# BACKUP ROLL OIL FILM BEARINGS NEW DEVELOPMENTS HYDRAULIC LOCKING TOOL, RETROFIT HYDRAULIC LOCKNUT AND TEFLON NECK SEAL.

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**Summary:**

Oil film bearings have been successfully used on backup roll bearings for decades. There have been many improvements since their inception and today's bearings are significantly better than their predecessors, although the principles of operation are still the same. Improvements in materials and designs have increased bearing life and product quality.

This paper examines two areas of development made by DanOil bearings to improve bearing performance:

1. **Mounting and locking devices** - this is primarily concerned with operational safety aspects of older bearings and the consistancy of mounting force.
2. **Roll neck sealing** - aimed at improving the operational characteristics, strip quality and seal life, resulting in cost savings.

**Keywords:** Bearings, locknuts, seals

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## Mounting & Locking Devices

Older bearings that have the threaded-ring locknuts (TR) and the quick-change locknuts (QC) must be tightened using a crane. A steel pin is inserted in the locknut with the wire rope attached to the pin and wrapped around the locknut. The locknut is then tightened by pulling up on the wire rope using a crane. This can be seen in Figure 1.


Fig 1 Traditional Method of Tightening Locknut

The practice of tightening the locknut using a crane rope is dangerous to the workers because the wire rope can break or the holding pin can spring loose. It is common to see the roll shop workers lift the chock off the ground during tightening. This can exceed the working capacity of the wire rope.

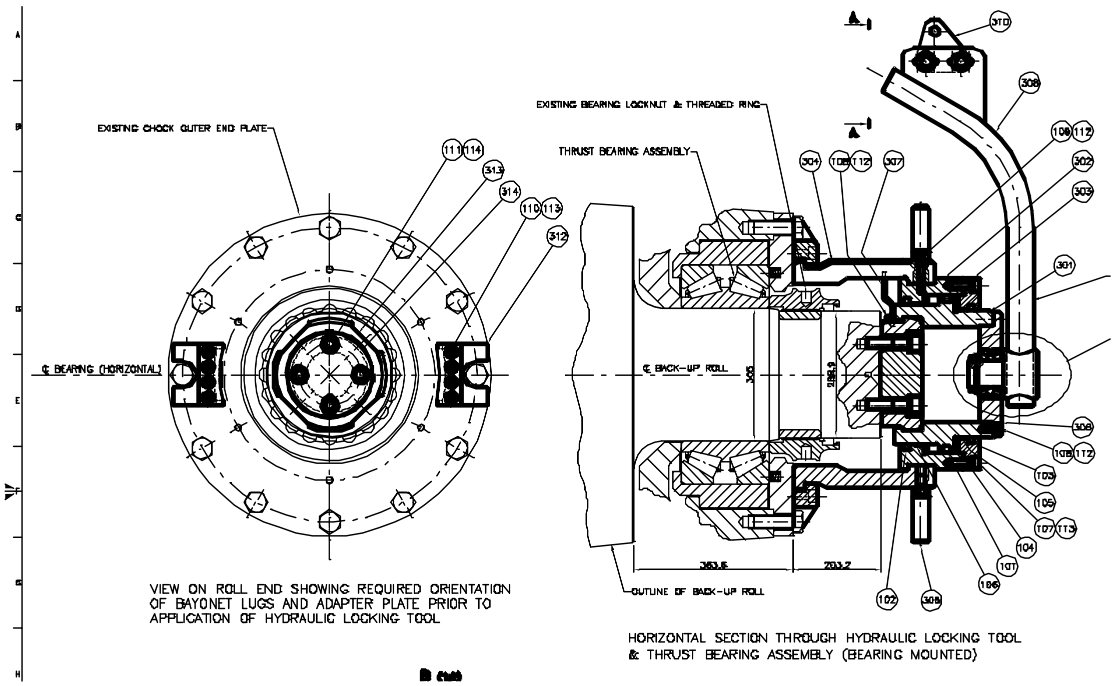
With ever increasing awareness of safety, roll shop operators are seeking an alternative tightening method to reduce the potential risk of injury from broken wire ropes and flying retaining pins. In addition to safety concerns, tightening the locknut by this method does not ensure repeatable mounting forces, which could lead to loose bearings on the roll neck. Loose bearings result in vibration during operation, causing poor strip quality and fretting between the roll neck and sleeve bore. It can also result in excessive seal leakage. If the mounting force is too high, bearings are difficult to remove from the roll.

