

Building a Reliability Centered Lubrication program: Part II

Management support from all levels is needed to meet your program's performance objectives.

In June we outlined the steps involved in delivering a reliability centered lubrication (RCL) program. Following are the seven topics we introduced:

1. Developing a RCL strategy.
2. Estimating RCL financial merit.
3. Evaluating machines for criticality and RCL requirements.
4. Establishing and managing work schedules.
5. Establishing machine health monitoring and program control plan via lubricant analysis.
6. Setting organizational knowledge (management and labor) expectations and developing a growth plan.
7. Tying program results to management performance evaluation.

We covered topics 1-3 in June and now we'll address 4-7 in this article.

WORK SCHEDULES

Following the decision to pursue RCL and the establishment of a priority list for all production assets, the next step is to construct and begin scheduling work practices that are designed to improve machine performance. This is done by carefully evaluating a drive train for each of the lubricated components in the train and assigning precisely accurate products, replenishment frequencies, replenishment volumes and *in situ* sump management activities (cooling, filtration, dehydration) to the sump in question.

KEY CONCEPTS

- Reliability Centered Lubrication provides precise lubrication and machine care practices based on each machine's importance.
- Plants perform several lubrication tasks annually using a computerized task management system beyond the capabilities of traditional CMMS systems.
- A lubricant sampling and analysis routine provides feedback on whether the strategies are delivering the expected results.

Component	Make	Model	Details
Element Bearing	SKF	22234CCKW33	Component Type
			Component Size
			Shaft Speed
			Static Rating (C/P - for bearings)
			Verify Oil or Grease Lubricated
			Degree of seal (shielded, sealed, open)
			Seal Type
			Relubrication Method (manual vs. automatic)
			OEM designated lubricant
			OEM original fill lubricant type if any
			OEM designated Lubricant volume
			Operating Temperature
			Operating Atmosphere - moisture
			Operating atmosphere - temperature
			Operating atmosphere - dust or dirt
			Operating atmosphere - process chemicals

Figure 1 | Reliability Centered Lubrication Assessment Detailed Data Collection Criteria for Bearings.

This idea differs from the typical approach that is predominantly focused on the lubricant type and brand. Obviously lubricant selection must be done carefully. The central difference becomes whether to focus predominantly on the lubricant or the machine.

Hydraulic system management offers an example of the contrast between these two important choices. Modern, high-performance hydraulic systems depend on impeccably clean oils. It is the rule rather than the exception that equipment suppliers recognize the need for high-level, filter element performance but often do not specify media that delivers the required results. Various reasons can be offered for this, but the argument boils down to money. Unless the machine owner recognizes the value of high-performance elements and demonstrates willingness to purchase inevitably higher priced elements to preserve system performance, the machine supplier is unlikely to promote the high-end (and high priced) option given the risk of decreased future sales.

Following the RCL mindset, each machine is evaluated based on its importance (criticality ranking), operating conditions and component sensitivities. A lubricant is selected to meet the design criteria, and the machine's contamination control require-

ments also are evaluated for needed adjustments to cooling, filtration and dehydration to preserve system function. With this approach, the lubricant is important, but the machine assessment is incomplete if only the lubricant-specific criteria is addressed.

Figure 1 represents the type of information required for element bearings—a very common component. This level of details is extended to all other components in the train as well. During the evaluation process, the person making decisions for lubrication practices must become thoroughly familiar with the machine's components and operating challenges.

A systematic and orderly process is needed to keep up with multiple decisions for multiple components on multiple machines in a production facility. It makes sense to organize the collection of plant machines around material flow through the facility, starting where the raw material enters the production site and concluding where finished goods exit the site, too. Additionally, it makes sense to organize the collection of machine component details following the flow of energy through the machine. The majority of machine drivers are electric motors, followed by couplings, drives, bearings and other driven components. Figure 2 represents the collection of lubrication details for components that make up a conveyor belt, with each decision influenced by the reliability objectives and operating conditions.

The process that one would follow to survey the industrial facility is defined in the January 2008 issue of TLT (available digitally at www.stle.org). Following the principles from this article, the reliability engineer collects component-specific data for all machines in the production site, prepares plans and work schedules designed to enhance oil-wetted component protection and sets the new tasks into a scheduled plan.

