# Industrial case study on CAT Dragline 8200 Lubrication system

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**ABSTRACT**

This paper is based on my case study of CAT Dragline 8200 lubrication system. Draglines are big earth moving machine which can excavate deep down the earth. As the machine has to endure very harsh and dusty environment it's machinery parts and ropes needs constant lubrication to be operation and be in their optimum condition. Inside dragline there's a lube room which has all the machinery for lubrication like pumps, lube tanks. All lubrication system is controlled by the PLC unit and HMI screen is used by the operator to choose if to keep lubrication system manual or automatic .Lincoln Injectors are used inject lube over the moving gear or ropes. After my study understood the lubrication system of the machine and various different aspects of the machine.

**Keyword**: Dragline, lube room, PLC, HMI, Lincoln injector, Lubrication, Harsh Enviroment.

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**Introduction**
**CATERPILLAR DRAGLINE 8200**

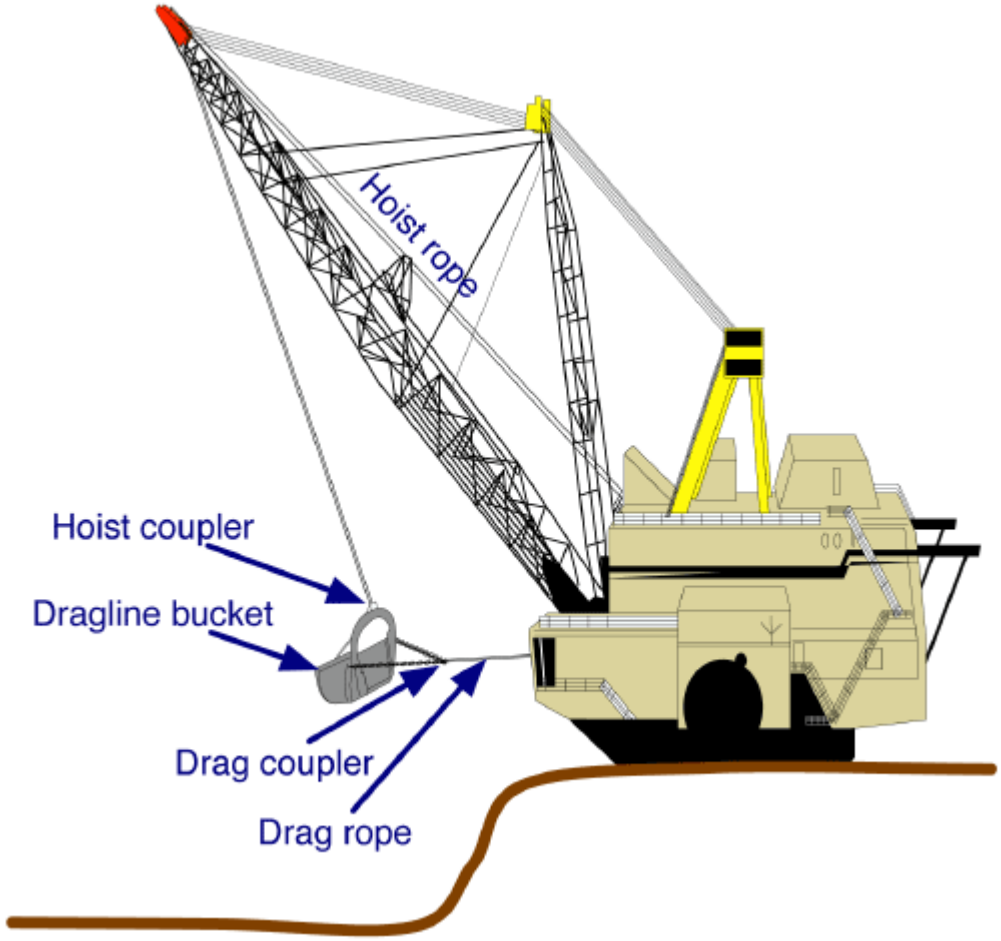
Dragline has the ability to excavate very deep down the earth. Word drag is used because it has the ability to drag material at far distance from the machine. Dragline consists of drag rope, large bucket, boom, hoist rope and driving motors.
A large bucket is attached with dragline boom (it is truss like structure). Bucket is controlled with the help of number of ropes and chains. There are two separate function ropes which are attached with bucket. These are:
1. Hoist rope

2. Drag rope

Hoist rope is controlled with the help of electric motor and it supports the hoist-coupler assembly and the bucket from the boom. The second one i.e., drag rope is used for drawing of bucket horizontally towards the machine.

