



Operation and Maintenance Manual

Enerpac MM3000i

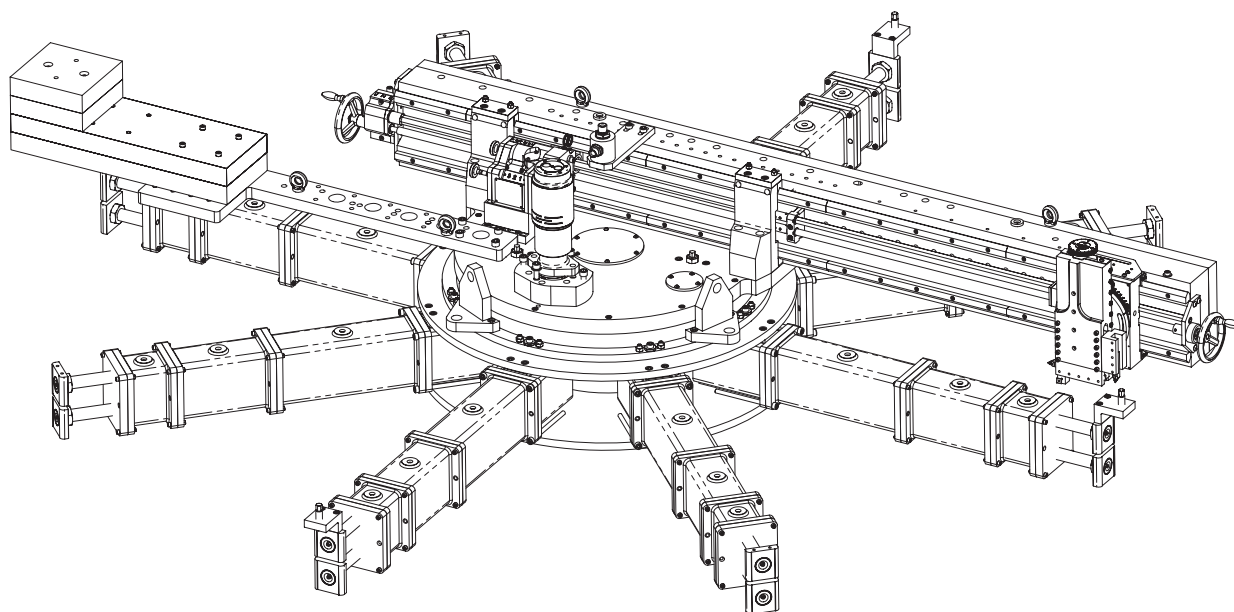
Flange Facing Machine (45-120" Internal Mounted Flange Facing Machine)

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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

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MIRAGE MACHINES LTD	SERIAL NUMBER: <input type="text"/>
8-10 ENTERPRISE WAY	YEAR OF MANUFACTURE: <input type="text"/>
JUBILEE PARKWAY	SUPPLY: <input type="text"/>
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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 1.3.
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.

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



Figure 1: Motor showing safety labels

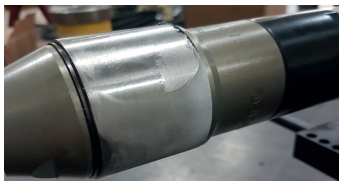


Figure 2: Frost/ ice on Motor

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.

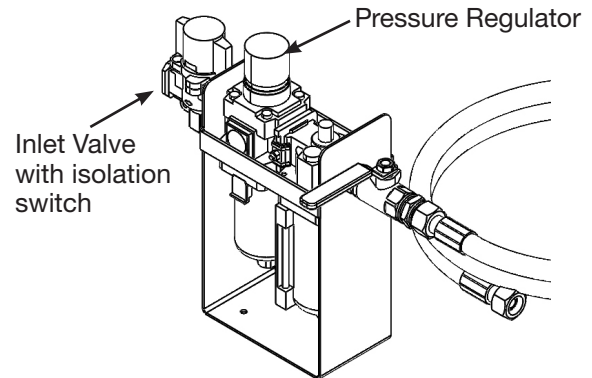


Figure 3: Air Lubrication Unit

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.

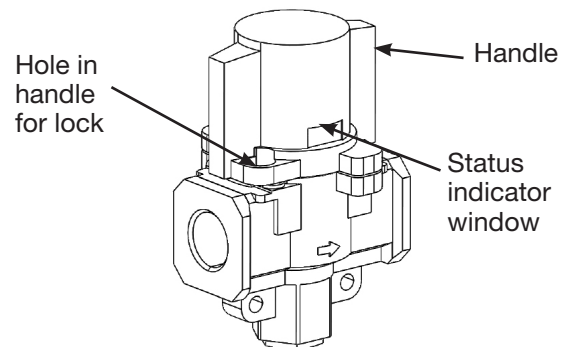


Figure 4: Inlet valve

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.

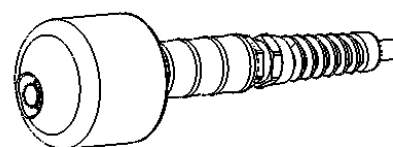


Figure 5: Hold-to-run control



1.3 Machine Hazard Zone

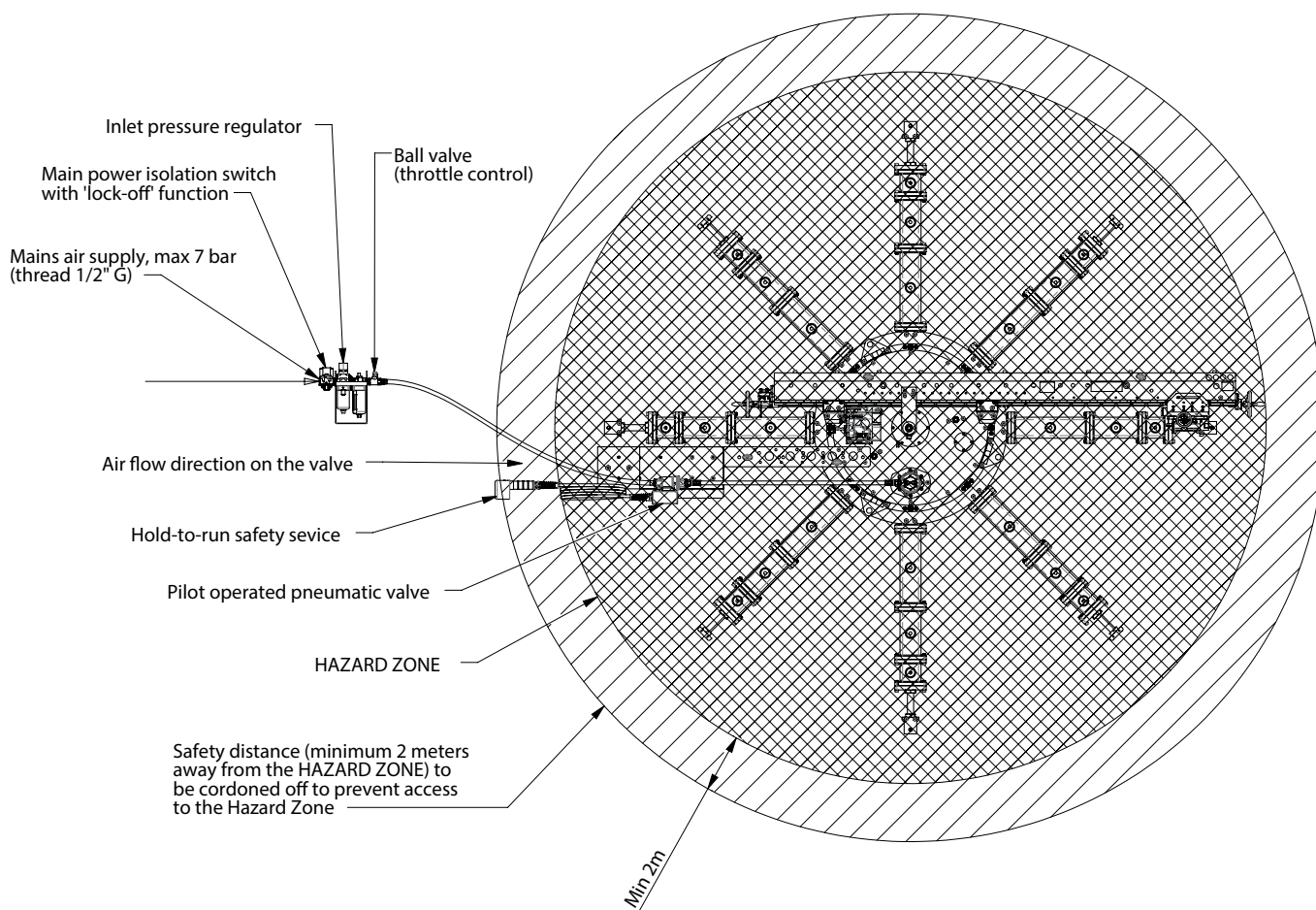


Figure 6: Supplied system layout drawing showing hazard area to be cordoned off



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:

6. Only the operator is allowed to enter cordoned off zone, if necessary.
7. Ball valve (throttle control) should be nearly closed in order to slowly start up the machine.
8. Operator to be outside of cordoned off zone and operate the machine by using the hold to run device.
9. 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 MM3000i 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 7: Risk Assessment Checklist before installation

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

Figure 8: Risk Assessment Checklist after installation

	<u>After Installation</u>
<input type="checkbox"/>	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.
<input type="checkbox"/>	I evaluated and mitigated the potential risks specific to the work environment.
<input type="checkbox"/>	I checked that all affected personnel understand the hazard zone (section 1.3) and are outside of it.
<input type="checkbox"/>	I followed the required Maintenance Intervals with the recommended lubricants in section 8.
<input type="checkbox"/>	I checked that all affected personnel have the required personal protective equipment, as well as any site-required or regulatory equipment.
<input type="checkbox"/>	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.
<input type="checkbox"/>	I planned the safe guarding of any chips or swarf produced by the machining process.
<input type="checkbox"/>	I considered that the tool tip cutter will be sharp and have planned adequate protection for handling.

2. Compliance Statement(s)

2.1 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. Motor | 5. Fixing Jaws |
| 2. Gearbox | 6. Balance weight |
| 3. Tool Post | 7. Hold-to-run device* |
| 4. Internally Mountable base | 8. Air Lubrication unit* |

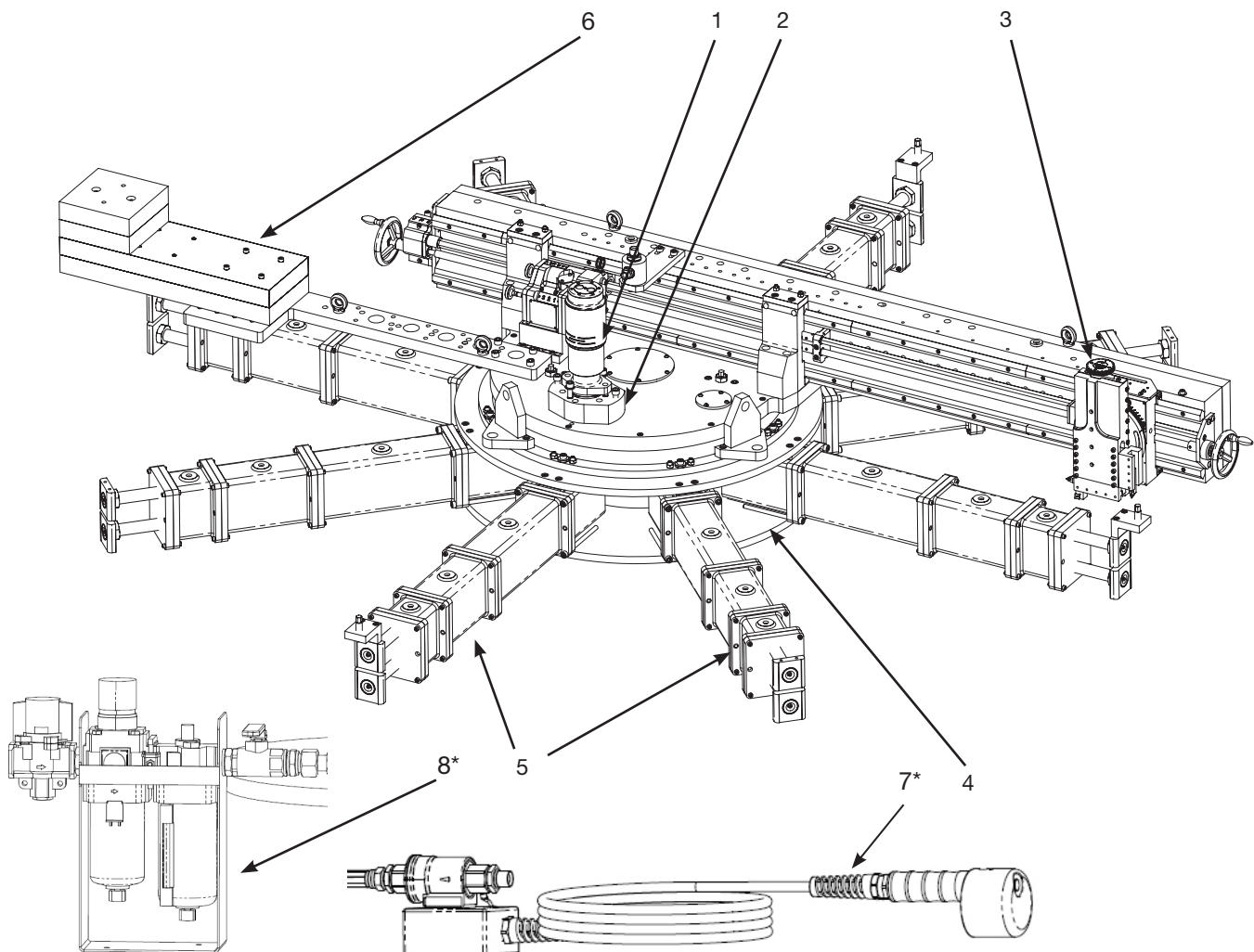


Figure 7: Major features and components

3.2 Machine Description

This machine has been designed for performing facing operations on flanges. It can be used for seal groove machining. The machine is manually fixed and levelled to the flange using the clamping Jaws. 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 Callout Art

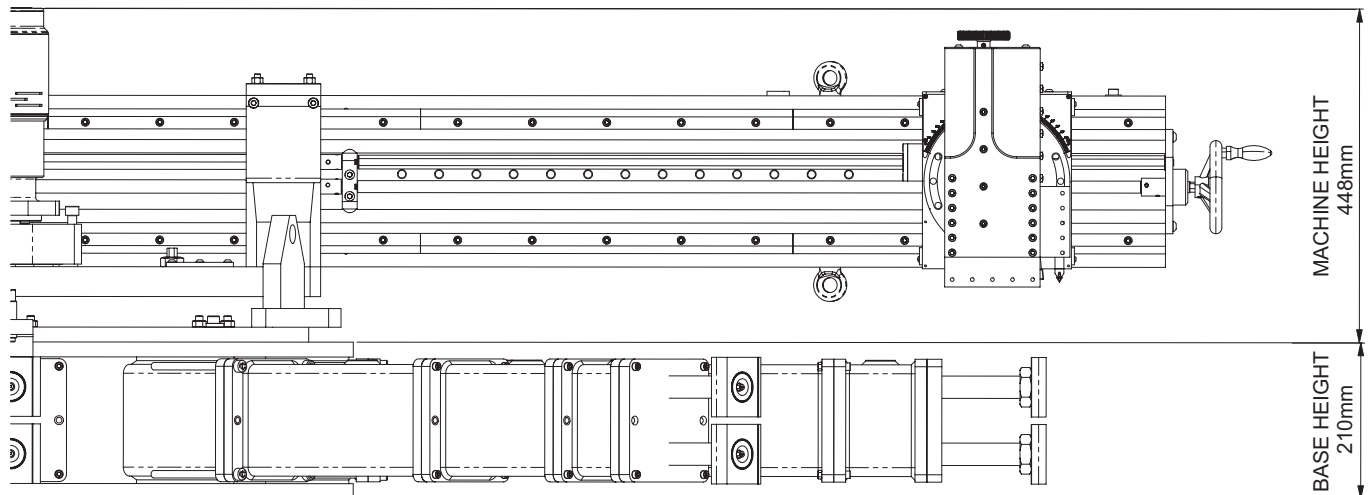


Figure 8: Dimensional Information

4.2 Dimensional Table

Description	Value	
Maximum Clamping Diameter	2800mm	110"
Minimum Clamping Diameter	1120mm	44"
Motor	3.0kW @ 6 bar	40hp @ 87psi
Maximum Facing Diameter	3050mm	120"
Minimum Facing Diameter	1150mm	45.3"
Maximum Swing Diameter	3655mm	144"
Minimum Swing Diameter	2620mm	103"
Tool Post Vertical Travel	100mm	4"
Machine RPM	Min. 3	Max. 12
Machine Weight (Machine & Base)	1375kg	3032lb
Supply	2.89m ³ /min @ 6bar	102ft ³ /min @ 87psi
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 MM3000i.
- 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 for the machine can be found in the mechanical specification table.

5. Installation

5.1 Installing base to work piece



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 section 9, MM3000i-12, table for Clamping arrangements for different diameters).



Note that the 4 opposing legs must have the same arrangement.

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.

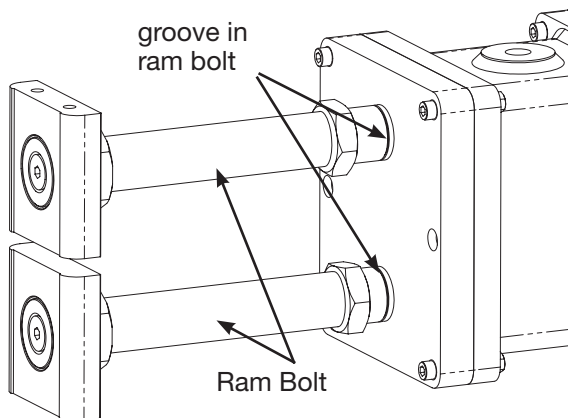


Figure 9: Ram bolt showing groove

4. Bolt the setting straps onto the fixed jaws, ensuring that the straps overlap the bore dimension by at least 25mm (1.0").

