



Operation and Maintenance Manual

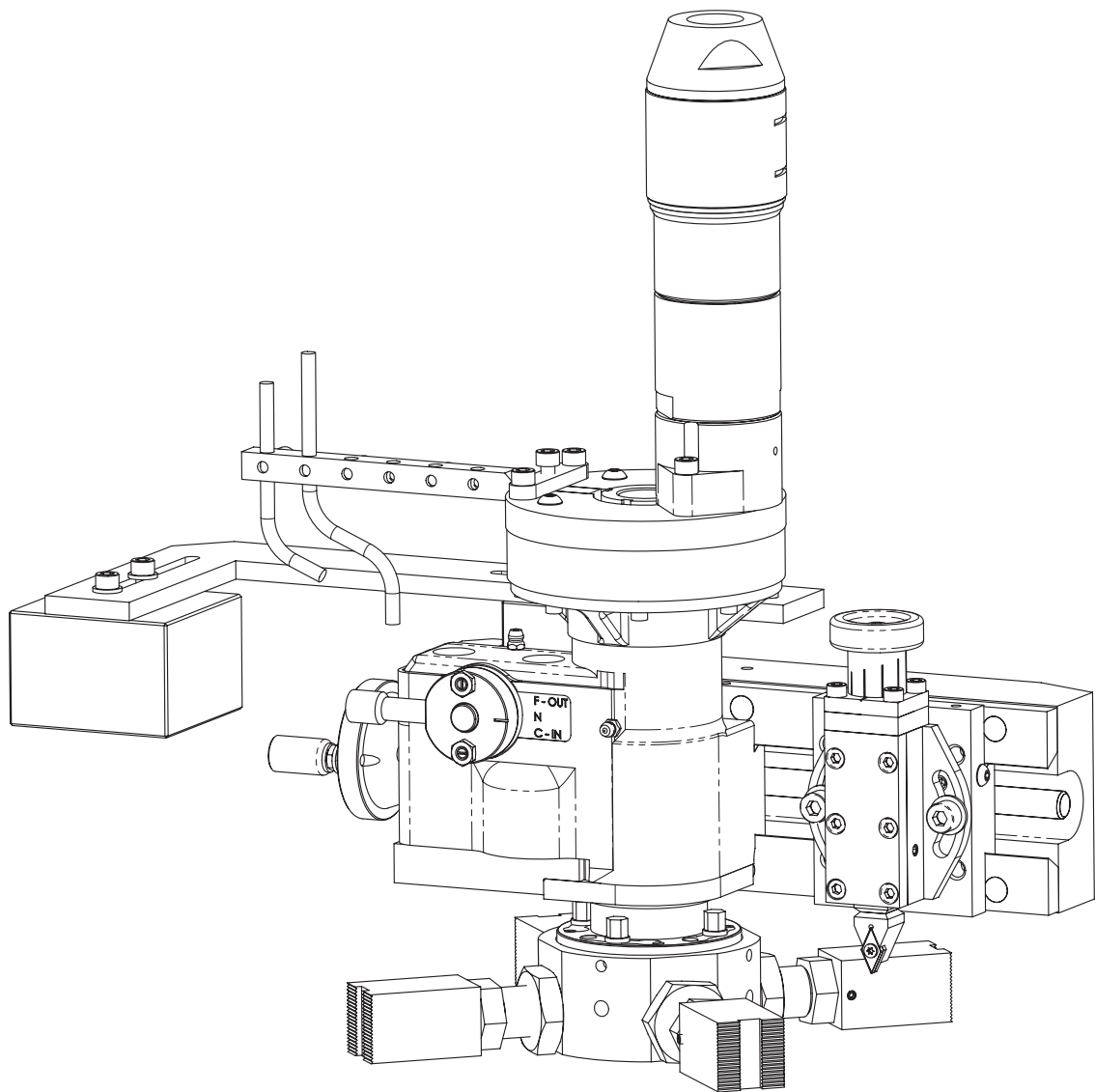
Enerpac MM305i **Flange Facing Machine (2-12" Internal Mounted Flange Facing Machine)**

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To reduce the risk of injury, user must read and understand this document before use.

ABOUT US

Enerpac is a global market leader in high pressure hydraulic tools, controlled force products, portable machining, on-site services and solutions for precise positioning of heavy loads. As a leading innovator with a 110-year legacy, Enerpac has helped move and maintain some of the largest structures on earth. When safety and precision matters, elite professionals in industries such as aerospace, infrastructure, manufacturing, mining, oil & gas and power generation rely on Enerpac for quality tools, services and solutions. For additional information, visit www.enerpac.com.



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WARRANTY

Refer to the Enerpac Global Warranty document for terms and conditions of the product warranty. Such warranty information can be found at www.enerpac.com.

NAMEPLATE

MIRAGE AN ENERPAC BRAND	MACHINE TYPE:
MIRAGE MACHINES LTD	SERIAL NUMBER:
8-10 ENTERPRISE WAY	YEAR OF MANUFACTURE:
JUBILEE PARKWAY	SUPPLY:
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UNITED KINGDOM	WEIGHT:
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1. Safety

Read all instructions carefully. Follow all recommended safety precautions to avoid personal injury as well as damage to the product and / or damage to other property. Enerpac cannot be responsible for any damage or injury from unsafe use, lack of maintenance, or incorrect operation. Do not remove warning labels, tags, or decals. In the event that any questions or concerns arise, contact Enerpac or a local Enerpac distributor for clarification.

Save these instructions for future use.

If you have never been trained on high-pressure hydraulic safety, consult your distributor or service center for information about Enerpac Hydraulic Safety Courses.

This manual follows a system of safety alert symbols, signals, words, and safety messages to warn the user of specific hazards. Failure to comply with these warnings could result in death or serious personal injury, as well as damage to the equipment or other property.



The Safety Alert Symbol appears throughout this manual. It is used to alert you to potential physical injury hazards. Pay close attention to Safety Alert Symbols and obey all safety messages that follow this symbol to avoid the possibility of death or serious injury.

Safety Alert Symbols are used in conjunction with certain Signal Words that call attention to safety messages or property damage messages and designate a degree or level of hazard seriousness. The Signal Words used in this manual are DANGER, WARNING, CAUTION, and NOTICE.

DANGER Indicates a hazardous situation that, if not avoided, will result in death or serious personal injury.

WARNING Indicates a hazardous situation that, if not avoided, could result in death or serious personal injury.

CAUTION Indicates a hazardous situation that, if not avoided, could result in minor or moderate personal injury.

NOTICE Indicates information considered important, but not hazard related (e.g. messages related to property damage). Please note that the Safety Alert Symbol will not be used with the signal word.

1.1 Safety Precautions

The manufacturer has made every effort to ensure that the information given in this Operation & Maintenance manual, and other publications relating to this machine is correct and understandable. However, it is acknowledged that there may be errors or omissions in this publication.

The company also reserves the right not to provide updates, corrections or amendments to this publication but will keep customers up to date with all changes that may affect the machine operation. Any updates which affect the safe use of the machine shall be communicated to the customer in a prompt and appropriate manner.

Mandatory Safety Signs

ISO 7010 SYMBOL	SAFETY DESCRIPTION
	EYE PROTECTION MUST BE WORN
	EAR PROTECTION MUST BE WORN
	HARD HATS MUST BE WORN
	PROTECTIVE GLOVES MUST BE WORN
	PROTECTIVE FOOTWEAR MUST BE WORN
	OVERALL MUST BE WORN
	MACHINE GUARDS MUST BE USED

1.1.1 Handling

Customers, users and operators of the machines must be aware of the nature of the equipment supplied.

Although inherently robust, the machine is a precision tool and may be damaged by poor handling, tipping and falling, inadequate transport arrangements over e.g. rough terrain, misuse by operators and use outside its design specification.

Such poor handling may result in either broken or damaged parts or disturbance to fine settings resulting in an inability to meet the specified machining tolerances and capabilities.

1.2 Safety Procedures

Detailed in this section is a list of good Health and Safety practices that the manufacturer advise users to adhere to. Due to the nature of portable machine tools, not every eventuality can be catered for and the following is not exhaustive, as such the manufacturer strongly advise that the user carries out their own risk assessments based on the machining and environment in which they intend to use the machinery.

Machine Hazards /signs

ISO 7010 SYMBOL	HAZARD DESCRIPTION
	DANGER HIGH VOLTAGE
	WARNING MOVING MACHINERY
	CAUTION MOVING MACHINERY
	WARNING KEEP HANDS CLEAR

1.2.1 Pre-Operational Safety Checks

1. Always read safety signs / labels.
2. Ensure no slip / trip hazards are present in workspaces and walkways.
3. Locate and ensure you are familiar with the operation of the ON / OFF starter and E-Stop (if fitted). Do not leave equipment on top of the machine.
4. Ensure each tool is in good condition and securely mounted.
5. Secure / Remove loose items.
6. Faulty equipment must not be used.
Immediately report any suspect machinery.

1.2.2 Operational Safety Checks

1. Operator is fully conversant and trained in use of equipment.
2. Keep clear of moving machine parts.
3. Never leave the machine running unattended.
4. Follow correct clamping procedures - keep overhangs as small as possible and check work piece is secure.
5. Set the correct speed to suit the tool, the depth of cut and the material.
6. Before making adjustments and measurements or before cleaning swarf accumulations switch off and bring the machine to a complete standstill.
7. The lighting in the machine working environment shall be a minimum of 500 lumen.

1.2.3 Housekeeping

1. Switch off the machine.
2. Remove milling cutters, drill attachments and tap attachments and store them safely (if applicable).
3. Leave the machine and work area in a safe, clean and tidy state.

1.2.4 Noise Emissions

1. If this machine is driven by hydraulic motors, then airborne noise emissions of the machine will not exceed 70 db (A). For the hydraulic power pack noise emissions please refer to the hydraulic power pack manual.
2. If this machine is driven by pneumatic (air) motors, then airborne noise emissions of the machine will exceed 70 db (A). The ear protection must be worn! The exact value can be found in the 'Pre-Use Functional Checklist' which is included in the document pack.



1.2.5 Potential Hazards

1. Sharp cutters. Use protective gloves when handling cutters.
2. Moving components – hair / clothing entanglement. Keep clear of hazard zone when the machine is in operation. See section 2.3.
3. Skin irritation. Overalls and gloves should be worn stop direct contact with swarf and lubricants.
4. Metal splinters and burrs. Wear gloves when handling the machine or any sharp object. Swarf should be removed with pliers as well as protective gloves.
5. Flying debris. Keep clear of hazard zone when the machine is in operation. Eye protection should be worn to prevent eye injuries.
6. Fumes. Continuous cutting of metal can create fumes, therefore the machine must be used in a well ventilated area.

7. **Extreme Temperatures:**
Heat. The cutting tool and its surrounding areas will become hot after continuous use. Gloves should be worn when handling these components.

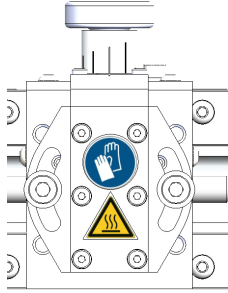


Figure 1: Tool holder showing safety labels

Frost. The pneumatic motor can become cold when used extensively. Gloves should be used when handling this component.

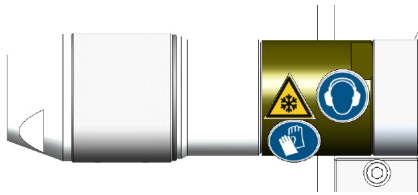


Figure 2: Motor showing safety labels



Figure 3: Frost/ ice on Motor

8. Fire or explosion. Machining aluminium, titanium, magnesium, graphite, or alkali metals can result in fire, explosion or noxious dust. If unsure, consult the manufacturer for guidance.
9. Trip hazards from hoses or other equipment at low level.
10. Hearing Loss. Use appropriate ear protection when in the vicinity of the machine in operation.

1.2.6 Foreseeable misuse

- Machining in other environments (temperature, materials, workpiece size) than what is specified in machine specification can cause damage to the machine and cause the injury.
- Do not use any other base leg extension combinations, other than what is specified in the base assembly drawings. Not enough thread engagement will have a severe effect on the stability of the machine and can cause damage to the machine and cause the injury.
- Do not use machine on poor quality and unstable workpiece (flange). The machine is clamped to the workpiece, so the workpiece structure provides the foundation and stability for the machine. If not adhered to, then this will have a severe effect on the stability of the machine and can cause damage to the machine and cause the injury.

1.2.7 Machine safety features

Pressure Regulator

The air lubrication unit comes with a pressure regulator. This limits the air pressure to 7Bar to ensure the air supply into the machine will not cause damage to the machine and its surrounding area.

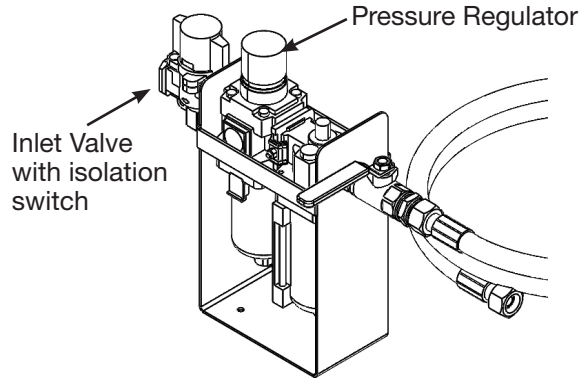


Figure 4: Air Lubrication Unit

Isolation Switch

The air lubrication unit also comes with an inlet valve with a lockable isolation switch.

The inlet valve has an indicator window to show its status;

SUP : Supply

EXH : Exhaust

To change the status of the valve, push down the handle then turn 90 degrees. Use the holes in the handle to lock the handle in position.

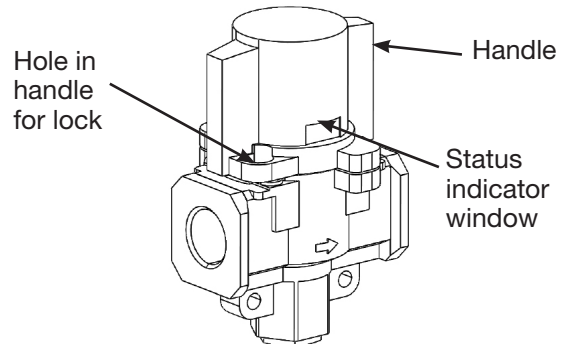


Figure 5: Inlet valve

Hold-to-Run Device

The machine is operated using a hold-to-run device which shall be located at a minimum of 2m away from the danger zone.