**Dragline Motion:**

In a cycle of excavation, the bucket is positioned above the material to be excavated. The bucket is then lowered and the Drag Rope is then drawn so that the bucket is dragged along the surface of the material. The bucket is then lifted by using the Hoist Rope. A swing operation is then performed to move the bucket to the place where the material is to be dumped. The dragrope is then released causing the bucket to tilt and empty. This is called a dump operation.




Cat 8200 is the second biggest dragline produced by Caterpillar that comes with a bucket capacity up to 61m$^3$ and 100m (328ft) long boom. The AC-powered walking dragline weighing up to 4,173t has 19.5m base diameter and offers up to 48.2m of dumping height and 49.7m of digging depth.

The Cat 8200 is powered by four 1,650hp drag motors; four 1,650hp hoist motors; four 1,650 hp swing motors; and two 1,650hp walk motors. The rated suspended load of the dragline is up to 181,437kg.

**LUBRICATION SYSTEM ON DRAGLINE**

Inside the dragline machinery there's room called "LUBE ROOM". Lube room consists of seven lube pump systems. These system supplies the required lubrication to the various components of the dragline.

**MPG:-**

**AD SYSTEM:**

1. Hoist drum shaft ( SLV -3) , 2. Hoist pedestal bearing (SLV-1), 3. Drag drum shaft(SLV-3), 4. Centre journal bearing(SLV-4 X 2). 5. Swing shaft bearing (SLV-2 X 4)

**AP SYSTEM:**

1. Propel pinion bearing(SLV-2 X 2), 2. Centre journal bushing(SLV-4 X 2).

**SYSTEM 'B':**

1. Fair lead(SLV-3 & SLV-6 X 2), 2. Foot pin(SLV-1 X 6), 3. Tri-Structure(SLV-4 X 4), 4. Hoist rope Roller (SLV-4), 5. Intermediate support rope pin(SLV-3 & SLV-6 X 2), 6. Boom intermediate support rope pin(SLV-4 X 2), 7. Boom top.(R.H = SLV-6 & SLV-4, L.H.=SLV-6 X 2)

**OGL:-**

**CP SYSTEM:**

1. Propel cam(SLV-6 X 4), 2. Propel pinion bushing(SLV-4 X 2) , 3. Stabilizer arm valve joint(SLV-3 & SLV-4 & SLV-4 X 2), 4. Propel bull gear(SLV-6 X 2), 5. Propel pinion bushing(SLV-4 & SLV-4 X 2).

**CD SYSTEM:**

1. Hoist Bull gear(SLV-6 & SLV-6 & SLV-6 & SLV-6 X 2), 2. Drag bull gear(SLV-6 & SLV-6 & SLV-6 & SLV-6 X 2), 3. Swing gear(SLV-6 X 2), 4. Swing roller(SLV-2 X 2)

**WRL:-**

**EH SYSTEM:** 1. Tri-Structure rope(1 Divider valve), 2. Boom point(1 Divider valve).

**ED SYSTEM:** 1. Fair lead -upper sheave & lower sheave(1 Divider valve).

There are total **312** injectors in the whole system.

**Types of Lubricant**

Manual lube points are lubricated using the following types of lubricant:

1. Open Gear Lubrication (OGL)

2. Multi-Purpose Grease (MPG)

3. Wire Rope Lubrication (WRL)

4. Electric Motor Grease (EMG)

**Auto lube System :**

The automatic lubrication system consists of three oil reservoirs. They contain:

1. Open Gear Lubrication (OGL)

2. Multi-Purpose Grease (MPG)

3. Wire Rope Lubrication (WRL)

These reservoirs provide lubricant to five independent lubrication systems. They are:

1. The Open Gear System Dig

2. The Open Gear System Dig Propel

3. The Rotating Frame System

4. The Front End System

5. The Wire Rope Lubrication System

Each system control panel has either one or two output circuits that are labelled “Line CD and Line CP.” These circuits (lines) are plumbed to the various components they lubricate throughout the dragline.

Open Gear System Control Panel (OGL Reservoir):

**Line (CD)**

• LH Rail

• RH Rail

• LH & RH Swing Pinions

• RH Drag Gears • LH Hoist Gear

**Line (CP)**

• LH Propel Gear

• RH Propel Gear

• Manual Lubrication Hose Reel mounted on the roller circle

• RH Inboard Propel Bearings

• RH Propel Linkage

• RH Outboard Propel Bearings

• LH Inboard Propel Bearings

• LH Propel Linkage

• LH Outboard Propel Bearings

**Rotating Frame System Control Panel (MPG Reservoir) Line (AD):**

• LH & RH Rotating Bearing Injectors

• Centre Journal A.F. Bearings

• LH & RH Drag Bearings

• LH & RH Hoist Bearings Line (AP)

• LH & RH Propel Pinion A.F. Bearing

• Centre Journal Bushing

**Front End System Control Panel (MPG Reservoir) Line (B):**

• Boom Bearings

• Tri-Structure Bearings

• Fairlead Bearings.