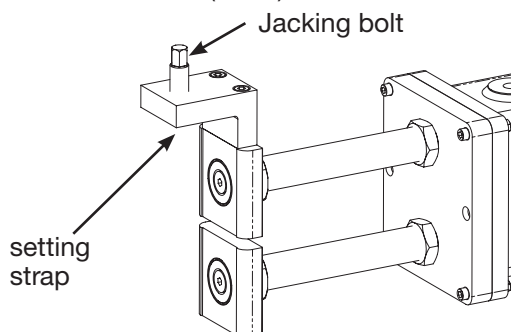


Figure 10: Setting straps on Work piece

5. Position the base into the flange bore. Check centralisation by measuring and adjust ram bolts as necessary. Lifting equipment and slings may be used to lift the base assembly to the work piece.
6. Adjustments can be made tightening and loosening opposing jacking bolts. The setting straps are left in place until the base unit is fully installed



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 workpiece, tighten the ram bolts to 300NM. 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.

8. When the base is secured to the work piece, remove the setting straps.

5.2 Installing machine to base

1. Install eight mounting machine bolts (M10x45 socket head cap screw) to the machine assembly.

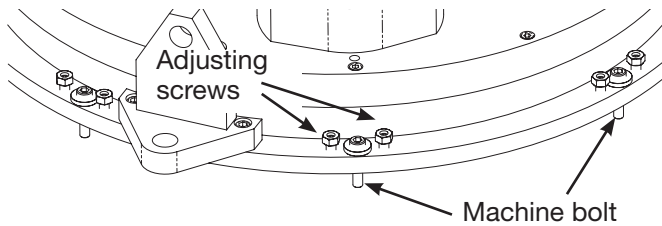


Figure 11: Mounting Bolt

2. Ensure the toolpost is fully retracted and the cutting tool has been removed.
3. Lift the machine carefully over the bush and align bolt hole positions to avoid having to rotate the machine any great distance. Refer to section 5.3.

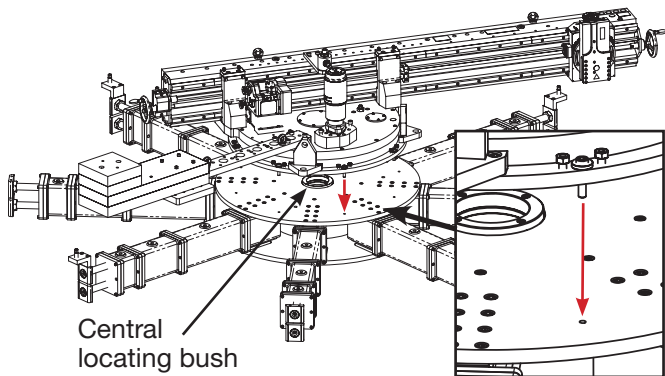


Figure 12: Installing machine to base assembly

4. Screw the mounting bolts to the base assembly
5. A magnetic base clock is used to aid radial adjustment of the machine. This can be placed on the tool post and positioned on to the flange face.
6. Survey the flange and, if required, the adjustable screws can be used to level the machine parallel with the flange. See figure 11.
7. When the machine is secured to the base, remove lifting points on the machine, specified in section 5.3.

5.3 Lifting



The machine and the base are supplied in two separate assemblies. Care should be taken when lifting the units.

Lifting points should be torqued to the figures specified in the table of recommended general torque settings for fasteners given in the appendix, section B1.

Base: up to 700kg approx.

Machine: 825kg approx.

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

For ease of lifting the balance of the assembly can be changed by moving the slide way arm.

MACHINE LIFTING POINTS - 3

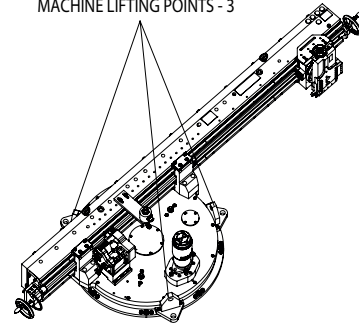
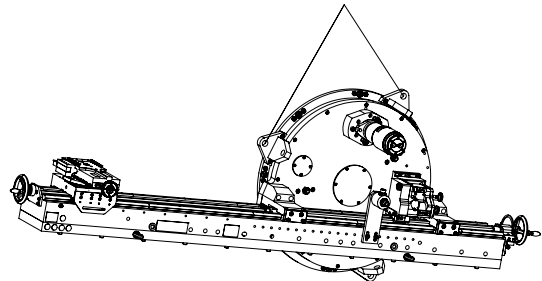


Figure 13: Machine Lifting Point Horizontal mounting

MACHINE LIFTING POINTS - 2



NOTES:
1. MOVING THE ARM CENTRAL WILL HELP TO BALANCE.

Figure 14: Machine Lifting Point Vertical mounting



Do not lift the machine with the base attached



When lifting the machine, only the labelled lifting points should be used.



Note: Lifting Points are removed after assembly to base.

6. Operation

DANGER

No machine adjustments should be made while the machine is in operation. Turn and lock off the isolation valve on the power supply before making any adjustments.

6.1 Connecting the machine to the power supply

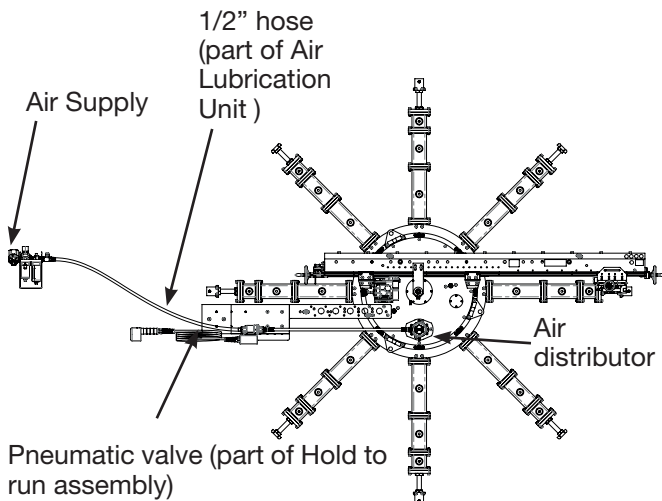
Attach the 1/2" hose to the motor coupling adapter. The free end of the 1/2" hose should be attached to the pilot operated pneumatic valve from the hold to run unit.

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).



OBSERVE DIRECTION OF FLOW ON VALVE

Figure 15: Pneumatic 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.

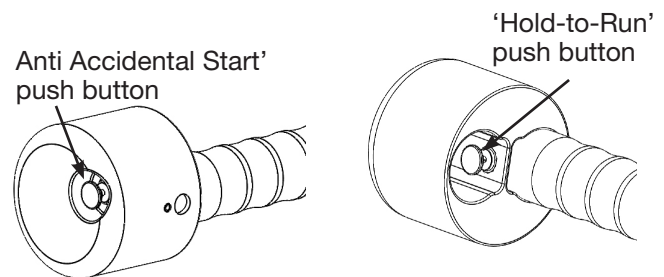


Figure 16: Hold-to-run handle

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

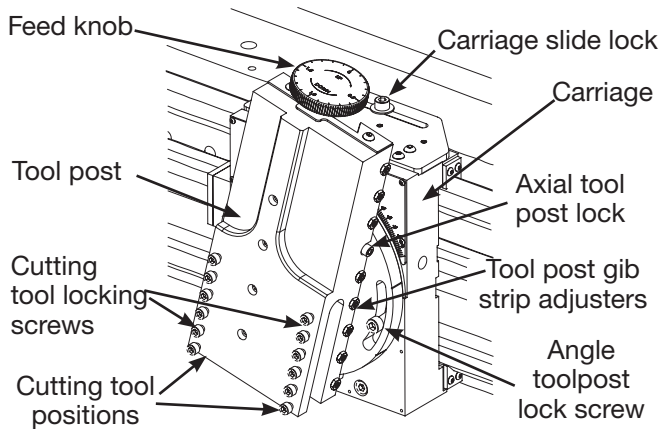


Figure 17: Tool post assembly

CAUTION

When facing, ensure the carriage slide lock is removed. When boring ensure the lock is tightened to maintain a fixed carriage position.

Inserting the cutting tool

Install the tool provided in either of the tool slots and tighten - over tightening of the screws could result in thread or tool post damage.

Setting the Tool Post Angle

The angle of the tool post may be altered - loosen the two screws as indicated and the tool post will swivel. Tighten the two screws to lock at the required angle.

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 obstructions.

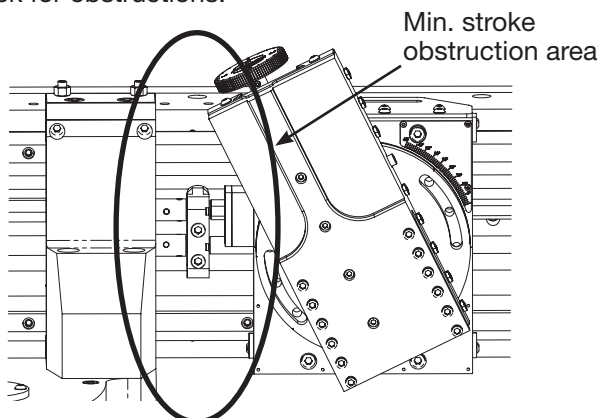


Figure 18: Tool post clash check

Setting the depth of cut

The tool post will feed approximately 2mm (0.078") per revolution of the feed knob. Increment values are shown on the feed knob.

Accurate depth of cut setting is achieved by placing the magnetic clock on the tool post. Zero the dial on the flange face and then add depth of cut.

To lock the cutting depth, tighten the Axial tool post lock. Loosen when making any changes to the height of the cutting tool.

6.6 Facing Feed Gear Selection

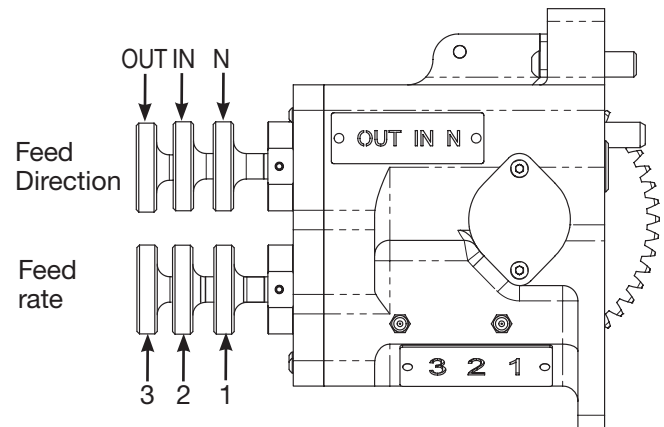


Figure 19: Facing feed gear selection

Feed Direction	Feed Gear	Feed Rate mm/rev	Feed Rate Grooves/inch
Out	1	0.122	208
Out	2	0.191	133
Out	3	0.464	55
In	1	0.145	175
In	2	0.227	112
In	3	0.553	46

Selecting Feed rate

1. Check feed rate table. See Appendix.
2. Select required feed and push or pull feed selector to required position.

Selecting Feed Direction

1. Check required direction.

'IN' will traverse the tool towards the centre.

'OUT' will traverse the tool away from the centre.

2. Select the required direction and push or pull the feed selector to the required position
3. The direction lever can be rotated to engage feed rate and direction

6.7 Boring Feed Selection

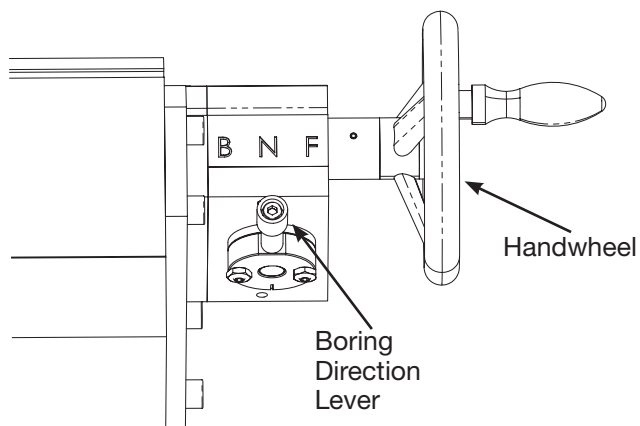


Figure 20: Direction lever for Boring operation

For Facing operation, push the lever away from the surfacing arm (lever should point at 'F') whilst rotating the hand wheel.

For Boring operation, push lever towards the surfacing arm (Lever should point at 'B') whilst rotating the knurled dial on the tool post.

For conventional boring, the feed direction should be set to 'IN'. For reverse boring, set the feed direction to 'OUT'

NOTICE

When using the tool post in boring mode it is recommended to lock the carriage. See Figure 17. The plate, screw and washer are provided to do this. It is important to remember to remove the screw before using the machine in facing mode. Failure to do so could result in damage to the machine.

Boring rate		
gear	mm per rev	inch per rev
1	0.03	0.00118
2	0.06	0.00236
3	0.13	0.00511

6.8 Facing Arm Setting

1. When it is necessary to move the surfacing arm, loosen the main drive to arm locking bolts.
2. Loosen the arm clamp plate screws in the arm support bracket and the arm should now slide. Slide to the required position.
3. To accurately locate the arm apply finger tight pressure to the main drive – arm locking bolts and then whilst supporting the arm weight tighten the clamp screws in order from 1 – 3 and then fully tighten the drive – arm locking bolts. This will ensure the arm is located correctly and is perpendicular to the rotation drive hub.

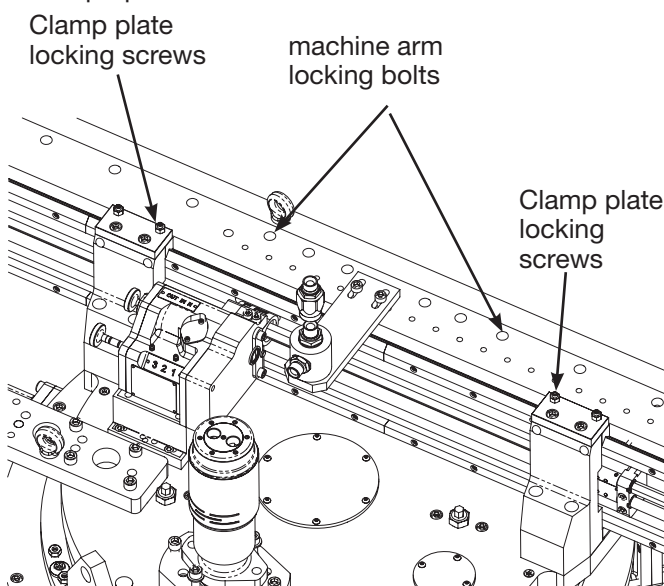
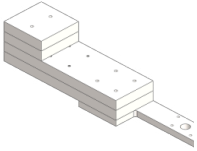
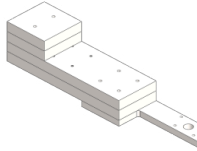
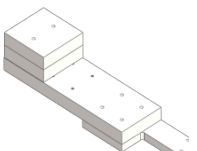


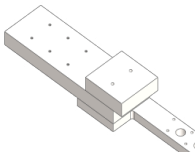
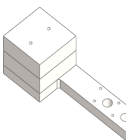
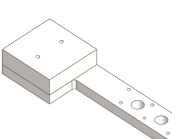
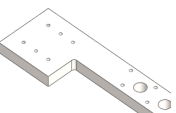
Figure 21: Machine arm

6.9 Machine Balancing

When orientated in a position other than horizontally flat (sitting on the bottom of its base plate) the MM3000I's Counterweight arm will need to be set depending on where the Facing Arm is positioned on the machine & where the Tool Post Carriage is in relation to the facing arm. In most cases the Tool Post Carriage will be required to move radially when the machine is rotating,

in these cases an average Tool Post radius should be taken. Some approximate Counterweight settings are shown below to allow an initial, quick set up of the machine. These settings are correct assuming that the Tool Post Carriage is at full travel (stroke) but should be finely adjusted to your specific machine set up.

Hole configuration Number	1	2	3
Counter weight Configuration	Use all weights at maximum radius from machine.	Use all weights at maximum radius from machine.	1 Large plate & 2 small plates all at maximum radius from machine.
image			

Hole configuration Number	4	5	6	7
Counter weight Configuration	1 large plate at max radius from machine, 1 small plate at minimum radius from the machine.	2 small weights	1 small weight	No Weights
image				

Note: All measurements taken with a single point Tool Post fitted at maximum radius (stroke) & Counterweight arm at first set of holes.

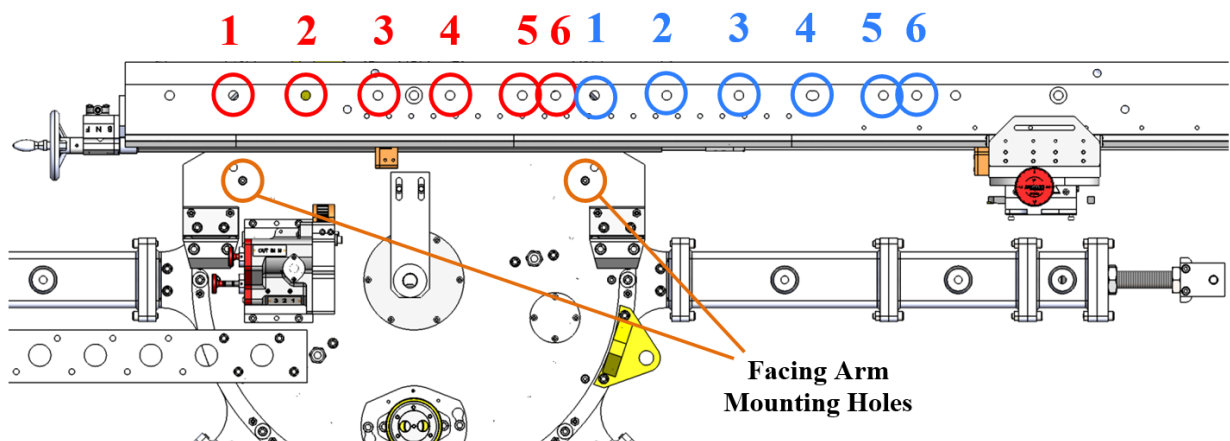


Figure 22: Facing Arm Mounting Holes & the 6 corresponding Hole Configurations in the Facing arm.

For further, fine adjustment the position of the weights can be adjusted on the arm or added & removed. The entire arm assembly can also be adjusted in or out

radially by removing the four bolts that hold it to the machine & adjusting as needed.