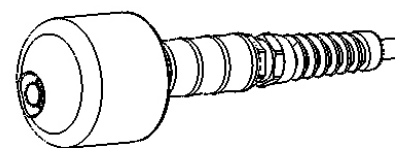


Figure 6: Hold-to-run control

1.3 Machine Hazard Zone

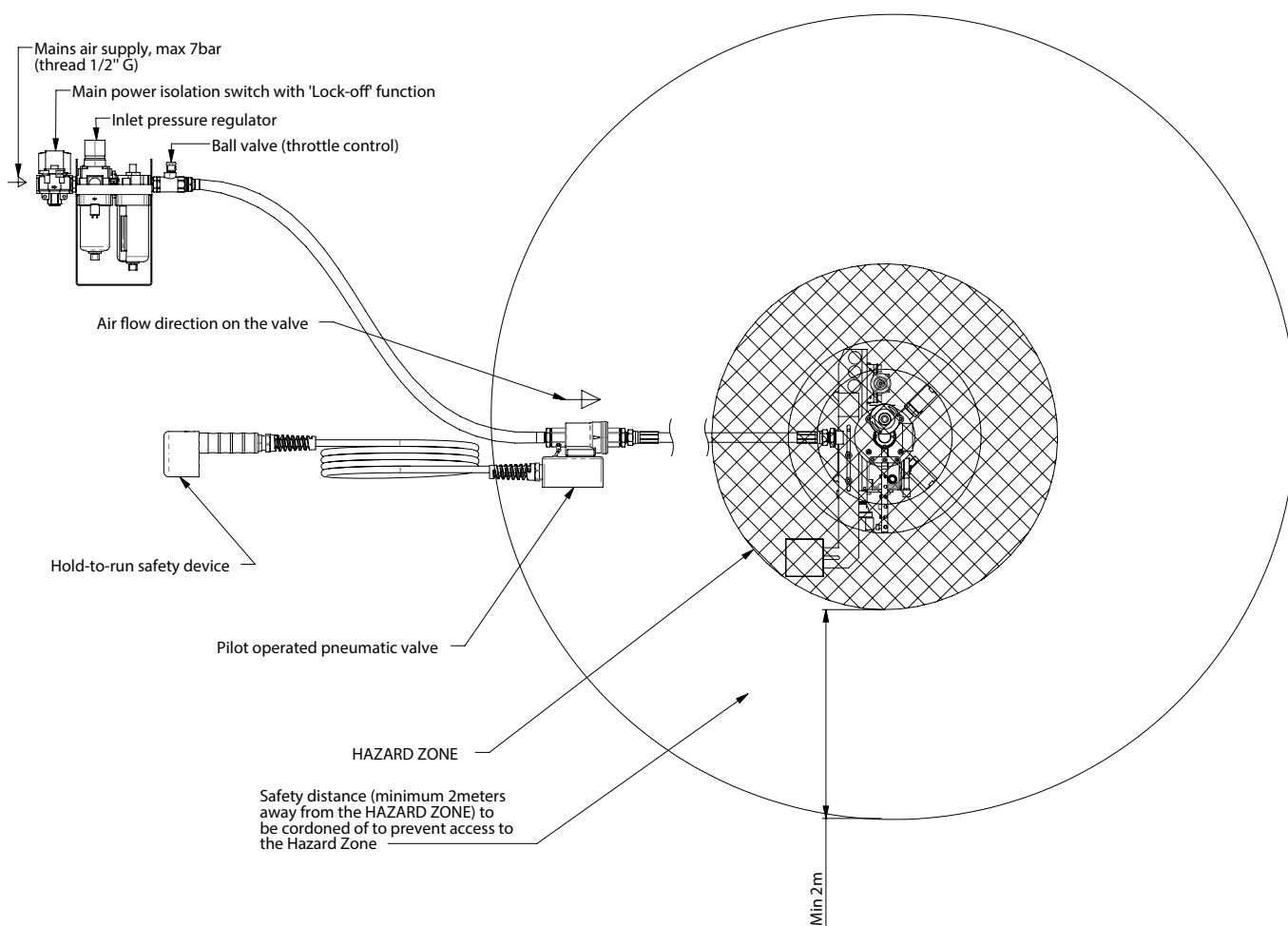


Figure 7: Supplied system layout drawing showing hazard area to be cordoned off

⚠ DANGER

The machine mains air valve must be switched off and locked off whilst performing the below tasks:

1. Setting up the machine into the work-piece.
2. Performing any maintenance, if necessary, before cut.
3. Cordoning off the area, a minimum 2m away from hazard zone.
4. All of the controls must be placed outside of the cordoned off zone.
5. Before switching the valve on, make sure there are no personnel in cordoned off zone.

After machines mains air valve is switched on:

1. Only the operator is allowed to enter cordoned off zone, if necessary.
2. Ball valve (throttle control) should be nearly closed in order to slowly start up the machine.
3. Operator to be outside of cordoned off zone and operate the machine by using the hold to run device.
4. Whilst the machine is running, no personnel including the operator, is allowed to enter the cordoned off zone under any circumstances.

1.4 Risk Assessment Checklist

The following checklist should not be taken as a comprehensive list of things to be vigilant for when installing and operating the MM305i flange facing machine. However these checklists are typical of the types of risks the assembler and operator should be considering. Use these checklists as part of your risk assessment.

Figure 8: Risk Assessment Checklist before installation

	<u>Before Installation</u>
☐	I understand how this machine operates and identified the best placement for the controls, cabling, and the operator (having reviewed the manual and section 1 in particular).
☐	I removed or mitigated all identified risks (such as shearing, cutting, crushing, tripping, entanglement, or falling objects).
☐	I considered the need for personnel safety protection and guarding and installed any necessary guards, if supplied.
☐	I read the Machine Assembly instructions and took inventory.
☐	I created a lift plan, for each of the setup lifts required during the setup of the machine.
☐	I located the fall paths involved in lifting. Precautions have been taken to keep workers away from the identified fall path.
☐	I have noted all the warning labels on the machine.
☐	I considered and mitigated any other potential risks specific to the working environment.
☐	I have checked that all of the ram bolts are not damaged or corroded.

Figure 9: Risk Assessment Checklist after installation

	<u>After Installation</u>
☐	I checked that the machine is safely installed and the hazard zone is cordoned off as section 1.3. If the machine is installed at an elevated position, I checked that the machine is safeguarded against falling.
☐	I evaluated and mitigated the potential risks specific to the work environment.
☐	I checked that all affected personnel understand the hazard zone (section 1.3) and are outside of it.
☐	I followed the required Maintenance Intervals with the recommended lubricants in section 8.
☐	I checked that all affected personnel have the required personal protective equipment, as well as any site-required or regulatory equipment.
☐	I identified all possible pinch points, such as those caused by rotating parts, and informed the affected personnel, noting that no other personnel are allowed in the hazard zone unless the machine is isolated and locked off.
☐	I planned the safe guarding of any chips or swarf produced by the machining process.
☐	I considered that the tool tip cutter will be sharp and have planned adequate protection for handling.

2. Compliance Statement

EU Declaration of Conformity



Enerpac declares that this product fulfils all the relevant provisions of the directives and standards written on the declaration of conformity.

A copy of the EU and UK declaration of conformity is enclosed with each shipment of this product.

3. Features & Components

3.1 Feature Diagram

1. Pneumatic motor
2. Gearbox
3. Tool Post
4. Internally Mountable base
5. Fixing Jaws
6. Striker Arm
7. Balance weight
8. Hold-to-run device
9. Air Lubrication unit

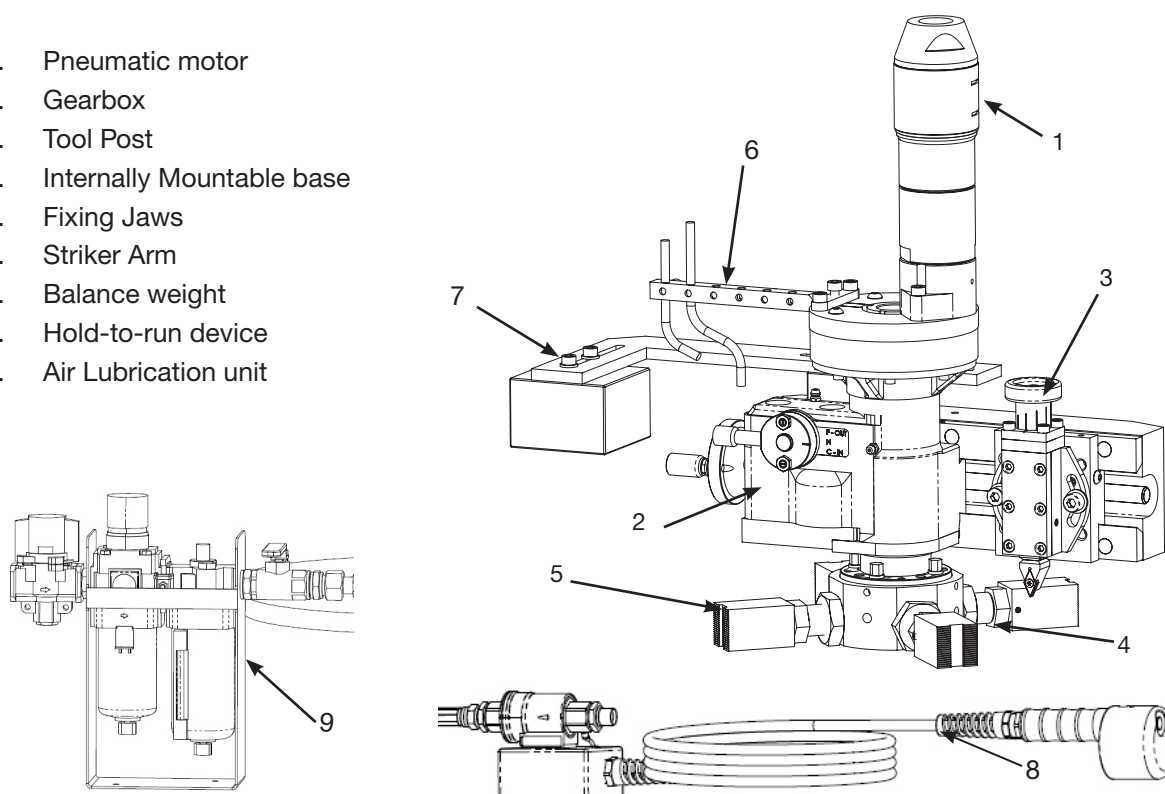


Figure 8: Major features and components of MM305i - Flange Facing Machine

3.2 Machine Description

This machine has been designed for performing facing and boring operations on flanges. It can be used for seal groove machining, weld preparation and counter boring. The machine is manually fixed and levelled to the flange using the Base assembly. The machine motor rotates the toolpost assembly around the flange and by using fixed gears will produce continuous feed across the flange surface for groove gramophone finishes to ASME Standard.

4. Technical Product Data

4.1 Dimensional Art

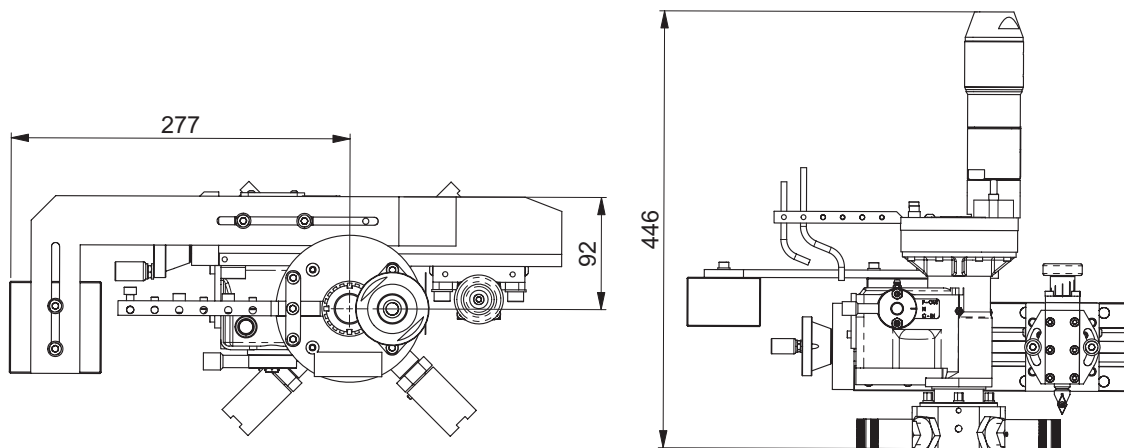


Figure 9: Dimensional Information

4.2 Specification Table

Description	Value	
Maximum Clamping Diameter	305mm	12"
Minimum Clamping Diameter	50mm	2"
Pneumatic Motor	0.8kW	1.1hp
Maximum motor RPM	270RPM	
Machine Weight (Machine & Base)	24kg	53lb
Maximum Facing Diameter	305mm	12"
Minimum Facing Diameter	50mm	2"
Minimum Swing Diameter	390mm	15.35"
Tool Post Vertical Travel	40mm	1.6"
Machine RPM	min. 20	max. 80
Designed for General Use		

4.3 Service and Supplies

4.3.1 Personnel

As a specialist portable machine the minimum standard for an operator is to be:

- The operator must be trained and conversant with the MM305i.
- The operator to be able to identify the correct and incorrect use of static or portable machines.
- Comply with all local and internationally recognised safe use of powered machines.

4.3.2 Services

The recommended services required for the MM305i machine is clean dry air at 7 bar and 1500L/min.

5. Installation

5.1 Installing machine to work piece

⚠ WARNING

Before installation, visually inspect all ram bolts to ensure the threads are in good working condition.

1. Measure the mounting bore of the flange to be machined and ensure this is within the working parameters of the machine.
2. Select the required components for the base size (see MM305i-5, table for 'Clamping arrangements for different diameters' in Section 9). Note that all 4 legs must have the same arrangement.

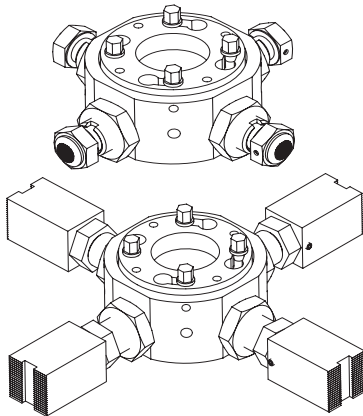


Figure 10: Clamping Arrangements

For smaller bores a collet clamp is supplied. See 'Base assembly' drawing to identify the exact part numbers to use in different diameter bores. The collet clamp uses three jaws to clamp inside the work piece bore. These are radially moved outwards or inwards by turning the 16 A/F Hex bar at the top of the assembly. Four M10 button head bolts in the top cone flange are used as setting straps for the larger bore diameters.

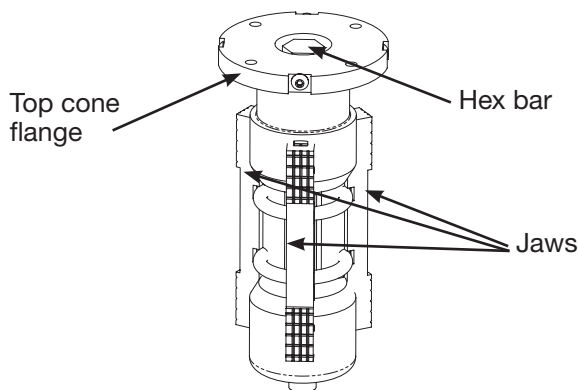


Figure 11: Collet Clamp

3. Assemble the base components so that it measures 6mm (equally around its perimeter) below the bore mounting dimension. This is to be completed away from the work piece.



Note that the ram bolts on the extension legs can only be moved out a certain length to ensure that enough engagement remains between the leg and bolt. There is a groove on the leg to indicate allowable full extension length.

Do not unscrew the legs any further out once the groove is visible.

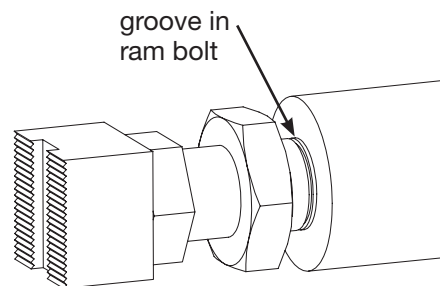


Figure 12: Ram bolt showing groove

4. Bolt the setting straps onto the MMI2425 setting ring base, and by using four MMI 2109 bolts secure the setting ring to the base, ensuring that the straps overlap the bore dimension by at least 25mm (1.0"). Refer to Figure 10.
5. Position the base into the flange bore and screw out the ram bolts. Check centralisation by measuring and adjust as necessary.

