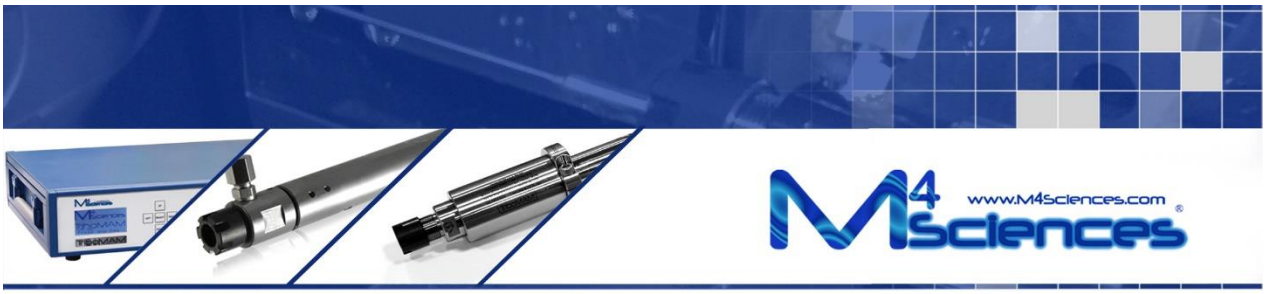

TriboMAM Drilling Actuator
User Manual
(Micro/Mini/Meso/Standard/Kilo^2/Mega^2)

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M4 Sciences TriboMAM®- drilling system

Thank you for purchasing a TriboMAM- drilling system. Together with the MEC-PA11033 Controller, the TriboMAM drilling system uses Modulation-Assisted Machining (MAM®) to enable the improvement of drill speeds and feed rates for high-aspect ratio centerline drilling in CNC lathes. This manual provides information regarding safety precautions, installation procedures and operating protocols in the use of the TriboMAM- drilling system.

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1 Safety

Review the following precautions to maintain safety and prevent damage to the instrument or equipment connected to it. The safety features of this instrument may be ineffective if the equipment is not operated in the manner stated in this manual. Refer all maintenance procedures to qualified personnel. Failure to conform to the following requirements can lead to damage to the TriboMAM, significant personal injury and possibly death.

1.1 Critical Installation and Operation Notes

- Refer to the MEC-PA11033 User Manual for specific safety precautions and protocols associated with use and installation of the MEC-PA11033 Controller.

- Ensure that the MEC-PA11033 Controller is properly grounded. If the power source does not have a ground connection available, ground the Controller using the ground stud connection on the rear panel of the Controller.

- Do not attempt to disassemble/repair the TriboMAM or MEC Controller. Servicing of TriboMAM system equipment should only be conducted by M4 Sciences or other qualified personnel.

- Do not drop the TriboMAM drilling system. Impact loading can damage the TriboMAM.

- Coolant line is rated at 1,250 psi (86 bar, 8.6 MPa). Coolant system pressure needs to be at or below this maximum setting. Only high-pressure coolant tubing specified by M4 Sciences may be used for supplying high-pressure coolant to the TriboMAM. Use of non-specified tubing may result in unexpected rupture of the line.

- Use caution in setting tool offsets (e.g. touch-off procedures).

- Set Spindle Override to 100%. Feedrate Override should not be more than 100%.

- Do not cycle the power of the HV output on/off during a drill cycle.

- Cleaning of the TriboMAM drilling system should be done only with electrical contact cleaner or an alternate method approved by M4 Sciences. Do not submerge the TriboMAM in a liquid solution for cleaning.

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1.2 Safety Terms and Symbols

- These terms may appear in this manual:

  Warning: Warning statements identify conditions or practices that could result in injury or loss of life.

  Caution: Caution statements identify conditions or practices that could result in damage to this product or other equipment.

- These symbols may appear on the instrument:


Warning, risk of electric shock


Caution, refer to Operator's Manual

CAT I — Installation category I (overvoltage category): Classification for the operation of a unit using voltage systems or circuits with required standardized limits for transient voltages. Category I pertains to voltages supplied at the peripheral level, with smaller tolerances for transient voltages as specified by the Low-Voltage Safety standard (EN 61010-1).

CAT II — Installation category II (overvoltage category): Classification for the operation of a unit using voltage systems or circuits with required standardized limits for transient voltages. Category II pertains to using voltage supplied on the local level (example: local wall outlets) with smaller tolerances for transient voltages as specified by the Low-Voltage Safety standard (EN 61010-1).

Danger: High-voltage generating equipment, including the MEC-PA11033 amplifier and related supplies are not designed, rated, or qualified to be operated in an environment or atmosphere which contains combustible or explosive materials or gases which may be ignited by electrical discharges.

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2 Introduction

2.1 Primary System Components

The TriboMAM replaces conventional drill holders and oscillates the drill using electro-mechanical actuation. The TriboMAM is connected to and electrically driven by the MEC-PA11033 controller through a coaxial cable. The TriboMAM has the capability to accommodate through-tool coolant at a maximum rating of 1,250 psi (86 bar, 8.6 MPa).

Figure 1. TriboMAM-mini drilling system with 2 positions for the SSMB/SSMC coaxial power cable connector.

Figure 2. MEC-PA11033 Controller.

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2.2 System Description

The TriboMAM drilling system alters the mechanics of the chip formation that occurs during drilling by enabling Modulation Assisted Machining (MAM®). In MAM, the drilling process is divided into a series of cuts that are determined by the modulation conditions. This forms the drilling chips into smaller fragments that are more easily evacuated from the drilling zone. MAM also improves lubrication of the contact interface. These benefits enable improvements to drill speeds and feed rates.

The TriboMAM drilling system is designed for high-aspect ratio centerline drilling in CNC lathes (length to diameter > 7). The TriboMAM drilling system replaces existing drill collet extenders. The MEC-PA11033 controller enables MAM for the TriboMAM drilling system. When installed properly, the system will oscillate the drill in the direction of drill feed. The oscillation conditions will depend on several factors, including the drill diameter, feed rate, workpiece rotational speed and number of drill flutes. The MEC-PA11033 controller uses the programmed drilling conditions to determine the appropriate modulation conditions.

2.3 Receiving Inspection

Visually inspect the components for physical damage such as dents, nicks, scratches, broken fittings, etc. External damage may indicate more serious damage has occurred within the instrument. In the event of damage, notify M4 Sciences and request instructions. Do not attempt to use a damaged instrument.

2.4 Hardware Installation

The text below outlines the procedure for installing the TriboMAM with the MEC-PA11033 Controller. Prior to installation, refer to operational checks in Section 4 of this manual for pre-installation verification of the TriboMAM operation.

2.4.1 Controller Setup

The MEC-PA11033 is designed for operation on a flat surface and is air-cooled. Allow a minimum of 50 mm (2 in) of free space around the heat exchange fins on the rear panel.

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1. Place the MEC-PA11033 Controller in a convenient location on a flat surface near or on the machine. Follow all operation instructions in MEC-PA11033 User Manual. The standard coaxial power cable is 20 ft (6 m) long.

2.4.2 TriboMAM Installation and Setup

Warning: Verify that the tool pocket has been properly indicated and reference position for the tool centerline has been established prior to TriboMAM installation.

1. Clean the tool post and the TriboMAM shank with a lint-free cloth. Do not use any solvents or abrasives to clean the TriboMAM.

2. Install the TriboMAM in the tool post in an orientation such that the electrical connector and coolant fittings are easily accessible. If the SSMB/SSMC-type electrical connector is in the optional port location, the fitting will be attached at the TriboMAM rear as shown in Figure 3.

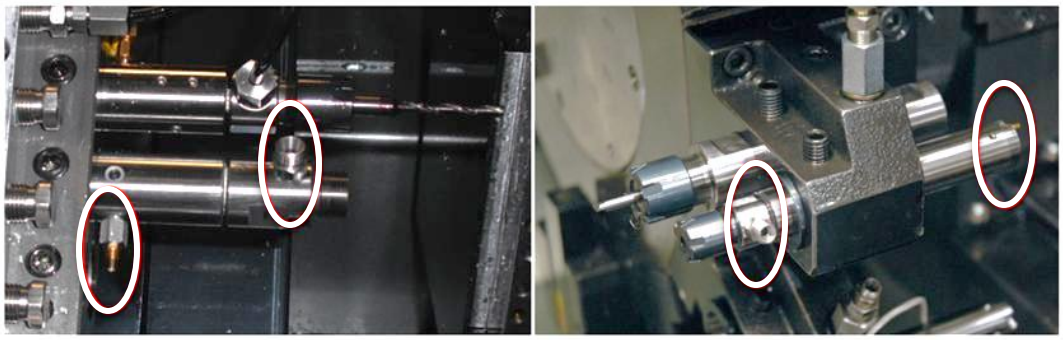

Figure 3. TriboMAM installed with convenient access from machine front. Standard SSMBR/SSMCR port position shown in left, optional port position shown in right.

3. Verify that the TriboMAM shank and the TriboMAM nose do not interfere with the motion of all slides, tools and other tool blocks.