Items	Make	Model	No.	Components	Type	Make	Model
Drive Train - Conveyor A1							
Motor	GE	5KS511SN3260HB	1	2	Bearing	SKF	90BCO3JP3 75BCO3JP3
Coupling	Falk	1080T	1				
Gear Reducer	Falk	2145 Y2B	1	2	Seal Backstop	Falk Falk	Type K PRT 65
Coupling	Falk	1140T	1				
Head Pulley				2	Bearing	SKF	22234CCK/W33 22234CCK/W34
Snub Pulley				2	Bearing	SKF	22230C/W35 22230C/W36
Tail Pulley				2	Bearing	SKF	22230C/W37 22230C/W38
Troughing Rollers	Cont. Conv	78AH650-66G	192	3	Bearing	Timken	LM 11949
Return Roller Bearings	Cont. Conv	78AH650-66G	48	2	Bearing	Koyo	UCF208-24

Figure 2 | Example of an assembled machine component set required to make appropriate decisions for a belt conveyor.

Sub-Assembly	Product	Qty.*	Number of Points	Relubrication Cycle	Method of Application	Analysis	Test Slate	Lubrication Procedure
Belt Conveyor A1								
Motor	#2 RB	32 cc	2	Semi Annual	Pressure Gun	NA	NA	Motor Relubrication
Coupling	CPGL Gr	Fill	2	Annual	Pressure Gun	NA	NA	Gear Coupling
Gearbox	220 EP	110 Gal	1	Weekly	Oil Bath	Frequency	Tests	Gearbox Top-up
Shaft Seals	#2 RB	8 cc	2	Quarterly	Pressure Gun	NA	NA	Seal Relubrication
Backstop Housing	100 R&Q	1 Pint	2	Monthly	Oil Bath	Frequency	Tests	Backstop Sump Top-up
Backstop Seal	#2 RB	8 cc	6	Quarterly	Pressure Gun	NA	NA	Seal Relubrication
Drive Roll	#2 EP	225 cc	2	Bi-Weekly	Pressure Gun	NA	NA	Bearing Relubrication
Snub Drive Roll	#2 EP	180 cc	2	Bi-Weekly	Pressure Gun	NA	NA	Bearing Relubrication
High Tension Roll	#2 EP	180 cc	2	Bi-Weekly	Pressure Gun	NA	NA	Bearing Relubrication
Tail Pully Roll Brng	#2 EP	180 cc	2	Bi-Weekly	Pressure Gun	NA	NA	Bearing Relubrication
Bend Pully Roll Brng	#2 EP	76 cc	14	Monthly	Pressure Gun	NA	NA	Bearing Relubrication
Snub Head Roll Brng	#2 EP	180 cc	2	Monthly	Pressure Gun	NA	NA	Bearing Relubrication
Return Roll Brng	#2 EP	180 cc	48	Bi Monthly	Pressure Gun	NA	NA	Bearing Relubrication
Idler Bearings	#2 EP	4 cc	Misc.	Annually	Pressure Gun	NA	NA	Bearing Relubrication

Figure 3 | Set of lubrication details that defines the schedule, tasks, products and volumes for a belt conveyor.

Figure 3 illustrates what the completed set of details would look like for the previously noted conveyor. Each component should have each decision well-defined, and in writing. Some components such as the oil-lubricated drive may have multiple routine tasks in a fully developed procedure, including:

- Housekeeping
- Mechanical fitness evaluation (a simple mechanical inspection for any signs of heat, noise, odor, vibration, looseness, incorrect operating state)
- Internal visual inspection (using a borescope)
- Level check and top-up
- Drain and fill
- Pressure flush and fill
- Design, installation and use of upgrades (including sample fittings, breathers, fluid couplings for oil filtration)
- Routine lubricant filtration using a side-stream (kidney-loop) filter
- Sample test slate (development of primary and secondary tests, alarms sets for each test and frequency)
- Sample collection method and frequency.

This may seem overdone for a routine lube requirement if the machine does not impact production or is not a safety risk. However, it represents the right type of work if the focus is on maximizing machine-run potential.

For sophisticated sump requirements such as a paper machine-circulating system or a gas or steam turbine system, there could be other non-routine tasks that are driven by changes in lubricant state, operating conditions, etc. Once all the tasks are determined, the next challenge is to optimize the frequency of occurrence for each task and set them into an efficient linear sequence or route.

