NORD-LOCK GROUP

TSR+ Hydraulic Bolt Tensioners

USER MANUAL

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BOLTIGHT™

FOREWORD

Thank you for choosing Boltight equipment.

Before using the equipment you are advised to study this manual carefully.

Boltight Limited is an ISO 9001:2015 company and our bolt tensioning equipment has been designed to comply with the European Pressure Equipment Directive and the UK Pressure Equipment Regulations and is CE marked and UKCA marked respectively. The pressures and forces involved with the use of this equipment are high and it is therefore imperative that users of the equipment read and understand the operating manual, paying particular attention to the safety information in Section 1.

CONTENTS

SECTION 1 – HEALTH & SAFETY INSTRUCTIONS

1.1 SAFETY NOTES

Hydraulic bolt tensioning tools are very powerful and capable of inducing very high bolt stresses. This equipment will give many years of safe tensioning when used in accordance with these instructions.

Anyone using hydraulic bolt tensioning equipment must be properly trained to use the equipment and must take adequate steps to ensure their own safety and the health and safety of others where bolt tensioning operations are being performed. Boltight can offer training courses either at its UK base or on site anywhere in the world.

Please read the manual before attempting to use the equipment. Do not use the equipment if you are not already an experienced user of hydraulic bolt tensioning equipment. Your attention is particularly drawn to the notes in **RED**.

When using hydraulic bolt tensioners, loads of many hundreds of tonnes or even thousands of tonnes can be induced. If the bolt material is incorrect or faulty or the tool is incorrectly installed, the broken bolt could be propelled at high speed along the axis of the bolt. This is a very rare occurrence. If there is a failure, anyone standing near the bolt tensioning tool or in line with the axis of the bolt during the tensioning operation will suffer critical, possibly fatal, injury. It is therefore essential that anyone operating this equipment is properly trained and takes every precaution to ensure that nobody is allowed to stand, work or stray near to or in line with the axis of any hydraulic bolt tensioning tool during the bolt tensioning operation.

At no time should anyone allow any part of their body to be positioned over the puller of a bolt tensioning tool, whilst the pressure is rising or when it is pressurised. In the case of studbolts with nuts at each end it is important that nobody stands in line with the long axis of the bolt at either end during the tensioning operation.

Do not approach a bolt tensioning tool whilst it is being pressurised. Remember that a damaged bolt or tool is most likely to fail at this critical time. When the operating pressure has been reached, approach a pressurised bolt tensioning tool only for as long as it takes to turn the permanent nut always keeping away from the axis of the bolt and the puller.

Bolt Tensioning tools **MUST** always be used with a hydraulic pump which has a pressure limiting device. Always check that the pump stall pressure is set at or below, the maximum working pressure for the tool being used.

Clear all personnel from the area where the bolt tensioning operation is to be performed. Position the pump a safe distance away from the bolt tensioning tools. Set up barriers and warning signs, or make other adequate arrangements to prevent unauthorised personnel from accidentally straying into the bolt tensioning area.

Never leave a pressurised bolt tensioning tool unattended. Keep the bolt tensioning tools under pressure for the minimum time necessary to complete the bolt tightening job. The tools should only be used as a bolt tensioning tool. **DO NOT** use the tools as hydraulic jacks or for any other purpose.

Take care when handling the tools. Large tools may be heavy and require the use of lifting equipment. The bridge and load cell of the larger tools are not held together. The load cell and bridge are easily taken apart.

Do not try to tighten a leaking hydraulic connection when it is under pressure. First release the pressure then repair the leak.

1.2 EUROPEAN PRESSURE EQUIPMENT DIRECTIVE

The TSR+ range of hydraulic bolt tensioning tools have been designed to operate at pressures up to 1500 bar with Group 2 liquid (hydraulic oil ISO 32 or ISO 46) with a volume less than 10 litres. This equipment aligns with:

- Category 1:- 2014/68/EU European Pressure Equipment Directive
- Category 1:- UK Pressure Equipment (Safety) Regulations 2016.

Under these regulations the equipment must therefore:

a) be safe;

b) meet the essential safety requirements covering design, manufacture and testing;

c) be accompanied by adequate instructions for use;

d) be marked to identify the manufacturer and CE marked and the UKCA mark respectively.

The regulations call for pressure equipment to be pressure tested at 1.43 times the maximum pressure. However the regulations recognise that in some cases this may be harmful or impractical. Due to the very high bolt stresses developed, it is impractical to pressure test the equipment at 1.43 times the maximum pressure. It would also be harmful to the seals if the equipment was tested at these pressures. All equipment has been tested to 1.1 times the maximum pressure where appropriate and a test certificate has been issued.

1.3 USING QUICK CONNECTORS

DO NOT pressurize the connectors when they are disconnected.

Check that there is no pressure in the system before attempting to connect or disconnect the couplings.

To connect the quick connect coupling and nipple, first check there is no pressure in the system. Pull back the shroud by hand and push the coupling onto the nipple. When together, release the shroud which will spring back to connect the coupling and nipple together. The coupling should now be locked using the safety locking sleeve (SLS). To disconnect, again check there is no pressure in the system. Pull back the shroud by hand, and pull the coupling and nipple apart. Once apart release the shroud.

Pull the shroud into the retract position

Insert the nipple into the coupling whilst the shroud is in the retract position

Allow the shroud to spring back into the forward position

Check the red line is not visible – if red line is visible the connection is not safe to use

To close the safety locking sleeve (SLS) push the shroud forward to the back of the collar and rotate – release to lock

This image shows the SLS in the locked position – this joint is now safe to use

1.4 HOSES

Boltight supply flexible hydraulic hoses which have a small plastic core tube surrounded by multiple high tensile steel spiral windings. The outside of the hose is molded with a coloured plastic coating. Most hoses also have a clear plastic cover which provides additional protection against damage when in use. Each hose is identified with a serial number. All hoses are pressure tested and test certificates are issued.

Three types of hose are available which are identified by the colour of the molded plastic coating beneath the clear plastic cover. The maximum working pressure for the hose is sometimes marked on the outside of the coloured plastic coating; however this is the working pressure of the hose **ONLY** and not the hose **ASSEMBLY.**

The maximum working pressure of a hose assembly is often limited by the pressure rating of the quick connect couplings and/or the fittings on the end of the hose. Although the hose may be capable of operating at higher pressures the limit you must observe is shown below along with the minimum bend radius.

COLOUR	MAX WORKING PRESSURE	MIN BEND RADIUS
GREEN	1000 bar	95 mm
BLUE	1500 bar	130 mm
RED	2500 bar	200 mm

Hoses are fitted with self sealing quick connect couplings at one or both ends.

YOU MUST OBSERVE THE FOLLOWING HEALTH & SAFETY INSTRUCTIONS WHEN USING HYDRAULIC HOSES:

- Discard and do not use any hose that does not have an identifying serial number.
- Discard and do not use any hose that shows any sign of damage:
  - **to the coloured molded plastic coating;**
  - **where the spiral windings are exposed;**
  - **where the spiral windings are damaged or broken;**
  - **where there is damage to the swaged metal ends;**
  - **do not allow any hose to be kinked or knotted.**
- Hoses which have been kinked or knotted will have suffered damage and must be discarded.
- Do not allow heavy objects to fall on, rest on, or roll over the hoses.
- Do not allow hoses to be subjected to temperatures higher than 60°C.
- Discard and do not use any hose which has been subjected to heat or fire.
- Do not bend the hose tighter than the minimum bend radius of the hose or it will be kinked.
- Do not exceed the maximum working pressure of the hoses.
- Only use the hoses for their intended purpose – for use with Boltight hydraulic equipment.
- After use check the hoses for damage, wipe to remove dirt and oil, refit dust caps and prepare for storage.
- When not in use store the hoses in a safe place where they cannot easily be damaged.
- Do not mix the coloured hoses. The end fittings /quick disconnect couplings have different pressure ratings.
- Never move hose end connectors or quick disconnects from one colour hose to another.
- All Boltight tools are marked with maximum operating pressure - ensure tools are compatible with the hoses you are using.
- Never use the hoses as a handle to carry or pick up the bolt tensioning tools.

If in doubt contact your representative for further information.

1.5 HYDRAULIC BOLT TENSIONING TOOLS

Maximum pressure

The bolt being tensioned may have a maximum load less than that generated by the tensioner at maximum working pressure. The operator needs to confirm and check what the maximum pressure is for the particular application being tensioned.

The maximum pressure for the hydraulic bolt tensioners can be found in **Section 4**.

Do not exceed the maximum working pressure.

The operational pressure for an application is often not limited by the stud material yield. See **Section 4** for a tool pressure vs. initial bolt stress graph. The tooling has been issued with a pressure/load certificate. Never exceed the tested load or pressure, whichever is lower.

Maximum stroke

Observe the maximum piston stroke.

A highly visible red line indicates when the piston has reached its maximum stroke. The pump should be stopped as soon as the red indicator can be seen. If the tool exceeds maximum piston stroke then the stroke limiting valve will activate to vent the oil internally. This protects the seals and cylinder body from accidental over stroke.

1.6 PERSONAL PROTECTIVE EQUIPMENT (PPE)

When using bolt tensioning tools the operator should ensure that they are wearing the correct Personal Protective Equipment (PPE).

This equipment includes (but is not limited to):

- eye protection;
- gloves;
- overalls;
- hard hat;
- steel toe-capped boots or shoes;
- any other site specific PPE required.

SECTION 2 – OPERATING INSTRUCTIONS

Introduction

A hydraulic bolt tensioner is simply an annular jack with a hollow bore. Much like a jack, a hydraulic pushing force is generated, however instead of lifting a heavy object the force is transferred into stretching a bolt. To allow the transfer of force into the bolt a hydraulic tensioner utilises a threaded puller, bridge and nut rotating socket to effectively transfer and lock in the tensioned load within a joint.

Unlike conventional tightening methods bolt tensioning does not use torque and does not require any forceful turning of the nut or bolt, like impact wrenches, flogging spanners or hydraulic torque wrenches. All of these methods have one common limitation, **FRICTION**.

Friction accounts for up to 80% of the energy lost when torque tightening a joint, giving only 20% transferable energy for bolt tension.

Bolt tensioning tools can be grouped together to enable multiple bolts to be tightened simultaneously, to the same high and accurate pre-load. This is particularly useful when compressing gaskets in pipeline or pressure vessel flanged connections. The high load developed from the multiple bolt tensioning tools, is evenly distributed around the joint causing the gasket to flow into the surface irregularities of the flange giving a much better seal.

Flexible hoses with self sealing quick connect couplings are used to group the bolt tensioning tools together to form a hydraulic ring main. The ring main and tensioning tools are pressurised using an air driven pump working from a compressed air supply or an electric pump.

IMPORTANT NOTICE

The images shown in this section of the manual show tools with two hydraulic connections. However the instructions equally apply to having one hydraulic connection.

Remember that if your tool has two hydraulic connections it is necessary to fit a blank plug to the quick connect coupling/nipple before applying any pressure.

2.1 MAIN COMPONENT PARTS

1 Puller

The puller consists of an internal female thread which mates with the bolts male thread. A knurled external flange allows for ease of rotation when assembling onto the bolt and several tommy bar holes allow for additional leverage when required. The outer flange of the puller reacts on the hydraulic load cells piston to allow transfer of the load directly into the bolt.