Hole position	1	2	3	4	5	6
Swing Diameter (mm)	3655	3395	3135	2880	2620	2755

⚠ 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 or remove 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.

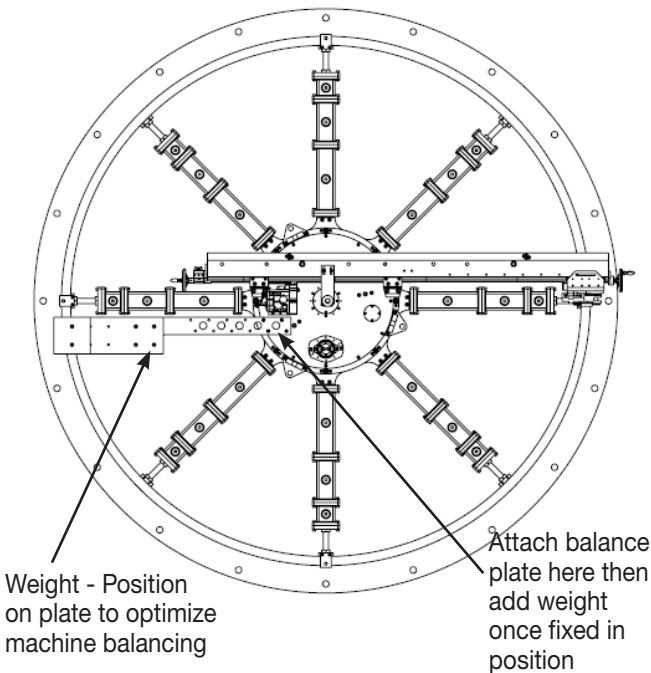


Figure 23: Machine balancing

6.10 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.

⚠ WARNING

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.

6.11 Machine Disassembly

To disassemble the machine follow the below procedure:

1. Switch off the inlet isolation valve before disconnecting the hoses from the machine. On the pneumatic model 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 eight machine bolts on the base. Refer to figure 12. The arm assembly will need to be moved around in order to gain access to each bolt.
3. Once the bolts are loosened, lift off the machine assembly. Refer to Section 5.3 for Lifting guidance.
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.

6.12 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.

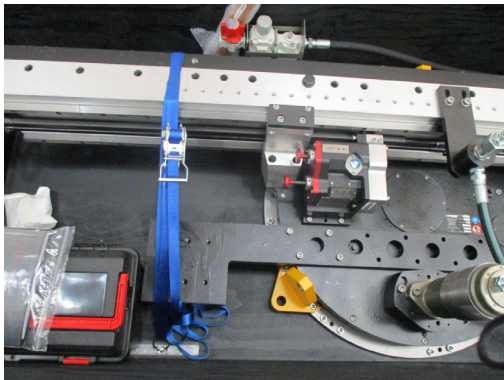


Figure 24: Storage box 1 with machine assembly

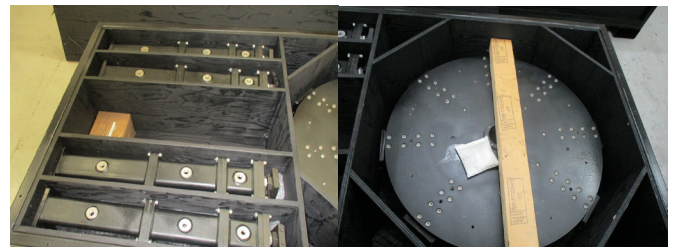


Figure 25: Storage box 2 with base assembly

8. Maintenance

8.1 General Maintenance



NO MACHINE ADJUSTMENTS SHOULD BE MADE WHILE THE MACHINE IS IN OPERATION. TURN AND LOCK OFF THE ISOLATION VALVE ON THE POWER 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
10 hours	1. Clean all components	SAE 10 oil or WD40
	2. Check all components are present and stored correctly	
	3. Check cutting inserts and replace where required	
100 hours	1. Check and adjust tool post Gib strip and carriage.	Reference corrective maintenance section
	2. Grease main hub bearings – 5 shots.	00 EP Lithium semi fluid grease
	3. Grease gearbox – 2 shots	00 EP Lithium semi fluid grease
1000 Hours	1. Check main bearing for lift	Reference corrective maintenance section
	2. Clean and oil base components	SAE 10 oil
	3. Check and adjust Gib strip and carriage.	Reference corrective maintenance section
5000 Hours	1. Strip and replace Air motor veins and bearings.	ISO 32 hydraulic oil
	2. Remove proprietary parts lightly oil and re fit	SAE 10 oil
	3. Re run 1000 Hours actions	

8.2 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

8.3 Maintenance - Corrective

⚠ DANGER

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

8.3.1 Facing Arm (ref. MM3000i-4)

1. Remove the main arm bolts. Slacken off the adjuster screws in the arm support unit which clamps the surfacing arm perpendicular to the hub and remove clamping plate.

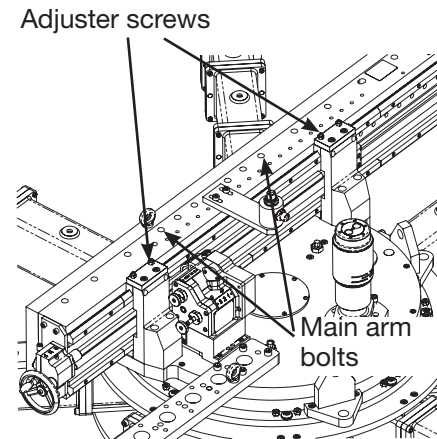


Figure 26: Facing arm connections

2. Arm should then slide backwards to release
3. Insert 2 x M16 eye bolts into arm, remove arm using vertical lift

The procedure for installation is the reverse of the removal ensuring that the PTO box (ref mm2000i-8) fits into the gearbox opening and it is in mesh with the output gear in the gearbox.

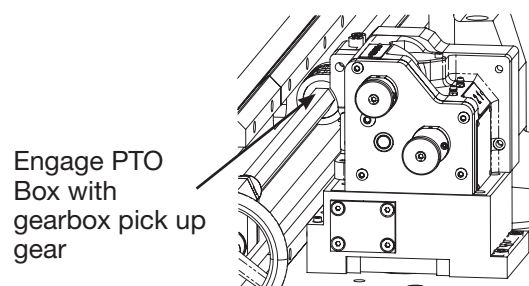


Figure 27: PTO Box gear

To check the correct installation - lift in the surfacing arm should be no more than 0.15mm (0.005").

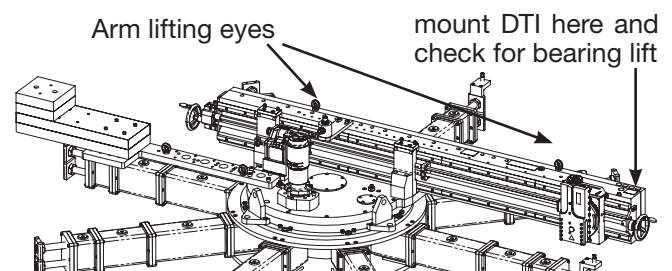


Figure 28: MM3000i machine

8.3.2 Tool post gib strip (ref. MM1080ie-2)

1. Ensure that the axial lock screw has not been tightened.
2. Slacken lock nuts on the Gib strip adjusters and slacken grub screws.
3. Working from one end, adjust grub screws only when there is sufficient location on the slide way to prevent over tightening. To adjust tighten fully then back off one quarter of a turn and tighten the lock nut.
4. Check the tool post movement along its stroke to ensure free sliding movement and no sideways movement.

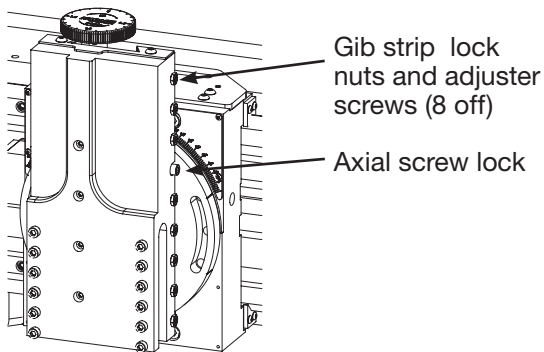


Figure 29: Tool post

8.3.3 Slide way carriage (ref. MM3000i-4)

1. Slacken lock nuts on the gib strip adjusters and slacken grub screws.
2. Working with the hand wheel ensure the carriage will slide whilst tightening the grub screws and then use the lock nuts to fix the adjustment.

To check the correct installation - there should be no free play in the carriage slide assembly.

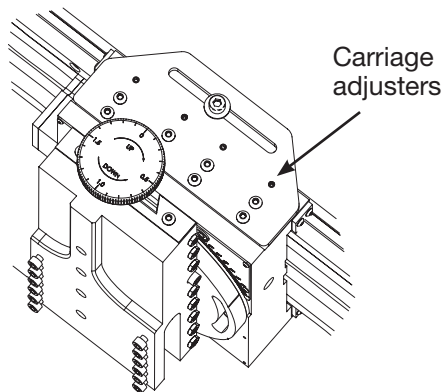


Figure 30: Toolpost carriage adjusters

8.4 Changing the insert cutting tip.

When handling the insert make sure to use protective gloves.

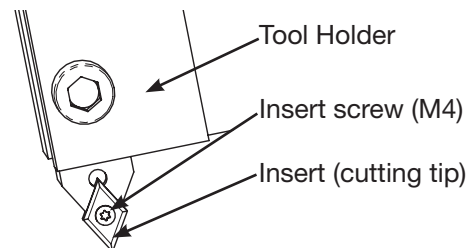


Figure 31: Insert and holder

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

8.5 Replacing shear pin in pick up gear

1. Remove 3 speed gearbox and gearbox support unit from base unit.

To do this; the pick-up gear and saddle which is attached to the facing arm, must be separated from the gearbox. This is done by unbolting 2 off M6 from the gearbox.

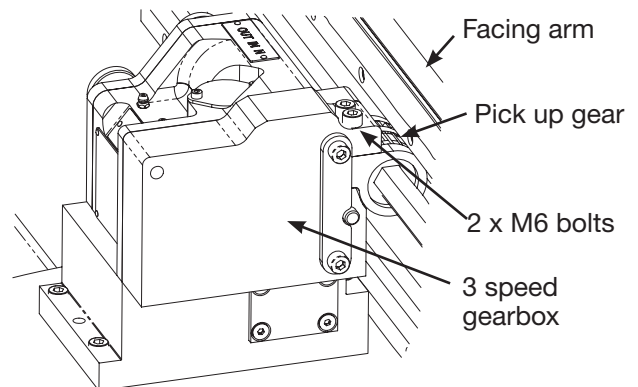


Figure 32: 3 speed gearbox

2. The Facing arm may need to be removed to be able to access two bolts at the back of the Gearbox support unit. This can be done by unbolting 2 off M8 on the Guide Support Unit from the base.

Alternatively, 2 off M10 bolts and 2 off M8 nuts on each Guide Support Unit can be loosened to allow the Facing Arm to be moved enough to access the two bolts at the back of the gear support unit.

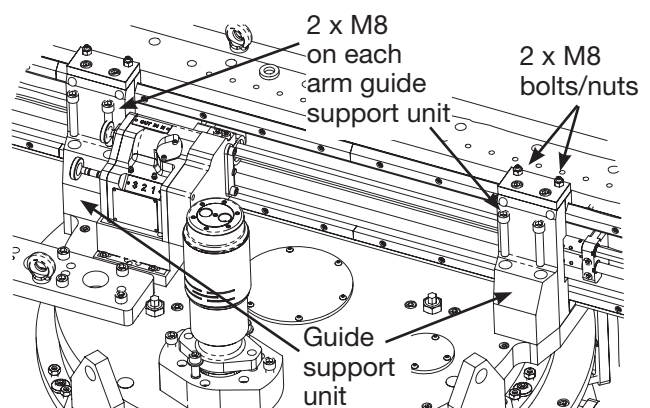


Figure 33: Guide supports

3. The Gearbox and gearbox support unit can now be lifted off the base unit by removing 4 off M8 bolts.

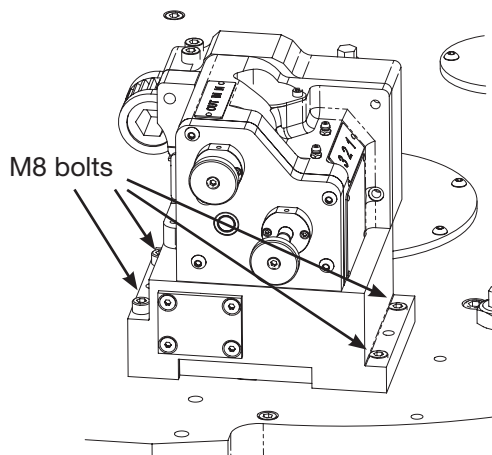


Figure 34: Removing gearbox from machine

4. Remove the gearbox support unit from the gearbox by removing 4 off M6 bolts.

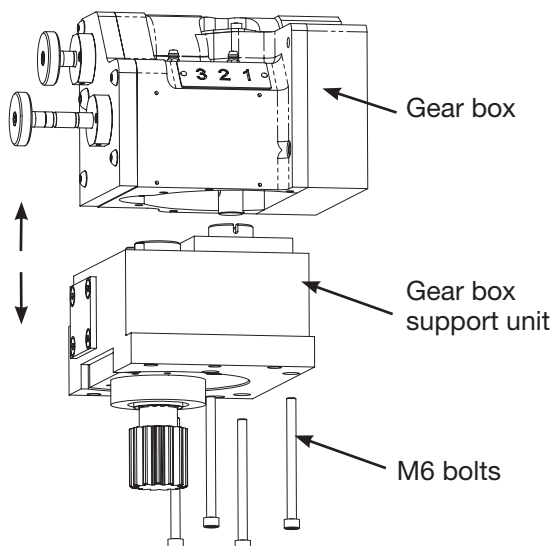


Figure 35: Separating gearbox from support unit

5. To access spiral pin on worm gear, remove cap, circlip and trapping ring. Then remove lock nut and washer.

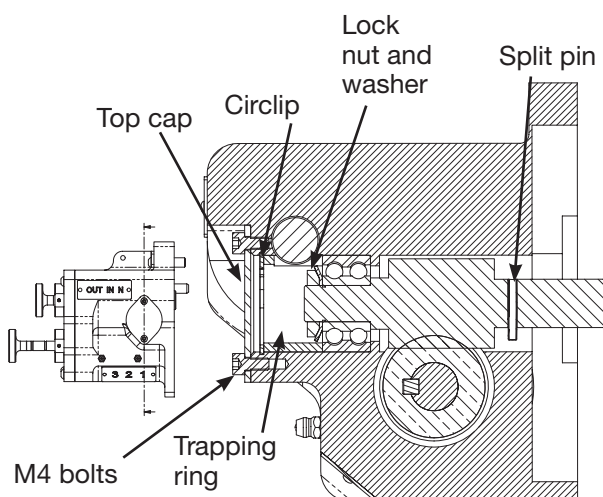


Figure 36: Sectioned Gearbox

The worm gear will now come loose. Note: the worm gear may need working loose if meshed to the adjacent gear.

6. The split pin can now be accessed. Punch out pin and replace. The pin has a shear strength of approximately 7.8kN.
7. Re-assemble by reversing the above procedure.

8.6 Dis-assembly of MM1080IE-33 to replace Keys

To allow the replacement of the drive keys within the gearbox, the MM1080IE-33 will have to be dis-assembled first. The following instructions detail this process.

1. Remove the worm gear assembly top plate, and take out the circlip



Figure 37: Top view of gearbox

2. Loosen the KM1 nut, use an allen key to jam the exposed gears so that the nut does not turn with the assembly when attempting to loosen.

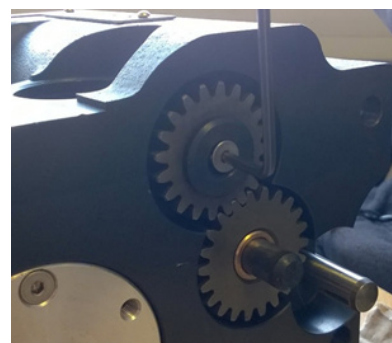


Figure 38: Allen key in gears

3. Remove the locknut and washer.
4. Unscrew the bolts on selector knobs and remove both.

5. Unscrew and remove the selector covers.

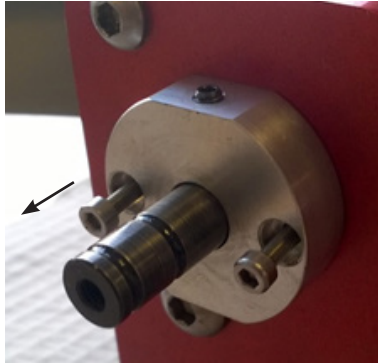


Figure 39: Remove covers

6. Undo the four bolts holding the red cover on, prise the cover off



Figure 40: Removing red end cover plate

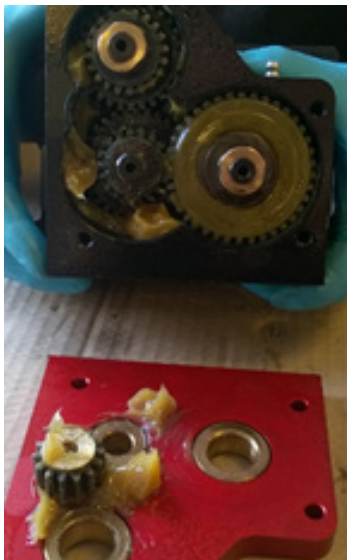


Figure 41: gearbox with red plate off

7. Knock out the top row of gears so that the exposed gear can be removed with the end float spacer

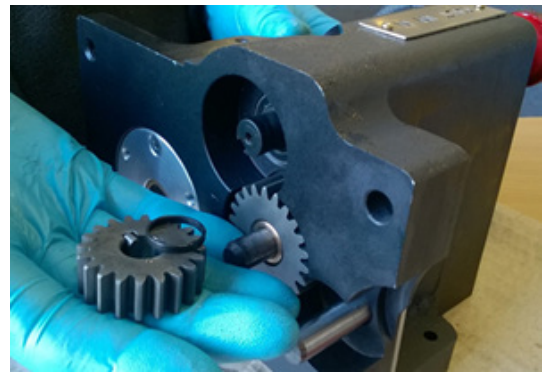


Figure 42: Remove gear

8. Remove the shaft entirely, re-attaching the selector knob can aid in removing the shaft.



Figure 43: Gearbox shaft

9. To access the key, slider the gears apart. To refit, hold it in place and push the gear over the top.
10. Loosen the three screws from the back cap and remove the cap.



