11070 Series
11071 Series
11072 Series
Cold Root Rolling Tools
for Rotary Shouldered Connections

Instruction Manual

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Introduction

Congratulations on your purchase of a CJ Winter Cold Root Rolling Tool. These tools have been designed specifically for use in the manufacture of Rotary Shouldered Connections using a CNC lathe. With proper use, these tool will cold root roll threads compliant with ANSI/API Specification 7.2:2008 and ISO 10424-2:2007, and in accordance with specifications NS-1 sub-spec 143 and DS-1 (Third Edition, Volume 3.33.6). This manual will help you use and maintain your tool.

What is Cold Root Rolling?

Cold root rolling is the process of burnishing the root radius of a previously cut thread, in a Rotary Shouldered Connection. A hardened roll, similar in profile to the thread being manufactured, is placed in contact with the root radius of the tapered thread, and pressure is applied to force the roller to penetrate into the cut surface of the root radius, displacing and cold-forming the thread material. This deformation cold-works the material, imparting an improved surface finish and compacts and displaces the grains of the root material. Industry experience with the cold root rolling process has suggested an increase in fatigue life of 3 to 5 times over similar un-treated connections under the same working environment. Some studies have noted laboratory results of up to 27 times better life attributable directly to cold root rolling process [(1)].

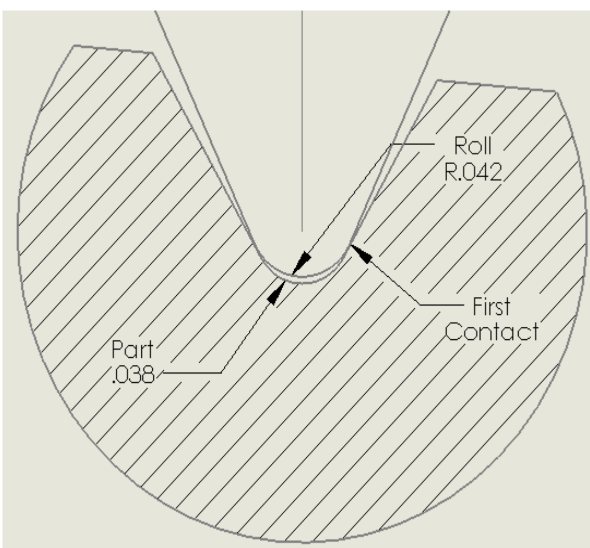


Figure 1: Roll Entering Root Contact

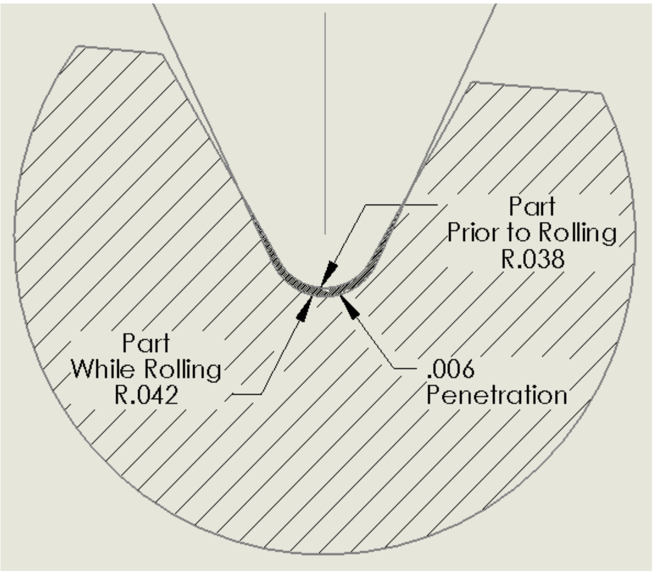


Figure 2: Roll Fully Engaged at .006" Penetration

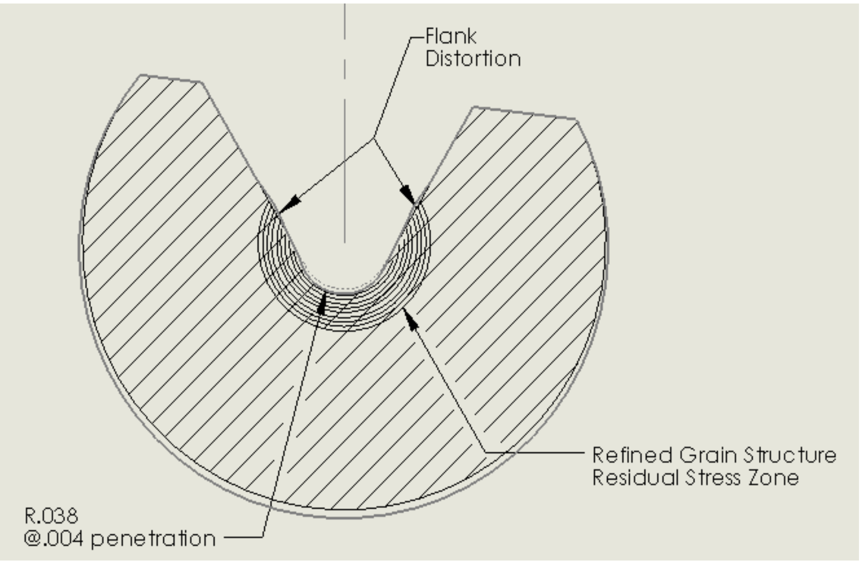


Figure 3: Final Result After Elastic Springback

Various studies have attributed the increase of fatigue life to one or more important effects of cold root rolling:

1. Cold root rolling imparts a thin zone of residual compressive stress in the root region. This residual compressive stress offsets the tensile stresses induced in service, and lowers the overall stress in the critical stress region of the thread root. Figure 4.0 is an illustration of the typical residual stress patterns that remain in the part after cold root rolling, as well as the condition and displacement of material throughout the root rolling process *(Note: the magnitude and depth of the stress plot has been exaggerated for clarity).*

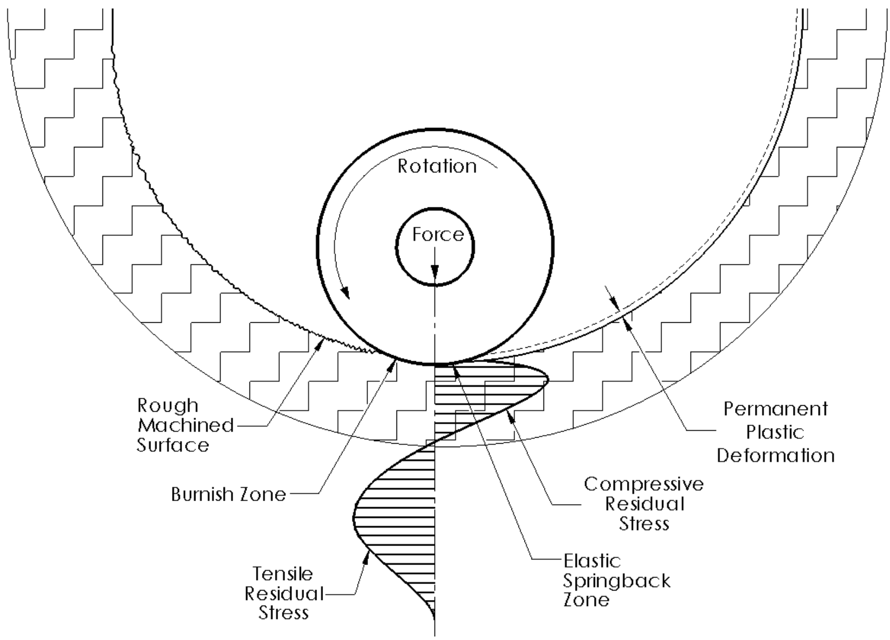


Figure 4: Residual Stress via Burnishing

2. The burnishing effect of the smooth roller on the root radius causes the small scratches and ridges left by the threading insert to flatten into a more uniform surface. These scratches have very small tip radii, at the leading edge, or bottom of the scratch. These small tip radii are considerable stress concentration factors, in one of the most highly stressed regions of the drill string connection. As a result, these scratches are the crack propagation points for most fatigue failures. Any method that minimizes or eliminates them enhances fatigue life.