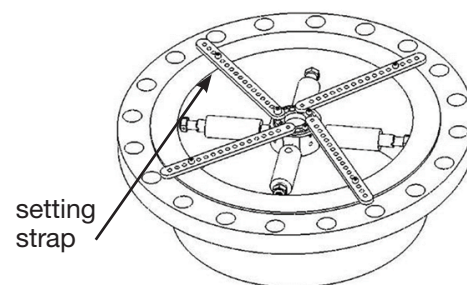


Figure 13: Setting straps on Work piece

6. Adjustments can be made tightening and loosening opposing jacking bolts.

⚠ CAUTION

Check that the walls of the work piece are able to withstand clamping forces without distortion. If the work piece is not able to withstand the forces, alternative means of clamping will be required. If not possible consult with the manufacturer for a custom resolution.

7. Once the base is correctly clamped to the work-piece, tighten the ram bolts to 80Nm. Then tighten the locking nut on the ram bolts to secure each leg.



Failure to correctly torque the bolts and also tighten lock nuts may result in the clamps becoming loose from vibration.

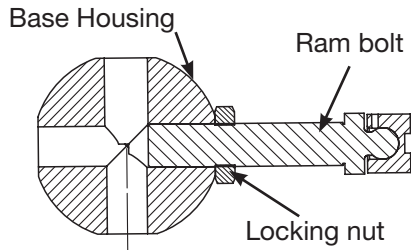


Figure 14: Leg Arrangement

8. When the base is secure to the work piece, remove the setting straps and lower the main machine body onto the base.
9. Secure the machine to the base by fitting the mast over the four MMI 2109 bolts. Twist the mast so that the bolts sit over the narrower hole diameter, and then tighten them to secure the machine to the base.

5.2 Installation of motor

The motor assembly below is fixed to the machine using 2 X M6 bolts to the gearbox. Take care not to damage the teeth on the gear when installing the assembly.

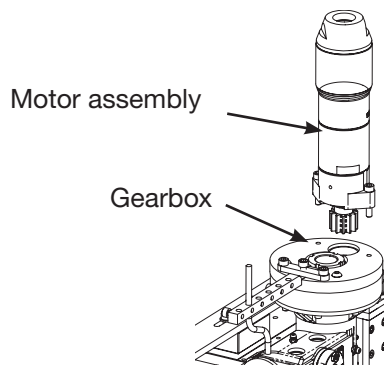


Figure 15: Motor Installation

5.3 Lifting



The machine and the base are supplied in two separate assemblies. Each of these assemblies are less than 25kg, however care should be taken when lifting the units.

Base: 5kg approx.

Machine (without counter weight): 17kg approx.

Ensure that adequate Personal Protection Equipment (for example, hand, eye and feet protection) is worn when handling the assemblies.

6. Operation

⚠ DANGER

NO MACHINE ADJUSTMENTS SHOULD BE MADE WHILE THE MACHINE IS IN OPERATION. TURN AND LOCK OFF THE ISOLATION VALVE ON THE PNEUMATIC SUPPLY BEFORE MAKING ANY ADJUSTMENTS.

6.1 Connecting the machine to the power supply.

Attach the 1/2" hose to the motor coupling adapter. The free end of the 1/2" hose should be attached to the pilot operated pneumatic valve from the hold to run unit.



Ensure the directional arrow is facing the correct orientation (Flow towards the motor).

Attach the 1/2" hose from the Air lubrication unit to the pilot operated pneumatic valve from the hold to run unit.

The air supply should be attached to the ALK inlet valve (1/2" G port).

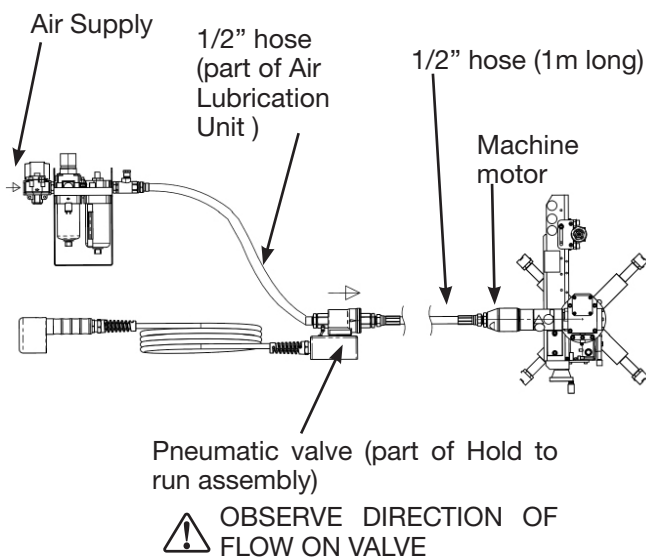


Figure 16: Connection system diagram

Schematic diagrams are located in the appendix.

6.2 Air Lubrication Unit

The Pneumatic machine requires an Air Lubrication Kit to prevent damage to the machine. This unit is provided as part of the machine supply. For the part number and further details of this unit, please refer to the machine General Arrangement drawing.

6.3 Operating hold-to-run

⚠ WARNING

When the machine has been fully set-up and connected to the power source, go through the safety checklist before beginning the cutting operation.

To operate the hold-to-run handle, first press on the anti accidental start button. Whilst holding this down, press down the 'hold-to-run' push button. The machine should now be running.

Release the anti accidental start button, but keep down the 'hold-to-run' push button to keep running the machine.

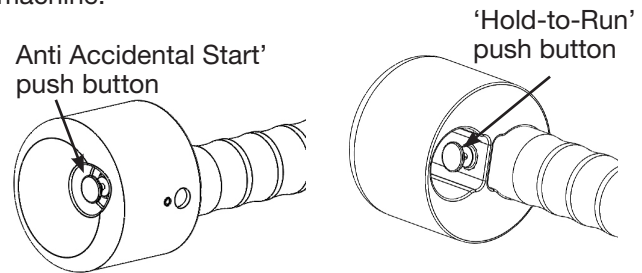


Figure 17: Hold-to-run handle

To stop the machine, and in case of emergency, release the button on the handle.

Hold-to-run device function summary:

Press 'Hold-to-run' button first, the machine **should not start**.

Press 'Anti Accidental Start' button first, the machine **should not start**.

Press 'Anti Accidental Start' button first, whilst holding this down, press 'Hold-to-Run' button, the machine **should start**.

Release 'Anti Accidental Start' button, the machine **should continue running** whilst holding down 'Hold-to-Run' button.

Release 'Hold-to-Run' button, the machine **should stop** immediately.

6.4 Restart Procedure

If a power loss occurs during a cutting operation, follow the below procedure:

1. Release the button on the hold-to-run handle.
2. Lock off inlet isolation valve on the Lubrication unit.
3. Investigate power loss.
4. When power is available, re-assess safety, then once out of the cordoned off area, unlock the isolation switch on the inlet valve.
5. Re-start the machine by operating the hold-to-run device .

6.5 Tool Post Setting

Setting the Tool Post Angle

To adjust the angle of the tool post, release the two M8 locking bolts $\frac{1}{2}$ - 1 turn each and move the tool post to the desired position. Re-tighten the M8 once in position.

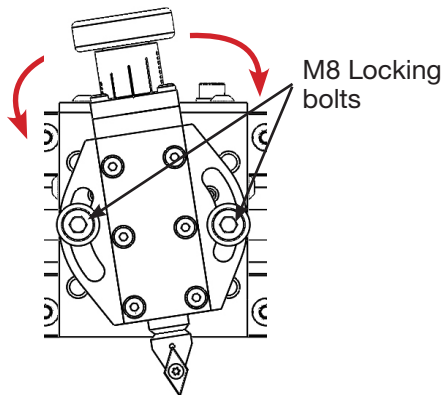


Figure 18: Setting angle of tool post

NOTICE

When the toolpost is angled, it can clash with the Gearbox assembly before the stroke of the machine finishes. Take care when traversing toolpost.

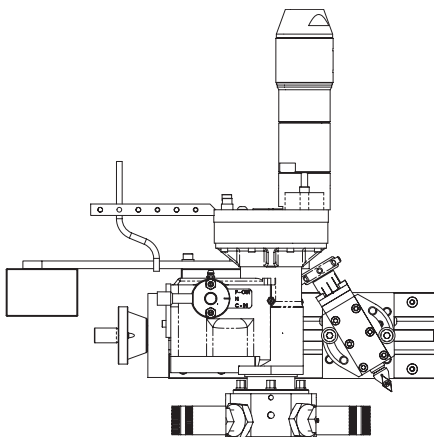


Figure 19: Position of Toolpost clash

⚠ DANGER

After setting up the toolpost, but before operation, the operator must, by hand, wind the carriage and toolpost to the minimum and maximum stroke on the arm to check for crashes.

Setting the Depth of cut

To alter the depth of cut, first make sure that the three M10 set screws are not tight.

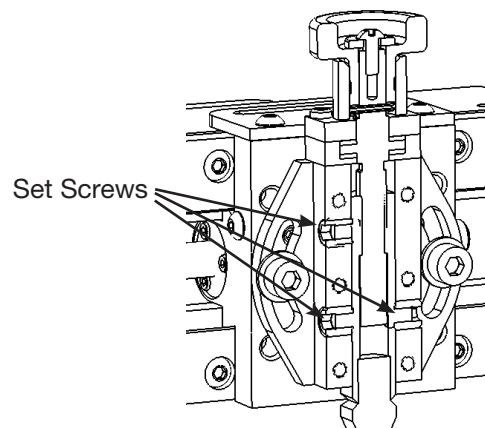


Figure 20: Location of set screws

When viewed from above, turning the hand wheel clockwise will feed the tool downwards. Turning the hand wheel anti-clockwise will feed the tool upwards.

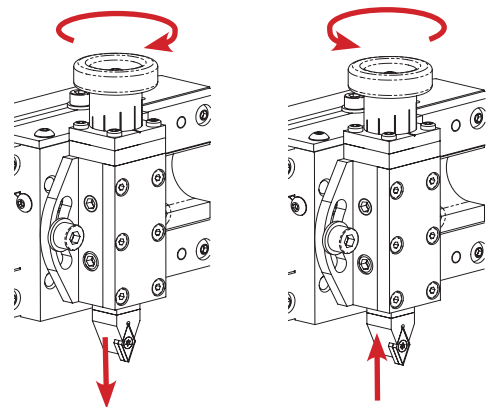


Figure 21: Toolpost vertical movement

When the tool is correctly positioned re-tighten ('finger tight' for light tension on the tool post) the three M10 set screws'.

6.6 Striker Boring feed setting

The striker mechanism is located into the main top cap and locked in by the two screws as shown.

The striker can be positioned either side of the toolpost starwheel to enable the toolpost to be fed down or up.

The star wheel is a direct replacement for the standard toolpost feed knob. It is essential however to ensure the drive pin is correctly seated into the feed knob slot.

The toolpost can be angled and so can the striker bar to accommodate this.

The star wheel can be left mounted onto the toolpost depending on preference.

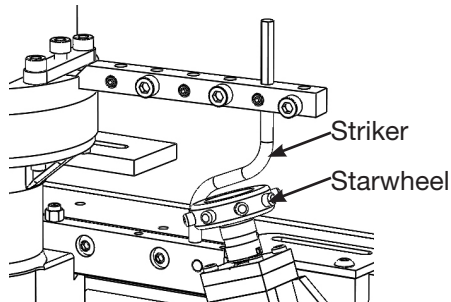


Figure 22: Star wheel and striker

6.7 Facing Feed Gear Selection

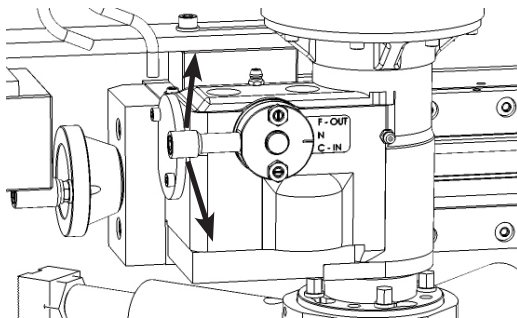


Figure 23: Facing feed gear selection

Gear Selector Position	Leadscrew Pitch Options	Feed Rate mm/rev	Feed Rate Grooves/inch
Fine	1.75mm (standard)	0.199	128
Coarse		0.795	32
Fine	1.25mm (standard)	0.142	179
Coarse		0.568	45
Fine	1.00mm (optional)	0.114	224
Coarse		0.455	56

The machine will come installed with a 1.75mm pitch leadscrew.

Selecting Feed rate

1. Check feed rate table.
2. Select required feed and push or pull feed selector to required position.
3. A single leadscrew will only be able to provide two feed rate speeds. To achieve the desired feed rate, it may be necessary to change the leadscrew.

NOTICE

When using the automatic feed function, turn the machine off before the tool post carriage reaches the extent of its travel to prevent it clashing with the 'Mast and Hub Assembly'.

6.8 Machine Balancing

CAUTION

When machining in any angular position other than horizontal, it is necessary to balance the machine. Attach the balance plate to the machine. Failure to balance the machine correctly will increase the load on the drive components.

To obtain balanced rotation, add the weight and move its position on the plate to obtain smooth rotation. There should be no increase or decrease in rotational speed. Pay attention to the 7 o'clock and 2 o'clock positions as this will be where the weight shift will be greatest.

2 o'clock position - machine rotation will increase if incorrectly balanced.

7 o'clock position - machine rotation will slow if incorrectly balanced.

For more accurate balancing, the motor can be removed and the machine swung by hand until it rotates at an even pace with no evidence of speed increase.

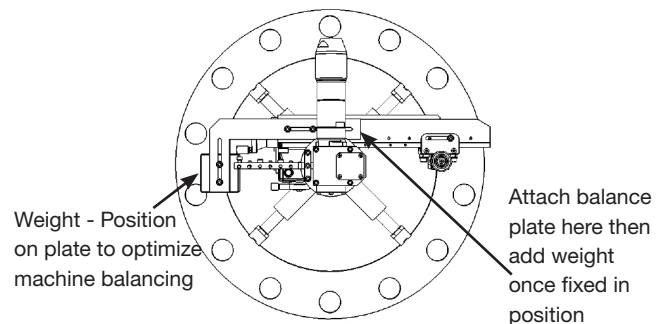


Figure 24: Machine balancing

6.9 Clearing Blockages

When machining, a build up of swarf can occur. Periodic clearing of the swarf around the machine tool should be carried out to prevent any blockages.



Wear protective gloves before commencing the below clearing procedure.

1. Release button on the hold-to-run handle.
2. Use a metal brush and pliers to remove swarf build-up.
3. Before re-starting the machine, re-assess safety, then once out of the cordoned off area start the hold to run device.

6.10 Machine Disassembly

To disassemble the machine follow the below procedure:

1. Switch off the inlet isolation valve on the lubrication unit before disconnecting the hoses from the machine. There should be 3 separate assemblies: the hold-to-run assembly, the Lubrication unit assembly, and the machine/base assembly (still on the work piece).
2. The machine now needs to be disconnected from the base by loosening each of the 4 MMI 2109 bolts on the base. The arm assembly will need to be moved around in order to gain access to each bolt.
3. Once the bolts are loosened twist the mast to the large key hole and lift off the machine assembly.

