

Oil Filtration Solutions Ltd.

Prepared by:

Bill Butler, *B.A., B.Sc*

Tel: 1.709.685.0450

Email: bbutler@oilfiltrationsolutions.com

Filtration Report

**Generation 2 Filtration™
on C.C.G.S. Cape Roger.
October 1, 2018**



**FRC Miranda Davits
Hydraulic Powerpack with a
600-liter oil reservoir.**

**OIL FILTRATION
SOLUTIONS LTD.**

OVERVIEW

On September 19, 2016, Oil Filtration Solutions Ltd. (OFS) was contacted by the Chief Engineer from the Canadian Coast Guard Ship Cape Roger, who was experiencing a significant water contamination issue on the FRC Miranda Davit hydraulic system (600-liter oil reservoir). He was seeking a low-cost solution to remove the water from the system and hydraulic oil, without replacing the hydraulic oil or decommissioning the hydraulic power pack, as the vessel was on emergency search and rescue standby. This brief report provides an overview of the use of Generation 2 Filtration™ (G2F) to solve the contamination problem.

We introduced one of our Generation 2 Filtration™ (G2F) mobile filter carts, used to provide constant filtration of the oil while the vessel was in port, without having to run or decommission the hydraulic power pack.

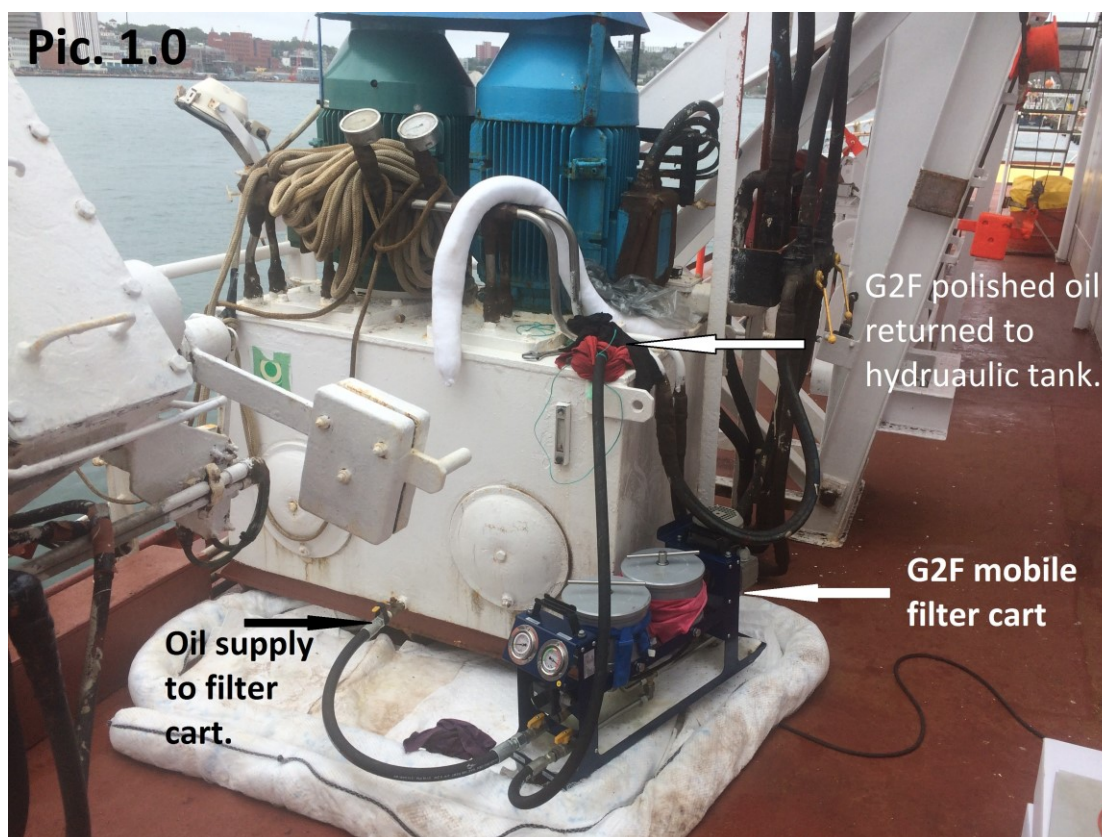
Once the concentration of water reached a manageable level, they installed a permanent G2F high-pressure filter unit, affording the removal of the remaining water and contamination when the hydraulic system was in operation while at sea. This particular hydraulic system operates in an extreme harsh environment on the deck of the vessel, however with the use of G2F, the system and oil will continue to be free of water and ultra-fine contamination, dramatically extending the life of the hydraulic system and oil with operational safety, reducing operating costs, and improving the reliability and operation of the equipment.