4. If the TriboMAM is installed on a sub-spindle tool slide, verify that no interference occurs with the sub-spindle pick-off motions.

5. Tighten screws in tool post to secure TriboMAM in tool post. Caution: tighten screws only to hand tight. Do not over tighten.

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2.4.3 Coolant line setup (if using through tool coolant)

Warning: Failure to follow these procedures could result in damage to equipment.

1. Set high-pressure system to less than 1,250 psi (86 bar, 8.6 MPa).

2. One end of the coolant line provided with the TriboMAM already has a swaged fitting for attaching the line to the TriboMAM compression fitting (coolant port). The opposing end does not have a swaged fitting attached so as to allow the user to determine the length of coolant line needed.

3. Follow these directions to re-install the existing fitting for the TriboMAM port.

Fix the pre-swage tool (TPSS-18-1) in a vise and prepare the flexible tubing and stainless steel ferrules as shown in Figure 4. The pre-swage tool will be used to pre-swage the stainless steel ferrules. The cone-shaped ferrule is denoted here as the front ferrule and the rear ferrule is more disk-shaped. Only use coolant lines provided/approved by M4 Sciences.

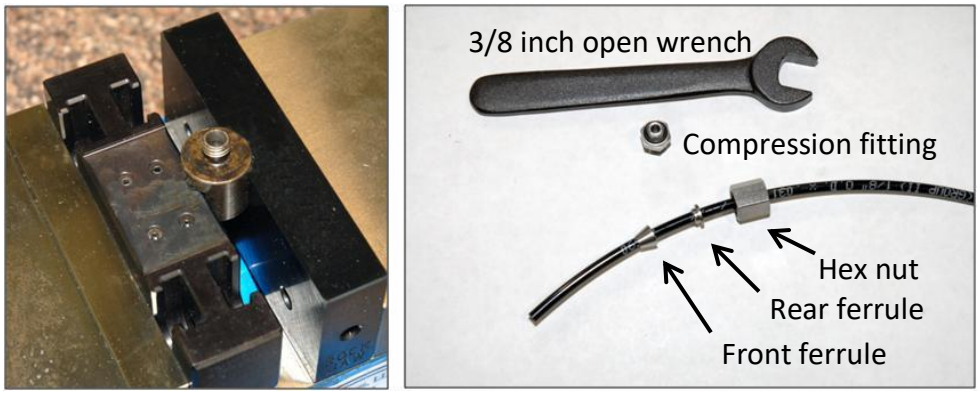

Figure 4. Pre-swage tool in vise (left) and appropriate configuration of coolant line components (right).

Place assembled coolant line components into the pre-swage tool as shown in Figure 5 and tighten with a 3/8 inch open wrench. Coolant line diameter should swell near the tip of the swage as shown in Figure 5.

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4. If the compression fitting (coolant port) was not fixed to the TriboMAM body prior to receipt, attach the fitting to the TriboMAM body and tighten with a 5/16 inch open wrench until the compression fitting is securely attached.

Figure 5. Swaging of assembled fitting by tightening in the pre-swage tool (left) and final swaged fitting on coolant line (right).

5. Connect the swaged coolant line to the TriboMAM coolant port and lightly tighten the connection until snug, this will be firmly secured in a later step.

6. The below procedure outlines the swaging and attachment of the coolant line to the machine's manifold block. For this purpose, straight and right angle 1/4 inch NPT x 1/8 inch compression fittings are provided with the coolant installation.

   The fittings are shown in Figure 6 and are also composed of stainless steel ferrules as in step 3.

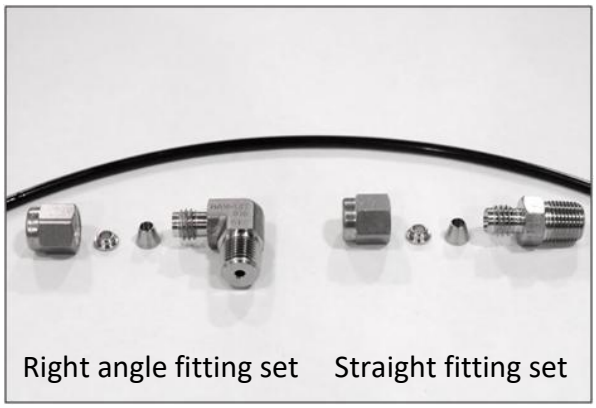

Figure 6. Provided compression fittings for coolant manifold.

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While the coolant fitting is shipped pre-assembled, it is possible that this pre-assembly may be disturbed prior to installation. The front and rear stainless steel ferrules must be in the order shown in the Figure 7. Pre-assemble the coolant fitting following the order of assembly as shown in Figure 7 and lightly tighten the hex nut to the compression fitting.

Remove the coolant line from the pre-assembly, as the line will not be swaged to until the last step of this process. Attach the appropriate (either right angle or straight style) pre-assembled coolant fitting to the coolant manifold and tighten secure as shown in Figure 7.

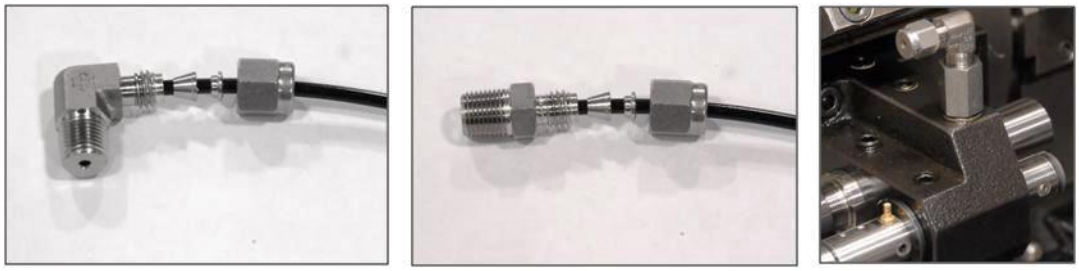

Figure 7**.** Pre-assembly order of fittings for coolant manifold (left and middle). Final pre-assembled fitting on coolant manifold and with coolant line removed (right).

As shown in Figure 8, route the coolant line from TriboMAM connection point to the machine coolant manifold and cut the line to an appropriate length with sufficient slack for anchoring and strain relief if necessary.

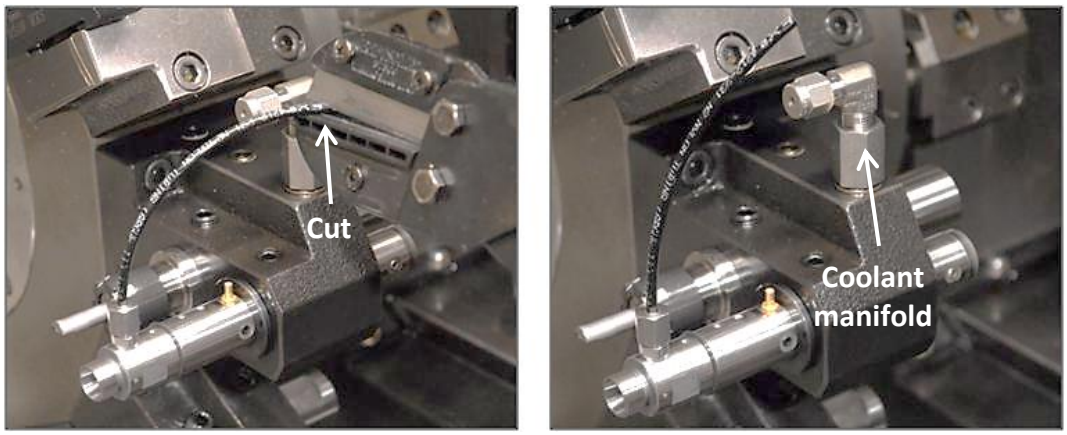

Figure 8. Shortening of coolant line to an appropriate length for routing to coolant manifold (left) and final length (right).

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If the machine coolant manifold port is an appreciable distance from the TriboMAM connection point, route the line as appropriate and anchor the coolant line using straps or ties to a rigid point 100 mm – 150 mm (4 inches – 6 inches) from the TriboMAM connection point to provide strain relief for the line. If the coolant line is routed to an off-slide connection, verify that the coolant line will not be pinched or snagged and has sufficient slack when the slide is moved through its maximum range.

Tighten the hex nut on the coolant line to the coolant manifold with a 3/8 inch open wrench as shown in Figure 9. This will swage the ferrules in the pre-assembled fitting to the coolant line. For the hex nut on the coolant line to be fixed to the TriboMAM body, care must be exercised in properly tightening so as to not damage the threads that secure the compression fitting to the TriboMAM.

Using a 5/16 inch open wrench to secure the compression fitting on the TriboMAM body, tighten the hex nut on the coolant line with a 3/8 inch open wrench until the coolant line is secured tightly to the TriboMAM. This will require holding the 5/16 inch wrench in place on the compression fitting (coolant port) base while using the 3/8 inch open wrench to tighten the hex nut. This is shown schematically in Figure 9.