**Wire Rope Lubrication System (WRL Reservoir) Line (EH, ED):**

• Fairlead Upper & Lower Drag Sheaves

• Tri-Structure Hoist Sheaves

• Boom Point Sheaves

All the lubrication systems are controlled by the Programmable Logic Controller (PLC) which is located inside the drag line lubrication room. It is equipped with a computer touch screen that allows operators to select manual or automatic operation. The PLC provides operators the flexibility to program lubrication cycles.

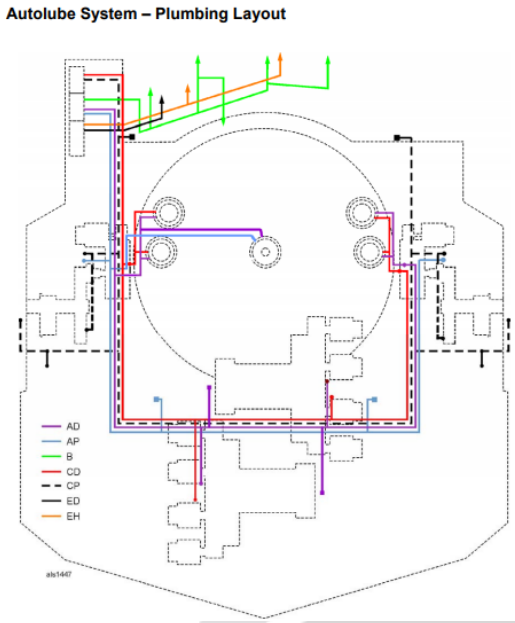



**Figure 1 Plumbing layout-Auto lube**

AD MPG: Rotating Frame - Dig ,CD OGL: Open Gears - Dig.

EH Wire Rope Spray: Hoist.

AP MPG: Rotating Frame - Propel.

AP MPG: Rotating Frame - Propel, B MPG: Front End, ED Wire Rope Spray: Drag.

**Auto lube System – Lubrication Pumps & Tanks**

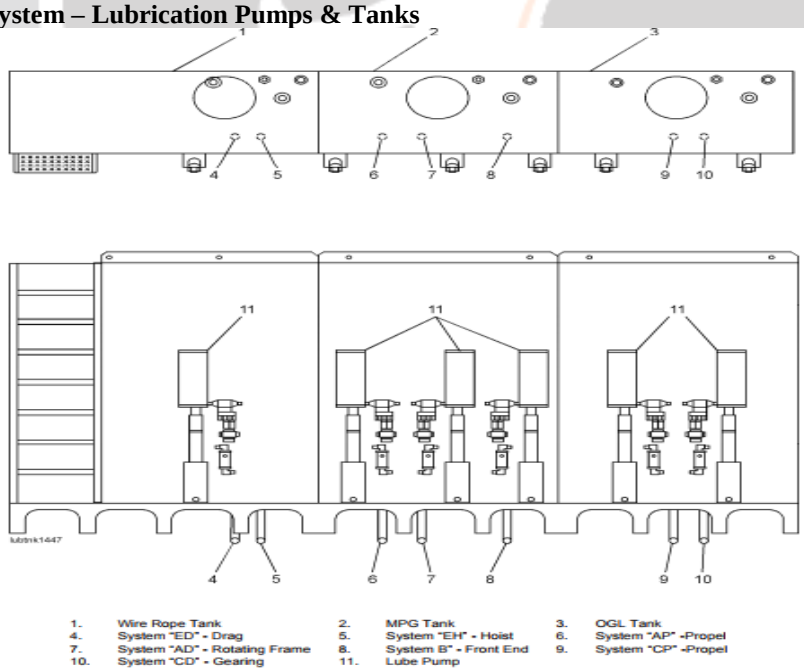



**Figure 2 Lubrication Pumps and Tanks**

**Auto lube –**

Typical Lubrication Cycle There are five independent lubrication systems on this 8200 dragline. Each system consists of an “A” and “B” circuit. Only one circuit per system can be operational at any given time. The cycle of automatic lubrication events that occur are controlled by the programmable logic controller (PLC) and are

dependent on variables such as in-use time duration, the number of operational repetitions the machine has performed as well as the mechanical mode selected by the operator. Automatic lubrication cycles differ when the machine is in dig mode versus propel mode. Manual lubrication is always available by selecting control options at the PLC cabinet which is located in the dragline lube room. Automatic lubrication cycles are controlled by software that includes electronic timers and counters. In addition, there are pumps, pressure transducers, nozzles, pipes and hoses mounted throughout the entire machine to protect bearings, gears and other wear-sensitive surfaces. During normal operation, the PLC directs five sub-panels to provide a measured amount of the specified lubricant to the system it protects. Upon completion of a cycle, the counter or timer is reset and the cycle begins again. If a fault is encountered, it is annunciated to the operator in the cabin. Faults can be reset by a technician or the operator. Some systems that count machine repetitions reset the fault when the next iteration begins.