3. Scratches provide prime locations for chemical erosion. The microscopic surface of a scratch is very jagged and porous, exposing a large surface area, and numerous molecular bonding sites, to the corrosive effects of liquids and gasses present in a drill string environment. The burnishing smoothes this surface, presenting a densely compressed and uniform surface. This burnishing eliminates outcroppings and inclusions, minimizes surface area, and inhibits chemical attack.

4. Root rolling the connection has a work-hardening effect on the surface of the material. On a molecular scale, the displacement of the crystalline lattice within the steel grain structure causes the crystal structure to change from a repetitive and uniform atomic structure, to one with many dislocations in the pattern. These dislocations in the iron matrix cause the crystal structure to interlock, and become more resistant to further deformation. This added resistance to deformation at the surface of the material helps prevent cracks from starting, and helps arrest microscopic cracks from growing into structural flaws that threaten the integrity of the joint. In lab studies, cracks that have occurred in cold rolled joints have exhibited a significantly lower Crack Aspect Ratio (Crack Length/Crack Depth). A 30% to 50% lower CAR means that cracks in cold root rolled products are more likely to be deep and short (as illustrated by the crack at the top of the pipe shown in Figure 5), rather than long and shallow (as illustrated by the crack at the bottom). A shallow crack is more likely to lead to a sudden and complete structural failure of the joint. A deep crack that partially penetrates the section wall is detectable via pressure drop of circulating drilling fluids, and allows for an early recovery of damaged string prior to complete structural failure of the joint [1].

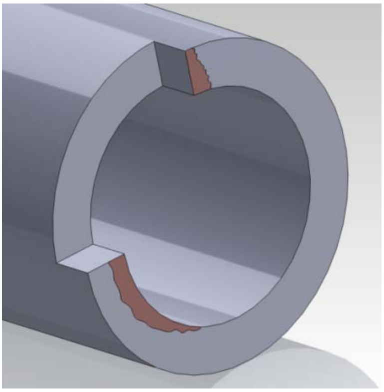


Figure 5: Crack Aspect Ratio

Why Root Roll Rotary Tapered Connections?

Cold Root Rolling is a requirement of DS-1 sec. 3.3.66 and NS-1 sub-spec 143, which require all new and re-cut BHA and HWDP connections with API thread forms to be Cold Root Rolled.

Cold Root Rolling is also a money saving process. Cold Root Rolling can drastically increase the fatigue life of each rotary shouldered connection in a typical drill string. It can also reduce the frequency of repairing connections in the field, and of having to fish for down-hole failures. With the increasing popularity of extended reach drilling, multi-lateral wells, "hard rock" and horizontal well applications, the stress and bending moments being placed on rotary threaded connections, plus the sheer number of rotary threaded connections being placed into service, is growing each day [(2)]. With these increased stresses, and increased number of connections, also comes the increased chance of a down-hole failure of the drill string. T.H. Hill estimates that the cost of a single down-hole failure can surpass 1 million dollars [(3)]. With that kind of risk, Cold Root Rolling is cheap insurance, significantly reducing costly drill-string failures.

Why Use CJ Winter's Cold Root Rolling Tools?

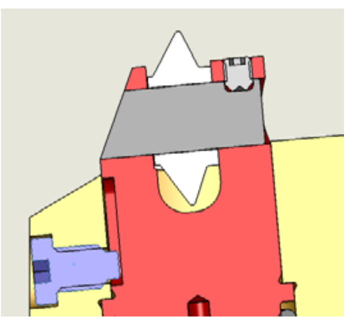
For over 45 years CJ Winter has been an industry leader in supplying thread rolls and thread rolling tools globally. CJ Winter has used that experience to design tools specifically for Rotary Shouldered Connections in the Petroleum Industry. We believe this is the only self-contained, commercially available tool that will cold root roll threads compliant with ANSI/API Specification 7.2:2008 and ISO 10424-2:2007, in accordance with NS-1 cold root rolling procedures, and DS-1 Third Edition, Volume 3.33.6. Our in-house engineering staff is always available to assist with any technical manufacturing situation.

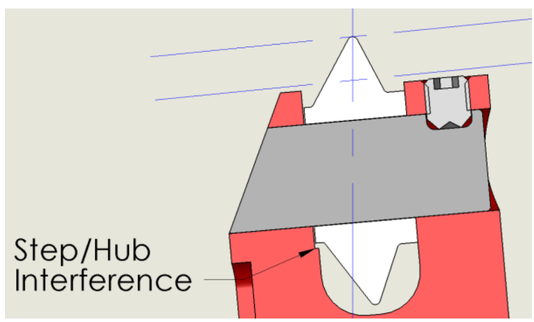
The CJ Winter cold root rolling tools and rolls also have some unique advantages.

This tool does not require an external power device to pressurize the roller piston. No hoses to tangle, no shut-off valves to leak, no manual pumps to lose. The only thing required to pressurize this tool is socket wrench.

This tool does not require an external accumulator to roll the run-out thread. It is a requirement of both NS-1 and DS-1 to maintain full pressure on the roller until the last remnant of the run-out thread [(4)]. This requirement either forces perfect synchronization of the retraction of the cutting tool and roller, or an accumulator to allow the roller to retract into the holder body. Since perfect synchronization can be exceedingly difficult, the CJ Winter holder comes standard with an integral accumulator to allow for the extra roller travel in this critical region.

The rolls in this tool *cannot* be loaded incorrectly. Rotary Tapered Connections use threads that are tapered. The rolls and roll pins on a Cold Rolling tool are tipped slightly to minimize side forces on the rolls and tool components as they travel up that taper. Because the form on a standard API roll is not symmetric, assembly orientation is critical. When using OEM supplied rolls with the **EPL® system** *(Error Proof Loading® - Patents Pending),* rolls CANNOT be loaded backwards. Unlike other tools, you do not rely on an imprecise and often over-looked, visual verification of the 5° skew on the thread form. The EPL system uses an asymmetric hub system where the hub on one side of the roll is larger than the other. The asymmetric hubs work in conjunction with a step in the roll holder to create Step/Hub interference if the user attempts to load the roll backwards. This eliminates this all too common mistake that can ruin a Rotary Shouldered Connection, and require a connection to be re-cut, or discarded.





