ø2.65 ± .01.**

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	4-Jaw Lathe Chuck	N/A
T2	Flywheel Lathe Chuck Fixture	N/A
T3	Flywheel OP #20 Master Gage	N/A
T4	ACR-5 Brazed Carbide Insert Right Hand Turning Tool	320 RPM - .008 in/rev
T5	Turning Tool Holder	N/A
T6	3/16" Allen Wrench	N/A
T7	Rotary Deburring Tool	N/A
T8	Flywheel OD Go / No Go Gage	N/A

SETUP PICTURE



Operator Notes:

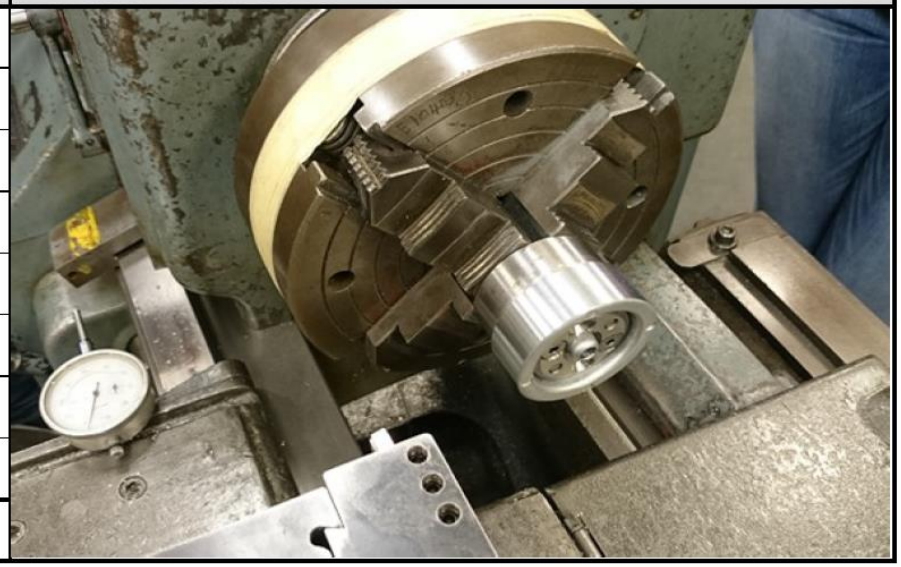
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MANUFACTURING OPERATION SETUP SHEET			Sheet: 4 of 5
OPERATOR:		MACHINE TOOL:	ENGINE LATHE #3 or #8
PART :	FLYWHEEL	DATE:	
DRAWING:	IME AIR MOTOR FLYWHEEL REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	ZA-8 ZINC	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INDICATE THE FIXTURE CONCENTRIC WITH THE 4-JAW CHUCK AND PLACE MASKING TAPE OVER THE CHUCK SO THE FIXTURE CANNOT BE ADJUSTED BY THE OPERATOR DURING PRODUCTION. INSTALL THE OP#30 MASTER GAGE ON THE FIXTURE AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. SET THE LATHE TO OPERATE AT A SPEED OF 360 RPM, FEED OF .008 IN/REV, REVERSE GEAR, AND COMPOUND AT 0 PARALLEL WITH THE CROSS SLIDE. INSTALL THE FACING & CHAMFER TOOLS IN THE LEFT HAND TOOL HOLDER, MAKING SURE THE TIP OF EACH TOOL IS SET AT THE LATHE'S CENTERLINE HEIGHT WHEN INSTALLED ON THE TOOL POST. TOUCH THE FACING TOOL OFF ON THE MASTER GAGE'S FRONT FACE AND LOCK THE SADDLE IN THIS POSITION. (*THIS STEP IS ONLY DONE DURING 1ST SETUP OR IF PRODUCING SCRAP PARTS!*) (*LOOSEN THE TOOL HOLDER AND PULL THE TOOL AWAY FROM THE WORKPIECE WHEN RETRACTING THE TOOL OFF OF THE MASTER GAGE OR WHEN THE WORKPIECE IS NOT SPINNING BETWEEN TOOL* WITH THE SADDLE LOCKED IN PLACE, INSTALL THE CHAMFER TOOL SO THE MIDDLE OF THE CUTTING EDGE LINES UP WITH THE EDGE OF THE MASTER GAGE AND ZERO COMPOUND SLIDE DIAL. INSTALL THE WORKPIECE ON THE FIXTURE WITH THE EJECTOR PIN MARKS POINTING OUTWARDS AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. TURN ON THE LATHE AND USE THE AUTOFEED TO FACE THE WORKPIECE'S RIM AND HUB. (*DO NOT MOVE CARRIAGE DURING THIS MANUFACTURING OPERATION, IT IS LOCKED DOWN!*) TURN OFF THE LATHE, LOOSEN THE TOOL POST, MOVE THE TOOL AWAY FROM THE WORKPIECE, RETRACT THE CROSS SLIDE, AND INSTALL THE CHAMFER TOOL. TURN ON THE LATHE, POSITION THE CHAMFER TOOL ON THE WORKPIECE'S EDGE USING THE CROSS SLIDE, USE THE COMPOUND SLIDE TO CHAMFER THE WORKPIECE (*60 ON COMPOUND DIAL!*). RETRACT THE COMPOUND SLIDE AND RESET IT BACK TO ZERO ACCOUNTING FOR THE MACHINE'S BACKLASH (*THIS WAY IT WILL BE ZEROED FOR THE NEXT WORKPIECE!*). REMOVE THE PART FROM THE FIXTURE USING THE 1/8" ALLEN WRENCH AND CHECK OPERATION WITH FLYWHEEL OP#30 GO / NO GO GAGE **THICKNESS OF .95 ± .01. & CHAMFER .03 X 45°**

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	4-Jaw Lathe Chuck	N/A
T2	Flywheel Lathe Chuck Fixture	N/A
T3	Flywheel Op #30 Master Gage	N/A
T4	ACL-5 Brazed Carbide Insert Left Hand Turning Tool	320 RPM - Manual Feed
T5	XXX-5 Brazed Carbide 45 Chamfer Insert Turning Tool	N/A
T6	Facing & Chamfer Tool Holder	N/A
T7	1/8" Allen Wrench	N/A
T8	Flywheel OP #30 Go / No Go Gage	N/A

SETUP PICTURE



Operator Notes:

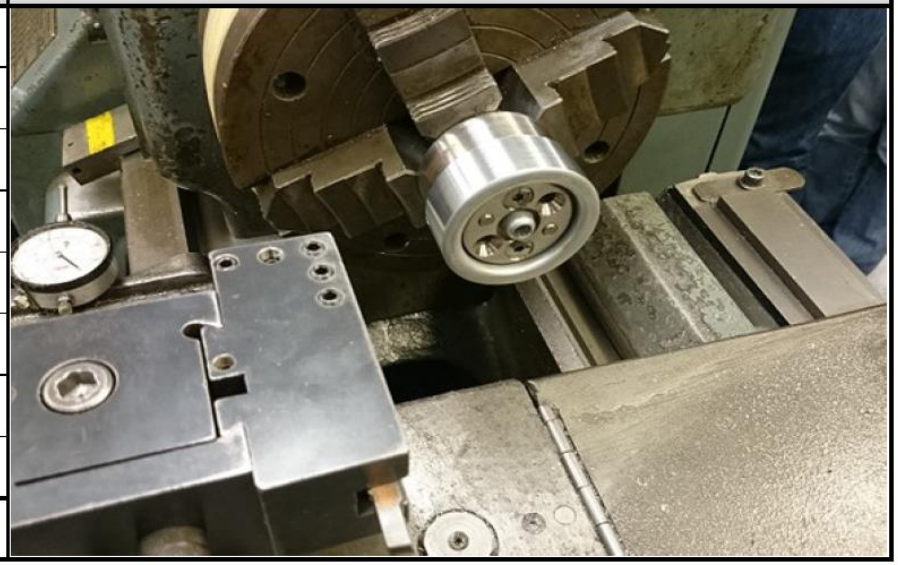
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MANUFACTURING OPERATION SETUP SHEET			Sheet: 3 of 5
OPERATOR:		MACHINE TOOL:	ENGINE LATHE #4 or #9
PART :	FLYWHEEL	DATE:	
DRAWING:	IME AIR MOTOR FLYWHEEL REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	ZA-8 ZINC	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
40	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INDICATE THE FIXTURE CONCENTRIC WITH THE 4-JAW CHUCK AND PLACE MASKING TAPE OVER THE CHUCK SO THE FIXTURE CANNOT BE ADJUSTED BY THE OPERATOR DURING PRODUCTION. INSTALL THE OP#40 MASTER GAGE ON THE FIXTURE AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. SET THE LATHE TO OPERATE AT A SPEED OF 360 RPM, FEED OF .008 IN/REV, REVERSE GEAR, AND COMPOUND AT 0 PARALLEL WITH THE CROSS SLIDE. INSTALL THE FACING & CHAMFER TOOLS IN THE LEFT HAND TOOL HOLDER, MAKING SURE THE TIP OF EACH TOOL IS SET AT THE LATHE'S CENTERLINE HEIGHT WHEN INSTALLED ON THE TOOL POST. TOUCH THE FACING TOOL OFF ON THE MASTER GAGE'S FRONT FACE AND LOCK THE SADDLE IN THIS POSITION. (*THIS STEP IS ONLY DONE DURING 1ST SETUP OR IF PRODUCING SCRAP PARTS!*) (*LOOSEN THE TOOL HOLDER AND PULL THE TOOL AWAY FROM THE WORKPIECE WHEN RETRACTING THE TOOL OFF OF THE MASTER GAGE OR WHEN THE WORKPIECE IS NOT SPINNING BETWEEN TOOL* WITH THE SADDLE LOCKED IN PLACE, INSTALL THE CHAMFER TOOL SO THE MIDDLE OF THE CUTTING EDGE LINES UP WITH THE EDGE OF THE MASTER GAGE AND ZERO COMPOUND SLIDE DIAL. INSTALL THE WORKPIECE ON THE FIXTURE WITH THE EJECTOR PIN MARKS POINTING OUTWARDS AND USE THE 1/8" ALLEN WRENCH TO TIGHTEN THE SCREWS ON THE FIXTURE PLATE. TURN ON THE LATHE AND USE THE AUTOFEED TO FACE THE WORKPIECE'S RIM ONLY. (*DO NOT MOVE CARRIAGE DURING THIS MANUFACTURING OPERATION, IT IS LOCKED DOWN!*) TURN OFF THE LATHE, LOOSEN THE TOOL POST, MOVE THE TOOL AWAY FROM THE WORKPIECE, RETRACT THE CROSS SLIDE, AND INSTALL THE CHAMFER TOOL. TURN ON THE LATHE, POSITION THE CHAMFER TOOL ON THE WORKPIECE'S EDGE USING THE CROSS SLIDE, USE THE COMPOUND SLIDE TO CHAMFER THE WORKPIECE (*60 ON COMPOUND DIAL!*). RETRACT THE COMPOUND SLIDE AND RESET IT BACK TO ZERO ACCOUNTING FOR THE MACHINE'S BACKLASH (*THIS WAY IT WILL BE ZEROED FOR THE NEXT WORKPIECE!*). REMOVE THE PART FROM THE FIXTURE USING THE 1/8" ALLEN WRENCH AND CHECK WITH FLYWHEEL THICKNESS GO / NO GO GAGE **FINAL THICKNESS OF .90 ± .01. & CHAMFER .03 X 45°**

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	4-Jaw Lathe Chuck	N/A
T2	Flywheel Lathe Chuck Fixture	N/A
T3	Flywheel Op #30 Master Gage	N/A
T4	ACL-5 Brazed Carbide Insert Left Hand Turning Tool	320 RPM - Manual Feed
T5	XXX-5 Brazed Carbide 45 Chamfer Insert Turning Tool	N/A
T6	Facing & Chamfer Tool Holder	N/A
T7	1/8" Allen Wrench	N/A
T8	Flywheel OP #30 Go / No Go Gage	N/A

SETUP PICTURE



Operator Notes:

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MANUFACTURING PART ROUTING Sheet: 1 of 4

TEAM NAME/NUMBER:	
PART :	FRAME
DRAWING :	IME AIR MOTOR FRAME
MATERIAL:	A356 ALUMINUM

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS
OPERATION #10 & #20 ARE PARALLEL OPERATIONS AND CAN BE PERFORMED IN ANY ORDER!