**Typical Sequence of Events:**

1. The PLC energizes the diverter valve located on the system control panel.

2. After a two second pause, the solenoid supplies air pressure to drive the lubrication pump.

3. The pump builds pressure within the lubrication circuit.

4. When the circuit pressure reaches 2,500 PSI, the lube pump air solenoid and the diverter valve are de-energized. This vents circuit pressure back to the reservoir.

5. When the panel pressure transducer senses 800 PSI, the PLC records a successful lubrication cycle and resets for the next cycle.

**Cycle time and modes:-**

1. CP & AP- Operated in **PROPEL** mode. Cycle starts after every **2 steps**.

2. AD- Operated in **DIG** mode. Cycle starts after every **20 minutes**.

3. System 'B' - Operated in **DIG** mode. Cycle starts after **45 minutes.**

4. CD- Operated in **DIG** mode. Cycle starts after every **25 minutes.**

Every pump cycle is of **40 seconds**

Only System-'B' pump cycle is of **2 minutes.**

**Autolube System Components:**

• Air filter regulator/lubricator: Supplies clean lubricated air to the pump.

• Air pump solenoid: Controls the air to activate the lube pump.

• APX Air transducer: Monitors the air pressure output (Max. 200 PSI) from the compressor.

• End of Line pressure (EOL) switch: Senses the lubrication pressure at the end of the circuit (approx. 2,500 PSI).

• Pressure Gauges: Provide visual indication of the air pressures of any circuit.

• Spray air solenoid valves: Normally closed valves that supply regulated air to the lube sprays during lube cycles when requested by the PLC. This solenoid also provides post air after the lube cycle has been completed.

• Air-Driven Lubrication Pump: Pressurizes lubricant to a set pressure.

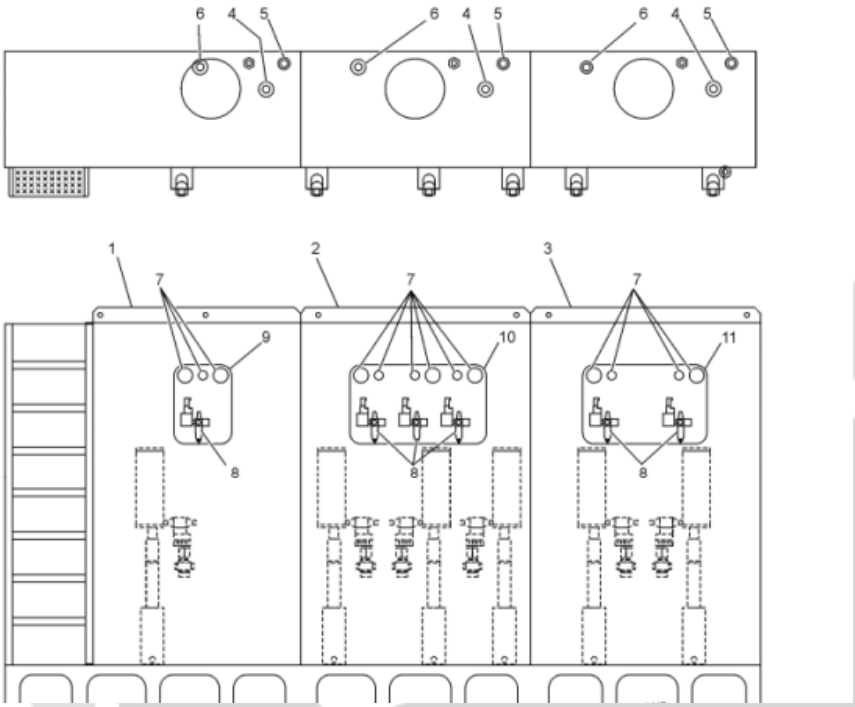
(Typ. 2,500 PSI)

• Panel Transducer Pressure switch: Senses the out - going pressure of the lube into the circuit. It is an analog device fed with a low 24 VDC supply. It provides an output proportional to the actual pressure in the line. It monitors faulty conditions and will annunciate any faults.