This tool requires no conversion between the values of hydraulic pressure, and roller force. To simplify the process and reduce the chance for a damaging error, the numerical values of the pressure gauge are the same for both PSI and Lbs force. Because we designed our working piston to be Ø1.128", which has an area of 1.00 in^2, no confusing lookup table is required to convert 1 PSI to 1 pound of force.

The supplied pressure gauge is liquid filled, and comes equipped with max indicating pointer so values can be observed after the cycle is complete, rather than during cycle with moving parts and coolant spraying about the lathe. The liquid filled gauge is IP67 rated against coolant ingress, and comes with NIST traceable certification from CJ Winter.

The 11071-SA series will roll all standard API Rotary Shouldered PIN connections.

The 11070-SA series will roll all standard API Rotary Shouldered BOX connections in the following ranges.

NC38 thru NC70
4-1/2 REG thru 8-5/8 REG
5-1/2 FH and 6-5/8 FH

Package Contents

This tool is shipped complete with everything you need to roll your thread roots (except hydraulic oil where shipping restrictions apply). In addition, you have been provided with all required non-standard tools and several spare parts, mostly hardware and seals, in the event one becomes damaged or lost. We don't want to shut down your line because someone dropped a set screw.

In the event you need a spare, each part (size permitting) is permanently identified with laser-marked part # for easy identification, and replacement.

The tool is supplied in a robust case designed specifically to protect your tool in shipping and at the job site, and to safely store your spare parts and user manual when not in use.

Machine Mounting

Both the 11070 series for Boxes and the 11071 series for Pins, mount to the CNC lathe tool holding turret via a shank that is available in standard Ø2.00", Ø2.50" and Ø65mm sizes. Other shank diameters are available on a custom order basis. Drill bushings can also be used to adapt to larger tool holders.

For most 11070 and 11071 variants, your tool holder must be able to accommodate a 4.25" long cylindrical shank. For models with shanks Ø2.375" or smaller, your tool holder must accommodate a longer, 5.50" shank. Most CNC lathes have more than adequate clearance behind the tool holder to accommodate this length of tool, but every new installation should check for possible interference with this tool, particularly during index of a tool turret. Overall dimensional drawings are available from our sales department to help determine which tool best fits your machine application.

These 11070 and 11071 tools are intended to be mounted in non-rotating, end-working tool holders. The shank should be fully inserted into the tool holder, right up to the shoulder, and retained using setscrews hand-tightened against the factory-supplied flat on the shank. Due to the thin walls of the accumulator (located inside the shank), and the forces required to Cold-Roll threads, we DO NOT recommend any portion of the shank be extended unsupported from the holder.

The 11072 series of tools for Pins mount directly to square shank turrets of a CNC lathe. This compact, low-profile tool is available for lathes with limited room for tooling, and has a profile that is less intrusive in a typical OD turning set-up. It is available in a 1.25" square shank as standard, but can be manufactured in 1.00" square, 1.50" square, and 25mm thru 38mm metric sizes. Other mounting systems can be evaluated by CJW Engineering upon special request.

Modification of these tools is not recommended. If you feel the need to modify your tool, please contact CJ Winter for technical advice.

Filling the Tool

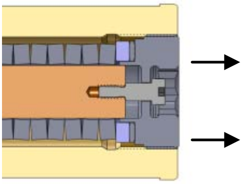
Your tool will typically come pre-filled from the factory, unless shipping regulations to your location prohibit it. If required, fill the tool with hydraulic oil and bleed out air prior to first use. This tool can be filled with any petroleum-based hydraulic oil.

The use of synthetic hydraulic oil, or additives known to have compatibility issues with Nitrile, is not recommended.

This may lead to leakage and ineffective rolling. Please check with your lubricant supplier to insure the compatibility with Parker compound Nitrile N674-70.

To fill 11070 or 11071 series tools:

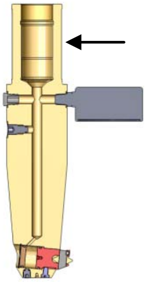
1. Remove the NPT plug where you wish to mount the gauge. Completely remove the course adjustment screw and accumulator assembly from the rear of the tool. Re-apply "never-seize" or similar thread lubricant to the threads prior to re-installation.



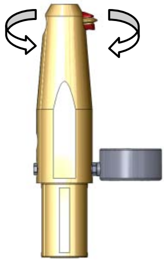
2. Clean the NPT threads with a wire brush. Install the gauge with ***Loctite® 5452 Fast Cure Thread Sealant*** into the indicated hole. Use of other thread sealants may require unacceptably long cure times, often a few hours or days, to reach the strength required to adequately seal a 10,000 psi connection.

Never operate tool with any plug or gauge that was not provided by CJ Winter. This tool is under extreme pressure when rolling, and most commercially available fittings will leak or fail under these loads.

3. Wait a minimum of 5 minutes for the thread sealant to cure (up to 30 minutes if room temperature is below 70°F, down to 32°F). Pull outward on the roll holder cylinder to ensure it is fully extended. Place the tool in a shallow oil drip-pan. Tip the tool upright, and fill the rear reservoir with oil within roughly 3.0" from the top. Replace the accumulator assembly. It may not be possible to thread the assembly in yet, but the o-ring should seal the oil.

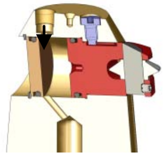


4. Flip the tool so the roller end is towards the top, and rock it back and forth several times, leaning towards and then away from each threaded port, to allow all air bubbles to rise to the top of the tool.



5. Place the Allen® driver and socket wrench into the course adjustment screw, and allow the tool to lay in the drip pan.

6. Slowly remove the air purge plug. Cover this port with a rag to prevent a sudden spray or jet from escaping air and oil. Make sure the o-ring on the plug nose is still in place.



7. Gently push down on the tool, fully inserting the course-adjust screw in the rear of the tool. Rotate the tool, threading in the course adjusting screw that is prevented from spinning by the socket wrench, until oil starts to exit the air purge hole.

8. Continue threading in the coarse adjust screw until between .125" to .250" stands out from the back of the shaft. It may be necessary to add or remove oil thru the air purge port to achieve this standout.

9. Replace the purge plug. Make sure the o-ring is seated on the plug nose.

10. Ensure all fittings are pressure tight. Due to the significant torque that must be applied to the screw, we suggest securing the tool in a machine's tool holder or sturdy bench vise. Wipe the tool down to remove any excess oil, and turn the coarse adjust screw in until the pressure gauge reads the maximum pressure required for your application. Failure to reach this pressure indicates inadequate oil in the reservoir, entrapped air, or a leak. Absent of leaks, a slow but steady decrease of the pressure for the first few hours is normal, as the spring pack and o-rings take a set. This process can be accelerated by raising and lowering the pressure thru the range of 1000 to 4500 psi five to ten times.

DO NOT check for fluid leaks with your hand. Look for pooling of oil near fittings, and use a rolled up piece of paper, or some similar object if you suspect you may have a leak.

To fill 11072 series tools:

1. Remove the course adjustment screw from the tool and apply "never-seize" or similar thread lubricant. Re-install, leaving .188" to .125" protruding.