The G2F bypass filtration technology is a bypass filter, with the unique ability to remove solid particulate down to 1-micron and water at 99.97% on a single pass from oil at a low cost, dramatically prolonging the oil and the equipment. Applications include hydraulic, transmission, gear, thermal, and diesel engine oil, and with the ability to filter heavy weight gear oils up to 400 cSt (For more information visit www.generation2filtration.com)

Mobile Filter Cart

The G2F mobile filter carts are used to polish oil before use, or to provide continuous filtration of oil whereby a source of pressure for oil supply to a permanent G2F filter unit is unavailable, or situations such as this, requiring the immediate removal of water from a highly contaminated hydraulic system vital to the crew and operation of the vessel, without incurring downtime.

The filter cart (model G2F-POR102, operating at 110 volts, flow rate of 6 liters/minute) obtained oil supply from an existing port located at the bottom of the reservoir, and returned the G2F polished oil back to the reservoir via the filler port, located on top of the tank.



Results Using G2F

Unfortunately, an oil sample was not taken prior to using the G2F filter cart. However, the appearance of the oil indicated a significant water contamination problem. An oil sample was taken after 24 hours of filtration and six (6) G2F filter elements. The oil tested having 1.1272 % or 11,272 ppm of water and an ISO cleanliness code (measuring particulate) of 17/15/12 (Appendix 1.0).

Although the oil still contained water, it tested to be two (2) ISO cleanliness codes cleaner (measuring particulate) than the ISO cleanliness grade of brand new unused hydraulic oil, having only 758 pieces of dirt per 1 ml of oil > 4 microns in size, while new oil has 1,247 (Appendix 1.0).

The Chief Engineers and crew continued to use the mobile filter cart while the vessel was on stand-by between search and rescue calls. Eight days and 18 replacement elements later, on September 28th the oil tested to contain just 0.3066% or 3,066 ppm of water, a reduction of 8,206 ppm or 72.79%. A permanent G2F filter unit, model G2F-HP250 was then installed the same day (Pic. 1.1) to remove the remaining water and any future contamination while the vessel is in operation.



Laboratory Findings

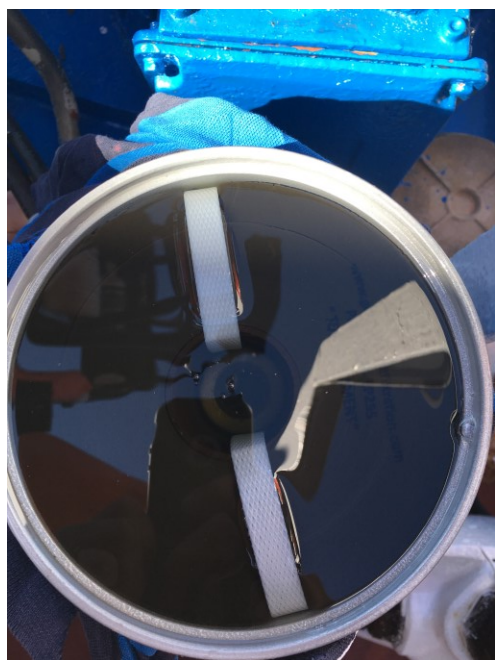
The laboratory report (appendix 1.0) from Gastops laboratory in Mount Pearl, NL, Canada, validates the ability of G2F to remove water and ultra-fine contamination, reclaiming the oil, cleaner than brand new unused hydraulic oil, while the hydraulic system was in use. Most industrial equipment recommends no more than 250 ppm of water. Oil analysis laboratories consider 100 ppm negligible or no water present, while the hydraulic oil in this power pack, running 2-3 hours per week, in a moisture laden harsh environment, tested to have only 19 ppm or no water by laboratory standards, virtually eliminating acid and varnish formation and associated negative effects on the hydraulic system. More importantly, the ISO particle count shows the oil is now cleaner than the ISO cleanliness grade of brand new unused hydraulic oil, exceeding the recommended ISO cleanliness requirements to maximize hydraulic component life (Appendix 2.0 & Appendix 3), eliminating the need to replace the oil, as hydraulic oil will last indefinitely if kept clean, as long as it is not subjected to abnormal high temperatures resulting in thermal breakdown of the oil.