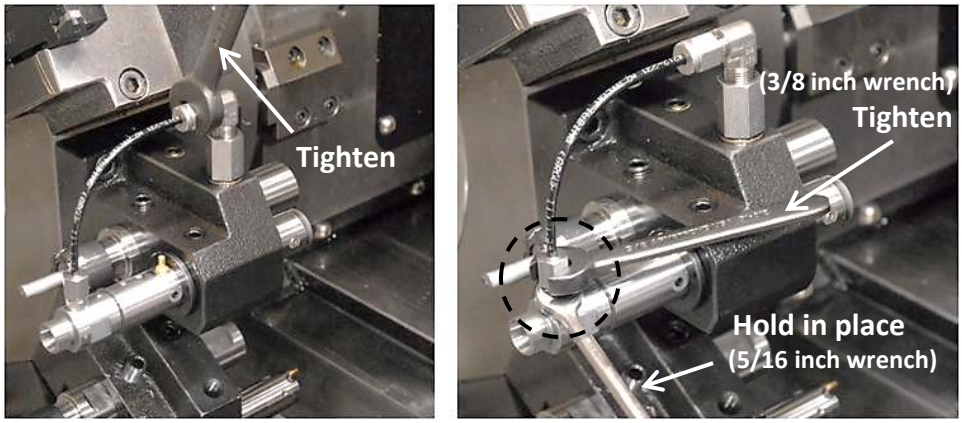

Figure 9. Tightening of the hex nut on the coolant line to the compression fitting on the coolant manifold (left). Tightening of the hex nut on the coolant line to the compression fitting on the TriboMAM body (right).

Warning: Verify coolant line installation by running high-pressure system for at least 10 minutes after drill tool is installed. Coolant line may burst or leak if installation is incorrect. Follow all appropriate safety requirements with coolant line installation and high-pressure coolant operation.

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2.4.4 TriboMAM power cable

The TriboMAM may be configured with one of two types of electrical connectors. These are SSMB (snap-on) and SSMC (screw-on) types. The SSMB connector is round in shape and is a snap-on connection. The SSMC connector is hexagonal and is a screw-on connection. The SSMC male connector can be readily identified as threads are present at its base to allow fixation with the SSMC female connector.

(a) (b) (c)

Figure 10. (a) Examples of female SSMB (top) and female (bottom) connectors, (b) male SSMB connector and (c) male SSMC connector.

1. Attach the power cable as shown below. For SSMB-type connections, pressing the female connector of the high-voltage cable against the male connector of the TriboMAM / Controller will secure the electrical connection. For SSMC-type connections (shown below), the female connector is screwed in to the male connector using a 5/32 inch wrench until the connection is snug.

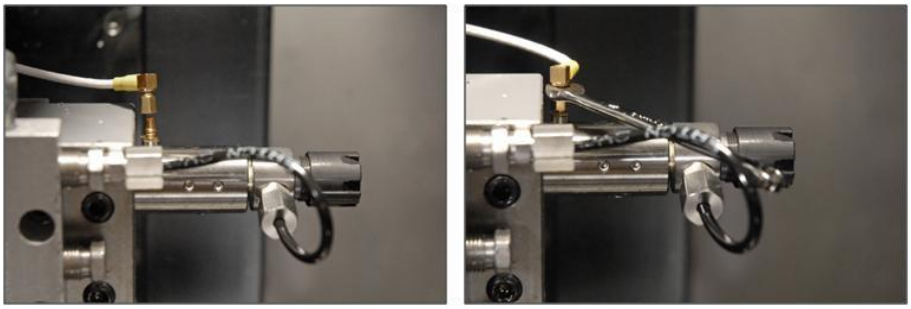

Figure 11. Tightening of power cable to TriboMAM body with 5/32 inch wrench.

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2. Anchor the power cable to a point on the slide 100 mm – 150 mm (4 inch – 6 inch) from the TriboMAM connection point to provide strain relief for the cable. Anchor the power cable to a convenient location from the lathe interior (e.g. through grommet hole, coolant tank, along coolant lines, etc.). Ensure that the cable will not be pinched or snagged and has sufficient slack when the slide is moved through maximum range.

Warning: Verify that power cable does not interfere with machine movements or other tools.

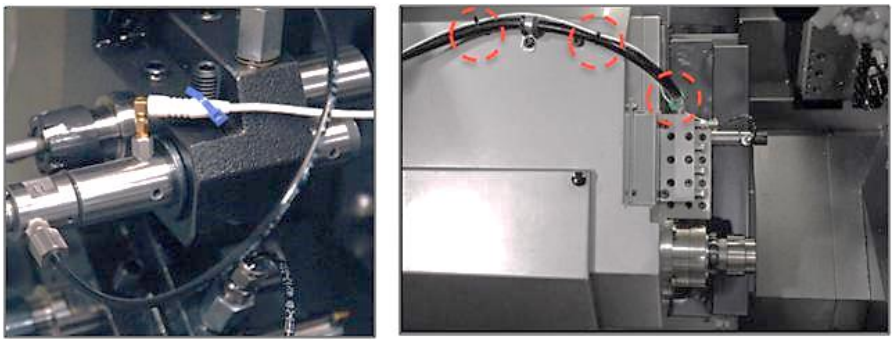

Figure 12. Strain relief of power cable provided by anchoring cable to tool block (left) and routing of power cable away from TriboMAM connection point (right). Anchor points shown in red circles.

Warning: Ensure that the power is off at the MEC-PA11033 Controller.

Warning: The high-voltage output connector carries high voltage. DO NOT touch the high-voltage output connector or the load circuit while the MEC-PA11033 is operating. An electrical shock could result. Always turn off the MEC-PA11033 before making changes to the load connections. The maximum voltage at the high voltage output connector is +150 V.

3. Connect the opposite end of the high-voltage cable to the high-voltage output connector (labeled HV OUT) on the MEC-PA11033 Controller as shown below.

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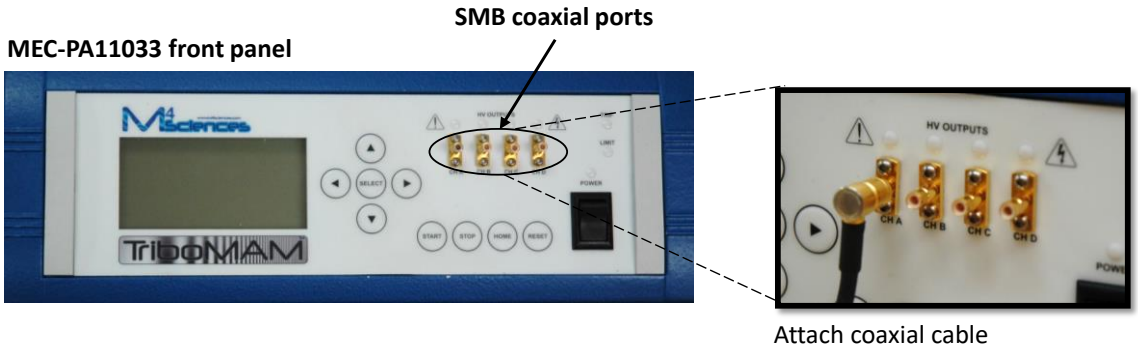

Figure 13. Attaching the TriboMAM power cable to the front panel of the MEC-PA11033 Controller.

2.4.5 Drill installation

Warning: Special caution is needed while securing a drill to the TriboMAM and in tightening the ER-11 collet nut to avoid over-torqueing. Excessive torque during drill install may damage the TriboMAM.

1. To prevent excessive torque from damaging the TriboMAM, use a 17 mm open wrench on the flat surfaces at the front of the TriboMAM body while tightening the ER-11 collet nut as shown below.

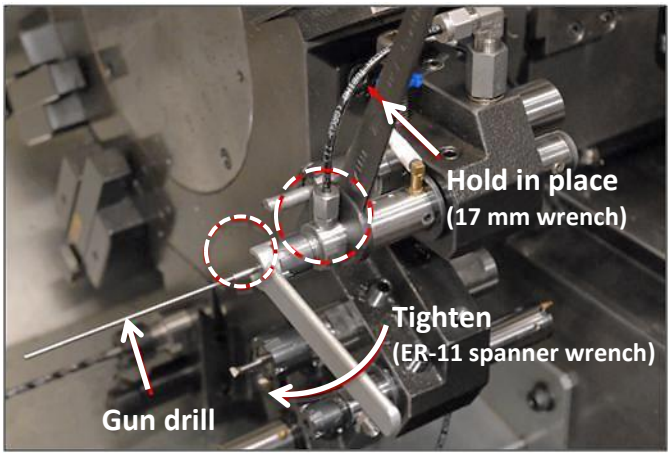

Figure 14. Drill install procedure.

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2.4.6 Installation check

1. Re-verify that the TriboMAM is secure in the tool block.

2. Check clearance of the TriboMAM drilling system (front and back) on all slides, tools, and tool blocks as well as proper electrical cable and coolant line routing / anchoring by testing the maximum range of motion of the machine axes.

