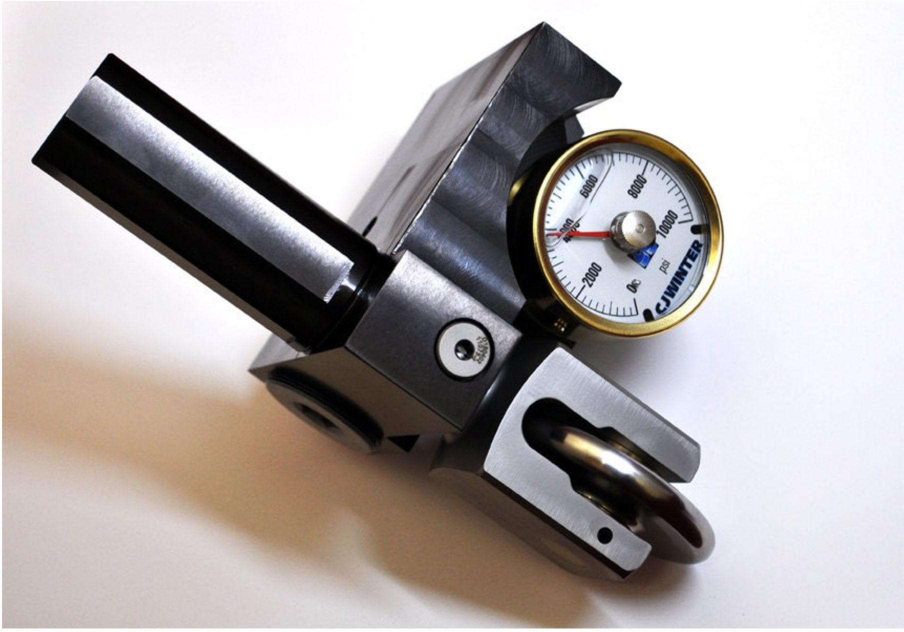
11073 Series
Cold Roll Tools
for Contour Burnishing

Instruction Manual



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Introduction

Congratulations on your purchase of a CJWinter Cold Roll Contour Burnishing Tool. These tools have been designed specifically to manufacture fatigue-prone components in the Oilfield and Heavy Transportation industries using a CNC lathe. With proper use, these tool will enhance the fatigue life of your highly-stressed, high cycle components. This manual will help you use and maintain your tool.

What is Cold Roll Contour Burnishing?

Cold Roll Contour Burnishing is the process of single point burnishing a previously cut contour, with a roller, at "room temperature" in lathe turned components. A hardened roll, typically with a radius tip profile, is forced into contact with the turned profile, and pressure is applied to force the roller to slightly penetrate into the cut surface, displacing and cold-forming the near-surface material. This deformation cold-works the material, imparting an improved surface finish and compacts and displaces the grains of the base material. Industry experience with the cold roll contour burnishing process has suggested an increase in fatigue life over similar un-treated components under the same working environment.