Table 1.0 – Laboratory test results showing percentage of water and ISO cleanliness codes of hydraulic oil on the Miranda Davits hydraulics using G2F.

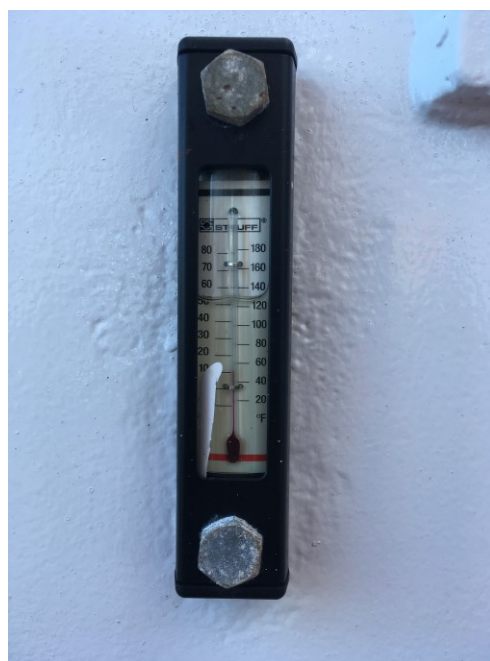
NEW UNUSED OIL					
2 years later					
After 24 elements					
After 6 elements					
Date Sampled	NEW OIL	9/24/2018	9/28/2016	9/20/2016	
Lab No	609574	2340377	1786965	1779829	
Machine / Lube Cond.		U / N	U / M	U / C	
Lube Hours		Unknown	Unknown	50	
PARTICLE COUNT (particles per ml) ISO 4406:99					
Pore Block Particle Count Alarm Limits Marginal (19/17/16)					
Pore Block ISO Code	17/16/12	17/16/12	17/16/12	17/15/12	
>4 Micron	1247	969	1014	758	
>6 Micron	485	377	410	294	
>14 Micron	36	28	31	22	
>50 Micron	1	1	1	0	
>100 Micron	0	0	0	0	
WATER (%) a-ASTM D6304C b-IWI-134* c-Crackle d-IWI-135 e-IWI-370*					
Water		0.0019 (a)	0.3066 (a)	1.1272 (a)	
19 ppm - 3,068 ppm - 11,272 ppm					

Visual Confirmation

After taking an oil sample on September 24, 2018, we inspected and replaced the G2F element. It was highly contaminated (pictured below left) with ultra-fine contamination, reducing its ability to remove additional dirt from the hydraulic system. Although the oil was visually clean in the reservoir inspection/sight glass (pictured below right), regular element changes are required to maintain clean oil. It is our recommendation to visually inspect the element monthly and replace if necessary.



Dirty G2F Filter Element



Tank Sight Glass

The used G2F element will identify hydraulic problems before they become costly repair ventures (Appendix 4.0). Regular element inspection is highly recommended.

Benefits & Cost-Savings

Implementation of Generation 2 Filtration™ offers several measurable cost-saving benefits:

1. Without the use of G2F technology, it would have been a time-consuming task (downtime) and a costly venture to flush the hydraulic system, pumps and hoses, and to replace and dispose of 600 liters of oil, while taking the vessel out of commission. More importantly, the usual process of flushing would not remove all water from the oil contained throughout the hydraulic system. G2F got it down to just 0.0019% or 19 ppm and continues to polish the hydraulic oil while the vessel is in operation today.
2. The oil was not replaced:
 - Saved the cost to purchase 600 liters of new oil (\$2,000).
 - Saved the cost to dispose of 600 liters of the contaminated oil (\$500-\$700).
 - Reduced the vessels GHG emissions and associated environmental impact.
3. After 2 years ISO cleanliness level of the oil is still maintained cleaner than the ISO cleanliness grade of brand-new unused oil, dramatically reducing mechanical wear while greatly improving equipment reliability (Appendix 5.0).
4. The permanent filter unit will continue to keep the oil clean, dramatically prolonging the life of the hydraulic system (Appendix 6.0).
5. If a permanent G2F filter unit was installed prior to the water contamination issue (at a cost of less than \$2,500 installed), regular element inspection and replacement would have identified the problem in its infancy stages, dramatically reducing the mechanical wear, time, and cost to clean up the oil (Appendix 4.0).
6. The installation of the permanent G2F unit was able to keep the oil clean on this application that is used infrequently. The more the power pack is in use, the greater the amount of G2F filtration, and would provide greater results on powerpacks that are used frequently such as steering, aqua-masters, or CPP systems, and provide a return on investment (ROI) in a relatively short period of time due to savings on oil, with larger returns on reduced mechanical wear, extended component life, and reduced downtime.