• Timers and counters: The internal software, within the PLC creates timers and counters with great flexibility. The PLC provides all the logic to create all lube cycles and combinations to detect faults, which will be shown in the HMI.

• HMI (Human Machine Interface): Provides graphical information of the parameters of the lube system and manual cycles of any of the systems. Provides a register of the various faults recorded in the system. It also provides the ability to change the timing of intervals between lube cycles.

**Autolube System – Control Panels:**




1. Wire Rope Tank 2. MPG Tank 3. OGL Tank 4. System "ED" - Drag 5. System "EH" - Hoist

6. System "AP" -Propel 7. System "AD" - Rotating Frame

8. System B" - Front End 9. System "CP" -Propel 10. System "CD" - Gearing, 11. Lube Pump

**Gearcase Lubrication :**

Lubrication of all the major gear cases is accomplished by circulating filtered oil to the gear trains and upper swing case bearings. Each gear case has a separate system which consists of a pump, flow indicator, sediment collector, 149 micron filter with dirt indicator and shut off valve.

**Gearcase Lube Capacities:**

The following is a list of lube capacities for each of the gear case, not including any associated piping:

| Gear case | Qty. | Capacity(gallons) | (ea.case)lit | Total(gallons) | (litres) |
|---|---|---|---|---|---|
| Swing | 4 | 145 | 548 | 580 | 2,195 |
| Propel | 2 | 330 | 1,249 | 660 | 2,498 |
| Hoist(per half) | 1 | 250 | 946 | 500 | 1,892 |
| Drag(per half) | 1 | 250 | 946 | 500 | 1,892 |
| | | | Total all gear case: | 2,240 | 8,476 |

**Types of Lubricant**

Manual lube points are lubricated using the following types of lubricant:

1. Open Gear Lubrication (OGL)

2. Multi-Purpose Grease (MPG)

3. Wire Rope Lubrication (WRL)

4. Electric Motor Grease (EMG)

**Open Gear Lube (OGL) :**

Circuits operate by atomizing lubricant and spraying or dripping it across the flank of the gear teeth. The regulated air supply to these spray nozzles is controlled by normally-closed solenoid valves. These solenoid valves are opened three seconds before the pump supplies fluid pressure and remain open five seconds after the cycle is complete.

**Auto lube OGL – Open Gear Lubrication:**

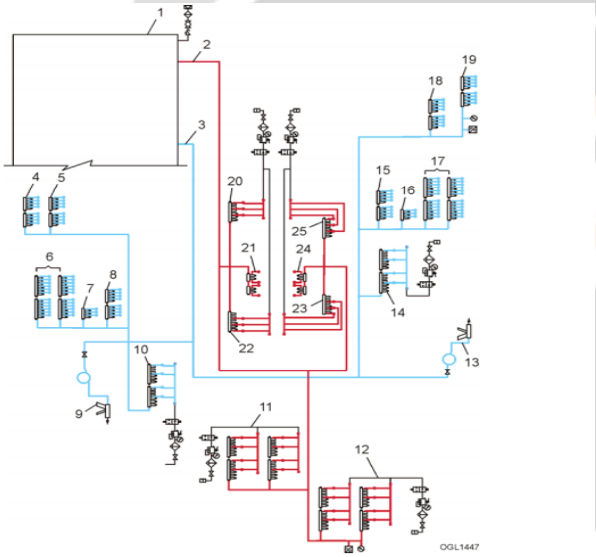



**Figure 3 Auto lube OGL**

1. Lube Room, 2. System “CD” (Red Lines), 3. System “CP” (Blue Lines).4. Eccentric Outboard Bushing - LH, 5. Eccentric Inboard Bushing - LH, 6. Walking Cam-LH7. Stabilizer - LH, 8. Ball Joints & Pins - LH, 9. Hand Grease Gun - Roller Circle-LH.10. Propel Pinion - LH, 11. Hoist Gear , 12. Drag Gear, 13. Hand Grease Gun - Roller Circle- RH.14. Propel Pinion - RH, 15. Ball Joints & Pins - RH, 16. Stabilizer - RH, 17. Walking Cam - RH.

18. Eccentric Inboard Bushing - RH, 19. Eccentric Outboard Bushing - RH, 20. Swing Pinion #1. 21. Rails - Left . 22. Swing Pinion #3. 23. Swing Pinion #4. 24. Rails - Right. 25. Swing Pinion #2.

**Multi-Purpose Grease (MPG) :**

Circuits use the pressure sequences to utilize the capillary nature of the grease. Viscosity of the lubricant is a consideration calculated into the software timers and counters of the PLC.