Figure 44: Removing cap

11. Pull out the worm wheel from the underside of the gearbox

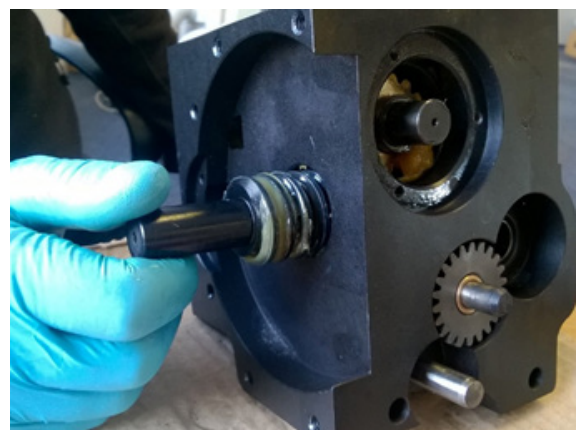


Figure 45: Removing worm gear

12. Remove the spacer / shims and worm gear
13. Pull out the key with long nose pliers



Figure 46: Removing gear

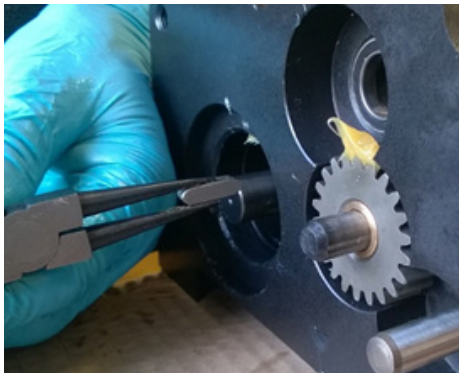


Figure 47: Removing key

14. Re-attach the selector knob and pull out the gears from the handwheel side of the gearbox.



Figure 48: Gear shaft

15. Slide the gears down the shaft to access the drive key

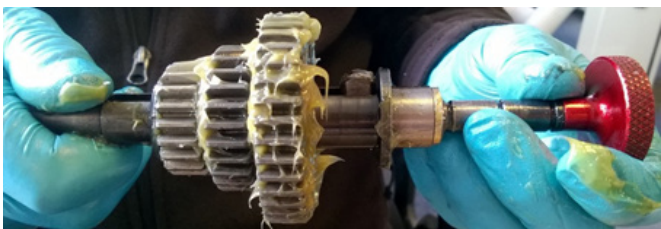
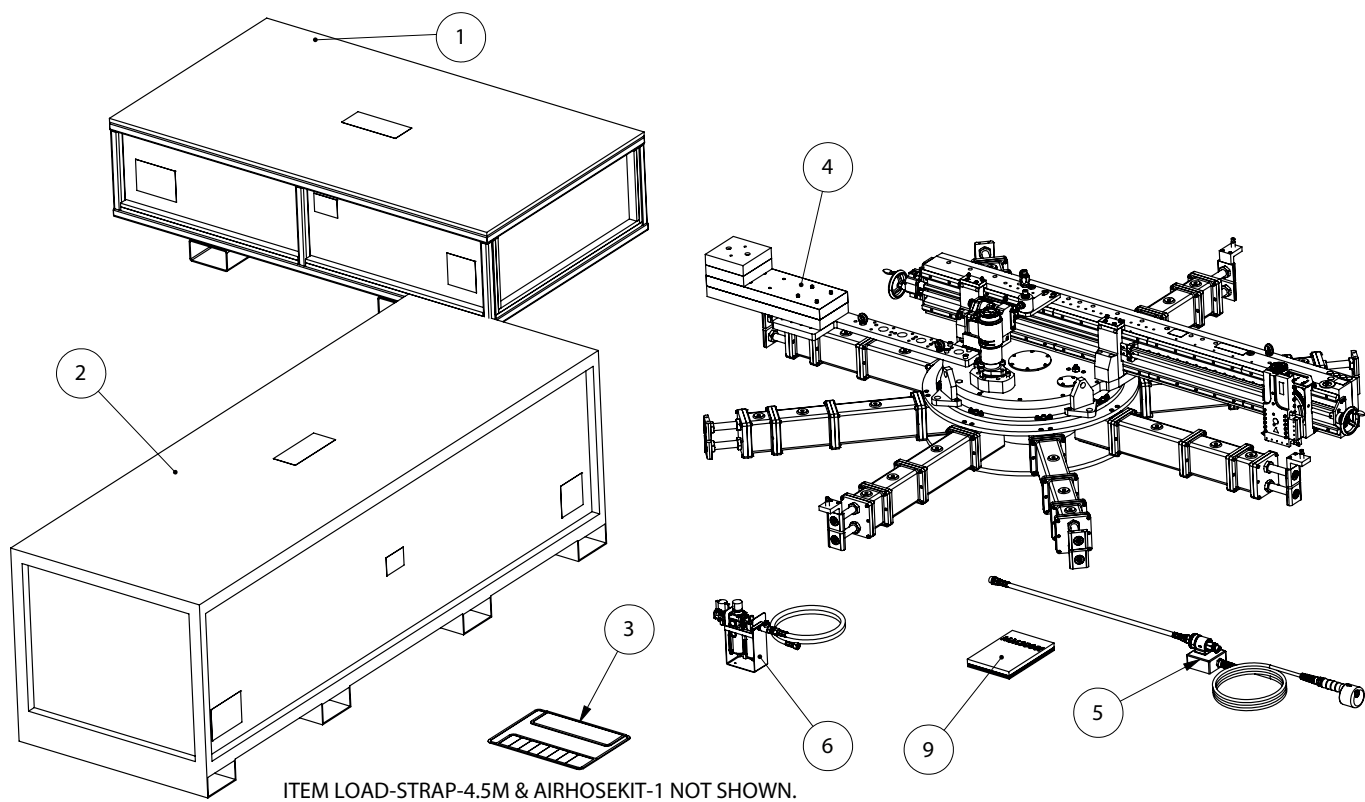


Figure 49: Slide gears

16. Re-assembly is the reverse of the above.

9. Parts List

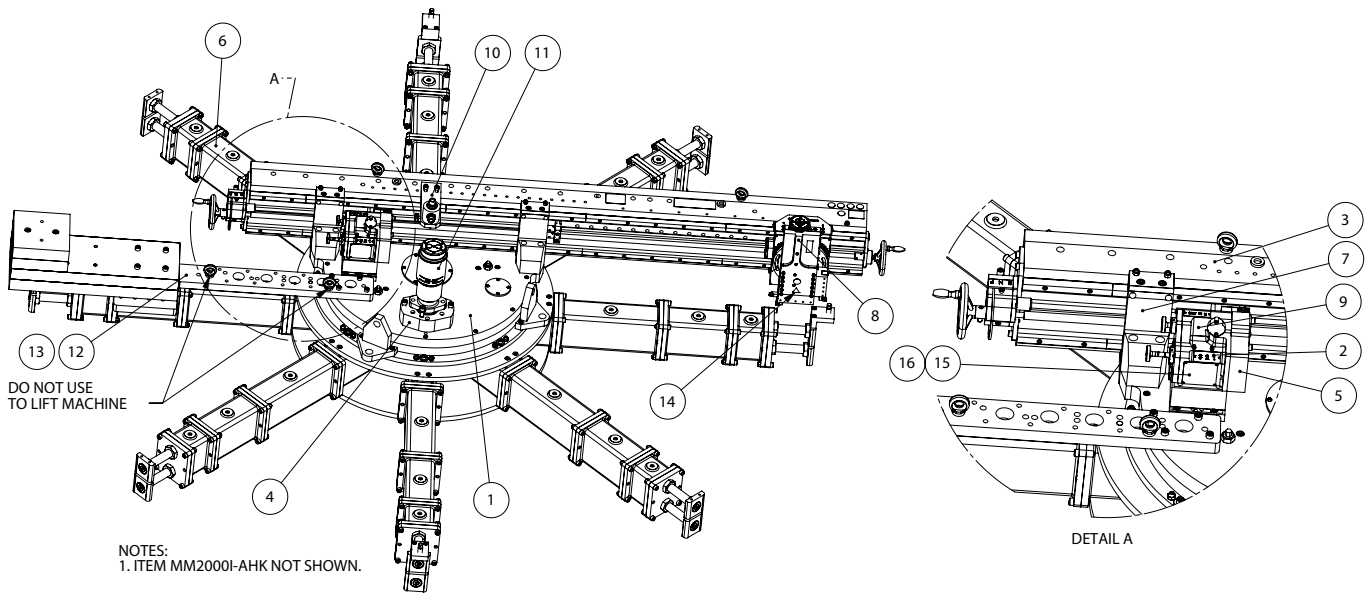
9.1 MM3000i Pneumatic Assembly (MM3000i, Revision B) Views



9.2 MM3000i Pneumatic Assembly (MM3000i, Revision B) Table of Parts

Item Number	Part Number	Description	QTY
1	MM3000i-12-013	MM3000i BOX FRAME	1
2	MM3000i-12-030	Machine and Arm Transportation Box	1
3	MM3000i-TK	MM3000i TOOLKIT	1
4	MM3000i-P-M	FLANGE FACING (PNEUMATIC) MACHINE	1
5	DMH-PNEUMATIC	PNEUMATIC DEAD MANS HANDLE	1
6	LARGE-ALK	LARGE FILTER LUBRICATOR KIT	1
7	LOAD-STRAP-4.5M	4.5M MACHINE LOAD STRAP	3
8	AIRHOSEKIT-1	RUBBER PNEUMATIC HOSE	1
9	DOC-MM3000i	Document Pack for MM3000i	1

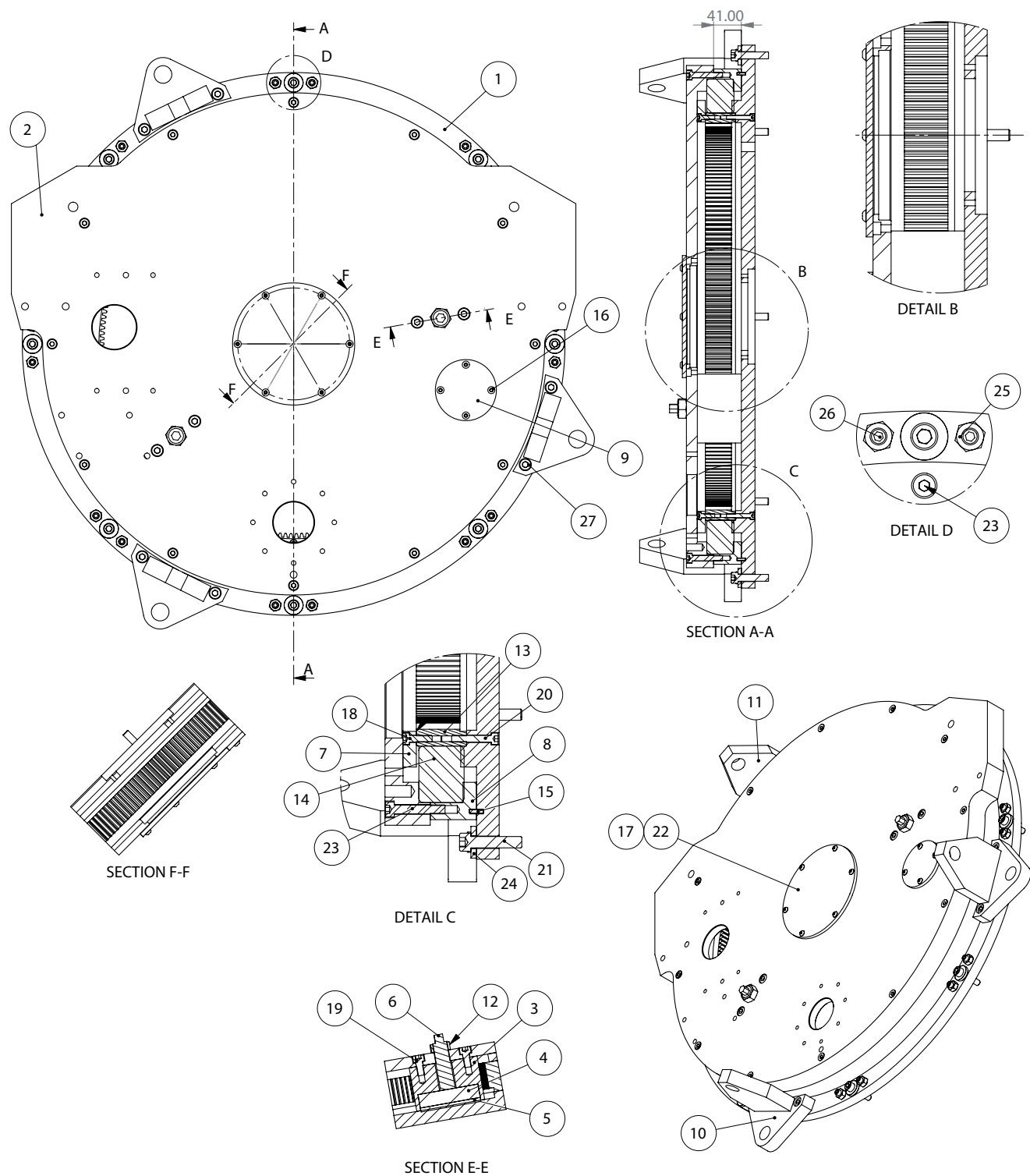
9.3 Flange Facing Pneumatic Machine (MM3000i-P-M, Revision A) Views



9.4 Flange Facing Pneumatic Machine (MM3000i-P-M, Revision A) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI3000-1	Drive Ring	1
2	MMI3000-3	GEARBOX SUPPORT UNIT	1
3	MMI3000-4	2.2 METRE FACING ARM	1
4	MMI3000-5	drive gear unit - turning	1
5	MMI3000-6	TRANSFER BULKHEAD	1
6	MM3000i-12	BASE ASSEMBLY	1
7	MM600IE-15	ARM GUIDE SUPPORT UNIT	2
8	MM1080IE-2	TOOLPOST ASSEMBLY	1
9	MM1080IE-33	3 SPEED GEARBOX	1
10	MM1080IE-39	Air distributor assembly	1
11	MT30LT0145HCL4F	AIR MOTOR	1
12	MM3000i-39	COUNTER WEIGHT ASSLY	1
13	MMI3000-1-012	balance plate	2
14	LABEL-PACK-6	Label Pack for MM2000i & MM3000i	1
15	MM2000i-29-001	3 SPEED GEARBOX LEGEND	1
16	No 2 x 3/16"	HAMMER DRIVE SCREW	4
17	MM2000I-AHK	HOSE KIT CONNECTING DISTRIBUTOR TO DRIVE MOTOR	1

9.5 MMI3000i Drive Ring (MM3000i-1, Revision N) Views

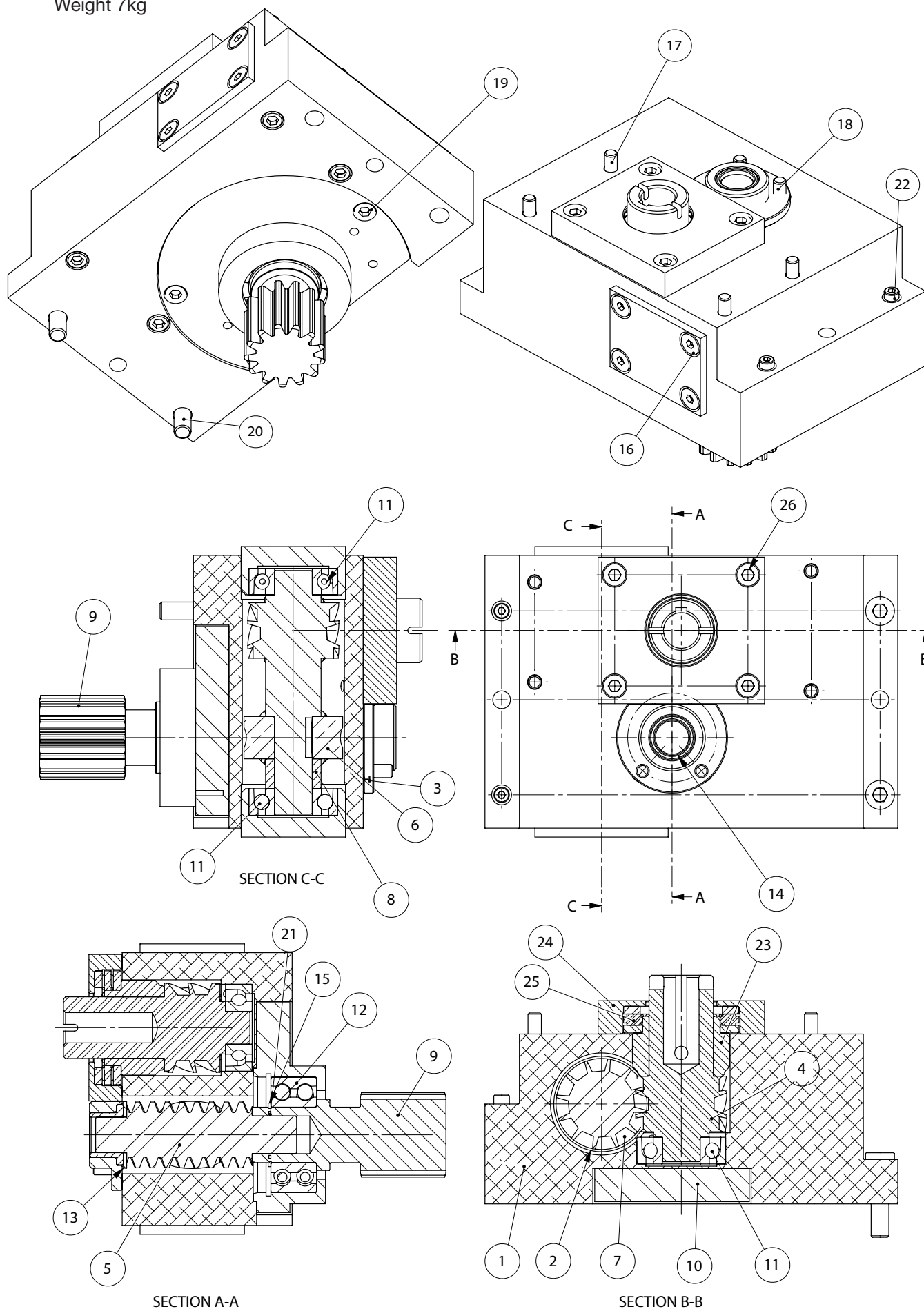


9.6 MMI3000i Drive Ring (MM3000i-1, Revision N) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI3000-1-001	BASEPLATE	1
2	MMI3000-1-002	TURNTABLE	1
3	MMI3000-1-008	damper housing	2
4	MMI3000-1-009	damper washer	2
5	MMI3000-1-010	TUFNOL FRICTION PAD	2
6	MMI3000-1-011	ram bolt	2
7	MMI3000-1-014	BEARING TRAPPING RING	1
8	MMI3000-1-015	BEARING OUTER MOUNTING RING	1
9	MMI3000-1-016	blanking plate	1
10	MMIE601104	VERTICAL LIFT BRACKET	3
11	MMIE601105	HORIZONTAL LIFT BRACKET	3
12	OD 0172	locknut	2
13	MMI260102	222T INTERNAL GEAR	1
14	CRB 60040UUE08	cross roller bearing	1
15	coil 3.18mm x 12.7	natural 66 nylon strip	1
16	M6 X 20	Hex Socket Button Head	4
17	M6 x 20	Hex Socket Button Head - BS EN ISO 7380	6
18	M6 x 20	Hex Socket Head - BS EN ISO 4762	24
19	M10 x 20	Hex Socket Head	4
20	M6 x 35	Hex Socket Head - BS EN ISO 4762	24
21	M10 x 45	socket head cap screw	8
22	MMI3000-1-018	BLANKING PLATE	1
23	M8 x 45	Hex Socket Head - BS EN ISO 4762	12
24	MMI3000-1-007	Heavy Duty M10 washer	8
25	M10	Hex Nut Style 1 - BS EN 24331	16
26	GN. 13984	M10 x 32 BTSS Grub Screw	16
27	M10 x 30	Hex Socket Head 12.9 High Tensile	12