Task frequency is determined by risk of lubrication-related failure. The higher the risk of failure from around which the task is built, the more frequently that task is repeated.

For instance, the risk of failure is high for a machine if the sump runs dry. Using the conveyor noted earlier as an example, if the conveyor drive runs low or dry, the machine will fail very quickly. If the drive is tightly sealed and operating in a low-stress environment where there is little likelihood of breakage creating a catastrophic leak, then the level check task may be done weekly to monthly. If the drive is already leaking at a heightened rate (first, plug the leak) then this may be changed to daily or weekly. If the leak is profuse, it may require attention on a shift-by-shift basis or multiple times per shift. This is determined during the component's evaluation, and adjusted as needed thereafter.

Grease-lubricated component replenishments can follow a more objective method, with replenishment based on the rate of displacement of the lubricant over time, which is driven by the lubricant type, frequency of component contacts and by rate of contaminant corruption. Open gear grease replenishment is determined by product type and gear pitchline velocity (a function of gear size and shaft rotation). Bearing replenishment is determined by bearing type, contamination load and pitchline velocity. Replacement of grease in pivot points such as hinge pins on loaders and fifth wheels

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on a freight truck are more subjective but can be calculated as well.

These decisions are not complex, but the large number of decisions for the large number of components on each machine creates a complex requirement: identifying all task types, frequencies and getting them uniformly and efficiently scheduled.

The finished assembly of tasks for a production center can represent a tremendously large number of items to schedule, execute, close and record.

To illustrate the size of the job at hand, consider the routine that is designed for the conveyor described previously (see Figures 2 and 3) and shown in Figure 4. Accounting for all tasks per year for all components, this simple conveyor produces 1,754 tasks to track per calendar year. A simple component such as a critical pump, including the motor, coupling and pump assembly, can produce 66 events to manage per year. A site with 300 pumps can generate roughly 20,000 events just to support the pumps.

Sub-Assembly	Product	Number of Points	Relube Cycle	Annual Tasks/ea.	Cumulative Tasks
Belt Conveyor A1					
Motor	#2 RB/ISO100	2	Semi Annual	2	4
Coupling	CPGL Gr	2	Annual	2	4
Gearbox	220 EP	1	Weekly	52	52
Shaft Seals	#2 RB/ISO100	2	Quarterly	4	8
Backstop Housing	100 R&O	2	Monthly	12	24
Backstop Seal	#2 RB/ISO100	6	Quarterly	4	24
Drive Roll	#2 EP/ISO460	2	Bi-Weekly	26	52
Snub Drive Roll	#2 EP/ISO460	2	Bi-Weekly	26	52
High Tension Roll	#2 EP/ISO460	2	Bi-Weekly	26	52
Tail Pully Roll Brng	#2 EP/ISO460	2	Bi-Weekly	26	52
Bend Pully Roll Brng	#2 EP/ISO460	14	Monthly	12	158
Snub Head Roll Brng	#2 EP/ISO460	2	Monthly	12	24
Return Roll Brng	#2 EP/ISO460	48	Bi Monthly	26	1248
Idler Bearings	#2 EP/ISO460	Misc.	Sealed	1	-

Figure 4 | The net task obligation for lubrication tasks is based on the task total per year for all components.

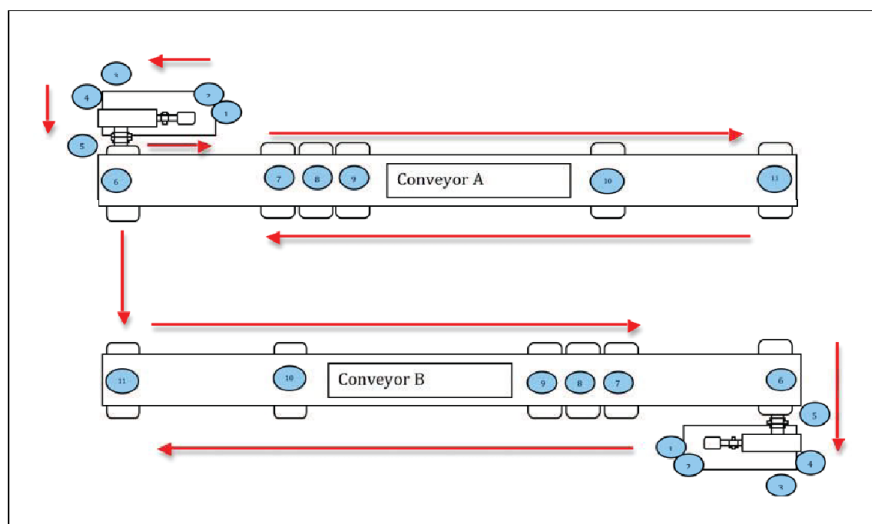


Figure 5 | Efficient lubrication routes is primarily determined by component location.