**Auto lube MPG – Rotating Frame Lubrication:**

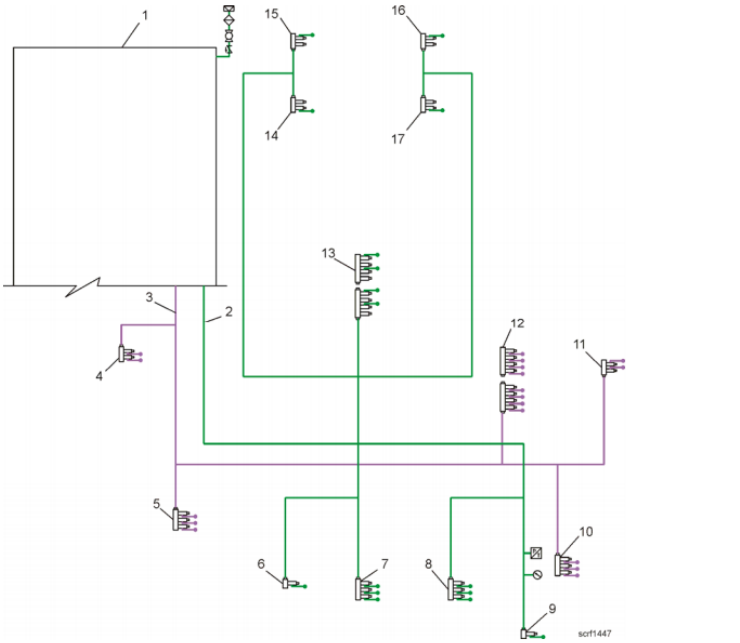


**Figure 4 Auto lube MPG**

1. Lube Room. 2. System "AD" (Green Lines). 3. System "AP" (Purple Lines).4. Propel Pinion Bearings - LH. 5. Hook Shoe - LH. 6. Drag Drum Shaft .7. Hoist Drum Shaft/Internal Shaft. 8. Drag Drum Shaft/Internal Shaft. 9. Hoist Drum Shaft.10. Hook Shoe - RH. 11. Propel Pinion Bearings - RH. 12. Centre Journal Bushings.13. Centre Journal Anti-Friction Bearings. 14. Swing Pinion Bearings #3.15. Swing Pinion Bearings #1. 16. Swing Pinion Bearings #2.17. Swing Pinion Bearings #4.

**Auto lube MPG – Front End Lubrication:**

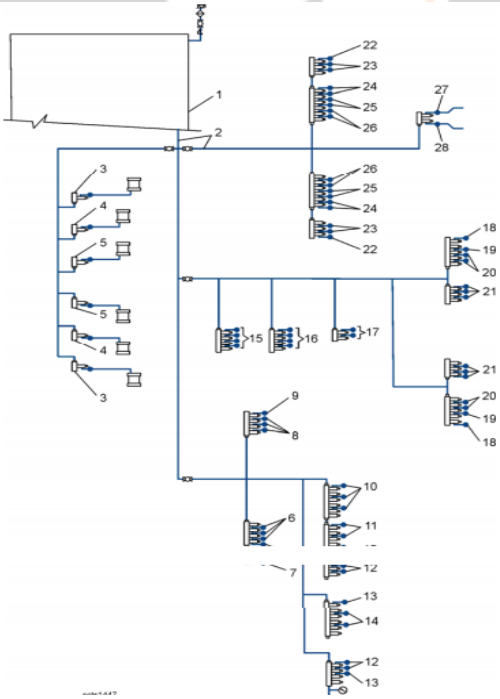


**Figure 5 Auto lube MPG - Front End Lubrication**

1. Lube Room. 2. System "B" (Blue Lines).3. Boom Foot Pin.4. Tri-Structure Pin.
5. Fairlead pin.6. RH Intermediate Suspension Rope Pin7. RH Damper Rope Pin.8. LH Intermediate Suspension Rope Pin.

9. LH Damper Rope Pin.10. Rear Sheave Thrust Washer.11. Rear Pivot Bushing.12. Boom Support Rope Pins. 13. Sheave Bearing.14. Front Sheave Bushing.15. Hoist Rope Rollers House.16. Hoist Rope Rollers-TriStructure .
17. Tri-Structure Hoist Sheaves.18. Tri-Structure Head Pin.19. Boom Support Head Pin.20. Rope Equalizer Pin.21. Intermediate Rope Support Pin. 22. Sheave.23. Bottom Thrust. 24. Journal - Bottom.25. Top Thrust. 26. Journal - Top.27. Left Drag Sheaves. 28. Right Drag Sheaves.