3. Verify that the drill is installed properly and the ER collet is secure.

4. Verify that all program positions and tool positions are correct.

5. Continuously run coolant for a minimum of 10 minutes to verify no leaks are present.

Warning: Failure to follow these installation checks could result in damage or failure of the TriboMAM drilling system.

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3 Operation

3.1 Initialization

1. Ensure that the TriboMAM controller output is off.

2. Set TriboMAM tool offsets according to the standard instructions from the machine manufacturer.

3. If a high-pressure coolant line is used, verify that the high-pressure coolant setting is adjusted to ≤ 1,250 psi (86 bar, 8.6 MPa).

4. Dry cycle program to verify clearance of the TriboMAM drilling system, drill tool and electrical/coolant cabling on any slide/sub-slide motions.

5. Input the process parameters (drill diameter, number of flutes, rotational speed, feed rate) into the MEC-PA11033 Controller per the instructions in the MEC-PA11033 User Manual.

3.2 General Operation

The TriboMAM is ready for operation after completing the initial steps of setting the TriboMAM drill tool offsets and programming the MEC-PA11033 Controller with the baseline machining process parameters. Follow the MEC-PA11033 User Manual for instructions on starting and stopping the TriboMAM operation, as well as for emergency stops.

It is generally good practice to ensure that the baseline machining process is stable using the TriboMAM drilling system in the OFF position. After this is verified, optimization can be carried out by adjusting the machining parameters and updating the MEC Controller to reflect these adjustments.

Warning: For proper operation, the TriboMAM must be programmed correctly with the actual machining parameters. Discrepancy between the actual and programmed values will affect the performance of the TriboMAM drilling system. Any feed rate and spindle speed override controls should not be adjusted beyond 100% during the drill cycle.

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3.3 Process Optimization

TriboMAM users with equipment capacity for process development can quickly explore the potential to make significant increases in drilling production rates. Large increases in drilling feed rate and/or surface speed can be tested using the TriboMAM system. While premature tool failure is expected during exploratory testing, regardless of whether either a standard drill holder or the TriboMAM is used, the user can quickly establish the potential performance envelope of the TriboMAM drilling system for a particular application. TriboMAM users unable to incur costs of interrupted production and/or drill tool replenishment for process development should perform more incrementally-based changes to the drilling process, along with some monitoring of the performance of the new process over some appropriate period of time.

The information provided in this section is a summary of useful practices for developing an improved drilling process using a TriboMAM drilling system. The general engineering methods and practices employed to develop production drilling processes are unchanged with the use of the TriboMAM system. Review all installation and operation instructions for the TriboMAM drilling system and the MEC-PA11033 controller prior to beginning any drilling process development.

Follow ALL safety requirements and warnings provided by the machine tool manufacturer, the drill manufacturer, collet or collet nut manufacturer and the safety requirements described in the TriboMAM drilling system and MEC-PA11033 controller installation guides. M4 Sciences is not responsible for the improper use of equipment or the use of drilling conditions that may cause damage to machines, tools, or possible injury to personnel.

Baseline drilling process already established

The TriboMAM is designed to improve drilling processes that are already optimized or established in production by the user. In this case, the CNC drilling conditions (e.g., drill type, drill feed rate, spindle speed and tool wear rate) are already known by the user. For installations where the baseline drilling conditions have already been established, these conditions may be used as a reference for test drilling with the TriboMAM system. The TriboMAM drilling system may allow increases in drilling speed (e.g., spindle RPM) and/or feed rate while testing a new drilling process.

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In general, if a baseline drilling process is already established, then increased drilling productivity can be accomplished by increasing drill feed rate. In some cases, especially in high length-to-diameter ratio drilling in high strength materials, increases in drilling feed rate may increase thrust forces in drilling. These increased forces can exceed the buckling stability load of a particular drill tool. In these cases, increased drilling productivity may be achieved by increasing drilling spindle speed.

The following guidelines outline four different types of drilling processes commonly used for industrial drilling applications. Each of these examples refers to an existing drilling process as a reference condition and utilizes incremental changes in the drilling process to achieve increased drilling productivity using the TriboMAM drilling system. As in practical machining process engineering, the drill tool life must be considered when defining a new production drilling process using the TriboMAM drilling system.

(1) Single flute gun-drilling with high-pressure through-tool coolant

Follow the drill tool manufacturer's recommended conditions for pilot hole drilling. After proper installation of the TriboMAM drilling system install a new drill for process testing. Incrementally increase the feed rate by 10% increments and drill several parts at each increment of feed rate (verify that the CNC program conditions match the MEC-PA11033 controller conditions).

Continue to incrementally increase feed rate until (1) the quality requirements are exceeded and/or (2) an acceptable level of drilling cycle time and drill wear rate is achieved. Drill breakage can occur as feed rate is incrementally increased. If drill tool failure occurs, then reduce the feed rate to a condition that achieves acceptable production rate and/or drill tool life.

(2) Twist flute drilling with high-pressure through tool coolant – no peck cycles

Follow the drill tool manufacturer's recommended conditions for pilot hole drilling. After proper installation of the TriboMAM drilling system install a new drill for process testing. Incrementally increase the feed rate by 10% increments and test drill several parts at each feed rate increment (verify that the CNC program conditions match the MEC-PA11033 controller conditions for each test).

Continue to incrementally increase feed rate until (1) the quality requirements are exceeded and/or (2) an acceptable level of drilling cycle time and drill wear rate is

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achieved. Drill breakage can occur as feed rate is incrementally increased. If drill tool failure occurs, then reduce the feed rate to a condition that achieves acceptable production rate and/or drill tool life.

(3) Twist flute drilling with high-pressure through tool coolant –with peck cycles

Follow the drill tool manufacturer's recommended conditions for pilot hole drilling. After proper installation of the TriboMAM drilling system install a new drill for process testing. For twist flute drilling with high-pressure through tool coolant and peck cycles, the TriboMAM may be used to reduce the number of peck cycles. The TriboMAM may also be able to achieve increased feed rate and/or rotational speeds.

Incrementally decrease the number of peck cycles and test drill several parts at each new peck cycle condition (verify that the CNC program conditions match the MEC-PA11033 controller conditions). Continue to incrementally decrease the number of peck cycles until (1) the quality requirements are exceeded and/or (2) an acceptable level of drilling cycle time and drill wear rate is achieved. Drill breakage can occur as the quantity of peck cycles decreases. If drill tool failure occurs, then increase the number of peck cycles to a condition that achieves acceptable production rate and/or drill tool life.

(4) Twist flute drilling with flood coolant – with peck cycles

The TriboMAM can be used in peck drilling applications with flood coolant. In these cases it is often important that the tip of the drill is lubricated at some time interval to prevent premature drill failure or unacceptable drill tool wear rate. The number of peck cycles required depends on the process and the requirements of the user.

Follow the drill tool manufacturer's recommended conditions for pilot hole drilling. After proper installation of the TriboMAM drilling system, install a new twist-flute drill for process testing. For twist flute drilling with flood coolant and peck cycles, the TriboMAM may be used to reduce the number of peck cycles. The TriboMAM may also be able to achieve increased feed rate and/or rotational speeds.

Incrementally decrease the number of peck cycles and test drill several parts (verify that the CNC program conditions match the MEC-PA11033 controller conditions). Continue to incrementally reduce the number of peck cycles until (1) the quality requirements are exceeded or (2) an acceptable level of drilling cycle time is achieved. Drill breakage can occur as the quantity of peck cycles decreases. If drill tool failure

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occurs, then increase the number of peck cycles to a condition that achieves acceptable production rate and/or drill tool life.

NO existing baseline drilling process established

The TriboMAM drilling system is designed to improve drilling operations that have already been established. If the TriboMAM is installed into a new machining process where no baseline drilling process is already established, then follow the drill tool manufacturer's recommended practices for pilot drilling and conditions for workpiece rotational speed and drill feed rate to establish a baseline drilling process. After an acceptable baseline process is established, the TriboMAM tool may be used to incrementally increase workpiece speed and/or drill feed rate following the guidelines outlined below.

It is critical that the TriboMAM be programmed correctly with the actual machining parameters. Discrepancy between the actual and programmed values for these parameters will affect the performance of the TriboMAM drilling system.

Programming Example for TriboMAM drilling system *and MEC-PA11033 controller*:

In this sample program the TriboMAM was programmed to eliminate the peck drilling cycle and the G83 command was removed from the CNC program and replaced with a G1 command. In some drilling applications peck drilling may not be completely eliminated and the optimal process conditions must be established by actual drilling results.

1) Baseline drilling process – peck drilling cycle

Material: Oxygen Free High Conductivity Copper Alloy 101
Drill: Diameter 3.0 mm, 2 flute drill with thru-tool coolant
Coolant pressure: 1,500 psi (103 bar)
Spindle: 6500 RPM
Feed rate: 0.050 mm/rev

CNC code (G83 peck drilling cycle 0.150 mm peck depth, feedrate: 0.050 mm/rev):
M3 S1=6500
X0.0 Z1.0
G83 Z-75.0 R0.100 Q0.050 F0.050
G0 Z1.0
2) TriboMAM drilling process

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Coolant pressure: 1,250 psi (86 bar)*
Select Setup Menu in MEC controller – choose Model Mini
Program 1
Dia = 3.0000 mm
Flutes = 2
RPM = 6480**
Feed = 0.050 mm/rev

Changes to CNC code:
M3 S1=6480 **
G1 Z-75.0 F0.050
G0 Z1.0

* **Important**: The machine coolant pressure was reduced to 1,250 psi (86 bar) to meet the specifications of the TriboMAM drilling system

** **Important**: The spindle RPM must be a multiple of 60 and the CNC spindle RPM must be programmed to match the TriboMAM program.