2. Pull outward on the roll holder cylinder to ensure it is fully extended. Orient the tool on the bench so that the rear fill port plug is facing upwards. Remove the plug, and make sure the o-ring on the plug nose is still in place.

3. Fill the syringe supplied with your tool with 35 cc's of hydraulic oil. You typically only need 30 to 33cc's of oil to fill this tool, but fill amount will vary depending on the settings of the various adjustment screws.

The use of synthetic hydraulic oil, or additives known to be incompatible with Nitrile, is not recommended.

This may lead to leakage and ineffective rolling. Please ask your lubricant supplier to insure the compatibility with Parker compound Nitrile N674-70.

4. Insert the syringe until it meets resistance (roughly 3"), and fill the tool. Stop when the oil starts to bubble up near the top of the fill port.

5. Replace the fill port plug. Make sure the o-ring is seated on the plug nose.

6. Remove the second fill port plug located on the large chamfer angle, once again checking for the o-ring.

7. Orient the tool so that this port is the highest point on the tool, and all faces are at roughly 30 to 45 degree angles to your workbench. Insert the syringe, and continue filling the tool. Once oils starts to bubble near the top of the port, stop.

8. To bleed any air bubbles that may be trapped in cross-holes, please tip the tool in various directions, always keeping the open port near the top of the tool. Top off with oil until the port seat is covered. Re-insert port plug.

9. Ensure all fittings are pressure tight. Due to the significant torque that must be applied to the Coarse Adjust Screw, we suggest securing the tool in a tool holder or sturdy bench vise. Wipe the tool down to remove any excess oil drips, and turn the coarse adjust screw in until the pressure gauge reads the maximum pressure required for your application. Failure to reach this pressure indicates inadequate oil in the reservoir, entrapped air, or a leak. Absent of leaks, a slow but steady decrease of the pressure for the first few hours is normal, as the spring pack and o-rings take a set. This process can be accelerated by raising and lowering the pressure thru the range of 1000 to 4500 psi five to ten times.

Safety

When the tool is pre-charged the hydraulic fluid is under tremendous pressure.

DO NOT replace any components with non OEM components.

All the OEM supplied components have been designed and rated to operate safely at up to at least 8,000 lbs, which is more than twice the maximum required roller force for any standard API Rotary Threaded Connection. Hydraulic fluid under pressure can be very dangerous. A pinhole leak can puncture the skin, injecting toxic fluids into body tissue, or in extreme cases, even slicing soft tissue.

DO NOT check for fluid leaks with your hand.

Use a rolled up piece of paper as a wand, or some similar object if you suspect you may have a pinhole leak. Also, the pressure can propel components such as plugs and gauges should they come loose from their mounting threads. CJ Winter recommends every precaution be taken whenever the tool is under pressure, that would normally be used around hydraulic machinery.

WEAR SAFTEY GLASSES.

Whenever practical, use this tool in a CNC lathe with an enclosure, and keep the door closed. When servicing the tool, relieve the pressure using the coarse adjust screw BEFORE removing any other component. Do not remove any plugs, the retaining ring, or the gauge until the pressure reads near ZERO. If you are injured at any time when using or servicing this tool, follow your company procedure for reporting injuries and seek medical attention immediately.

Periodic Maintenance

CJ Winter recommends an annual teardown and inspection of this tool.

We recommend the periodic replacement of the o-rings in the tool, as well as a replacement of the Bellville washer stack. The frequency of replacement depends greatly on the severity of service the tool sees, the type of connection being rolled, and the adherence to proper setting and operation procedures. The frequency should be determined by your own in-shop experience, and be scheduled in a preventative manner. At a minimum, we recommend replacement of these components during the annual inspection.

The supplied gauge is certified with NIST traceability. NS-1 and DS-1 specifications require the gauge be recalibrated every 6 months. You can perform this re-certification in-house, or C.J. Winter can perform this service for you. Contact C.J. Winter sales for pricing and delivery. We also suggest stocking one extra gauge per facility to be used while others are out for calibration.

ONLY replace this gauge with an OEM supplied replacement.

This gauge, as well as all the plugs, retaining rings, and other components supplied with this tool, have been rated for the anticipated pressure spikes of the Cold Root Rolling process. Replacement with unapproved aftermarket gauges or hardware could compromise the function and safety of the tool.

The remaining components are not generally considered "wear" parts, and should be replaced only in the event of damage or excessive wear.

For safety reasons, CJ Winter does not recommend modification of any part of this tool.

Quality Control

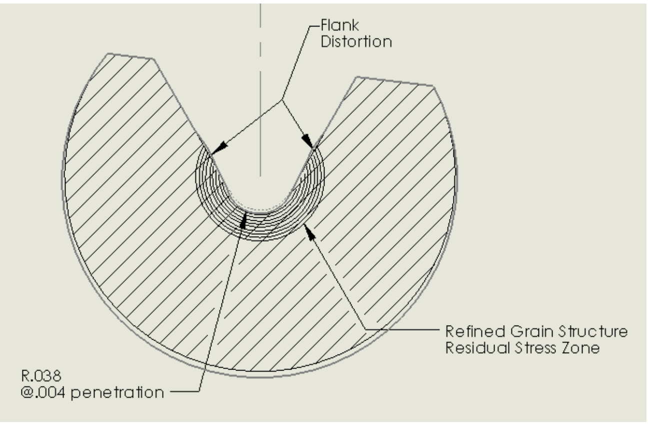
Per API Spec 7-2 section 7.5, Cold Root Rolling is performed after a connection has been inspected and certified to conform to the proper thread specs.

Cold Root Rolling displaces material on the root of the thread, which will cause an increase in thread depth, and often will slightly distort the thread flanks.

As a result, attempts to use thread gauges used after Cold Root Rolling may show a change in the gauge standoff. This change is anticipated and permissible by API Spec 7-2 section 7.5, and will not affect the interchangeability of connections [(5)].

Prior to Cold Root Rolling, both NS-1 and DS-1 specifications require the thread root be cleaned and inspected for scratches that visually are estimated to exceed .002". Scratches exceeding .002" may leave remnant defects after Cold Root Rolling, and are not allowed [(4)].

After Cold Root Rolling, a visual inspection under 10x magnification shall be performed to ensure the root has been burnished, and has a smooth and shinny appearance. Quantitative inspection should be performed using an appropriate micrometer and anvil tip to measure tooth depth, as described and illustrated in API 7-2 Section H.4.3. The NS-1 specification requires an increase in tooth height of .002" to .006". The DS-1 recommends ***(but does NOT require)*** a minimum of .004" increase in tooth depth after cold rolling [(4)].