2 Hydraulic load cell

The hydraulic load cell produces the force required to tension a bolt. High pressure hydraulic oil is delivered via up to two self sealing quick connections. Both the puller and bridge are integral parts in the delivery of hydraulic force. The puller fits within the internal bore of the load cell and the bridge is assembled within a recess. The hydraulic load cell has piston retract and piston stroke limiting technology built in.

3 Socket

The socket allows for the easy rotation and seating of a joints hexagonal nut to lock in the bolt tension load during tensioning operation. Drilled holes in the socket allow for rotation to be made via the use of tommy bars, creating ample leverage and a safe working distance from the joint. The socket is captive in bridge.

4 Bridge

The bridge and internally mounted socket fit over the nut and bolt. The bridge acts like a pillar and reacts off the joint of the application during tensioning. Carefully designed cutouts to the rear and sides of the bridge allow for an optimised fitment between adjacent bolts and rear obstructions such as welds or machined radius on flanges. A front access window allows for socket rotation and nut wind down during tensioning.

5 Bolt

An extra length of thread must protrude through the nut for the tensioner to screw onto and apply the bolt tension. The length of the bolt is very important. Details are given in **Section 2.3 Step 1. NOTE:** Good quality bolts and nuts will make the tensioning operation quicker and more accurate.

2.2 RECOMMENDED PRACTICES

To obtain the best results from your hydraulic bolt tensioning equipment you should carefully follow the operating instructions given in the following pages. You should also observe the instructions given below.

DO NOT try to pressurise the hydraulic load cell unless it is properly seated on its bridge and the puller has been correctly fitted onto the bolt to be tightened or released. If the hydraulic cylinder is pressurised when it is not seated on a bridge or when a puller is not fully engaged the hydraulic load cell may be damaged beyond safe or repairable use.

DO NOT operate the hydraulic load cell when not assembled to the required joint as pressurization may cause permanent damage to load cell.

2.3 TENSIONING A BOLT

Step 1

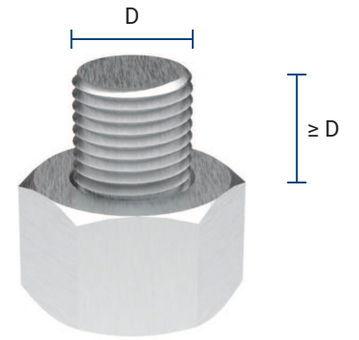
Ensure the joint has been assembled using the correct nuts and bolts required for tensioning.

To ensure the safe and effective use of the hydraulic bolt tensioner ensure that a minimum of 2x bolt diameters of bolt length is protruding from the surface of the joint face. Bolt protrusion in excess of 2x bolt diameter is acceptable.

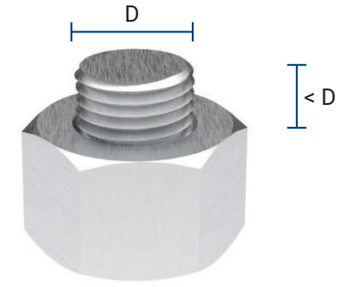
It is imperative that the correct bolt length is available prior to the hydraulic tensioner activation as failure to do so may result in the threads stripping off the bolt and the bolt tensioner puller.

HEALTH & SAFETY WARNING

If only a few threads protrude and an attempt is made to apply tension the bolt threads will strip and components of the tensioner could be propelled with the possibility of serious injury and may cause damage to the bolt and tensioner.



CORRECT AND SAFE



WRONG AND DANGEROUS

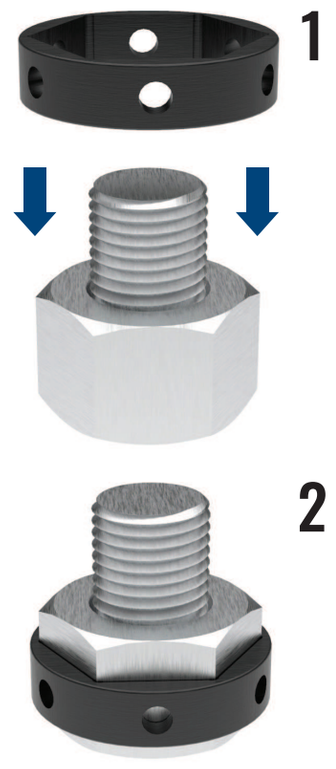
Step 2

As standard tools are supplied with captive socket, when tensioning bolts with hexagon nuts it is common place to utilise the socket to rotate and wind down the nut so that it seats on the surface of the application locking in the load. A tommy bar is used to give assisted leverage and ensure a safe working distance.

The TSR+ tools feature a circular groove located in the bridge to allow the fitment of a socket retaining ring, this gives the option of captivating the socket within the bridge. If this option is chosen there is no need to place the socket over the nut separately to the bridge and this step can be ignored.

When using the bolt tensioner on a joint which utilities drilled round or hexagon nuts the socket can be removed. The nut can then be turned down with the corresponding sized tommy bar.

Ensure the bridge is seated on a flat and level surface and avoids any adjacent nuts or application obstructions. Ensure the bridge does not largely overhang or react off uneven surfaces.



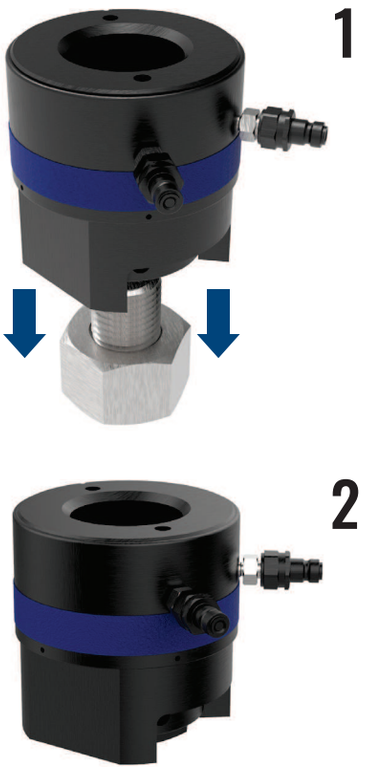
Step 3

Place the load cell and bridge assembly over the nut, bolt and socket.

The load cell and bridge are assembled together using set screws positioned radially on the lower outside diameter of the load cell. The bridge and load cell can be rotated relative to each other. This allows the self sealing quick connect hydraulic connection on the load cell to be placed in the best position for connecting the flexible hydraulic hose. On applications where space is limited above the bolt, it may be helpful to separate the bridge and the load cell, placing them individually onto the bolt.

If disassembly is required use an appropriately sized hex key to loosen the set screws. Once loose separate the bridge from the load cell. To reassemble reverse this process however do not over tighten the set screws as this will lock the bridge in place and prevent rotation.

A window in the front of the bridge allows access to the socket with a tommy bar. The bridge may have flats on each side to clear any adjacent nuts. The bridge and load cell may have an angled flat at the back to clear any obstruction behind the bolt and nut, such as the hub of a weld neck flange.



Step 4

Place the puller into the centre of the load cell and lower until the bottom face of the puller touches the top face of the bolt. Carefully engage the puller onto the bolts mating threads by turning in a clockwise direction. If the puller becomes tight do not force it as this may be an indication of damaged threads, incorrect thread sizing or an obstruction. The puller should rotate freely, a tommy bar can also be used to rotate the puller down once the mating threads have been fully engaged.

Step 5

Continue to wind down the puller until the lower face of the pullers flange firmly contacts the top face of the load cells piston. Excessive force is not required.

During the rotation of the puller, ensure that the bolt remains stationary as failure to do so could result in a reduced thread engagement in both the puller or application.

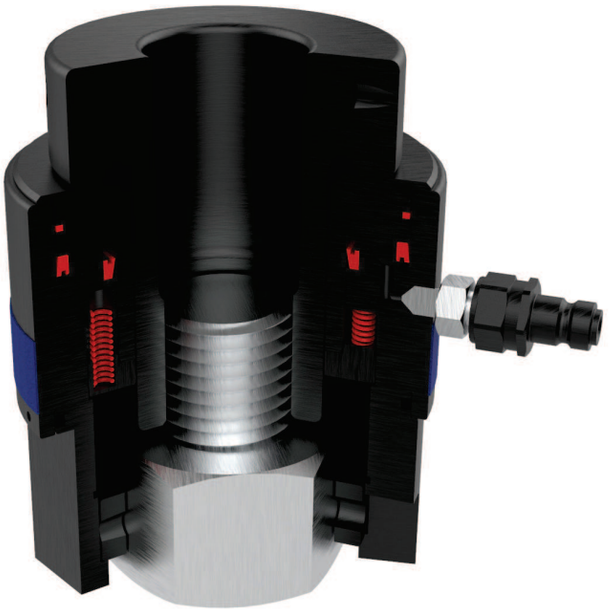
The puller is in full contact with the top of the hydraulic load cell.

The puller is not fully in contact with the top of the hydraulic load cell.

Step 6

The bolt tensioner is now locked in place and cannot fall off. The tool is now ready for the hydraulic hose to be connected.

Once the puller has been screwed down, check the thread engagement with the bolt is still correct.

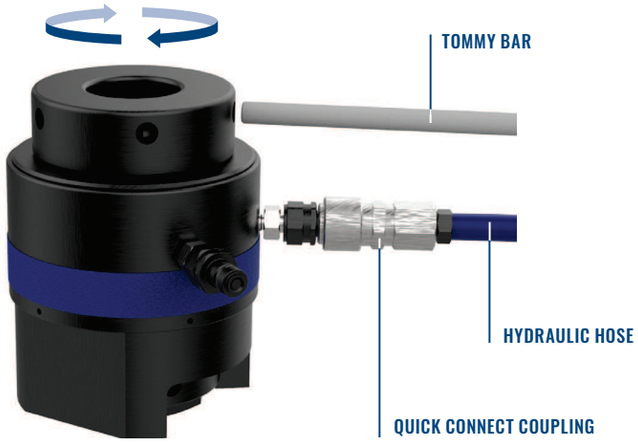


Step 7

Connect the tensioner to corresponding hydraulic hose and pump unit.

Make sure the quick connect coupling is fully engaged. See **Section 1.3** “Using quick connectors.”

If required re-tighten the puller into position. Open the pumps oil return to tank valve and ensure the piston does not retract further. If it does then simply wind down the puller to regain piston engagement.



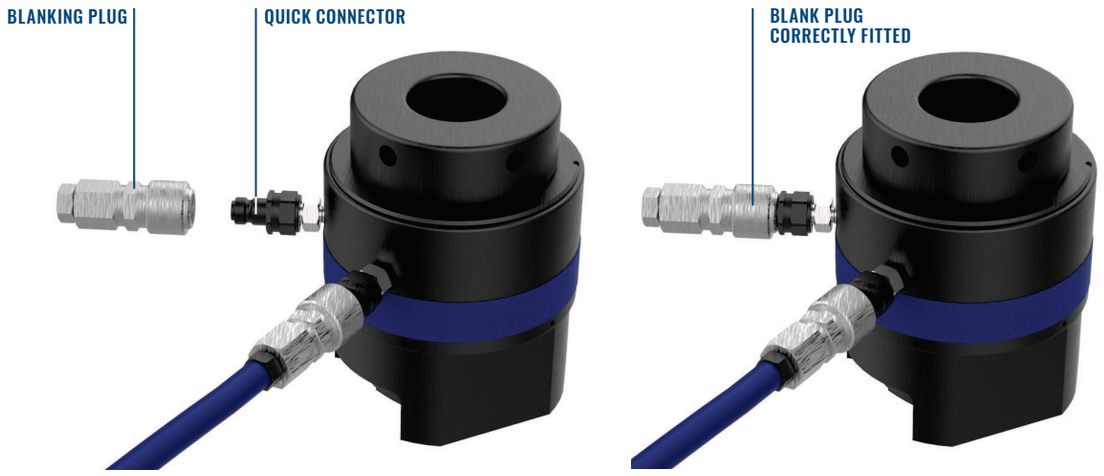
Step 8

If required, fit a blanking plug to the open quick connector.