9.7 Gearbox Support Unit (MMI3000-3, Revision F) Views

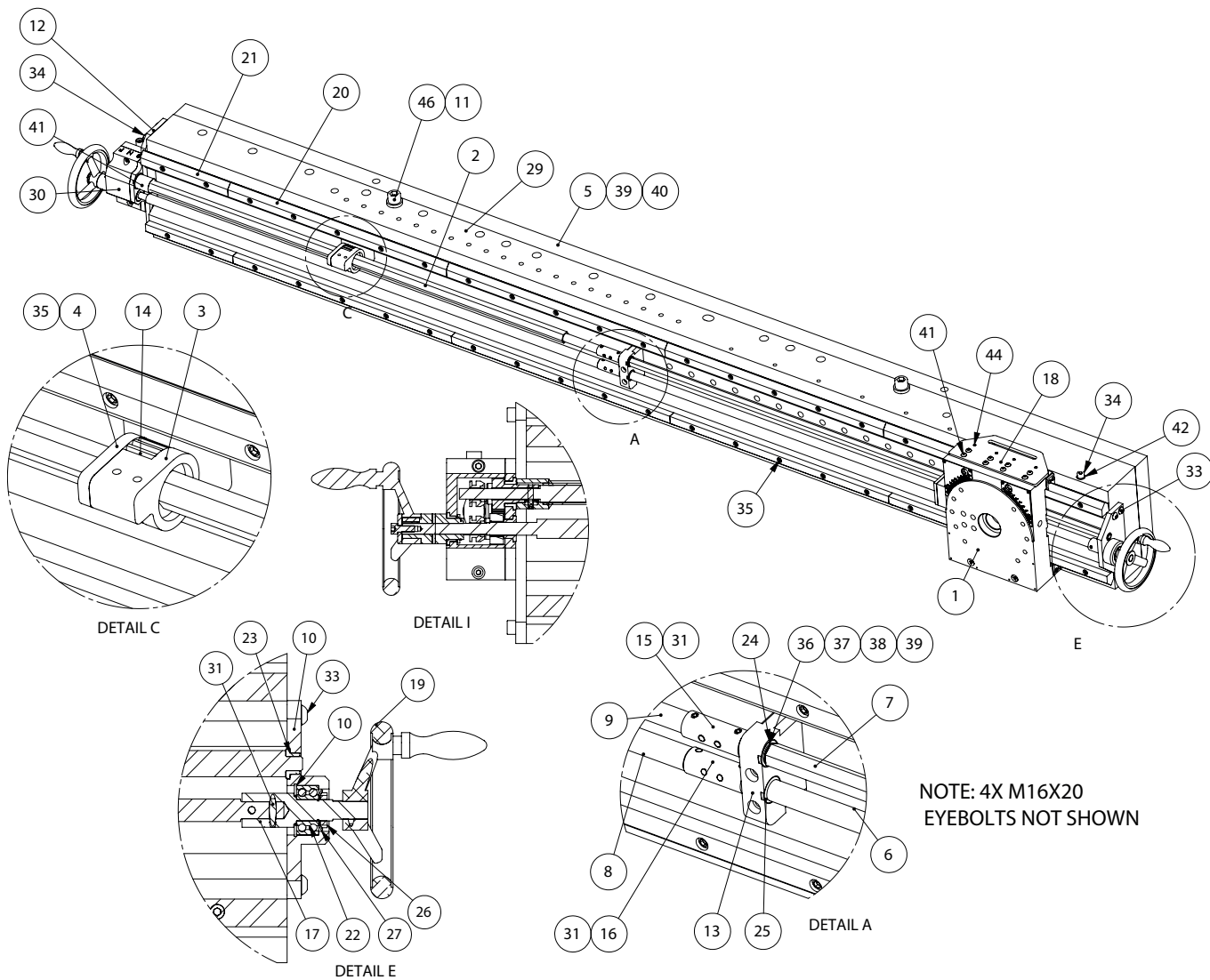
Weight 7kg



9.8 Gearbox Support Unit (MMI3000-3, Revision F) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI3000-3-001	GEARBOX TRANSFER BOX	1
2	MMI3000-3-002	bearing cap	2
3	MMI3000-3-003	WORM SUPPORT	1
4	MMI3000-3-004	10T 10DP CROSS HELICAL GEAR R.H.	1
5	MMIE 6506	1 START 12 DP FEED WORM R.H.	1
6	MMIE 6507	1 start 18T 12 dp wormwheel R.H.	1
7	MMIE 6509	10T 10 DP CROSS HELICAL GEAR R.H	1
8	MMIE 6511	SPACER	1
9	MMIE 6515	13T PICK UP GEAR	1
10	MMIE 6518	13T PICK UP GEAR SUPPORT CAP	1
11	7203	single row ang con brg	3
12	3205 2RS	double row ang con brg	1
13	WC14DU	DU thrust washer	1
14	AMF162015	flanged oilite bush	1
15	D1400 0250	External Circlip	1
16	M6 X 12	Hex Socket CTSK Head	8
17	M6 x 80	socket head cap screw	4
18	M6 X 10	Hex Socket Button Head	2
19	M6 x 20	Hex Socket Head	3
20	M8 x 30	Hex Socket Head	2
21	D1300 0520	External Circlip	1
22	M4 x 30	SOCKET HEAD CAP SCREW	2
23	MMI3000-3-007	SPACER BOSS	1
24	MMI3000-3-008	BEARING HOUSING	1
25	81107 TN	CYLINDRICAL ROLLER THRUST BEARING	1
26	M6 x 16	Hex Socket Head - BS EN ISO 4762	4

9.9 2.2m Facing Arm (MMI3000-4, Revision K) Views



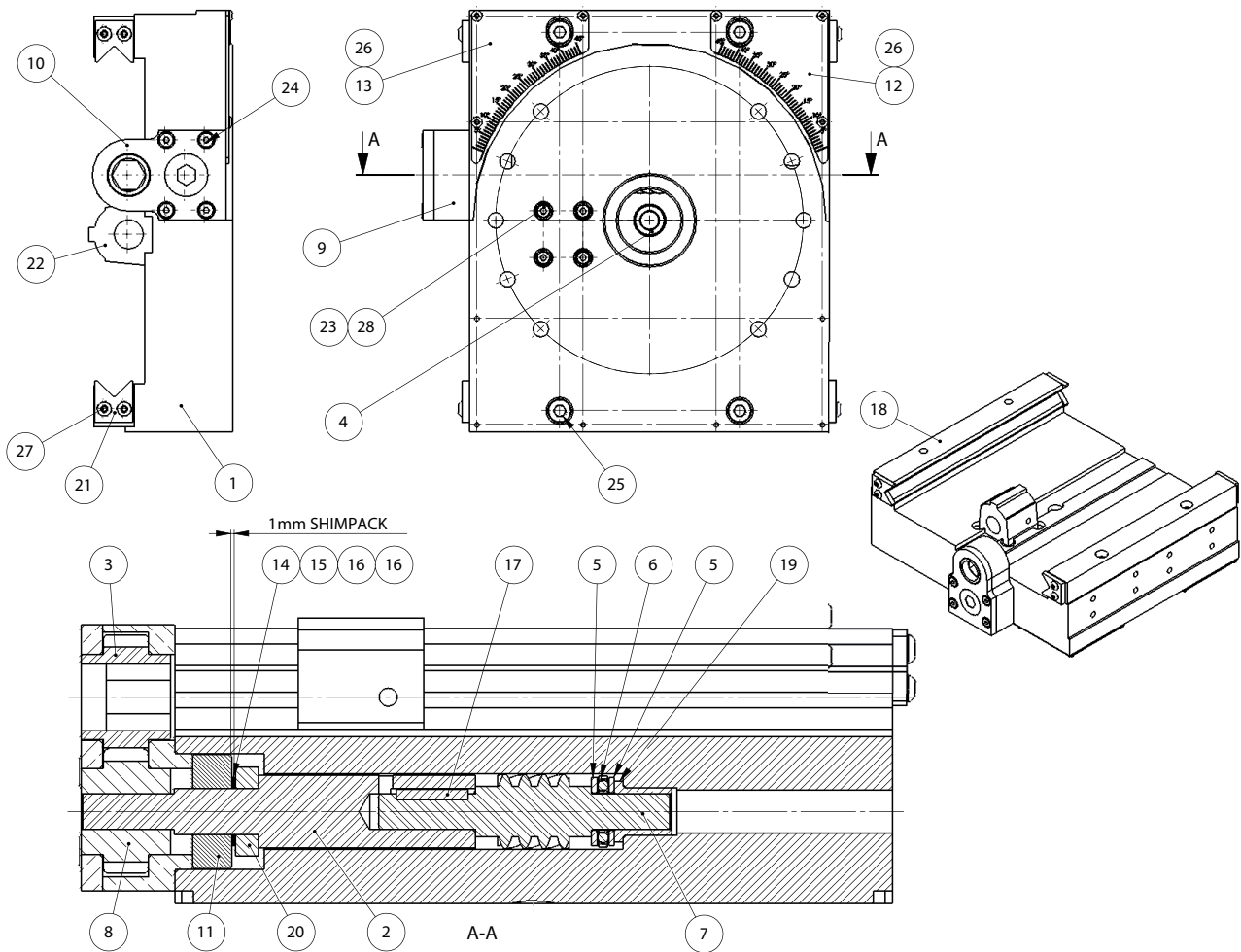
9.10 2.2m Facing Arm (MMI3000-4, Revision K)Table of Parts

Item	Part Number	Description	QTY
1	MM600IE-3	POWER CARRIAGE	1
2	MMI3000-4-001	COUPLING SHAFT	1
3	MMI3000-4-002	20t GEAR SADDLE	1
4	MMI3000-4-003	20t GEAR SADDLE LID	1
5	MM10801502	FACING ARM BACKPLATE	1
6	MM10801503	LEADSCREW	1
7	MM10801504	HEX DRIVE SHAFT	1
8	MM10801505	LEADSCREW EXTENSION	1
9	MM10801506	HEX DRIVE EXTENSION	1
10	WP4300-3004	THRUST CAP	1
11	WP4300-3010	ARM BOLT WASHER	2
12	MMIE 6348	ARM END PLATE	1
13	MMIE 6343	BULKHEAD	1
14	MMIE 6628	20t 12DP PICK UP GEAR	1
15	MMI 4340	BULKHEAD COUPLING	1
16	MMI 4341	BULKHEAD COUPLING	1
17	MMI 4343	LEADSCREW ADAPTOR THRUST END	1
18	MMIE 6350	BORING PLATE	1
19	OM 0309	leadscrew handwheel	1
20	LWRPV90500	SKF RAIL 500 LONG	8
21	LWRV90200	SKF RAIL 200 LONG	2
22	3202 2rs	double row ang con brg	1
23	AMF101510	flanged oilite bush	1
24	AMF101520	flanged oilite bush	1
25	AMF121520	flanged oilite bush	1
26	KM2	locknut	1
27	MB2	lockwasher	1

Item	Part Number	Description	QTY
28	M16COL- LARED-EYE- BOLT	EYEBOLT	4
29	MM10801501	2.2 Metre facing arm	1
30	MM1080IE-13	SELECTOR UNIT	1
31	MM1080i-2-008	COUPLING PIN	10
32	CCZ517028-1A	M5X12 GR12-9 SOCKET HEAD CAP SCREW	2
33	CBE823028-1E	M8X25 GR10-9 BUTTON HEAD CAP SCREW	4
34	CCZ823028-1A	M8X25 GR12-9 SOCKET HEAD CAP SCREW	5
35	MMI8388A	MODIFIED M8 BUTTON HEAD SCREW	44
36	CPS10x16x1	PRECISION SHIM	1
37	CPS10x16x0.5	PRECISION SHIM	1
38	CPS10x16x0.2	PRECISION SHIM	2
39	CPS10x16x0.1	PRECISION SHIM	1
40	D1300-0350	INTERNAL CIRCLIP	1
41	CBE617028-1E	M6X12 GR10-9 BUTTON HEAD CAP SCREW	8
42	M8-WASHER	M8 FLAT WASHER	1
43	M5X0.8X20 CUGS14-9	M5X20 GR14-9 SET SCREW, CUP COARSE	1
44	CZZ621028-5A	M6X20 GR14-9 SET SCREW, FLAT COARSE	4
45	M5X- 0.8X6CPGS14-9	M5X6 GR14-9 SET SCREW, CONE COARSE	1
46	M16X2X- 280SHCS12-9	M16X280 GR12-9 SOCKET HEAD CAP SCREW	2
47	CCZ1035028-1A	M10X55 GR12-9 SOCKET HEAD CAP SCREW	22

9.11 MM2000i/MM2000i-H Power Carriage (MM600IE-3, Revision J) Views

Weight 9kg



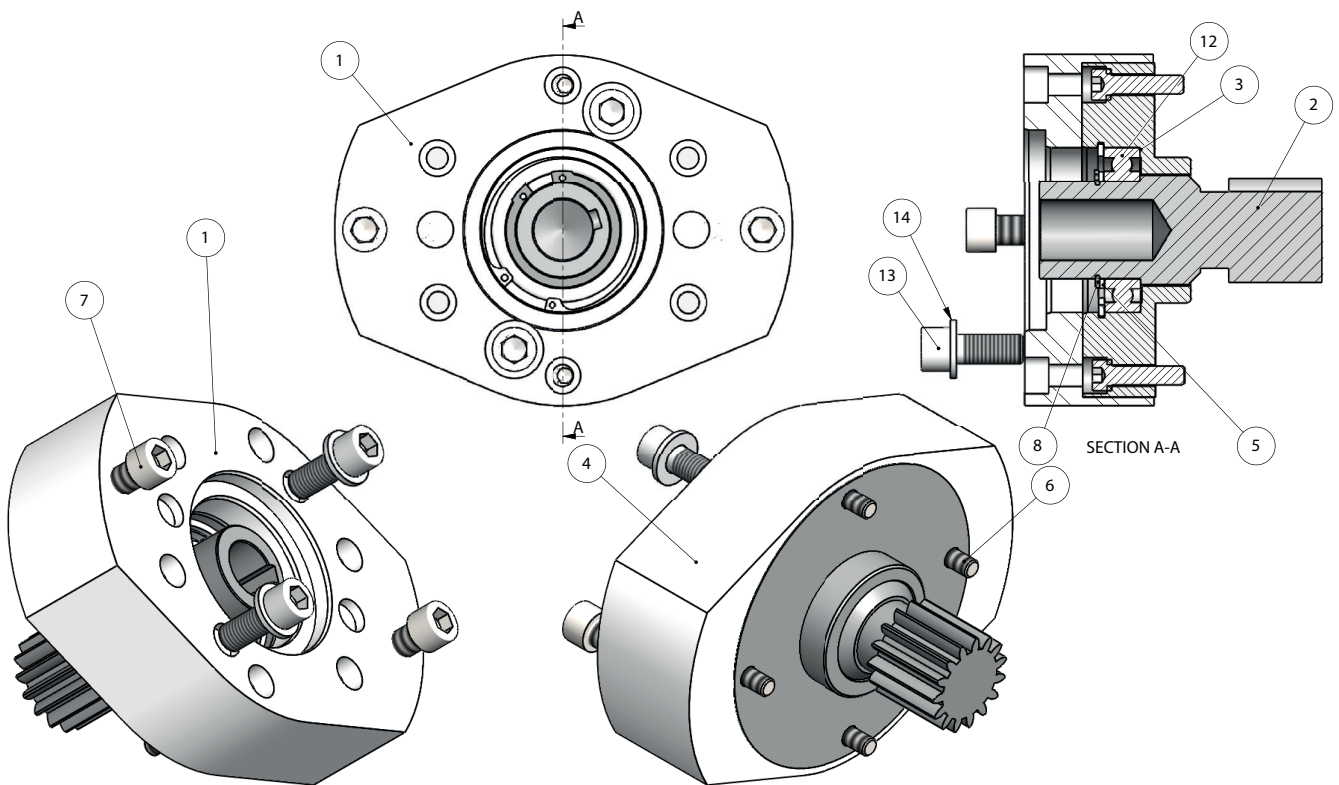
9.12 MM2000i/MM2000i-H Power Carriage (MM600IE-3, Revision J) Table of Parts