**Auto lube MPG – Foot Pin Lubrication:**

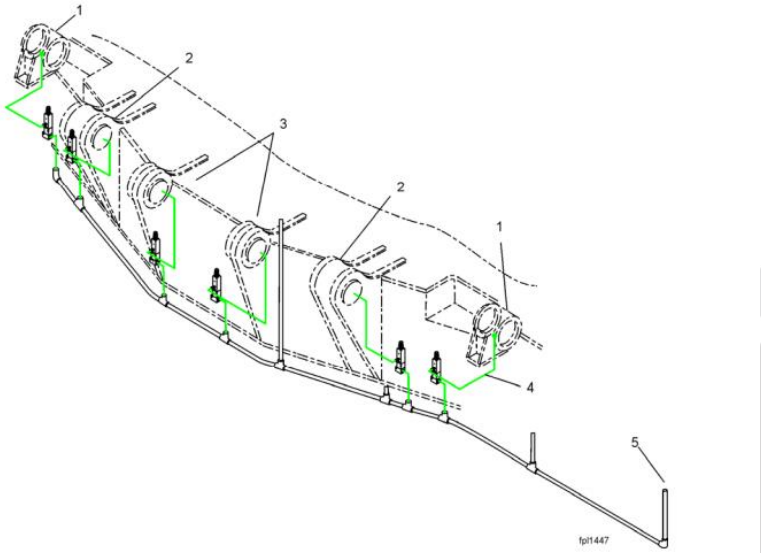



**Figure 6 Auto lube MPG -Foot Pin Lubrication**

1. Boom Foot Pins. 2. Tri-Structure Pins. 3. Fairlead Pins . 4. System “B” (Green Lines) 5. From Lube Room

**Wire Rope Lubrication (WRL):**Circuits use mechanical injector nozzles that measure the amount of lubricant that is distributed to the various sheaves, ropes and drums. When multiple components are lubricated at once, the injectors are mounted on appropriate manifolds that separate each component spray.

**Auto lube WRL – Rope Spray Lubrication:**

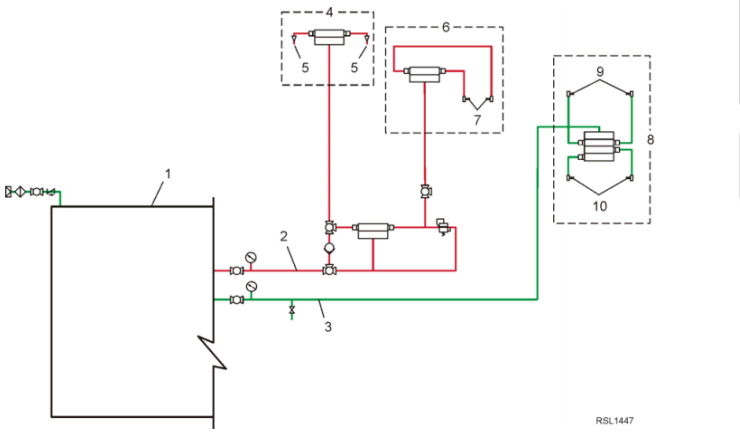
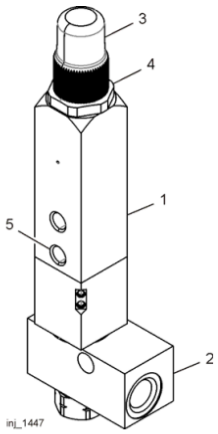



**Figure 7 Auto Lube WRL- Rope Spray Lubrication**

1. Lube Room.2. System “EH” (Red Lines).3. System “ED” (Green Lines).4. Boom Point .5. Drip Feed Points. 6. Tri-Structure. 7. Hoist Sheaves .8. Fairlead .9. Upper Drag Sheaves. 10. Lower Drag Sheaves

**Lincoln Type SL-V Lubricant Injectors :**

These pressure-operating, spring-reset, series-installed injectors are supplied in banks mounted on manifolds or individually. Each injector expels a maximum of 1.31 cc (.08 in3) of lubricant from its outlet port each cycle. Dual outlet ports on each injector permit the injectors to be piped in series for increased lube supply to a common point




1. Injector 2. Manifold 3. Adjustment Cap
4. Lock Nut 5. Outlet Port

*SL-V Injector*

**Figure 8 SL-V Injector**

MAXIMUM Operating Pressure: 6,000 PSI (413 bar)

RECOMMENDED Operating Pressure: 2,500 PSI (172 bar)

MINIMUM Operating Pressure: 1,850 PSI (128 bar)

MAXIMUM Recharge Pressure: 1000 PSI (69 bar)

**Lincoln SL-V XL Injectors :**

The SL-V XL injectors on this machine dispense Open Gear Lubricants (OGL) to the swing pinions. These pressure operating, spring reset injectors are equipped with dual outlet ports which permit the injectors to be piped in series to increase the lube supplied if required. The SL-V XL will expel a maximum of 5.0 cc (0.305 in3) of lube each cycle. The injector output is adjustable; the system has been designed for the maximum output.