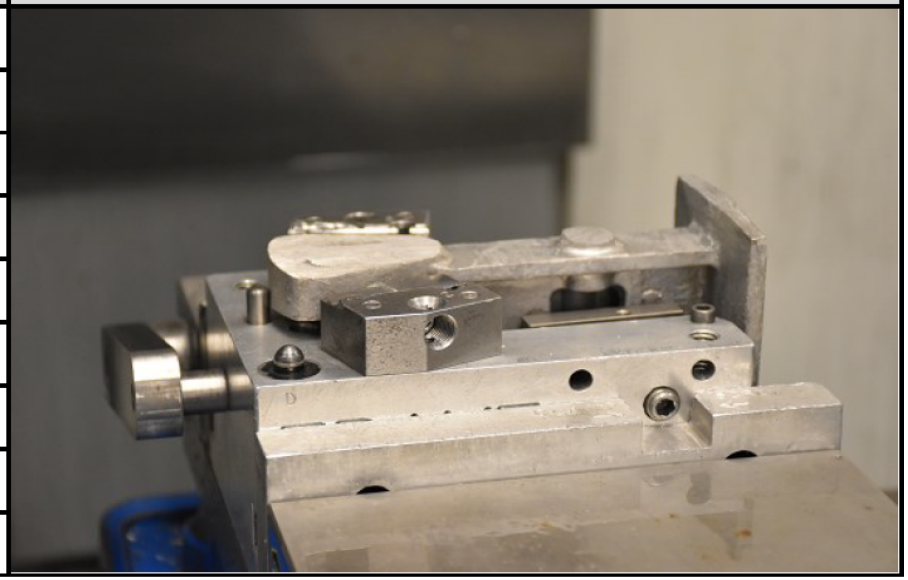
OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD	OPERATION TIME (min)
10	DEBURR CASTING, FACE MILL CYL HEAD & CRANK DISK FACE, DRILL INTAKE & EXHAUST HOLES, DRILL & REAM PIVOT / CYLINDER MOUNTING HOLE, DRILL & REAM MAINSHAFT HOLE	HAAS CNC 4-AXIS MINI MILL	MILLING VISE, VISE STOP, FRAME CASTING SHUTTLE FIXTURE, 1/4" ALLEN WRENCH, 2.0" 4-FLUTE CARBIDE INSERT FACE MILL, #1 DRILL BIT, 19/64" DRILL BIT, 8 mm REAMER, FRAME SHAFT HOLE GO / NO-GO GAGE.	VALVE FACE CLEANED UP, INTAKE HOLES Ø.201 ± .005 PIVOT AND MAINSHAFT HOLES Ø.3150 +.0005 -.0000		
20	FACE MILL BOTTOM OF CASTING, DRILL BASE MOUNTING HOLES, & DEBURR BOTTOM	HAAS CNC MINI MILL #1	MILL FIXTURE,7/8" BOX WRENCH, 2.0" 4-FLUTE CARBIDE INSERT FACE MILL, & #7 HSS JOBBER DRILL	BOTTOM OF CASTING FACE CLEANED UP & MOUTING HOLES Ø.203 ± .005		
30	COUNTERBORE PIVOT HOLE, DEBURR , CLEAN, INSPECT, & PLACE IN INVENTORY	MANUAL DRILL PRESS #2	FRAME COUNTERBORE FIXTURE & Ø 5/16 CAP SCREW COUNTERBORE TOOL	COUNTERBORE Ø.4740 ± .01 DEPTH .450 ± .005		

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MANUFACTURING OPERATION SETUP SHEET — Sheet: 2 of 4

OPERATOR:		**MACHINE TOOL:**	HAAS 4-AXIS MINI MILL
PART :	FRAME	**DATE:**	
DRAWING:	IME AIR MOTOR FRAME REV B	**QTY MACHINED:**	**QTY SCRAPED:**
MATERIAL:	A356 - ALUMINUM	**MGR APPROVAL:**	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
10	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** TOUCH ALL TOOLS OFF AT THE 4.000" GAGE LINE ON THE 4-AXIS MINI MILL - Z ZERO POINT .720" ABOVE TOP SURFACE OF FIXTURE, X & Y ZERO CENTER OF PIVOT HOLE IN FIXTURE. INSPECT CASTING/WORKPIECE QUALITY AND WITH A SMALL SQUARE FILE DEBURR THE PARTING LINE INSIDE THE CENTER CUTOUT WHERE THE MAINSHAFT HOLE WILL BE DRILLED AND REAMED. LOAD THE WORKPIECE AGAINST THE DATUM TARGETS IN THE FRAME MILLING VISE FIXTURE, DOUBLE CHECK BOTH SET SCREWS ARE TIGHT, AND THE WORKPIECE IS SECURE IN THE FIXTURE. USING THE AIR NOZZLE, BLOW THE CHIPS OFF OF THE LOCATING SURFACES IN THE MILLING VISE AND LOAD THE FIXTURE IN THE VISE (*MAKE SURE SETSCREW IS VISIBLE THROUGH THE JAW!*) SET THE FIXTURE AGAINST THE DATUM STOP ON THE LEFT SIDE OF THE VISE AND CLAMP THE FIXTURE IN THE VISE. (*DOUBLE CHECK THE PART AND FIXTURE ARE SECURE IN THE VISE!*) LOAD CNC PROGRAM #O00144 (FRAME OP#10) INTO THE HAAS CONTROL. MAKE SURE ALL THE TOOL HEIGHT OFFSETS ARE SET AT THE 4.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE. SET Z ZERO HEIGHT (G57) ON THE TOP SURFACE OF THE FIXTURE & X- Y-ZERO LOCATION (G57) ON THE UPPER LEFT CORNER OF THE FIXTURE, WHERE IT LOCATES IN THE MILLING VISE. RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOLS DURING THE ENTIRE CNC OPERATION. UNCLAMP THE VISE, BLOW OFF THE WORKPIECE, AND FIXTURE INSIDE THE MACHINE BEFORE REMOVING FROM THE MACHINE INSPECT THE FRONT MAKING SURE THE DRAFTED SURFACES WERE CLEANED UP, AND THE HOLES WERE REAMED TO THE **FINAL SIZE OF Ø.3150 +.0005 -.0000** WITH THE GO / NO-GO GAGE.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS	SETUP PICTURE
T1	Kurt Milling Vise with Hard Jaws & Stop	N/A	
T2	Frame Casting CNC Vise Fixture & 1/4" Allen Wrench	N/A	
T3	1.5" 4-Flute Carbide Insert Face Mill	3400-RPM 25-IPM	
T4	#3 Center Drill	5500-RPM - 15-IPM	
T5	F Size HSS Jobber Drill	5000-RPM & 21-IPM	
T6	19/64 HSS Jobber Drill	3500-RPM & 20 IPM	
T7	8 mm HSS Reamer	800-RPM & 12-IPM	
T8	Square File	N/A	
T9	Frame Mainshaft Hole Go / No-Go Gage	N/A	