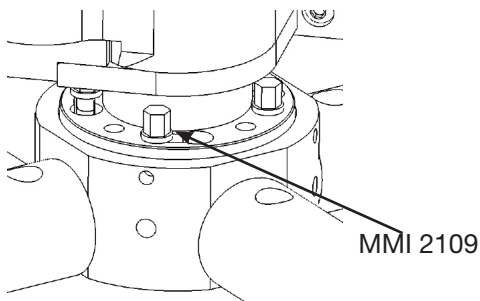


Figure 25: MMI 2109 bolt

4. To safely remove the base assembly from the work piece, secure the setting straps back onto the base unit to ensure the base does not fall while loosening the ram bolts. The base can now be lifted out.

6.11 Recommended Lubricants.

The air lubricating unit uses AW32 hydraulic oil. For all other lubricants refer to the maintenance schedule tables for recommended lubricants.

7. Storage

Storing the machine in the original box will extend the longevity of the machine. Before storing make sure the machine is clean and dry. Pay particular attention to the V grooves in the rail. Grease the leadscrew and slide ways (using WD40 or similar) before storing the machine.

Use the below images to assist with re-packing the machine.



Figure 26: Bottom Level of storage box



Figure 27: Top Level of storage box

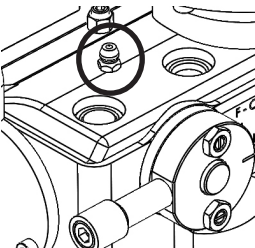
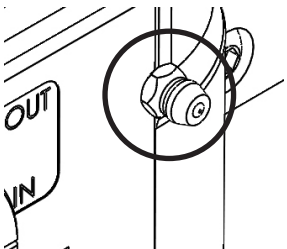
8. Maintenance



NO MACHINE ADJUSTMENTS SHOULD BE MADE WHILE THE MACHINE IS IN OPERATION. TURN AND LOCK OFF THE ISOLATION VALVE ON THE PNEUMATIC SUPPLY BEFORE MAKING ANY ADJUSTMENTS.

General wear and tear items should be replaced with like for like components as per the machine general assembly drawings detailed in this manual. Failure to do so may result in a machine that is not fit for purpose and is outside the design intent it was supplied for. Items that require specific maintenance regimes and products will be detailed here in.

General Maintenance Schedule		
Time Period (of machine use)	Action	Recommended Lubricant
After every use	Clean all cutting debris from machine. Pay particular attention to lead screws, pivots, sealing, sliding & rotating faces.	General water displacing / cleaning oil.
As required	Replace cutting tool/cutting tool inserts.	N/A
Every 10 hours	Apply a small amount of low viscosity oil to all lead screws, pivots, sliding & rotating faces.	Mineral based SAE 10 oil.
	Check all securing nuts & bolts are tight.	N/A
Every 100 hours	Check for backlash in lead screw/lead screw nut & correct if necessary.	N/A
Before long term storage (12 months minimum)	Protect machine, components & accessories from corrosion. Store all machine components securely in original packing box.	General, oil based, rust inhibitor.

Machine Specific Maintenance Schedule		
Time Period (machine use)	Action	Recommended Lubricant
Every 20 hours	Grease gearbox via the grease nipple, 2 shots. 	Lithium based 'Extreme Pressure' Grease (EPL).
Every 20 hours	Grease Mast via Grease Nipple in casting, 2 shot. 	Lithium based 'Extreme Pressure' Grease (EPL)

8.1 Safely maintaining hydraulic/pneumatic system

WARNING

- Never work on a hydraulic/pneumatic system unless fully trained.
- Carefully review the manuals before beginning work. Ask questions about anything you do not fully understand.
- Maintain a clean work area free of slipping hazards and debris.
- Use all required safety equipment.
- Always use safety glasses.
- Block, secure or lower to the ground components that may move, rotate or fall.
- Relieve system pressures. (Note: Some systems use accumulators that store pressure. Identify the system before working on it.)
- Use extreme caution when disconnecting lines. Severe burns from hot fluid can result.
- Use test equipment designed for higher pressures than the system being repaired. Use of gauges, lines, connectors, etc., designed for lower pressures can result in bursting or equipment damage. (Note: A good rule is to use equipment rated at twice what is expected. Example: For a 2500 psi system, use a 5000 psi gauge.)
- DO NOT USE HANDS OR FINGERS to find leaks. Fluid under high pressure can be injected into skin causing extreme injury and serious infection. "Note: High-pressure hydrocarbon injection injuries may produce substantial necrosis of underlying tissue despite an innocuous appearing external wound. These injuries often require extensive emergency surgical debridement and all injuries should be evaluated by a specialist in order to assess the extent of injury. Early surgical treatment within the first few hours may significantly reduce the ultimate extent of injury."
- Clean up spills immediately. Hydraulic fluid is an oily substance which can cause slipping, falling and resulting injuries.
- Do not work under equipment/apparatus being supported by hydraulics. Stops, safety pins, etc. must be in place prior to beginning repairs.
- Review the Material Safety Data Sheets (MSDSs) for all chemicals used

DANGER

NO MACHINE ADJUSTMENTS SHOULD BE MADE WHILE THE MACHINE IS IN OPERATION. TURN AND LOCK OFF THE ISOLATION VALVE ON THE PNEUMATIC SUPPLY BEFORE MAKING ANY ADJUSTMENTS.

8.2 Changing Leadscrews

The machine comes with two leadscrews of 1.75mm and 1.25mm pitch.

To change the leadscrew on the machine follow the

below procedure:

1. Manually wind tool post assembly off from lead screw.

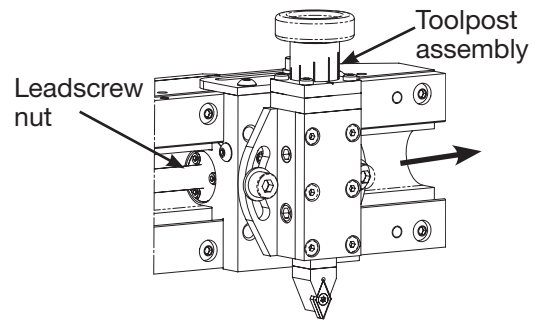


Figure 28: Tool post

2. Change the lead screw nut on the toolpost carriage by unscrewing 3 screws. (It is important that each leadscrew nut is kept with its corresponding leadscrew.)
3. Remove the balance weight (if it is fixed onto the machine).
4. Put the machine into gear (to stop the leadscrew rotating) and remove the 13mm nut which attaches the handle to the leadscrew.

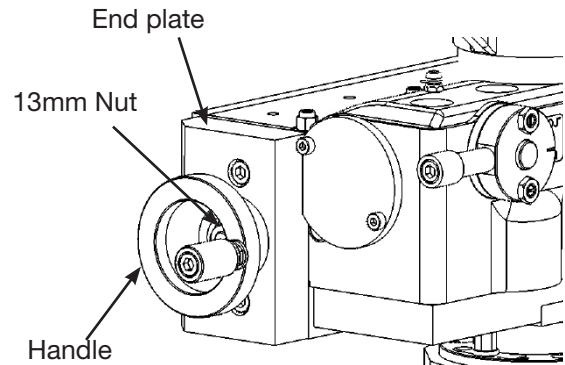


Figure 29: Arm handle

5. Wind off the handle whilst still in gear.
6. Remove 2 socket head screws in the end cap. Then remove the endcap as well as the bearings located in the endcap housing.
7. Remove leadscrew and replace with the required leadscrew.
8. Reassemble following the above procedure in reverse order.

8.3 Changing the insert cutting tip.



When handling the insert make sure to use protective gloves.

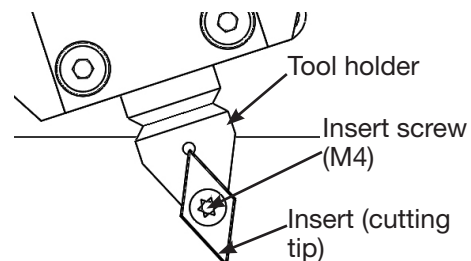
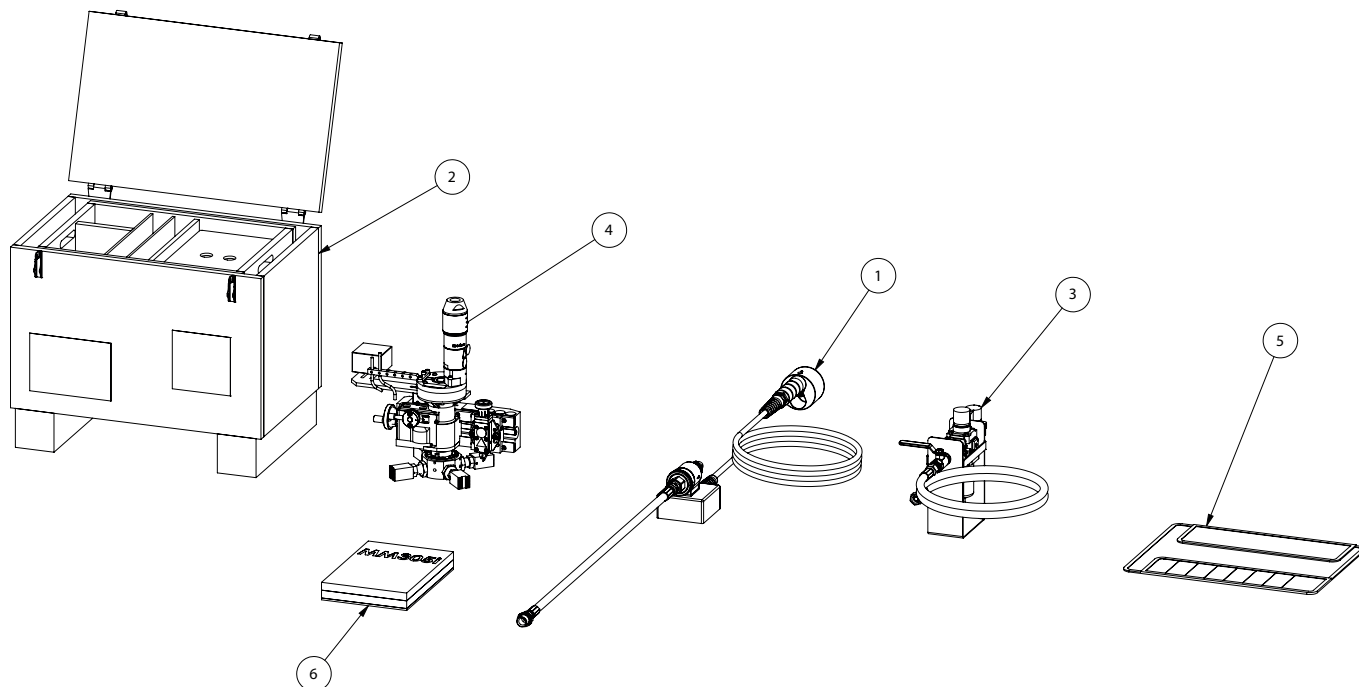


Figure 30: Insert and holder

The insert is attached to the tool holder by the screw. Ensure the screw is tight once the cutting tool insert has been changed.

9. Parts List

9.1 MM305i Assembly (MM305i, Revision E) Views

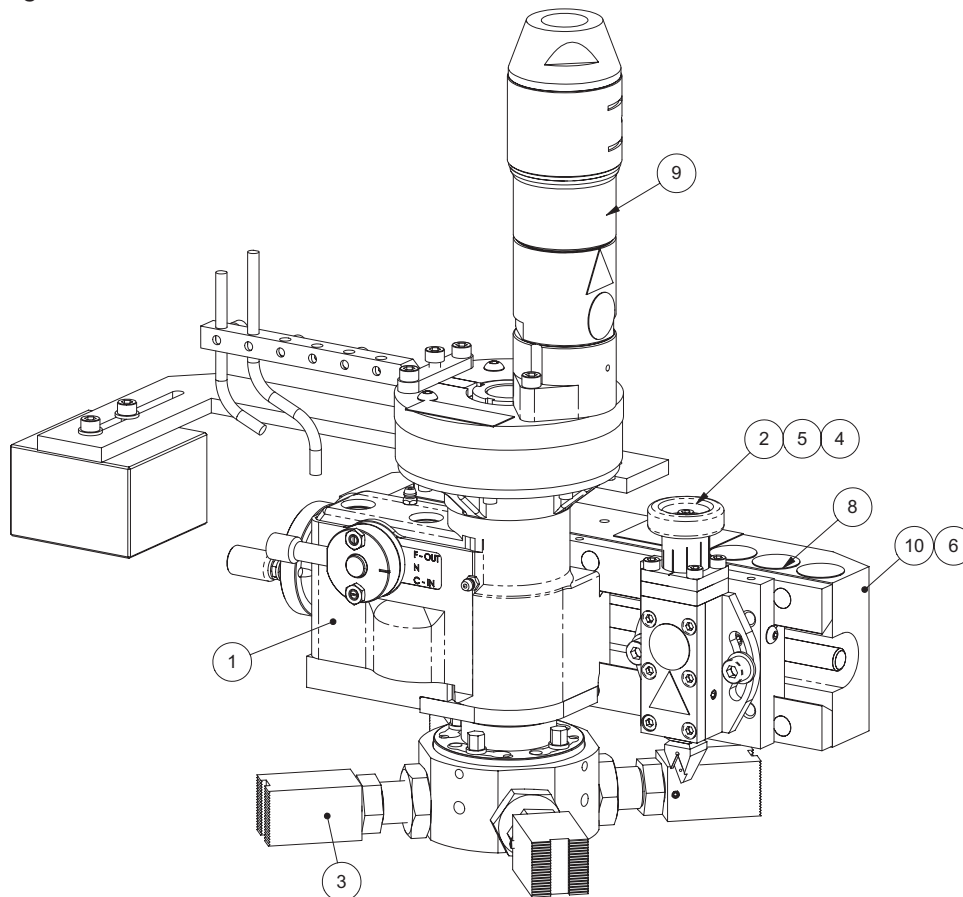


9.2 MM305i Assembly (MM305i, Revision E) Table of Parts

Item Number	Part Number	Description	QTY
1	DMH-PNEUMATIC	PNEUMATIC DEAD MANS HANDLE	1
2	MM610i-BOX	TRANSPORTATION BOX	1
3	LARGE-ALK	LARGE FILTER LUBRICATOR KIT	1
4	MM305i-P-M	FLANGE FACING (PNEUMATIC) MACHINE	1
5	TOOLKIT-08	MM305I/MM500I/MM610I TOOLKIT	1
6	DOC-MM305i	Document Pack for MM305i	1