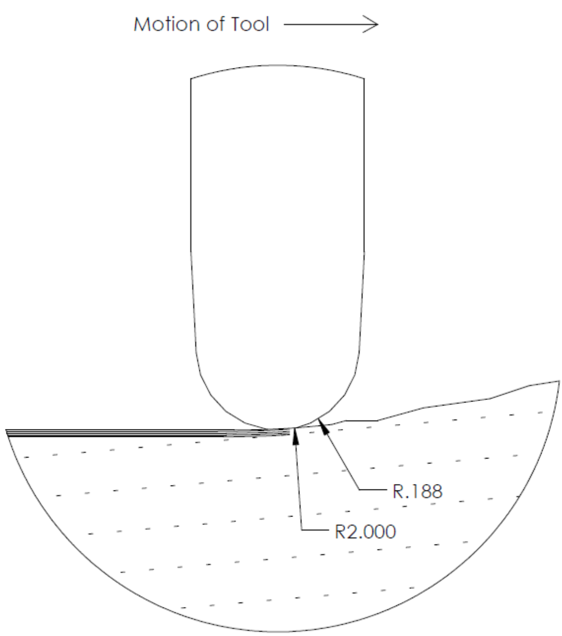


Figure 1: Roll Traveling Right-to-Left Up Incline

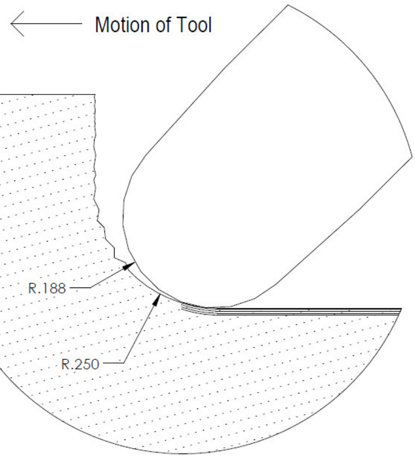


Figure 2: Roll in 45° Tool Holder Approaching Shoulder

Various studies have attributed the increase of fatigue life to one or more important effects of Contour Burnishing:

1. Cold Rolling imparts a thin zone of residual compressive stress in the near-surface material of the part. This residual compressive stress offsets the tensile stresses induced in service, and lowers the overall stress in the critical stress regions of the part being processed. Figure 4.0 is an illustration of the typical residual stress patterns that remain in the part after Contour Burnishing, as well as the condition and displacement of material throughout the Contour Burnishing process *(Note: the magnitude and depth of the stress plot has been exaggerated for clarity).*

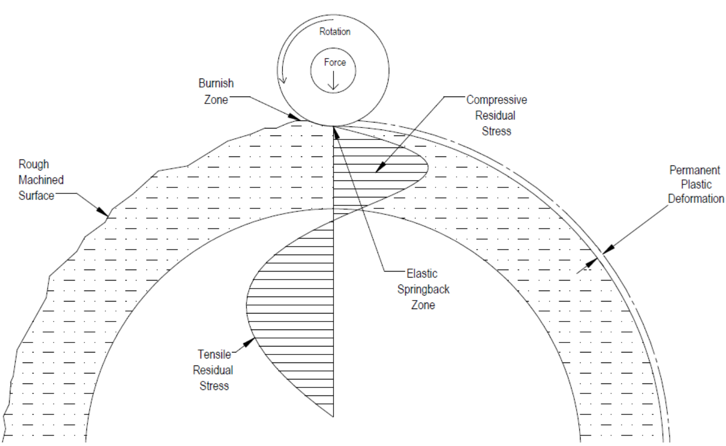


Figure 3: Residual Stress via Burnishing

2. The burnishing effect of the smooth roller on the contour causes the small scratches and ridges left by the turning 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, and when located near shoulders or flanges, are one of the most highly stressed regions of the part. These scratches are likely propagation points for most fatigue failures. Any method that minimizes or eliminates them enhances fatigue life of the part.

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

4. Cold Rolling 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 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 component. In lab studies of oilfield connections, cracks that have occurred in cold rolled joints, have exhibited a 30% to 50% lower Crack Aspect Ratio (Crack Length/Crack Depth). Cracks in cold root rolled products are more likely to be deep and short (illustrated at the top of the pipe in Figure 5), rather than long and shallow (illustrated by the crack at the bottom). Shallow cracks are more likely to lead to a sudden structural failure. A deep, but short crack is more easily detectable via pressure drop of circulating drilling fluids, and allows for an early recovery of damaged drill string prior to complete structural failure of the joint (1).

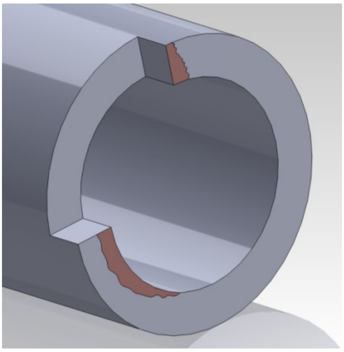


Figure 4: Crack Aspect Ratio

Why Cold Roll your components?

Cold Rolling is often an OEM requirement of a particular component.

For the end user of highly stressed, fatigue-prone components, Cold Rolling is also a money saving process. For example, in the oilfield industry, Cold 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 of the drill string. 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).

In the rail industry, a recent report by the US DOT estimates the cost of the average train derailment at 22.5 million dollars(7). With 19 derailments in the US attributable to broken axles / wheel sets between 2011 and 2014(8), the yearly costs are staggering. With that kind of risk, Cold Rolling is cheap insurance, reducing the likelihood of fatigue failures in critical-to-function parts.

