Precitech Grinder Systems
Supplemental Manual

Installation & Operation Manual

M17931/B

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AMETEK®
ULTRA PRECISION TECHNOLOGIES

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SECTION 1

Safety

General Cautions and Warnings

Read The Instruction Manuals - The INSTALLATION AND MAINTENANCE MANUAL and the OPERATION MANUAL must be read and thoroughly understood by those responsible for the installation, operation and maintenance of this Ultra Precision Machining System. Pay particular attention to the **WARNING** and **CAUTION** paragraphs to prevent injury to personnel or damage to the machine.

Operator Training - Operators must be trained in the proper and safe use of this Ultra Precision Machining System.

Be Safety Conscious - Observe all local safety codes and regulations. Do not operate or service this Machining System under unsafe conditions.

Terms Used

WARNING - In this manual, the word **WARNING** is used to indicate procedures which, if not followed, may result in injury to personnel.

SPECIFIC WARNING

GENERAL WARNING (REFER TO MANUAL)

CAUTION - In this manual, the word **CAUTION** is used to indicate procedures which, if not followed, may result in damage to the machine.

IMPORTANT - In this manual, the word **IMPORTANT** is used to indicate an item, the understanding of which is necessary to achieve full and correct operation.

NOTE - In this manual, the word **NOTE** is used to indicate items of an explanatory nature that support, but are not vital to the text.

Electrical Hazard Types

Below are the types of electrical hazards as defined by the safety guidelines for servicing ultra precision machining systems. These hazards may be encountered during maintenance and servicing tasks. Technicians working on this system must be familiar with these electrical hazard types.

Type 1 - Equipment is fully de-energized.

Type 2 - Equipment is energized, but live circuits are covered or insulated to preclude accidental shock.

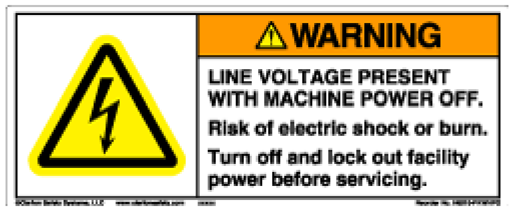
Type 3 - Equipment is energized and live circuits of less than 30 Vrms, 240 VA, and 20 joules are exposed to accidental contact.

Type 4 - Equipment is energized and live circuits of greater than 30 Vrms, 240 VA, or 20 joules are exposed to accidental contact; or radio frequency (rf) is present.

GENERAL ELECTRICAL HAZARD

Type 5 - Equipment is energized and adjustment requires physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes.

SPECIFIC ELECTRICAL HAZARD



Safety Suggestions

WARNING -Wear Safety Glasses - Operators and maintenance personnel must wear safety glasses whenever the PRECITECH spindle is running. It is good practice to wear safety glasses around the machine at all times.

WARNING - Wear A Dust Mask - The diamond-turning process may produce swarf or chips that float in the air. A protective mask must be worn over the operator s nose and mouth to prevent inhaling or ingesting substances that may be toxic.

WARNING - Dress properly - Do not operate the PRECITECH Machining System while wearing jewelry, loose fitting clothing, neckties, shirtsleeves, or unprotected long hair.

WARNING - Stay Alert - Do not operate the PRECITECH Machining System while under the influence of medication, drugs, or alcohol.

WARNING - Safety Guards Must Be In Place - Operators must be sure that all guards are in place while the PRECITECH Machining System is running to protect against bodily injury.

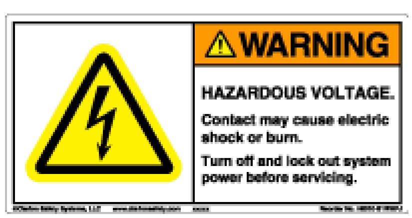
WARNING - Adjustable Guard - The adjustable guard shields the operator from lube spray and fine chips that naturally fly from the rotating spindle during the machining process. There are times, however, when the operator needs to fine-tune the setup of the tool, lubrication or chip extraction, while the spindle is rotating. At these times, the operator may slide the adjustable guard aside for access to the cutting area, but this guard must otherwise remain closed during the machining process for maximum safety.

WARNING - Maintain the Machine Properly - Do not operate this machining system when it is in need of repair or service. Proper maintenance will help avoid machine downtime, loss of production and injury to personnel.

Warning - Do Not Disable Machine Safety Interlocks - Many safety features have been built into the Machining System and should not be disabled. Special applications and service may require temporary interlock override, please consult with Precitech.

Warning - Electrical/Electronic Troubleshooting - Must be performed by personnel trained to troubleshoot electrical circuits. An electrical hazard exists when personnel exceed the limitations of their training.

Warning - Electrical Repair - Main Disconnect must be turned OFF before attempting any repairs of electrical components. Follow your Lock Out-Tag-Out procedure so that another person cannot accidentally start the machine. This device can also be used as an Emergency OFF switch in the event of an unforeseen electrical hazard.



WARNING - Hydraulic/Pneumatic Repair - Do not attempt to repair or service pneumatic or hydraulic components while the PRECITECH

Machining System is connected to the pneumatic or hydraulic power sources or if either system remains under pressure.

WARNING - Material Safety Data Sheet (MSDS) - PRECITECH provides a MSDS and hazard warning labels on containers for each of its products considered to be hazardous within the meaning of the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard, 29 CFR 1910.1200. Read and understand the MSDS and hazard warning labels before using any hazardous material.

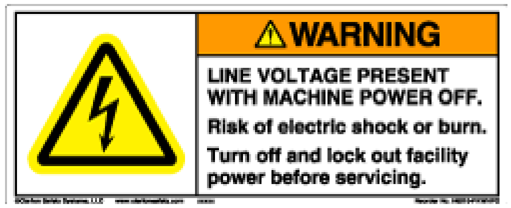
LOCK OUT-TAG OUT Defined - The placement of all hazardous energy under the exclusive control of an authorized employee(s) performing the service or maintenance, following a procedure established by the employer as required by OSHA 29 CFR 1910.147, Isolation of Energy Sources-Machinery Safety Directive 89/392EEC the Control of Hazardous Energy.

LOCK OUT-TAG OUT Capabilities - The machine comes equipped with the means to secure the energy systems of the machine in a manner consistent with all **LOCK OUT-TAG OUT** requirements.

- The Main Electrical Disconnect Switch allows a lock to be inserted in the handle when the switch is in the OFF position. This ensures that the Electrical System of the Machine is in a condition where it can be safely serviced. This device can also be used as an Emergency OFF switch in the event of an unforeseen electrical hazard.

Electrical
Lockout Here

- This Machine is equipped with an accessory receptacle. This receptacle is fed from a separate power source in addition to the Machine Main Feed. **Although the E STOP Switch is depressed and the Main Disconnect Switch is OFF and locked, there may be voltage potential at this receptacle.**



- In order to fully (secure) **LOCK OUT-TAG OUT** this receptacle, the plug for the source conductor must be pulled and covered with a lockable shell (boot) made expressly for this purpose.

- The Pneumatic Supply Lockout Valve is clearly labeled. This valve allows a lock to be inserted in the handle when the valve is in the OFF position.

Pneumatic
Lockout Here

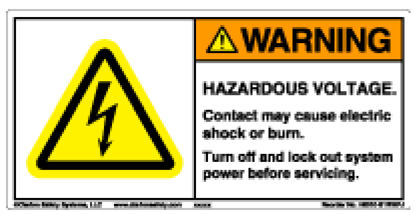
Always follow your companies LOCK OUT-TAG-OUT procedure so that another person cannot accidentally start the machine.

System Interlocks

Precitech Machining Systems are designed with mechanical, electrical, and pneumatic components whose use is dedicated to protecting the operator and the machine.

All Cabinet Doors and Service Access Panels have tool-operated latches or fasteners to prevent casual entry.

The Electrical Cabinet is mechanically interlocked to prevent exposure to lethal voltage. The electrical cabinet door cannot be opened unless the Main Disconnect is turned OFF.

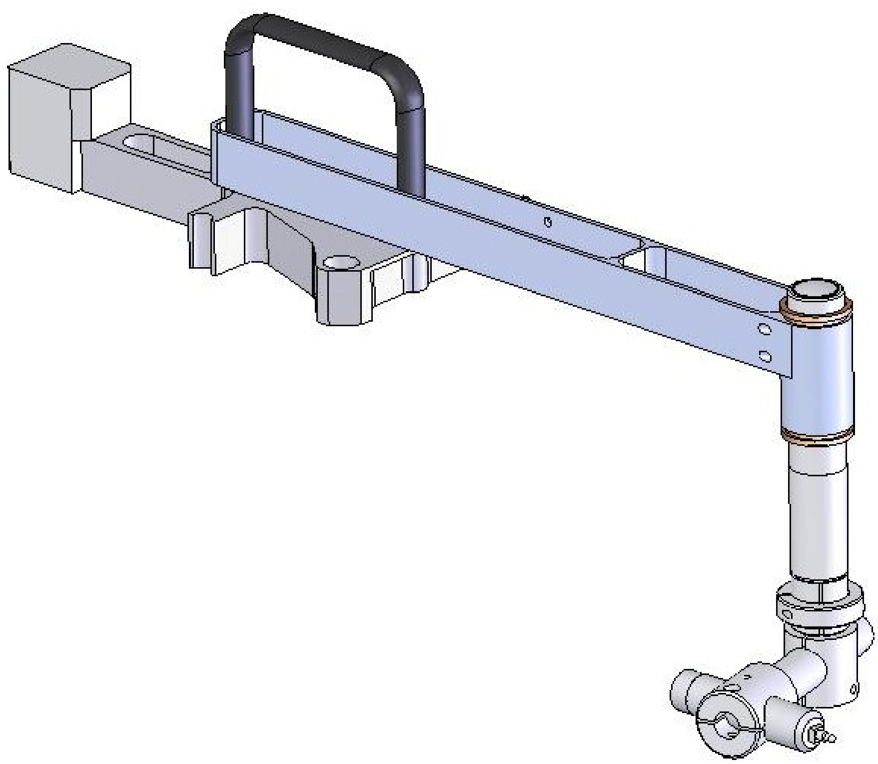


Warning Labels

This label is located on the sliding guard door that protects the operator during a machining cycle. When this guard must be slid aside to allow operator access to the cutting area, it is imperative that safety glasses be worn.

SECTION 2

LVDT Tool Setter A15415-05



Description

The LVDT tool setter A15415-05 uses a Precitech designed air bearing slide inside a 0.75 inch diameter housing. On one end is mounted a LVDT core. The other end carries a replaceable ruby ball tip. The air bearing slide provides zero friction and therefore low tip forces are possible. The tip force comes from gentle pneumatic pressure behind the air bearing and is adjustable. The unit kinematically mounts on the top of the spindle with high repeatability and positions the LVDT with the sensing direction parallel to the travel of the Z slide.

The LVDT tool setter is used to measure the offset positions between a tool or grinding wheel and the work spindle or B axis centerline positions. It can also be used to measure the radius of the tool or wheel. Tools are probed in three positions and the resulting data is used by the controller to accurately compute tool radius and offset positions.

Air Bearing LVDT Specifications

Side stiffness	.05 mm/gmf @ 60 psi
Ruby tip diameter	0.125 inch (3.175 mm), others available
Tip thread size	#4-48
Air flow rate	< 0.5 scfm
Tip force	3-7 grams, adjustable

Mount and Connect

If your machine includes a cover over the work spindle, open this to expose the kinematic balls on the spindle. Clean the ball seats and the mating rods on the bottom of the tool setter with a cloth to remove any contaminants. Mount the LVDT tool setter on the kinematic balls provided on the work spindle. Plug in the electrical wire to the channel A input of the Integrated Gage Amplifier (IGA) board (Channel B is reserved for Ultracomp) and hook up the air line to the ‘Probe Air’ connection port. Verify the Probe Air pressure is set at 60 psi. The air bearing LVDT can now be uncovered and should be tested for free motion (not sticking).

Align the LVDT

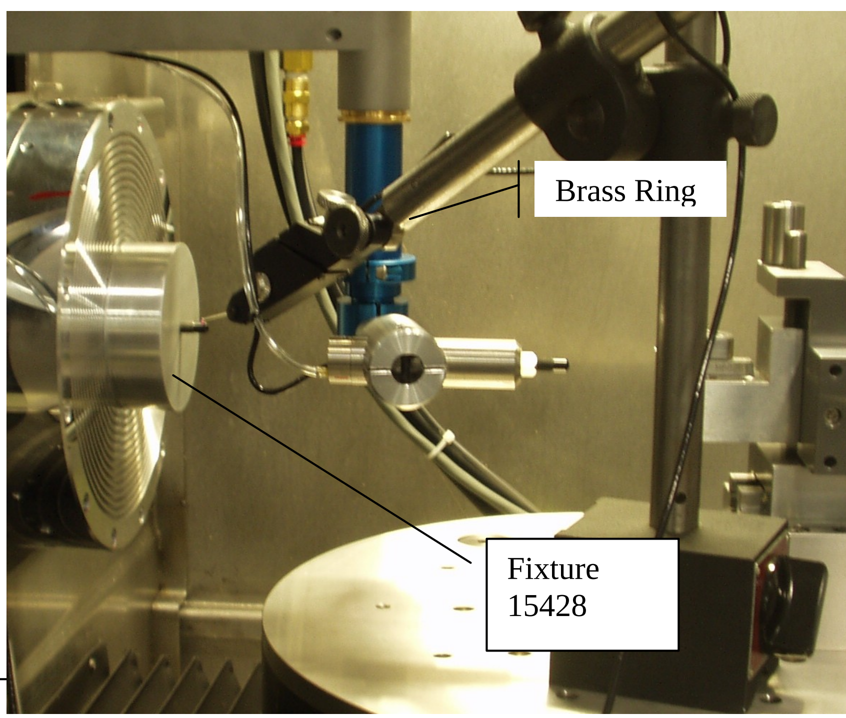
Using an indicator, align the body of the LVDT so that it runs parallel to the Z axis motion of the machine to less than 5 microns per 5 mm travel both on top of the LVDT housing and on the side of the housing.

Calibrate Output Linearity and Offset

The electrical LVDT output signal can be viewed on the UPX screen under the Integrated Gage Amplifier window (Channel A). The probe should be touched to ensure the signal is being amplified correctly, then set up to touch against any rigid object on the tooling plate such as a tool holder. Jog the Z slide to null the LVDT, press the RESET OFFSET button to cancel any offset, and again move Z to null the gage. When the machine Z axis is moved 10 microns and displaces the LVDT by this amount, the LVDT output should also read 10 microns. Adjust this calibration using the CAL pots on the gage amplifier board until the slide motion is measured correctly within 2% (0.2 microns). Adjust the Offset pot until both the positive and negative travel directions and Forward / Reversed display reflect equal amplitudes. You may wish to label the IGA channel A input connector with a tag reading "Cal for LVDT Toolsetter" with the inspector initials and date of the calibration.

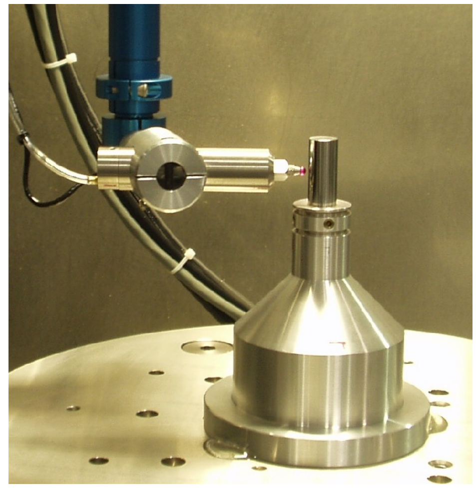
Set LVDT Height

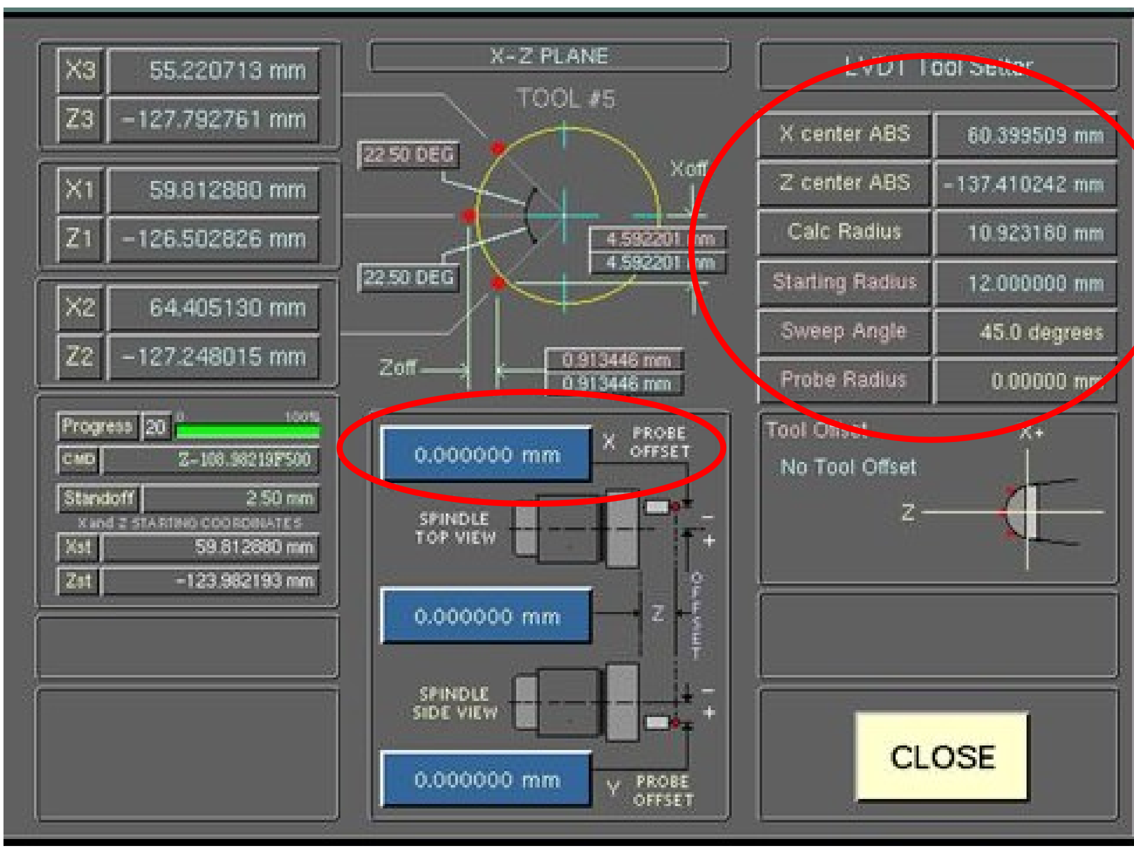
Adjust the height of the LVDT body until the probe is at the same height as the work spindle. This can be accomplished in multiple ways such as using a transfer reading from a 0.75 inch diameter part mounted and aligned to rotate true with the work spindle. There is also a fixture (15428) that accepts a contact point (168-0052) where the height of the two contact points (one in each) can be transferred to set the height. The height adjustment is accomplished by turning the brass locking rings on the vertical threaded body of the tool setter.



Calibrate Contact Point Radius

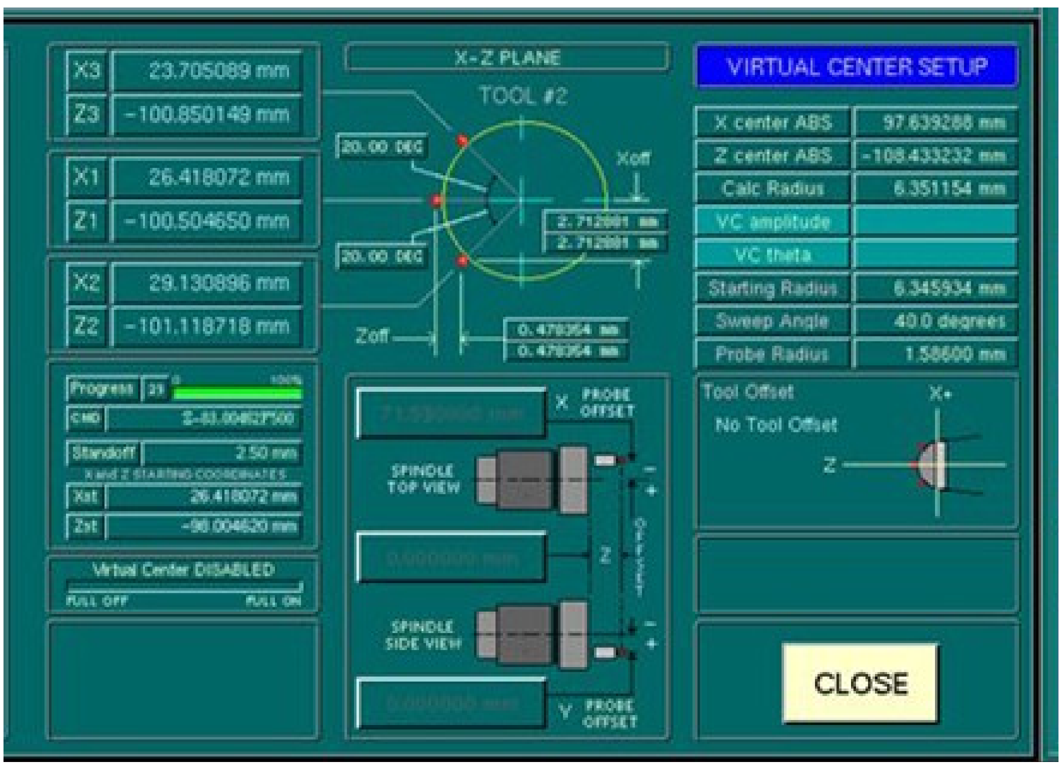
Use the LVDT tool setter to measure the radius size of a calibrated pin, dowel, or other artifact placed vertically on the tooling plate. If the reported size (Calc Radius) is not correct this error is subtracted from (or added to) the Probe Radius so that the size of the artifact is measured correctly. Write this number down on a piece of paper for future reference.