Setting the Roller Pressure

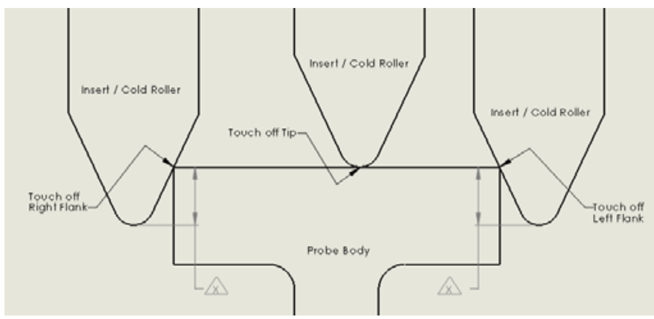
Mount the tool in the turret, and pre-charge the tool pressure to 95% of the value below. During the first use, there may be a gradual pressure drop as the o-rings and internal springs take a set. Before and after rolling, monitor the tool pressure to ensure the displacement of the roller raises the pressure the remaining 5% to the MINIMUM chart value. If there is an insufficient rise pressure, there may be too little contact between the roller and part. A tool offset should be made to increase the roller contact, which will raise the pressure to meet the NS-1 and DS-1 force requirements listed below [(4)]. NOTE: The work cylinder is Ø1.128, which has an area of 1.00 in^2. The conversion of PSI to pounds of force is 1:1.

Connection	Thread Form	Req. Roller Force (lbs) (1PSI = 1 Lb force)		Recommended CJW Roller	
		Pin	Box	Pin	Box
NC23	V-0.038R	1575	3375	EPL-038-P1	-
NC26	V-0.038R	1800	3150	EPL-038-P1	-
NC31	V-0.038R	1800	2925	EPL-038-P1	-
NC35	V-0.038R	1800	2925	EPL-038-P1	-
NC38	V-0.038R	1800	2925	EPL-038-P1	EPL-038-B1
NC40	V-0.038R	1800	2700	EPL-038-P1	EPL-038-B1
NC44	V-0.038R	1800	2700	EPL-038-P1	EPL-038-B1
NC46	V-0.038R	2025	2700	EPL-038-P1	EPL-038-B1
NC50	V-0.038R	2025	2700	EPL-038-P1	EPL-038-B1
NC56	V-0.038R	2025	2700	EPL-038-P1	EPL-038-B1
NC61	V-0.038R	2025	2475	EPL-038-P1	EPL-038-B1
NC70	V-0.038R	2025	2475	EPL-038-P1	EPL-038-B1
NC77	V-0.038R	2025	2475	EPL-038-P1	EPL-038-B1
2-3/8 REG	V-0.040	900	1800	EPL-040-P1	-
2-7/8 REG	V-0.040	900	1575	EPL-040-P1	-
3-1/2 REG	V-0.040	900	1575	EPL-040-P1	-
4-1/2 REG	V-0.040	900	1350	EPL-040-P1	EPL-040-B1
5-1/2 REG	V-0.050	1350	1800	EPL-050-P1	EPL-050-B1
6-5/8 REG	V-0.050	1350	1800	EPL-050-P1	EPL-050-B1
7-5/8 REG	V-0.050	1350	1575	EPL-050-P1	EPL-050-B1
8-5/8 REG	V-0.050	1350	1575	EPL-050-P1	EPL-050-B1
5-1/2 FH	V-0.050	1350	1800	EPL-050-P1	EPL-050-B1
6-5/8 FH	V-0.050	1350	1800	EPL-050-P1	EPL-050-B1

Preparing the Tool

First, install the appropriate roller in the roll holder. We recommend using CJ Winter's EPL series of cold rolls in this tool. EPL series rolls are designed with the Error Proof Loading system, to ensure the asymmetric rolls used in Cold Root Rolling are loaded in the proper orientation. When inserting the roll, make sure the bore and pin are clean, and lubricated with EP grease or oil.

Many modern CNC's will have tool probing capable of pre-setting the X and Z location of both the centerline of the thread insert, and the centerline of the roll. To establish an accurate centerline, first probe the X location by touching off the tip. Next, touch off each flank of the tool, making sure that both sides of the tool are probed using the same Δ X offset. The average of the two location values will be the centerline of the tool.



On machines without probing, the operator will "touch-off" the END of the tool's body to a qualified face, and "touches-off" the insert or roll tip to the OD of the part. Since the distance between the end of the tool's body and the centerline of the thread form is different between the thread insert and the roll, the length of the rolling tool must be compensated. Consider this example... if the insert's thread form centerline to the end of the tool body is .250", but the distance on the roll is .750", the "touched off" length of the cold-root-rolling tool must be shortened by .500", so that the thread insert, and roll line up when programmed to go to the same Z-axis point. These measurements require precision equipment like an optical comparator for best results.

On some newer Mazak lathes, Mazatrol offers an option called "re-thread", which greatly simplifies the synchronization of two threading tools. To use "re-thread" simply jog the machine until the roll is partially engaged in the pre-cut thread. Spin the roll by hand, and then slowly jog the machine towards one flank until the roll binds. Note the Z-axis position, and then jog the machine until the roll binds on the opposite flank. Move the roll back to the average of the two binding points. Lastly, jog the machine down into the thread until the roll binds on the root. "Teach" this as the roll position. When "re-threading" with this tool, the thread path will be synchronized.

The Cold Rolling Procedure

API 7-2 does not dictate a procedure for the cold rolling process. Speeds, pressures, even roller geometry are left to the discretion of the user.

Both NS-1 and DS-1 however, outline many of these parameters, and may be specified by your customer or end user as a requirement for their connections. For example, the full recommendations of DS-1 can be found on pages 83 thru 85 of volume 3, third edition [(4)]. In the event your customer requires strict adherence to any third-party specification, and our procedure differs in any way, we suggest you consider the customer requirements to supersede ours.

We suggest cleaning and gauging the thread just prior to Cold Root Rolling to avoid possible thread contamination. Flood coolant should be activated during the Cold Root Rolling Operation.

To set the penetration amount of the roller into the root, we suggest using tool wear or tool geometry offsets rather than changing the part diameter in the CNC threading canned cycle.

On most machines, changing the part diameter, SFM or RPM, or Z start point of the cut, can affect the angular start point relationship of the cut vs. rolled thread, and cause a mismatch between the tool paths that would be detrimental to part quality and roll life.

For the purposes of cold root rolling, the roller should be introduced at the same, or similar, depth of cut for each of 3 passes as required by the NS-1 and DS-1 specs.

NS-1 *requires* a minimum increase in tooth height after cold rolling of .002" to .006". DS-1 *recommends,* but does not *require*, a minimum increase in tooth height after cold rolling of .004" [(4)]. To achieve these result, a wear offset of double the per-side penetration, or at least .008", would need to be used. In practice, a much larger wear offset will likely be required to accommodate both the elastic spring-back of the thread material, as well as any deflection in the tool and machine. This offset can be .200" or more to achieve the required pressure and recommended penetration. While this may seem like an excessive offset, the majority of this penetration is absorbed internally by the moving piston of the tool, and the resulting loads on most styles of machine tools are generally similar to the forces encountered during the thread cutting process.

Speed of Cold Root Rolling

The surface speed at which root rolling occurs is not generally a significant contributor to part quality. Using the same RPM and a similar tool path for both the thread cutting insert as well as the thread roller greatly simplifies the synchronization of the two tools, such that the roller follows the same path that has been previously cut, and does not exert any forces on the thread flanks.