### Hydraulic Locking Tool (HLT)

DanOil's Hydraulic Locking Tool (HLT) is an alternative to using a crane and wire rope. The HLT hydraulically pushes the sleeve onto the roll neck with a known and consistent force. It also pulls the sleeve off the roll neck if it is stuck. The design has the following features:

- Safe to use.
- Ensures repeatable mounting force.
- Easy to operate.
- Economical.
- Modifications to existing equipment are minimal.

To attach the HLT to the roll, an adaptor is bolted on the end of the roll and two latches, or clamps, are bolted to the outside of the chock, as seen in the drawing below. This is where the HLT attaches to the roll and chock. If the roll adaptors are left with the roll, a new end cover is needed to make room for the roll end adaptor. In most cases, the chock latches are left with the chock. Two latches are needed for each chock.




The HLT slides onto the roll adaptor and engages it when the bayonet is turned 45 degrees. Hydraulic pressure is applied to the hydraulic cylinder and the bearing is pushed onto the roll neck. The locknut is tightened by hand and the locking key is put in place. Hydraulic pressure is removed and the HLT is turned 45 degrees and removed from the adaptor.

Fig 2 Hydraulic Tool

The HLT arms engage the chock clamps in the same manner for pulling the bearing off the roll.

The HLT shown in Figure 2 was tested on a hot strip mill in Europe. The bayonet that attaches the HLT to the roll is seen on the inside and the arms that hook to the latches are shown on the outside.

After the HLT engages the roll and is pressurized, the existing locknut is tightened by hand and the locking key is inserted in the usual way, as can be seen in Figure 3.

After the HLT is depressurized and removed, the endcovers are fitted in the usual manner.


The bearing is removed from the roll by removing the endcover and locking key, engaging the adaptor and chock clamps, pressurizing the push-up cylinder and loosening the threaded locknut. After the locknut is loose, the pressure is removed from the pushup cylinder and the pull-off hydraulic cylinder is pressurized, pulling the chock off the roll with the bearing sleeve.

*Fig 3 Tool in Use*

**Hydraulic Locking Tool – Conclusions**

1. The HLT eliminates the need for a crane and crane rope to tighten the locknut. It is a safe procedure that reduces risk of injury to the roll shop workers.
2. The hydraulic cylinder pushes the bearing onto the roll neck with repeatable force, eliminating friction in the threads of the locknut.
3. The HLT is easy to operate
4. The HLT is economical. There is one cost for the locking tool, chock clamps and adaptors, which is much cheaper than replacing all the locknuts on a tandem mill.
5. The only modifications required are drilling and tapping holes to accept the roll adaptor and chock latches.

## Retrofit Hydraulic Locknut

The retrofit hydraulic locknut (RHL) focused on the mounting and dismounting of chocks with a device that does not require roll or chock modifications. The goal was to develop a hydraulic locknut that can take the place of the existing threaded-ring locknut or quick-change locknut. The RHL is half the standard hydraulic locknut that is used on hundreds of bearings throughout the world.

The RHL shown in Figure 4 takes the place of the threaded-ring locknut. The only additional parts are the chock endplate spacer, which is fitted between the chock endplate and the chock endcover, and the bayonet adaptor that replaces the