Calibration of the LVDT Tool Setter to the Work Spindle Centerline

Turn or grind a setup stud so that the part is produced with less than a micron of X offset. Alternatively, set a tool using the Optical tool setter. This tool or wheel with known accurate X position is then the master for calibrating the X offset of the LVDT tool setter to the work spindle. Use the LVDT tool setter routine (with the same tool active from the tool table) to measure the tool or wheel position. The resulting values are shown in the <u>X Center ABS</u> on the LVDT tool setter window (shown above). Enter a corrected value to the <u>X Probe Offset</u> value and repeat the LVDT measurement until the resulting <u>X Center ABS</u> number matches the known accurate X position for the tool. Write these numbers down on a piece of paper for future reference.



Tool Set Procedure for XZ Grinding using the LVDT tool setter

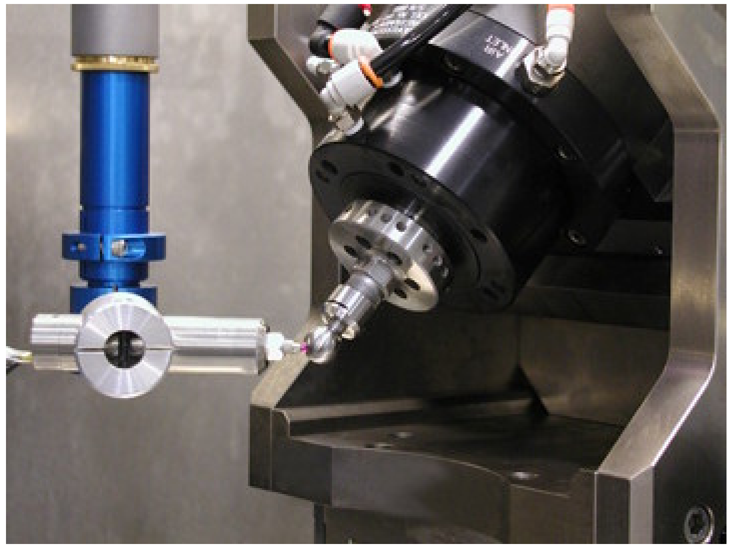
[Typical for use with vertical axis spindles and when the rotary B axis will not be used.]

First enter MDI mode and cancel all machine offsets by entering G59 without parameters and then entering G92 without parameters. In Setup mode, open the TOOL TABLE and select the tool number to be used for this wheel or tool. Enter nominal radius and sweep values for this tool number, then press the LVDT TOOL SETTER button.

Select the type of the tool set from the choices by pressing the appropriate X/Z button. Clean the kinematic mount on the spindle and the bottom of the tool setter, then mount the tool setter to the spindle. Put tape on the grinding wheel so it does not rotate during the measurements. Jog the machine axes to put the wheel near the LVDT tip and then null the tip using the IGA screen. Crown the wheel in the X direction until the peak is found, then back off by 2 mm in the Z direction.

When ready, set the feed rate override to 100%, then press the START PROBE TOOL # button and the green START pushbutton. The routine will probe the wheel in three locations and display the results in the window. Press CLOSE and SAVE to save the results.

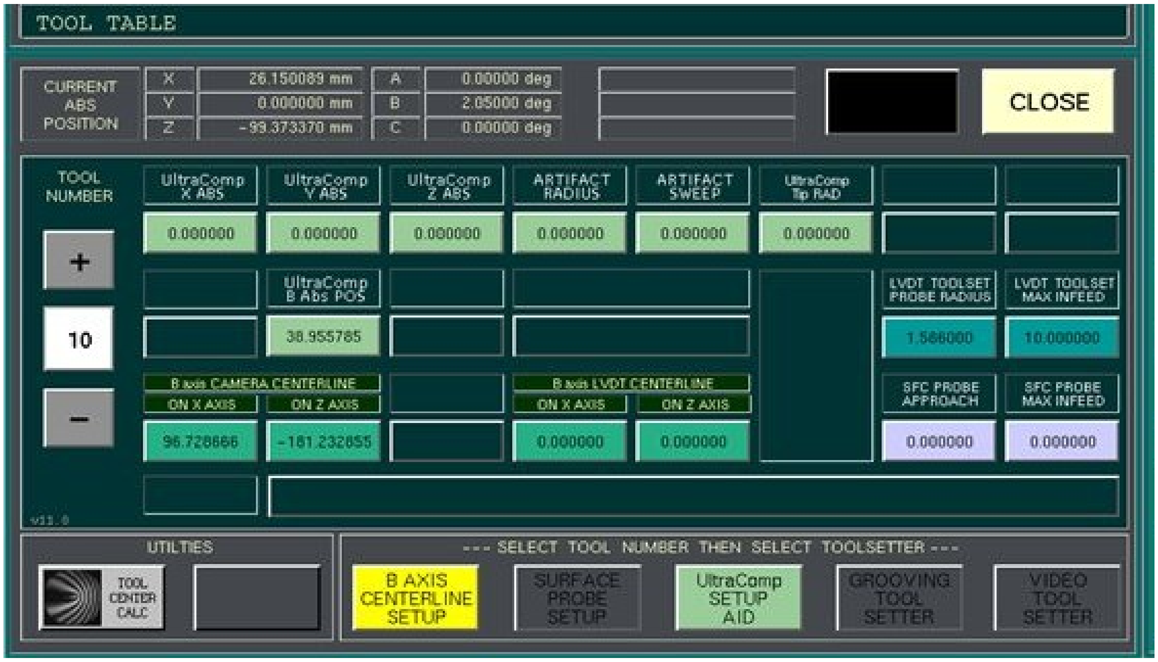
Calibration of the LVDT Tool Setter to the Rotary B Axis Centerline with Virtual Centering Software



Mount a tooling ball (sphere) in the collet of the grinding spindle, or a pin vertically near the B axis centerline. Tape the spindle to prevent rotation during the calibration. Position the B axis at approximately 45 degrees away from the operator, and position the X & Z axes until the sphere or pin is near the LVDT probe tip.

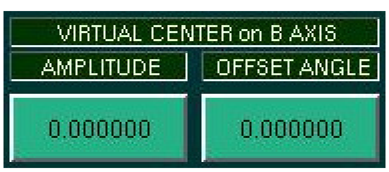
Verify the LVDT is calibrated by setting it to null against the sphere, then jog the machine a known amount such as 0.02 mm in Z and witness the display reading on the IGA screen for the LVDT displacement. It should match the machine motion within 2% or be recalibrated if necessary.

Go to the TOOL TABLE and select Tool number 10. Touch the yellow “B AXIS CENTERLINE SETUP” softkey. Touch the “FIND B(X,Z) CENTERLINE using LVDT” softkey. Enter the sphere radius in the “ARTIFACT RADIUS” field, and a sweep angle of 30 degrees (half of total sweep) in the “ARTIFACT SWEEP” field. Touch “BEGIN B AXIS CL SETUP”, jog the axes if needed, and press the green START pushbutton. The sphere will be probed and the results reported in X1, Z1, B1, and Calc Radius 1. Touch “ROTATE B AXIS 90 DEGREES POSITIVE” and the B axis will rotate to a new location. Jog the axes to bring the sphere and probe tip near each other and repeat the procedure. Touch “BEGIN B AXIS CL SETUP”, jog the axes if needed, and press the green START pushbutton. The sphere will be probed and the results reported in X2, Z2, B2, and Calc Radius 2. **<u>If</u>** the results are to be discarded and the sequence to be restarted, press the button “RESET COORDS”. Press CLOSE, then YES to Save Results, then Save again. The results are displayed in the Tool #10 window in the “ON X AXIS” and “ON Z AXIS” fields of the B Axis LVDT CENTERLINE area. Record these numbers for future reference.



Virtual Center is active any time a tool number is active that contains values in “Virtual Center Amplitude” and “Virtual Center Offset” fields. **The user must be aware that when a tool number that contains entries in these fields is called, axes motion will occur.** The Virtual center offsets become active immediately following activation of a tool number.

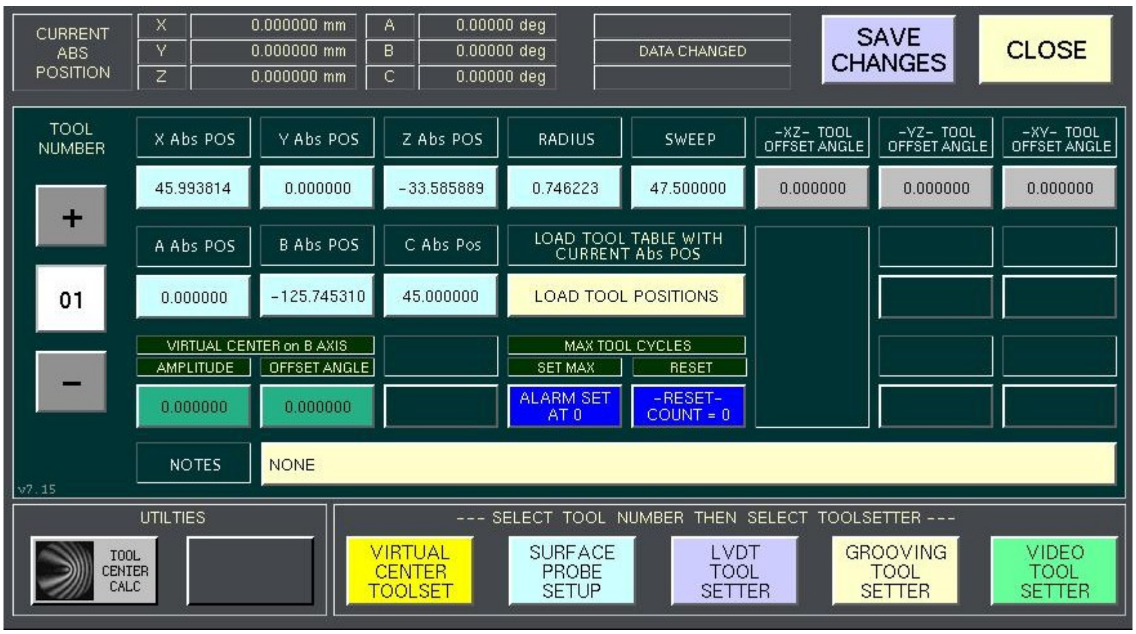
Virtual Center is disabled by setting AMPLITUDE to zero, or by selecting an alternate tool.



If a Virtual Center assigned tool is active and the offsets are cleared (i.e. set to zero) the user must also be aware that axes motion will occur as the offsets are removed.

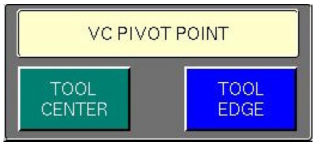
Tool Set Procedure for XZB Grinding using the LVDT Tool Setter With Virtual Center Software

[Use when the rotary B axis will be used in tool normal grinding.]
In MDI mode, cancel any machine offsets by entering G92 without parameters and G59 also without parameters. In Setup mode, Open the TOOL TABLE, and select the desired tool number. The Tool Table window is shown below. Enter the nominal radius and sweep for the grinding wheel. Zero out any existing virtual center data. Tape the grinding wheel so it does not rotate during the measurement.



Select 

, then select the image showing the LVDT tool setter and a grinding spindle. Clean the spindle kinematic balls and the bottom of the tool setter using a cloth to remove any contaminants, then mount the tool setter on the work spindle. Jog the axes to position the LVDT tip near the wheel then display the output on the IGA screen and null the LVDT against the wheel. Crown the wheel to determine the high point in X, then back away 2 mm. Set the Feed rate override to 100%, then when ready press the START PROBE # button and the green START button. The routine will then probe the wheel in three locations and display the results of the tool set.



Select TOOL EDGE when exiting to set the edge of the wheel to be the virtual center of rotation of B. Use this mode if multiple tool set locations are to be repeated around the radius of the tool. Select TOOL CENTER when exiting to set the center of the radius to be the virtual center of rotation of B. Use this mode to allow the B axis to be shifted in rotation to present fresh tool (for some applications) or for use when testing the software on a dowel pin.

Also note that when the Virtual Center tool set routine is active, the offsets are made active when the user exits the tool set page. This will cause motion of the machine so the axes should be jogged into a clearance position before exiting the tool window. Ensure to SAVE the results when closing the window.

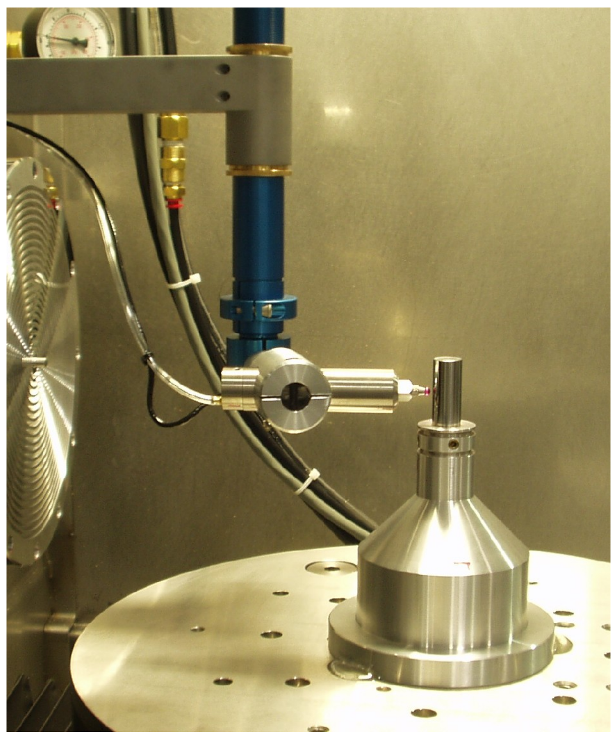
Validation of Virtual Center Toolset Calibration

To check the quality of the tool set and operation of Virtual Centering, setup a round test part, artifact or pin eccentric from the B axis centerline by 5-10 mm. Go to the TOOL Table, and enter the part radius in the RADIUS field, and enter 40 degrees in the SWEEP field for Tool #2. Close the Tool Table and activate tool #2 using the MDI command T2. Go back to the Tool Table and perform the Virtual LVDT Tool Set routine on the test part. Save the resulting data to Tool #2. Close the screen, selecting CENTER data. Jog the axes until the LVDT toolset probe is nulled on the surface of the test part, using the IGA screen to view the displacement of the LVDT. Find the crown of the test part by jogging back and forth in the X direction. With T2 active, rotating the B axis should cause a shift of the X and Z slides, such that the center of the test part does not move in respect to the probe tip. The display reading of the LVDT probe should have very minimal movement.

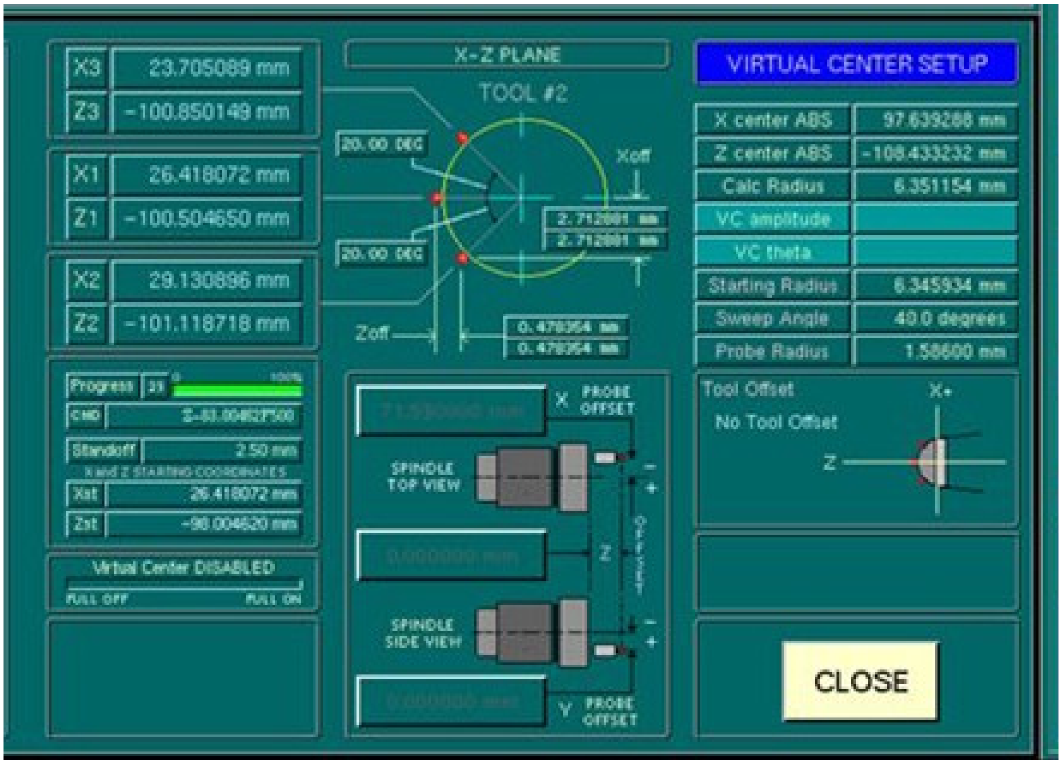
Calibration of the LVDT Tool Setter to the B axis centerline without Virtual Centering.

Install the LVDT tool setter to the work spindle. Place the 3 mm pin and fixture (or equivalent similar fixture) on the B axis table and indicate the pin to run accurately in rotation with the B rotation within 0.000040 inch at the working height of the tools. Epoxy the fixture to keep it from moving during the remaining calibration. The LVDT tool setter can be monitored on the IGA screen on the UPX controller. Move the machine axes until the probe is touching the pin. Crown the pin by moving X until a peak is reached. Then null the gage in Z.

Verify the LVDT is calibrated by jogging the machine a known amount such as 0.02 mm in Z and witness the display reading on the IGA screen for the LVDT displacement. It should match the machine motion within 2% or be recalibrated if necessary.



The center of B is this X position and a Z position offset from the current position by the radius of the pin. Record these values in the B Axis LVDT CENTERLINE field for Tool #10.



Tool Set Procedure for XZB Grinding using the LVDT Tool Setter Without Virtual Center Software

[sharp edged wheels] Install the grinding wheel into the collet of the high speed spindle. The B axis should be set to be 0.0 when the two spindles are parallel. Rotate the B axis until it is at the angle where it is intended to be used. Install the LVDT tool setter to the work spindle. Move the X axis until the probe aligns with the side of the wheel and move Z to position the tool setter at the B axis centerline. Ensure the wheel does not interfere with the probe during this motion. Move the high speed spindle sideways on top of B using the XZ sliding adjustment if needed to establish clearance. Move the high speed spindle sideways until the probe is then nulled. Check the run out of the wheel surface and dress if necessary before continuing. Move Z to clearance, Rotate the B axis to zero, and align the X axis to align with the end of the wheel. Move Z to position the LVDT null over the B axis and shift the high speed spindle axially until the probe is nulled.

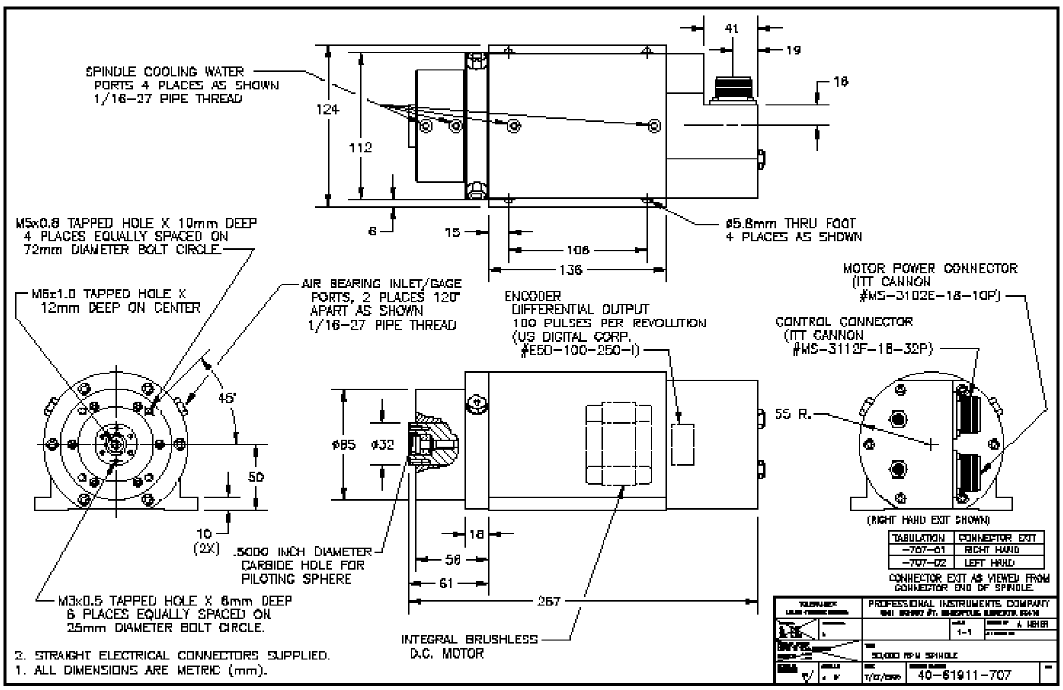
[ball shaped wheels] Install the grinding wheel into the collet of the high speed spindle. Rotate the B axis until it is at 90 degrees. Install the LVDT tool setter to the work spindle. Move the X axis until the probe aligns with the edge of the wheel and move Z until the probe is nulled. Check the run out of the wheel surface and dress if necessary before continuing. Record this value of Z. Back Z away, rotate B to -90 degrees, realign X, and probe the other side of the wheel. The Z null position on the other side should be the same as the first side. Any error represents the amount the high speed spindle is shifted away from the B axis centerline. Move the Z by half the error, and shift the high speed spindle the same half of the error (move to clearance first to avoid a crash). Repeat probing both sides of the wheel until they repeat within the tolerance desired (at least smaller than the error motion of the wheel surface). At this point move the rotary B axis to zero, move the X to align with B, and probe the wheel vertex. Shift the high speed spindle axially if needed until the probe is at the same Z position as the two side probings. This will provide stock for dressing 180 degrees of wheel grinding area. Repeat the probing at all three points to ensure the parts have not shifted during the alignment and bolt all joints down tight.