However, in reality that is not always practical. Lower rolling speeds help to reduce galling and wear of the roller/pin interface, but higher speeds are more productive. While rolling at the same RPM that the thread is cut is usually advantageous from a set-up standpoint, roll burnishing speeds should be limited to a maximum of 60 SFM for internal, and 100 SFM for external threads for reasonable roller life. When running high-load applications, such as small box threads, non-magnetic or work-hardening materials, we recommend reducing the SFM by 50% or more from these maximums to avoid galling. We also recommend using a spray lubricant or oil-can to re-apply lube to the roll ends, and spin the roll manually to feel for signs of galling just prior to each rolling attempt.

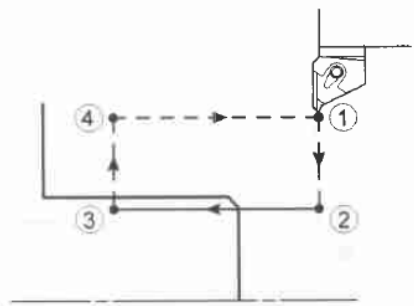
CNC Programming

The roller tool path must be synchronized to the previously cut thread. To accomplish this, we recommend using a similar canned threading cycle for both thread cutting and Cold Root Rolling. On most CNC controllers, this is best accomplished with CAM generated G32 cycles, or a combination of G72 and G32 cycles, using the similar OD, Lead, Taper Angle, start and stop points, chamfers, and speeds.

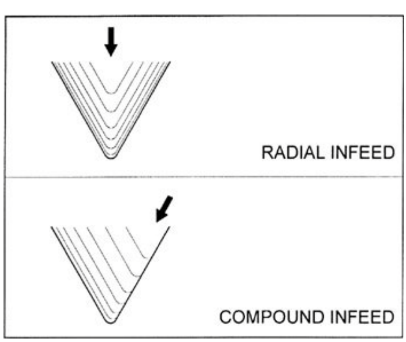
There are 3 distinct CNC programming methods that can be used to generate and cold-roll threads. G32, G92 and G76. Each will get the job done, but some will be easier to setup, synchronize, and ensure proper operation. Your shop may be familiar with a programming style that has worked well for thread cutting with a single insert in the past, but that programming style may not lend itself well to the synchronizing of multiple tools required in Cold Rolling. We will go into a detailed description of all three threading cycles, and their strengths and weaknesses, but for cold rolling, we recommend the G32 method detailed here over all others.

- ## G32 Threading Command

G32 is the most basic, but also the most versatile, of the threading commands. A G32 line is similar to a G01 linear feed move, except that feed is defined as per revolution, and feed rate is valid only in one axis. For the tapered threads found on Rotary Shouldered Connections, even though the move is in both X and Z axis, feed is controlled and defined by the Z-axis movement ONLY.

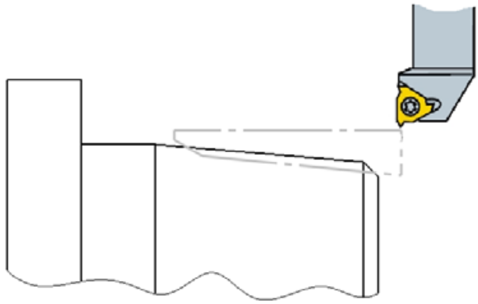


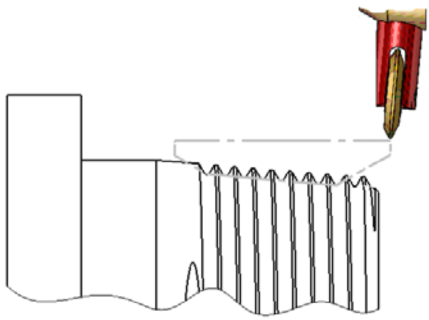
G32 is also a simple, 1-motion command. It controls the thread generation motion ONLY (from point 2 to point 3). It does not retract the tool from the cut (3 to 4), it does not back the tool out to the start plane in Z (4 to 1), and it does not feed the tool to the proper depth for the next cut (1 to 2). These motions must be independently programmed as separate lines. As a result, the multiple passes that are required to cut a thread to full depth, require at least 4 lines of code for every depth of cut. For a deep thread with 15 passes required for the various depths of cut, this can be a block of code exceeding 60 lines. Attempting to change variables like the start and end points, the amount of taper, or the depth of cuts while at the machine can be very challenging and time consuming. The use of a CAM program for off-line programming can greatly simplify this.



G32 threading typically uses a radial-style infeed, where the thread insert cut each progressive deeper pass straight down the center of the tooth form. This style of infeed is generally not optimal. It places a long insert edge in contact with the work piece at every pass, and creates a V-profile chip that is harder to break, and places greater stress on the cutting insert. Radial infeed can lead to premature insert failure, chatter, lead errors. The operator's remedy is usually to decrease the depths of cut for any given pass, which will lead to an excessive number of passes, and a longer cycle time. However, with the use of a CAM program, the infeed style is generally selectable, and the X and Z values for each G32 line will be automatically compensated to achieve a compound infeed.

When it comes to cold root rolling, G32 programming has a notable advantage over the other threading commands. Multiple G32 lines can be written on consecutive program lines that have non-collinear geometry. In other words, three G32 commands can be written on back to back lines, the first for a decreasing tapered thread, the second for an increasing tapered thread, and the last for a exit chamfer. The pitch between the threads will be maintained throughout the transitions. This can come in very helpful if, for example, you want to burnish the exit chamfer thread, or if you want the roll to only burnish some of the threads, but not all of them. CJ Winter suggests using 3 consecutive G32 lines for the cold-root-rolling tool. The first G32 line should be on a reverse taper, so the burnishing roll "drops into" the pre-cut thread and engages the thread 3 pitches past the start of the thread. The second G32 line should follow the thread taper up to the shoulder. The last G32 line should exit the "last scratch" thread at the same taper angle as the thread insert. The roll should then rapid away from part contact by at least the magnitude of the pre-load wear offset, then rapid back out to the Z-axis start point, and lastly rapid down to the X-axis start point. This 6 line sequence ensures the roll is always supported on both sides by the cut thread as load is applied, reducing the side load on the roll, and avoiding any blemishes to the leading chamfer on Pins, and C'bores on Boxes. It also ensures full rolling pressure is applied throughout the last scratch region, and the roll will clear the thread crest upon retraction.