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4 TriboMAM Functional Test

Note: This functionality is only available in MEC-PA11033 software V9.22 and later. Contact M4 Sciences for further instructions if a functional test is to be performed using controllers with earlier software versions.

The TriboMAM drilling system oscillates in the axial direction of the body. During operation of the TriboMAM tool, the total stroke or amplitude of the oscillation is dependent on both the drilling process and the actual programmed conditions at the MEC-PA11033 Controller interface. In some cases, the TriboMAM drilling system emits an audible sound. These audible sounds are normal. However, for some programs and drill conditions no sound is audible and the oscillation of the drill tool may not be visible or sensible by human systems. These cases are most common when the drilling feed rates are lower than 0.025 mm/rev (0.001 inch/rev) and the work-spindle RPM is lower than 2400 rpm.

If damage to the TriboMAM tool is suspected, then verify proper operation using the following test verification procedure. If you believe the TriboMAM tool is not functioning properly, this test should be completed prior to contacting M4 Sciences.

Note: The function test requires a test indicator with 0.002 mm (0.0001 inch) increments. Do not attempt to perform this test with improper gage instruments.

Bench testing

Place the test indicator (with 0.002 mm increments) against the front shoulder of the TriboMAM drilling system ER collet nose as shown to the right. Establish a zero reference on the dial indicator using normal gage practices. Using the MEC-PA11033 Controller, go to the *System Setting* and select *Function Test*. When this test is selected, the MEC-PA11033 controller is outputting a low frequency voltage oscillation at maximum amplitude for verify the TriboMAM operation.

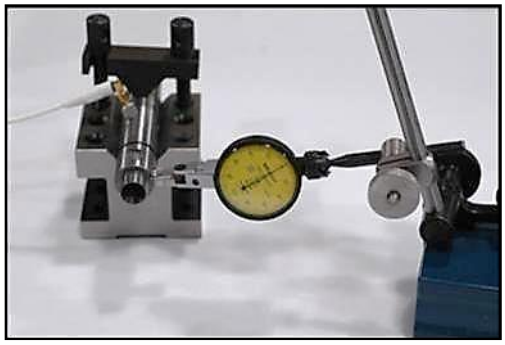

Figure 15. TriboMAM functional test using test indicator.

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The screen on the MEC controller will display a message that Function Test is running. The test can be halted at any time by any button. The total range of the displacement, read as the difference between maximum and minimum on the test indicator, should meet the specifications below. If the total displacement measured using the test indicator does not meet this specification then contact M4 Sciences.

Drilling System Type	**Displacement**	**Notes:**
TriboMAM-micro	> 0.016mm [> 0.0006 inches]	
TriboMAM-mini/meso	> 0.048mm [> 0.0019 inches]	
TriboMAM-standard	> 0.096mm [> 0.0038 inches]	
TriboMAM-kilo^2/mega^2	> 0.065mm [> 0.0026 inches]	

On-machine testing

The protocol for on-machine testing is similar to that of bench testing, with the exception that the TriboMAM is tested after machine installation. Mount the test indicator on a magnetic moveable base and repeat the above instructions for bench testing.

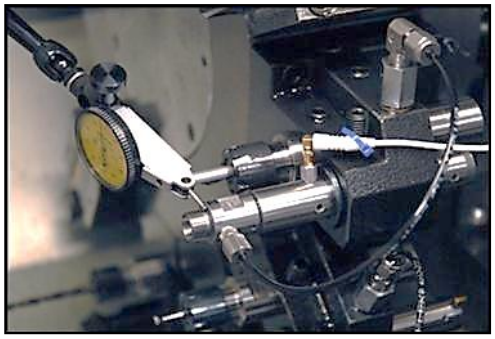

Figure 16. Functional test using test indicator on machine. Note the strain relief tie down for power cable.

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5 Installation Checklist

This checklist includes important items for a new installation of the TriboMAM. This checklist does not to include all necessary steps for installation, and is only a supplement of the documentation. Please refer to Section 2 of this manual and also to the MEC-PA11033 User Manual for installation protocols.

Baseline process checks

- Note the positions and types of the external coolant lines.
- Locate safety equipment in the plant (fire extinguishers, safety PPE, etc. know where fire suppression is activated if applicable).
- Record baseline drilling cycle time and G-code lines.

TriboMAM installation

- Verify that TriboMAM shank or nose will clear all slides and tools on other blocks. If TriboMAM is installed on sub-spindle, verify no interference at pick-off by sub-spindle.
- Check set screws / hold down on TriboMAM tool.
- Verify proper torque procedure of TriboMAM tool collet nose.
- Verify high-pressure coolant is less than 1,250 psi (86 bar, 8.6 MPa).
- Check positioning of external coaxial cable and coolant lines, ensure proper strain relief to TriboMAM. Check cables or coolant lines allow all slide movements.
- Test high-pressure coolant line for minimum of 10 minutes prior to actual testing to check for any leaks.

Controller installation

- Refer to MEC-PA11033 Controller Manual for installation details.
- Place the controller on the machine or other surface (e.g. on top of bar feeder, high pressure coolant tank). Ensure that the external heat sink fins are not obstructed.
- Check incoming power supply line to amplifier for proper ground and voltage. If ground cannot be verified then bond ground post at back of amplifier to machine or external ground.
- Verify that the controller is not in E-Stop prior to power on.
- Verify SSMB or SSMC cable connection at TriboMAM.

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- Provide strain relief to power cable and zip tie to rigid point approximately 100 mm – 150 mm (4" – 6") from connection at TriboMAM and check for proper lengths to accommodate slide movements.

Operation setup

- Feed rate override must not cause feed rate to be different than programmed CNC value.
- Verify proper selection of TriboMAM/TriboMAM on MEC Controller.
- If power amplifier output does not turn ON then check programmed conditions.
- Verify that the programmed value of RPM at the MEC controller matches the spindle RPM in the CNC code. RPM must be an increment of 60 RPM.
- Do not turn TriboMAM On/Off during actual drilling (e.g. if TriboMAM is off, do not turn on mid-cycle, etc.).

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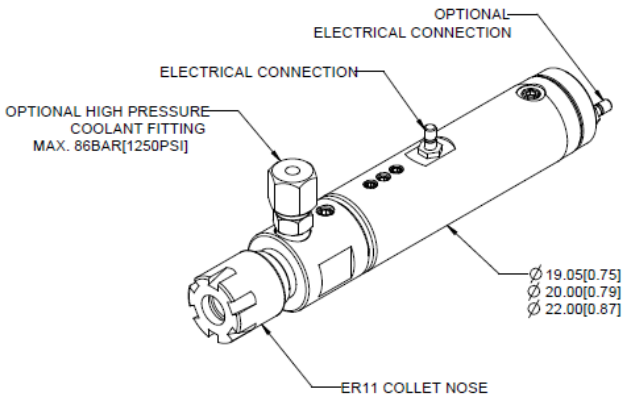
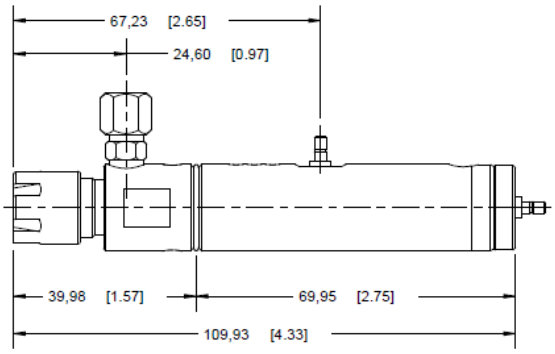
6 Specifications

6.1 TriboMAM-micro

Drilling diameter:	0.2 mm to 2.0 mm
Feed rate:	up to 0.015 mm/rev/flute
Maximum spindle speed:	9,960 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)