Spare Parts for the LVDT tool setter:

Ruby stylus tip 0.125 inch diameter 168-0019
Ruby stylus tip 0.062 inch diameter 168-0018
Ruby stylus tip 0.031 inch diameter 168-0017
Replacement probe cover 03264 + 101-0022 O ring + 700-0397 set screw
Replacement 10 foot extension cable A11133

SECTION 3

PI 50,000 RPM Motorized Air Bearing Spindle



Air Bearing Specifications

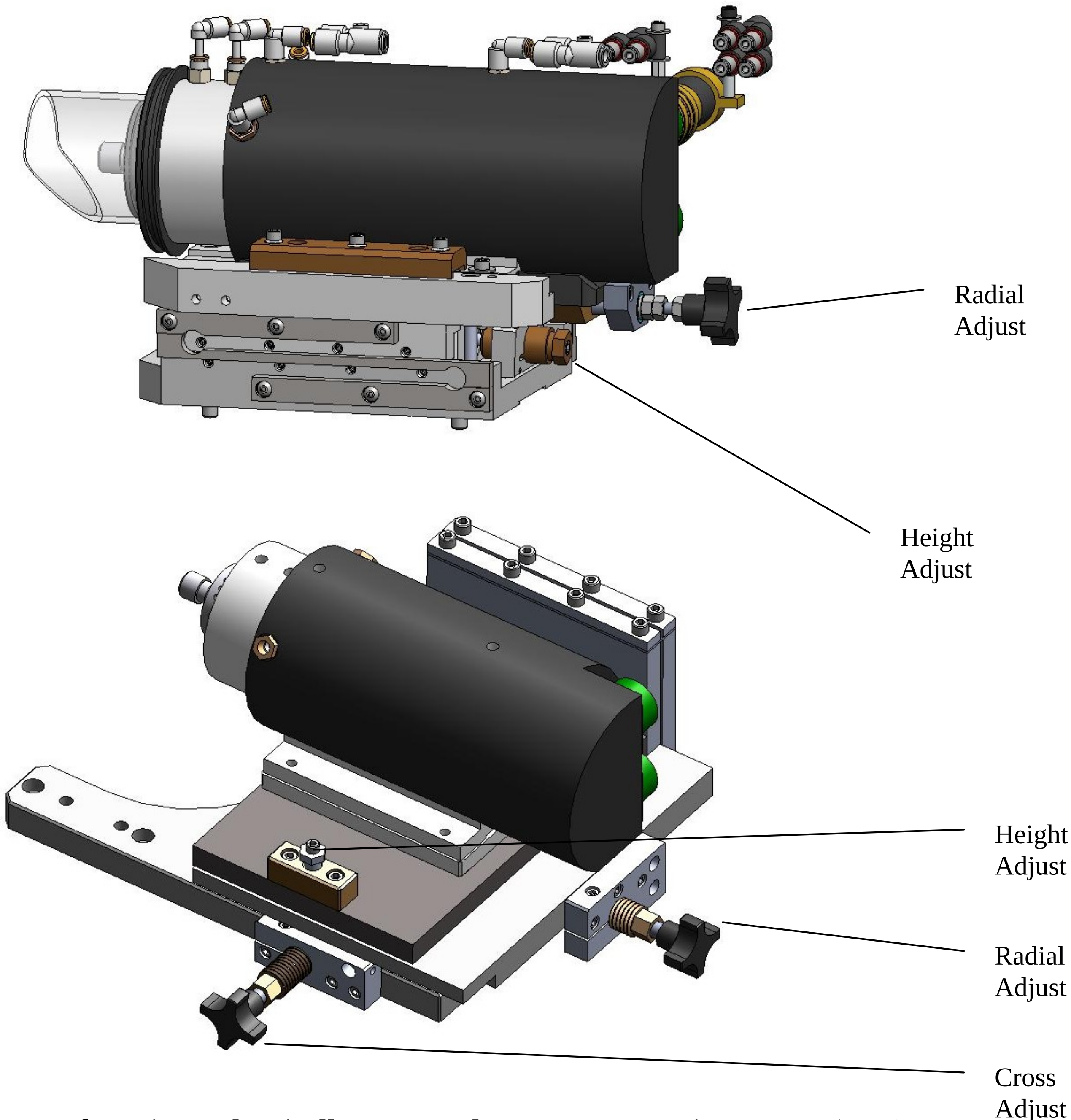
Where the word Ultimate is used below, this is the point where the air bearing will not float any more and the spindle is likely to seize under these conditions. It is recommended to maintain forces less than half of the Ultimate ratings.

Data as provided by the Spindle Supplier:

Inlet Air Pressure	6.9 Bar
Air Flow Rate	10 lpm
Ultimate Axial Load Capacity	340 N
Ultimate Radial Load Capacity at the Spindle Nose	195 N
Axial Stiffness	65 N/um
Radial Stiffness at the Spindle Nose	20 N/um
Axial Error Motion	<25 nm at 50,000 RPM
Radial Error Motion	<25 nm at 50,000 RPM
Maximum Speed	50,000 RPM
Spindle Weight	6.8 kg

Estimated Values:

Liquid coolant flow rate is estimated at 1 lpm@50 psi pressure
Heat load versus RPM is estimated at 400 watts at 30,000 RPM
Chiller requirements: 1200 Watts for full speed range operation

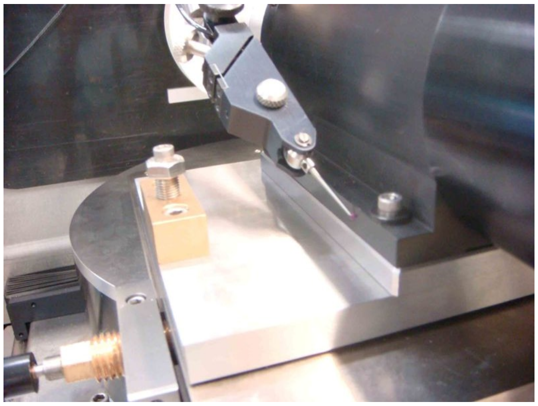


Setup of Horizontal Spindle Mounted on Rotary B axis A17750 (Top) or A16810-04 (Bottom)

Mounting Grinder
Clear the B axis (or round tooling riser) table top and clean and stone the mounting surface. Also clean and stone the mounting surfaces for the grinder parts. Mount the grinder on the tabletop. Due to the weight of the grinder, it is recommended to use a crane to lift the grinder into place. Tapped holes are

provided in the grinder for the use of lifting rings. Ensure the connectors are clear of any contaminants, and purge the air line of any contaminants. With the machine in E stop, connect the power cables, signal cables, air line to the air bearing, spindle coolant hoses, and spray mist hoses or flood coolant hose and nozzle. Collect any dust caps or hose plugs and bag these with a label indicating the contents.

Align the Parts



Mount a pin in the collet of the grinding spindle. If the B axis is present, rotate the B axis until the side of the grinding spindle mount is parallel to the Z axis using an indicator and zero the B axis angle in this location (G92B0). Indicate the side of the pin and examine if the pin moves parallel when the grinding spindle is moved along the radial positioning slide. If the pin is not moving parallel then loosen the spindle mounting bolts and tap the spindle into alignment with the radial slide travel. If this step is not completed the wheel will shift in X offset when it is adjusted along this slide. Realign the spindle to the Z axis using B rotation and rezero the B axis in this location.

Setting of Grinding Spindle Height

Mount the pointer A13782 in the work spindle and align it to run true with the spindle axis of rotation. The pin size in A13782 should be the same size as the pin in the grinding spindle collet. Indicate the height of the pin in the work spindle, and then move the indicator to read the height of the pin in the grinding spindle collet. If necessary, adjust the grinding spindle height by loosening the clamping bolts and adjusting the spindle up and down until the grinding spindle is at the correct height. Retighten the clamping bolts and remove the pin and fixture A13782.

Aligning with B axis Centerline

The A17750 assembly does not have provisions for cross axis motion so this requires the use of Virtual Centering software to put the edge of the wheel at the center of rotation of the B axis. The A16810 assembly does have a cross axis slide so this can be used to position the wheel edge over the B axis centerline.

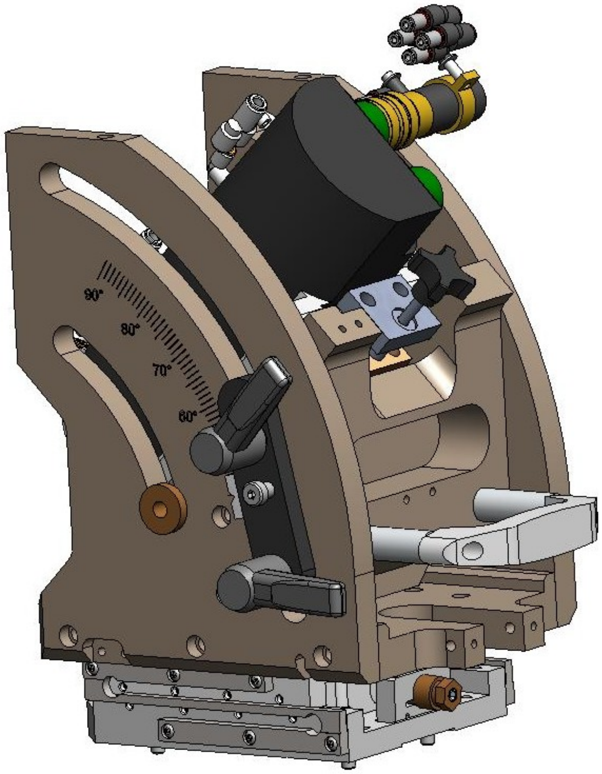
For process instructions see the section later in this manual on General Grinder

Operational Notes.

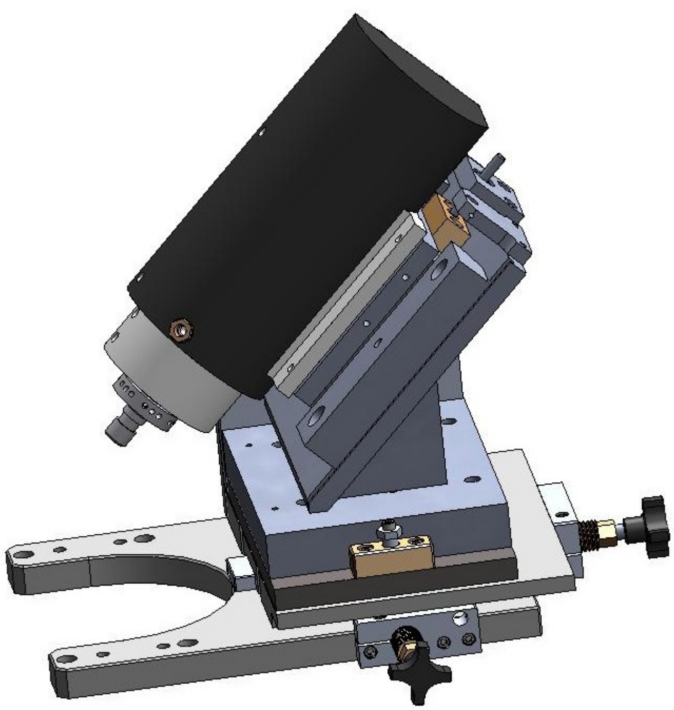
Fine Setting of Wheel Height

Once the ground part has been examined under a microscope, it may show the need to fine tune the wheel height to remove any center defect that was not ground correctly. For these fine adjustments, place an indicator in a position to measure the spindle height motion. For the A17750 assembly, the height is adjusted using the wedge plate under the grinder. Loosen the four clamping bolts and shift the height using the brass hex under the spindle. For the A16810 assembly, there is a drive screw on one side and flexure on the other side of the spindle. Loosen the clamp bolts and adjust the drive screw to change height, and then reclamp the bolts.

Setup of 45 Degree Fixed Spindle Mount (A16810-04) (right) -OR- 45 Degrees to Vertical Adjustable Spindle Mount (A17750) used with 45 Degree Spindle Orientation (left)

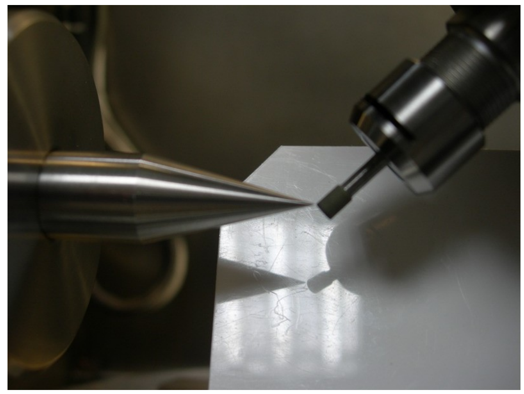


Mounting Grinder:
Clear the B axis (or round tooling riser) table top and clean and stone the mounting surface. Also clean and stone the mounting surfaces for the grinder parts. Mount the grinder on the tabletop. Due to the weight of the grinder, it is recommended to use a crane to lift the grinder into place. Tapped holes are provided in the grinder for the use of lifting rings. Ensure the connectors are clear of any contaminants, and purge the air line of any contaminants. Connect the power cables, signal cables, air line to the air bearing, spindle coolant hoses, and spray mist hoses or flood coolant hose and nozzle. Collect any dust caps or hose plugs and bag these with a label indicating the contents.



Align the Parts:
Mount a pin in the collet of the grinding spindle. If the B axis is present, rotate the B axis until the side of the grinding spindle mount is parallel to the Z axis using an indicator. Zero the B

axis angle in this location (G92B0). Indicate the side of the pin and examine if the pin moves parallel when the grinding spindle is moved up and down the 45 degree slide. If the pin is not moving parallel then loosen the spindle mounting bolts and tap the spindle into alignment with the 45 degree slide travel. If this step is not completed the wheel will shift in X offset when it is adjusted in height.



Coarse Setting of Wheel Height:
Mount the grinding wheel in the spindle. Mount the pointer A17775 in the work spindle and align it to run true with the spindle axis of rotation. Jog the slides to close the gap and examine the height of the wheel against the pointer. If necessary, adjust the spindle height by loosening the clamping bolts and adjusting the spindle up and down the 45 degree slope with the coarse adjustment screw until the wheel is at the correct height by eye with an eye loupe. Retighten the slide clamping bolts.

Aligning with B axis Centerline:
The A17750 assembly does not have provisions for cross axis motion so this requires the use of Virtual Centering software to put the edge of the wheel at the center of rotation of the B axis. The A16810 assembly does have a cross axis slide so this can be used to position the wheel edge over the B axis centerline.

For process instructions see the section later in this manual on General Grinder Operational Notes.

Fine Setting of Wheel Height:
Once the ground part has been examined under a microscope, it may show the need to fine tune the wheel height to remove any center defect that was not ground correctly. For these fine adjustments, place an indicator in a position to measure the spindle height motion. For the A17750 assembly, the height is adjusted using the wedge plate under the grinder. Loosen the four clamping bolts and shift the height using the brass hex under the spindle. For the A16810 assembly, there is a drive screw on one side and flexure on the other side of the spindle. Loosen the clamp bolts and adjust the drive screw to change height, and then reclamp the bolts. See below:

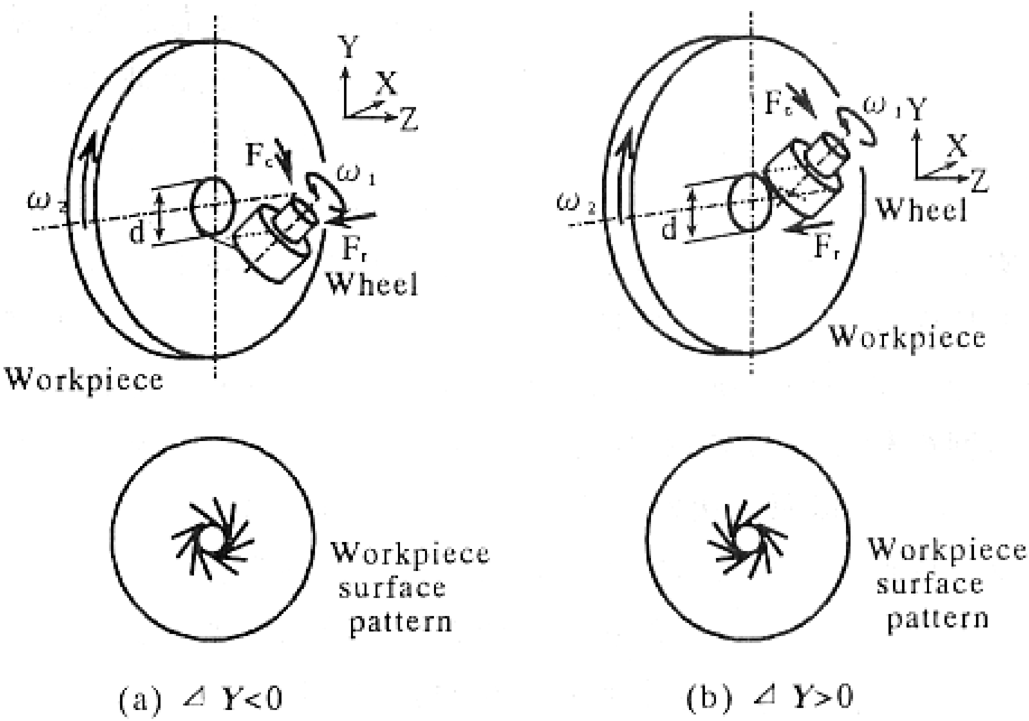
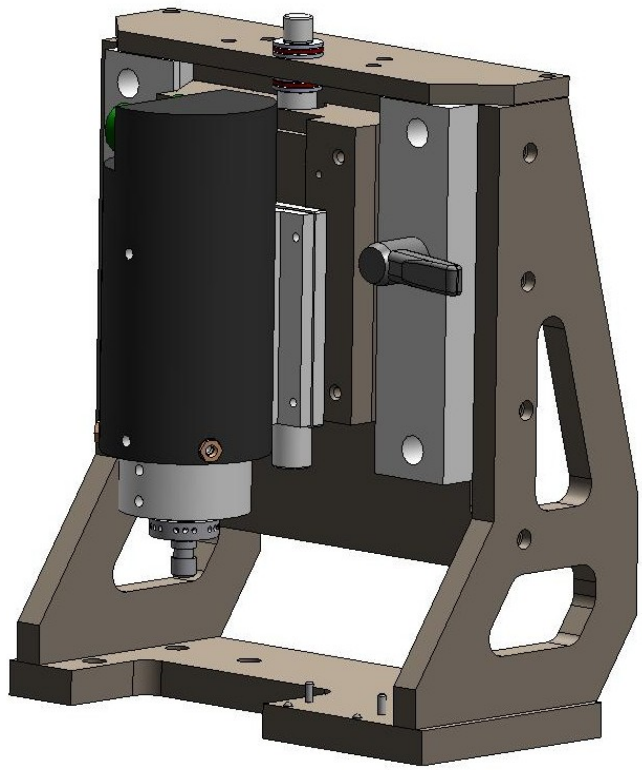


Fig.4 The effect of wheel setting error in the Y-direction on the workpiece surface pattern

Setup of Vertical Spindle Mount A16810-03

Mounting Grinder:
Clear the B axis (or round tooling riser) table top and clean and stone the mounting surface. Also clean and stone the mounting surfaces for the grinder parts. Mount the grinder on the tabletop. Due to the weight of the grinder, it is recommended to use a crane to lift the grinder into place. Tapped holes are provided in the grinder for the use of lifting rings. Ensure the connectors are clear of any contaminants, and purge the air line of any contaminants.



Connect the power cables, signal cables, air line to the air bearing, spindle coolant hoses, and spray mist hoses or flood coolant hose and nozzle. Collect any dust caps or hose plugs and bag these with a label indicating the contents.

Align the Parts:
Mount a pin in the collet of the grinding spindle. If the B axis is present, rotate the B axis until the side of the grinding spindle mount is parallel to the Z axis using an indicator and zero the B axis angle in this location (G92B0). Indicate the side of the pin and examine if the pin moves parallel when the grinding spindle is moved up and down the vertical slide. If the pin is not moving parallel then loosen the spindle mounting bolts and tap the spindle into alignment with the vertical slide travel. If this step is not completed the wheel will shift in X offset when it is adjusted in height.