An example of G32 code for a NC38 pin connection is provided here:

<u>G32 Code for NC38 Pins</u>

```
%
O0001 ( NC38 pin Threading-Burnishing )
M69
G99 G54 G18 M46
G0 G28 U0.
T07                                   (Thread Cutting Insert)
Z1.
G97 S400 M03
M8 (coolant ON)
G0 X3.47 Z.2561
X2.7204
G99 G32 X3.3402 Z-3.45 F.25           (1st thread cutting pass)
G32 U0.3 W-0.25 F.25                  (end chamfer pullout - relative X & Z moves)
G0 X3.47                              (rapid retract in X)
Z.2501                                (rapid retract in Z)
X2.6986                               (rapid position for next pass)
G32 X3.3174 Z-3.45 F.25               (2nd threading pass)
G32 U0.3 W-0.25 F.25                  (end chamfer pullout - relative X & Z moves)
G0 X3.47
    (90 lines of code - cutting passes 3 thru 17 - omitted for brevity)
Z.2022
X2.526
G32 X3.1368 Z-3.45 F.25
G32 U0.3 W-0.25 F.25
G0 X3.47
```

Z.2	**(final pass Z start position)**
X2.518	**(final pass X start Ø)**
G32 X3.1284 Z-3.45 F.25	(last thread cutting pass - #18)
G32 U0.3W-0.25 F.25	
G0 X3.47	
Z.2	**(spring pass Z start position)**
X2.518	
G32 X3.1284 Z-3.45 F.25	(spring pass)
G32 U0.3W-0.25 F.25	
G0 X3.47	
Z.2561	
M9	(Coolant Off)
G0 G28 U0.	(Home)
T08	(Cold Root-Rolling Tool)
Z1.	
M0	(Stop- Inspect thread & reset gauge for pass #1)
G97 S400 M03	
M8 (coolant ON)	
G0 X3.47	
Z.2	**(same as final cutting pass Z start position)**
W0.125	**(synchronizing offset)**
X[2.518+.1208+.1208+.1208+.1208]	(final pass start Ø+4*TH)
G32 X2.6763 Z-0.75 F.25	(X intercept = stpX + ((3*P)+sptZ)*(taper))
	(X intercept = 2.518+((3*.25)+.2)*(2/12))
G32 X3.1284 Z-3.45 F.25	(continuation of rolling pass #1)
G32 U0.3W-0.25 F.25	(end chamfer pullout - relative X & Z moves)
G0 X3.60	***(extra pullout required for roller piston travel)***
Z.2	
X2.518	
M9	(coolant off)
M0	(Stop- Reset gauge for pass #2)
G97 S400 M03	
M8	(coolant ON)
G0 X3.47	
Z.2	**(same as final cutting pass Z start position)**
W0.125	**(synchronizing offset)**
X[2.518+.1208+.1208+.1208+.1208]	(final pass start Ø+4*TH)
G32 X2.6763 Z-0.75 F.25	(X intercept = stpX + ((3*P)+sptZ)*(taper))
	(X intercept = 2.518+((3*.25)+.2)*(2/12))
G32 X3.1284 Z-3.45 F.25	(continuation of rolling pass #2)
G32 U0.3W-0.25 F.25	(end chamfer pullout - relative X & Z moves)
G0 X3.60	***(extra pullout required for roller piston travel)***
Z.2	
X2.518	
M9	(coolant off)
M0	(Stop- Reset gauge for pass #3)
G97 S400 M03	
M8	(coolant ON)
G0 X3.47	
Z.2	**(same as final cutting pass Z start position)**
W0.125	**(synchronizing offset)**
X[2.518+.1208+.1208+.1208+.1208]	(final pass start Ø+4*TH)
G32 X2.6763 Z-0.75 F.25	(X intercept = stpX + ((3*P)+sptZ)*(taper))
	(X intercept = 2.518+((3*.25)+.2)*(2/12))
G32 X3.1284 Z-3.45 F.25	(continuation of rolling pass #3)

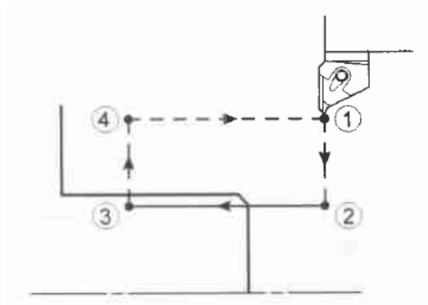
```
G32 U0.3W-0.25 F.25          (end chamfer pullout - relative X & Z moves)
G0 X3.60                     (extra pullout required for roller piston travel)
Z.2
X2.518
M9                           (coolant off)
G0 G28 U0.                   (Home)
M30 %                        (Program END- Inspect thread)
```

G32 code for a NC38 boxes would be similar in structure. The important things to note for both pins and boxes are:

- In the event cutting and rolling do not occur at the same RPM (see section "Speed of Cold Root Rolling"), then a synchronizing offset "W" must be added to the roller pass Z-start position to compensate for the effects of servo lag at different RPMs. This offset should always be positive, but will vary by machine make and model, and by the speeds and feeds used during thread cutting and rolling. The amount of this offset will be determined at the first set-up, and will be valid for that particular machine as long as no changes are made to the thread cutting or rolling code.
- The roller starts at the same Z position as the insert, and at an X position that is at least 2 tooth-heights disengaged from the thread compared to the thread insert (program as start Ø + 4xTH).
- The roller intercepts the thread root approximately 3.0 pitches from the start of the thread face using the formulas
  - For pins: X intercept = stpX + [(3.0*P)+sptZ]*(taper)
  - For boxes: X intercept = stpX - [(3.0*P)+sptZ]*(taper)
- The roller finishes at the same X and Z position as the insert, with the same pullout geometry.

G92 Thread Cycle

G92 is the next evolution of threading commands. Like a G32 command, a G92 cycle defines feed as per revolution, and feed rate is valid only in one axis.



Unlike a G32 command, a G92 cycle is a complex, multi-motion cycle. A single line of G92 programming will not only control the feed motion of the tool during the threading cut, but will also control the retract of the tool from the cut and will pull the tool back to the starting plane. However, moving to each successive depth of cut (motion 1 to 2) must be programmed as individual lines.

Unlike G32, the entire G92 thread profile must be linear (either straight or tapered). As a result, you cannot use G92 to burnish only some of the threads by dropping into the first or second pitch as described in the G32 section. This may cause unbalanced loads on the roller, and could cause unintended marking of part surfaces adjacent to the thread.

G92 is a MODAL cycle, so each additional depth of cut can be called out as a new line by calling out a simple X value. This reduces the number of programming lines.

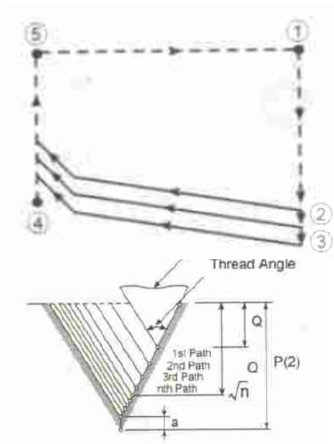
The infeed using G92 will be a radial plunge infeed, with the same drawbacks described in the G32 cycle, unless also programmed in a CAM software.

The retraction or exit chamfer that generates the last scratch is usually controlled by a machine parameter.

While the code for G92 cycles may appear simpler, the programmer gives up a lot of control over the thread shape, and the tool motion that can be achieved using a longhand G32 threading command.

G76 Threading Canned Cycle

G76 is the most complete of threading commands. G76 is a canned cycle that will cut the entire thread, with multiple infeed passes and pullouts, controlling all of the parameters needed to generate that thread, in a single command. G76 can be written as a 1 or 2 line command depending on the vintage of your controller. The principle advantages are: a compact code that is easy to edit at the machine, built-in advanced infeed and chamfering techniques for better thread quality and cutting insert life.



The principle limitations of the G76 threading canned cycle are:

- Unlike G32, the entire G76 thread shape must be a straight line.
- You must take at least 1 rough pass, and 1 finish pass. To cold-roll while conforming to the NS-1 or DS-1 spec, you are required to perform a minimum of 3 rolling passes anyway, but a G76 cycle does not allow the option of a 1-pass rolling cycle.