*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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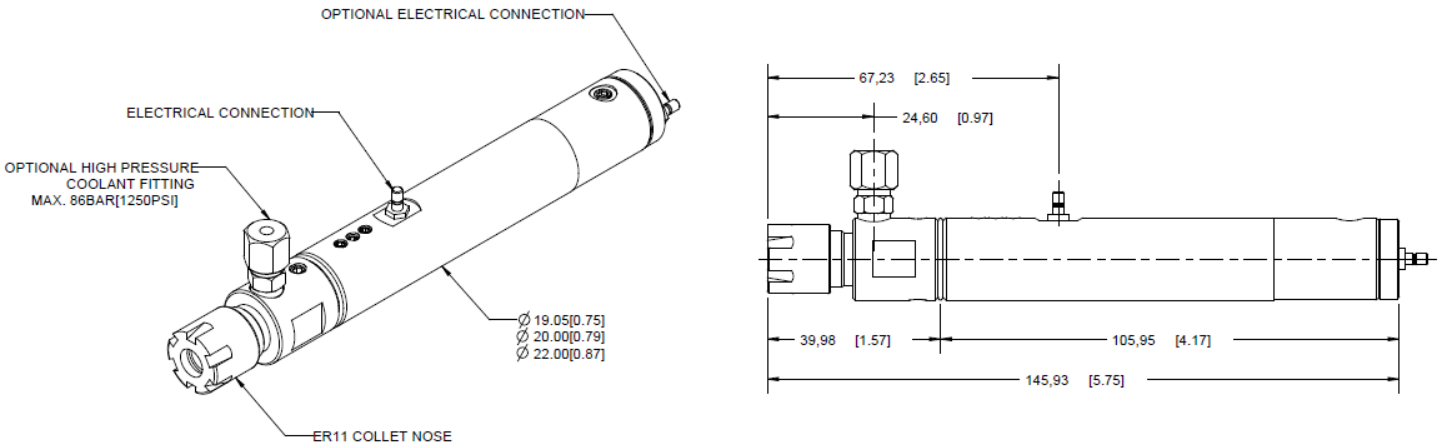
6.2 TriboMAM-mini

Drilling diameter:	0.2 mm to 3.5 mm
Feed rate:	up to 0.040 mm/rev/flute
Maximum spindle speed:	9,960 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)



*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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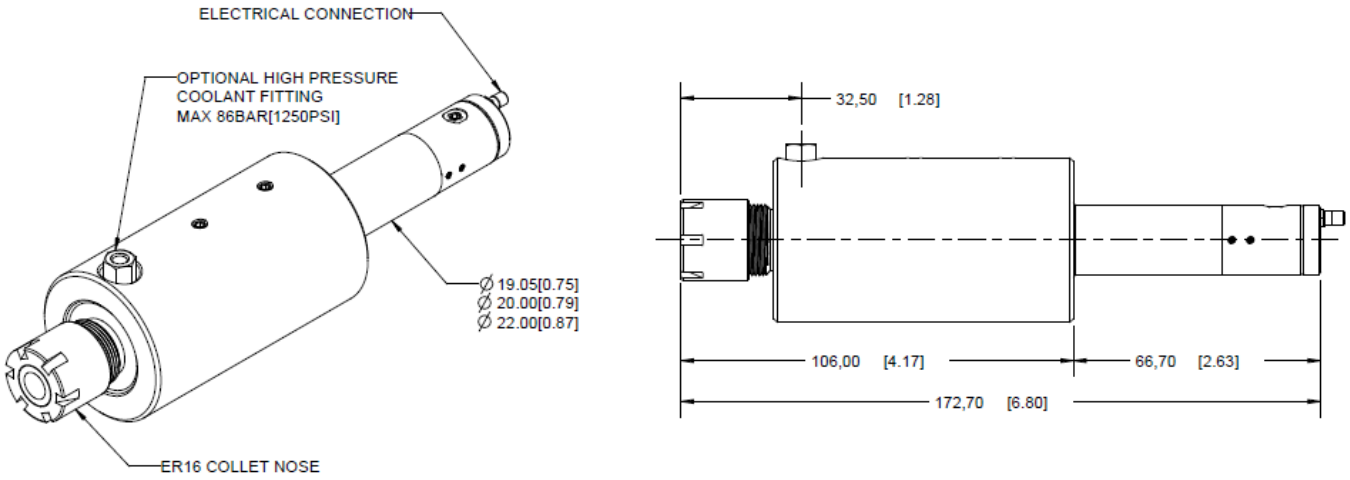
6.3 TriboMAM-meso

Drilling diameter:	0.5 mm to 5.0 mm
Feed rate:	up to 0.040 mm/rev/flute
Maximum spindle speed:	9,960 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)



*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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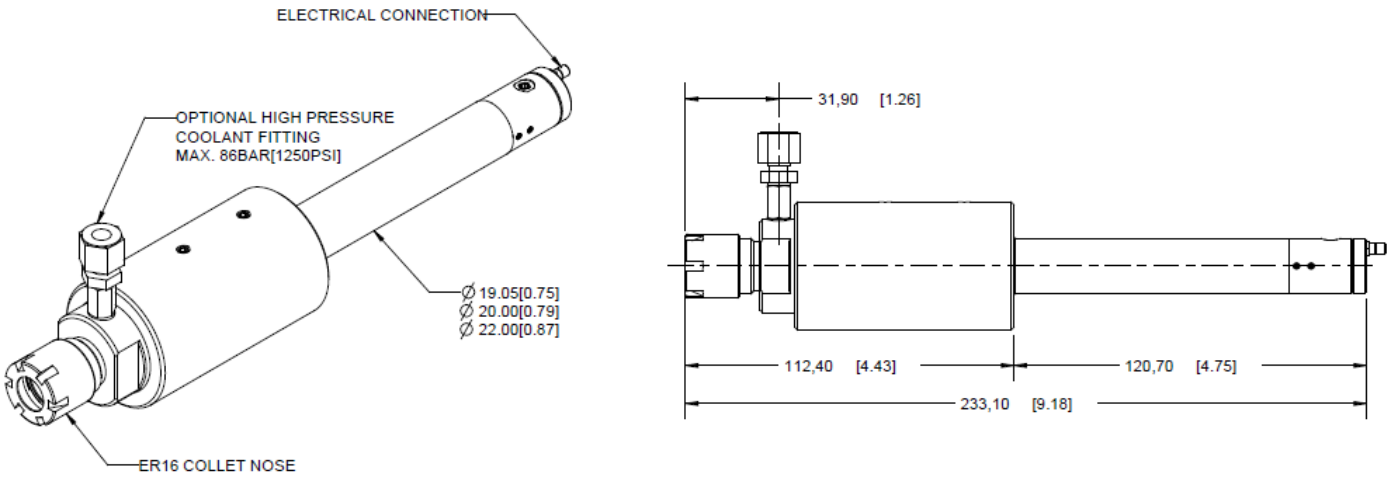
6.4 TriboMAM-standard

Drilling diameter:	2.0 mm to 6.5 mm
Feed rate:	up to 0.080 mm/rev/flute
Maximum spindle speed:	7,200 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)



*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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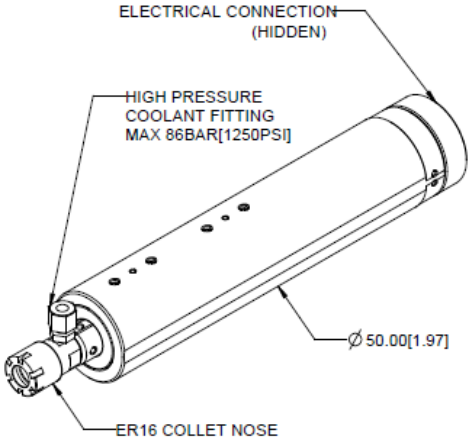
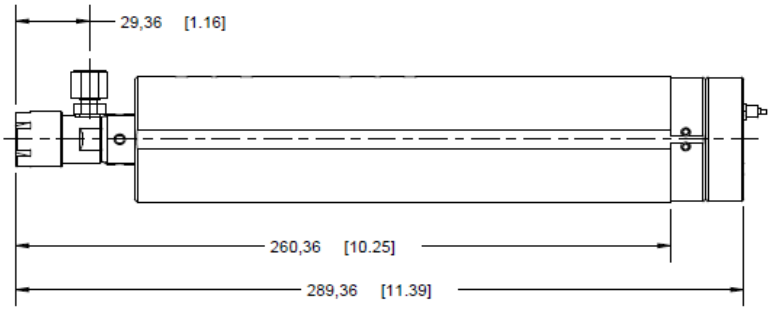
6.5 TriboMAM-kilo²

Drilling diameter:	5.0 mm to 10.0 mm
Feed rate:	up to 0.060 mm/rev/flute
Maximum spindle speed:	6,000 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)