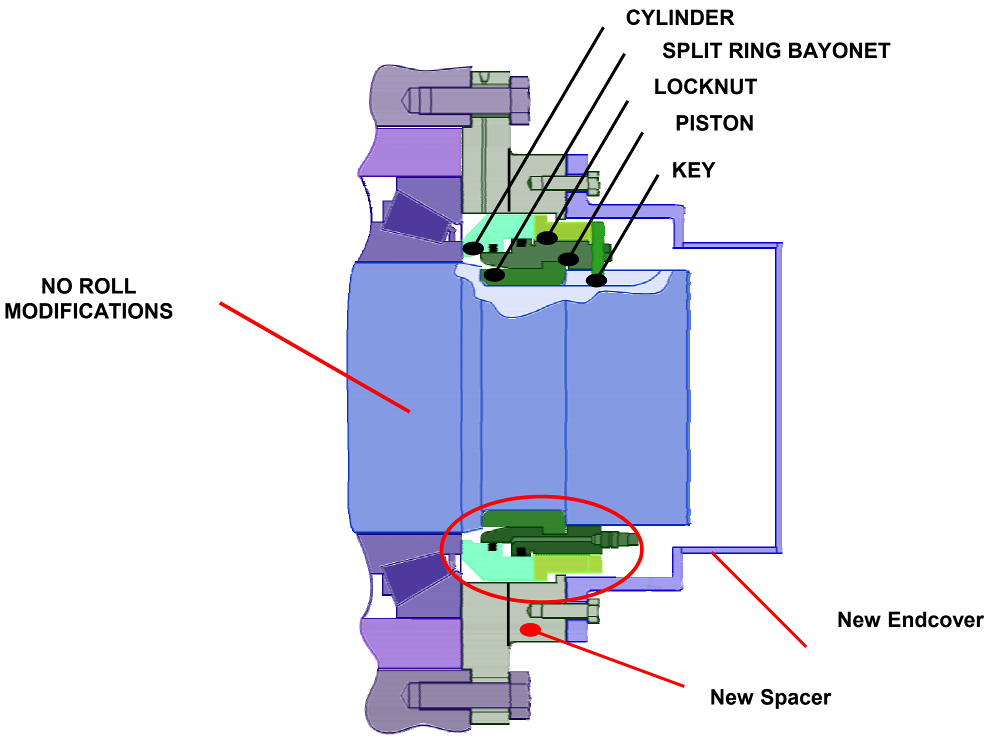



*Fig 4 Hydraulic Locknut Components*

threaded ring, or the existing chock endplates can be modified by machining the bore to accept the RHL.

The hydraulic locknut is designed to replace the existing threaded-ring or QC locknut. The RHL stays with the chock when the bearing is dismounted from the roll, as shown in Figure 5.

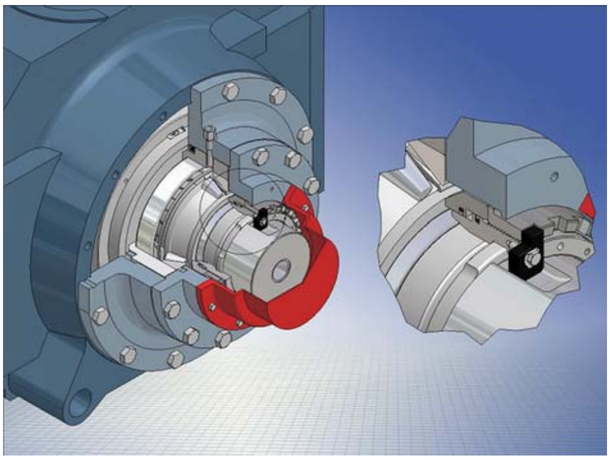


*Fig 5 Hydraulic Locknut Arrangement*

The scope of supply for the RHL for one stand is;

- α Four chock endplate spacers, two thrust side and two non-thrust side.
- α Four split bayonet rings, two thrust side and two non-thrust side.
- α Four retrofit hydraulic locknuts, two thrust side and two non-thrust side.
- α Four locking keys
- α One portable hydraulic pump and hose
- α One locknut spanner

The bearing is placed on the roll either by crane or by chocking car to within 10mm of its final axial position. After connecting the hydraulic supply hose and ensuring that the cylinder control valve is vented to tank, the locknut is unscrewed, thus extending the piston forward toward the flange end of the sleeve. The locknut is unscrewed until the indicator line marked on the roll is just visible. Using the spanner tool, the piston is then turned through $45^o$ to engage the bayonet adaptor until the piston keyways and the roll end are in line. Using the portable hydraulic pump, the cylinder is pressurized to push the bearing up the roll neck. The locknut is hand tightened using a small bar, the locking key is fit in, and the cylinder is vented to the tank via the control valve. The hydraulic hose can then be disconnected and the endcover installed. The locknut does not rely on hydraulic pressure to hold the bearing on the roll. It is held on the roll by the mechanical threaded locknut.

**Conclusion**
The RHL is more suited to existing mills because there are no modifications required to the backup rolls or chocks. In addition, the design has been kept simple to minimize costs, allowing the new locking to be phased in when the existing locknuts wear out and are replaced.