An industrial facility with a large number of production machines can generate tens of thousands of tasks per year. Considering the large number of items to manage, a computer-based scheduling program designed for lubrication task management is a practical requirement. Assembly of tasks into a linear sequence through the production department, instead of a list based on the collection of components in the train, helps the technician efficiently accomplish each of the tasks in the work list. Figure 5 illustrates how the sequence could be structured to minimize the number of steps between components in the two drive trains.

Once placed into the database, the collection of tasks can be organized by route and linear sequence to create an efficient work management plan. Figure 6 illustrates organization of tasks with this approach using a computerized program by Generation Systems. The work schedule is generated, the work due is listed in the route, the route is published (printed or uploaded to a PDA) and executed. After the work is performed, it is acknowledged and closed. If a task is not completed on its normal schedule, it is automatically republished in the next route.

A fair amount of organizational knowledge is required to build a plan, create practices, build a schedule and route and manage the routes and tasks.

MACHINE HEALTH MONITORING PROGRAM

The machine condition analysis plan via the lubricant sampling and analysis routine provides feedback on whether the tactics in use are delivering the expected results. Lubricant analysis is often relegated to testing for the sake of measuring lubricant health, but in reality that provides only nominal value to the site. When used to measure changing machine health as a means to eliminate defects from the operating sumps (moisture, airborne particulate, wear debris, oxidation byproducts, excessive heat and air, etc.), lubricant-based analysis is a powerful and highly valuable tool.

Following are things to consider:

- Identification of machines based on criticality (not sump size)
- Sample port hardware selection
- Sample port location and installation
- Frequency selection
- Test slate identification for primary and secondary tests
- Alarm metrics for all tests in use
- Data management mechanism
- Data use plan.

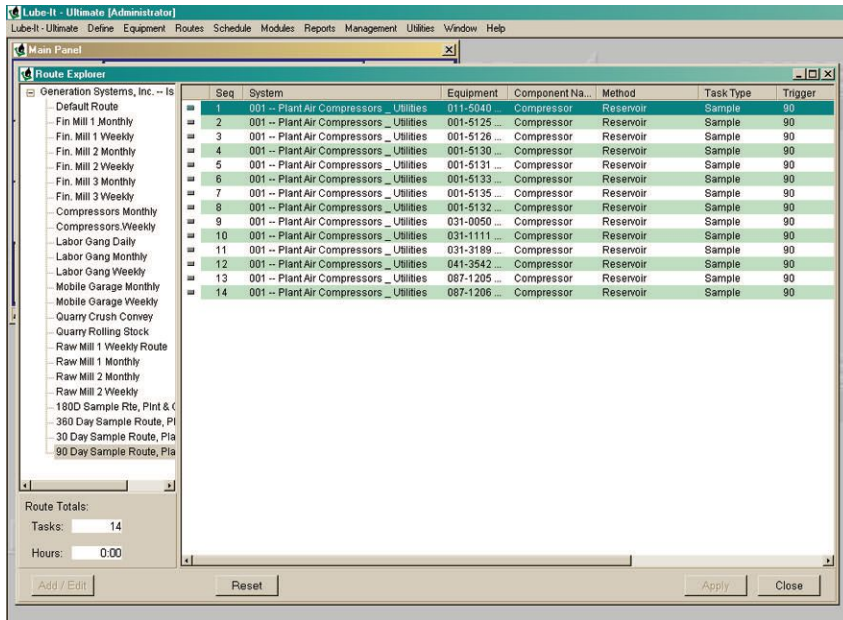


Figure 6 | The use of route-based scheduling systems enables the management of large numbers of tasks to be issued and tracked efficiently.

There are several Best Practices articles published in TLT in 2009 and 2010 that addresses each of these topics (available digitally at www.stle.org).

principles. This should include the relationship between required capital and expected return.