Item No.	Part Number	Description	QTY
1	MMIE 6340	CARRIAGE	1
2	MMIE 6342	PTO TRANSFER SHAFT	1
3	MMI 8306	20t PICK UP GEAR	1
4	MMI 8393 G	OILITE BUSH	1
5	MMI 8395 A	THRUST WASHER	2
6	MMI 8395B	Thrust bearing	1
7	MMI 30317	10T HELICAL GEAR TRANSFER SHAFT	1
8	MMI 30319	20t 16DP GEAR	1
9	MMI 30323	PTO GEARBOX CASE	1
10	MMI 30324	PTO GEARBOX CASE LID	1
11	MMI 30344	BEARING PRELOAD SPACER	1
12	MM600IE-3-001	R/H ANGLE LABEL	1
13	MM600IE-3-002	L/H ANGLE LABEL	1
14	CPS13x19x0.5	PRECISION SHIM	1

Item No.	Part Number	Description	QTY
15	CPS13x19x0.3	PRECISION SHIM	1
16	CPS13x19x0.1	PRECISION SHIM	2
17	KK3-20A	TYPE A KEY	1
18	MM600IE-3-003	'M' RAIL GUIDE	2
19	AMF101316	Flanged Oilite Bush	1
20	FT 1/2	THRUST BEARING	1
21	LWEARM9	WIPER	4
22	503-165-373-14	ballscrew nut	1
23	M4-BOLTRETAINER	M4 Bolt Retaining Washer	4
24	M5 x 30	Hex Socket Low Head	4
25	M8 x 60	Hex Socket Head	4
26	M3 x 6	Hex Socket Button Head	6
27	M4 x 10	Hex Socket Button Head - BS EN ISO 7380	8
28	M4 x 25	Hex Socket Head - BS EN ISO 4762	4

9.13 Drive Gear Unit - Turning (MMI3000-5, Revision D) Views

Weight 9kg

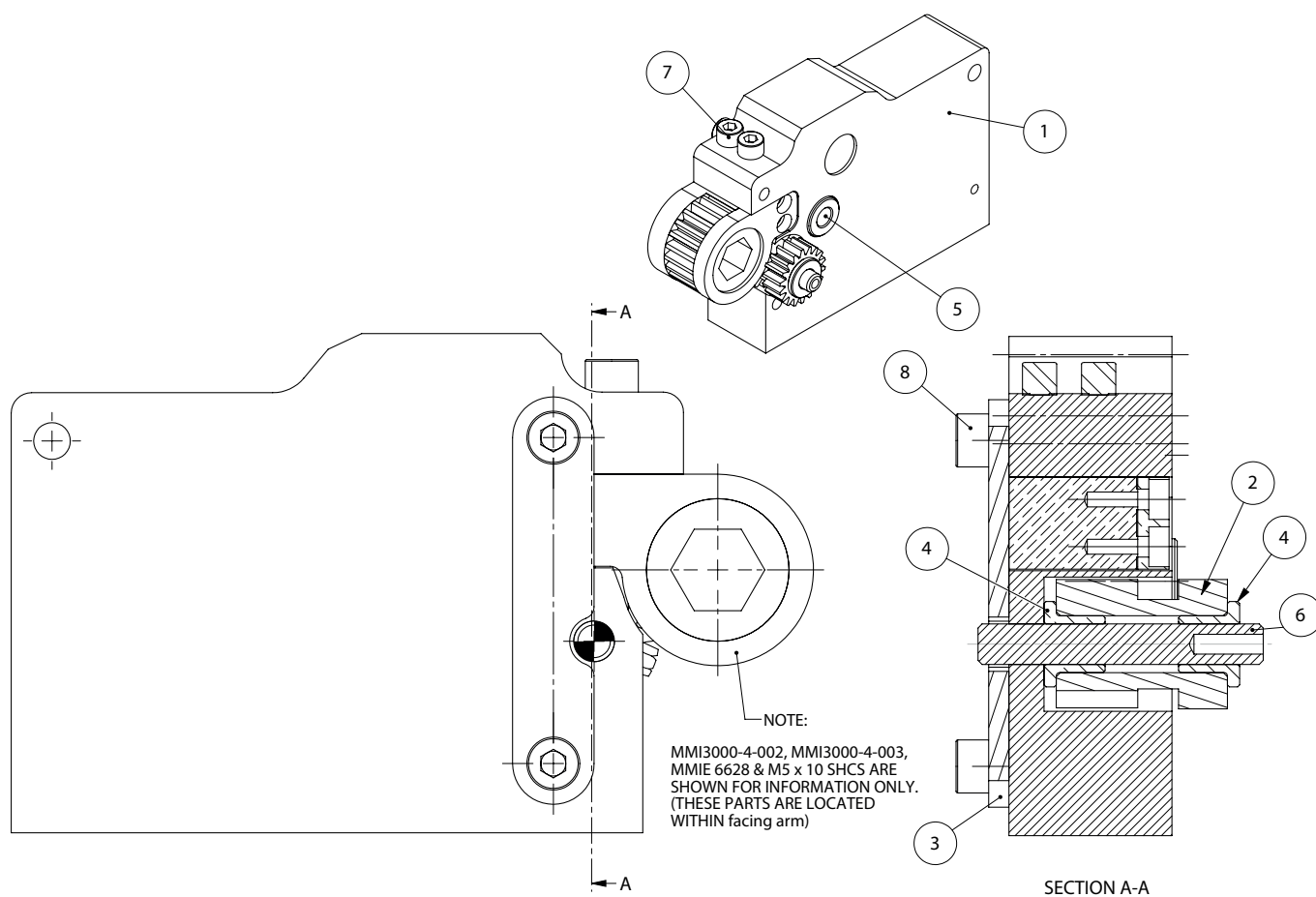


9.14 Drive Gear Unit - Turning (MMI3000-5, Revision D) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI3000-5-002	QR turning flange	1
2	MMI3000-5-003	15 tooth drive gear	1
3	MMI3000-5-004	15t Gear Housing	1
4	MMI3000-5-005	Motor mount housing	1
5	MMIE601304	WASHER	1
6	M8 x 30	Hex Socket Head	4
7	M12 x 35	Hex Socket Head	2
8	D1400 0400	EXTERNAL CIRCLIP	1
9	D1300 0680	INTERNAL CIRCLIP	1
10	OMP160	151-0314	1
11	OMP 250	151-0316	1
12	6008-2RS	Deep Groove Ball Bearing - 40 x 68 x 15mm	1
13	M12 x 30	Hex Socket Head - BS EN ISO 4762	2
14	Bright washer BS 4320 - M12	WASHER (FORM A)	2

9.15 Transfer Bulkhead (MMI3000-6, Revision E) Views

Weight 2.6kg

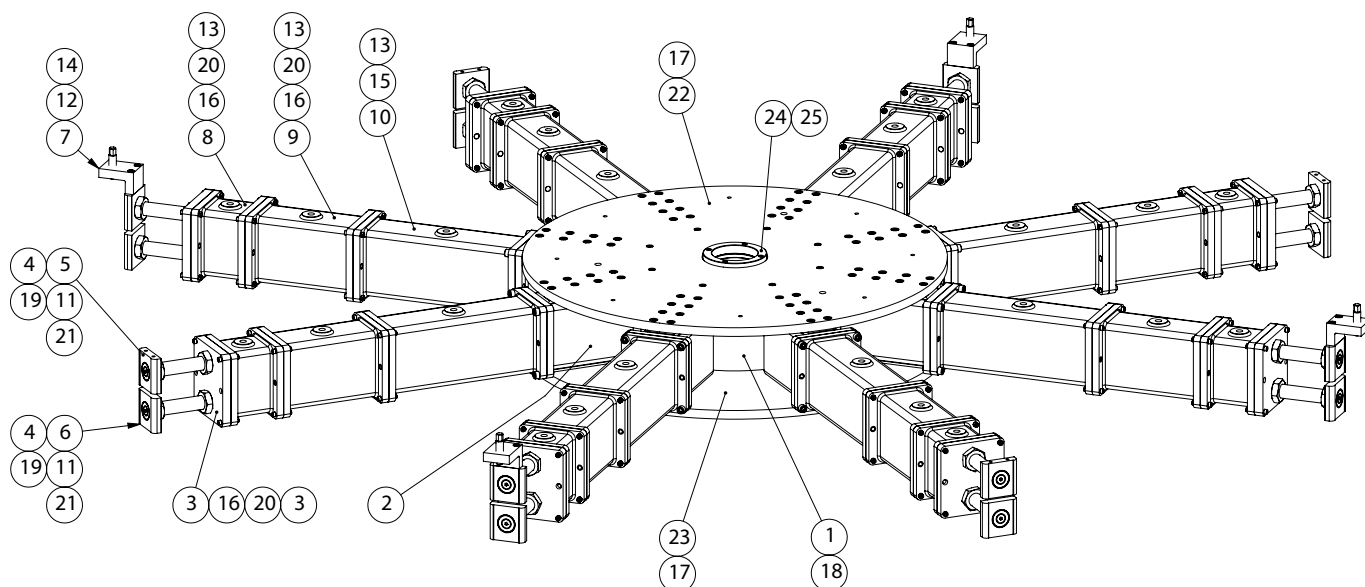


9.16 Transfer Bulkhead (MMI3000-6, Revision E) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI3000-6-001	BULKHEAD	1
2	MMI3000-6-002	18t TO 13t OUTPUT GEAR	1
3	MMI3000-6-003	KEEPER PLATE	1
4	MM860LT-2-007	Flanged Oilite Bush	2
5	AMF101516	Flanged Oilite Bush	1
6	Ø10 X 70	EXTRACTABLE DOWEL	1
7	M8x90	Socket Head Cap Screw	2
8	M8x20	Hex Socket Head - BS EN ISO 4762	2

9.17 Base Assembly (MM3000i-12, Revision J) Views

Weight 682kg



CLAMPING DIAMETERS				
MIN	MAX	MM2000i-5-009 125mm EXTENSION	MM2000i-5-010 250mm EXTENSION	MM2000i-5-011 375mm EXTENSION
44"	54"	-	-	-
54"	64"	✓	-	-
64"	74"	-	✓	-
74"	84"	-	-	✓
84"	94"	✓	-	✓
94"	104"	-	✓	✓
104"	110"	✓	✓	✓

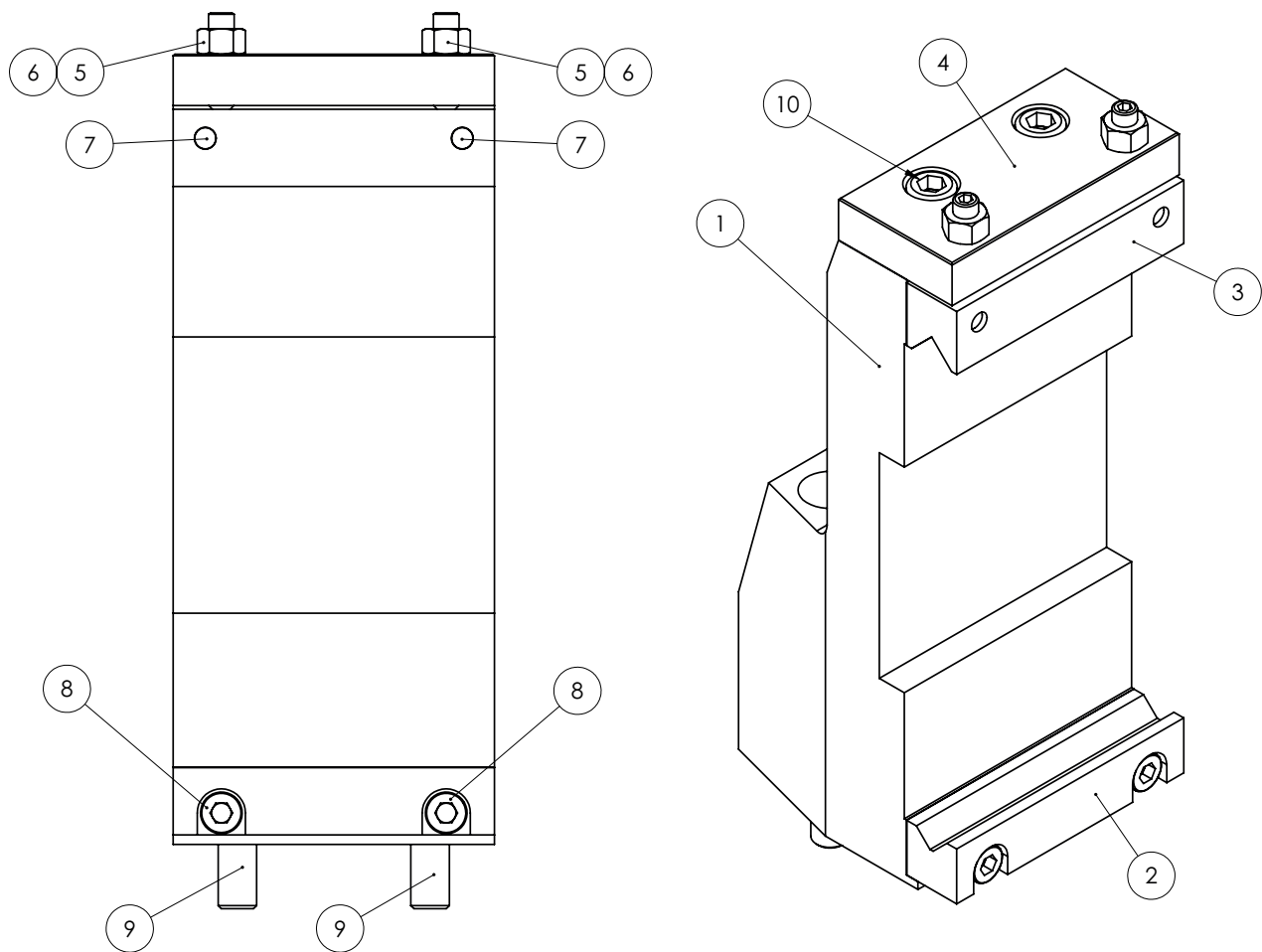
9.18 Base Assembly (MM3000i-12, Revision J) Table of Parts

Item No.	Part Number	Description	QTY
1	MM3000i-12-016	SPACER SUPPORT TUBE	1
2	MM3000i-12-017	BASE SPACER BLOCK	8
3	MM2000i-5-004	FOOT PLATE	8
4	MM2000i-5-005	FOOT SCREW	16
5	MM2000i-5-006	FOOT PAD	8
6	MM2000i-5-007	FOOT PAD	8
7	MM2000i-5-008	SETTING STRAP	4
8	MM2000i-5-009	125 EXTENSION	8
9	MM2000i-5-010	250 EXTENSION	8
10	MM2000i-5-011	375 EXTENSION	8
11	MM2000i-5-012	FOOT WASHER	16
12	MM2000i-5-014	JACKING SCREW	4
13	MM2000i-5-015	LOCATION PIN	64
14	M8 x 60	Hex Socket Head	8

Item No.	Part Number	Description	QTY
15	M10X35SHCSA2SS	Hex Socket Head - BS EN ISO4762	32
16	M6 x 10	Hex Socket Head - BS EN ISO4762	96
17	M10 x 25	Hex Socket Head	128
18	M8 x 25	Hex Socket Head	16
19	M10 x 25	Hex Socket CTSK Head - BS EN ISO 10642	16
20	M6 NUT	Hex Nut Style 1	96
21	M30 HALF NUT	Hex Thin Nut	16
22	SRB3000-H-6-001	TOP PLATE	1
23	SRB3000-H-6-002	BOTTOM PLATE	1
24	SRB3000-H-6-004	LOCATING RING	1
25	M6 x 25	Hex Socket Head - BS EN ISO 4762	4

9.19 Arm Guide Support Unit (MM600IE-15, Revision E) Views

Weight 5kg

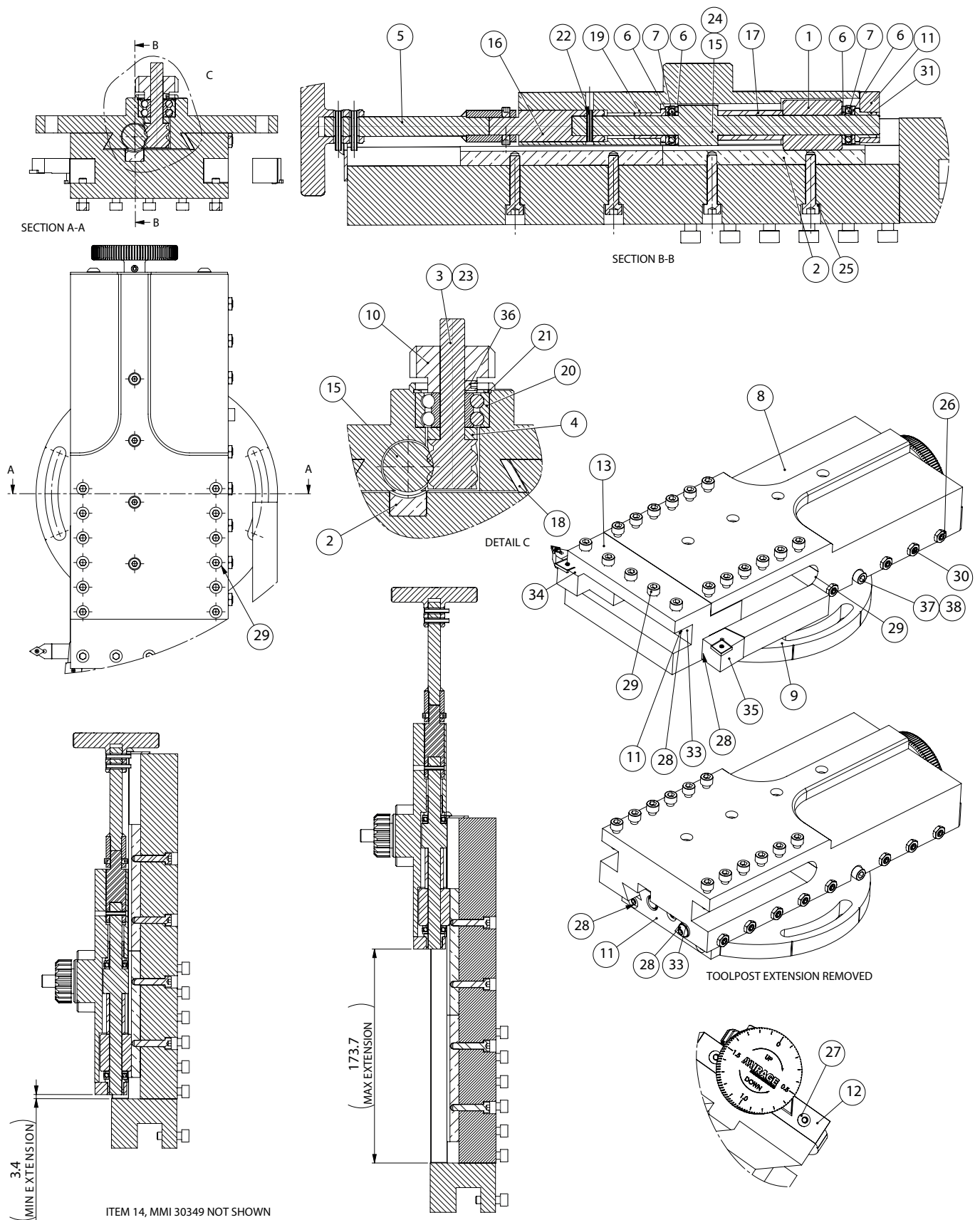


9.20 Arm Guide Support Unit (MM600IE-15, Revision E) Table of Parts

Item Number	Part Number	Description	QTY
1	MMIE601501	GUIDE BLOCK	1
2	MMIE601502	MODIFIED LWRPM9 RAIL	1
3	MMIE601503	MODIFIED LWRPM9 RAIL	1
4	MMIE601504	CLAMP PLATE	1
5	M8	Hex Nut Grade C	2
6	M8x30	Flat Point Grub Screw	2
7	M8 x 30	Hex Socket Head	2
8	M8 x 25	Hex Socket Head	2
9	M12 x 70	Hex Socket Head - BS EN ISO 4762	2
10	M10 x 25	Hex Socket Head - BS EN ISO 4762	2