Ensure the connector is fully engaged.

Only when the second hydraulic connection has been plugged can the tool be pressurised.

See **Section 2.5** of this manual to learn how to use multiple tooling for simultaneous bolt tightening operations.



TENSIONING A BOLT – HEALTH & SAFETY

The bolt tensioning tool is now ready to be pressurised. Before proceeding read the Health & Safety Instructions given in **Section 1** of this manual then proceed as follows:

- Ensure suitable PPE has been utilised prior to pressurisation.
- Clear all personnel from the area where the bolt tensioning operation is to be performed. Position the pump a safe distance away from the bolt tensioning tools. Set up barriers and warning signs, or make other adequate arrangements to prevent unauthorised personnel from accidentally straying into the bolt tensioning area.
- Release the oil pressure immediately if any unauthorised person moves into the bolt tensioning area and especially is anyone stands in front of the puller of a bolt tensioning tool under pressure or stands in line with the long axis of a bolt being tensioned.
- Determine the correct working pressure for the bolts to be tightened. Proceed with the following operations keeping the bolt tensioning tools under pressure for the minimum time necessary to complete the bolt tightening operation.

Step 9

Utilising the pressure load information as shown in **Section 4 — Technical Information**, slowly activate the hydraulic pump to raise the hydraulic pressure within the tensioner. During activation the piston will move out of the load cell as the bolt is stretched and the joint is compressed.

DO NOT exceed the maximum piston stroke. This is indicated by a red line around the piston.

DO NOT exceed the maximum pressure for the tool.

DO NOT stand in line with the axis of the bolt and the Puller of the bolt tensioning tool when it is under pressure.

A highly visible red line indicates when the piston has reached its maximum stroke. Stop the pump as soon as the red indicator can be seen. If the tool is over stroked the valve will activate and oil will be vented internally to prevent damage to the tensioner.

Ensure the stroke of the piston is observed during pressurisation. If the maximum piston stroke indicator becomes visible, **STOP** the pump and wind down the nut as shown in **Step 10**.

If a second pull of the joint is required reset the tensioner and wind the puller back down as shown in **Step 7**.

Step 10

Use a tommy bar to turn the socket clockwise, to tighten the nut.

Insert the tommy bar through the window in the bridge until it engages with the furthest right hole in the socket.

Turn the socket clockwise as far as it will go. If the tommy bar comes into contact with the bridge, remove it and engage the next furthest right hole in the socket.

Continue to rotate the socket until the nut is firmly seated on the face of the application.

Step 11

Once the desired tensioning pressure has been reached and the nut has been fully seated on the surface of the joint the pressure within the tool can be released, locking the load within the joint.

Release the pressure by slowly opening the pressure release valve on the hydraulic pump.

The TSR+ has been supplied with an automatic piston return system. The piston will return to 0mm stroke once the pressure release valve has been opened. Keep the pressure relief valve open until the piston has fully retracted.

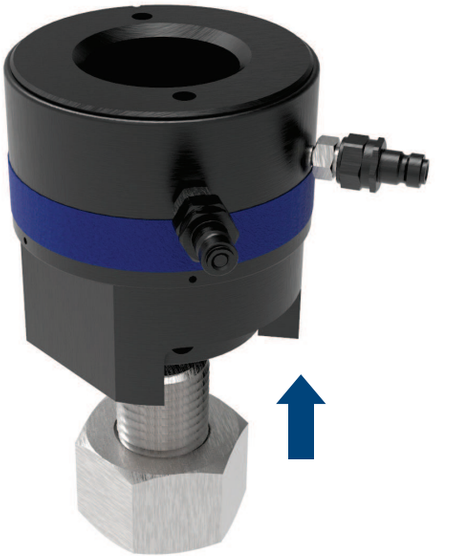
Once the piston has fully retracted, please repeat steps 9 to 11 to complete the process for a second time. After which, the tensioner can be removed from the joint. If required disconnect the hydraulic hoses prior to tool removal.

Step 12

Remove the puller from the joint by rotating anti-clockwise. Use a tommy bar for added leverage if required.

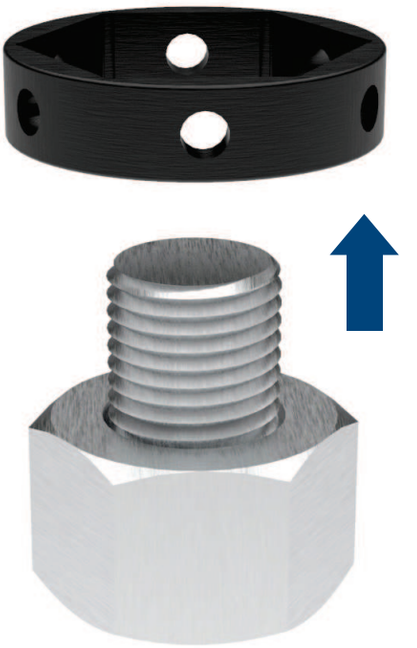
Step 13

Remove the load cell and bridge.



Step 14

If it is not retained in the bridge, remove the socket.



2.4 DE-TENSIONING A BOLT

Step 1

De-tensioning of a bolt follows many of the steps as shown in the previous section. There are however a few key differences in the process which are explained within the following section.

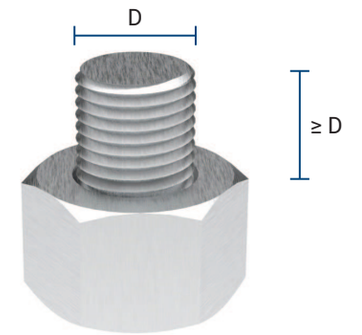
First visually inspect the bolts to be de-tensioned. To ensure the safe and effective use of the hydraulic bolt tensioner ensure that a minimum of 2x bolt diameter of bolt length is protruding from the surface of the joint face. Bolt protrusion in excess of 2x bolt diameter is acceptable.

It is imperative that the correct bolt length is available prior to the hydraulic tensioner activation as failure to do so may result in the threads stripping off the bolt and the bolt tensioner puller.

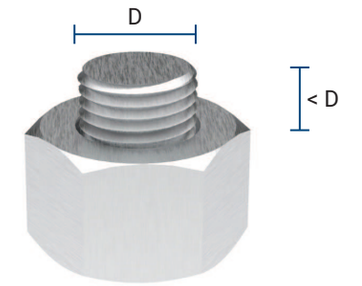
Next ensure that the threads are clean and have not been damaged. Any damage to the threads should be rectified with a thread file or die nut before attempting to assemble the hydraulic bolt tensioning tool onto the bolt.

HEALTH & SAFETY WARNING

If only a few threads protrude and an attempt is made to apply tension the bolt threads will strip and components of the tensioner could be propelled with the possibility of serious injury and may cause damage to the bolt and tensioner.



CORRECT AND SAFE



WRONG AND DANGEROUS

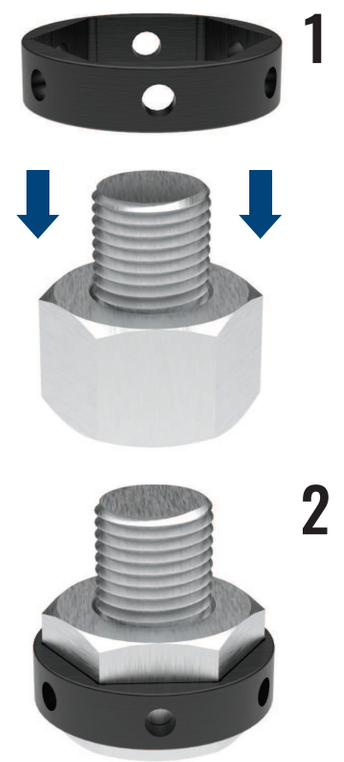
Step 2

Place the socket over the nut to be untightened. When tensioning bolts with hexagon nuts it is common place to utilise the socket to rotate and wind down the nut so that it seats on the surface of the application locking in the load. A tommy bar is used to give assisted leverage and ensure a safe working distance.

The TSR+ tools feature a circular groove located in the bridge to allow the fitment of a socket retaining ring, this gives the option of captivating the socket within the bridge. If this option is chosen there is no need to place the socket over the nut separately to the bridge and this step can be ignored.

When using the bolt tensioner on an joint which utilises drilled round or hexagon nuts the socket can be removed. The nut can then be turned down with the corresponding sized tommy bar.

Ensure the bridge is to be seated on a flat and level surface and avoids any adjacent nuts or application obstructions. Ensure the bridge does not largely overhang or react off uneven surfaces.



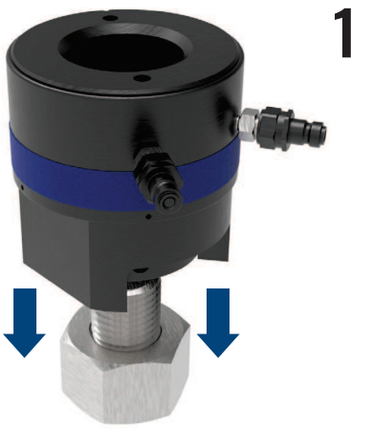
Step 3

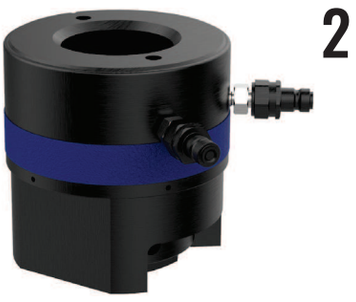
Place the load cell and bridge assembly over the nut, bolt and socket.

The load cell and bridge are assembled together using set screws positioned radially on the lower outside diameter of the load cell. The bridge and load cell can be rotated relative to each other. This allows the self sealing quick connect hydraulic connection on the load cell to be positioned in the best position for connecting the flexible hydraulic hose. On applications where space is limited above the bolt, it may be helpful to separate the bridge and the load cell, placing them individually onto the bolt.

If disassembly is required use an appropriately sized hex key to loosen the set screws. once loose separate the bridge from the load cell. To reassemble reverse this process however do not over tighten the set screws as this will lock the bridge in place and prevent rotation.