9.3 MM305i Machine Assembly (MM305i-P-M, Revision A) Views

Weight 24kg

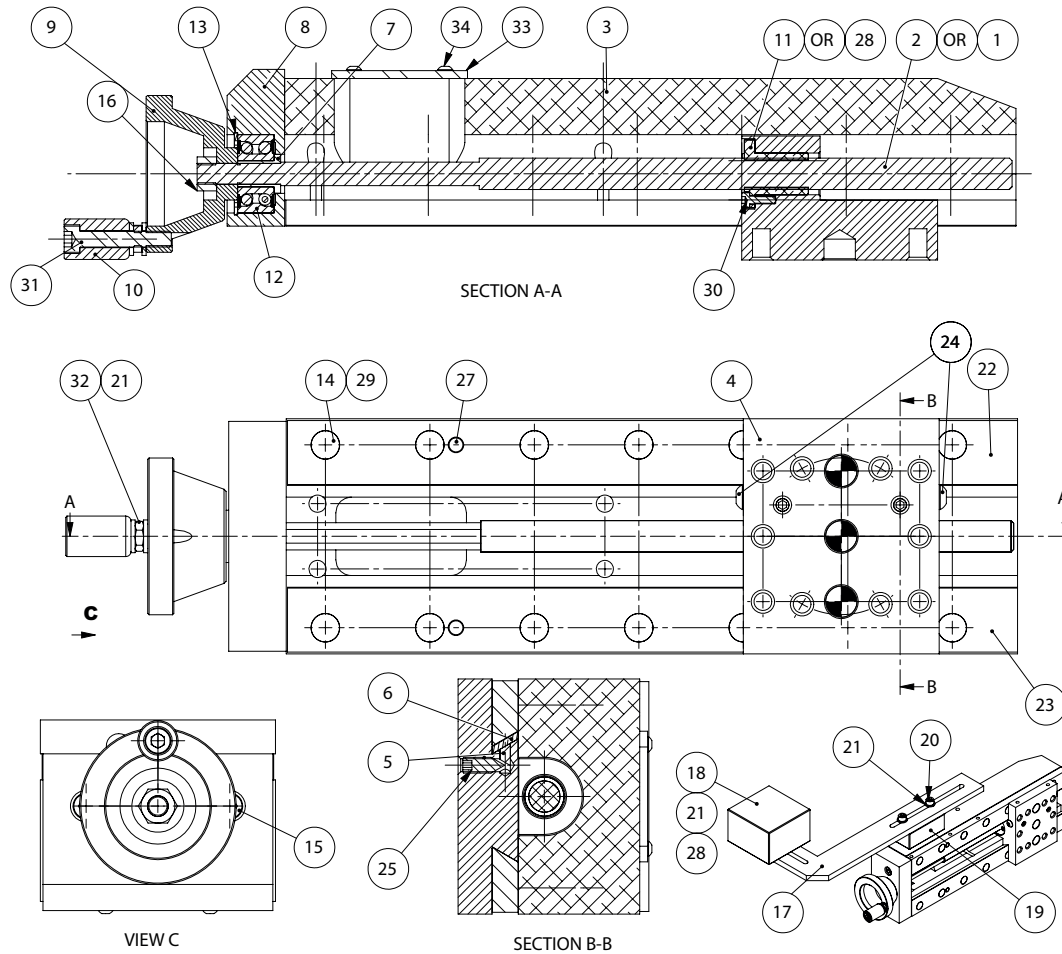


9.4 MM305i Machine Assembly (MM305i-P-M, Revision A) Table of Parts

Item Number	Part Number	Description	QTY
1	MM500i-1	MAST, HUB & GEARBOX	1
2	MM500i-3	TOOLPOST ASSEMBLY	1
3	MM305i-5	2 - 12 BASE ASSEMBLY	1
4	M8	WASHER (FORM A)	2
5	M8 x 16	Hex Socket Head	2
6	M6 x 50	Hex Socket Head - BS EN ISO 4762	4
8	LABEL-PACK-1	Label Pack for MM610i & MM305i	1
9	MM250i-1	MOTOR DRIVE ASSEMBLY	1
10	MM 250i-3	2" - 12" SURFACING ARM	1

9.5 2"-12" Surfacing Arm (MM250i-3, Revision L) Views

Weight 9kg



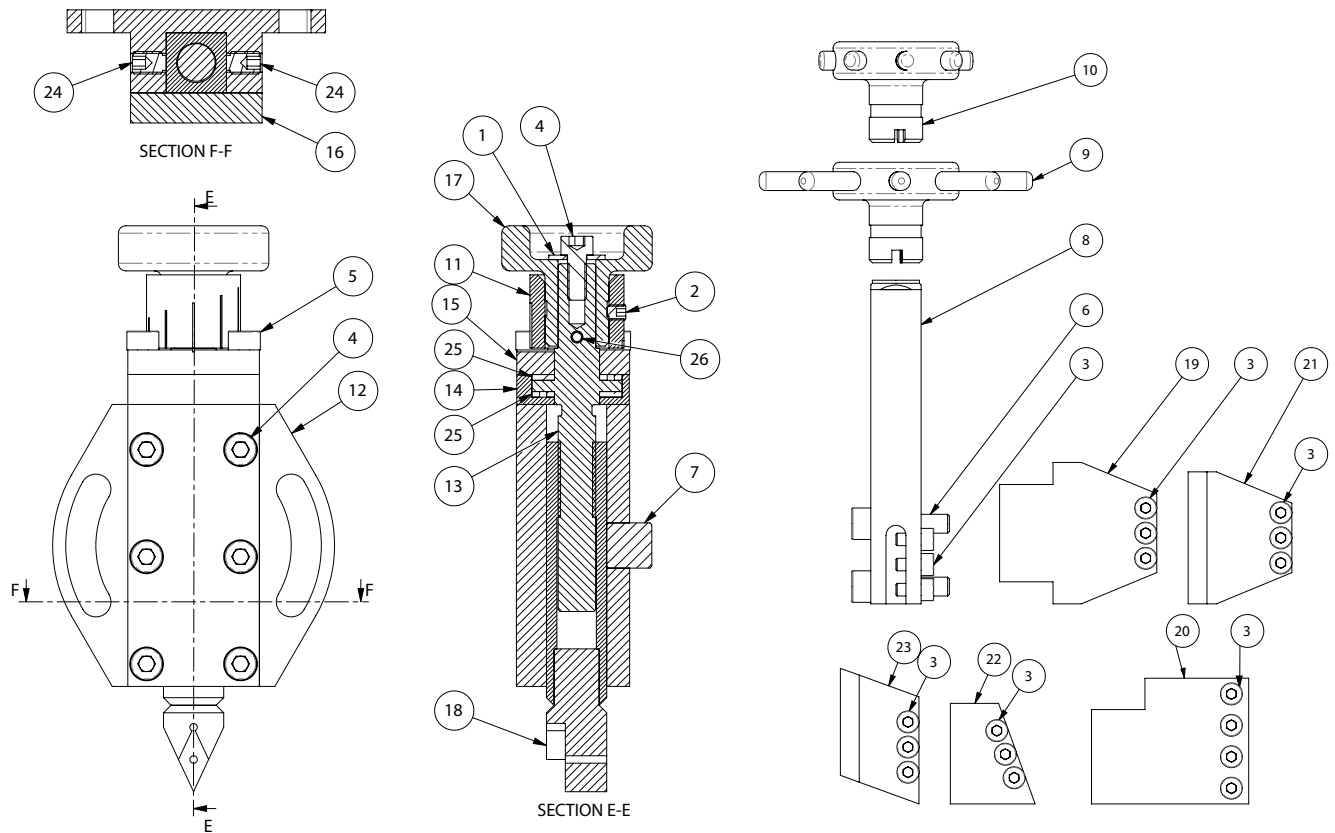
9.6 2"-12" Surfacing Arm (MM250i-3, Revision L) Table of Parts

Item	Part Number	Description	QTY
1	MMI 2303B	250i LEADSCREW	1
2	MMI 2303 D	250i 2 start right hand lead-screw	1
3	MMI 2304	SURFACING ARM	1
4	MMI 2305	CARRIAGE	1
5	MMI 2305 B	GIB STRIP PIN	2
6	MM500i-1-003	Carriage Gib Strip	1
7	MMI 2314	Bearing collar	1
8	MMI 2320	END CAP	1
9	MMI 2328	Handwheel	1
10	MMI 8359	HANDWHEEL HANDLE	1
11	MM610i-3-005	1.25 PITCH 2 START NUT	1
12	3200-2RS	Double row ang con brg	1
13	D1300-0300	DIN 472 INTERNAL CIR-CLIP	1
14	M6 x 16	Hex Socket Button Head - BS EN ISO 7380	14
15	M6 x 25	Hex Socket Head	2
16	M8	Hex Nut Style 2 - BS EN 24033	1

Item	Part Number	Description	QTY
17	MMI 2326	balance plate laser cut	1
18	MMI 2327	balance weight	1
19	MMI 2428	BALANCE PLATE SPACER	1
20	M6 x 45	Hex Socket Head	2
21	M6	WASHER (FORM A)	6
22	MM250i-3-001	Guide rail upper	1
23	MM250i-3-002	Guide rail lower	1
24	M5 X 12	Hex Socket Button Head	2
25	MMI 2305 A	GIB STRIP GRUB SCREW	2
26	MME 3327D	leadscrew nut 2 start r.h.	1
27	6 X 20	ø6 DOWEL	4
28	M6 x 25	Hex Socket Head - BS EN ISO 4762	2
29	C6	11mm Rail Plug	14
30	M3 x 10	Hex Socket Head - BS EN ISO 4762	3
31	M6X35	Hex Socket Head - BS EN ISO 4762	1
32	M6	Hex Thin Nut Grade AB - BS EN 24149	1
33	MM250i-3-003	COVER PLATE	1
34	M3 x 8	Hex Socket Button Head - BS EN ISO 7380	4

9.7 Toolpost Assembly (MM500i-3, Revision N) Views

Weight 1.5kg



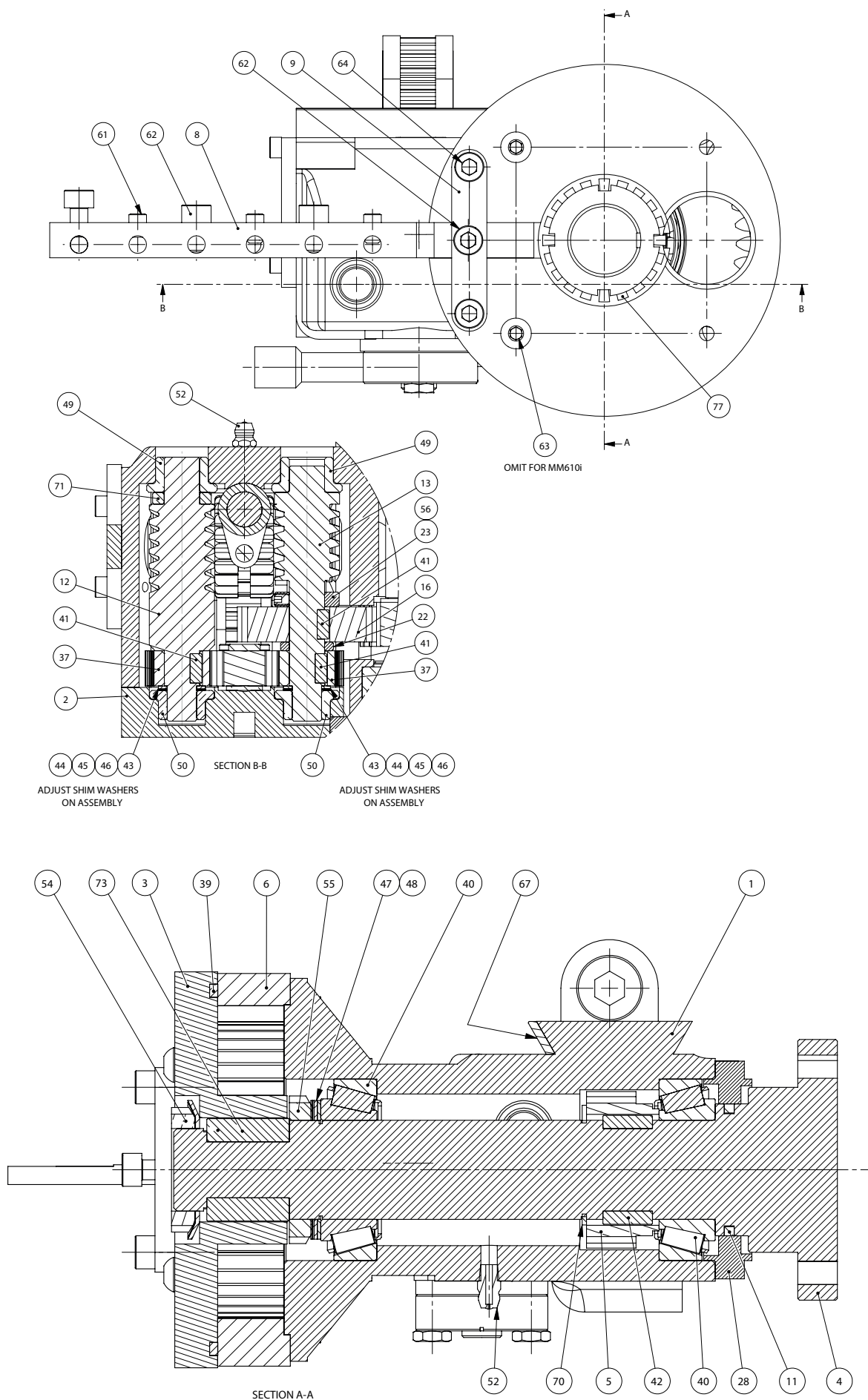
9.8 MM305i Assembly (MM305i, Revision N) Table of Parts

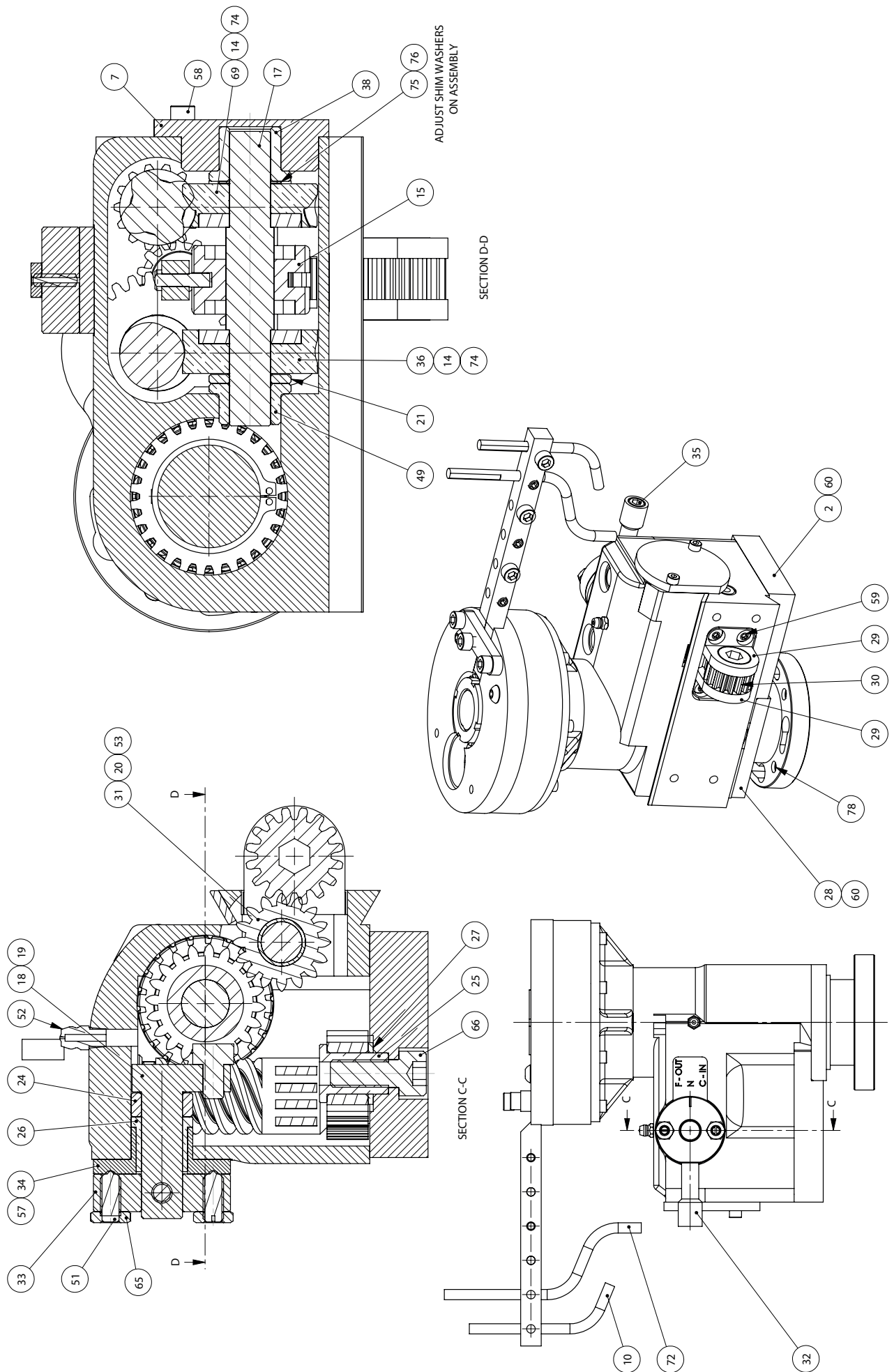
Item	Part Number	Description	QTY
1	M5-PWSH-BZP	Penny Washer ISO 7093	1
2	M4 x 5	Socket Set Screw Flat Point - BS 4168-2	1
3	M4x0.7x8-SHCS-12.9-BZP	M4x0.7 GR 12.9-BZP Socket Head Cap Screw ISO 4762	19
4	M5x0.8x12-SHCS-12.9-BZP	M5x0.8 GR 12.9-BZP Socket Head Cap Screw ISO 4762	7
5	M5x0.8x20-SHCS-12.9-BZP	M5x0.8 GR 12.9-BZP Socket Head Cap Screw ISO 4762	4
6	M6x1x25-SHCS-12.9-BZP	M6x1 GR 12.9-BZP Socket Head Cap Screw ISO 4762	2
7	MM500i-3-001	PIVOT PIN	1
8	MM500i-3-032	TOOL HOLDER ASSEMBLY	1
9	MM500i-3A	long leg striker assembly	1
10	MM500i-3B	Short Leg Striker Assembly	1
11	MME 3335	ROLLING DIAL	1
12	MMI 2306	TOOLPOST	1
13	MMI 2307	TOOLPOST FEED SCREW	1