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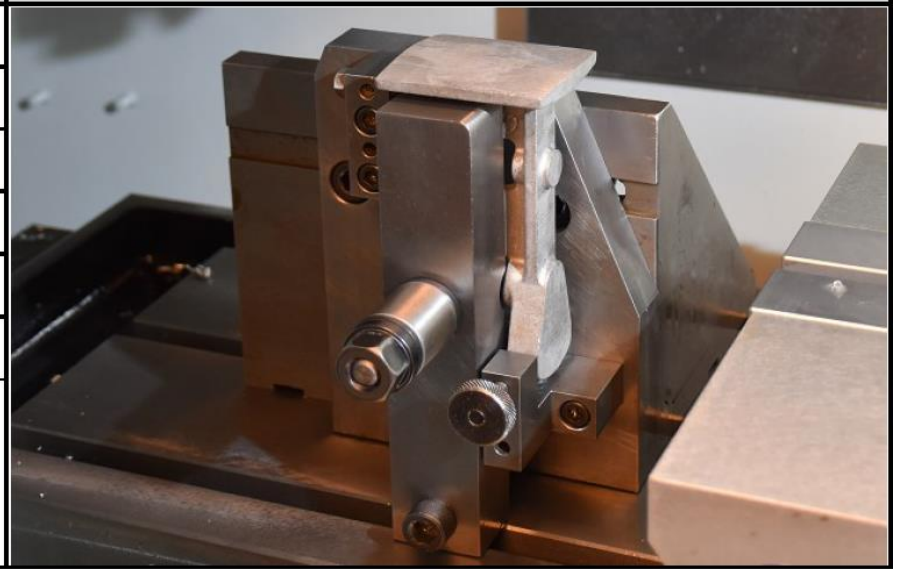
MANUFACTURING OPERATION SETUP SHEET			Sheet: 3 of 4
OPERATOR:		MACHINE TOOL:	HAAS MINI MILL #1
PART :	FRAME	DATE:	
DRAWING:	IME AIR MOTOR FRAME REV B	QTY MACHINED:	QTY SCRAPED:
MATERIAL:	A356 - ALUMINUM	MGR APPROVAL:	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE FRAME FACE MILLING FIXTURE ON THE CNC MILL'S TABLE, USE A TEST INDICATOR TO ALIGN THE FIXTURE PARALLEL TO THE MACHINE'S X-AXIS, AND TIGHTEN FIXTURE DOWN TO THE LOAD CNC PROGRAM #O00020 (FRAME OP20) INTO THE HAAS CONTROL. MAKE SURE ALL TOOL HEIGHT OFFSETS ARE TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE TOP SURFACE & X- Y-ZERO LOCATION (G58) ON THE UPPER LEFT CORNER OF THE FIXTURE'S SETUP GAGE. USING THE AIR NOZZLE, BLOW THE CHIPS OFF OF THE DATUM LOCATING TARGETS ON THE FIXTURE PLATE EVERY TIME A PART IS LOADED. LOAD THE WORKPIECE AGAINST THE DATUM TARGETS IN THE FIXTURE AND TIGHTEN THE THUMB SCREW AT THE BOTTOM TO LOCATE THE WORKPIECE IN PLACE. MAKE SURE WORKPIECE IS LOCATED IN FIXTURE CORRECTLY AND THE BASE IS NOT TILTED IN THE FIXTURE, REALIGN IF NECESSARY. USE THE 7/8" OPEN ENDED BOX WRENCH TO CLAMP THE WORKPIECE IN THE FIXTURE. RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOLS DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE FIXTURE, BLOW OFF THE WORKPIECE INSIDE THE MACHINE BEFORE REMOVING IT FROM THE MACHINING CENTER. INSPECT THE BOTTOM MAKING SURE THE DRAFTED SURFACE WAS CLEANED UP, AND THE MOUNTING HOLES WERE DRILLED TO THE CORRECT SIZE OF Ø.203 ± .005 DEBURR THE BOTTOM OF THE WORKPIECE USING THE ROTARY DEBURRING TOOL.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Frame Face Milling Fixture	N/A
T2	7/8" Open Ended Box Wrench	N/A
T3	Frame Face Milling Fixture Setup Master-Gage	N/A
T4	2.0" 4-Flute Carbide Face Mill (T1 & H1 in CNC program)	6000-RPM & 36-IPM
T5	#7 HSS Jobber Drill	3801-RPM & 18-IPM
T6	Rotary Deburring Tool	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET Sheet: 4 of 4