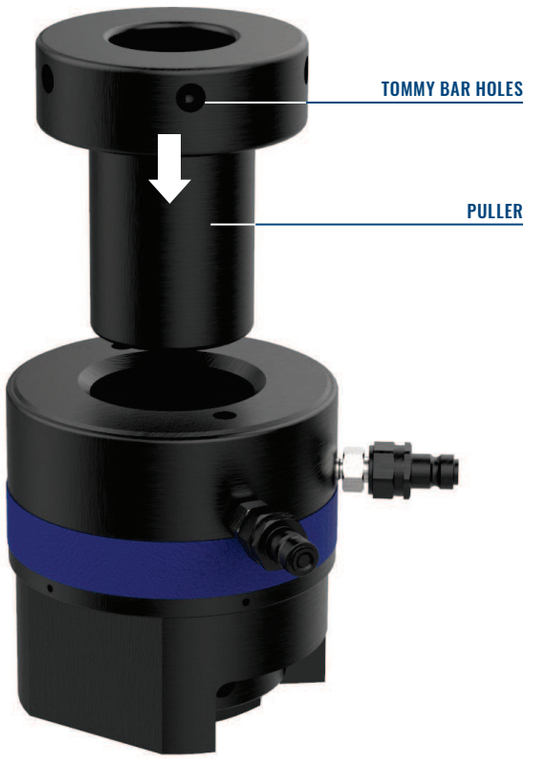
A window in the front of the bridge allows access to the socket with a tommy bar. The bridge may have flats on each side to clear any adjacent nuts. The bridge and load cell may have an angled flat at the back to clear any obstruction behind the bolt and nut, such as the hub of a weld neck flange.





Step 4

Place the puller into the centre of the load cell and lower until the bottom face of the puller touches the top face of the bolt. Carefully engage the puller onto the bolts mating threads by turning in a clockwise direction. If the puller becomes tight do not force it as this may be an indication of damaged threads, incorrect thread sizing or an obstruction. The puller should rotate freely, a tommy bar can also be used to rotate the puller down once the mating threads have been fully engaged.



Step 5

IMPORTANT: Now turn back the puller at least one full revolution. This operation ensures the piston can retract into the load cell when the bolt becomes free and needs to return to its original length.

If this step is missed the load retained in the bolt will be transferred from the nut to the puller during the de-tensioning operation which in turn will lock the puller in place so that it cannot be removed.

In the event of this happening , re-tighten the bolt using the bolt tensioner, tighten the nut using the tommy bar and release the oil pressure. The puller can then be wound back the one full turn necessary to avoid this situation arising again.

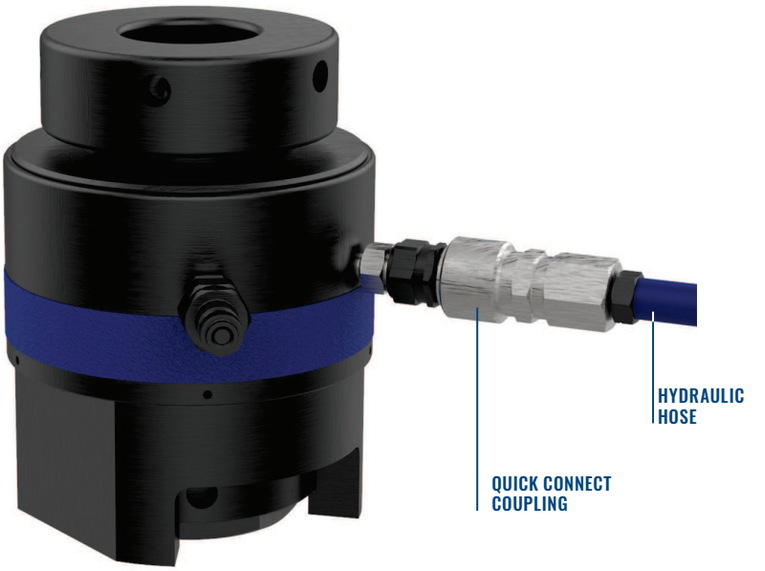
The tool is now ready for the hydraulic hose to be connected.

Step 6

Connect the tensioner to corresponding hydraulic hose and pump unit.

Make sure the quick connect coupling is fully engaged.

DO NOT tighten the Puller with the tommy bar.



Step 7

If applicable fit a blank nipple to the quick connect coupling.

Ensure the connector is fully engaged.

Only when the second hydraulic connection has been plugged can the tool be pressurised.

DE-TENSIONING A BOLT – HEALTH & SAFETY

The bolt tensioning tool is now ready to be pressurised. Before proceeding read the Health & Safety Instructions given in **Section 1** of this manual then proceed as follows:

- Ensure suitable PPE has been utilised prior to pressurisation.
- Clear all personnel from the area where the bolt tensioning operation is to be performed. Position the pump a safe distance away from the bolt tensioning tools. Set up barriers and warning signs, or make other adequate arrangements to prevent unauthorised personnel from accidentally straying into the bolt tensioning area.
- Release the oil pressure immediately if any unauthorised person moves into the bolt tensioning area and especially is anyone stands in front of the puller of a bolt tensioning tool under pressure or stands in line with the long axis of a bolt being tensioned.
- Determine the correct working pressure for the bolts to be tightened. Proceed with the following operations keeping the bolt tensioning tools under pressure for the minimum time necessary to complete the bolt tightening operation.

Step 8

Utilising the pressure load information as shown in **Section 4 — Technical Information**, slowly activate the hydraulic pump to raise the hydraulic pressure within the tensioner. During activation the piston will move out of the load cell as the bolt is stretched and the joint is compressed.

DO NOT exceed the maximum piston stroke.
This is indicated by a red line around the piston.

DO NOT exceed the maximum pressure for the tool.

DO NOT stand in line with the axis of the bolt and the Puller of the bolt tensioning tool when it is under pressure.

A highly visible red line indicates when the piston has reached its maximum stroke. Stop the pump as soon as the red indicator can be seen. If the tool is over stroked the valve will activate and oil will be vented internally to prevent damage to the tensioner.

Ensure the stroke of the piston is observed during pressurisation. If the maximum piston stroke indicator becomes visible, **STOP** the pump and wind down the nut as shown in **Step 10**.

If a second pull of the joint is required reset the tensioner and wind the puller back down as shown in **Step 7**.

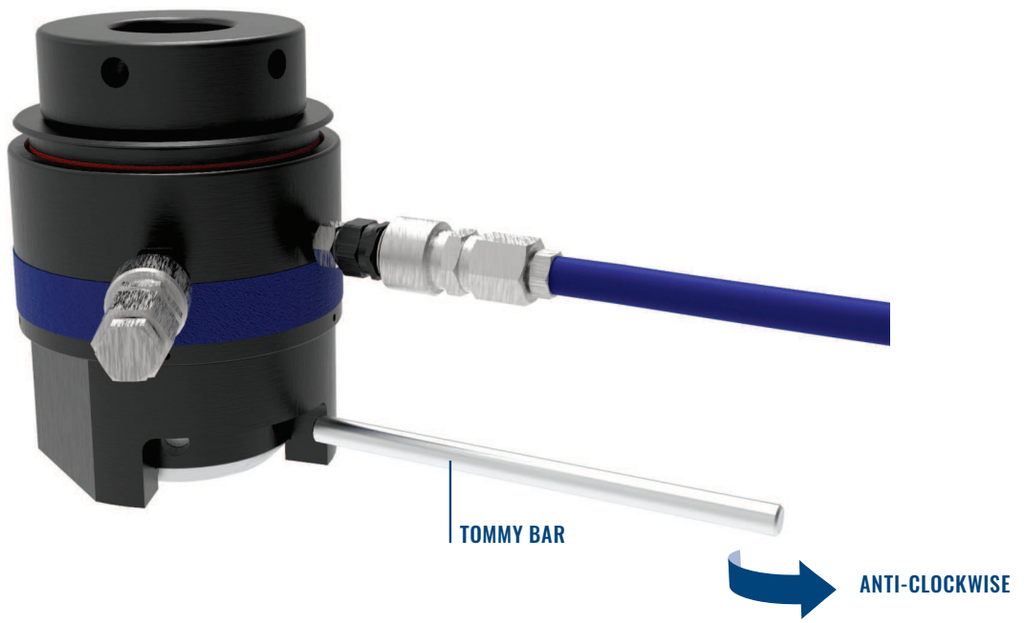
Step 9

Use a tommy bar to turn the socket anti-clockwise, to loosen the nut.

Insert the tommy bar through the window in the bridge until it engages with the hole the furthest left in the socket.

Turn the socket anti-clockwise. If the tommy bar comes into contact with the bridge, remove it and engage the next hole in the socket.

Continue turning the socket until the nut has been undone one full turn. Do not let the nut come into contact with the puller.



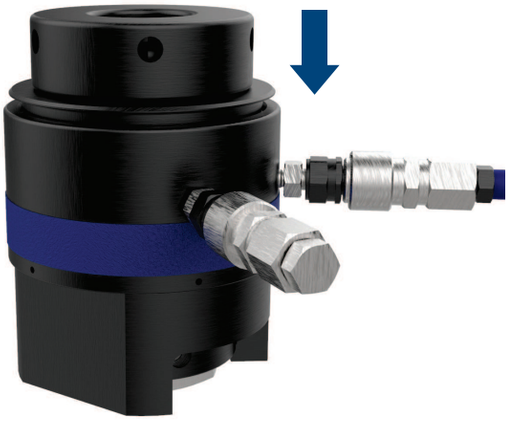
Step 10

Once the desired tensioning pressure has been reached and the nut has been released from the surface of the joint. The pressure within the tool can be released.

Release the pressure by slowly opening the pressure release valve on the hydraulic pump.

The TSR+ has been supplied with an automatic piston return system. The piston will return to 0mm stroke once the pressure release valve has been opened. Keep the pressure relief valve open until the piston has fully retracted.

Once the piston has fully retracted, the tensioner can be removed from the joint. If required disconnect the hydraulic hoses prior to tool removal.

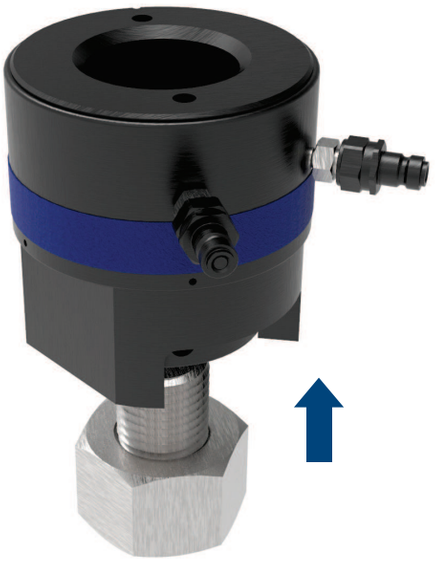


Step 11

Remove the puller from the joint by rotating anti-clockwise. Use a tommy bar for added leverage if required.

Step 12

Remove the load cell and bridge.



Step 13

If it is not retained in the bridge, remove the socket.

2.5 SIMULTANEOUS BOLT TENSIONING

Ensure you have read and understood both the bolt tensioning and de-tensioning methods as shown in the previous sections prior to conducting a simultaneous bolt tensioning operation.

Simultaneous bolt tensioning improves the speed and efficiency when performing a tensioning operation on a multi stud application. Boltight recommend a minimum of 25% bolt coverage when tensioning a joint, with 100% coverage giving the largest advantage in speed and accuracy. When it is not possible to fit 1 tensioner per bolt, Boltight recommend reducing to 50% bolt coverage.