Appendix 1.0 – Laboratory Analysis



Machine Condition

UNKNOWN

Lubricant Condition

NORMAL

Machine Name: CCGS Cape Roger - Miranda Davits

Tel: 709-748-2677, Fax: 709-748-8771

Analysis Report

Component Information		Sample Information		Customer Information
Machine Type:	Hydraulic System	Sump Size: 600	Received: 09/25/2018	Oil Filtration Solutions
Lubricant:	PETRO-CANADA/HYDREX AW 68		Report: 09/25/2018	PO Box 16125
Machine MFG:	SCHATT HARDING		Sample No.: 3635 - 1 - 2 - 3	CBS, NL A1X2E2
Machine MOD:	FRC Davit Power Pack		Analyst/Test: DR / KFPC	Contact: Bill Butler

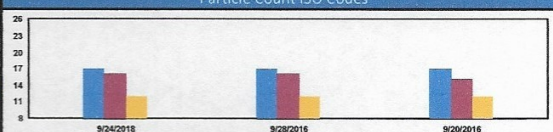
PROBLEMS No problems found with current sample.

COMMENTS The results for this sample indicate normal conditions. Please continue scheduled sampling.

CUSTOMER NOTES

Date Sampled	NEW OIL	9/24/2018	9/28/2016	9/20/2016		
Lab No	609574	2340377	1786965	1779829		
Machine / Lube Cond.		U / N	U / M	U / C		
Lube Hours		Unknown	Unknown	50		
PARTICLE COUNT (particles per ml) ISO 4406-99						
Pore Block Particle Count Alarm Limits Marginal (19/17/16)						
Pore Block ISO Code	17/16/12	17/16/12	17/16/12	17/15/12		
>4 Micron	1247	969	1014	758		
>6 Micron	485	377	410	294		
>14 Micron	36	28	31	22		
>50 Micron	1	1	1	0		
>100 Micron	0	0	0	0		
WATER (%) a-ASTM D6304C b-IWI-134* c-Crackle d-IWI-135* e-IWI-370*						
Water		0.0019 (a)	0.3066 (a)	1.1272 (a)		

Particle Count ISO Codes



Appendix 2.0 – Recommended ISO Cleanliness Levels



Revised Dec. 8, 2009

ISO Particle Counts Recommended Cleanliness Chart

Most Sensitive System Component	Recommended ISO Target Level		
	Low/Med. Pressure Under 2000 psi Moderate Conditions	High Pressure 2000-2999 psi (or low/medium pressure plus severe conditions)	Very High Pressure 3000 psi and above (or high pressure plus severe conditions)
Pumps			
Fixed Gear/Fixed Vane	20/18/15	19/17/14	18/16/13
Fixed Piston	19/17/14	18/16/13	17/15/12
Variable Vane	18/16/13	17/15/12	Not Applicable
Variable Piston	18/16/13	17/15/12	16/14/11
Valves			
Check Valve	20/18/15	20/18/15	19/17/14
Directional (solenoid)	20/18/15	19/17/14	18/16/13
Standard Flow Control	20/18/15	19/17/14	18/16/13
Cartridge Valve	19/17/14	18/16/13	17/15/12
Proportional Valve	17/15/12	17/15/12	16/14/11
Servo Valve	16/14/11	16/14/11	15/13/10
Actuators			
Cylinders, Vane Motors, Gear Motors	20/18/15	19/17/14	18/16/13
Piston Motors, Swash Plate Motors	19/17/14	18/16/13	17/15/12
Hydrostatic Drives	16/15/12	16/14/11	15/13/10
Bearings			
Journal Bearings	17/15/12	Not Applicable	Not Applicable
Roller Bearings	16/14/11	Not Applicable	Not Applicable
Ball Bearings	15/13/10	Not Applicable	Not Applicable

...because what happens on the inside really counts

If you have any questions about
this chart, please contact your
Regional Account Manager.