OPERATOR:		**MACHINE TOOL:**	DRILL PRESS #2
PART :	FRAME	**DATE:**	
DRAWING:	IME AIR MOTOR FRAME REV B	**QTY MACHINED:**	**QTY SCRAPED:**
MATERIAL:	A356 - ALUMINUM	**MGR APPROVAL:**	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE FRAME COUNTERBORE FIXTURE ON THE DRILL PRESS TABLE BY ALIGNING THE CENTER DOWEL PIN WITH THE DRILL PRESS'S SPINDLE, AND TIGHTENING THE FIXTURE TO THE TABLE. INSTALL THE COUNTERBORE TOOL INTO THE DRILL CHUCK AND USE THE CHUCK KEY TO TIGHTEN THE DRILL CHUCK. SET THE TABLE HEIGHT SO THE WORKPIECE IS 1.0" AWAY FROM THE BOTTOM OF THE TOOL WHEN THE QUILL IS FULLY RETRACTED, AND LOCK THE TABLE. SET THE QUILL STOP AT A DEPTH .450 ± .005 BELOW THE SURFACE OF THE WORKPIECE. USE THE CHIP BRUSH TO REMOVE ALL OF THE CHIPS ON THE FIXTURE EVERY TIME A THE FIXTURE IS LOADED. INSTALL THE WORKPIECE ON THE FIXTURE BY PLACING THE REAMED PIVOT HOLE OVER DOWEL PIN AND USE THE TOGGLE CLAMP TO SECURE THE WORKPIECE TO THE FIXTURE. SET THE DRILL PRESS SPEED TO 620-RPM PUT ONE DROP OF CUTTING OIL IN THE LOCATION WHERE THE COUNTERBORE WILL BE MACHINED ON THE WORKPIECE. TURN ON THE DRILL PRESS AND MANUALLY FEED THE QUILL, USING A PECKING MOTION (CLEARS CHIPS),UNTIL THE QUILL BOTTOMS OUT ON THE STOP. TURN OFF THE DRILL PRESS, REMOVE THE CHIPS USING THE CHIP BRUSH, AND REMOVE THE WORKPIECE FROM THE FIXTURE. INSPECT THE COUNTERBORE'S DIAMETER OF Ø.4740 ± .01 AND DEPTH OF .450 ± .005.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Frame Counterbore Fixture	N/A
T2	5/16" Socket Head - .3125" Pilot Diameter Counterbore Tool	840-RPM & Manual Feed
T3	A9 Aluminum Cutting Fluid	N/A
T4	Chip Brush	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING PART ROUTING Sheet: 1 of 4

TEAM NAME/NUMBER:	
PART :	MAINSHAFT
DRAWING :	IME AIR MOTOR MAINSHAFT REV B
MATERIAL:	5/16 W1 GROUND TOOL STEEL DRILL ROD

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS

OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD FOR COST REPORT	OPERATION TIME (min)
10	CUT STOCK TO FINISH LENGTH	COLD SAW	MAINSHAFT SAW STOP & AIR CLAMP	SHAFT LENGTH 3.96 ± .01		
20	DEBURR / CHAMFER BOTH ENDS AND INSPECT FINISH LENGTH	ABRASIVE BELT SANDER	BELT SANDER WITH COARSE BELT, MAINSHAFT FINISH LENGTH GO / NO GO GAGE	NO BURRS & SHAFT LENGTH 3.96 ± .01		
30	MILL SHAFT FLAT,	HAAS CNC MINI MILL #6	CHICK ONE LOCK MILLVISE, MAINSHAFT SOFTJAW SET WITH DOWEL PIN STOP, 5/8"-4 FLUTE CARBIDE END MILL, FLAT FILE, D-SHAPE GO / NO GO GAGE	SHAFT FLAT LENGTH .550 ± .015 SHAFT FLAT HEIGHT $.260\ ^{+.001}_{-.009}$		
40	STRAIGHT KNURL END OF SHAFT, DEBURR, CLEAN, INSPECT, AND PLACE IN INVENTORY	ENGINE LATHE #12	2J COLLET CHUCK, 5/16" 2J COLLET, STRAIGHT KNURLING TOOL	STRAIGHT KNURL .25" WIDE		

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MANUFACTURING OPERATION SETUP SHEET				Sheet: 2 of 4
OPERATOR:		MACHINE TOOL:	COLD SAW	
PART :	MAINSHAFT	DATE:		
DRAWING:	IME AIR MOTOR PISTON REV B	QTY MACHINED:		QTY SCRAPED:
MATERIAL:	5/16" W1 TOOL STEEL DRILL ROD	MGR APPROVAL:		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
10	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** SET THE SAW STOP AT THE 3.96" CUT LENGTH AND LOCK THE STOP IN PLACE USING THE 1/4" ALLEN WRENCH & SOCKET HEAD CAP SCREW MAKE SURE ALL CHIPS ARE REMOVED FROM SAW STOP AND VISE BEFORE CLAMPING THE WORKPIECE IN THE VISE CLAMP THE WORKPIECE IN THE VISE AND BACK THE VISE JAWS OFF THE ROD HALF-A-TURN ALLOWING THE STOCK TO MOVE FREELY IN THE VISE. (GAP NEEDS TO BE < .125") PULL THE LEVER DOWN TO ENGAGE THE AUTO VISE CLAMPING MECHANISM AND MAKE SURE THE WORKPIECE IS CLAMPED SECURELY IN THE VISE BEFORE CUTTING (DO NOT TURN ON SAW YET) TURN ON THE SAW'S POWER TO SPEED SETTING #1 MAKE SURE THE WORKPIECE IS SET AGAINST THE SAW STOP, PULL THE TRIGGER ON THE HANDLE TO TURN ON THE SAW, AND CUT THE WORKPIECE TO A **FINAL LENGTH OF 3.96 ± .01** DEBURR THE EDGES OF THE WORKPIECE BEFORE CHECKING EVERY CUT LENGTH USING THE MAINSHAFT CUT LENGTH GO / NO GO GAGE

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	14.0" X .125" Thick 120 Tooth High Speed Steel Cold Saw Blade	Speed Setting I on Saw
T2	1/4" Allen Wrench	N/A
T3	Mainshaft Cut Length Go No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET				Sheet: 3 of 4
OPERATOR:		MACHINE TOOL:	ABRASIVE BELT SANDER	
PART :	MAINSHAFT	DATE:		
DRAWING:	IME AIR MOTOR PISTON REV B	QTY MACHINED:		QTY SCRAPED:
MATERIAL:	5/16" W1 TOOL STEEL DRILL ROD	MGR APPROVAL:		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS, HEARING PROTECTION*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** MEASURE THE GAP BETWEEN THE WORK STOP/REST AND ABRASIVE BELT BEFORE PERFORMING THIS MANUFACTURING OPERATION! IF THE WORK STOP/REST HAS A GAP > .125" ADJUST THE GAP TO BE < .125" TURN ON BELT SANDER AND LIGHTLY TOUCH THE END OF THE MAINSHAFT TO THE BELT SANDER WHILE ROTATING THE WORKPIECE, DEBURRING THE FRONT FACE ON THE WORKPIECE REPEAT THE PROCESS ABOVE TO DEBURR THE OPPOSITE FRONT FACE ON THE WORKPIECE (*DO NOT REMOVE TOO MUCH MATERIAL!*) SET THE WORKPIECE AT A 45° ANGLE WITH RESPECT TO THE ABRASIVE BELT AND SLOWLY ROTATE THE WORKPIECE WHILE TOUCHING THE ABRASIVE BELT, MAKING A SMALL CHAMFER REPEAT THE PROCESS ABOVE TO CHAMFER THE OPPOSITE END OF THE WORKPIECE INSPECT THE FINAL WORKPIECE LENGTH USING THE GO / NO GO GAGE