Item	Part Number	Description	QTY
14	MMI 2308	THRUST HOUSING	1
15	MMI 2309	TOP CAP	1
16	MMI 2310	TOOLPOST COVER PLATE	1
17	MMI 2313	TOOLPOST HANDWHEEL	1
18	MMI 2319 B	TOOL HOLDER FABRICATION	1
19	MMI 2322	TOOLHOLDER	1
20	MMI 2323	TOOLHOLDER	1
21	MMI 2329	SECONDARY TOOLHOLDER	1
22	MMI 2330	LENS RING TOOLHOLDER	1
23	MMI 2331	3" LENS RING EXTENSION HOLDER	1
24	SBCP6-8	M6x1 Socket Set Screw Dog Point (Brass Tip)	3
25	WC10DU	DU WASHER	2
26	Ø3 x 16	Spring Pin	1

9.9 Mast, Hub & Gearbox (MM500i-1, Revision R) Views

Weight 7.2kg



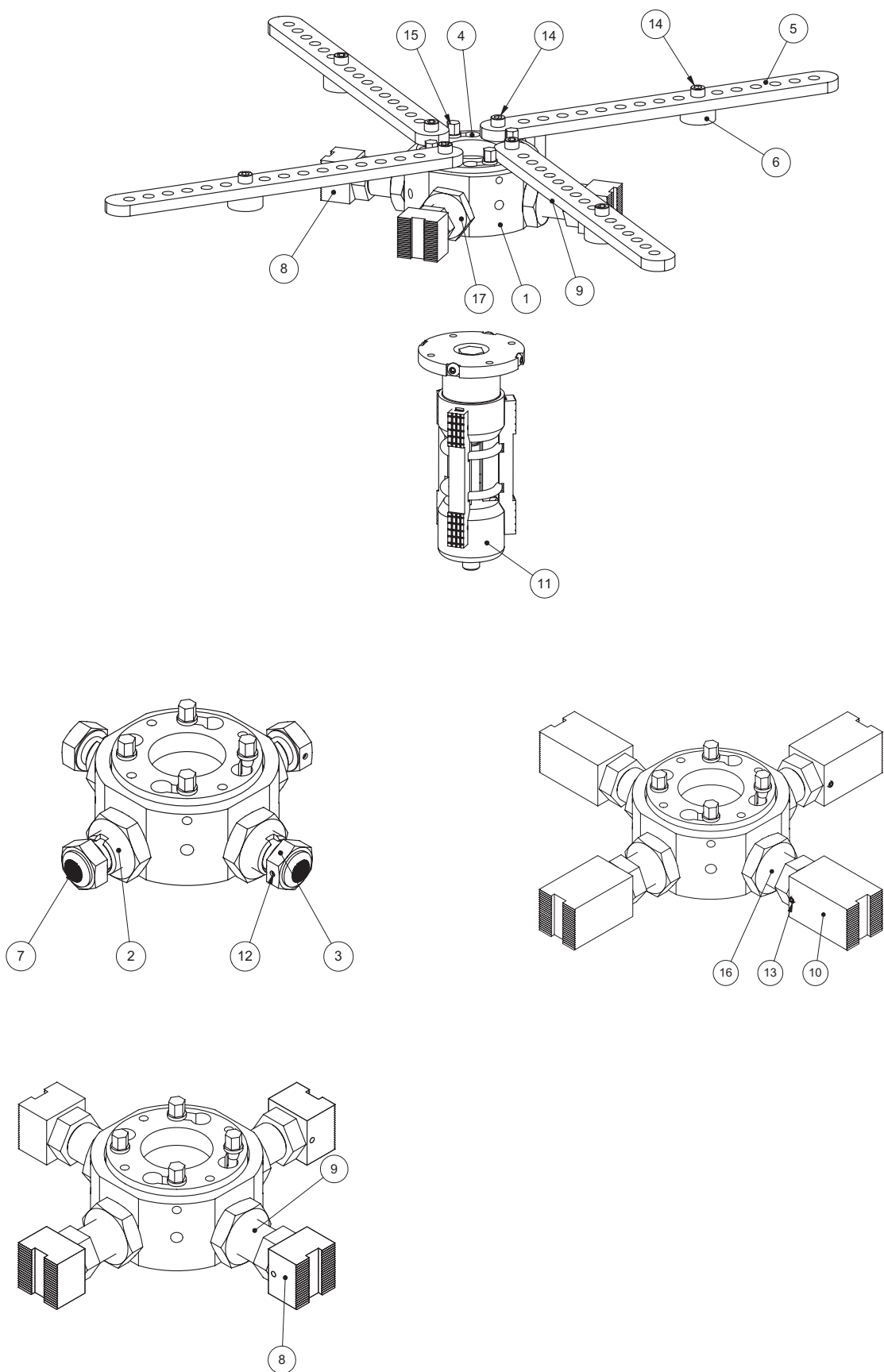


9.10 Mast, Hub & Gearbox (MM500i-1, Revision R) Table of Parts

Item	Part Number	Description	QTY
1	MMI 2101	HUB	1
2	MMI 2102	COVER PLATE	1
3	MMI 2103	MOTOR MOUNTING PLATE	1
4	MMI 2104 A	MAST	1
5	MMI 2105	28T GEAR	1
6	MMI 2107	45T INTERNAL DRIVE GEAR	1
7	MMI 2108	END BEARING CAP	1
8	MMI 2120	STRIKER ARM	1
9	MMI 2121	STRIKER ARM RETAINING PLATE	1
10	MMI 2122	STRIKER	1
11	MMI 2127	NYLON SEAL	1
12	MMI 2201	4 START WORM	1
13	MMI 2202	1 START WORM	1
14	MMI 2205	DRIVEN DOG PLATE	2
15	MMI 2206	SHUTTLE GEAR	1
16	MMI 2207	28T GEAR	1
17	MMI 2210	SELECTOR DRIVE SHAFT	1
18	MMI 2212	GEAR SELECTOR SHAFT	1
19	MMI 2214	4MM SELECTOR PIN	1
20	MMI 2215	OUTPUT GEAR SHAFT	1
21	MMI 2216	SPACER	1
22	MMI 2217	SPACER	1
23	MMI 2218	STOP COLLAR	1
24	MMI 2220	SPACER	1
25	MMI 2224	IDLER POST	1
26	MMI 2226	MODIFIED BUSH	1
27	MMI 2227	MODIFIED WC08 DU THRUST WASHER	1
28	MMI 2229	SHOE PLATE	1
29	MMI 2301	DRIVE SADDLE	2
30	MMI 2302	16t DRIVE PINION	1
31	MMI 8216	16t REVERSE GEAR	1
32	MMI 8235	GEAR SELECTOR HANDLE	1
33	MMI 8345	SURFACING ARM SELECTOR IDENT	1
34	MMI 8348	DRIVE INDENT HOUSING	1
35	M6 x 55	Socket Head Cap Screw	1
36	MME 3208	1 START WORMWHEEL	1
37	MME 3216	14t GEAR	2
38	MM500i-1-001	Flanged Oilite Bush	1
39	F002 104.7 x 112.5 x 2.5	ECOFLOX 1	1
40	32006	TAPER ROLLER BEARING	2

Item	Part Number	Description	QTY
41	KK4-10A	TYPE A KEY	3
42	KK4-15A	TYPE A KEY	2
43	CPS10x16x1	PRECISION SHIM	2
44	CPS10x16x0.1	PRECISION SHIM	2
45	CPS10160.15	PRECISION SHIM	2
46	CPS10160.25	PRECISION SHIM	2
47	CPS30x42x1	PRECISION SHIM	2
48	CPS30x42x0.5	PRECISION SHIM	2
49	AMF121812	Flanged Oilite Bush	3
50	AMF101610	Flanged Oilite Bush	2
51	3210.W006	SPRING PLUNGER	2
52	M6	STRAIGHT GREASE NIPPLE	2
53	MB1212DU	DU BUSH	1
54	KM5	locknut	1
55	KM6	locknut	1
56	M4 x 5	Socket Set Screw Flat Point - BS 4168-2	1
57	M4 x 8	Socket Countersunk Head Screw	2
58	M4 x 12	Hex Socket Head	10
59	M5 x 10	Hex Socket Button Head	4
60	M5 x 20	Hex Socket Head (Stainless)	5
61	M6 x 10	Socket Set Screw Flat Point - BS 4168-2	3
62	M6 x 10	Hex Socket Head	4
63	M6 X 10	Hex Socket Button Head	2
64	M6 x 12	Hex Socket Cap Screw	2
65	M6	Hex Thin Nut	2
66	M8 x 1.25 x 20	SOCKET HEAD CAP-SCREW	1
67	MM500i-1-002	GIB STRIP	1
68	MMI 2209	14T IDLER GEAR	1
69	MMI 2203	4 START WORMWHEEL L/H	1
70	D1400 0300	External Circlip	1
71	MMI 2219	SPACER	1
72	MMI 2123	Striker	1
73	KK8-7-25A	TYPE A KEY	2
74	M4 x 8	Hex Socket Head	8
75	CPS12x18x0.5	PRECISION SHIM	1
76	CPS12x18x0.1	PRECISION SHIM	2
77	MB 5	MB 5 BEARING LOCK WASHER	1
78	M8 X 10	Socket Set Screw Flat Point - BS 4168-2	4

9.11 2-12" Base Assembly (MM305i-5, Revision A) Views

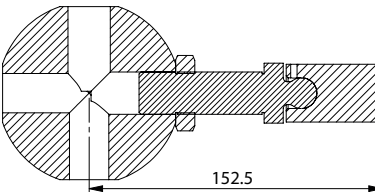
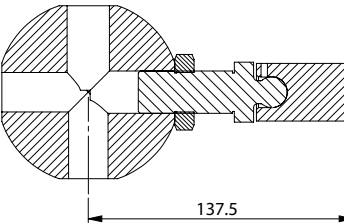
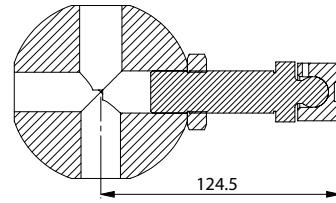
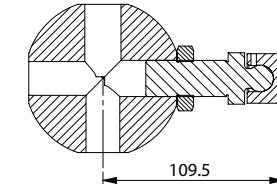
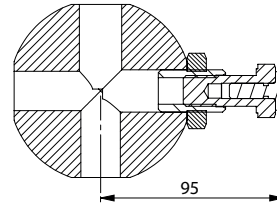
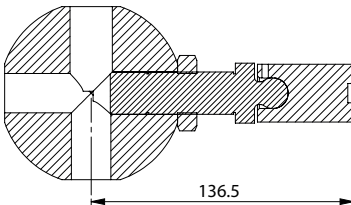
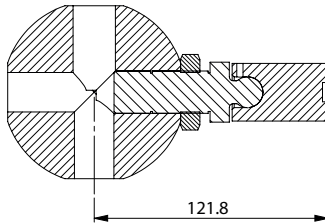
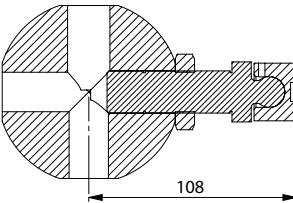
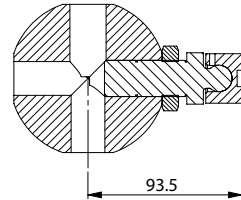
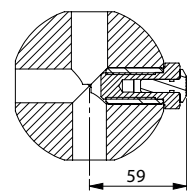


9.12 2-12” Base Assembly (MM305i-5, Revision A) Table of Parts

Item	Part Number	Description	QTY
1	MMI 2401	BASE HOUSING	1
2	MMI 2408	adaptor	4
3	MMI 2409	gripper housing	4
4	MMI 2425	setting ring	1
5	MMI 2426L	setting strap	4
6	MMI 2427	setting strap boss	4
7	MMI 8408	GRIPPER	4
8	MMI 8409A	GRIPPER BLOCK	4
9	MMI 8426	SMALL RAM BOLT	4
10	MMI 8438	EXTENDED GRIPPER BLOCK	4
11	MM500i-7	Ø48mm TO Ø122mm COLLET CLAMP	1
12	M4 x 6-C	Socket Set Screw Dog Point	8
13	M4 x 8-C	Socket Set Screw Dog Point	4
14	M6x1x20-SHCS-12.9-BZP	M6x1 GR 12.9-BZP Socket Head Cap Screw ISO 4762	8
15	MMI 2109	BOLT	4
16	MMI8433	INTERMEDIATE RAM BOLT	4
17	M22X1.5NUT4	M22 GR 4 THIN NUT, FINE BS EN ISO 4035 (BZP)	4