9321 - 48 Street
Edmonton, AB T6B 2R4
Phone: (780) 462-2400
Fax: (780) 462-2420
Toll Free: 1-877-962-2400

95 Copernicus Blvd.
Brantford, Ontario N3P 1N4
Phone: (519) 720-9700
Fax: (519) 720-9705

Appendix 3.0 – Cat Oil Analysis Guide

9



Scheduled Oil Sampling Guide

ANALYSIS GUIDE

NOTE: THESE CHARTS ARE FOR GENERAL USE ONLY AND DO NOT INDICATE DEFINITE LIMITS OF WEAR METALS FOR ANY SPECIFIC MAKE OR MODEL. Wear patterns are best established after evaluation of three samples taken at the same oil change intervals. Make, model, application, age, makeup oil added, time of use or recent repairs can cause the values to vary greatly from those shown. Values are given in parts per million (PPM).

Primary Elements	Secondary Elements	Potential Wear	Problem Area & Causes
Silicon (Dirt)	Aluminum	Pistons, Rings, Liners	Air Induction System Filters, Turbocharger Breathers, Contamination — Dirt
Iron		Liners, Pistons, Crankshafts, Valves, Gear Train	Contamination — Dirt, Abnormal temperatures, Lack of lubrication, Storage (rust)
Chromium	Molybdenum	Piston Rings	Blow-by, Oil consumption
Aluminum	Chromium	Pistons & Rings	Blow-by
Aluminum or Copper	Lead, Tin	Bearings	Low or fluctuating oil pressure
Sodium	Silicon, Boron	Cooling System	Water Pump, Cylinder head, Liner seals, Oil cooler, Anti-freeze
Silver		Wrist-Pin Bushings	Due to use of zinc based oil
Iron	Chromium, Aluminum	Piston Rings, Liners	Abnormal operating temperature — dirt, Restricted air induction system
Lead-Tin	Copper, Aluminum	Bearing	Dirt contamination, Lack of lubricant

OIL ADDITIVES USED TO IDENTIFY OIL TYPE

Lead	}	Additives in Grease	Sodium	}	Additives in Coolant
Boron			Silicon		
Sodium			Boron		
Silicon			Chromium		
Boron, Silicon, Molybdenum — Lube Oil Additive					
Calcium, Magnesium — Lube Oil Detergent					
Zinc (ZDP), Calcium — Oxidation and Wear Inhibitor					

SUGGESTED SAFE WEAR LEVELS

(expressed in parts per million)

Diesel Engines		Transmissions		Hydraulics		Final Drives — Diffs.	
Silicon (Dirt)	5-20	Silicon (Dirt)	5-30	Silicon (Dirt)	1-10	Silicon (Dirt)	25-75
Iron	10-80	Iron	10-100	Iron	1-15	Iron	50-300
Chromium	2-10	Chromium	1-4	Chromium	1-3	Chromium	2-6
Aluminum	4-15	Aluminum	6-10	Aluminum	1-10	Copper	30-100
Copper	10-30	Copper	20-250	Copper	1-20		-
Sodium	10-50	Sodium	10-50		-		-
Lead	5-30		-		-		-
Tin	5-30		-		-		-

ISO FLUID CLEANLINESS GUIDELINES FOR HYDRAULIC COMPARTMENTS

ISO Code	Recommendations Component	Relative Sizes of Particles and Comparison of Dimensional Units		
		Size of Familiar Objects		
		Substance	Micron	Inch
20/16	Low Pressure Systems			
18/15	Low Pressure Control System			
16/13	Vane/Piston, Pumps & Motors, Control Valves	Grain of Table Salt	100	.0039
15/12	Highly Sophisticated Systems and Hydrostatic Transmission	Human Hair	70	.0027
14/11	Sensitive Servo Systems	Lower Limit of Visibility	40	.00158
12/9	High Performance Sensitive High Pressure Systems	Talcum Powder	10	.0003

A Proactive Approach to Maintenance

G2F is a low cost 'Proactive' maintenance asset management tool reducing long-term maintenance costs, while providing short-term savings on oil, standard Filter, downtime, waste oil and offering quick return on the capital investment. Common problems can be identified by the condition of the G2F element.