MAXIMUM Operating Pressure: 3,500 PSI (241 bar)

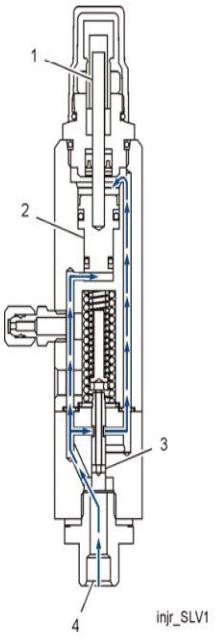
RECOMMENDED Operating Pressure: 2,500 PSI (172 bar)

MINIMUM Operating Pressure: 1,850 PSI (128 bar)

MAXIMUM Recharge Pressure: 300 PSI (21 bar)

**Stage 1**

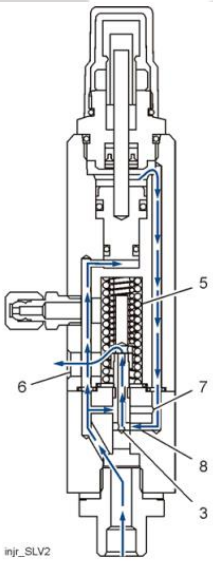
The injector starts in its normal or rest position. Incoming lubricant is directed through the slide valve to both sides of the piston. The pressure of the incoming lubricant acting on both sides of the piston causes the piston to move downward against the shoulder and fills the measuring chamber. The indicator stem is fully retracted away from the stop of the adjusting screw.




1. Indicator Stem 2. Piston 3. Slide Valve 4. Lubricant Supply

**Stage 2**

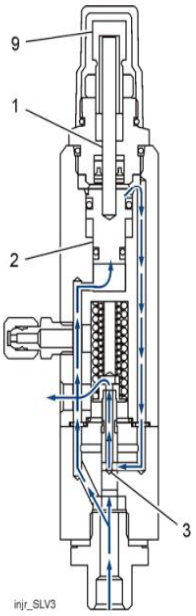
Further increase in pressure causes the slide valve to move against the force of the springs. As the slide valve moves, it closes passage 1 and opens passage 2 to the outlet port. The pressure of the incoming lubricant is now acting only upon the bottom of the piston. The incoming lubricant displaces the piston which forces the lubricant in the measuring chamber to be dispensed through passage 2, through the slide valve and through the outlet port to the lube point.




3. Slide Valve 5. Spring 6. Outlet Port
7. Passage 1 8. Passage 2

**Stage 3**

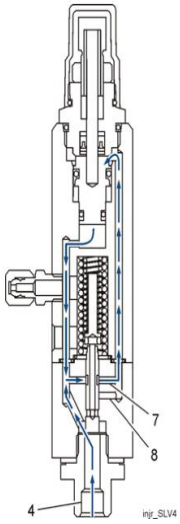
The piston will dispense lubricant until the indicator stem hits the stop of the adjusting screw. The volume of lubricant dispensed can be adjusted by limiting the travel of the piston. The piston and slide valve remain in this position until the lubricant pressure in the supply line is vented.




1. Indicator Stem 2. Piston 3. Slide Valve 9. Adjusting Screw

**Stage 4**

As the pressure in the supply line vents to 1000 psig [69 bar], the slide valve moves downward and closes passage 2 and opens passage 1. The lubricant pressure in the supply line is now acting upon both sides of the piston causing it to move downward. As the piston moves downward, a volume of lubricant flows from the underside of the piston. It them flows past the slide valve, through passage 1 and into the upper side of the piston. Since the volume on top of the piston is greater than the volume under the piston, an additional volume of lubricant flows from the supply line to the upper side of the piston. This volume of lubricant leaving the supply line causes the pressure to drop very quickly. The piston may or may not fully return to the shoulder, depending upon the volume of lubricant in the supply line. The injector is now ready for the next cycle.




4. Lubricant Supply 7. Passage 1 8. Passage 2

**Figure 9:Lincoln SLV Injector**

**Conclusion:** According to my observation I understood the basic overall mechanism of Dragline 8200, How the machine operates and got the overview of how the machine operates in coal mine.

From my case study I understood various different aspects of the draglines lubrication system, like how different lubrication are taken to various parts of the machine and how according to the requirements flow ratio of injectors are altered.

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