Coarse Setting of Wheel Height:
Mount the grinding wheel in the spindle. Mount the pointer A17775 in the work

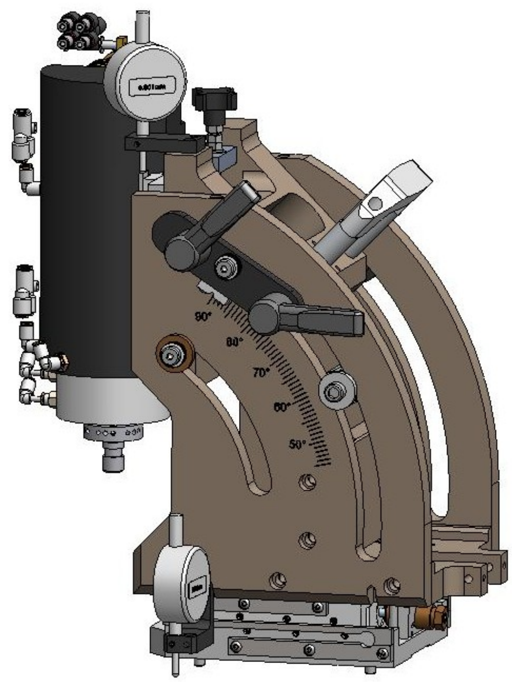
spindle and examine the height of the wheel against the pointer. If necessary, adjust the spindle height by loosening the clamping bolts and adjusting the height with the adjustment screw until the wheel is at the correct height by eye with an eye loupe. Retighten the clamping bolts.

For process instructions see the section later in this manual on General Grinder Operational Notes.

Fine Setting of Wheel Height:
Once the ground part has been examined under a microscope, it may show the need to fine tune the wheel height to remove any center defect that was not ground correctly. For these fine adjustments, place an indicator in a position to measure the spindle height motion. Loosen the clamp bolts and adjust the drive screw to change height, and then reclamp the bolts.

Setup of 45 Degrees to Vertical Adjustable Spindle Mount (A17750) used with Vertical Spindle orientation

Mounting Grinder:
Clear the B axis table top (or round tooling riser) and clean and stone the mounting surface. Also clean and stone the top and bottom mounting surfaces for the wedge plate height adjuster. Mount the wedge plate on the B axis tabletop. Clean and stone the bottom surface of the grinder mount, then install the grinder to the wedge plate. Due to the weight of the grinder, it is recommended to use a crane to lift the grinder into place. Tapped holes are provided in the vertical grinder for the use of lifting rings. Ensure the Ultracomp mount will fit and shift the spindle mount by one set of bolt holes if necessary. Ensure the connectors are clear of any contaminants, and purge the air line of any contaminants. Connect the power cables, signal cables, air line to the air bearing, spindle coolant hoses, and spray mist hoses or flood coolant hose and nozzle. Collect any dust caps or hose plugs and bag these with a label indicating the contents.



Align the Parts:
Mount a pin in the collet of the grinding spindle. If the B axis is present, rotate the B axis until the side of the grinding spindle mount is parallel to the Z axis using an indicator and zero the B axis angle in this location (G92B0). Indicate the side of the pin and examine if the pin moves parallel when the grinding spindle is moved up and down the vertical slide. If the pin is not moving parallel then loosen the spindle mounting bolts and tap the spindle into alignment with the vertical slide travel. If this step is not completed the wheel will shift in X offset when it is adjusted in height.

Coarse Setting of Wheel Height:
Mount the desired grinding wheel in the spindle. Mount the pointer A17775 in the work spindle and align it to run true with the spindle axis of rotation. Jog the slides to close the gap and examine the height of the wheel against the pointer. If necessary, adjust the spindle height by loosening the four clamping bolts (larger size, in slots) and adjusting the height with the coarse adjustment screw until the wheel is at the correct height by eye with an eye loupe. Retighten the four clamping bolts.

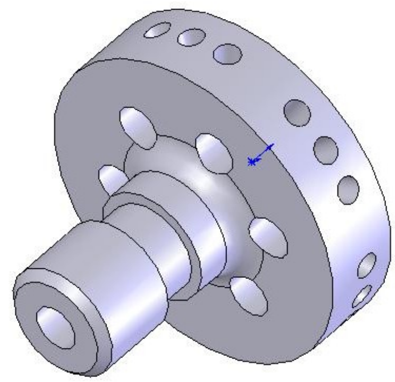
For process instructions see the section later in this manual on General Grinder Operational Notes.

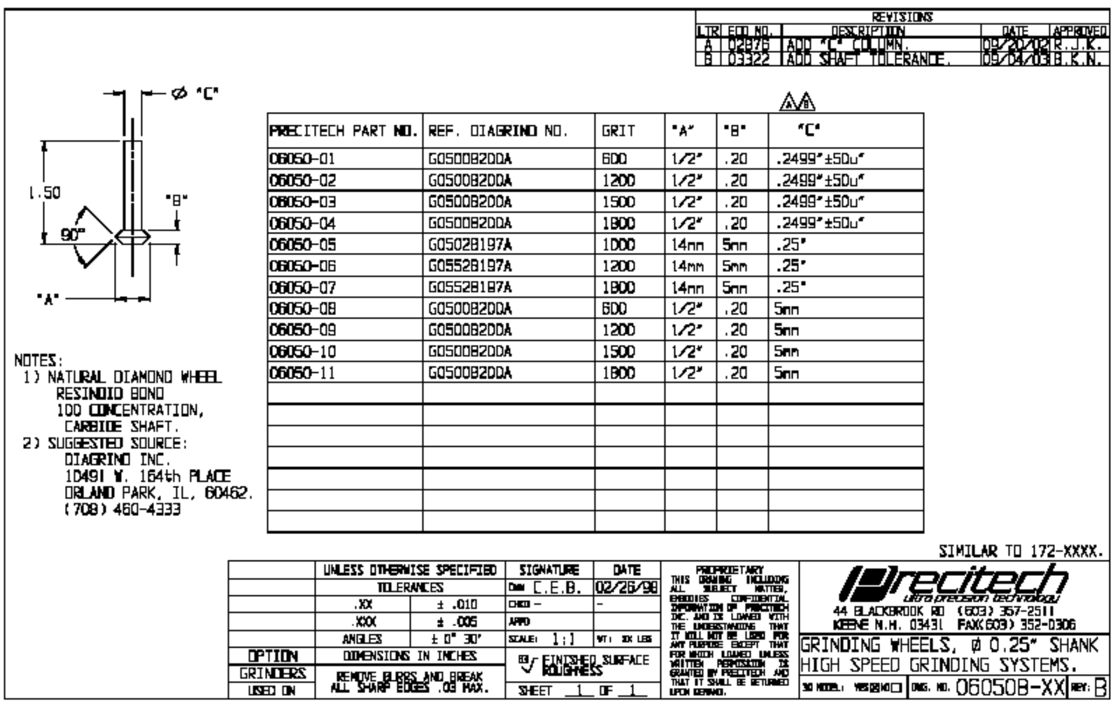
Fine Setting of Wheel Height:
Once the ground part has been examined under a microscope, it may show the need to fine tune the wheel height to remove any center defect that was not ground correctly. For these fine adjustments, place an indicator in a position to measure the spindle height motion. Loosen the clamp bolts and adjust the drive screw to change height, and then reclamp the bolts.

Spindle Tooling for the PI 50,000 RPM Spindle

This spindle is available with two types of tooling, either a collet or a bolt on flycutting head.

Collet A11777:
The 50,000 RPM spindle collet is A11777. It uses an ER-11 style collet which is available in 0.5 mm increments from 0.5 mm diameter up to 7.0 mm diameter size. The collet is clamped manually using spanner wrenches. The collet adapter is provided with balancing holes.





REVISIONS				
LTR	ECO NO.	DESCRIPTION	DATE	APPROVED
A	02876	ADD "C" COLUMN.	09/20/02	R.J.K.
B	03322	ADD SHAFT TOLERANCE.	09/04/03	B.K.N.

PRECITECH PART NO.	REF. DIAGRIND NO.	GRIT	"A"	"B"	"C"
06050-01	G0500B2DDA	600	1/2"	.20	.2499"±50u"
06050-02	G0500B2DDA	1200	1/2"	.20	.2499"±50u"
06050-03	G0500B2DDA	1500	1/2"	.20	.2499"±50u"
06050-04	G0500B2DDA	1800	1/2"	.20	.2499"±50u"
06050-05	G0502B197A	1000	14mm	5mm	.25"
06050-06	G0552B197A	1200	14mm	5mm	.25"
06050-07	G0552B197A	1800	14mm	5mm	.25"
06050-08	G0500B2DDA	600	1/2"	.20	5mm
06050-09	G0500B2DDA	1200	1/2"	.20	5mm
06050-10	G0500B2DDA	1500	1/2"	.20	5mm
06050-11	G0500B2DDA	1800	1/2"	.20	5mm

NOTES:
1) NATURAL DIAMOND WHEEL
RESINOID BOND
100 CONCENTRATION,
CARBIDE SHAFT.
2) SUGGESTED SOURCE:
DIAGRIND INC.
10491 W. 164th PLACE
ORLAND PARK, IL, 60462.
(708) 460-4333

SIMILAR TO 172-XXXX.

	UNLESS OTHERWISE SPECIFIED		SIGNATURE	DATE
	TOLERANCES		DWN C.E.B.	02/26/98
	.XX	± .010	CHKD –	–
	.XXX	± .005	APPD	
	ANGLES	± 0° 30'	SCALE: 1:1	WT: XX LBS
OPTION	DIMENSIONS IN INCHES		FINISHED SURFACE ROUGHNESS	
GRINDERS	REMOVE BURRS AND BREAK ALL SHARP EDGES .03 MAX.		SHEET 1 OF 1	
USED ON				

PROPRIETARY
THIS DRAWING INCLUDING ALL SUBJECT MATTER, EMBODIES CONFIDENTIAL INFORMATION OF PRECITECH INC. AND IS LOANED WITH THE UNDERSTANDING THAT IT WILL NOT BE USED FOR ANY PURPOSE EXCEPT THAT FOR WHICH LOANED UNLESS WRITTEN PERMISSION IS GRANTED BY PRECITECH AND THAT IT SHALL BE RETURNED UPON DEMAND.

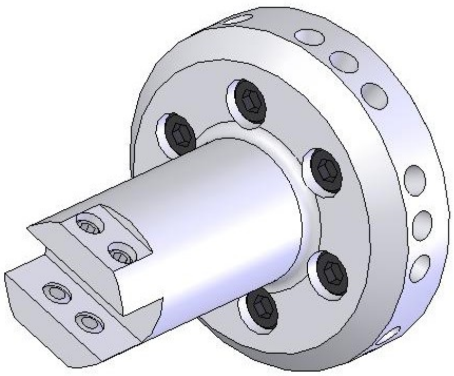
Precitech ultra precision technology
44 BLACKBROOK RD (603) 357-2511
KEENE N.H. 03431 FAX(603) 352-0306

GRINDING WHEELS, Ø 0.25" SHANK
HIGH SPEED GRINDING SYSTEMS.

3D MODEL: YES NO | DWG. NO. 06050B-XX | REV: B

Grinding Wheel 06050
Insert the desired grinding wheel or milling tool into the collet and insert it until it bottoms out. This enables the wheel to be reinserted with repeatability. Ideally all of the wheels used will have the same overall length so that wheels can be changed without resetting the spindle height. Bring the part to be ground and fixture to the machine and examine the interaction of the wheel and part. It may be necessary to extend the wheel out from the collet to provide shank clearance with the part and fixture.

Flycutting Head
The flycutting head A13510 is used to carry a shank based diamond cutting tool at high speed for flycutting operations. These are typically used in the creation of freeform surfaces by raster milling or spiral milling. The shank based tool is mounted using setscrews. Balancing holes are also provided in the adapter.



Electrical Power to Grinder Cart (if Supplied)

The grinder cart is factory wired (to customer specification) for 208 VAC or 230 VAC, 50/60 Hz, single phase. The power connection should be made to a dedicated receptacle controlled by a 30 amp circuit breaker (slow response, type c/d). Maximum power rating is 2.0 KVA.

SECTION 4

SP-75 15,000 RPM Motorized Air Bearing Spindle

This grinder attachment utilizes a high-stiffness, vertically mounted 15,000RPM air bearing spindle, which may be fitted with a grinding wheel or diamond flycutting head to rotate in the horizontal plane. The attachment can be used to grind harder materials, which cannot be diamond turned, or spiral CNC mill freeform non axis symmetric surfaces. The spindle has a relieved nose for accepting a large array of parts. Spherical and aspherical parts may be ground with diamond grinding wheel diameters ranging from 55mm (2.0") to 127mm (5.0").

Air Bearing

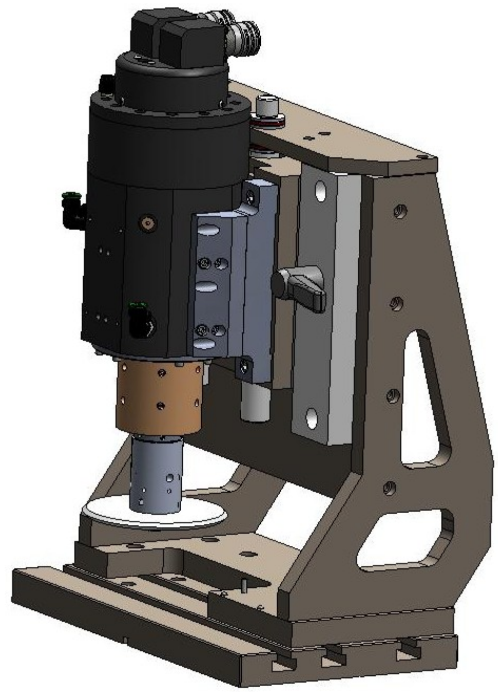
Radial Load Capacity at spindle nose (derated 50%) 27 kg (60 lbs) @100 psi

Axial stiffness	105 N/um
Radial Stiffness	35 N/um
Axial and Radial Motion accuracy	<50 nm
Water cooling passages	Provided
Maximum Speed	15,000 RPM

Grinding wheel diameter range from 55mm (2.0") to 127mm (5.0")

Setup of Vertical Mount (A16810-03)

Mounting Grinder:



Clear the B axis table top (or round tooling riser) and clean and stone the mounting surface. Also clean and stone the mounting surfaces of the grinder mount, then install the grinder to the tabletop. Due to the weight of the grinder, it is recommended to use a crane to lift the grinder into place. Tapped holes are provided in the vertical grinder for the use of lifting rings. Ensure the connectors are clear of any contaminants, and purge the air line of any contaminants. Connect the power cables, signal cables, air line to the air bearing, spindle coolant hoses, and spraymist hoses or flood coolant hose and nozzle. Collect any dust caps or hose plugs and bag these with a label indicating the contents.

Align the Parts:
Mount a pin in the collet of the grinding spindle. If the B axis is present, rotate the B axis until the side of the grinding spindle mount is parallel to the Z axis using an indicator and zero the B axis angle in this location (G92B0). Record this ABS angle in case it is needed later. Indicate the side of the pin and examine if the pin moves parallel when the grinding spindle is moved up and down the vertical slide. If the pin is not moving parallel then loosen the spindle mounting bolts and tap the spindle into alignment with the vertical slide travel. If this step is not completed the wheel will shift in X offset when it is adjusted in height.

Coarse Setting of Wheel Height:
Mount the desired grinding wheel in the spindle. Mount the pointer A17775 in the work spindle and align it to run true with the spindle axis of rotation. Jog the slides to close the gap and examine the height of the wheel against the pointer. If necessary, adjust the spindle height by loosening the clamping bolts and adjusting the height with the adjustment screw until the wheel is at the correct

height by eye with an eye loupe. Retighten the clamping bolts.

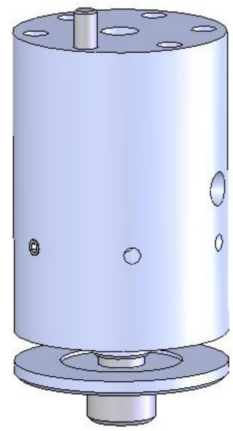
For process instructions see the section later in this manual on General Grinder Operational Notes.

Fine Setting of Wheel Height:
Once the ground part has been examined under a microscope, it may show the need to fine tune the wheel height to remove any center defect that was not ground correctly. For these fine adjustments, place an indicator in a position to measure the spindle height motion. Loosen the clamp bolts and adjust the drive screw to change height, and then reclamp the bolts.

Spindle Tooling for the SP75 Spindle

Arbor:

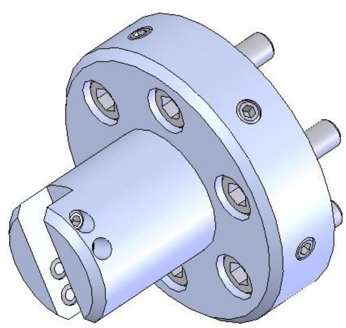
The arbor acts as an adapter for the grinding wheel and extends the wheel away from the spindle body for clearance with concave work pieces. The arbor is 1.75 inches (44.5 mm) in diameter so the effective minimum wheel diameter is about 2 inches (50 mm). The pilot on the arbor for the grinding wheel is 0.500/.499 inches (12.700/12.675 mm) diameter and 0.20 inches (5.08 mm) long.



A10939-14 1.33 inches (33.8 mm) long
A10939-04 2.5 inches (63.5 mm) long
A10939-12 3.5 inches (88.9 mm) long
A10939-05 4.5 inches (114.3 mm) long

Grinding Wheel for Arbor A10939:

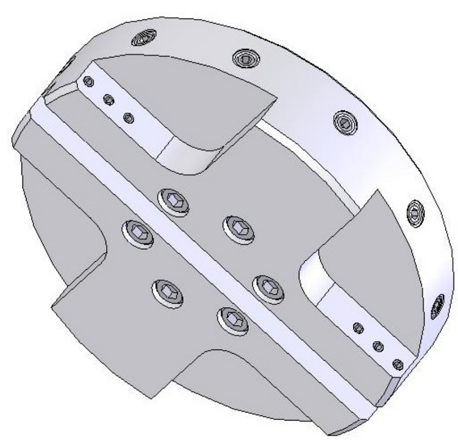
The grinding wheel can have a pointed or vee shaped edge or a radiused edge. The minimum thickness is 0.2 inches and a center hole of 0.500/0.505 inches (12.700/12.827 mm) is required. Reference 172-0007 (320 grit) through 172-0011 (1800 grit)



Flycutting Head 1 Inch (25 mm) Diameter:

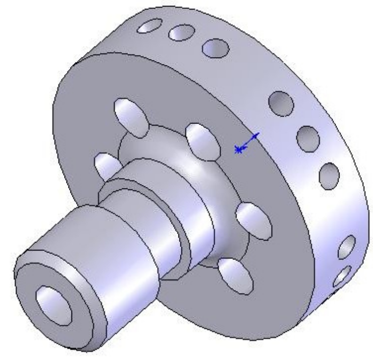
This head accepts a diamond cutting tool mounted to a 0.25 inch (6.35 mm) square steel shank. It is provided with balancing holes and mounting hardware. Note that this does not fit the PI spindle, only the SP75 spindle.
A10939-01

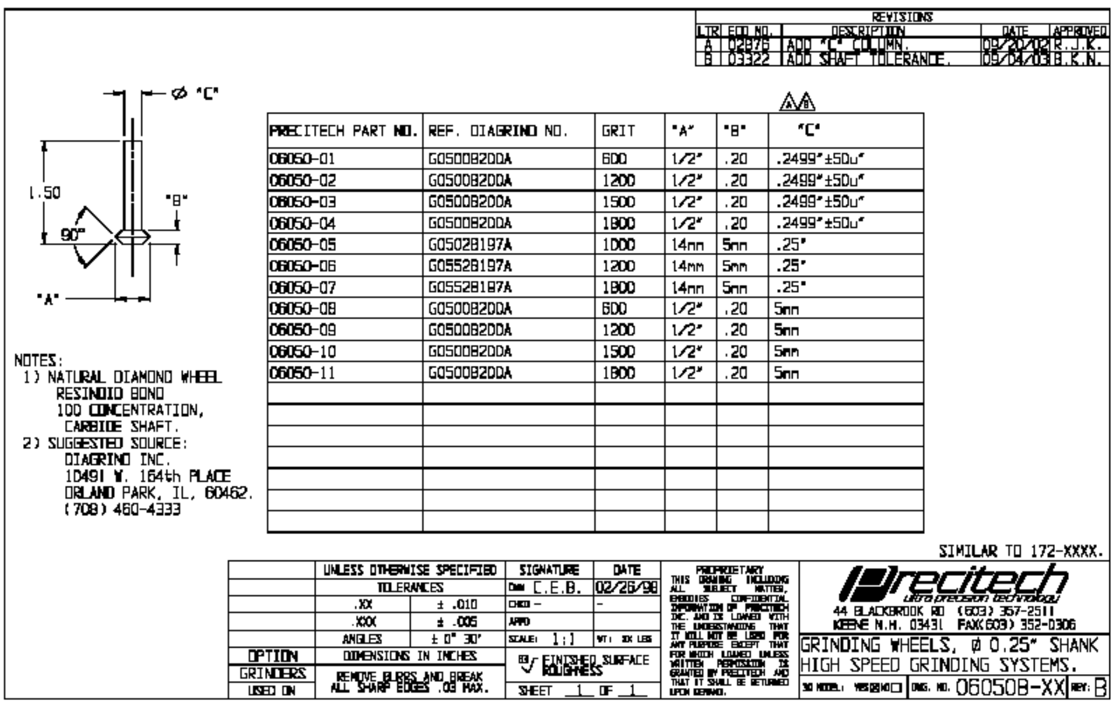
Flycutting Head 4.25 Inches (108 mm) Diameter:



This head accepts a diamond cutting tool mounted to a 0.25 inch (6.35 mm) square steel shank. A second shank is mounted on the opposite side for balancing purposes. It is provided with balancing holes and mounting hardware. The invar version is for use when thermal drift must be minimized.
A10939-02 Invar
A10939-03 Aluminum

Collet A10900:
The SP75 spindle collet is A10900. It uses an ER-11 style collet which is available in 0.5 mm increments from 0.5 mm diameter up to 7.0 mm diameter size. The collet is clamped manually using spanner wrenches. The collet adapter is provided with balancing holes.