Normal Element (A) – Changed at proper intervals, preventing contamination build-up, obtaining good system hygiene.

Contaminated Oil (B) – Element is light black in colour indicating a 'higher than normal concentration of ultra-fine contamination is present in the oil.

Metal Dust Particles Present (C) – High concentration of metal dust – abnormal abrasion among sliding parts. Change element and sample oil to investigate source of wear.

Overdue Element Change (D) – Element is completely saturated with contamination, the media implodes, indicating the element is overdue for changing. Increase frequency of element change and monitor.

Excessive Water Contamination (E) – Element is spongy and shrunken indicating water is present in the oil.

Appendix 5.0 – Life Extension Method (Solids)

Reducing the amount of solid particulate in oil dramatically increases the life of the oil and the equipment it lubricates, and the Life Extension Method for particulate estimates this value.

Assuming the hydraulic oil was only (1) one ISO dirtier than brand new oil at a 18/15, in 24 hours of filtration G2F reduced it down to a 17/15/12 or 15/12 using the oil ISO coded system, increasing the life of the hydraulic system by a factor of (2) two.

Life Extension Method

The Life Extension Method (LEM) is a compilation of various test results applied to illustrate how component life can be extended by clean oil. There are three separate tables:

- Hydraulic Systems
- Roller Element Bearings
- Moisture

Hydraulic Systems:

17/14 = NEW OIL **15/12** = after 24 hrs filtering with G2F **Life Extension Factor (LEF)** **????** = BEFOFE G2F

Initial ISO	2x	3x	4x	5x	6x	7x	8x	9x	10x
23/20	20/17	19/16	18/15	17/14	17/13	16/13	16/12	15/12	15/11
22/19	19/16	18/15	17/14	16/13	16/12	15/12	14/11	14/11	14/10
21/18	18/15	17/14	16/13	15/12	15/11	14/11	14/10	13/10	13/10
20/17	17/14	16/13	15/12	14/11	13/11	13/10	13/9	12/9	12/8
19/16	16/13	15/12	14/11	13/10	13/9	12/9	12/8	11/8	11/8
18/15	15/12	14/11	13/10	12/9	12/8	11/8	-	-	-
17/14	14/11	13/10	12/9	12/8	11/8	-	-	-	-
16/13	13/10	12/9	11/8	-	-	-	-	-	-
15/12	12/9	11/8	-	-	-	-	-	-	-
14/11	11/8	-	-	-	-	-	-	-	-
13/10	11/8	-	-	-	-	-	-	-	-
12/9	11/8	-	-	-	-	-	-	-	-

Example: By reducing the particulate levels from an ISO 21/18 to an ISO 15/12, component life is increased by a factor of 5.

Appendix 6.0 – Life Extension Method (H₂O)

Water, emulsified or free-standing dramatically decreases the life of the oil and equipment as evident by the Life Extension Method (LEM), indicating the increase in hydraulic system life by reducing the water content of the oil. By installing G2F the water content in the Davits system was reduced to 19 ppm, increasing the life of the hydraulic system by a factor of more than (10) ten.

Moisture:

Increase Davit hydraulic system life by a factor of 10

AFTER it was 19 ppm

BEFORE

Life Extension Factor (LEF)

Initial PPM	2x	3x	4x	5x	6x	7x	8x	9x	10x
50,000	12,500	6500	4500	3125	2500	2000	1500	1000	782
25,000	6250	3250	2250	1563	1250	1000	750	500	391
10,000	2500	1300	900	625	500	400	300	200	156
5000	1250	650	450	313	250	200	150	100	78
2500	625	325	225	156	125	100	75	50	39
1000	250	130	90	63	50	40	30	20	16
500	125	65	45	31	25	20	15	10	8
250	63	33	23	16	13	10	8	5	4
100	25	13	9	6	5	4	3	2	2

1% water = 10,000

BEFORE = 11,272 ppm

AFTER = 19 ppm

Example: By reducing average fluid moisture levels from 2500 ppm to 156 ppm, component life is extended by a factor of 5.

For more information on the Life Extension Method please visit:

<https://www.machinerylubrication.com/Read/95/machine-life-extension>