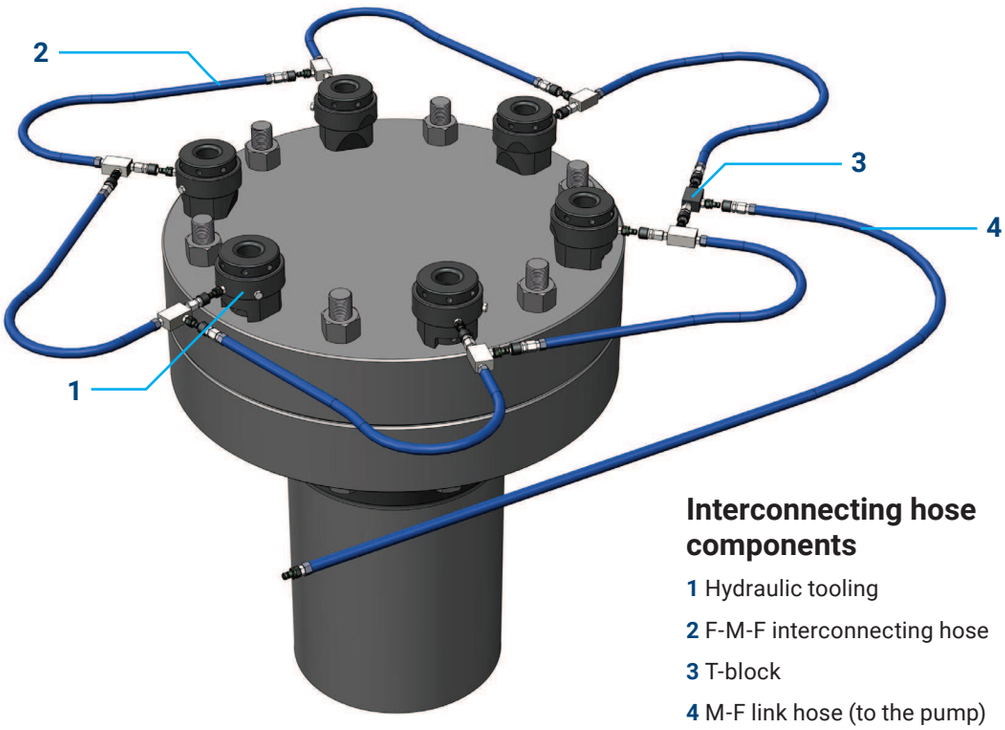
When tensioning bolts simultaneously the tensioning procedure is the same as tensioning a single bolt, however the hydraulic hose setup is different. The hydraulic hoses need to be interconnected in a pattern to allow effective oil flow and oil feed into each hydraulic tensioner simultaneously from a common pump unit.

The following section demonstrates examples of commonly utilised link hose setup. There are multiple ways hoses can be connected however the common objective is to ensure that oil is safely supplied to each tool simultaneously. Ensure all hose safety instructions are understood and that the minimum bend radius is utilised when selecting the hose setup.

If in doubt contact your representative for further information.

Interconnecting hose arrangement

The interconnecting hose arrangement is the most commonly recommended hose setup. It is well suited for multiple tensioning tools in large groups. As the setup is 100% external, forming a hydraulic ring-main, it allows easy manual piston reset or quick reset for auto return tensioners.



Interconnecting hose components

1 Hydraulic tooling

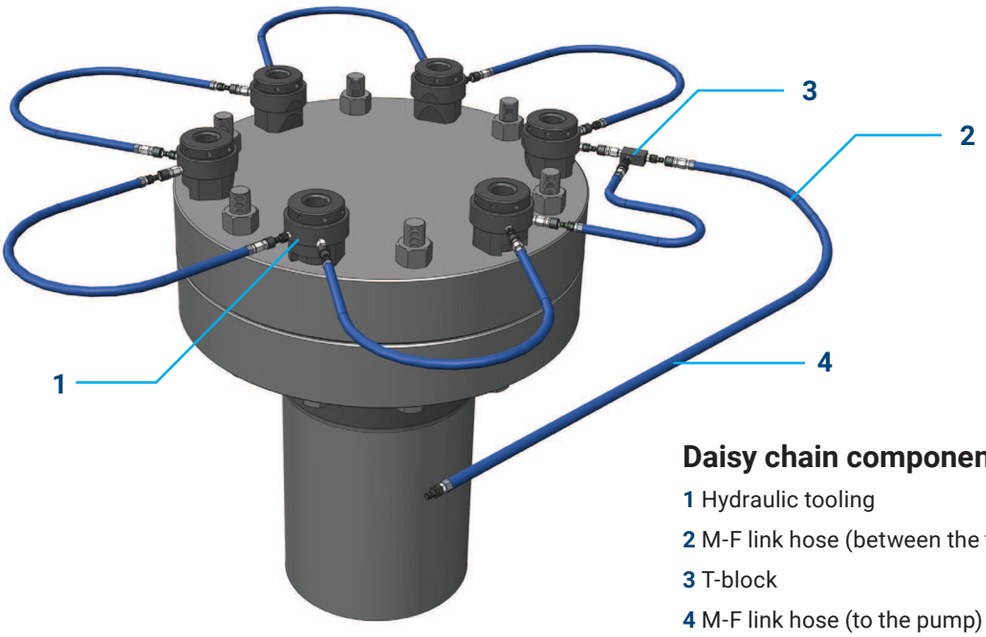
2 F-M-F interconnecting hose

3 T-block

4 M-F link hose (to the pump)

Daisy chain arrangement

The daisy chain arrangement is an affordable method of connecting multiple tools. It is best for simplicity, as only one type of hose needs to be specified, however with this setup oil must pass through every hydraulic cylinder increasing the resistance for manual piston reset or increasing the time reset takes for auto return tensioners.



Daisy chain components

1 Hydraulic tooling

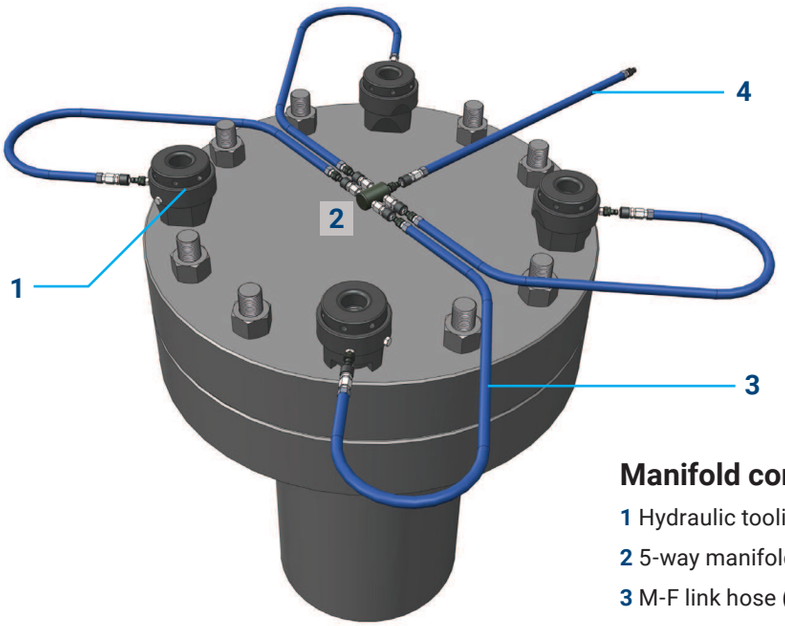
2 M-F link hose (between the tools)

3 T-block

4 M-F link hose (to the pump)

Manifold arrangement

The manifold arrangement is well suited to small groups of tensioning tools, particularly where the tensioner coverage pattern is spread out.



Manifold components

1 Hydraulic tooling

2 5-way manifold

3 M-F link hose (to the tools)

4 M-F link hose (to the pump)

SECTION 3 – MAINTENANCE & STORAGE

Introduction

A hydraulic bolt tensioning tool will provide many years of trouble free service if used, maintained and stored correctly.

Storage

Each tool is surface treated before leaving the factory. This provides a degree of corrosion protection but additional protection should be applied when the tools are to be stored for any period of time. It is recommended that, before storage, the tools should be dismantled into their three major components:

- Puller
- Hydraulic Cylinder
- Bridge Assembly

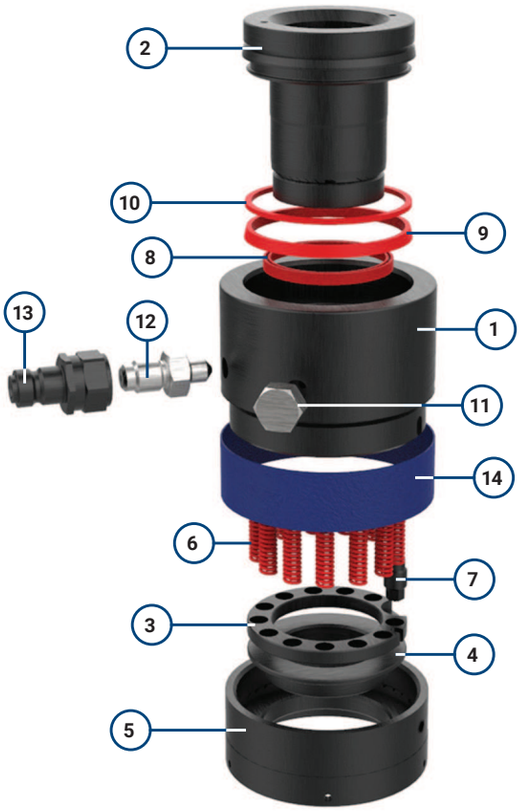
Each of these items should be checked for damage and if OK, lightly oiled and then reassembled. The reassembled tool must have the piston returned to the zero stroke position and the hydraulic connection must have its plastic protective cap fitted. The hydraulic bolt tensioner should be stored upright in a clean, dry environment.

Maintenance

Very little maintenance is required for a bolt tensioning tool.
The only items which may require changing will be the seals.