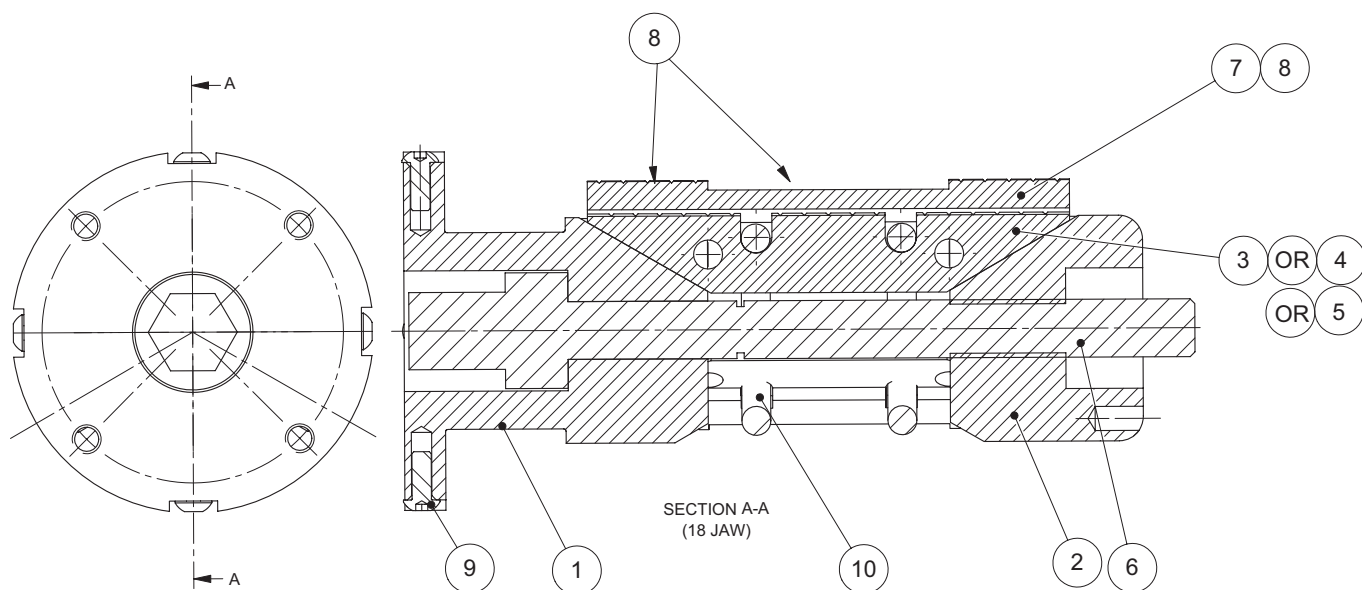
2-12" Base Assembly (MM305i-5, Revision A) Clamping Arrangement Table and Views

CLAMPING ARRANGEMENT FOR DIFFERENT DIAMETERS													
MIN	MAX	MM500i-7	MMI 2401	MMI 2408	MMI 2409	MMI 2425	MMI 2426L	MMI 2427	MMI 8408	MMI 8409A	MMI 8426	MMI 8433	MMI 8438
50mm	122mm	✓	✗	✗	✗	✗	✓	✓	✗	✗	✗	✗	✗
118mm	190mm	✗	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗
187mm	219mm	✗	✓	✗	✗	✓	✓	✓	✗	✓	✓	✗	✗
216mm	249mm	✗	✓	✗	✗	✓	✓	✓	✗	✓	✗	✓	✗
244mm	275mm	✗	✓	✗	✗	✓	✓	✓	✗	✗	✓	✗	✓
273mm	305mm	✗	✓	✗	✗	✓	✓	✓	✗	✗	✗	✓	✓



9.13 Ø48mm TO Ø122mm COLLET CLAMP (MM500i-7, Revision E) Views

Weight 2kg



NOTE:
FOLLOWING PARTS ARE HIDDEN

MM500i-7-002
MM500i-7-003
MMI 2405
MMI 2406

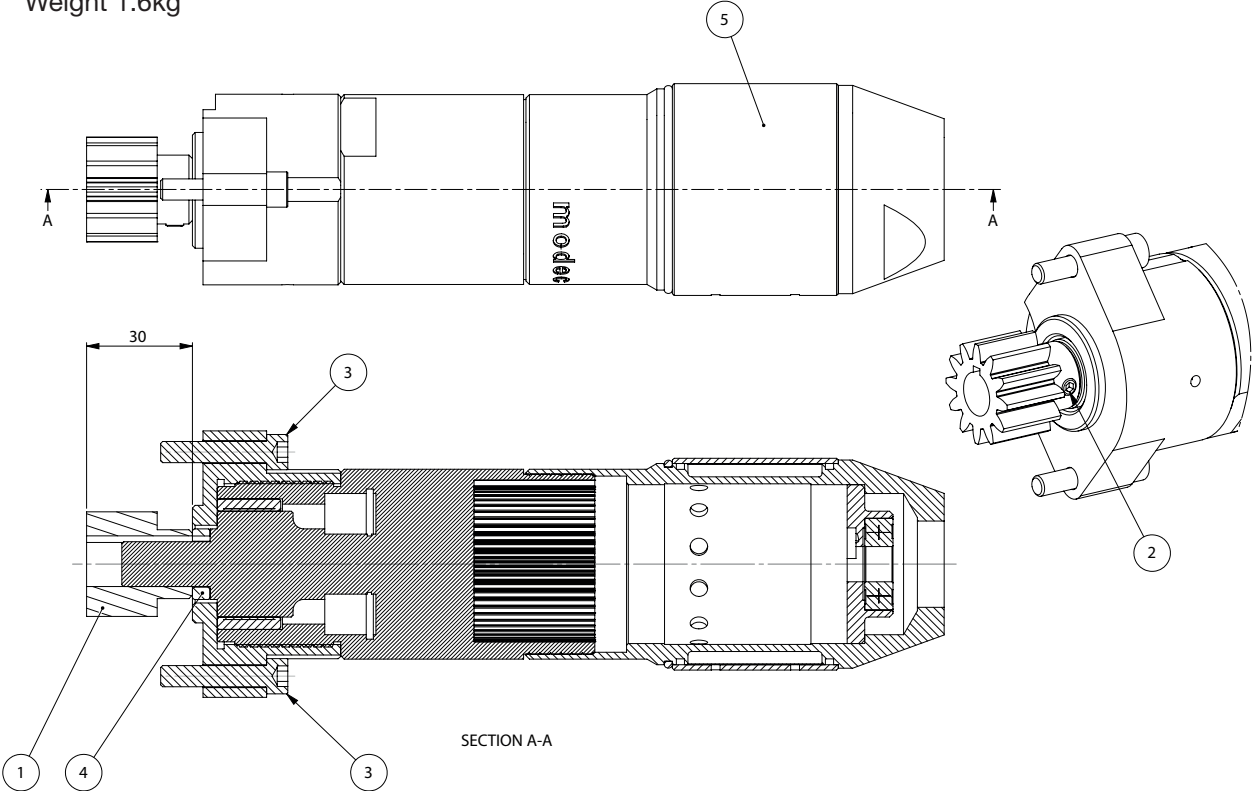
JAW RANGE			
JAW	MIN	MAX	EXTENSION
MMI 2404	48	68	88
MMI 2405	68	88	102
MMI 2406	88	108	122

9.14 Ø48mm TO Ø122mm COLLET CLAMP (MM500i-7, Revision E) table of parts

Item Number	Part Number	Description	QTY
1	MMI 2402	TOP CONE	1
2	MMI 2403	BOTTOM CONE	1
3	MMI 2404	18mm JAW	3
4	MMI 2405	25mm JAW	3
5	MMI 2406	35mm JAW	3
6	MMI 2407	CENTRE STUD	1
7	MMI 2410	JAW EXTENSION	3
8	M4 x 3	Socket Set Screw Flat Point	6
9	M4 x 10	Hex Socket Button Head - BS EN ISO7380	4
10	MM500i-7-001	Clamp Spring 100mm	2
11	MM500i-7-002	Clamp Spring 145mm	2
12	MM500i-7-003	Clamp Spring 210mm	2

9.15 Motor Drive Assembly (MM250i-1, Revision C) Views

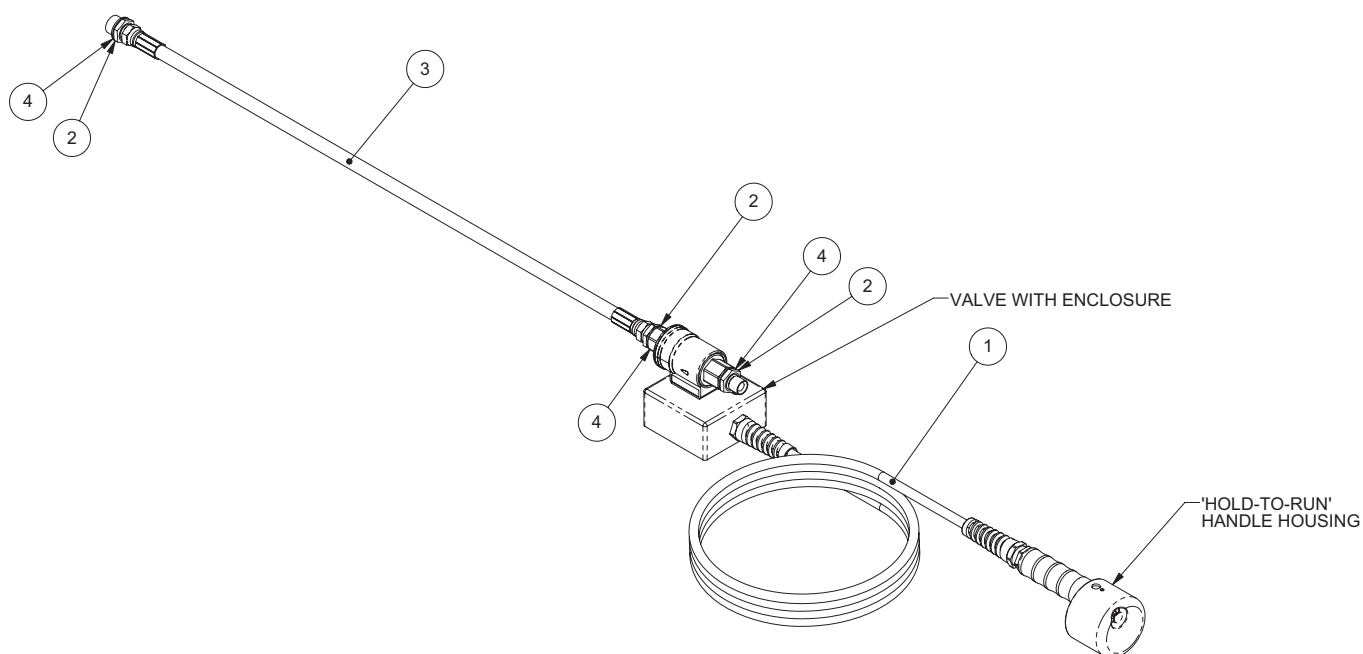
Weight 1.6kg



9.16 Motor Drive Assembly (MM250i-1, Revision C) Table of Parts

Item	Part Number	Description	QTY
1	MMI 2106	12t DRIVE GEAR	1
2	M5 x 4	Socket Set Screw Flat Point	1
3	M6 x 30	HEX SOCKET HEAD	2
4	MM250i-1-002	SPACER	1
5	MT10RT0271ICL1F	AIR MOTOR	1

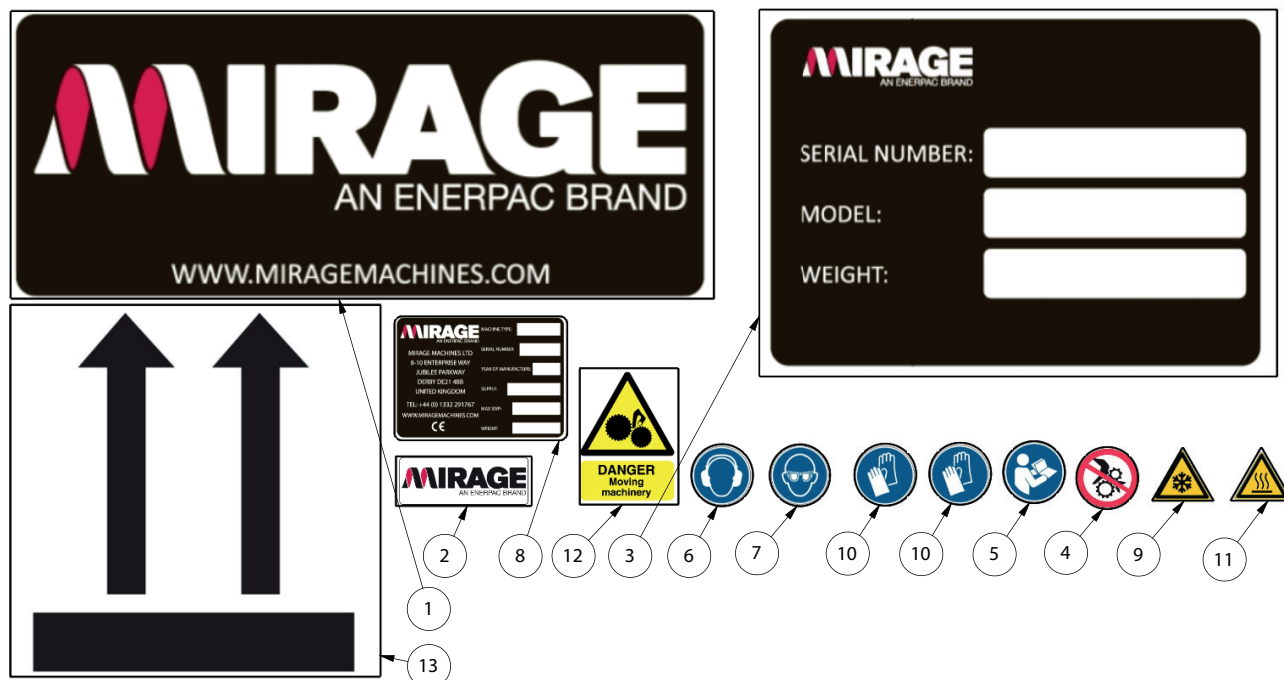
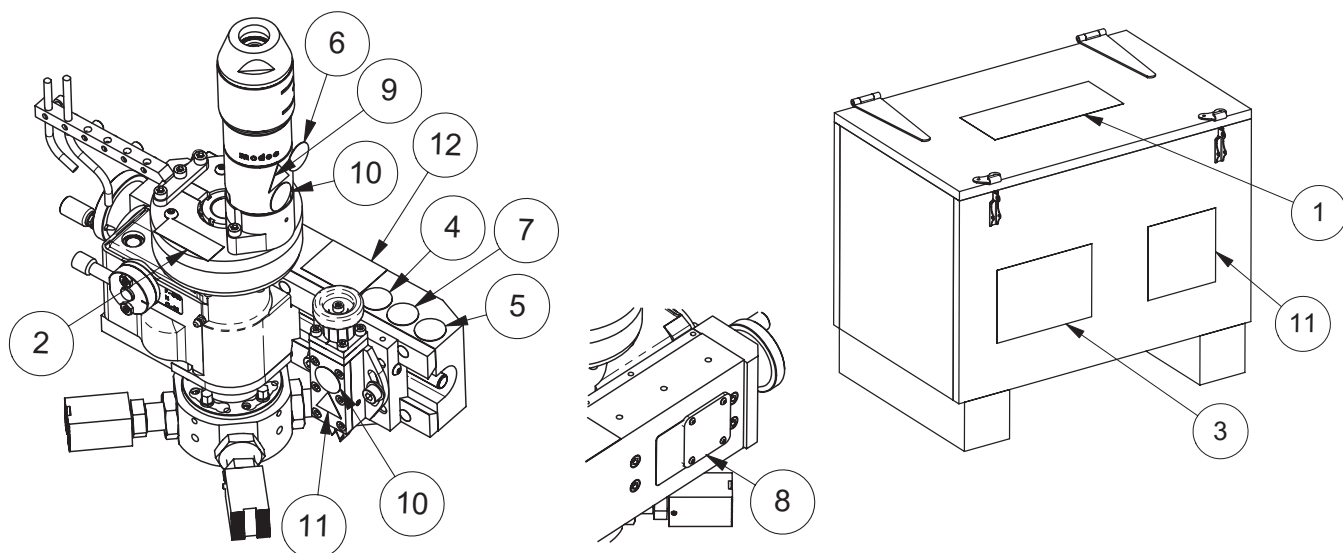
9.17 Pneumatic Dead Mans Handle (DMH-PNEUMATIC, Revision D) Views