*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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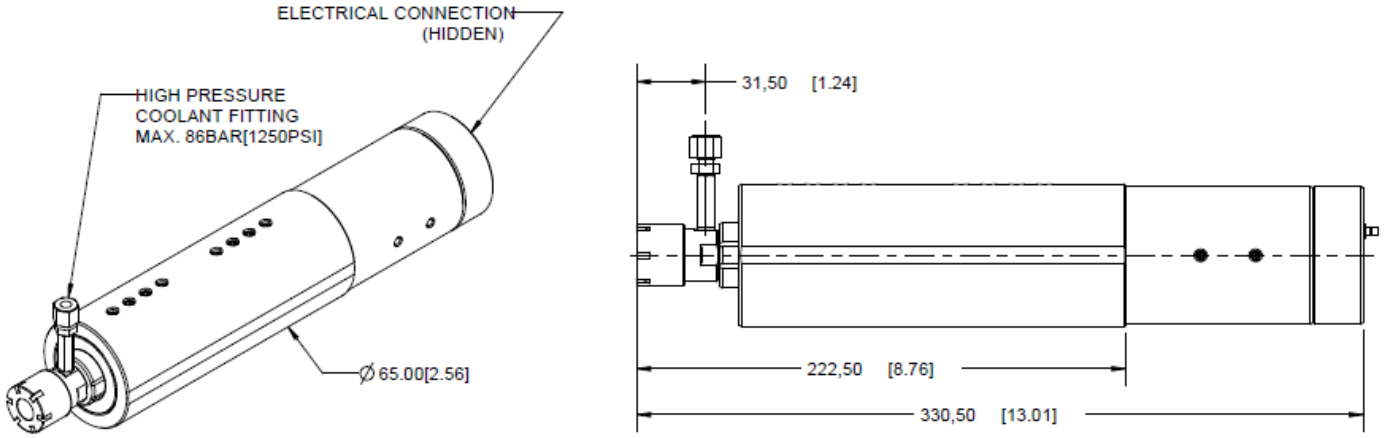
6.6 TriboMAM-mega²

Drilling diameter:	5.0 mm to 12.0 mm
Feed rate:	up to 0.060 mm/rev/flute
Maximum spindle speed:	6,000 rpm
Maximum coolant pressure:	1,250 psi (86 bar, 8.6 MPa)
	*5,000 psi (345 bar, 34.5 Mpa) available as option

Standard Dimensions (*not to scale)



*Dimensions are in mm [inches]. These dimensions may vary depending on the approved configuration. See Section 7 for Reference Materials. Consult the MEC-PA11033 User Manual for specifications of the MEC Controller.

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7 Spare Parts

Spare parts list:

Item	M4 P/N	Qty	Full Description	Supplier	Manuf.	Supplier P/N
Coolant Fitting	P004-0167	1	Stainless steel coolant fitting 1/8 compression tube to 10-32 male	Beswick	Beswick	MCB-18-1-303
Pre-swage Tool	I007-0241	1	Pre-swaging tool for Beswick fitting. New ferrules required for new compression connection.	Beswick	Beswick	TPSS-18-1 (SS)
Front Ferrule	P004-0240	1	Front ferrule for MCB-18-1-303 compression fitting - replaces ferrule for new compression connection	Beswick	Beswick	FF (stainless) for MCB-18-1-303
Rear Ferrule	P004-0239	1	Rear ferrule for MCB-18-1-303 compression fitting - replaces ferrule for new compression connection	Beswick	Beswick	FR (stainless) for MCB-18-1-303
Coolant Tubing	P004-0238	10	Nylon Tubing 1/8inch OD - (for high pressure coolant) 0.031" wall. Uses pre-swage tool TPSS-18-1 to pre-swage compression fitting from Beswick. No substitution available. TriboMAM warranty void if alternative tubing is used.	Trans. & Fluid Equip., Inc.	Eaton Synflex	4212-231 alt - 4212-233
Compression Fitting Straight	P004-0212	1	Compression - Tube Fittings - Metal Type: Male Connector Fitting Size: 1/8 End Connections: Comp x MNPT Tube Outside Diameter: 1/8 Thread Size: 1/8 Thread Type: MPT Material: Stainless Steel	MSC Industrial	Hamlet	86760519
Compression Fitting Elbow	P004-0211	1	Compression - Tube Fittings - Metal Type: 90° Elbow Fitting Size: 1/8 End Connections: Comp x MNPT Tube Outside Diameter: 1/8 Thread Size: 1/8 Thread Type: MPT Material: Stainless Steel	MSC Industrial	Hamlet	85552727

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8 ER Collets and Clamping Nuts (REGO-FIX)

8.1 TriboMAM-micro and -mini

ER 11-UP Ultra-Precision (mm) Collets

Type	Part No.	Clamping Range [mm]	Clamping Range [Inch]	Ø [Inch]
ER 11-UP Ø 1.0 mm	1111.01001	1.00 - 0.50	0.0394 - 0.0197	1/32"
ER 11-UP Ø 1.5 mm	1111.01501	1.50 - 1.00	0.0591 - 0.0394	-
ER 11-UP Ø 2.0 mm	1111.02001	2.00 - 1.50	0.0787 - 0.0591	1/16"
ER 11-UP Ø 2.5 mm	1111.02501	2.50 - 2.00	0.0984 - 0.0787	3/32"
ER 11-UP Ø 3.0 mm	1111.03001	3.00 - 2.50	0.1181 - 0.0984	-
ER 11-UP Ø 3.5 mm	1111.03501	3.50 - 3.00	0.1378 - 0.1181	1/8"
ER 11-UP Ø 4.0 mm	1111.04001	4.00 - 3.50	0.1575 - 0.1378	5/32"
ER 11-UP Ø 4.5 mm	1111.04501	4.50 - 4.00	0.1772 - 0.1575	-
ER 11-UP Ø 5.0 mm	1111.05001	5.00 - 4.50	0.1969 - 0.1772	3/16"
ER 11-UP Ø 5.5 mm	1111.05501	5.50 - 5.00	0.2165 - 0.1969	-
ER 11-UP Ø 6.0 mm	1111.06001	6.00 - 5.50	0.2362 - 0.2165	7/32"
ER 11-UP Ø 6.5 mm	1111.06501	6.50 - 6.00	0.2559 - 0.2362	1/4"
ER 11-UP Ø 7.0 mm	1111.07001	7.00 - 6.50	0.2756 - 0.2559	-

Hi-Q/ERMC 11 Clamping Nuts with Built-In Sealing System for Coolant through Tools

Type	Part No.	Ø [Inch]	Sealing Capacity [mm]	Sealing Capacity [Inch]
Hi-Q / ERMC 11 Ø 3.0 mm	3511.20300	3/32"	3.00 - 2.50	0.1181 - 0.0984
Hi-Q / ERMC 11 Ø 3.5 mm	3511.20350	1/8"	3.50 - 3.00	0.1378 - 0.1181
Hi-Q / ERMC 11 Ø 4.0 mm	3511.20400	5/32"	4.00 - 3.50	0.1575 - 0.1378
Hi-Q / ERMC 11 Ø 4.5 mm	3511.20450	-	4.50 - 4.00	0.1772 - 0.1575
Hi-Q / ERMC 11 Ø 5.0 mm	3511.20500	3/16"	5.00 - 4.50	0.1969 - 0.1772
Hi-Q / ERMC 11 Ø 5.5 mm	3511.20550	7/32"	5.50 - 5.00	0.2165 - 0.1969
Hi-Q / ERMC 11 Ø 6.0 mm	3511.20600	-	6.00 - 5.50	0.2362 - 0.2165
Hi-Q / ERMC 11 Ø 6.5 mm	3511.20650	1/14"	6.50 - 6.00	0.2559 - 0.2362
Hi-Q / ERMC 11 Ø 7.0 mm	3511.20700	-	7.00 - 6.50	0.2756 - 0.2559

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8.2 TriboMAM-standard and -meso

ER 16-UP Ultra-Precision (mm) Collects

Type	Part No.	Clamping Range [mm]	Clamping Range [Inch]	Ø [Inch]
ER 16-UP Ø 1.0 mm	1116.01001	1.00 - 0.50	0.0394 - 0.0197	1/32"
ER 16-UP Ø 1.5 mm	1116.01501	1.50 - 1.00	0.0591 - 0.0394	-
ER 16-UP Ø 2.0 mm	1116.02001	2.00 - 1.00	0.0787 - 0.0394	1/16"
ER 16-UP Ø 2.5 mm	1116.02501	2.50 - 1.50	0.0984 - 0.0591	3/32"
ER 16-UP Ø 3.0 mm	1116.03001	3.00 - 2.00	0.1181 - 0.0787	-
ER 16-UP Ø 3.5 mm	1116.03501	3.50 - 2.50	0.1378 - 0.0984	1/8"
ER 16-UP Ø 4.0 mm	1116.04001	4.00 - 3.00	0.1575 - 0.1181	5/32"
ER 16-UP Ø 4.5 mm	1116.04501	4.50 - 3.50	0.1772 - 0.1378	-
ER 16-UP Ø 5.0 mm	1116.05001	5.00 - 4.00	0.1969 - 0.1575	3/16"
ER 16-UP Ø 5.5 mm	1116.05501	5.50 - 4.50	0.2165 - 0.1772	-
ER 16-UP Ø 6.0 mm	1116.06001	6.00 - 5.00	0.2362 - 0.1969	7/32"
ER 16-UP Ø 6.5 mm	1116.06501	6.50 - 5.50	0.2559 - 0.2165	1/4"
ER 16-UP Ø 7.0 mm	1116.07001	7.00 - 6.00	0.2756 - 0.2362	-
ER 16-UP Ø 7.5 mm	1116.07501	7.50 - 6.50	0.2953 - 0.2559	9/32"
ER 16-UP Ø 8.0 mm	1116.08001	8.00 - 7.00	0.3150 - 0.2756	5/16"
ER 16-UP Ø 8.5 mm	1116.08501	8.50 - 7.50	0.3347 - 0.2953	-
ER 16-UP Ø 9.0 mm	1116.09001	9.00 - 8.00	0.3543 - 0.3150	11/32"
ER 16-UP Ø 9.5 mm	1116.09501	9.50 - 8.50	0.3740 - 0.3347	-
ER 16-UP Ø 10.0 mm	1116.10001	10.00 - 9.00	0.3937 - 0.3543	3/8"