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	80 Grit 2.0" X 24" Abrasive Belt	3600 RPM & Hand Feed
T2	Mainshaft Cut Length Go No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET — Sheet: 4 of 4

OPERATOR:		**MACHINE TOOL:**	HAAS MINI MILL #6	
PART :	MAINSHAFT	**DATE:**		
DRAWING:	IME AIR MOTOR PISTON REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	5/16" W1 TOOL STEEL DRILL ROD	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE MAINSHAFT CHICK VISE SOFT JAW SET AND USE A TEST INDICATOR TO MAKE SURE THE JAW IS ALIGNED PARALLEL TO THE MACHINE'S X-AXIS. LOAD CNC PROGRAM #O00030 (MAINSHAFT OP#30) INTO THE HAAS CONTROL. MAKE SURE THE TOOL HEIGHT OFFSET IS TOUCHED OFF AT THE 6.0" GAGE HEIGHT ABOVE THE MACHINE'S TABLE USING THE 6" TOOL SETTING GAGE. SET Z ZERO HEIGHT (G58) ON THE BOTTOM SURFACE OF THE SOFT JAW, X-ZERO LOCATION (G58) RIGHT EDGE OF STOP, & Y-ZERO LOCATION (G58) BOTTOM EDGE OF SOFT JAW. USING THE AIR NOZZLE, BLOW THE CHIPS OUT OF THE SOFT JAW EVERY TIME A PART IS LOADED AND UNLOADED. LOAD THE WORKPIECE AGAINST THE DATUM TARGETS IN THE SOFT JAW AND TIGHTEN THE MILLING VISE TO APPROXIMATELY 10 FT-LBS OF TORQUE. MAKE SURE WORKPIECE IS LOCATED IN JAW CORRECTLY AND IT IS NOT CLAMPED ON ANY CHIPS BEFORE RUNNING CNC PROGRAM #O00030 (MAINSHAFT OP30). RUN THE CNC PROGRAM AND MAKE SURE THE COOLANT NOZZLE REMAINS SPRAYING ON THE CUTTING TOOL DURING THE ENTIRE CNC OPERATION. UNCLAMP THE WORKPIECE FROM THE FIXTURE, BLOW OFF THE WORKPIECE INSIDE THE MACHINE BEFORE REMOVING IT FROM THE MACHINING CENTER. INSPECT THE MILLED FLAT MAKING SURE THE MILLED SURFACE HAS A GOOD SURFACE FINISH. USE THE SMALL FILE TO DEBURR THE FLASH ON THE WORKPIECE BEFORE INSPECTING. TO A LENGTH OF .550 ± .015 AND A HEIGHT OF USE THE MAINSHAFT FLAT GO / NO-GO GAGE TO INSPECT THE MILLED FLAT LENGTH OF .550 ± .015 AND MILLED HEIGHT OF .260 $^{+.001}_{-.009}$

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Chick One Loc CNC Milling Vise	N/A
T2	Mainshaft Chick One Lock Vise Soft Jaw Set	N/A
T3	5/8" 6-Flute Carbide Center Cutting End Mill (CNC Program T10 & H10)	1222-RPM & 12-IPM
T4	Mainshaft Flat Go / No-Go Gage	N/A

SETUP PICTURE



Operator Notes:

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MANUFACTURING OPERATION SETUP SHEET Sheet: 4 of 4

OPERATOR:		**MACHINE TOOL:**	ENGINE LATHE #12	
PART :	MAINSHAFT	**DATE:**		
DRAWING:	IME AIR MOTOR PISTON REV B	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	5/16" W1 TOOL STEEL DRILL ROD	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
40	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE 2J COLLET CHUCK ON THE LEBLONDE LATHE WITH 5/16" 2J COLLET SET THE LATHE TO OPERATE AT A ROTATIONAL SPEED OF 30 RPM INSTALL THE STRAIGHT KNURLING TOOL IN THE TOOL HOLDER AND MAKE SURE THE ROLLERS ARE ADJUSTED SYMMETRICALLY ABOVE AND BELOW THE CENTERLINE OF ROTATION. INSTALL THE WORKPIECE WITH APROXIMATELY 1.00" OF THE UN-MACHINED END PROTRUDING FROM THE COLLET CHUCK. TIGHTEN THE COLLET CHUCK WHEEL AND MAKE SURE THE PART IS SECURE IN THE COLLET BEFORE TURNING ON THE LATHE. TURN THE LATHE ON, MOVE THE KNURLING TOOL TO THE FRONT END OF THE MAINSHAFT, AND USE THE CROSS SLIDE TO MOVE THE KNURLING TOOL INTO THE PART, CREATING A STRAIGHT KNURL. BE CAREFUL NOT TO APPLY TOO MUCH PRESSURE ON THE KNURLING TOOL WHEN KNURLING AS IT MIGHT BEND THE WORKPIECE. RETRACT THE TOOL, TURN OFF THE LATHE, AND REMOVE THE WORKPIECE FROM THE COLLET CHUCK. SEND THE PART TO FINAL INSPECTION.