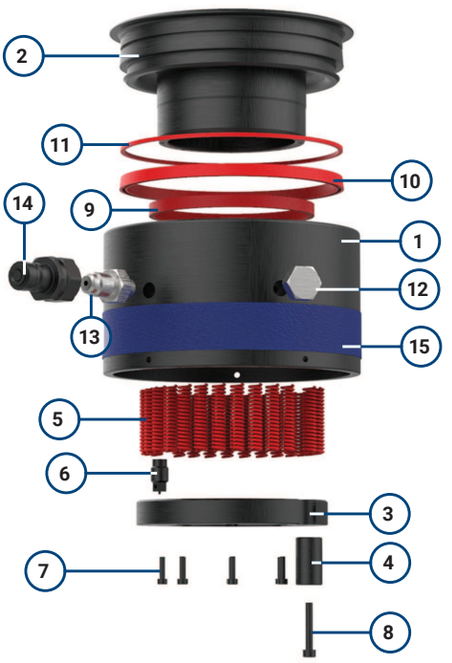
3.1 PARTS BREAKDOWN

TSR+1 to TSR+2 diagram



Item no.	Description	Part no.	Qty.
1	Cylinder body 1	TSRPx-CB-01*	1
2	Piston	TSRPx-PT-01*	1
3	Spring cap	TSRPx-SC-01*	1
4	Spring sleeve	TSRPx-SL-01*	1
5	Cylinder body 2	TSRPx-CB-02*	1
6	Retract springs	TSRPx-SPRING-01*	Contact Boltight
7	Stroke limit valve	BT-PRV-01	1
8	Inner seal	TSRPx-ID-SEAL*	1
9	Outer seal	TSRPx-OD-SEAL*	1
10	Indicator ring	TSRPx-Indicator-Ring	1
11	Blanking plug	BT-2524-03	1
12	Hydraulic adaptor	BT-1523-01	1
13	Quick connect nipple	BT-1502	1
14	Grip tape	GRIP-BL-25	1

TSR+3 to TSR+7 diagram



Item no.	Description	Part no.	Qty.
1	Cylinder body	TSRPx-CB-01*	1
2	Piston	TSRPx-PT-01*	1
3	Spring cap	TSRPx-SC-01*	1
4	Spring locking sleeve	TSRPx-SLS-01*	1
5	Retract springs	TSRPx-SPRING-01*	1
6	Stroke limit valve	BT-PRV-01	Contact Boltight
7	Spring cap screws		Contact Boltight
8	Spring locking sleeve screw		Contact Boltight
9	Inner seal	TSRPx-ID-SEAL*	1
10	Outer seal	TSRPx-OD-SEAL*	1
11	Indicator ring	TSRPx-Indicator-Ring*	1
12	Blanking plug	BT-2524-03	Contact Boltight
13	Hydraulic adaptor	BT-1523-01	Contact Boltight
14	Quick connect nipple	BT-1502	1
15	Grip tape	GRIP-BL-25	1

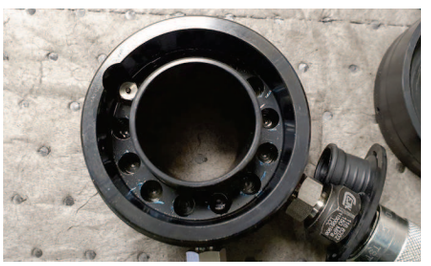
* Where '**TSRPx**' appears replace the '**x**' with the appropriate model number. E.g. for a TSR+2 Cylinder body the part number would be TSRP2-CB-01.

3.2 DISASSEMBLY OF LOAD CELL – TSR+1 & TSR+2

- Remove grip tape from the load cell.
- Place the tool upside down on a flat surface.
- Remove grub screw located on the outer body, using a suitable Allen key as shown.

- Fit an open hydraulic fitting to release any stored pressure in the load cell.
- Place the body in a soft jaw clamp (if required) and unscrew the lower body from the top body.

- Unscrew the spring sleeve to remove setting tension on the return springs.
- Remove the spring cap to expose the springs.



- Remove the springs from the load cell.

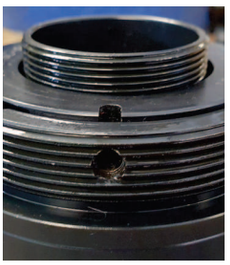
- Hold the load cell in soft jaw clamps.
- Use a soft end mallet/hammer to gently drive the piston out of the body.

- Body and piston are now ready for the seals to be replaced.

Move to Section 3.5 for seal replacement procedure.

3.3 REASSEMBLY OF LOAD CELL – TSR+1 & TSR+2

- Once the new seals have been fitted, assemble the piston into the body.
- Use a soft end hammer or a press to gently push the piston into the body.
- Install the springs, then install the spring cap ensuring each spring sits within the counter bore of the cap.



NOTE:
When installing the cap onto the springs ensure the slot on the cap is aligned with the hole on the tools body.

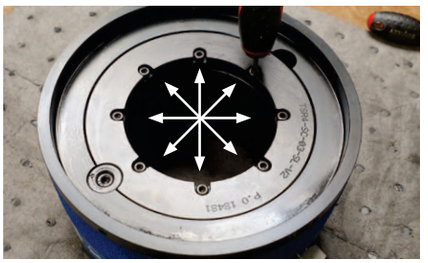
- Locate the spring sleeve.
- Use a suitably sized Allen key to restrict rotation of the spring cap when installing the spring sleeve.
- Install the spring sleeve and rotate until a positive stop can be felt.

- Locate the lower body.
- Screw the lower body onto the upper body.
- Ensure the screw hole on the outer diameter of the lower body aligns with the hole in the threads on the upper body.

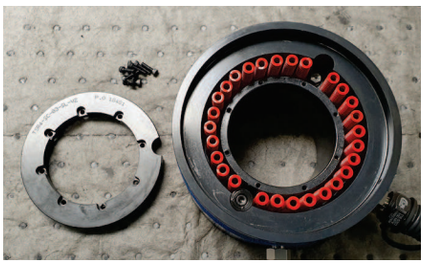
- Install the M6 grub screw back into the body and continue to screw in until the screw is flush with the outer body diameter.
- Finally install new grip tape onto the bodies using the machined groove as a guide.

See Section 3.6 for tensioner pressure test.

3.4 DISASSEMBLY AND ASSEMBLY OF LOAD CELL – TSR+3 & TSR+7



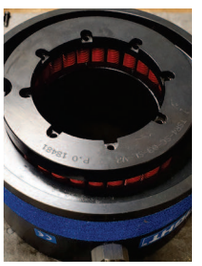
- Place the tool upside down on a flat surface.
- Carefully remove the screws by using a suitably sized Allen key.
- Use a cross pattern as shown, unscrewing a small amount each time. The cap contains the retraction springs and will be under a setting spring force.
- Continue to unscrew each screw in a set pattern until each screw can be removed.



- Remove the spring cap and screws.
- Remove the compression springs.
- Install an open hydraulic fitting to remove any residual pressure.

- Hold the load cell in soft jaw clamps.
- Use a soft end mallet/hammer to gently drive the piston out of the body.

Move to Section 3.5 for seal replacement procedure.

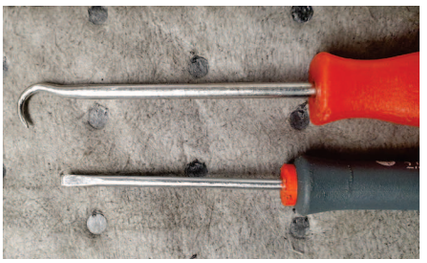


To reassemble the tool follow the steps as follows:

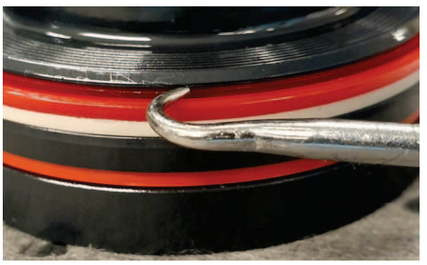
- Ensure that the Piston is lined up with the body by lining up the machined slot in the piston and drilled hole in the body.
- Use a hydraulic press to gently push the piston into the body ensuring both component remain aligned.
- Assemble springs back into the body.
- Assemble the spring cap ensuring its aligned as shown in the image opposite.
- Assemble the cap screws into the spring cap.
- Apply a low strength Loctite (222) on each screw.
- Tighten in a cross pattern in stages to ensure the springs compress equally.
- Continue to tighten the screws until a positive resistance can be felt.

See Section 3.6 for tensioner pressure test.

3.5 HYDRAULIC SEAL REPLACEMENT

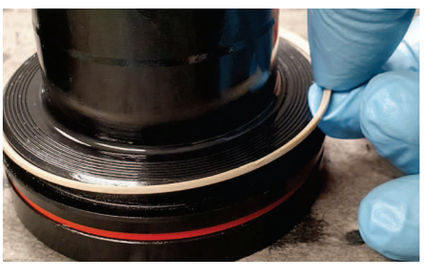


– To assist with changing the seals, a small flat screw driver and a picking hook should be utilised.



– Each seal consists of two parts. A red polymer lip seal complete with an anti extrusion ring.

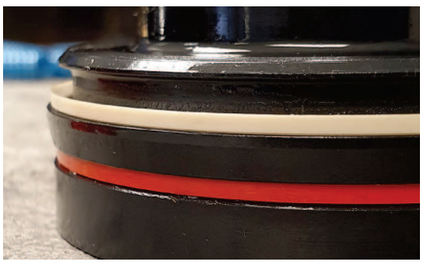
– Using the pick, gently pry out the lip seal taking care not to damage the metal work.



– The lower anti extrusion ring can simply be removed by hand.

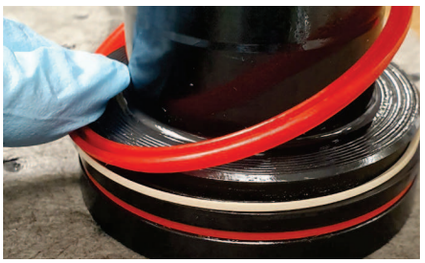
– Repeat the procedure as detailed above for the inner seal.

- Inspect the new seal kit (inner and outer seal) and ensure it is free from damage.
- Apply a thin layer of bearing grease to the surfaces of each of the seals.

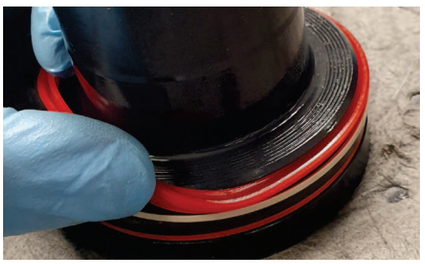


Outer seal installation:

- Install the extrusion ring first.
- Ensure the flat face of the ring sits flat on the piston as shown opposite.

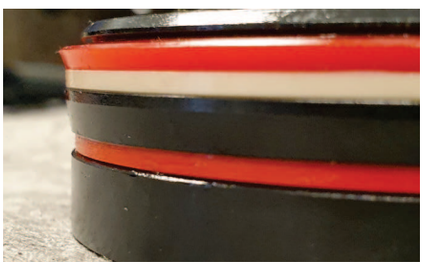


- Install the polymer seal.
- Start the fitment by pushing the seal into seal housing ensuring the lower outer edge of the seal fits behind the anti extrusion ring. The top inner surface of the seal should fit within the seal housing.

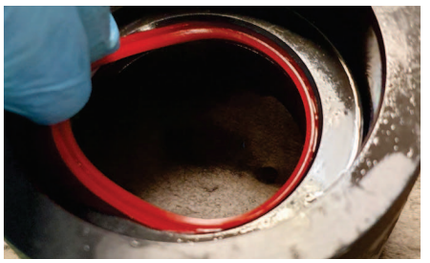


- Continue to feed the seal into the seal groove.
- As more of the seal is pushed into place the tighter the fitment will become. Use increasing force to push the seal into place.

- Once the seal has been placed into the seal housing a flat head screwdriver can be used to push the seal fully into the seal groove.

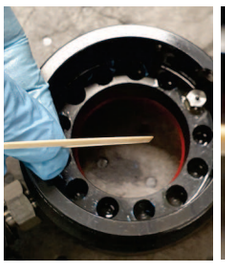


- The image opposite shows a successfully fitted outer seal.

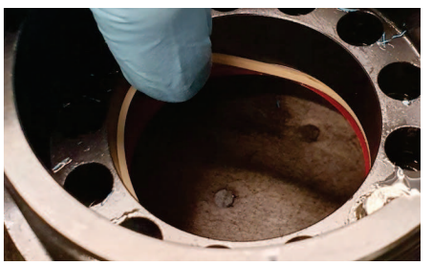


Inner Seal Fitting:

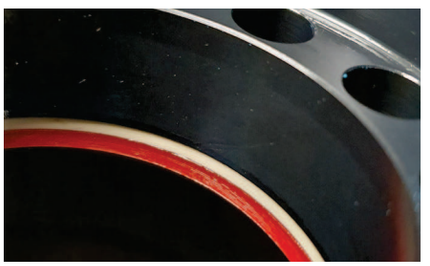
- First start with the lip seal.
- Gently feed the seal into the seal housing ensuring the V section faces the top or into the hydraulic area of the tool.
- Minimal force should be required for installation.