ER Clamping Nuts

Type	Part No.
Hi-Q / ERMC 16	3516.20000

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ER Sealing Disks DS/ER 16

Type	Part No.	Ø [Inch]	Sealing Capacity [mm]	Sealing Capacity [Inch]
DS/ER 16 Ø 3.0 mm	3916.00300	3/32"	3.00 - 2.50	0.1181 - 0.0984
DS/ER 16 Ø 3.5 mm	3916.00350	1/8"	3.50 - 3.00	0.1378 - 0.1181
DS/ER 16 Ø 4.0 mm	3916.00400	5/32"	4.00 - 3.50	0.1575 - 0.1378
DS/ER 16 Ø 4.5 mm	3916.00450	-	4.50 - 4.00	0.1772 - 0.1575
DS/ER 16 Ø 5.0 mm	3916.00500	3/16"	5.00 - 4.50	0.1969 - 0.1772
DS/ER 16 Ø 5.5 mm	3916.00550	7/32"	5.50 - 5.00	0.2165 - 0.1969
DS/ER 16 Ø 6.0 mm	3916.00600	-	6.00 - 5.50	0.2362 - 0.2165
DS/ER 16 Ø 6.5 mm	3916.00650	1/4"	6.50 - 6.00	0.2559 - 0.2362
DS/ER 16 Ø 7.0 mm	3916.00700	-	7.00 - 6.50	0.2756 - 0.2559
DS/ER 16 Ø 7.5 mm	3916.00750	9/32"	7.50 - 7.00	0.2953 - 0.2756
DS/ER 16 Ø 8.0 mm	3916.00800	5/16"	8.00 - 7.50	0.3150 - 0.2953
DS/ER 16 Ø 8.5 mm	3916.00850	-	8.50 - 8.00	0.3347 - 0.3150
DS/ER 16 Ø 9.0 mm	3916.00900	11/32"	9.00 - 8.50	0.3543 - 0.3347
DS/ER 16 Ø 9.5 mm	3916.00950	3/8"	9.50 - 9.00	0.3740 - 0.3543
DS/ER 16 Ø 10.0 mm	3916.01000	-	10.00 - 9.50	0.3937 - 0.3740

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8.3 TriboMAM-kilo² and -mega²

ER 20-UP Ultra-Precision (mm) Collets

Type	Part No.	Clamping Range [mm]	Clamping Range [Inch]	Ø [Inch]
ER 20-UP Ø 1.0 mm	1120.01001	1.00 - 0.50	0.0394 - 0.0197	1/32"
ER 20-UP Ø 1.5 mm	1120.01501	1.50 - 1.00	0.0591 - 0.0394	-
ER 20-UP Ø 2.0 mm	1120.02001	2.00 - 1.00	0.0787 - 0.0394	1/16"
ER 20-UP Ø 2.5 mm	1120.02501	2.50 - 1.50	0.0984 - 0.0591	3/32"
ER 20-UP Ø 3.0 mm	1120.03001	3.00 - 2.00	0.1181 - 0.0787	-
ER 20-UP Ø 3.5 mm	1120.03501	3.50 - 2.50	0.1378 - 0.0984	1/8"
ER 20-UP Ø 4.0 mm	1120.04001	4.00 - 3.00	0.1575 - 0.1181	5/32"
ER 20-UP Ø 4.5 mm	1120.04501	4.50 - 3.50	0.1772 - 0.1378	-
ER 20-UP Ø 5.0 mm	1120.05001	5.00 - 4.00	0.1969 - 0.1575	3/16"
ER 20-UP Ø 5.5 mm	1120.05501	5.50 - 4.50	0.2165 - 0.1772	-
ER 20-UP Ø 6.0 mm	1120.06001	6.00 - 5.00	0.2362 - 0.1969	7/32"
ER 20-UP Ø 6.5 mm	1120.06501	6.50 - 5.50	0.2559 - 0.2165	1/4"
ER 20-UP Ø 7.0 mm	1120.07001	7.00 - 6.00	0.2756 - 0.2362	-
ER 20-UP Ø 7.5 mm	1120.07501	7.50 - 6.50	0.2953 - 0.2559	9/32"
ER 20-UP Ø 8.0 mm	1120.08001	8.00 - 7.00	0.3150 - 0.2756	5/16"
ER 20-UP Ø 8.5 mm	1120.08501	8.50 - 7.50	0.3347 - 0.2953	-
ER 20-UP Ø 9.0 mm	1120.09001	9.00 - 8.00	0.3543 - 0.3150	11/32"
ER 20-UP Ø 9.5 mm	1120.09501	9.50 - 8.50	0.3740 - 0.3347	-
ER 20-UP Ø 10.0 mm	1120.10001	10.00 - 9.00	0.3937 - 0.3543	3/8"
ER 20-UP Ø 10.5 mm	1120.10501	10.50 - 9.50	0.4134 - 0.3740	13/32"
ER 20-UP Ø 11.0 mm	1120.11001	11.00 - 10.00	0.4330 - 0.3937	-
ER 20-UP Ø 11.5 mm	1120.11501	11.50 - 10.50	0.4528 - 0.4134	7/16"
ER 20-UP Ø 12.0 mm	1120.12001	12.00 - 11.00	0.4724 - 0.4375	15/32"
ER 20-UP Ø 12.5 mm	1120.12501	12.50 - 11.50	0.4921 - 0.4528	-
ER 20-UP Ø 13.0 mm	1120.13001	13.00 - 12.00	0.5118 - 0.4724	1/2"

ER Clamping Nuts

Type	Part No.
Hi-Q / ERMC 20	3520.20000

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ER Sealing Disks DS/ER 20

Type	Part No.	Ø [Inch]	Sealing Capacity [mm]	Sealing Capacity [Inch]
DS/ER 20 Ø 3.0 mm	3920.00300	3/32"	3.00 - 2.50	0.1181 - 0.0984
DS/ER 20 Ø 3.5 mm	3920.00350	1/8"	3.50 - 3.00	0.1378 - 0.1181
DS/ER 20 Ø 4.0 mm	3920.00400	5/32"	4.00 - 3.50	0.1575 - 0.1378
DS/ER 20 Ø 5.0 mm	3920.00500	3/16"	5.00 - 4.50	0.1969 - 0.1772
DS/ER 20 Ø 5.5 mm	3920.00450	7/32"	4.50 - 4.00	0.2165 - 0.1969
DS/ER 20 Ø 4.5 mm	3920.00550	-	5.50 - 5.00	0.1772 - 0.1575
DS/ER 20 Ø 6.0 mm	3920.00600	-	6.00 - 5.50	0.2362 - 0.2165
DS/ER 20 Ø 6.5 mm	3920.00650	1/4"	6.50 - 6.00	0.2559 - 0.2362
DS/ER 20 Ø 7.0 mm	3920.00700	-	7.00 - 6.50	0.2756 - 0.2559
DS/ER 20 Ø 7.5 mm	3920.00750	9/32"	7.50 - 7.00	0.2953 - 0.2756
DS/ER 20 Ø 8.0 mm	3920.00800	5/16"	8.00 - 7.50	0.3150 - 0.2953
DS/ER 20 Ø 8.5 mm	3920.00850	-	8.50 - 8.00	0.3347 - 0.3150
DS/ER 20 Ø 9.0 mm	3920.00900	11/32"	9.00 - 8.50	0.3543 - 0.3347
DS/ER 20 Ø 9.5 mm	3920.00950	3/8"	9.50 - 9.00	0.3740 - 0.3543
DS/ER 20 Ø 10.0 mm	3920.01000	-	10.00 - 9.50	0.3937 - 0.3740
DS/ER 20 Ø 10.5 mm	3920.01050	13/32"	10.50 - 10.00	0.4134 - 0.3937
DS/ER 20 Ø 11.0 mm	3920.01100	-	11.00 - 10.50	0.4330 - 0.4134
DS/ER 20 Ø 11.5 mm	3920.01150	7/16"	11.50 - 11.00	0.4528 - 0.4330
DS/ER 20 Ø 12.0 mm	3920.01200	15/32"	12.00 - 11.50	0.4724 - 0.4528
DS/ER 20 Ø 12.5 mm	3920.01250	-	12.50 - 12.00	0.4921 - 0.4724
DS/ER 20 Ø 13.0 mm	3920.01300	1/2"	13.00 - 12.50	0.5118 - 0.4921

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Supplier contact information:

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2) Transmission and Fluid Equipment, Ethan Bergman, 6912 Trafalgar Street, Fort Wayne, IN 46803, 260-493-3223 (office), 260-493-4085 (fax)

3) MSC Industrial, 1-800-645-7270, www.mscdirect.com

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