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	2J Collet Chuck	N/A
T2	5/16 2J Collet	N/A
T3	Straight Knurling Tool & Holder	30-RPM & Manual Feed

Operator Notes:

SETUP PICTURE



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MANUFACTURING PART ROUTING Sheet: 1 of 5

TEAM NAME/NUMBER:	
PART :	PISTON
DRAWING :	IME AIR MOTOR PISTON
MATERIAL:	DELRIN

NOTES: WEAR ALL PERSONAL PROTECTION EQUIPMENT (SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS) WHILE PERFORMING MANUFACTURING OPERATIONS

OP #	OPERATION DESCRIPTION	MACHINING CELL	TOOLING & FIXTURES	CRITICAL DIMENSIONS (in)	PROCESS NOTES & SCRAP RECORD FOR COST REPORT	OPERATION TIME (min)
10	CUT PART TO FINISH LENGTH	COLD SAW	HSS 14" COLD SAW BLADE, PISTON SAW STOP, AIR CLAMP, FILE, PISTON FINAL LENGTH GO/ NO GO GAGE	FINAL LENGTH 2.92 ± .01		
20	DRILL DOWEL PIN HOLE	MANUAL DRILL PRESS #3	DRILL FIXTURE, LETTER F DRILL BIT, PISTON HOLE GO / NO GO GAGE	HOLE SIZE Ø.257 ± .005		
30	GRIND OUTSIDE DIAMETER TO FINISH SIZE	CENTERLESS GRINDER	DELRIN PUSH ROD, PISTON OD GO / NO GO GAGE	FINAL DIAMETER Ø.744 ± .002		
40	CHAMFER OUTSIDE EDGES CLEAN, INSPECT AND PLACE IN INVENTORY	ENGINE LATHE #1	COLLET CHUCK, Ø.750 SPRING COLLET WITH STOP, 45° CHAMFER TOOL	CHAMFER SIZE .03 X 45°		

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MANUFACTURING OPERATION SETUP SHEET — Sheet: 2 of 5

OPERATOR:		**MACHINE TOOL:**	COLD SAW	
PART :	PISTON	**DATE:**		
DRAWING:	IME AIR MOTOR PISTON REV A	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	DELRIN	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
10	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** SET THE SAW STOP AT THE 2.92" CUT LENGTH AND LOCK THE STOP IN PLACE USING THE 1/4" ALLEN WRENCH & SOCKET HEAD CAP SCREW MAKE SURE ALL CHIPS ARE REMOVED FROM SAW STOP AND VISE BEFORE CLAMPING THE WORKPIECE IN THE VISE CLAMP THE WORKPIECE IN THE VISE AND BACK THE VISE JAWS OFF THE HALF A TURN ALLOWING THE WORKPIECE TO MOVE FREELY IN THE VISE. (GAP NEEDS TO BE < .125") BEFORE CUTTING PULL THE LEVER DOWN TO ENGAGE THE AUTO VISE CLAMPING MECHANISM AND MAKE SURE THE WORKPIECE IS CLAMPED SECURELY IN THE VISE BEFORE CUTTING. TURN ON THE SAW POWER TO SPEED SETTING #2 MAKE SURE THE STOCK IS SET AGAINST THE STOP, PULL THE TRIGGER ON THE SAW LEVER TO START THE SAW BLADE, AND CUT THE WORKPIECE TO A **FINAL LENGTH OF 2.92 ± .01** DEBURR THE EDGES OF THE PART BEFORE CHECKING EVERY PART USING THE PISTON CUT LENGTH GO / NO GO GAGE

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	14.0" X .125" Thick 120 Tooth High Speed Steel Cold Saw Blade	Speed Setting II on Saw
T2	1/4" Allen Wrench	N/A
T3	Piston Cut Length Go / No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET — Sheet: 3 of 5

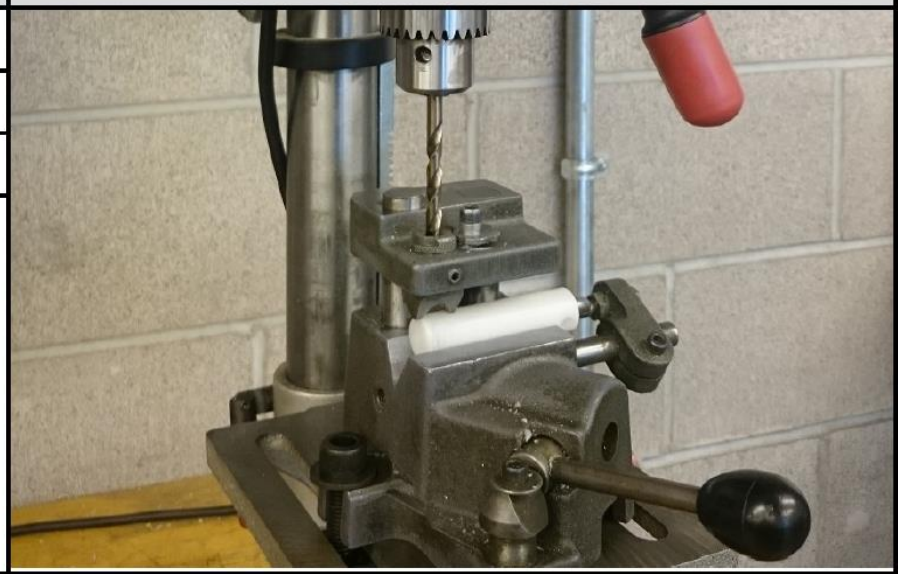
OPERATOR:		**MACHINE TOOL:**	DRILL PRESS #3	
PART :	PISTON	**DATE:**		
DRAWING:	IME AIR MOTOR PISTON REV A	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	DELRIN	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
20	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE LETTER F DRILL BIT INTO THE DRILL CHUCK AND TIGHTEN THE CHUCK WITH A CHUCK KEY INSTALL THE FIXTURE ON THE DRILL PRESS TABLE AND CONCENTRICALLY ALIGN THE DRILL BIT BUSING WITH THE DRILL BIT IN THE CHUCK SET THE DRILL PRESS SPEED TO 1720 RPM BY ADJUSTING THE BELTS IN THE HEAD ADJUST THE TABLE HEIGHT SO THE BOTTOM OF THE DRILL BIT IS AT THE BOTTOM OF THE DRILL BUSHING WHEN THE QUILL IF FULLY RETRACTED AND LOCK THE TABLE IN PLACE. INSURE THE DRILL BIT IS CONCENTRICALLY ALIGNED INSIDE THE DRILL BUSING AFTER LOCKING THE TABLE IN PLACE AND BEFORE TURNING ON THE DRILL PRESS SET THE DEPTH STOP ON THE QUILL SO THE DRILL BIT WILL GO THRU THE WORKPIECE BUT DOES NOT ALLOW THE CHUCK KEY TO TOUCH THE HARDENED DRILL BUSHING INSTALL THE WORPIECE IN THE DRILL JIG SO THE BACK FACE OF THE PISTON BOTTOMS OUT ON THE JIG'S LOCATING STOP (*MAKE SURE THE JIG IS FREE FROM CHIPS BEFORE INSTALLING PARTS!*) PULL THE LEVER ON THE JIG DOWNWARDS TO CLAMP THE WORKPIECE IN THE JIG TURN ON THE DRILL PRESS, SLOWLY PECK DRILL A Ø.257 HOLE THRU THE WORKPIECE, RETRACT THE CUTTING TOOL, AND TURN OFF THE DRILL PRESS CHECK THE **FINAL HOLE SIZE OF Ø.257 ± .005** USING THE PISTON HOLE GO / NO GO GAGE