Why Use CJ Winter's Contour Burnishing Tools?

For nearly 50 years CJWinter has been an industry leader in supplying threading and burnishing rolls globally.

In 2010, CJWinter used that experience to design tools specifically for Rotary Shouldered Connections in the Oilfield 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 Rolling procedures, and DS-1 Third Edition, Volume 3.33.6.

In 2015 CJWinter once again expanded its burnishing product line to include the Cold Roll Contour Burnishing Tools, specifically designed to burnish high stress regions of fatigue-prone components in the Oilfield and Heavy Transportation industries. These new Cold Roll Contour Burnishing tools share many of the best features of our highly successful thread Cold Root Rolling tools, and have some unique advantages over other commercially available systems.

This tool will continuously monitor the force being applied while burnishing. Many commercially available burnishing tools have no means to directly measure or monitor force applied to the burnishing tool. This feedback can be invaluable for determining if the process is properly performed and consistently controlled from part to part.

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.

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 fittings to disconnect, no manual pumps to misplace. The only thing required to pressurize this tool is socket wrench.

This tool does not require an external accumulator. It is a requirement of many OEMs to maintain a minimum burnishing force on the roller for the entirety of the target area. This requirement either forces perfect synchronization of the cutting tool and roller tool paths, or an accumulator to allow the roller to float in the holder body. Since perfect synchronization can be difficult, the CJWinter holder comes standard with an integral accumulator to allow for the extra roller travel in these critical regions.

The 11073-SA series will roll all standard API elevator and slip groove configurations.

Package Contents

This tool is shipped complete with everything you need to cold roll burnish your parts (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

The 11073 series of tools 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.

The three primary styles of tool available are Straight, RH45° and LH45°. Each presents the roll at a different angle reletive to the shank, in order to roll up shoulders in different 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.

In addition, round shanks with a Ø 1.500" are available, and 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 CJWinter for technical advice.

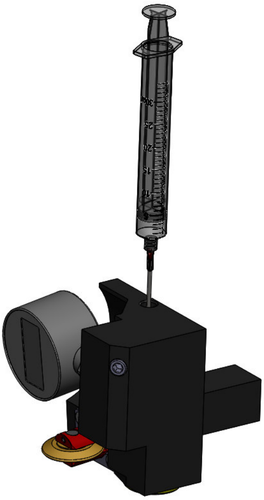
Filling the Tool

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.

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.

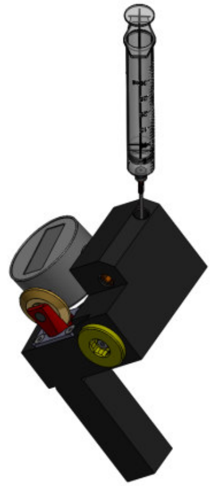
This may lead to leakage and ineffective rolling. Please ask your lubricant supplier to insure the compatibility with Parker compound Nitrile N674-70.

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. CJWinter 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

CJWinter recommends an annual teardown and inspection of this tool.

We recommend the periodic replacement of the piston 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 parts 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 Roll Contour Burnishing 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, CJWinter does not recommend modification of any part of this tool.