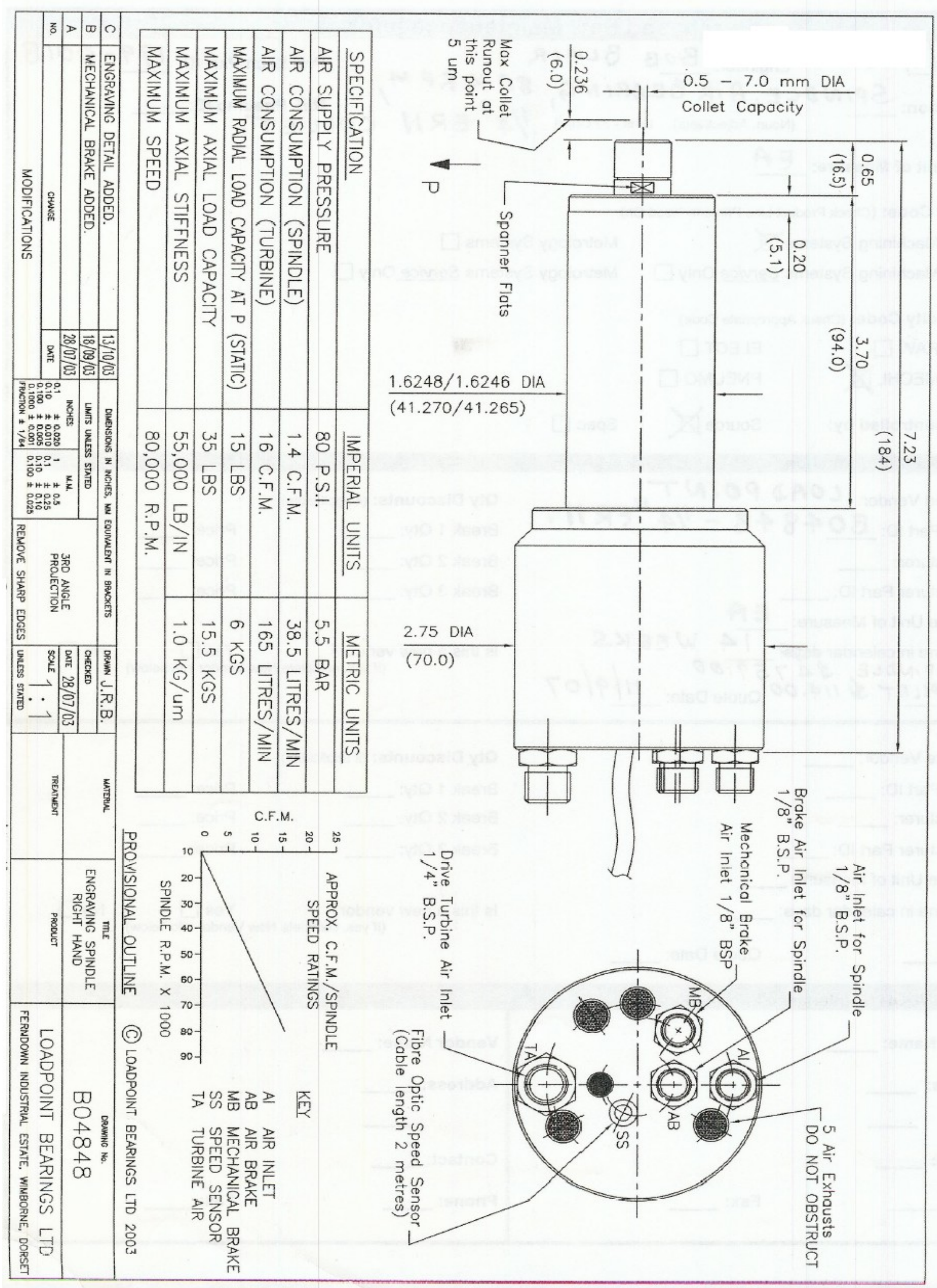
PRECITECH PART NO.	REF. DIAGRIND NO.	GRIT	"A"	"B"	"C"
06050-01	G0500B2DDA	600	1/2"	.20	.2499"±50u"
06050-02	G0500B2DDA	1200	1/2"	.20	.2499"±50u"
06050-03	G0500B2DDA	1500	1/2"	.20	.2499"±50u"
06050-04	G0500B2DDA	1800	1/2"	.20	.2499"±50u"
06050-05	G0502B197A	1000	14mm	5mm	.25"
06050-06	G0552B197A	1200	14mm	5mm	.25"
06050-07	G0552B187A	1800	14mm	5mm	.25"
06050-08	G0500B2DDA	600	1/2"	.20	5mm
06050-09	G0500B2DDA	1200	1/2"	.20	5mm
06050-10	G0500B2DDA	1500	1/2"	.20	5mm
06050-11	G0500B2DDA	1800	1/2"	.20	5mm

Grinding Wheel for Collet 06050:
Insert the desired grinding wheel or milling tool into the collet and insert it until it bottoms out. This enables the wheel to be reinserted with repeatability. Ideally all of the wheels used will have the same overall length so that wheels can be changed without resetting the spindle height. Bring the part to be ground and fixture to the machine and examine the interaction of the wheel and part. It may be necessary to extend the wheel out from the collet to provide shank clearance with the part and fixture.

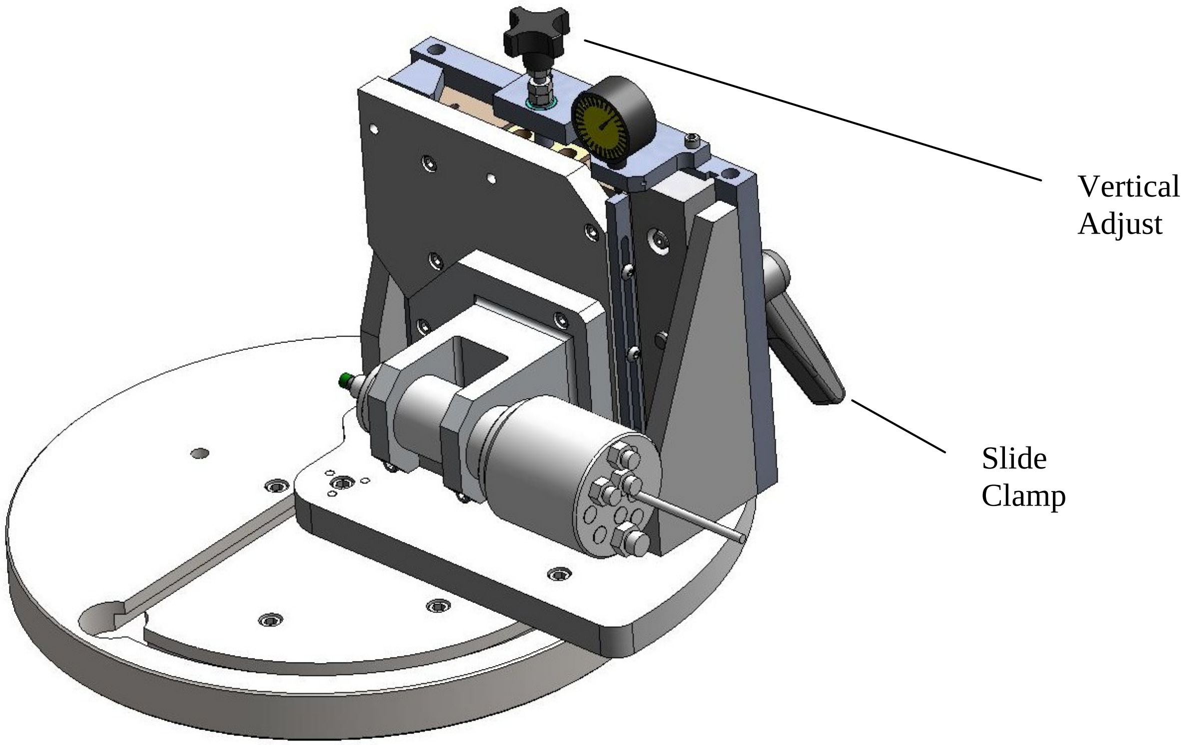
SECTION 5

Loadpoint 80,000 RPM Turbine Air Bearing Spindle

Air Bearing
For the spindle specifications, refer to the attached drawing:



SPECIFICATION	IMPERIAL UNITS	METRIC UNITS
AIR SUPPLY PRESSURE	80 P.S.I.	5.5 BAR
AIR CONSUMPTION (SPINDLE)	1.4 C.F.M.	38.5 LITRES/MIN
AIR CONSUMPTION (TURBINE)	16 C.F.M.	165 LITRES/MIN
MAXIMUM RADIAL LOAD CAPACITY AT P (STATIC)	15 LBS	6 KGS
MAXIMUM AXIAL LOAD CAPACITY	35 LBS	15.5 KGS
MAXIMUM AXIAL STIFFNESS	55,000 LB/IN	1.0 KG/um
MAXIMUM SPEED	80,000 R.P.M.	

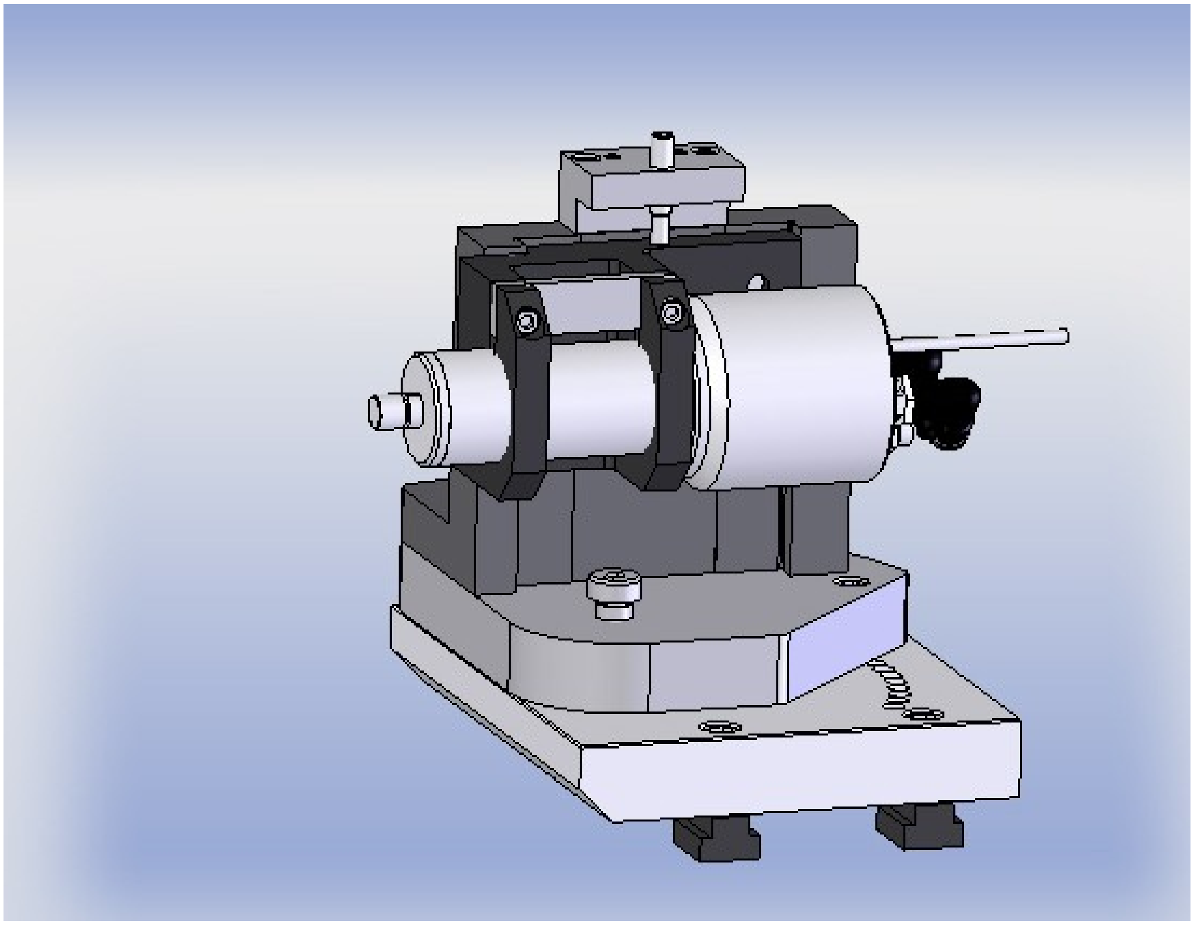


Setup of the Loadpoint Spindle A17670

This spindle option offers a flexible mount that allows the spindle to be positioned either horizontal, vertical, or at a 45 degree angle sloping downward. The base fits on the small rotary B axis (Nanoform 250) but was designed to mount on a riser without the rotary B axis. The spindle can swing to different angles in a manner like a rotary B axis but is then used in one fixed rotation position.

Setup of the Loadpoint Spindle A18825 (shown - Nanoform 700) and A16857 (Nanoform 250)

This spindle option is similar to the previous, but only allows pivot around a vertical axis of rotation in 5 degree increments. It mounts next to other tooling on the tee slot plate. There is a fine adjustment in height to set the two spindles at the same cutting height.



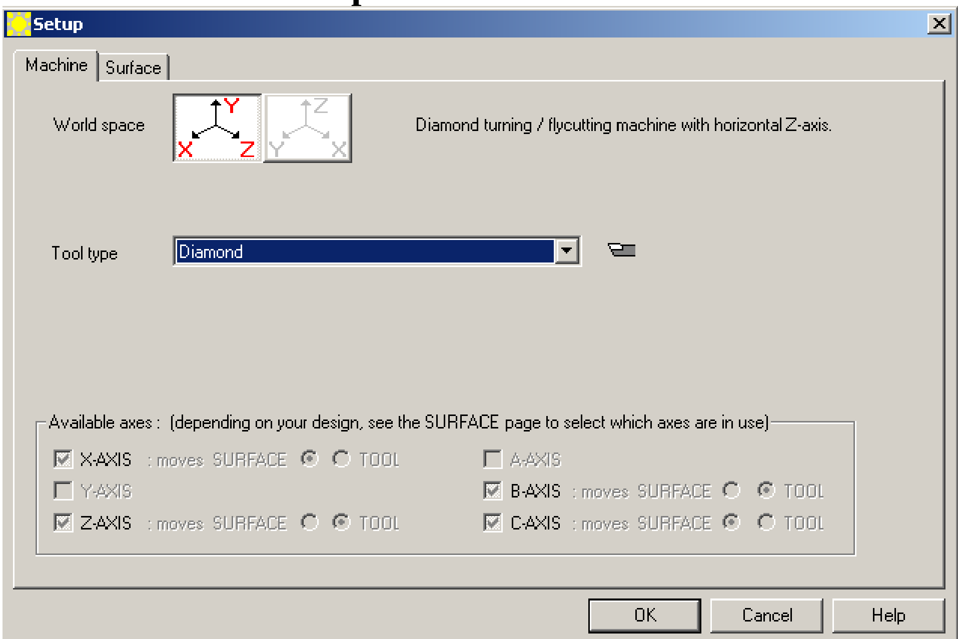
Spindle Tooling for the Loadpoint 80,000 RPM Spindle

The spindle is provided with a manually operated collet for holding milling tools and grinding wheels. As noted on the drawing, the sizes of shank tools that can be accommodated are 0.5 mm up to 5.0 mm diameter.

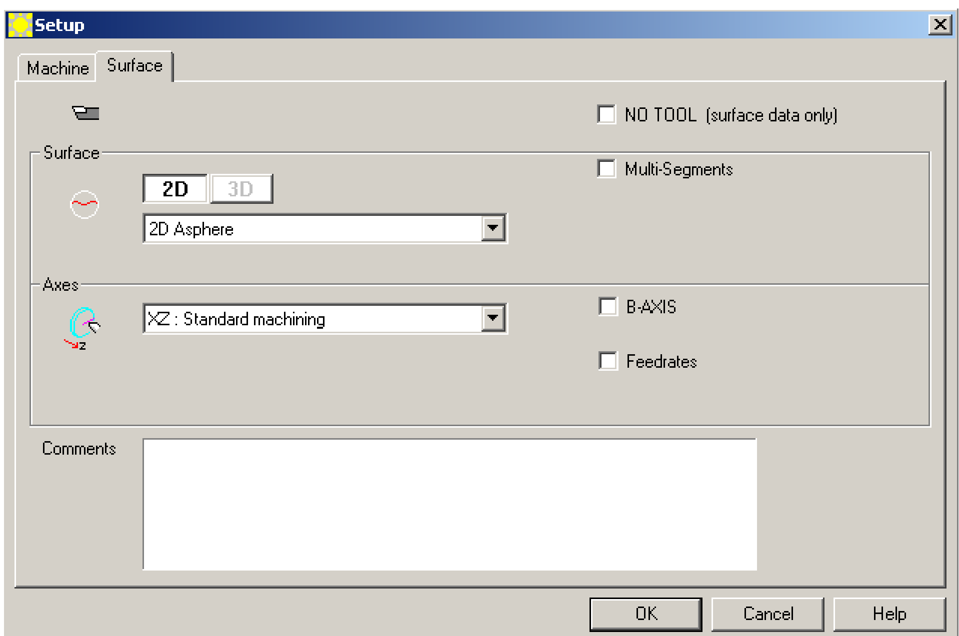
SECTION 6

DIFFSYS Programming Notes

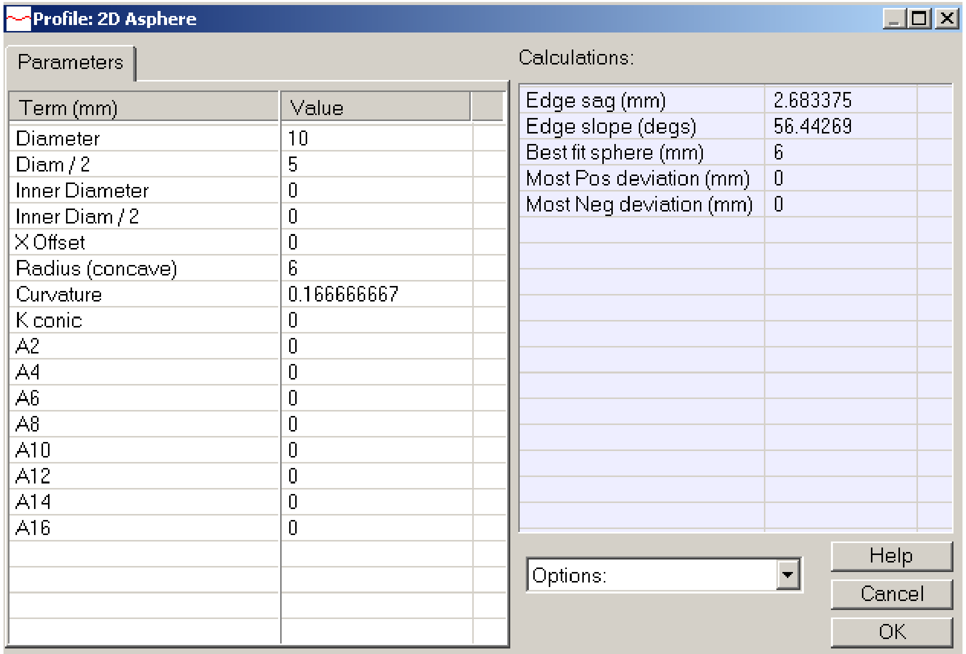
Vertical Grinder Setup



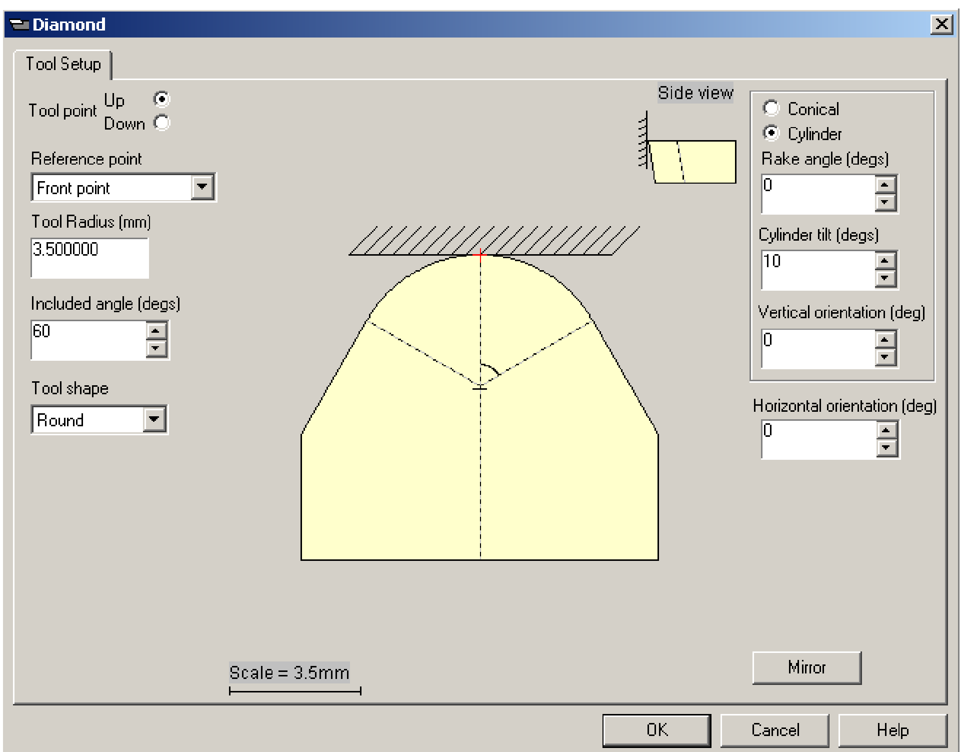
Select Diamond Tool even though a grinding wheel will be used.