- Rotate the body so that the bottom is now facing upwards.
- Ensure the anti extrusion ring orientation is correct. The flat surface of the ring should face up and react off the seal housing surface opposite the spring holes.



- Fit the ring between the flat metal surface and seal as shown opposite.
- Initial installation will require little force however as more seal is worked in the force will increase and a bulge may be created.
- Use gently downward force to push the ring into the seal housing.



- The image opposite shows a successfully fitted inner seal.

- Once seals have been fitted into the grooves, apply a little amount of grease around the seals before fitting the piston and body back together.
- Place the piston into the bore of the body and using a soft end hammer or press to push the piston into the body.
- Continue to push the piston into the body until the top of the piston is flush with the top of the body.

See Section 3.6 for tensioner pressure test.

3.6 TOOL PRESSURE TEST

Ensure the product instruction manual has been read and that all safety instructions are correctly followed:

- Visual inspect the tooling by checking for defects which may affect the tools operation

  Inspection should include:

- Examination of Puller Threads, checking for damage.
- Examination of the Pullers outer surfaces cracks or deep scoring on external flange radius.
- Overall condition of tooling and any signs of leaking oil.
- Quick connection and adaptor are tightly secured in place.
- Tightness of securing screws – where applicable.
- Overall tool condition.

If in doubt contact your representative for further information.

- Assemble the tensioner to an appropriate test stud, or test assembly.
- Please see **Section 2** for installation procedure.
- Connect the hydraulic tensioner to the pump via suitable hydraulic hose connection.
- Open the isolation valve allowing oil to return back to pumps tank.
- Ensure the Puller has been fully wound down so that it is in contact with the piston and ensure the piston has been returned to 0mm stroke.
- Activate the pump and allow the tool pressure to raise to the tools maximum working pressure of 1500bar **(DO NOT EXCEED THIS PRESSURE)**.
- Once 1500bar has been reached hold the pressure constant for 2 minutes. Note it is normal to see a small drop in pressure as the seal re-seats. If this happens top up the pressure to 1500bar.
- Once the tool has been taken to full pressure the test is complete.
- Disassemble the tools as shown in **Section 2**.

If the tool does not hold pressure or a visible leak can be detected, remove the pressure and perform checks once again. If in doubt contact your representative for further information.

SECTION 4 – TECHNICAL INFORMATION

4.1 OIL PRESSURE CALCULATIONS

The formula widely used to calculate the oil pressure to be used with a bolt tensioning tool is given below along with definitions of the terms used:

Bolt load
Residual Bolt Load required when the tensioning operation is complete.

Tensioning force
The load that will be applied by the bolt tensioner during the tensioning operation.

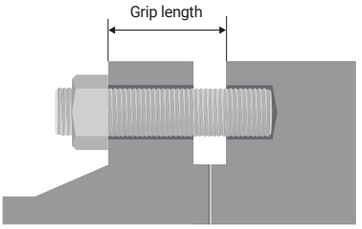
Load transfer factor
The ratio of **tensioning force** to **bolt load**.

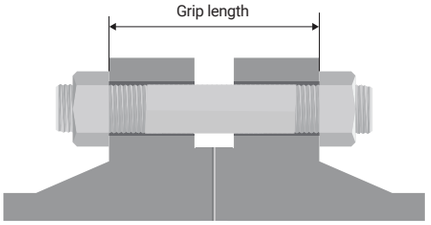
$$\text{Load transfer factor} = \frac{\text{Tensioning force}}{\text{Bolt load}} = 1.01 + \frac{\text{Bolt diameter (mm)}}{\text{Grip length (mm)}}$$

If the **Load transfer factor** calculates to less than 1.10 then use 1.10
Tensioning force = Bolt Load × Load Transfer Factor

$$\text{Oil Pressure (bar)} = \frac{10 \times \text{Tensioning Force (Newtons)}}{\text{Tool Pressure Area (mm}^2\text{)}}$$

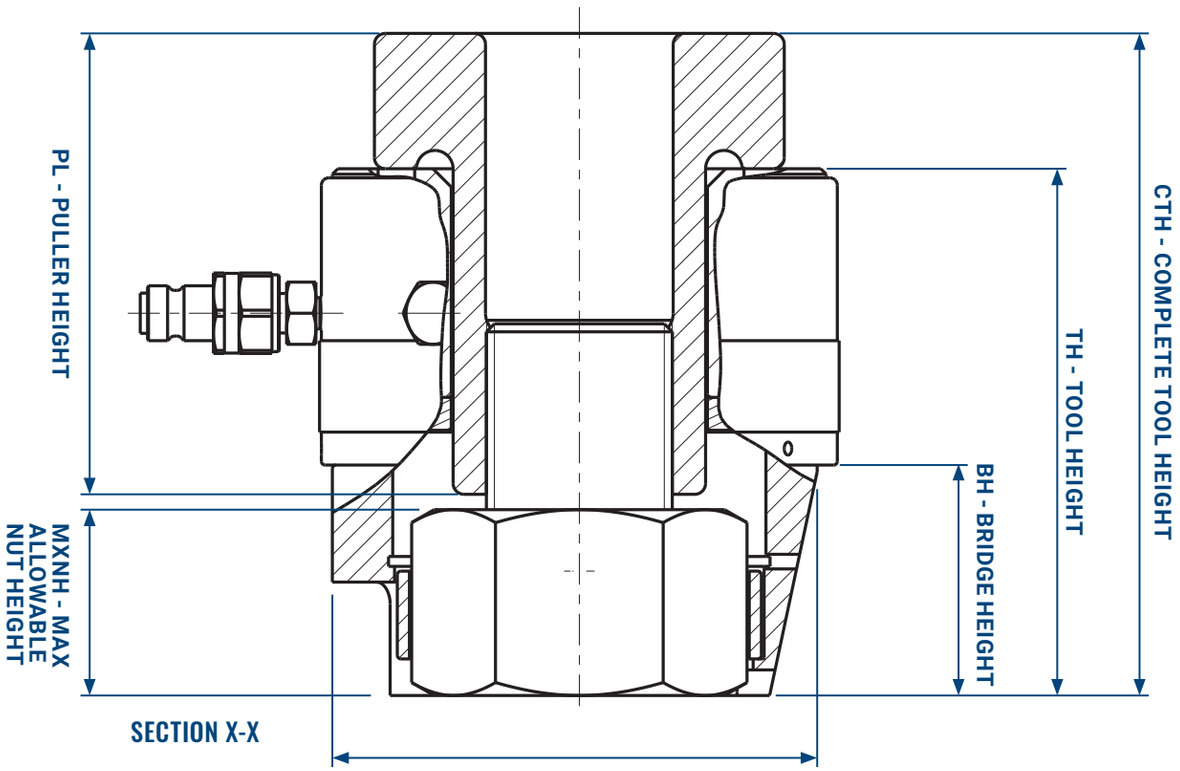
Check that the oil pressure calculated does not exceed the maximum working pressure of the bolt tensioning tool. Users who require highly accurate residual bolt stresses should perform a bolt extension measurement before and after tensioning. In this way residual bolt stresses can be calculated from the actual bolt extensions measured.

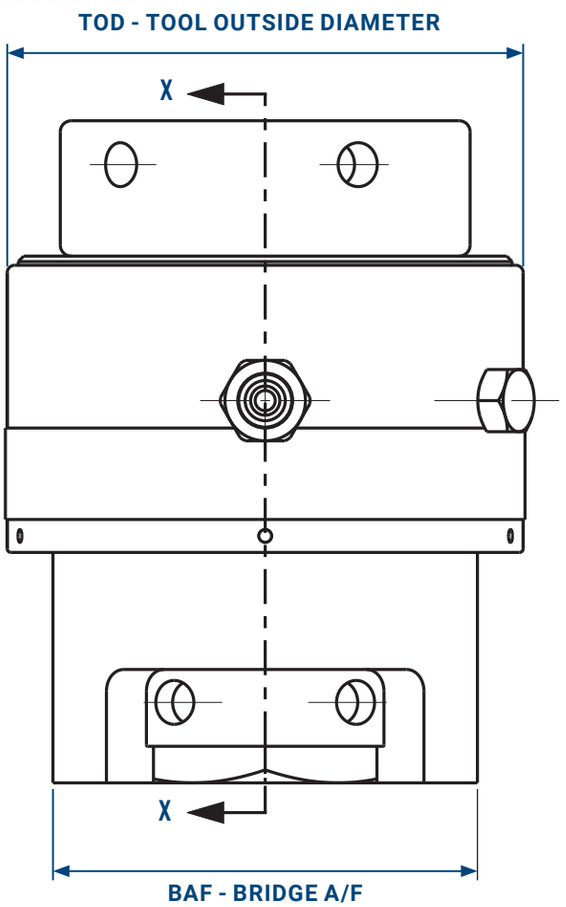




Always check that the tensioning force will not exceed 95% of the yield strength of the bolt material. If it does, the grip length of the bolt must be increased. Please contact your representative for advice on this.

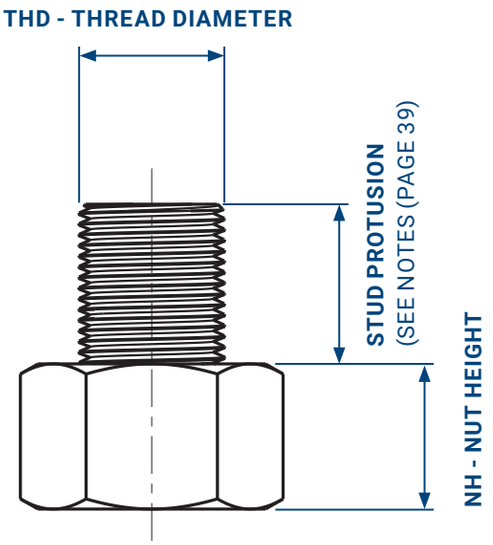
4.2 TOOL SPECIFICATION AND DIMENSIONS

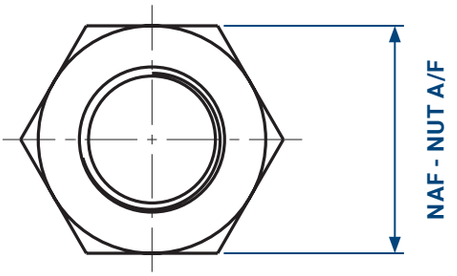




Do not use an oil pressure which will result in an initial bolt stress in excess of 95% of the minimum yield stress of the bolt material.

Refer to **pages 39 to 43** for specific tooling specification & dimensions.