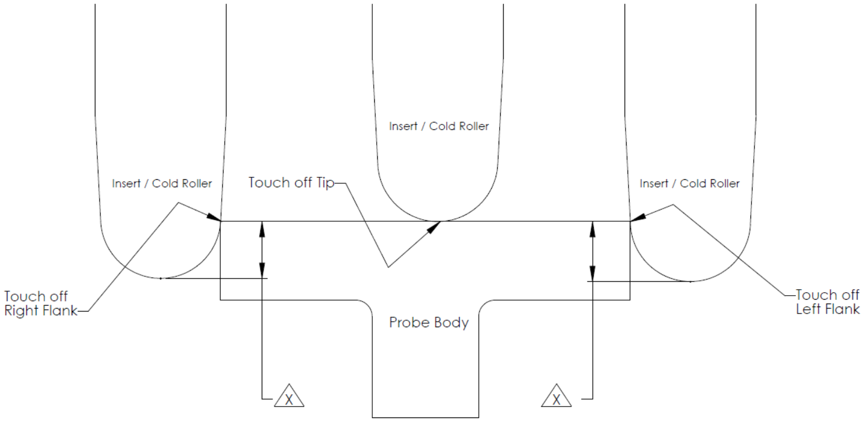
Setting the Roller Pressure

Mount the tool in the turret, and pre-charge the tool pressure to 95% of the desired process pressure. During the first use, there may be a gradual pressure drop as the o-rings and internal springs take a set. During rolling, monitor the tool pressure to ensure the displacement of the roller raises the pressure the remaining 5% to the desired 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. 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.

Preparing the Tool

First, install the appropriate roller in the roll holder. 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 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 roll tip to the OD of the part.

The Cold Rolling Procedure

Specific target variables such as surface finish, force requirements, and residual stress zones are usually set by the part OEM. Where their requirements differ from our recommendations, we suggest their requirements be given primary consideration.

Surface Preparation

Prior to burnishing, the surface should be free of tears and major defects deeper than .002", and have a surface finish between 94 and 125 Ra. Finer surface finishes may inhibit the free flow of material and require higher forces to burnish. The surface should be prepared in the same work-holding as the Cold Rolling operation, such that run out of the surface is minimized. Excessive run out will lead to fluctuations in the force being applied by the roller, and fluctuations in the quality of the finished product.

Speed of Cold Roll Contour Burnishing

The surface speed at which Cold Roll Contour Burnishing occurs is not generally a significant contributor to part quality, but does have an effect on process reliability. Lower rolling speeds help to reduce galling and wear of the roller/pin interface, but higher speeds are more productive. Roll burnishing speeds should be limited to a maximum of 100 SFM for external features for reasonable roller life. We recommend roughly half of that value, or 50 SFM, as a conservative starting point. When running high-load applications, such as non-magnetic or work-hardening materials, we recommend further reducing the SFM to 25 SFM or less 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.

Feed Rates

The Cold Rolling can be performed at a variety of feed rates to achieve the desired surface finish and operation speed. Lower feed rates will produce finer surface finishes, and generally will require less force than higher feed rates. However, very low feed rates will leave the roller in contact with the part for excessively long times, which will hurt throughput, as well as increase the risk of high roll temperatures and possible galling as a result. The chart below is a guide to the approximate finishes that can be achieved at various feed rates. These are only approximations, and an acceptable feed rate can only be determined by trial and error.

Feedrate (in/rev)	Roller Radius					
	0.094	0.125	0.188	0.25	0.313	0.375
0.0025	3	3				
0.0050	11	8	5	4	3	
0.0075	24	18	12	9	7	6
0.0100	44	33	22	16	13	11
0.0125			34	26	20	17
0.0150				37	29	25

Coolant Application

During setups, it is acceptable to run the roller dry for short periods to allow for visual confirmation of the process. However during automated production, it is highly recommended to have the roller OD under continuous spray from the machine coolant. Failure to run coolant can result in an overheated roll, which will promote galling and chipping.

CNC Programming

The roller tool path should be synchronized to the previously cut part to apply even pressure throughout. To accomplish this, we recommend programming the tool like a turning tool taking a finish pass on the part geometry, and using tool geometry compensation to fine tune the offsets required to meet process pressure at the machine.

On machines with articulating tool holders, where the inclination of the tool can be dynamically changed, we recommend keeping the contact point at or near the centerline of the roll whenever possible to minimize side forces.

- ### Non-CNC operation

Your CJWinter tool can also be used on manual lathes, or similar rotary equipment, that have sufficient size and rigidity to support the tools and loads required. However, when manually operating the tool, consistently maintaining a minimum roller pressure in the target area 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

Rolls can also be manufactured to a wide variety of special geometries to meet your special requirements. Please consult a sales representative for your special needs.

Legal Disclosure

Acknowledgements

This manual includes numerous references to, and excerpts from, previously published technical and functional material, and these references and excerpts have been included in accordance to copyright laws of the United States. These references are included for the purpose of providing the user with a single document with pertinent information required to use this tool. This manual is not intended as a replacement for the cited works, but rather as a supplement.

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

CJWinter 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.

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