## Roll Neck Sealing

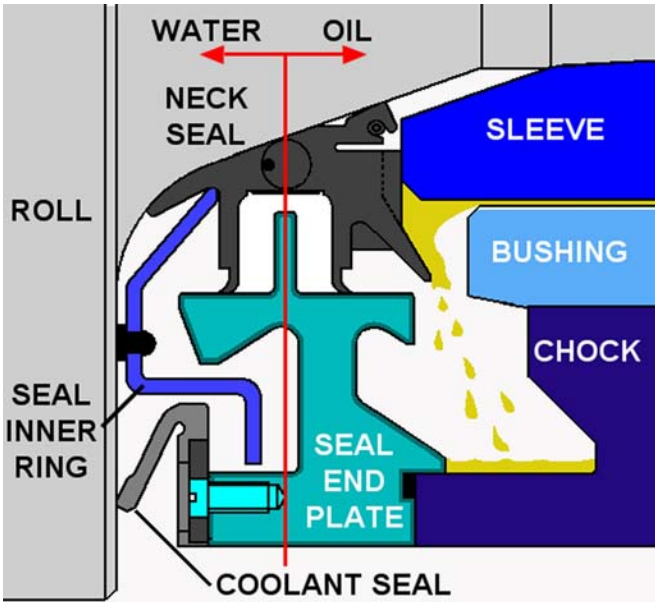



*Fig. 6. Sealing System*

The prime purpose of the roll neck seals is to keep the oil in the bearing and the rolling solution out. The coolant seal, shown in Figure 6, keeps the rolling solution away from the neck seal. The seal inner ring traps the neck seal between the roll and sleeve. A flinger also slings the rolling solution away from the neck seal if it gets past the coolant seal. A small opening at the bottom of the coolant seal allows rolling solution to drain away. The roll neck seal is designed to keep oil in the chock, and water out, by forming a barrier at the roll neck and seal endplate. The water side and oil side seal lips contact the seal endplate. The neck seal has a flinger on the oil side that slings oil back into the chock.

Over time, the coolant seal, neck seal and seal endplate deteriorate. The main reason for the deterioration is the embrittlement of the rubber due to heat. As the seal slides on the seal endplate, heat is generated by friction between the seal lips and endplate. In the conventional seal endplate, the surface is coated with ceramic to prevent wear. The ceramic is a thermal insulator and will not allow heat to be transferred into the steel endplate. Instead, it is transferred into the oil, rolling solution and seal lips. The heat that is transferred into the seal lips decreases seal life. The heat cures the rubber and it becomes brittle and cracks. When the seal lips crack, they will leak.

The ceramic on the sealing surface can chip or blister, which causes it to separate from the seal surface. The chipped or blistered ceramic is sharp and cuts the rubber seal lips.

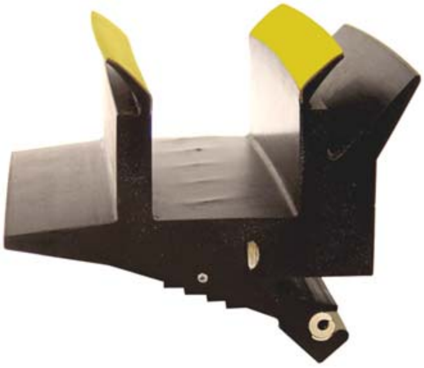
DanOil engineers have developed a new coolant seal, neck seal and seal endplate to overcome these problems.

**Coolant Seal**

The coolant seal is fixed to the seal endplate using stainless steel screws. A PTFE (Teflon) strip is molded into the seal lip, as can be seen in Figure 7. The PTFE strip reduces friction and increases seal life.

*Fig 7 PTFE Coolant Seal*

**Neck Seal**



The neck seal features PTFE lips to reduce heat generation and thus eliminate the hardening of the lips that leads to cracking and fluid loss in service. This seal is a single-piece construction that is interchangeable with the existing neck seals.

*Fig 8 PTFE Neck Seal*

**Two-Piece Seal**

When the conventional seal wears out, the whole seal is discarded. To reduce the cost, DanOil has designed a seal in two pieces, the base and the replaceable lip section. When the lips wear out, only the lip section, shown on the left side of Figure 9, is replaced. This reduces the replacement cost by more than 50%.