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	Piston Drill Jig	N/A
T2	F Size HSS Jobber Drill	840 RPM - Manual Peck Drill
T3	Piston Hole Go / No Go Gage	Speed II on Saw

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET Sheet: 4 of 5

OPERATOR:		**MACHINE TOOL:**	CENTERLESS GRINDER	
PART :	PISTON	**DATE:**		
DRAWING:	IME AIR MOTOR PISTON REV A	**QTY MACHINED:**		**QTY SCRAPED:**
MATERIAL:	DELRIN	**MGR APPROVAL:**		

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
30	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSPECT GRINDING WHEEL FOR BUILT UP MATERIAL BEFORE OPERATING GRINDER. IF MATERIAL IS STUCK TO THE WHEEL THE WHEEL MUST BE DRESSED BEFORE OPERATING THE MACHINE TOOL TURN ON GRINDING WHEEL AND ALLOW THE MACHINE TO WARM UP FOR 5 MINUTES BEFORE GRINDING THE FIRST PART MAKE SURE COOLANT IS COMPLETELY COVERING THE GRINDING WHEEL AND REGULATING WHEEL BEFORE FEEDING A WORKPIECE THROUGH THE MACHINE TOOL PLACE THE WORKPIECE ON THE STAGING AREA INFRONT OF THE GRINDING WHEEL (*SEE SETUP PICTURE*) USE THE DELRIN PUSH ROD TO START FEEDING THE WORKPIECE THROUGH THE GRINDER. (*DO NOT PUSH THE WORKPIECE THROUGH THE GRINDER IT WILL SELF FEED ONCE IT MAKES CONTACT WITH THE WHEEL!*) CHECK THE **FINAL GROUND OUTSIDE DIAMETER OF Ø.744 ± .002** USING THE PISTON OD GO / NO GO GAGE

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	10" Delrin Cylindrical Grinding Wheel	2500 SFM & 12 IPM
T2	Delrin Push Rod	N/A
T3	Piston OD Go / No Go Gage	N/A

Operator Notes:

SETUP PICTURE



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MANUFACTURING OPERATION SETUP SHEET — Sheet: 5 of 5

OPERATOR:		**MACHINE TOOL:**	ENGINE LATHE #1
PART :	PISTON	**DATE:**	
DRAWING:	IME AIR MOTOR PISTON REV A	**QTY MACHINED:**	**QTY SCRAPED:**
MATERIAL:	DELRIN	**MGR APPROVAL:**	

OP #	MACHINING OPERATION DESCRIPTION & CRITICAL DIMENSIONS
40	**INSURE ALL PERSONAL PROTECTION EQUIPMENT - PPE - (*SAFETY GLASSES, CLOSE TOED SHOES, LONG PANTS*) IS IN PLACE DURING THE ENTIRE MANUFACTURING OPERATION** INSTALL THE 2J COLLET CHUCK ON THE ENGINE LATHE MAKING SURE THE SPINDLE NUT IS SECURE INSTALL THE Ø.75 2J COLLET WITH STOP INTO THE COLLET CHUCK (*THE KEY IN THE CHUCK ALIGNS UP WITH THE KEYWAY IN THE COLLET!*) INSERT THE WORKPIECE INTO THE COLLET, POSITION IT AGAINST THE BACK STOP, AND TIGHTEN THE COLLET CHUCK ALIGN THE COMPOUND REST SO IT IS PARALLEL TO THE CROSS SLIDE AND TIGHTEN THE BOLTS ON THE COMPOUND REST LOCKING IT IN PLACE INSTALL THE 45° CHAMFER TOOL IN THE LEFT HAND TOOL HOLDER ON THE TOOL POST MAKING SURE TOOL POST IS SQUARED UP WITH THE COMPOUND REST (*SEE SETUP PICTURE!*) MOVE THE CARRIAGE SO THAT THE MIDDLE OF THE CHAMFER TOOL COMES IN CONTACT WITH THE EDGE OF THE UNCHAMFERD WORKPIECE AND LOCK THE CARRIAGE IN THIS POSITION SET THE COMPOUND DIAL TO ZERO (THE COMPOUND WILL BE USED TO MAKE THE CHAMFER FEATURE ON THE PART AND THE CROSS SLIDE WILL BE USED TO POSITION THE TOOL) BACK THE CUTTING TOOL OFF OF THE PART USING THE CROSS SLIDE (*KEEP THE COMPOUND SLIDE SET AT ZERO!*) AND TURN ON THE LATHE TO 640 RPM ADVANCE THE CUTTING TOOL FORWARD USING THE CROSS SLIDE UNTIL IT TOUCHES THE EDGE OF THE WORKPIECE MAKING A MICROCHIP CHAMFER THE PART USING THE COMPOUND SLIDE, RESET THE COMPOUND TO ZERO (*MAKE SURE BACKLASH IS ELIMINATED!*), AND BACK THE CUTTING TOOL BACK OFF WITH THE CROSS SLIDE STOP THE LATHE, FLIP THE PART OVER REPOSITIONING IT AGAINST THE STOP IN THE COLLET, AND TIGHTEN THE COLLET REPEAT THE CHAMFER PROCESS USING THE CROSS SLIDE TO POSITION THE TOOL AGAINST THE WORKPIECE AND THE COMPOUND SLIDE TO CUT THE **.03 ± .01 X 45° CHAMFER** VISUALLY INSPECT THE CHAMFER, WASH THE PART, AND SEND TO QUALITY CONTROL FOR INSPECTION

T#	TOOLING DESCRIPTION	TOOLING SETTINGS / SPEEDS & FEEDS
T1	2J Collet Chuck	N/A
T2	Ø.75 2J Collet with Stop	N/A
T3	45° Brazed Carbide Single Point Chamfer Tool	640 RPM & Manually Feed Chamfer
T4	Left Hand Lathe Tool Holder	N/A

Operator Notes:

SETUP PICTURE