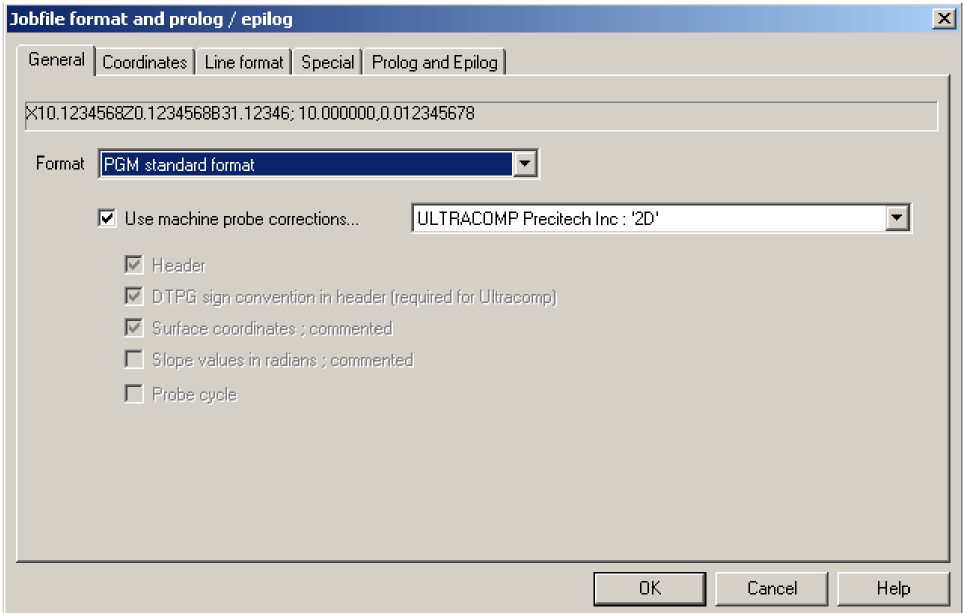
In this case no B axis rotation will be used so deselect the B-Axis check box.



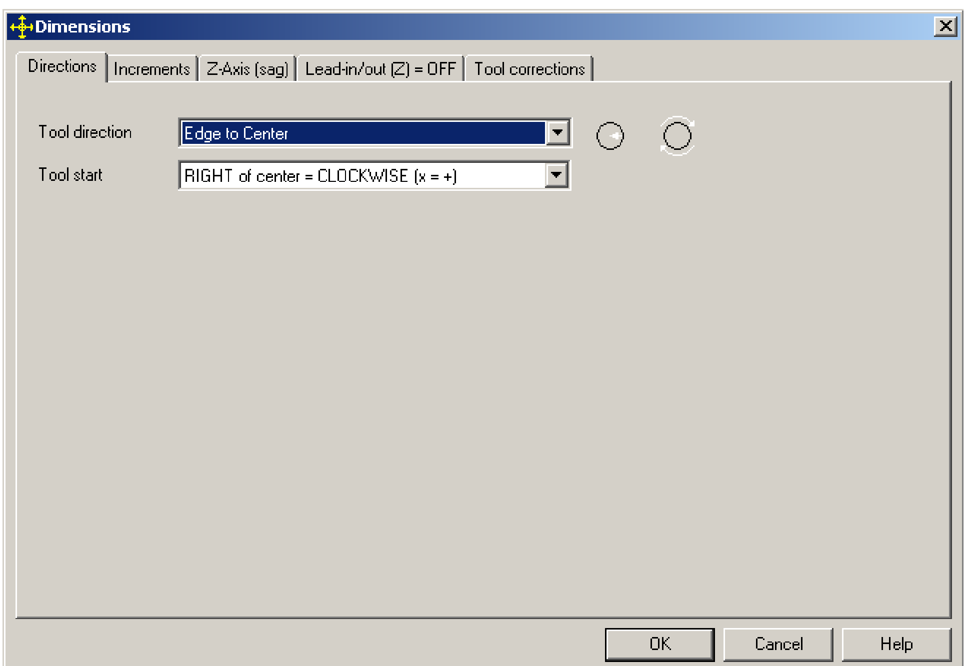
Enter data for the start and end of the program, curvature and aspheric parameters as applicable.



Enter most of the radius of the grinding wheel here, and the remainder in the tool table. Ensure the sweep is larger than the edge slope of the part surface.

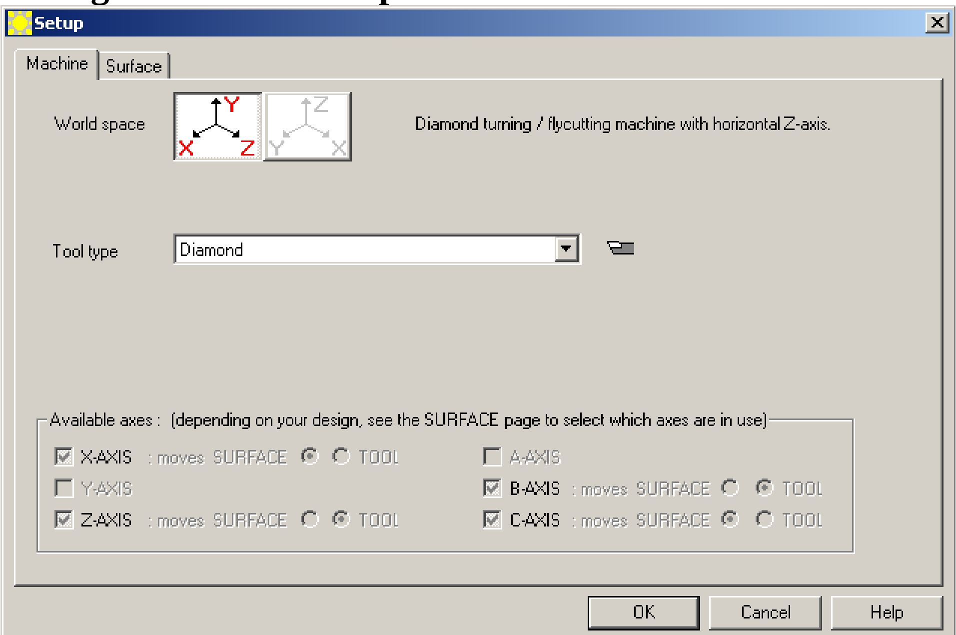


For Ultracomp to work the surface coordinates must also be in the file. Select PGM format and select the checkbox to include machine coordinates.

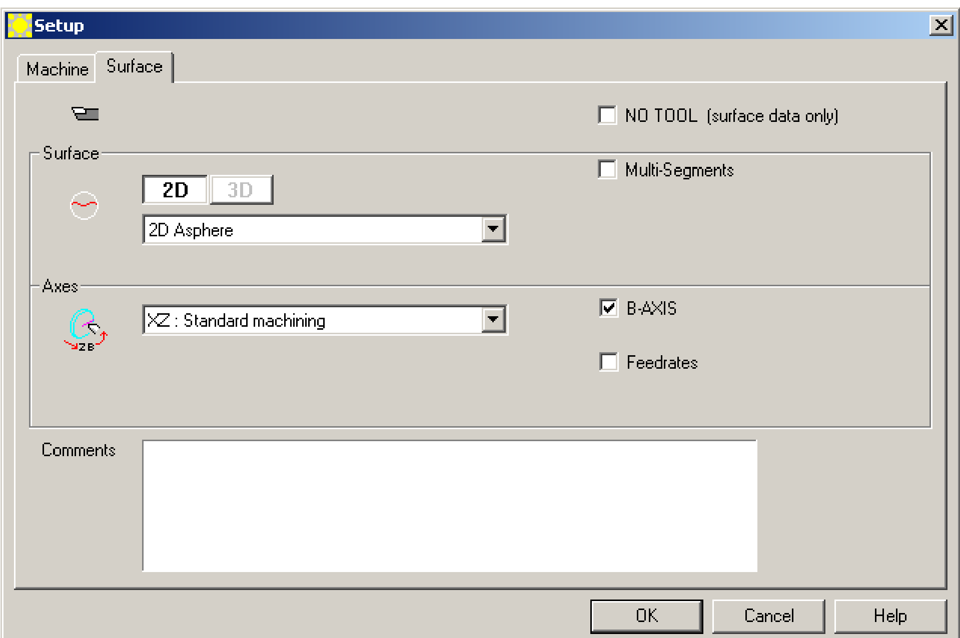


Select the machining zone to the right of the spindle centerline.

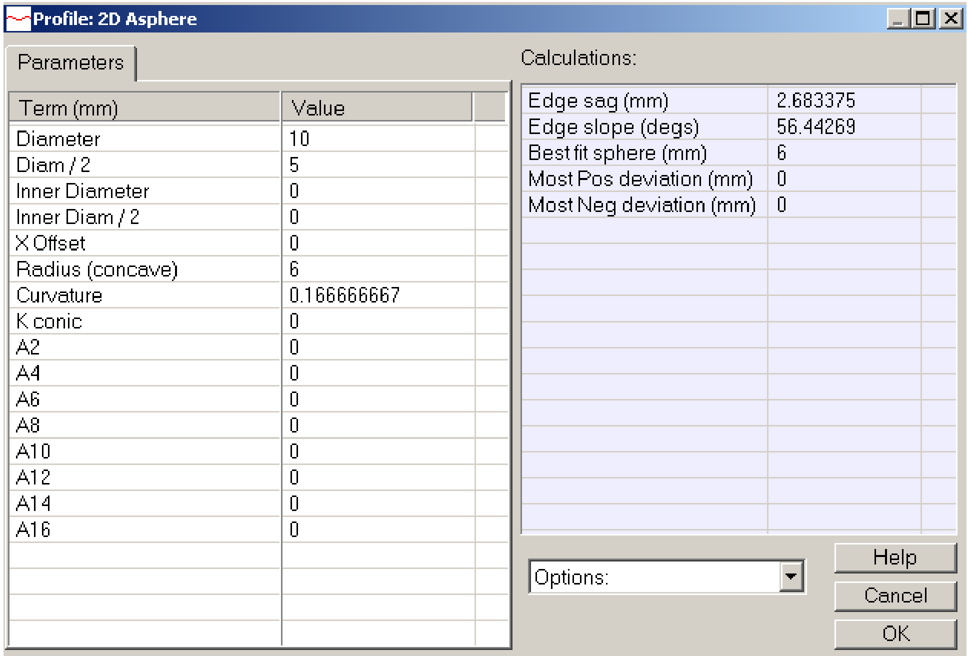
45 Degree Grinder Setup



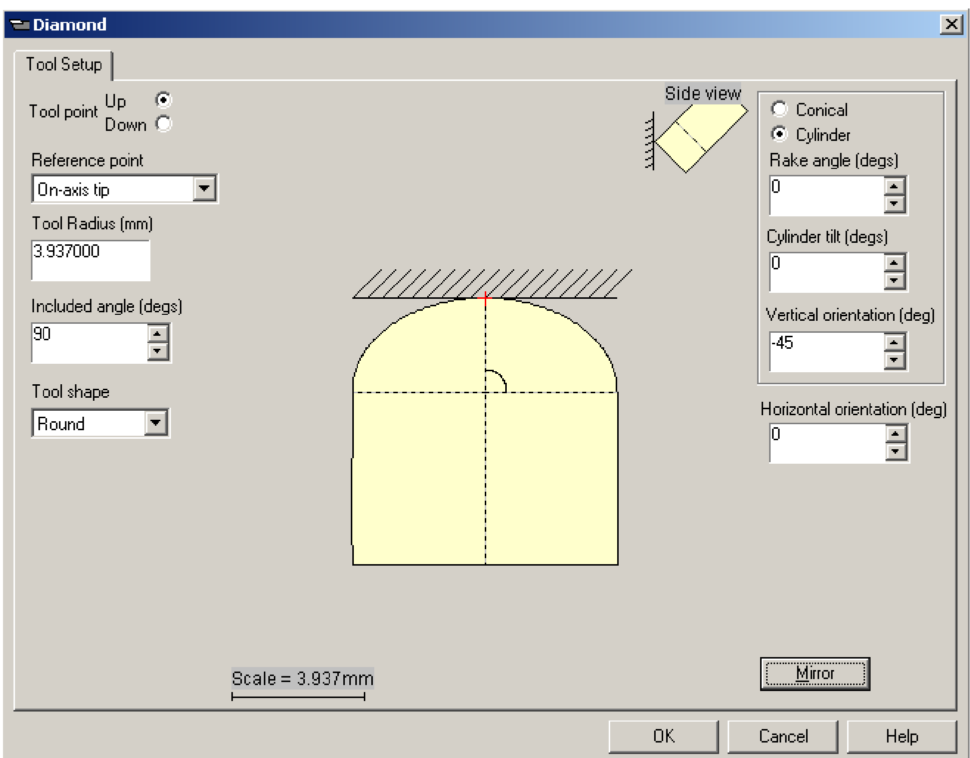
Select Diamond Tool even though a grinding wheel will be used.



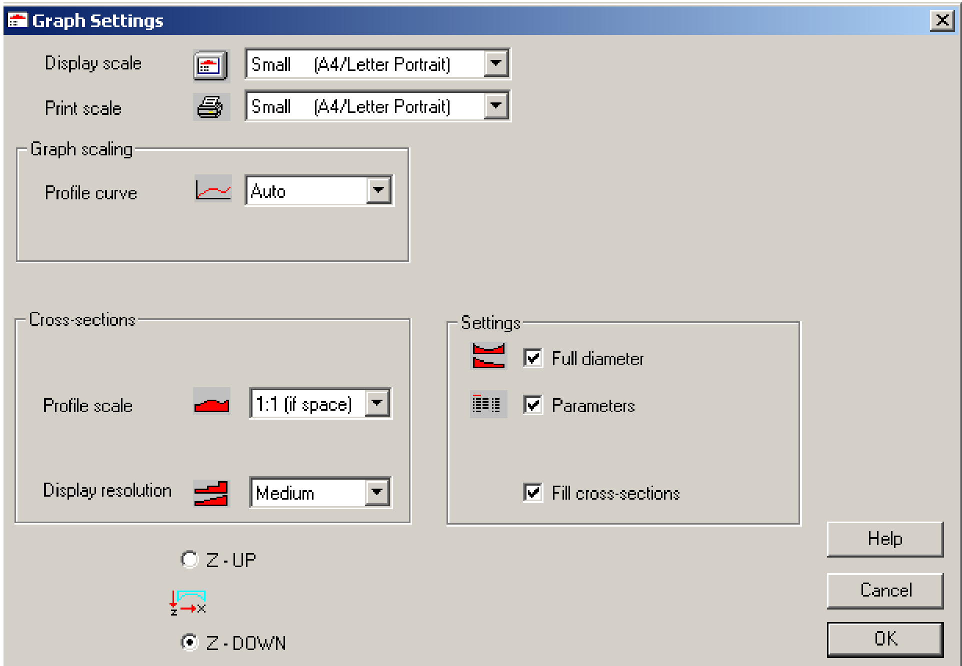
For tool normal grinding application select the B-Axis check box. Select the 2D asphere even if the part to grind is a sphere.



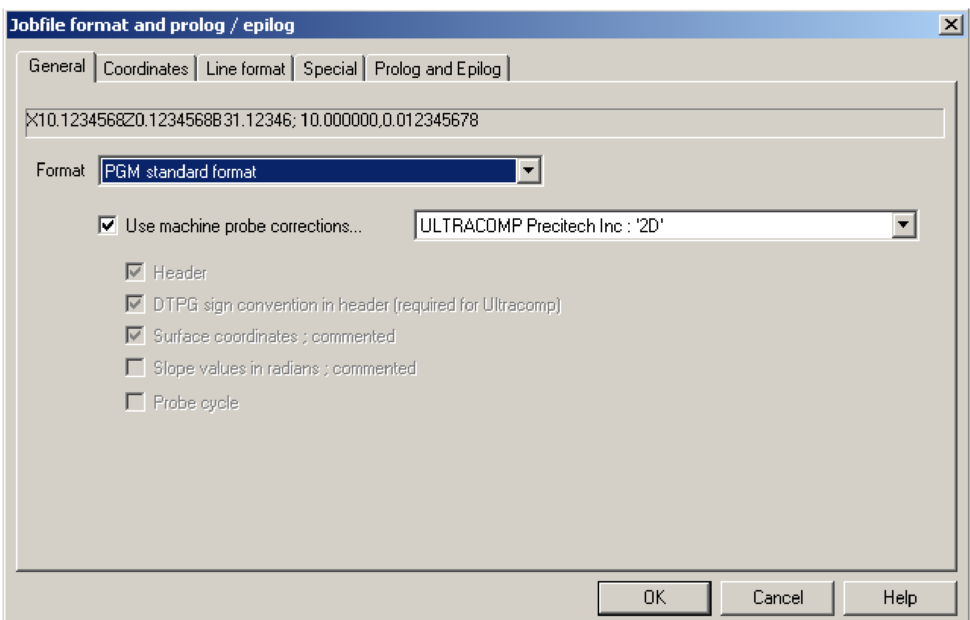
Enter data for the start and end of the program, curvature and aspheric parameters as applicable.



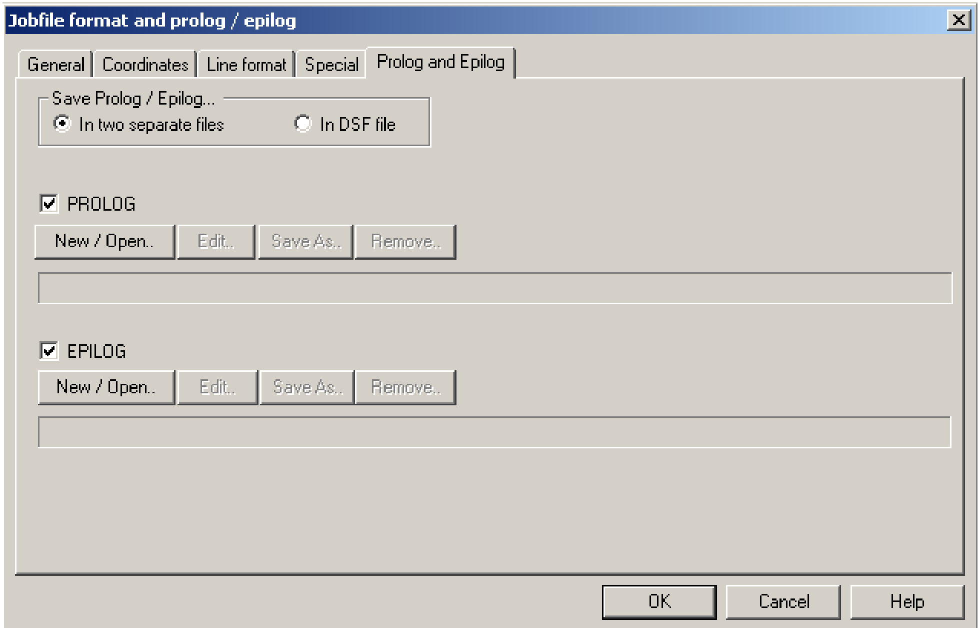
Include all of the wheel radius here and none in the tool table. Corrections must be done in DIFFSYS. Set the vertical orientation to -45 degrees.



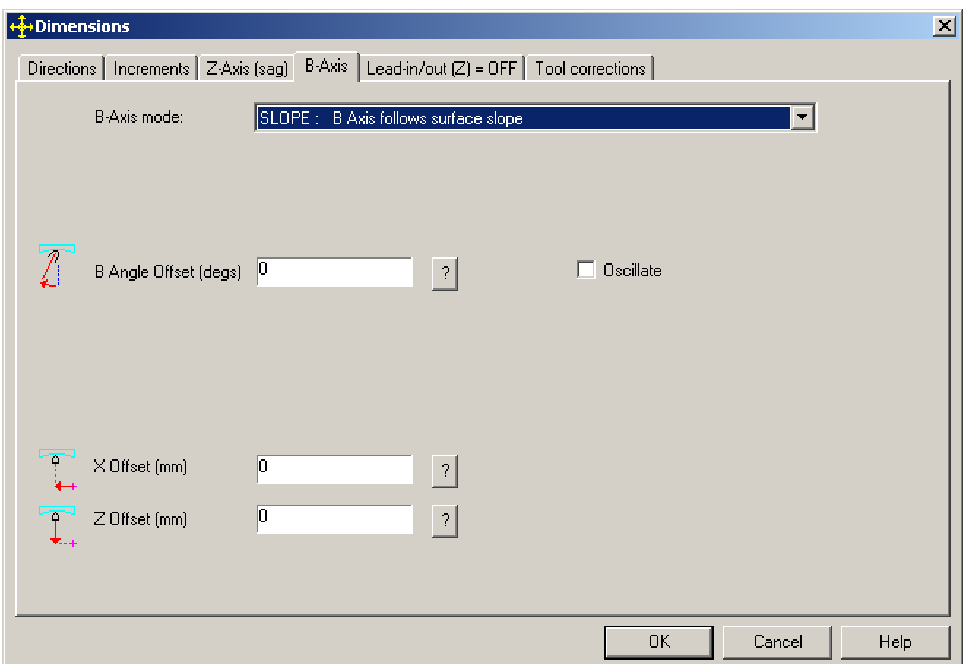
The graphing settings can be changed if necessary.