9.21 Toolpost assembly (MM1080IE-2, Revision K) Views

Weight 18.2kg

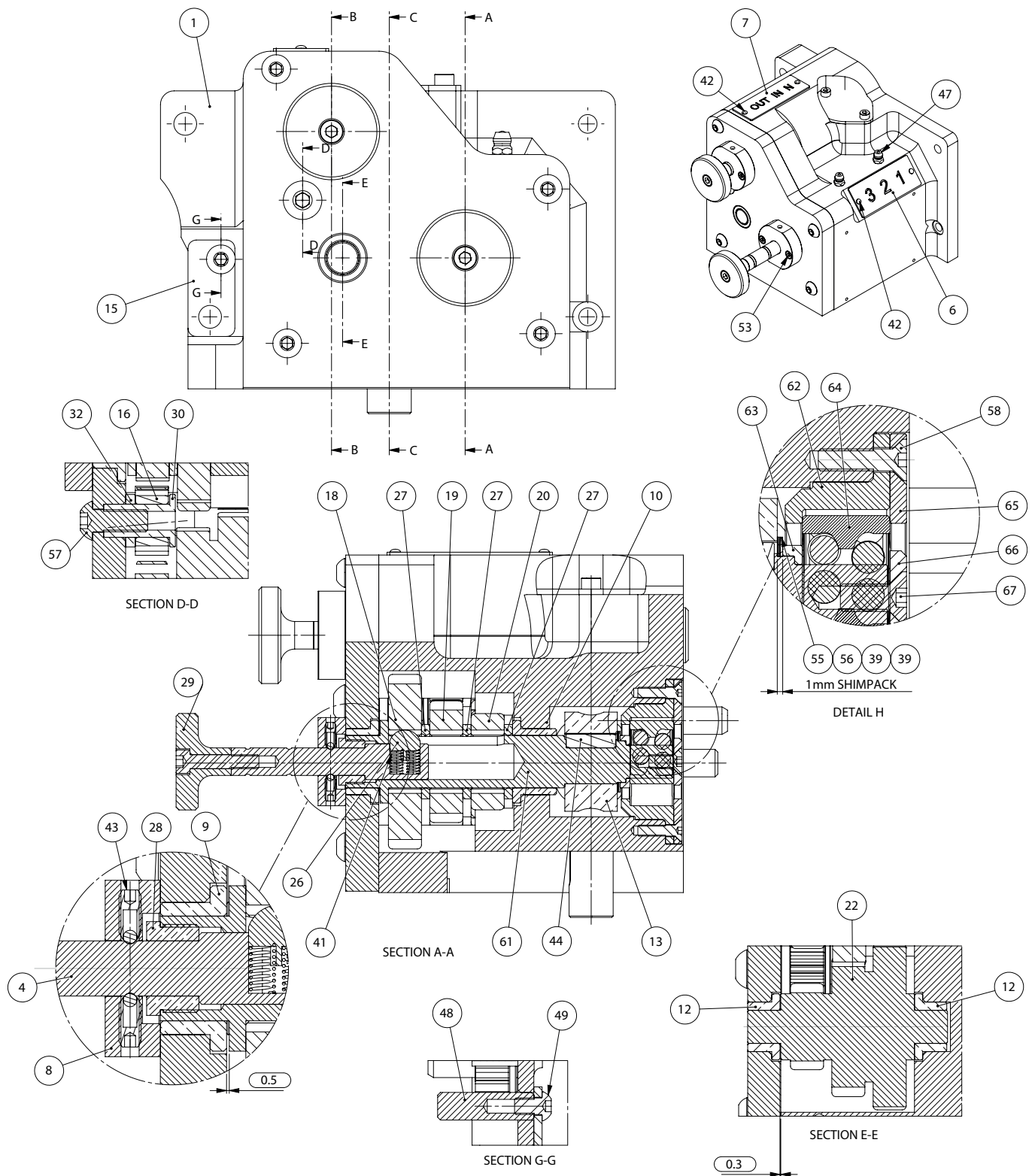


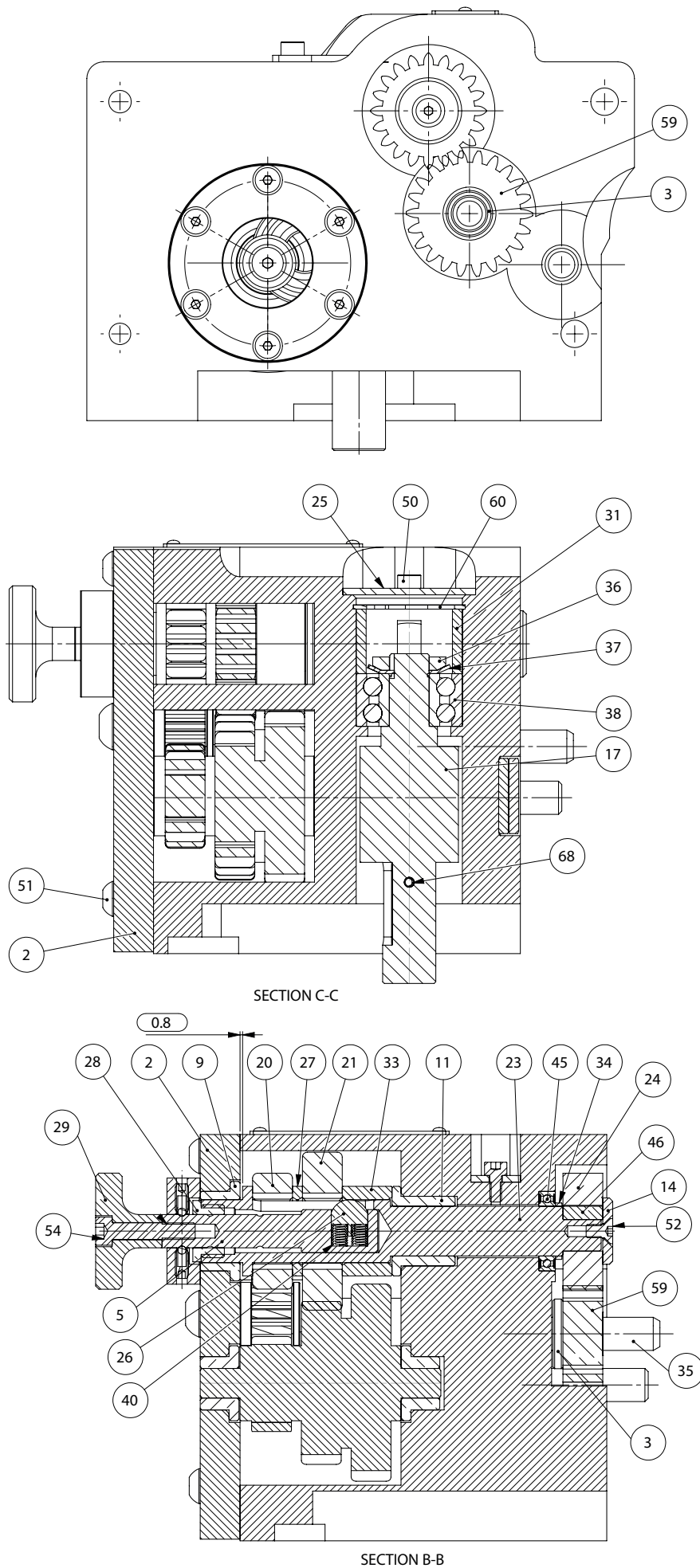
9.22 Toolpost assembly (MM1080IE-2, Revision K) Table of Parts

Item Number	Part Number	Description	QTY
1	MMI 8312	TOOLPOST FEED SCREW	1
2	MMI 8317	RACK	2
3	MMI 8335	10t GEAR ON SHAFT	1
4	MMI 8352	GEAR SPACER	1
5	MMI 8383	toolholder & handwheel assembly	1
6	MMI 8395 A	THRUST WASHER	4
7	MMI 8395B	thrust bearing	2
8	MMI 30314	TOOLPOST	1
9	MMI 30315	TOOLPOST SWIVEL PLATE	1
10	MMI 30318	18t helical gear	1
11	MMI 30321	END PLATE	1
12	MMI 30322	toolpost end plate	1
13	MMI 30348	toolpost extension	1
14	MMI 30349	TOOLPOST SIDE EXTENSION	1
15	MMI 30350	10t HELICAL GEAR TOOLPOST FEED	1
16	MMI 30351	10t HELICAL GEAR DRIVE SHAFT	1
17	MMI 30353	spacer	1
18	MMI 30354	GIB STRIP	1
19	AMF101316	FLANGED BUSH	1
20	3200-2RS	double row ang con brg	1
21	D1300 0300	INTERNAL CIRCLIP	1
22	Ø3 x 16	Spring Pin (Slotted - HD)	1
23	KK3-15A	TYPE A KEY	1
24	KK3-30A	TYPE A KEY	1
25	M5 x 25	Hex Socket Head St St	4
26	M6	THIN NUT	8
27	M6 X 10	Hex Socket Button Head	2
28	M6 x 12	Hex Socket Button Head - BS EN ISO 7380	4
29	M6 x 20	Hex Socket Head - BS EN ISO 4762	22
30	M6 x 35	Socket Set Screw Cone Point	8
31	AMF 101310	OILITE BUSH	1
34	IND-106-2010K	PCLNL 2020K12 (LH)	1
35	IND-106-2000K	PCLNR 2020K12 (RH)	1
36	M4 x 5	Socket Set Screw Flat Point - BS 4168-2	1
37	34020.W0064	THRUST SCREW HEADED M6x30.8	1
38	LCM065D 11 M	COMPRESSION SPRING, OD 7.49 WIRE DIA 0.66, ZP	1

9.23 3 Speed Gearbox (MM1080IE-33, revision E) Views

Weight 5kg





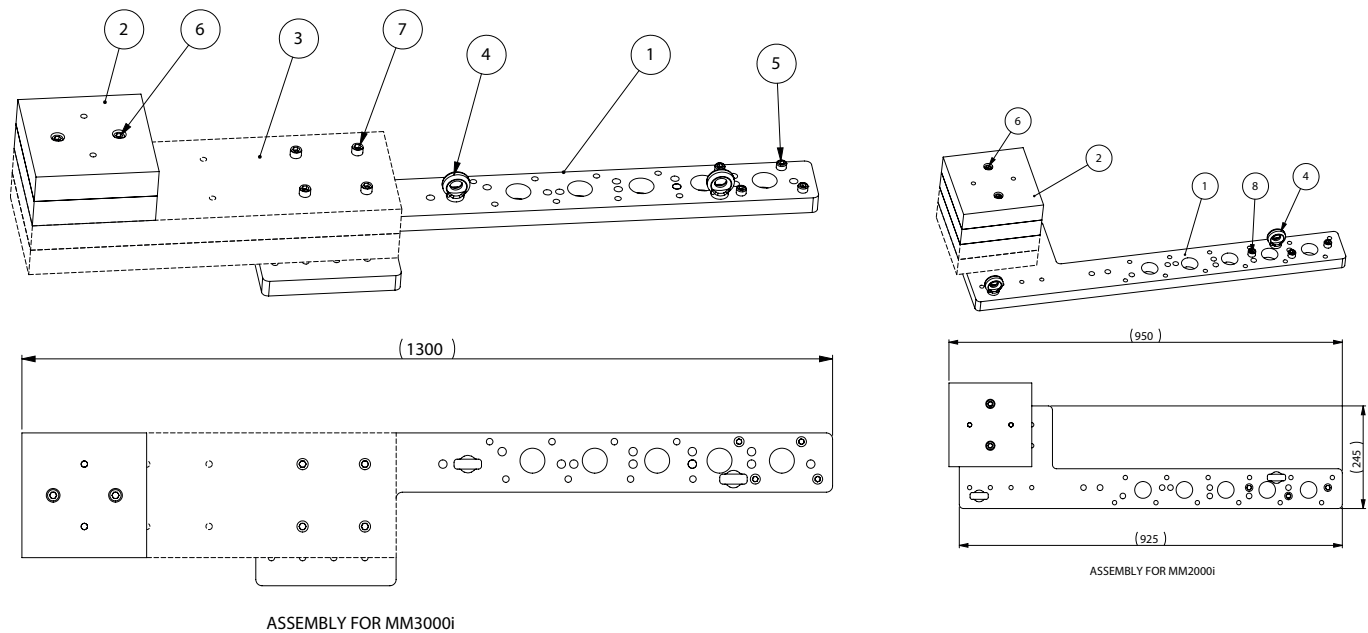
9.24 3 Speed Gearbox (MM1080IE-33, revision E) Table of Parts

Item	Part Number	Description	QTY
1	MM860LT-2-002	GEARBOX HOUSING	1
2	MM860LT-2-004	GEARBOX LID	1
3	MM860LT-2-007	Flanged Oilite Bush	1
4	MM860LT-2-008	SELECTOR SHAFT	1
5	MM860LT-2-010	SELECTOR SHAFT	1
6	MM860LT-2-013	LABEL - SPEED	1
7	MM860LT-2-015	LABEL - DIRECTION - MM3000i	1
8	MM860LT-2-016	RR CLIP HOUSING	2
9	MM860LT-2-017	OILITE BUSH	2
10	MM860LT-2-018	OILITE BUSH	1
11	MM860LT-2-019	OILITE BUSH	1
12	MM860LT-2-020	OILITE BUSH	2
13	MM860LT-2-022	14t 12 DP WORMWHEEL	1
14	MM860LT-2-023	CAPTIVE WASHER	1
15	MM860LT-2-024	KEEPER PLATE	1
16	MMI 2209	14T IDLER GEAR	1
17	MMI 7614	1 START 12 DP WORM	1
18	MMI 7616	38t 16 DP GEAR	1
19	MMI 7617	26t 16 DP GEAR	1
20	MMI 7618	20t 16 DP GEAR	2
21	MMI 7619	28t 16 DP GEAR	1
22	MMI 7620	36t 30t 18t 16 DP GEAR STACK	1
23	MMI 7623	FR SHAFT	1
24	MMI 7625	20t 16 DP OUTPUT GEAR	1
25	MMI 7627	BEARING COVER	1
26	MMI 7632	SELECTOR KEY	2
27	MMI 7634	GEAR SPACER	4
28	MMI 7637	SELECTOR END CAP	2
29	MMI 7638	SELECTOR KNOB	2
30	MMI 7639	IDLER POST	1
31	MMI 7654	BEARING TRAPPING RING	1
32	MMI 7657	IDLER WASHER	1
33	MMI 7680	SELECTOR KEY PARKING SLEEVE	1
34	MMI 7690	GEARBOX SPACER	1
35	MMI 8265	LONG LOCATION DOWEL	1
36	KM1	locknut	1
37	MB1	LOCK WASHER	1
38	3201-2RS	double row ang con brg	1
39	CPS15x22x0.1	PRECISION SHIM	2

Item No.	Part Number	Description	QTY
40	5	Compression Spring	2
41	5	Compression Spring	2
42	No 2 x 3/16"	HAMMER DRIVE SCREW	4
43	3150.W004	SPRING PLUNGER	4
44	KK5-18A	ROUNDED END FEATHER KEY	1
45	61802-2RS	SINGLE ROW DEEP GROOVE BALL BEARING	1
46	KK4-12C	TYPE C KEY	1
47	M6	STRAIGHT GREASE NIPPLE	2
48	Ø10 X 35	EXTRACTABLE DOWEL	1
49	M6 X 10	Hex Socket Button Head	1
50	M4 x 8	Hex Socket Head	2
51	M6 x 25	Hex Socket Button Head - BS EN ISO 380	4
52	M4 x 8	Socket Countersunk Head Screw	1
53	M3 x 12	Hex Socket Head	4
54	M5 x 25	Hex Socket Head St St	2
55	CPS15x22x0.5	PRECISION SHIM	1
56	CPS15x22x0.3	PRECISION SHIM	1
57	M8 x 20	Hex Socket Button Head	1
58	M4 x 16	Hex Socket CTSK Head - BS EN ISO 10642	6
59	MM860LT-2-003	22t 16DP GEAR	1
60	D1300-0320	DIN 472 INTERNAL CIRCLIP	1
61	MM1080IE-33-005	SELECTOR SLEEVE	1
62	MM1080IE-33-001	BEARING HOUSING	1
63	MM1080IE-33-003	END FLOAT SPACER	1
64	3201-2RS	ANGULAR CONTACT BEARING	1
65	MM1080IE-33-002	BEARING CAP	1
66	MM1080IE-33-004	RETAINING WASHER	1
67	M5 x 12	Hex Socket CTSK Head	1
68	M3 x 20	Spring Pin	1