Mixing and Matching Threading Cycles

Because the machine controllers use the same algorithms to control motion regardless of which threading command you choose, it can sometime be helpful to mix and match thread cycles. This is especially true when the SFM of the cutting and threading operations MUST be different for tool life and cutting condition purposes. For example, using a G76 cycle to control the repetitive thread cutting cycle, and then switching to a G32 cycle to cold roll will reap the benefits of easy program editing in the G76 cycle, while retaining the ability to drop into the second thread that the G32 cycle offers. However, one important area of concern is the motion of the tools at the end of the thread. It is important to have a good understanding of what the thread cutting tool will do in the "last scratch", as it is pulling out of engagement with the material, and then make sure the roller matches this motion exactly to apply full pressure throughout the entire "last scratch" region. In general, it is easiest to get good results when both thread cutting and rolling are written as a G32 code.

- ## Mazatrol Thread Cycle

Mazatrol is the proprietary conversational programming language used on Mazak brand lathes. It is very different than standard EIA programs, but some of its features can be very helpful as well. The "rethread" feature described in the earlier section on preparing the tool is by far the easiest way to ensure synchronization of the roller tool to the cut thread. In Mazatrol, you describe your thread and location, and a few other variables, and Mazak does the math to calculate the proper tool paths. We at CJ Winter have developed a Mazatrol Calculator tool, available as an Excel Spreadsheet from our sales and technical support personnel. The user enters in the basic thread parameters like OD, Pitch and Taper... and the calculator will tell you the Mazatrol values required to cut and roll a synchronized thread. Included below are examples of the process blocks required to cut and roll a thread in Mazatrol.

External Mazatrol Threading Example

					Thread Cutting Process							
Pno.	**MODE**	**#**	**CHAMF**	**LEAD**	**ANG**	**MULTI**	**HGT**	**NUMBER**	**V**	**DEPTH**		**TOOL**
1	THR OUT	0	*2*	0.2500	*58*	*1*	0.1208	*autoset*	500	*		*7*
SEQ			**SPT-X**	**SPT-Z**	**FPT-X**	**FPT-Z**						
1			3.3700	0.0000	3.9217	3.3100						
					Root Rolling Process							
Pno.	**MODE**	**#**	**CHAMF**	**LEAD**	**ANG**	**MULTI**	**HGT**	**NUMBER**	**V**	**DEPTH**		**TOOL**
2	THR OUT	1	2	0.2500	58	1	0.1208	*	500	0.1205		*8*
SEQ			**SPT-X**	**SPT-Z**	**FPT-X**	**FPT-Z**						
1			3.6116	0.0000	3.4325	0.3750						
2			*	*	3.9217	3.3100						

Internal Mazatrol Threading Example

					Thread Cutting Process							
Pno.	**MODE**	**#**	**CHAMF**	**LEAD**	**ANG**	**MULTI**	**HGT**	**NUMBER**	**V**	**DEPTH**		**TOOL**
1	THR IN	0	*2*	0.2500	*58*	*1*	0.1208	*autoset*	500	*		*7*
SEQ			**SPT-X**	**SPT-Z**	**FPT-X**	**FPT-Z**						
1			3.7030	0.6250	3.1197	4.1250						
					Root Rolling Process							
Pno.	**MODE**	**#**	**CHAMF**	**LEAD**	**ANG**	**MULTI**	**HGT**	**NUMBER**	**V**	**DEPTH**		**TOOL**
2	THR IN	1	2	0.2500	58	1	0.1208	*	500	0.1205		*8*
SEQ			**SPT-X**	**SPT-Z**	**FPT-X**	**FPT-Z**						
1			3.9446	0.6250	3.7447	0.3750						
2			*	*	3.1197	4.1250						

- ## Other Programming Methods

If you choose to use a programming method other than those recommended, several issues may arise. If you change RPM between thread cutting and root rolling, roll synchronization could be thrown off due to each machine's unique servo-lag. Even if you compensate by changing the Z-axis start points, you must take care to ensure the full roller pressure is being applied to the final scratch, and the roller is not being retracted too early. Early retraction will not apply full pressure in the "last scratch" region. "Last scratch" rolling is a requirement of both NS-1 and DS-1 and has been shown by several studies to be a key factor in maximizing the anti-fatigue properties of Cold Root Rolling in this most critical region [(1)].

Conversely, retracting the roller too late can be detrimental to seal life. While the tool has been designed to allow the roller to float upward in the last-scratch region by up to a full tooth height, this will increase the internal pressure of the hydraulic fluid as it is forced into the accumulator. Any momentary increase up to 8,000 PSI is tolerable, but will shorten the life of the o-ring seals and rollers. These pressure spikes should be avoided. In general, following our recommended procedures will avoid unnecessary complications.

- ## Non-CNC operation

Your CJ Winter tool can also be used on manual lathes, or similar oil-field rotary equipment, that have sufficient size and rigidity to support the tools and loads required. However, when manually operating the tool, consistently maintaining full roller pressure in the final scratch region may be exceedingly difficult. Reliance on the accumulator may be necessary, along with the decreased life expectancy of the o-ring seals and rollers.

Ordering Parts

Our sales staff will be happy to assist you in ordering rolls or replacement parts for your tools. We can be contacted in a variety of ways.

By phone at:	1-800-288-ROLL
	1-800-288-7655
By fax at:	585-235-6568
Or on the web at:	www.cjwinter.com

Standard rolls that conform to API specs can be ordered by the part number found on page # 16. Rolls can also be manufactured to alternate geometry to meet your special requirements. Please consult a sales representative for your options.

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Acknowledgements

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The information conveyed in this manual should not be the sole source for determining adherence to any official specification or standard.

CJ Winter encourages the users to acquire and familiarize themselves with the cited works as a whole, and to insure that newly released editions of these documents have not substantively changed the information provided since the printing of this manual.

Works Cited

1. *Fatigue life improvement of threaded connections by cold rolling.* **Knight, M.J., Brennan, F.P. and Dover, W.D.** 2, September 30, 2004, Journal of Strain Analysis, Vol. 40, pp. 83-93. DOI: 10.1243/030932405X7818.

2. *An Experimental Investigation of Fatigue-Crack Growth in Drillstring Tubulars.* **Dale, B.A.** 4, s.l. : Society of Petroleum Engineers, December 1998, SPE Drilling Engineering, Vol. 3. 15559-PA.

3. **T.H. Hill Associates, Inc.** Engineering Solutions - Failure Analysis. *www.thhill.com.* [Online] [Cited: February 13, 2012.] http://www.thhill.com/engineering_services/documents/failure_analysis.pdf.

4. **Tom H. Hill, P.E., et al.** Standard DS-1. 3 *Drill Stem Inspection.* s.l. : T.H. Hill Associates, January 2004. Vol. 3.

5. **API(American Petroleum Institute).** Specification for Threading and Gauging of Rotary Shouldered Thread Connections. s.l. : API Publishing Services, December 1, 2008. ANSI/API 7-2.

6. **Douglas, Jim.** "Prevent Rotary Shouldered Failures." April 13, 2011, American Association of Drilling Engineers. AADE-11-NTCE-31

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