TSR+ tools are designed to following Imperial Nut Dimensions

Imperial Thread Sizes	NAF		NH	
	mm	inch	mm	inch
4 in	155.6	6.125	101.6	4.000
3-3/4 in	146.1	5.750	95.3	3.750
3-1/2 in	136.5	5.375	88.9	3.500
3-1/4 in	127.0	5.000	82.6	3.250
3 in	117.5	4.625	76.2	3.000
2-3/4 in	108.0	4.250	69.9	3.750
2-1/2 in	98.4	3.875	63.5	2.500
2-1/4 in	88.9	3.500	57.2	2.250
2 in	79.4	3.125	50.8	2.000
1-7/8 in	74.6	2.938	47.6	1.875
1-3/4 in	69.9	2.750	44.5	1.750
1-5/8 in	66.5	2.620	41.3	1.625
1-1/2 in	60.3	2.375	38.1	1.500
1-3/8 in	55.6	2.188	34.9	1.375
1-1/4 in	50.8	2.000	31.8	1.250
1-1/8 in	46.0	1.812	28.6	1.125
1 in	41.3	1.625	25.4	1.000
7/8 in	36.5	1.438	22.2	0.875
3/4 in	31.8	1.250	19.1	0.750

TSR+ tools are designed to following Metric Nut Dimensions

Metric Thread Sizes	NAF		NH	
	mm	inch	mm	inch
M100	145	5.71	100	3.94
M95	135	5.31	95	3.74
M90	130	5.12	90	3.54
M85	120	4.72	85	3.35
M80	115	4.53	80	3.15
M76	110	4.33	76	2.99
M72	105	4.13	72	2.83
M68	100	3.94	68	2.68
M64	95	3.74	64	2.52
M60	90	3.54	60	2.36
M56	85	3.35	56	2.20
M52	80	3.15	52	2.05
M48	75	2.95	48	1.89
M45	70	2.76	45	1.77
M42	65	2.56	42	1.65
M39	60	2.36	39	1.54
M36	55	2.17	36	1.42
M33	50	1.97	33	1.30
M30	46	1.81	30	1.18
M27	41	1.61	27	1.06
M24	36	1.42	24	0.94
M22	32	1.26	22	0.87
M20	30	1.18	20	0.79

NOTES

Boltight always recommend to have at least 1xTHD stud protrusion above the nut. If not please make sure the correct amount of thread engagement is achieved before operating.

4.3 TECHNICAL INFORMATION – IMPERIAL BOLT SIZES

Tool No.	Bolt Diameter	Hydraulic Area	Max. Stroke	Max. Load		TOD		TH		
		mm^2	mm	kN	Lbf	mm	inch	mm	inch	mm
TSR+ 0	**3/4**	1,070	8	160	35,970	66	2.60	93	3.66	119
	7/8							93	3.66	119
TSR+ 1	**1**	1,870	10	280	62,950	87	3.43	117	4.61	145
	1-1/8							120	4.72	148
TSR+ 2	**1**	3,000	10	450	101,160	103	4.06	117	4.61	145
	1-1/8							120	4.72	148
	1-1/4							123	4.84	151
	1-3/8							126	4.96	154
TSR+ 3	**1-1/4**	4,400	10	660	148,370	118	4.65	123	4.84	153
	1-3/8							126	4.96	156
	1-1/2							129.5	5.10	159.5
	1-5/8							133	5.24	163
TSR+ 4	**1-1/2**	6,670	10	1,000	224,810	141	5.55	132	5.20	169
	1-5/8							135	5.31	172
	1-3/4							138	5.43	175
	1-7/8							141	5.55	178
	2							144	5.67	181
TSR+ 5	**2**	10,000	10	1,500	337,210	176	6.93	148	5.83	190
	2-1/4							154.5	6.08	196.5
	2-1/2							161	6.34	203
	2-3/4							167	6.57	209
TSR+ 6	**2-3/4**	16,670	10	2,500	562,020	219	8.62	167	6.57	220
	3							171	6.73	224
	3-1/4							180	7.09	233
	3-1/2							186	7.32	239
TSR+ 7	**3-1/2**	21,340	10	3,200	719,390	252	9.92	186	7.32	246
	3-3/4							192	7.56	252
	4							199	7.83	259

* These bridge across flats are designed with across flats set at an angle. The dimension given is the widest distance between the angled across flats.

** Above dimensions & spec refer to tool drawing on **pages 37 and 38.**

	CTH		BOD		BH		BAF*		PL	MXNH (inc. 2mm clearance)	
n	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
9	4.69	62.5	2.46	36	1.42	62.5	2.46	98	3.86	19	0.75
9	4.69	62.5	2.46	36	1.42	62.5	2.46	95	3.74	22	0.87
5	5.71	68	2.68	38	1.50	68	2.68	117	4.61	26	1.02
8	5.83	77.5	3.05	41	1.61	77.5	3.05	117	4.61	29	1.14
5	5.71	75	2.95	38	1.50	75	2.95	115	4.53	28	1.10
8	5.83	80	3.15	41	1.61	80	3.15	115	4.53	31	1.22
1	5.94	87	3.43	44	1.73	79	3.11	115	4.53	34	1.34
4	6.06	92.5	3.64	47	1.85	82	3.23	115	4.53	37	1.46
3	6.02	98	3.86	44	1.73	88	3.46	116.5	4.59	34.5	1.36
6	6.14	107	4.21	47	1.85	88	3.46	116.5	4.59	37.5	1.48
5	6.28	107	4.21	51	2.01	95	3.74	116.5	4.59	41	1.61
3	6.42	107	4.21	54	2.13	102	4.02	116.5	4.59	44.5	1.75
9	6.65	120	4.72	51	2.01	112	4.41	126	4.96	41	1.61
2	6.77	120	4.72	54	2.13	102	4.02	126	4.96	44	1.73
5	6.89	126	4.96	57	2.24	105	4.13	126	4.96	47	1.85
8	7.01	129.6	5.10	60	2.36	111	4.37	126	4.96	50	1.97
1	7.13	135	5.31	63	2.48	116	4.57	126	4.96	53	2.09
0	7.48	150	5.91	63	2.48	134	5.28	135	5.31	53	2.09
5	7.74	158	6.22	69.5	2.74	135	5.31	135	5.31	59.5	2.34
3	7.99	162	6.38	76	2.99	142	5.59	135	5.31	66	2.60
9	8.23	176	6.93	82	3.23	156	6.14	135	5.31	72	2.83
0	8.66	190	7.48	82	3.23	170*	6.69*	146	5.75	72	2.83
4	8.82	200	7.87	86	3.39	181*	7.13*	146	5.75	76	2.99
3	9.17	208	8.19	95	3.74	191*	7.52*	146	5.75	85	3.35
9	9.41	218	8.58	101	3.98	201*	7.91*	146	5.75	91	3.58
6	9.69	225	8.86	101	3.98	200	7.87	153	6.02	91	3.58
2	9.92	235	9.25	107	4.21	208	8.19	153	6.02	97	3.82
9	10.20	245	9.65	114	4.49	210	8.27	153	6.02	104	4.09

4.4 TECHNICAL INFORMATION – METRIC BOLT SIZES

Tool No.	Bolt Diameter	Hydraulic Area	Max. Stroke	Max. Load		TOD		TH		
		mm^2	mm	kN	Lbf	mm	inch	mm	inch	mm
TSR+ 0	**M20**	1,070	8	160	35,970	66	2.60	93	3.66	119
	M22							93	3.66	119
TSR+ 1	**M24**	1,870	10	280	62,950	87	3.43	117	4.61	145
	M27							117	4.61	145
TSR+ 2	**M24**	3,000	10	450	101,160	103	4.06	114	4.49	142
	M27							117	4.61	145
	M30							120	4.72	148
	M33							123	4.84	151
	M36							126	4.96	154
TSR+ 3	**M33**	4,400	10	660	148,370	118	4.65	123	4.84	153
	M36							126	4.96	156
	M39							129.5	5.10	159.5
	M42							133	5.24	163
TSR+ 4	**M39**	6,670	10	1,000	224,810	141	5.55	132	5.20	169
	M42							135	5.31	172
	M45							138	5.43	175
	M48							141	5.55	178
TSR+ 5	**M52**	10,000	10	1,500	337,210	176	6.93	148	5.83	190
	M56							154.5	6.08	196.5
	M60							155	6.10	197
	M64							161	6.34	203
	M68							167	6.57	209
TSR+ 6	**M72**	16,670	10	2,500	562,020	219	8.62	167	6.57	220
	M76							171	6.73	224
	M80							176	6.93	229
	M85							180	7.09	233
	M90							186	7.32	239
TSR+ 7	**M90**	21,340	10	3,200	719,390	252	9.92	186	7.32	246
	M95							192	7.56	252
	M100							192	7.56	252

* These bridge across flats are designed with across flats set at an angle. The dimension given is the widest distance between the angled across flats.

** Above dimensions & spec refer to tool drawing on **pages 37 and 38.**

	CTH		BOD		BH		BAF*		PL	MXNH (inc. 2mm clearance)	
n	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm	inch
9	4.69	62.5	2.46	36	1.42	62.5	2.46	96	3.82	21	0.83
9	4.69	62.5	2.46	36	1.42	62.5	2.46	95	3.74	22	0.87
5	5.71	68	2.68	38	1.50	68	2.68	119	4.69	24	0.94
5	5.71	68	2.68	38	1.50	68	2.68	116	4.57	27	1.06
2	5.59	75	2.95	38	1.50	75	2.95	115	4.53	25	0.98
5	5.71	75	2.95	38	1.50	75	2.95	115	4.53	28	1.10
8	5.83	80	3.15	41	1.61	80	3.15	115	4.53	31	1.22
1	5.94	87	3.43	44	1.73	79	3.11	115	4.53	34	1.34
4	6.06	92.5	3.64	47	1.85	82	3.23	115	4.53	37	1.46
3	6.02	98	3.86	44	1.73	88	3.46	116.5	4.59	34.5	1.36
6	6.14	107	4.21	47	1.85	88	3.46	116.5	4.59	37.5	1.48
5	6.28	107	4.21	51	2.01	95	3.74	116.5	4.59	41	1.61
3	6.42	107	4.21	54	2.13	102	4.02	116.5	4.59	44.5	1.75
9	6.65	120	4.72	51	2.01	112	4.41	126	4.96	41	1.61
2	6.77	120	4.72	54	2.13	102	4.02	126	4.96	44	1.73
5	6.89	126	4.96	57	2.24	105	4.13	126	4.96	47	1.85
8	7.01	129.6	5.10	60	2.36	111	4.37	126	4.96	50	1.97
0	7.48	150	5.91	63	2.48	134	5.28	135	5.31	53	2.09
5	7.74	158	6.22	69.5	2.74	135	5.31	135	5.31	59.5	2.34
7	7.76	162	6.38	70	2.76	142	5.59	135	5.31	60	2.36
3	7.99	162	6.38	76	2.99	142	5.59	135	5.31	66	2.60
9	8.23	176	6.93	82	3.23	156	6.14	135	5.31	72	2.83
0	8.66	190	7.48	82	3.23	170*	6.69*	146	5.75	72	2.83
4	8.82	200	7.87	86	3.39	181*	7.13*	146	5.75	76	2.99
9	9.02	200	7.87	91	3.58	181*	7.13*	146	5.75	81	3.19
3	9.17	208	8.19	95	3.74	191*	7.52*	146	5.75	85	3.35
9	9.41	218	8.58	101	3.98	201*	7.91*	146	5.75	91	3.58
6	9.69	225	8.86	101	3.98	200	7.87	153	6.02	91	3.58
2	9.92	235	9.25	107	4.21	208	8.19	153	6.02	97	3.82
2	9.92	235	9.25	107	4.21	208	8.19	148	5.83	102	4.02

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