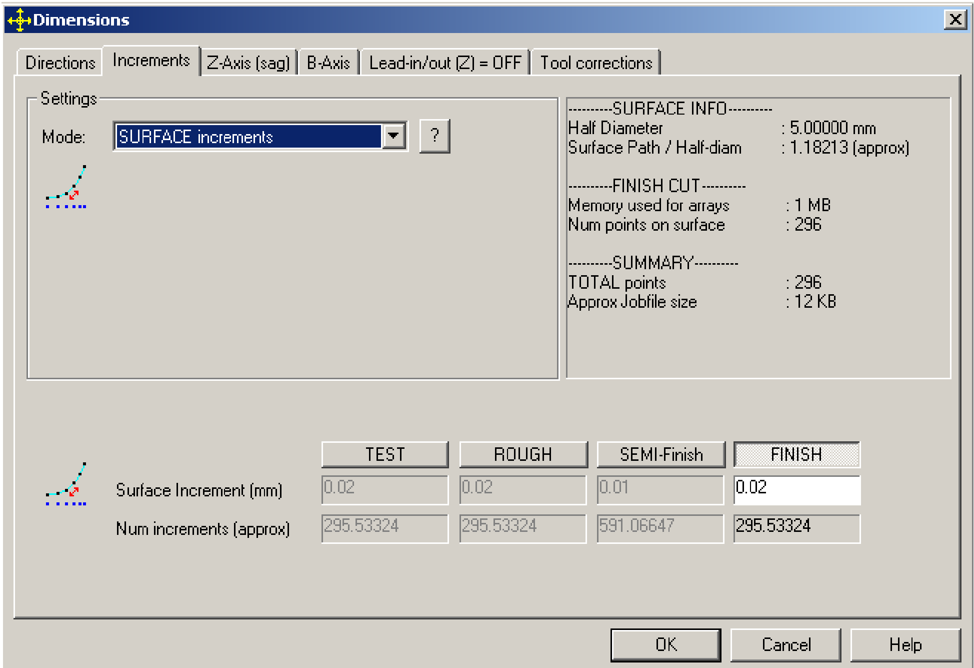
For Ultracomp to work the surface coordinates must also be in the file. Select PGM format and select the checkbox to include machine coordinates.



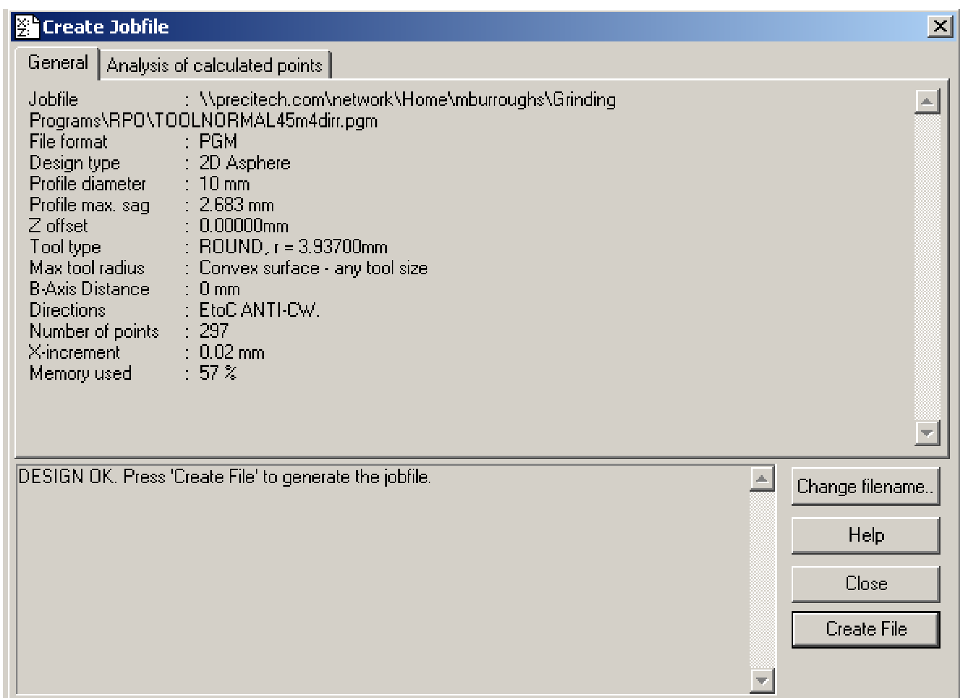
Select "In two separate files" to save to both the DSF (DIFFSYS) and PGM files.



Use the X Offset to correct for a bump in the center of the part if the tool path does not appear to reach center (after height correction). Use the Z Offset value to correct for the vertex radius of the ground surface.



Check the parameters under each tab to verify proper settings.



Create the part program.

SECTION 7

General Grinder Operational Notes

M and G code Command Summary

For an extended description for these commands, refer to the UPX Operation Manual, chapter 6.

Grinder Spindle Commands

M23 - Spindle ON CW
M24 - Spindle ON CCW
M25 - Spindle OFF

Format M23 [S{rpm}] or M25 for one spindle
Or M23.1[S{rpm}], M24.1[S{rpm}], M25.1 for each of multiple spindles

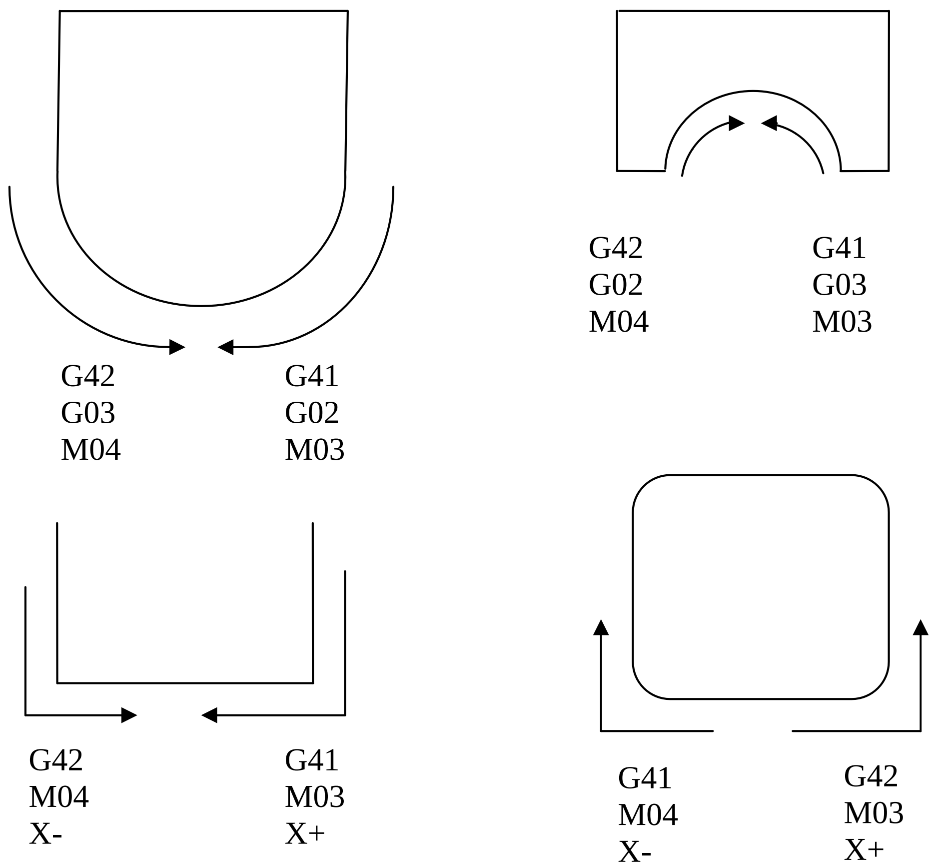
Tool Radius Compensation

G41 - TTRC Left of part
G42 - TTRC Right of part
G40 - Cancel TTRC
G46 - Move to Tangent Point
G82 S__ - Tool Radius Offset
G83 - Cancel G82 Offset

Tool Radius Offset – G82 S__

Example Usage: G82 S.01

Programming Cutter Compensation on Precitech Lathes



G18 = Compensation and Interpolation in XZ plane
G02 = Circular Interpolation Clockwise
G03 = Circular Interpolation Counterclockwise
G41 = Tool Nose Radius Compensation Left
G42 = Tool Nose Radius Compensation Right

General Grinding Parameters
This table includes suggested starting parameters for grinding process conditions.

Material	Wheel	Grit	smpm	Feed Rate	Depth of Cut
Roughing Glasses	Diamond Resin Bond	230-600 Grit 50% Concentration	1200	25 mmpm	0.010 mm
Intermed Glasses	Diamond Resin Bond	1200-1500 Grit 75% Concentration	1500	10 mmpm	0.002 mm
Finish Glasses	Diamond Resin Bond	1800 Grit 75% Concentration	2000	5 mmpm	0.001 mm or less
Roughing Carbides	Diamond Resin Bond	600-800 Grit 100% Concentration	1200	5 mmpm	0.010 mm
Intermed Carbides	Diamond Resin Bond	1200-1500 Grit 100% Concentration	1500	2 mmpm	0.002 mm
Finish Carbides	Diamond Resin Bond	1200-1500 Grit 100% Concentration	2000	1 mmpm	0.001 mm or less
Roughing Steels	CBN Resin Bond	230-600 Grit 100% Concentration	1200	25 mmpm	0.010 mm
Intermed Steels	CBN Resin Bond	600-800 Grit 100% Concentration	1500	10 mmpm	0.002 mm
Finish Steels	CBN Resin Bond	1200-1500 Grit 100% Concentration	2000	5 mmpm	0.001 mm or less
Roughing Ceramics	Diamond Resin Bond	220 Grit 50% Concentration	750	20 mmpm	0.005 mm
Intermed Ceramics	Diamond Resin Bond	320 Grit 50% Concentration	1000	10 mmpm	0.001 mm
Finish Ceramics	Diamond Resin Bond	600-800 Grit 50% Concentration	1000	5 mmpm	0.0003 mm

Typical Feeds, Speeds, and Depth of Cut
A typical grinding cycle will include multiple passes with decreasing depth of cut and decreasing feed rates. The objective is to remove the layer of subsurface damage left from the previous grind. A wheel with 5 micron sized diamonds is said to leave a subsurface damage layer of up to 5 microns deep. This obviously depends upon both the material being ground and the grinding forces. This

damage layer must be removed before the remaining surface will be free of damage from the previous grinding cycle. For example, grind with 0.002 mm DOC and 5 mmpm and repeat until the surface is cleaned up. Follow with 3 passes at 0.001 mm DOC and 2.5 mmpm, then 3 passes at 0.0005 mm DOC and 2.5 mmpm, then 3 passes at 0.0002 mm DOC and 2.5 mmpm, finally 3 passes at 0.0001 mm DOC with 1.25 mmpm feed rate.

It is also advisable to modify the spindle RPM to find a sweet spot in order to minimize surface effects that look like chatter marks. Any runout in the grit surface will leave repeating marks on the ground surface. When the work spindle and wheel spindle have an integral number ratio, such as work spindle 300 RPM and wheel spindle 3000 RPM, there will be a fixed ratio between the wheel and work piece that repeats 10 times per revolution (=3000/300). In this case the repeating marks reinforce each other to create radial mark patterns, also called star patterns including spiral shaped patterns. These patterns are noticeable to the eye and are typically not desirable even if the surface finish is within acceptable tolerances. To minimize this effect, select spindle speeds that do not form integral ratios, such as work spindle 299 RPM and wheel spindle 2827 RPM (=9.454849 ratio). Note that the final pass across the part should use the same RPM as the previous final pass to ensure the best process repeatability.

Mounting the Grinding Wheel
See the section appropriate for the grinding spindle being used.

Setting Wheel Height
See the section appropriate for the grinding spindle being used.

Truing and Dressing
True and Dress the wheel as outlined in the section on Dressing.

Balance The Spindle
Once the wheel is in the spindle, it must be balanced. This can be done using a field balancer, or by looking at slide following errors on the UPX controller and shifting the setscrew weights to improve the following error data. This method is not deterministic but is a functional way to balance. If a significant unbalance is expected, then balance the spindle at a slower speed first before running the spindle up to the operating speed. The final balance should be performed at the speed of operation. If the following errors are poor at this speed, then it is suggested to modify the spindle speed until the machine is not excited by the unbalance forces and the following errors are minimized. This will allow the

machine to produce the finest surface finishes.

Find Wheel Size and X Offset using the LVDT tool setter
See Section 2 of this manual for process instructions

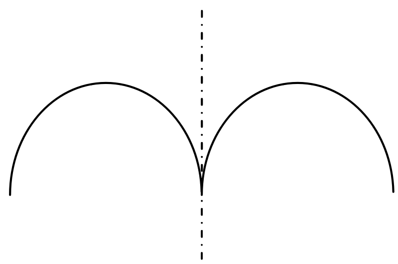
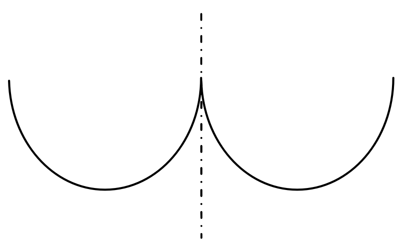
Find Wheel Size and X Offset without the LVDT tool setter
If a LVDT tool setter is not available use the following method:
A) Measure the wheel diameter using a micrometer and divide by 2 to obtain the radius.
B) Touch off the wheel against both sides of a round OD part that runs true to the spindle centerline to determine the X offset for the wheel. The X offset would then be the average of the two X ABS positions when touching the two sides of the pin.
C) Enter the wheel radius and X offset for the tool in the tool table for the tool called for in the part program. Write these numbers down for future reference. It is recommended that the part program compensate for most of the wheel radius (see instructions for G41 and G82 in the UPX manual) while a portion (0.1 to 0.2 mm) is left in the tool table for ease of minor radius adjustments during grinding. The total of the part program radius and tool table radius should equal the actual wheel radius.

Touching Off or Finding the Surface
To find the point for touching off, run the part program without coolant and without rotating either spindle. Rotate the grinding wheel by hand while it passes in front of the part to ensure the entire pass is clear. Shift the Z axis in one micron increments until the wheel touches the part which may be at the center or at the OD depending upon the shape of the pre ground work piece.

Depression or Hole at Center
It is very common to grind a hole or depression in the center of the part, which becomes visible when measuring the form error. The material to remove at the center is very small and this results in an easily created over grinding of the surface. For one thing, do not use any dwell period in the part program at the center of the part, this is not necessary. It is also allowed to remove the last few lines from a point to point part program, effectively pulling off the surface before the wheel reaches the zero position in X.

Correcting X Offset using Stylus Instrument

X offset using a stylus instrument has the shape of an M or a W depending upon the sign of the offset and the curvature of the part, as depicted here.

Shape of Residual Error	Corresponding X Error Direction
	For Convex Surface, Tool is not to Center. For Concave Surface, Tool is Past Center
	For Convex Surface, Tool is Past Center. For Concave Surface, Tool is not to Center.

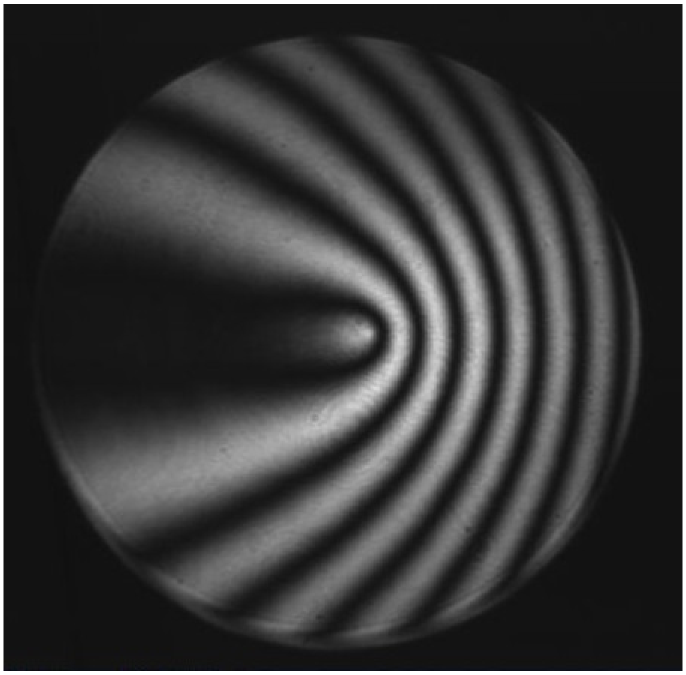
Calculation of X Error when trace ends and center are equal height:

X Error (microns) = Best Fit Spherical Radius (mm) * 8 * Peak to Valley (microns) / Diameter Traced (mm)

Note that this works best on spherical surfaces, and to use caution on aspheric surfaces.

Correcting X Offset using Interferometer

Position the test surface on the interferometer and get a return beam with fringe pattern. Manipulate the pattern until there is a null fringe from the center of the part to one edge as shown in this image.



Push gently on the optic toward the interferometer to shift the fringes and note the direction of the motion of the fringes when the beam path is made shorter.

For Concave surfaces,
If the fringe pattern moves away from the center of the part the tool has not reached the center of the part.
If the fringe pattern moves toward the center of the part the tool is past center.

For Convex surfaces,
If the fringe pattern moves away from the center of the part the tool is past center.
If the fringe pattern moves toward the center of the part the tool has not reached the center of the part.

Count the number of fringes in the pattern from the part center to the other side and this is used to determine the X offset position. Each fringe represents 0.316 microns of beam path difference.

X Error (microns) = # Fringes * 0.316 (microns) * Spherical Radius (mm) / Surface Diameter (mm)

Newer interferometer products will report the X offset value directly. It is still critical to determine the correct direction of correction.

Correcting Wheel Height using Microscope

If the wheel is too high or too low, this error can be visible when examining the center of the ground surface under a microscope. There will typically be a circular artifact at the center. Measure the diameter of the artifact and this represents two times the height error. For a vertical grinding spindle, if the grinding marks form a Z pattern at the center, this represents the wheel being too low. An S pattern will result from the wheel being too high. Below are images showing the effect for a 45 degree downhill grinder setup.

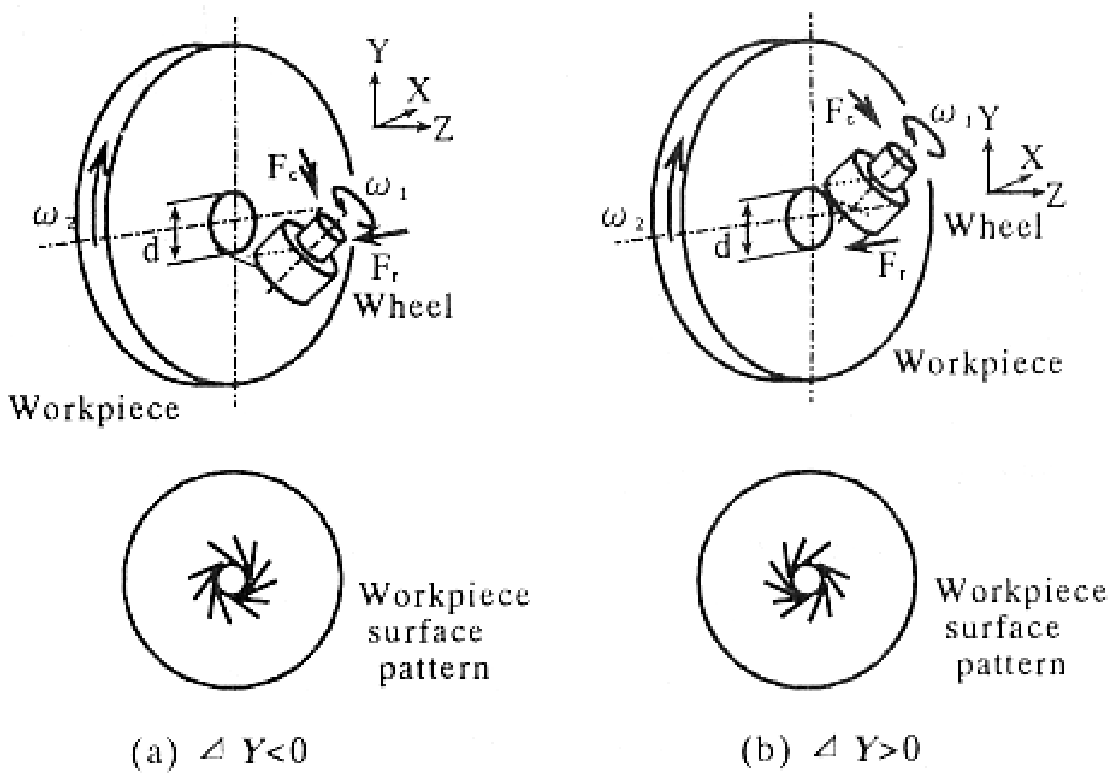


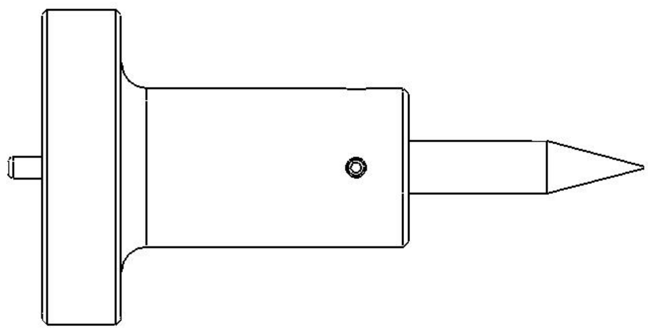
Fig.4 The effect of wheel setting error in the Y-direction on the workpiece surface pattern

SECTION 8

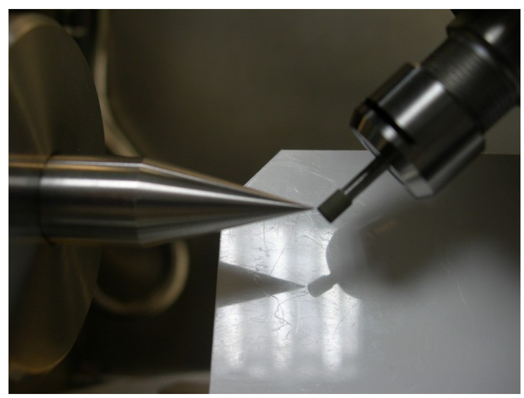
Grinding Wheel Dressers and Truers

Note: Truing is typically associated with taking a new or remounted grinding wheel and making the wheel surface run true with the grinding spindle axis. When the grit particles in the wheel have become worn and are not effective, then a wheel dresser is used to remove bond material, exposing fresh grit particles.