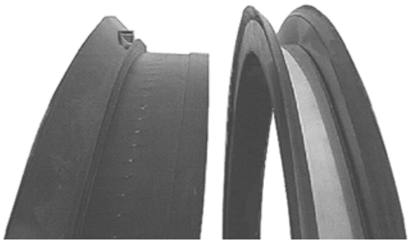


*Fig 9 Two-Piece Seal*

The replaceable lip section fits into the groove in the body of the seal. The assembly is trapped between the sleeve, roll neck, steel inner band and inner seal ring. This ensures that there will be no relative movement between the seal and roll neck during service.

Also, the two-piece seal is interchangeable with the existing neck seals. For optimum performance, DanOil's new seal endplates are recommended.

**Seal Endplates**

To eliminate the ceramic coating, DanOil engineers have applied a Nitrig hardening process to the endplate steel. The hardened surface reduces wear and increases corrosion resistance. The entire seal endplate is treated and provides corrosion protection on the inside as well as the outside surfaces. This is particularly useful in hot strip mills and plate mills where corrosion from water is a problem.

Another feature of the conventional seal endplate is that scrolls are machined into the sealing surfaces to pump the oil into the chock and water away from the chock. The scrolling is directional, requiring two different endplates for each stand. Because of the scrolling, careful management is needed to ensure that the correct seal endplate is used with the correct chock. During mounting of the bearing, the seal lips have to slide over the scrolls in the axial direction and the seal lips have a tendency to roll under during mounting. When the roll and bearing are placed in the mill and operation started, the seal lip is quickly worn away. It is for these reasons that DanOil has decided to eliminate the scrolls.

## Seal Operational Experience

The original test of the PTFE seals was done on an old hot strip mill. One set was used for a trial on stand F7. The 45-year-old mill is regarded as having a particularly harsh environment; with excessive scale and cooling water presence on a mill that is constantly working at or above its speed and heat design limits.

Prior to the tests, which began in July 2002, the performance and durability of the existing neck seal systems was unsatisfactory because of excessive oil leakage/water ingress, rapid seal lip wear and corroded seal endplates. This mill provided a severe and demanding test.

The first test period of 28 days (bottom chocks) and 19 days (top chocks) was in July and August of 2002. When all the seals were removed from the chocks for inspection, they were found to be in very good condition with no signs of wear, damage or material deterioration. There was no hardening of the seal lips and the 0.5mm thick PTFE strip was undamaged.

Success also followed the second, third and fourth test periods, which continued to show little signs of wear, damage or material deterioration even though the seals were running on old, worn, ceramic seal endplates. The neck seal in the top chock no.18 successfully survived the fifth test period in the mill without problems. The pair of seals in the bottom chocks, nos. 12 and 7, were inspected at various intervals and were in good condition. They are still in service.

### Two-Piece Neck Seals

Two, two-piece seals have been in service for several campaigns totaling 6 weeks in a hot strip mill. A second set has been in service most of last year. An inspection is schedule for this year when they are inspected.

### Coolant Seals

The coolant seal mounted on the outside face of the seal endplate is traditionally manufactured as a ring and then cut at the bottom to accommodate several bearing sizes. The life of the traditional coolant seal has been limited by excessive wear of the lip.

The DanOil coolant seal is molded as a continuous ring with an internal steel-reinforcing ring to prevent distortion of the seal between the mounting screws. The lip section is thicker and molded with PTFE for extended life.

The four coolant seals supplied for the tests have been mounted on the DanOil seal endplates since May 2002 and are still in service. The coolant seals have performed very well during this time. They are still undamaged and fit for service.

## Seal Endplate

The four seal endplates supplied for the tests were mounted onto the back-up roll chocks since May 2002. The seal endplates are still in service and have shown no signs of wear, damage or corrosion. Their running surfaces remain smooth and polished, and the external surfaces show minimal oxidation. Traditional mild steel endplates corrode quickly in the harsh mill environment.

## Conclusions

The PTFE seals have improved seal life by a factor of 3 to 4 times over the conventional seals. They remain flexible with no hardening or cracking of the lips, which improves life and reduces leakage. This is attributed to the low heat generation of the PTFE lips and the better heat conduction of the seal endplate. Several hot strip mills in the USA using this system have reported excellent results working on ceramic coated end plates. The seals can work satisfactorily with existing ceramic-coated seal endplates, but for maximum life and performance, the DanOil seal endplates are recommended.

The operation of the two-piece seal has proved effective and the seal will be manufactured with PTFE lips.