9.18 Pneumatic Dead Mans Handle (DMH-PNEUMATIC, Revision D) Table of Parts

Item	Part Number	Description	QTY
1	DMH1	DEAD MANS HANDLE	1
2	3/4"-1/2" ADAPTOR M-M	3/4" BSPP MALE x 1/2" BSPP MALE ADAPTOR	3
3	1/2" HOSE-1000 F-F	1/2" x 1/2" BSPP FEMALE-FEMALE HOSE	1
4	D400 027 12	3/4" DOWTY WASHER	3

9.19 Label Pack (LABEL-PACK-1, Revision C) Views



9.20 Label Pack (LABEL-PACK-1, Revision C) Table of Parts

Item	Part Number	Description	QTY
1	LABEL-MM-001	Box Packaging Sticker with WEB address (285 x 116)	1
2	LABEL-MM-004	Machine Logo Sticker - Small (55 x 20)	1
3	LABEL-MM-007	Box Contents Sticker (210 x 148 - A5)	1
4	LABEL-MM-008	Prohibition Label "Fingers out - rotating machinery" ISO 7010 (Ø25)	1
5	LABEL-MM-009	Mandatory Label "Refer to instructions" ISO 7010 - M002 (Ø25)	1
6	LABEL-MM-020	Mandatory Label "Wear ear protection" ISO 7010 - M003 (Ø19)	1
7	LABEL-MM-021	Mandatory Label "Wear eye protection" ISO 7010 - M004 (Ø19)	1
8	LABEL-MM-033	CE Aluminium Label (70 x 50)	1
9	LABEL-MM-063	Warning Label "Low temperature" ISO 7010 - W010 (21.5 x 25)	1
10	LABEL-MM-064	Mandatory Label "Wear protective gloves" ISO 7010 - M009 (Ø25)	2
11	LABEL-MM-065	Warning Label "Hot Surface" ISO 7010 - W017 (21.5 x 25)	1
12	LABEL-MM-066	Warning Label "Danger - Moving Machinery" (40 x 50)	1
13	LABEL-MM-067	Label 'This Way Up' (150 x 150)	1

9.21 MM305i Toolkit (Toolkit-08, revision A) Table of Parts

Part Number	Description	QTY
KEN5930480K	6 Pocket plain chisel roll	1
KEN5822590K	8mm Combi Spanner	1
KEN5824920K	Sliding T handle 3/8" SQ drive	1
KEN5825310K	13mm socket 3/8" SQ drive	1
KEN5825340K	16mm socket 3/8" SQ drive	1
KEN6025500K	Ball driver L wrenches	1
KEN0903060K	1/4" SQ 3" cobalt toolbit	2
KEN5803900K	24mm/27mm double ended spanner	1
DCGT11T304-PM2-WXN10	4mm Rad inserts grade WXN10	10
MIT3986083Z	Magnetic back	1
MIT3253587E	2046FDTL 58mm diameter	1
KEN0903740K	10mm SQ x 100mm cobalt toolbit	1
MM305I-0-003	M4 Cut-down allen key	1

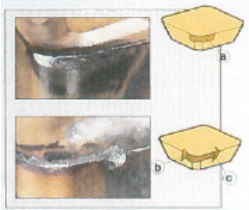
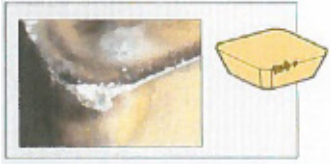
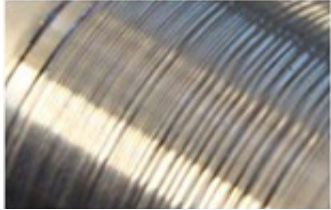
10. Troubleshooting



NO MACHINE ADJUSTMENTS SHOULD BE MADE WHILE THE MACHINE IS IN OPERATION. TURN AND LOCK OFF THE ISOLATION VALVE ON THE PNEUMATIC SUPPLY BEFORE MAKING ANY ADJUSTMENTS.

Symptom	Possible Cause	Corrective Action
The machine will not rotate	1. Pneumatic supply not available	Check supply
	2. Pneumatic supply is below the minimum required to operate the machine	Check supply
	3. Drive motor faulty	Remove motor and check operation
	4. Damage to drive gear train	Remove motor and check free rotation
	5. Faulty valve or emergency shut off operational	Check supply to motor
The machine does not traverse	1. The feed control lever is not correctly set	Check position
	2. Drive gear problem	Remove and check drive assembly operation
	3. Depth of cut too deep	Remove cutting tool and check rotation
Poor surface finish on the face	1. Machine out of balance	Check balance
	2. Machine base incorrectly installed	Check installation
	3. Machine installation bolts not tightened	Check bolts
	4. Tool inserts worn or damaged	Check tool & replace
	5. Depth of cut too deep	Reduce depth of cut
	6. Too much play in tool post gib strip or carriage	Adjust tool post & carriage
	7. Too much play in main hub bearings	Adjust bearing dampers
	8. Worn drive motor	Check motor
	9. Poorly adjusted surfacing arm	Check and adjust
	10. General poor machine condition	Refer to the manufacturer

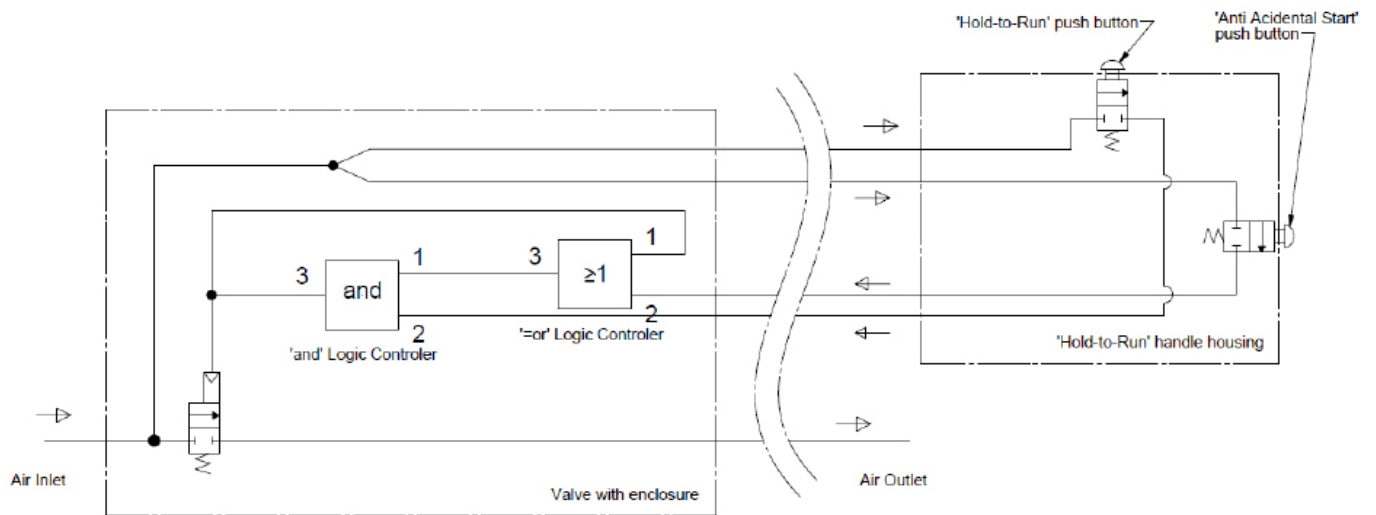
Cutting Tip Wear

Issue	Reason for wear		
Thermal cracks 	Small cracks perpendicular to the cutting edge causing chattering and poor surface finish.	Thermal cracks due to temperature variations caused by: Intermittent machining	Select a tougher grade with better resistance to thermal shocks
		Varying coolant supply	Coolant should be applied copiously or not at all.
Built up edge (B.U.E) 	Built up edge causing poor surface finish and cutting edge chattering when the B.U.E. is torn away	Work piece material is welded to the insert due to : Low cutting speed	Increase cutting speed
		Low feed	Increase feed
		Negative cutting geometry.	Select a positive geometry
Vibrations	Machine vibrates badly causing poor surface finish/accelerated machine wear.	Wrong cutting data	Reduce cutting feed
			Increase cutting feed
			Change cutting depth
		Bad stability	Reduce overhang
Flank & notch wear 	a) Rapid flank wear	a) Cutting speed too high or insert has insufficient wear resistance.	Reduce cutting speed. Select more resistant grade of insert.
		a) Feed too low	Increase feed rate
	b)/c) Notch wear causing poor surface finish & risk of edge breaking.	b)/c) Material work hardens	Reduce cutting speed. Select tougher grade
		b)/c) Skin & scale	Increase cutting speed.
Frittering 	Small cutting edge fractures (chattering) causing poor surface finish and excessive flank wear.	Grade too brittle.	Select tougher grade.
		Insert geometry too weak.	Select insert with tougher geometry
		Built up edge	Increase cutting speed or select a positive geometry.
			Reduce feed at beginning of cut.
Poor Surface finish 	Wavy, rough or inconsistent finish on work piece.	Feed too high	Reduce feed.
		Wrong insert position	Change position
		Deflection	Check overhang
		Bad stability	Check stability

Appendix - Additional Reference Material

A Additional Schematic diagrams

A1 Hold-to-run schematic diagram



B Additional Technical Data

B1 Recommended general torque settings for fasteners

Thread Ø	Tensile Strength		Torque Setting	
	kN	lbs	Nm	in-lbs
M3	6.54	1470	2.1	19
M4	11.4	2560	4.6	41
M5	18.5	4160	9.5	85
M6	26.1	5870	16	140
M8	47.6	10700	39	350
M10	75.4	17000	77	680
M12	110	24700	135	1200
M14	150	33700	215	1900

Thread Ø	Tensile Strength		Torque Setting	
	kN	lbs	Nm	in-lbs
M16	204	45900	330	2900
M20	306	68800	650	5750
M22	374	83950	875	7725
M24	441	99100	1100	9700
M30	701	158000	2250	19900
M32	860	193500	3050	27000
M36	1020	229000	3850	34100

B2 Cutting feed and speed calculations

To find	Using	Metric		English	
Cutting speed	RPM, Dia	m/min	$V = \text{RPM} \times 0.00314 \times \text{Dia}$	Ft / min	$V = \text{RPM} \times \text{Dia} \times 3.82$
RPM	V, Dia	Revs/min	$\text{RPM} = \frac{V}{3.14 \times \text{Dia}} \times 1000$	Revs /min	$\text{RPM} = \frac{V}{\text{Dia} \times 3.82}$
Feed rate	RPM, FPT, NT	mm/min	$\text{FR} = \text{RPM} \times \text{FPT} \times \text{NT}$	Inches/min	$\text{FR} = \text{RPM} \times \text{FPT} \times \text{NT}$
Feed per Tooth	FR, RPM, NT	mm/tooth	$\text{FPT} = \frac{V}{\text{RPM} \times \text{NT}}$	Inches/tooth	$\text{FPT} = \frac{V}{\text{RPM} \times \text{NT}}$
Feed / Rev	RPM, FR	mm/Rev	$\text{FRR} = \text{FR} / \text{RPM}$	Inches/Rev	$\text{FRR} = \text{FR} / \text{RPM}$
Metal removal	DC, RC, FR	cm ³ /min	$\text{MR} = \text{DC} \times \text{RC} \times \text{FR} \times 1,000$	Inches ³ /min	$\text{MR} = \text{DC} \times \text{RC} \times \text{FR}$
Horse Power	MR, C, WC, PC	HP	$\text{HP} = \text{MR} \times \text{C} \times \text{WC} \times \text{PC} \times 0.015$	HP	$\text{HP} = \text{MR} \times \text{C} \times \text{WC} \times \text{PC}$

V = cutting speed (m/min or Ft/min)

Dia = Diameter of cutting tool

RPM = spindle revs /min

FPT = Feed per tooth (mm or Inches)

NT = Number of teeth

FR = Feed rate (mm/min or inches/min)

FRR = Feed rate per revolution

DC = axial depth of cut

RC = radial engagement of cut (mm or inches)

MR = Metal removal rate (cm³/min or inches³/min)

HP = horse power (estimate of the power required at the motor assumes 75% efficiency)

C = cutting edge constant (from table 1)

WC = wear constant (from table 2)

PC = power constant (from table 3)

Table 1 (Use FPT number in feed rate calculation to obtain cutting edge constant C)							
Feed in	C	Feed in	C	Feed mm	C	Feed mm	C
0.002	1.40	0.018	0.94	0.02	1.40	0.45	0.94
0.004	1.25	0.020	0.90	0.10	1.25	0.50	0.90
0.006	1.15	0.025	0.86	0.15	1.15	0.60	0.86
0.008	1.08	0.030	0.83	0.20	1.08	0.75	0.83
0.010	1.04	0.035	0.80	0.25	1.04	0.90	0.80
0.012	1.00	0.040	0.78	0.30	1.00	1.00	0.78
0.014	0.97	0.050	0.75	0.35	0.97	1.25	0.75
0.016	0.94	0.060	0.72	0.40	0.94	1.50	0.72

Table 2 (Determine the type of operation to obtain constant W)	
Type of operation	W
Turning – finishing cuts	1.00 – 1.10
Turning – roughing cuts	1.60 – 2.0
Milling – finishing cuts	1.10 – 1.25
Milling – Heavy metal removal face milling	1.30 – 1.60
Drilling – normal to hard to drill materials	1.30 – 1.50

Table 3 (Determine material to obtain constant PC)				
Material Type	Hardness - HB	Tensile Strength – n/mm ²	PC (inch)	PC (metric)
Plain carbon steels	<200	< 700	0.51 – 0.62	1.39 – 1.69
Free machining and stainless steels	< 260	< 850	0.74 – 0.92	2.02 – 2.51
Alloy steels	< 340	< 1200	0.80 – 1.00	2.18 – 2.73
High alloy steels and castings	< 450	< 1500	1.00 - 1.20	2.73 – 3.28
Aluminium		< 300	0.25 – 0.33	0.68 – 0.90
Cast iron	< 300		0.63 – 0.86	1.72 – 2.35
Stainless steel	< 340	< 1200	0.80 – 1.00	2.02 – 2.51
Heat resistant super alloys		< 1250	1.00 – 1.10	2.73 – 3.00

B3 Flange face surface finish

ANSI / ASME 16.5, 16.47, 16.42 - ISO 7005-1

Finish	Surface Finish	Feed Rate
RF - Stock finish	125-500 μ in	0.032"
	3.2-12.5 μ m	0.80mm
RF - Smooth	125-250 μ in	0.012"
	3.2-6.3 μ m	0.30mm
Hydrogen	79-125 μ in	0.008"
	2-3.2 μ m	0.20mm
RTJ	32-63 μ in	0.008"
	0.8-1.6 μ m	0.20mm

Micrometer μ m	Micro - inch μ in	Roughness Grade N	Roughness Grade ∇
12.5	500	N10	∇
6.3	250	N9	$\nabla\nabla$
3.2	125	N8	$\nabla\nabla$
1.6	63	N7	$\nabla\nabla$
0.8	32	N6	$\nabla\nabla\nabla$
0.4	16	N5	$\nabla\nabla\nabla\nabla$

NOTES

[illegible]