9.25 Counter weight Assembly (MM3000i-39, Revision B) Views

Weight 152kg



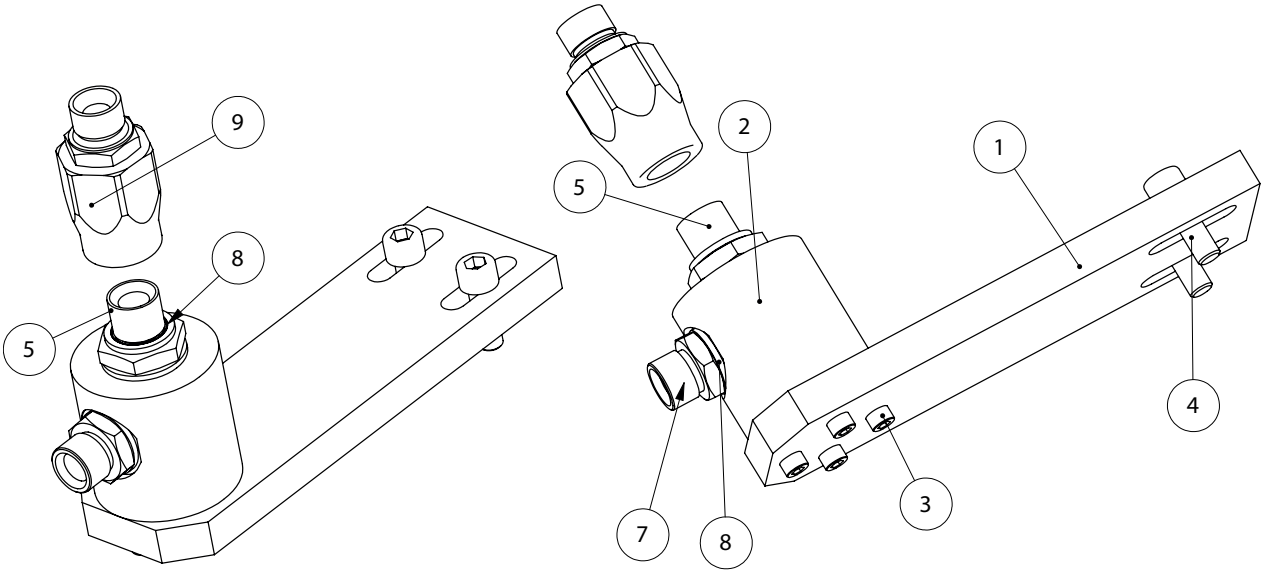
9.26 Counter weight Assembly (MM3000i-39, Revision B) Table of Parts

Item Number	Part Number	Description	MM2000 QTY	MM3000 QTY
1	MM3000i-39-001	BALANCE PLATE	1	1
2	NEG0147	BALANCE WEIGHT	4	2
3	MMI3000-1-012	Balance plate	-	2
4	M16COLLARED-EYE-BOLT	EYEBOLT	2	2
5	CCZ1029028-1A	M10X40 GR12-9 SOCKET HEAD CAP SCREW COARSE ISO 4762 (BZP)	-	4
6	CCZ1243028-1A	SCREW-SHCS, FLAT, HEX, M12X1.75X80, STL/12.9, ZINC	8	4
7	CCZ1253028-1A	SCREW-SHCS, FLAT, HEX, M12X1.75X130, STL/12.9, ZINC	-	4
8	CCZ1229028-1A	SCREW-SHCS, FLAT, HEX, M12X1.75X40, STL/12.9, ZINC	3	-

For MM3000i machine use 'MM3000 QTY' column above.

9.27 Air Distributor Assembly (MM1080IE-39, revision G) Views

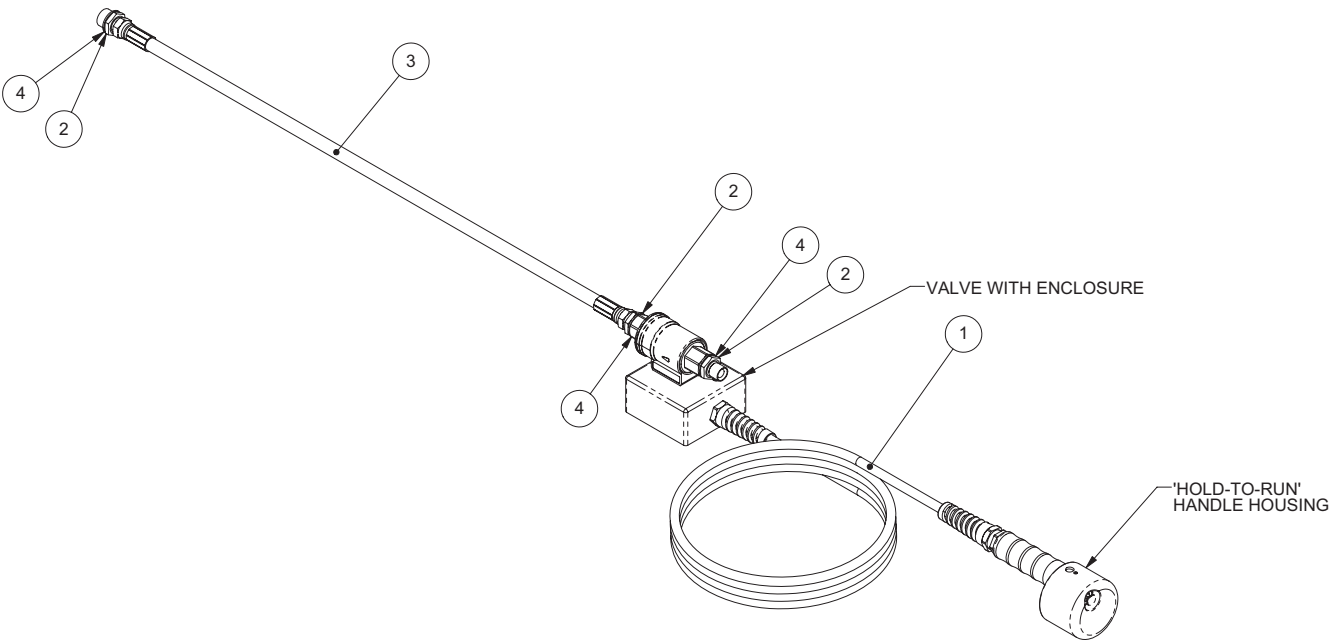
Weight 3.5kg



9.28 MM2000i Air Distributor Assembly (MM1080IE-39, Revision G) Table of Parts

Item Number	Part Number	Description	QTY
1	MM1080IE-39-002	Air Distributor Mounting Plate	1
2	MM1080IE-39-001	Air Distributor	1
3	M6 x 30	Hex Socket Head	4
4	M10 x 30	Hex Socket Head	2
5	1/2-3/4" MALE-MALE	3/4" BSPP Make x 1/2" BSPP Male	1
6	D400 027 12	3/4" Dowty Washer	1
7	BMBM 0808	BSP STRAIGHT MALE 1/2 -MALE 1/2	1
8	DOWTY08	1/2" Dowty Washer	3
9	HMFS08	BSP SWIVEL ADAPTOR 1/2"	1

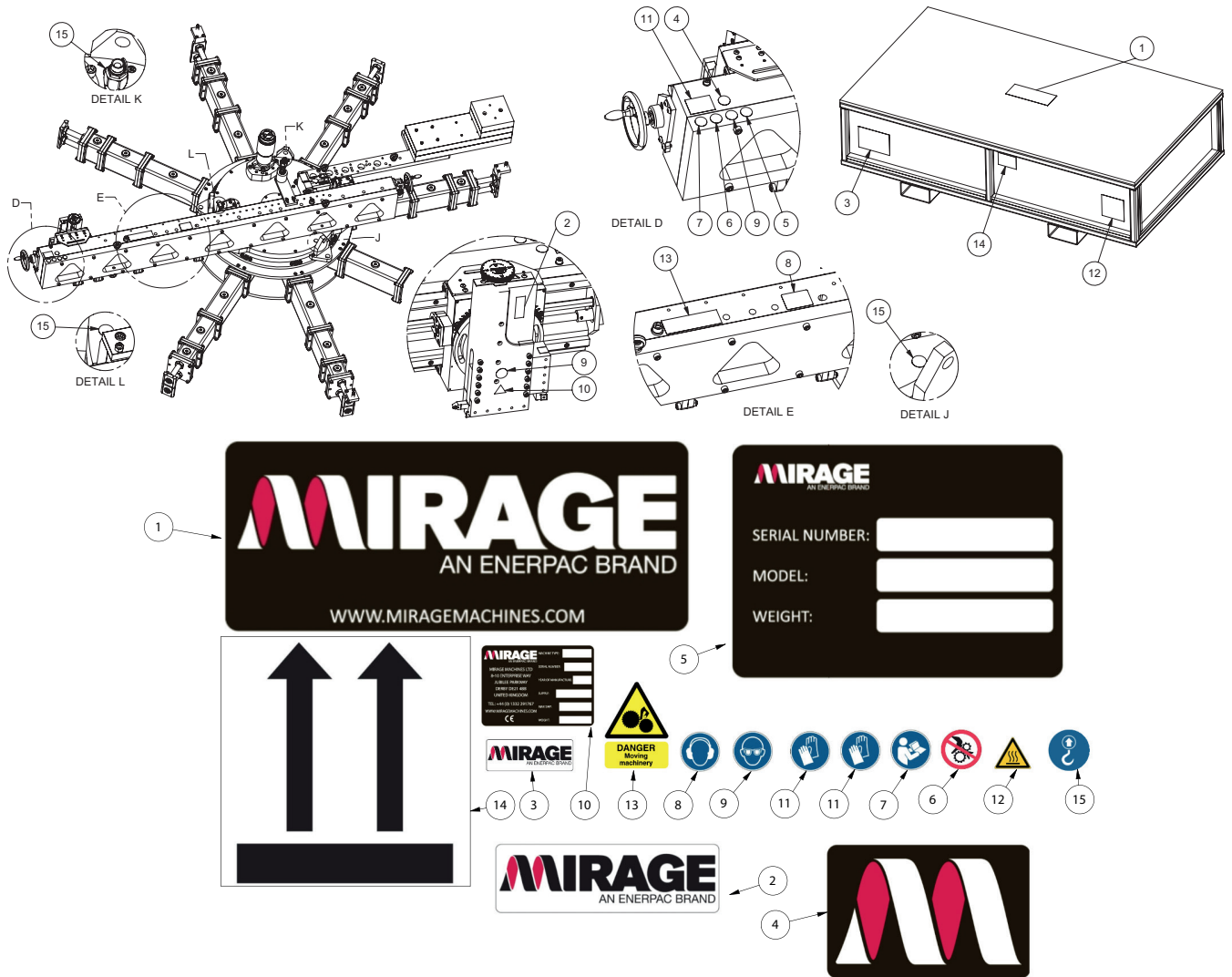
9.29 Pneumatic Dead Man’s Handle (DMH-Pneumatic, Revision D) Views



9.30 Pneumatic Dead Man’s Handle (DMH-Pneumatic, Revision D) Table of Parts

Item Number	Part Number	Description	QTY
1	DMH1	Dead Man's 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

9.31 Label Pack (LABEL-PACK-6, Revision A) Views



9.32 Label Pack (LABEL-PACK-4) Table of Parts

Item Number	Part Number	Description	QTY
1	LABEL-MM-001	Box Packaging Sticker with WEB address (285 x 116)	2
2	LABEL-MM-003	Machine Logo Sticker - Medium (148 x 45)	1
3	LABEL-MM-004	Machine Logo Sticker - Small (55 x 20)	1
4	LABEL-MM-005	Box Packaging 'M' Sticker (122 x 86)	2
5	LABEL-MM-007	Box Contents Sticker (210 x 148 - A5)	2
6	LABEL-MM-008	Prohibition Label "Fingers out - rotating machinery" ISO 7010 (Ø25)	1
7	LABEL-MM-009	Mandatory Label "Refer to instructions" ISO 7010 - M002 (Ø25)	1
8	LABEL-MM-020	Mandatory Label "Wear ear protection" ISO 7010 - M003 (Ø19)	1
9	LABEL-MM-021	Mandatory Label "Wear eye protection" ISO 7010 - M004 (Ø19)	1
10	LABEL-MM-033	CE Aluminium Label (70 x 50)	1
11	LABEL-MM-064	Mandatory Label "Wear protective gloves" ISO 7010 - M009 (Ø25)	2
12	LABEL-MM-065	Warning Label "Hot Surface" ISO 7010 - W017 (21.5 x 25)	1
13	LABEL-MM-066	Warning Label "Danger - Moving Machinery" (40 x 50)	1
14	LABEL-MM-087	Label 'This Way Up' (150 x 150)	2
15	LABEL-MM-088	Mandatory Safety Label: "Lift Point" ISO 3864-2	3

9.33 Machine Toolkit (MM3000i-TK, Revision B)

Part Number	Description	QTY
DCGT11T304-PM2-WXN10	11 SEAT. 4MM RAD INSERTS	10
KEN5822610K	10MM COMBINATION SPANNER	1
KEN5822770K	24MM COMBI SPANNER	1
KEN5822820K	30MM COMBI SPANNER	1
KEN5822880K	46MM COMBINATION SPANNER	1
KEN5823130K	13MM SPANNER	1
KEN5823220K	22MM SPANNER	1
KEN5826430K	1/2" SQUARE DRIVE PUSH THROUGH RATCHET	1
KEN5826520K	1/2" EXTENSION	1
KEN5826940K	12MM SOCKET 1/2" SQ DR	1
KEN5827010K	19MM SOCKET 1/2" SQ DR	1
KEN5930520K	POCKET PLAIN CHISEL ROLL	1
KEN5932320K	TOOLBOX WITH TOTE AND ORGANISER	1
KEN6012120K	12MM ALLEN KEY	1
KEN6015140K	14MM ALLEN KEY LONG ARM	1
KEN6025500K	BALL DRIVER L WRENCHES	1
MAGNETIC-BACK-900928	MAGNETIC BACK - MITUTOYO 900928	1
MIT3253587E	MITUTOYO DIGIMATIC DIAL TEST INDICATOR 2046S 58MM DIA	1
SDJCL2020K11	LEFT HAND TOOLHOLDER FOR DC STYLE INSERTS	1
SDJCR2020K11	RIGHT HAND TOOLHOLDER FOR DC STYLE INSERTS	1
SDNCN1616H11	TOOL HOLDER: NEUTRAL	1
SPRINGPIN-3X28	SPRING PIN (SLOTTED-LD)	10
KEN5801650K	65MM OPEN JAW SPANNER	1



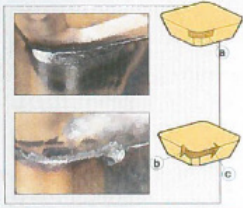


10. Troubleshooting



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. Supply not available	Check supply
	2. 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 selector is not correctly positioned and the facing feed gears are not engaged	Check position
	2. The direction selector is in neutral or not correctly engaged - if both gears are engaged this should not rotate	Check position and ensure there is no rotation
	3. Drive key problem	Remove and check gearbox assembly operation
	4. Carriage has been run off the lead screw	Check lead screw nut and screw are engaged
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. Turning tool not ground correctly or worn	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

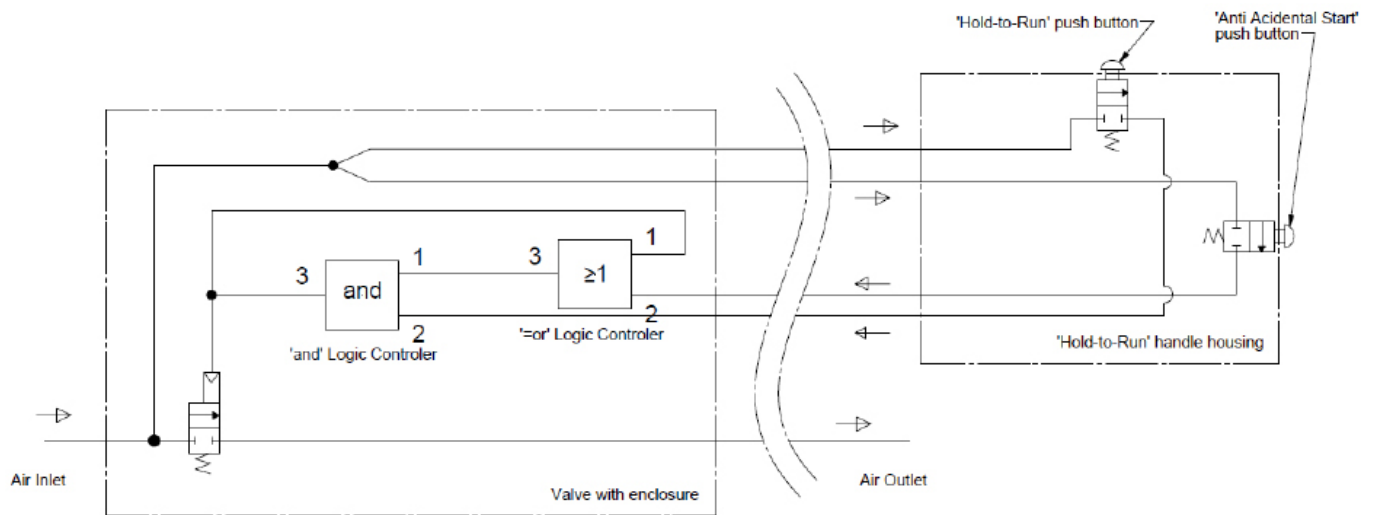
Cutting Tip Wear

Issue	Reason for wear		
Thermal cracks 	Small cracks perpendicular to the cutting edge causing frittering 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 frittering 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 (frittering) 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	$\text{FPT} = \frac{\text{FR}}{\text{RPM} \times \text{NT}}$	Inches/tooth	$\text{FPT} = \frac{\text{FR}}{\text{RPM} \times \text{NT}}$
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	$\nabla\nabla\nabla\nabla$