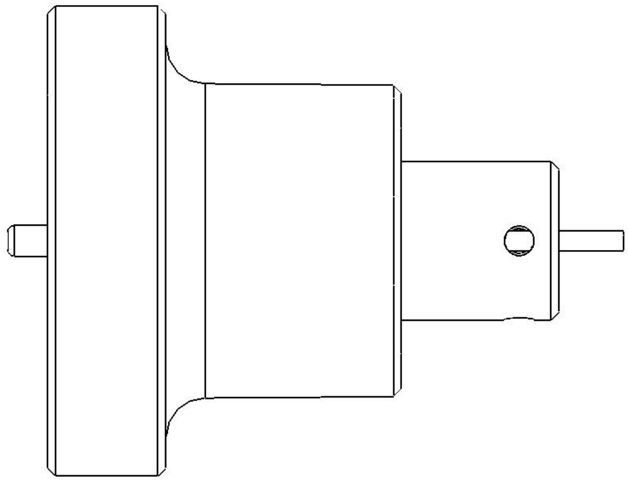
The devices in this section are referred to as dressers but in general they are all truing devices. They are used to accomplish both truing and dressing of the wheel surfaces.



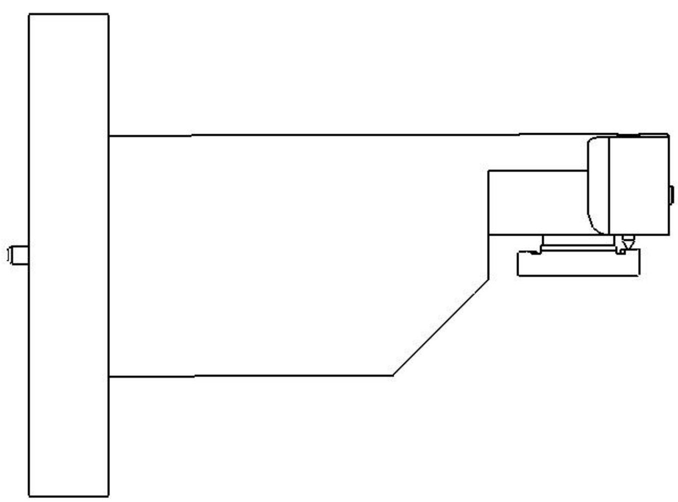
Pointer #1:



The pointer (A17775) is used to indicate the height of the wheel for rough height adjustment during setup. Mount the pointer to the vacuum chuck of the work spindle with low vacuum level. Put an indicator on the conical pointer section and tap the pointer base until the pointer has good alignment with the rotation of the spindle. Shift to high vacuum once the pointer alignment is complete. Note that there may be two height adjustments in the grinder and if so the fine adjustment should be put in the center of travel before adjusting the coarse adjustment. Set the wheel height using an eye loupe then lock the height adjustment in place.

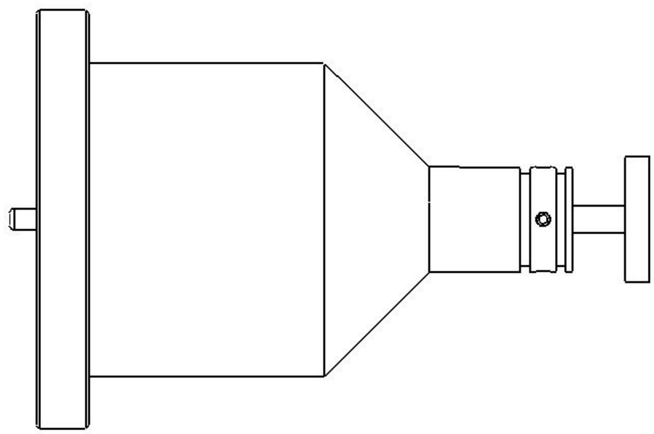


Pointer #2
This pointer (A13782 with 3 mm pins or A13782-01 with 0.25 inch pins) is used to set up the horizontal grinding spindle height. One pin is mounted in the grinding spindle, and a second pin with the same diameter is mounted in the work spindle. By indicating the top of the two pins the two spindle heights can be compared.



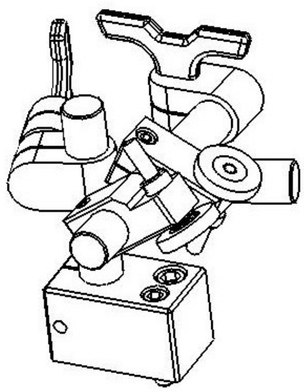
Nib Dresser
The nib dresser (A12670 with 6 inch length or A12670-01 with 8 inch length) accomplishes two tasks; it trues the wheel with a radiused shape to run true to the grinding spindle, and sets the wheel vertex at the exact height of the work spindle. Mount the dresser to the vacuum chuck and indicate the OD to run true.

A removable plate has four settings for radius. With the plate in place, shift the nib until it touches the desired radius position then lock the nib in place. Remove the plate and the nib is set at the desired radius. The closer the nib is to the work spindle centerline, the smaller the wheel radius will be generated. Run the grinding spindle at a slow speed for dressing and truing or the wheel will grind away the dressing nib and the desired dressing action will not be performed. The nib dresser is moved across the face of the wheel by rotating the nib dresser in rotation about the work spindle by hand or by use of the C axis (if installed) of the work spindle.



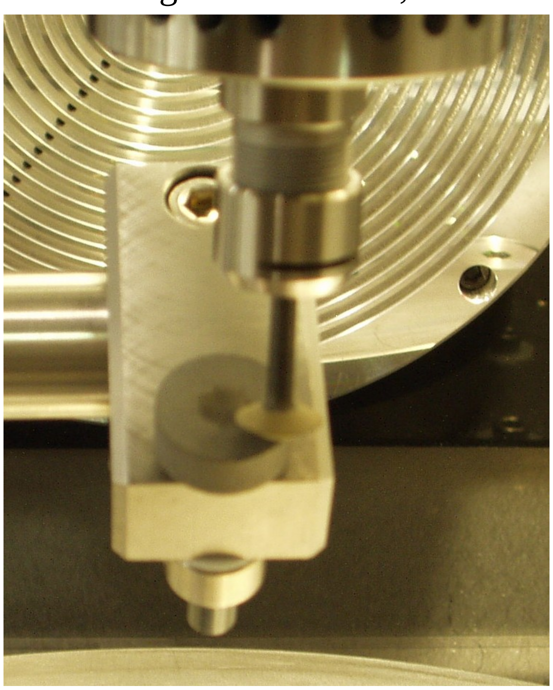
Work Spindle Mounted Dresser

This dresser (A17783) is used on stick shaped wheels in vertical oriented grinding spindles. It is supplied with two sizes of dressing wheels. It is used in dressing the OD of stick wheels. Run both spindles and jog or increment the two wheels into contact. Increment in Z until the wheel is dressed and then allow the dressing action to taper off during a dwell period before pulling them apart.

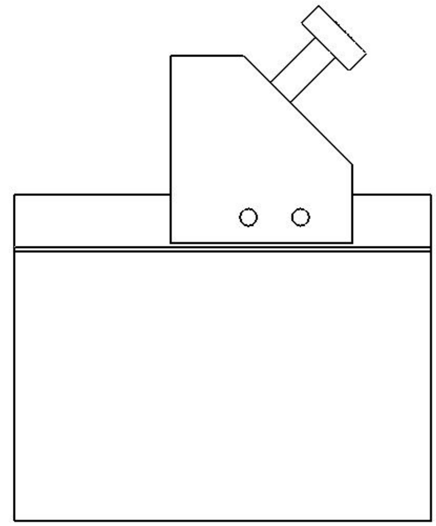


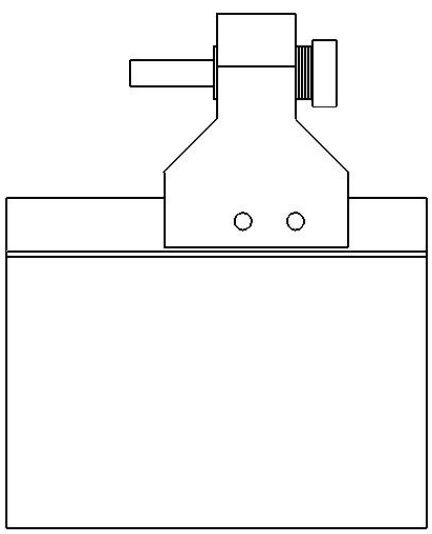
Flexible Dresser A17777

This dresser is used on wheel types that are not easily dressed using the more typical dresser types, including stick wheels on 45 degree downhill grinding spindles, stick wheels on horizontal spindles, wheels on spindles at angles other than 45 degrees or vertical, and vee shaped disk type grinding wheels.



45 Degree Downhill Spindle Dresser
This dedicated purpose dresser (A13529) is used with stick type wheels mounted in 45 degree downhill grinding spindles. The dresser base mounts to the B axis tabletop. The dresser wheel is moved up against the end of the stick wheel and locked in this position. The grinding spindle is then shifted by hand down the slope of the 45 degree angle, while dressing the wheel. In this manner the cutting edge of the wheel is kept in a fixed height location at the work spindle centerline height.





Horizontal Spindle Dresser
This dresser (A13529) functions similar to the above dresser, but is used with stick wheels mounted in the horizontal grinder on a B axis. The dresser wheel is moved up against the end of the stick wheel and locked in this position. The grinding spindle is then shifted axially by hand, while dressing the wheel. In this manner the cutting edge is kept at the same relative location with respect to the B axis centerline.

SECTION 9

Other Accessories

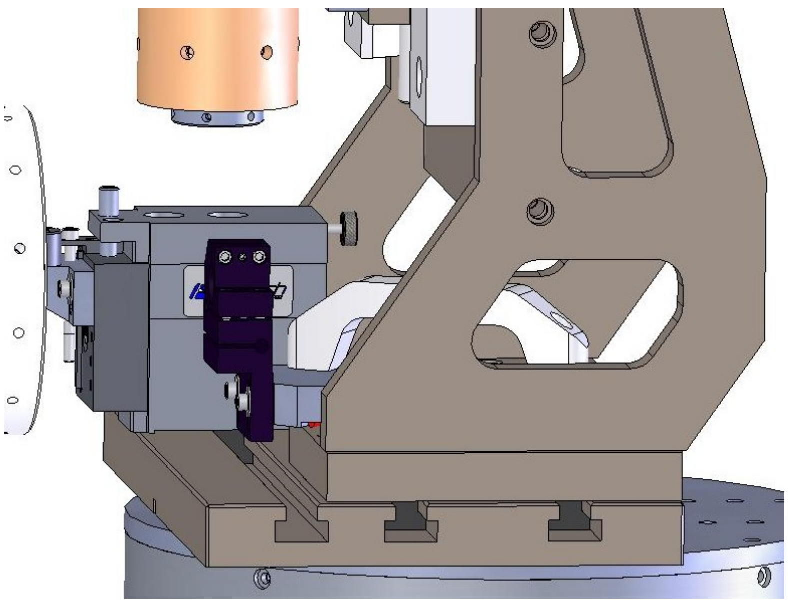
Coolant System Options:
The coolant system is designed to store, pump, filter, and saturate the grinding area with grinding coolant. The filter provides filtration of the coolant to 5 microns (130µ"). The coolant pump can be plugged into the accessory outlet on the machine (which recieves power from the customer wall outlet). In this manner any electrical noise from the coolant pump will not affect the machine. The accessory outlet has a switched outlet where the coolant pump should be plugged in. This outlet can be energized using the UPX code M20 and deenergized using M21. The coolant type will depend upon the material being ground. At Precitech we typically use Challenge 300 by Intersurface Dynamics Ltd.

A12680-01 - 15 Gallon Reservoir with pump and filter 230 VAC
A12680-02 - 15 Gallon Reservoir with pump and filter 115 VAC
A12680-03 - 6 Gallon Reservoir with pump and filter 230 VAC
A12680-04 - 6 Gallon Reservoir with pump and filter 115 VAC
A13744 - Coolant nozzle and magnetic base

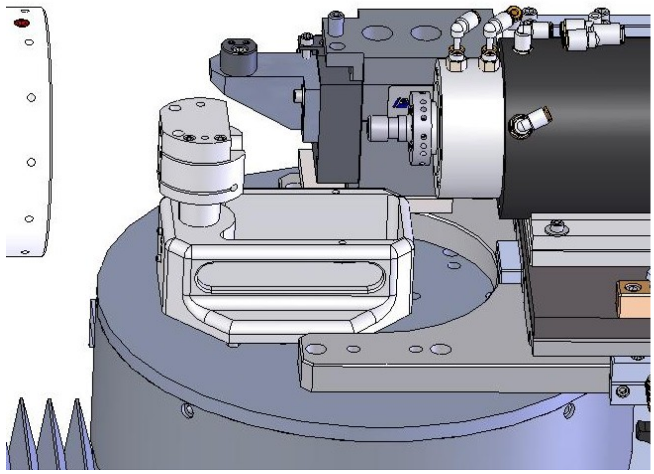
131-0032 Coolant Filter Cartridge, 5 micron (spare part)
183-0007 Diamond Grinding Fluid Concentrate (consumable)

Tool Holders and Ultracomp Mounts
Tool holders can be mounted next to the grinding/milling spindle for the preparation of fixtures or diamond turning in conjunction with grinding or milling.

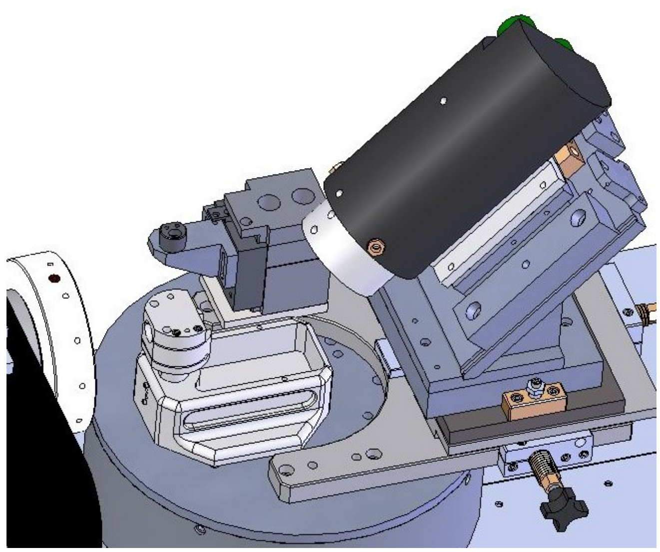
Use of Ultracomp allows the on machine measurement of aspheric surfaces and in process correction of repeatable form errors. Ultracomp consists of a hardware/software portion, and probe mount to suit the individual application. The hardware/software component of Ultracomp is A17622. The special Ultracomp mount depends upon the grinder design and is shown below.

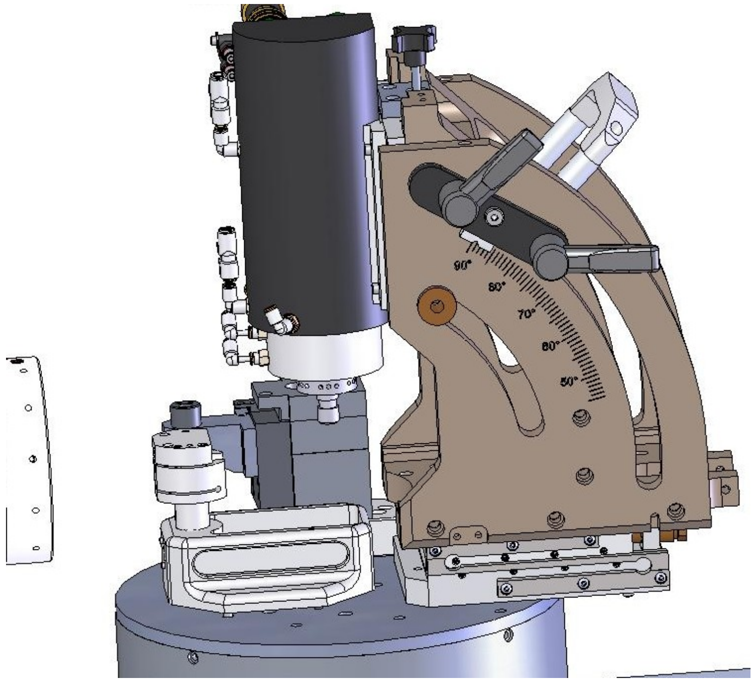


This image shows the vertical spindle mount with SP75 spindle but which also accepts the PI spindle. The tool holder is A15945-01 (metric) or A15945-02 (english hardware) and the Ultracomp mount is A17540. The base for the Ultracomp mount is built into the vertical spindle mount.

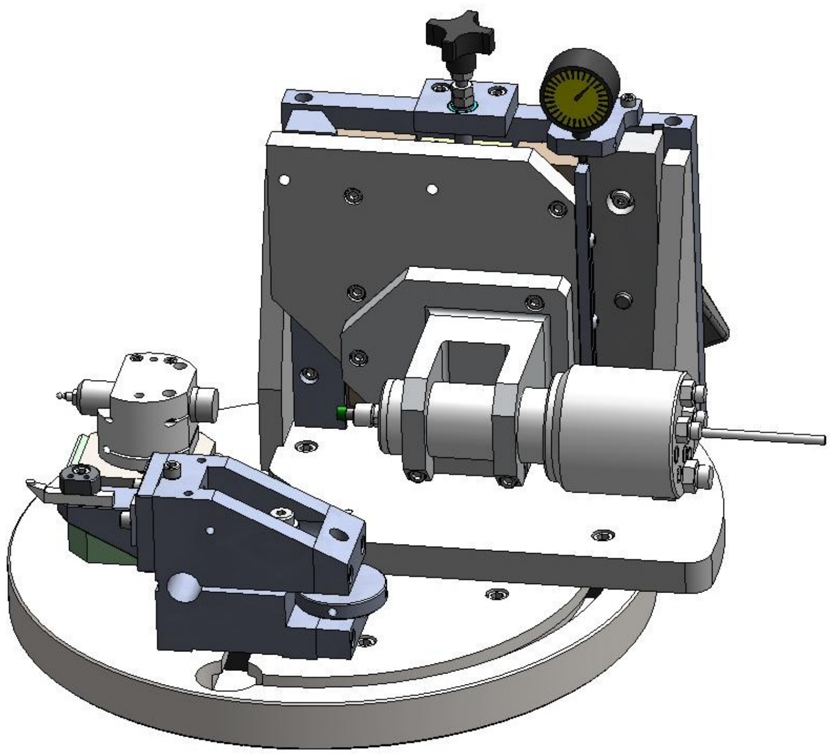


These two images show the horizontal and 45 degree fixed angle downhill spindle mounts with PI spindle. The tool holder for both setups is A11063 on riser 17623. The Ultracomp mount is A15395-01. The base for the Ultracomp mount is built into the B axis tabletop.





This image shows the adjustable angle spindle mount with PI spindle. The tool holder is A11063 on riser 13774. The Ultracomp mount is A15395-01. The base for the Ultracomp mount is built into the B axis tabletop.



This image shows the turbine spindle mount with spindle. The tool holder is A16895 and the Ultracomp mount is A17695. The base for the Ultracomp mount is included with the A17695 assembly. The tool holder and Ultracomp mount can switch places if desired.

SECTION 10

Cleaning and Maintenance

Maintenance

By practicing good housekeeping and regular maintenance, the machine will reward you with a long and dependable service life.

Daily (by operator)

- Check spray mist reservoir and fill as needed
- Vacuum loose swarf and chips from the machine
- Rotate spindle by hand in purge mode for 60 seconds to clear debris

Monthly (by operator)

- Check oil hydrostatic sight glass level with machine off over 1 hour and fill as needed with Mobil Velocite 10 oil.
- Empty the catch cup under the granite pan in back of the machine
- Clean enclosure windows and wipe inside of enclosure
- Clean electrical cabinet fan filters
- Check bellows integrity, not getting jammed up with swarf

Quarterly (by supervisor)

- Check function of door interlock switches and controls (not bypassed)
- Check that safety devices (goggles) are being used by the operator
- Check that MSDS sheets are available for any hazardous substances the operator may come in contact with

Annually (by service and IT department)

- Perform annual maintenance per check sheet
- Back up software files

Cleaning

It is important to prevent the accumulation of cutting byproducts including swarf, coolant, and lubricants. Swarf can be removed with a shop-type or portable vacuum. A small natural bristle paintbrush and soft lint-free wipers are also useful cleaning tools.

CAUTION - Do not use a blowgun or compressed air of any kind to clean the area around the slides and spindle. Damage may occur if swarf is forced under slide way covers or into the spindle chuck or collet.

Electrical Cabinet Air Filter Cleaning

Fan intake and exhaust filter screens are located on the machine electrical cabinet and control cabinet.

The fan filter cover screen snaps on and off. Wedge a flat screwdriver blade under cover s edge to lift it off.

Clean or replace filter as needed. Part number 147-0108 (bag consists of five 100ppi foam filter elements).

SECTION 11

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