Maintenance management. The focus is on *what*. Maintenance

ORGANIZATIONAL KNOWLEDGE DEVELOPMENT

The speed and effectiveness of program implementation is determined by the quality and depth of knowledge of those involved, including managers, engineers and technicians. This question reaches beyond the capacity of the program designer (engineering level) to the level of knowledge held by the technician conducting the work and his first-level supervisor. Given the cost of instruction, there is room for debate within the organization about how much training is enough for each level. There is no single correct answer, but the following guidelines are worth considering:

Senior management (general, financial, purchasing, operations). The focus is on *why*. Senior management should understand the principles behind precision lubrication, the relationship between those principles and optimized machine lifecycles and the scope of activities that are necessary to fulfill the



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nance management should understand the same things—as noted for senior management. Additionally, maintenance management should be firmly involved in strategic and tactical program development planning. This includes awareness of key strengths and weaknesses, awareness of the tactics necessary to make improvements and metrics that will be used to periodically evaluate results.

Reliability management and engineering. The focus is on *why, what* and *how*. Given the responsibility to make the program work, reliability engineering and management shoulders the largest requirement for knowledge development. Every facet of the program should be thoroughly understood, beginning with the initial benchmarking, as discussed in Part I of this article, to the long-term use of lubricant-based machine health measurement. Every aspect of the program should be studied for full awareness.

Frontline maintenance supervision. The focus is on *how*. Frontline supervisors should be fully aware of the development plan (company defined and adopted goals and objectives, expected labor changes, materials required for implementation) and be prepared to support the program plan. Additionally, supervisors should be aware of the principles of precision lubrication, understand how these influence machine lifecycles and understand the tactics that will be adopted to pursue reliability.

Technical labor. The focus is on *why* and *how*. Technical labor is called upon to endure the greatest degree of change. Given this, it is helpful to provide labor with a clearly defined plan, the required tools and orderly management of the details. Since much of the success of this program falls on the personal effort of these workers, they should be given as much of the reasoning as they can tolerate for the changes that they will be asked to adopt. While some may not care why something should be done, most do—even if they won't state this openly.

Figure 7 provides a matrix of positions and topics for those positions

Lubricant analysis is often relegated to testing for the sake of measuring lubricant health.

that would be most useful to create knowledge levels needed for successful program creation.

MANAGEMENT PERFORMANCE EVALUATION

Jack Welch, former CEO of General Electric, has publicly promoted the idea that strategic change takes time. According to Welch, it takes five years to fully integrate a new strategy into an organization. Having worked through the change process at several organizations, this author fully supports Welch's supposition. Accordingly, senior management must be committed to provide at least five years of vocal and visual support. However, only saying encouraging things is inadequate. Unless there are meaningful consequences for getting the job done or for failing to do so, the initiative won't survive.

To bring all positions fully onboard with achieving the changes defined in the initial plan, each of the positions should have their specific areas of responsibility recorded into their annual objectives. The objectives should include requirements for frequent review of the plan vs. the timeline and should be specific about what is needed of each position to support the program.

Following are some non-site-specific examples to consider:

Senior management

- Provide vocal and financial support for RCL (Reliability Centered Lubrication) objectives.
- Review results vs. plan (quarterly).
- Support training for the initiative by completing the recommended content.
- Provide an opening statement at the beginning of each training session.

Maintenance management

- Lead annual RCL program objectives (review and adjustment).
- Provide vocal and financial support for RCL objectives.
- Review results vs. plan (monthly).
- Support training for the initiative by completing the recommended content and reviewing results and progress toward the plan.
- Support reallocation of labor needed to fulfill task requirements.

Reliability management and engineering

- Position RCL as a key job performance indicator.
- Participate in annual program adjustments.
- Review results vs. plan (quarterly).
- Lead monthly reviews of key performance indicators with maintenance supervisors and technicians.
- Provide engineering support for supervisors and technicians for lubrication improvement objectives.
- Actively promote communication between team members.
- Conduct RCFAs (Root Cause Failure Analyses) and actively identify improvement opportunities for the lubrication program.
- Achieve STLE's CLS and OMA certifications denoting competence in machine lubrication and oil analysis.
- Coordinate lubricant analysis program activities.
- Serve as a liaison between lubricant and filtration suppliers and maintenance and site manage-

Topic Category	Minutes	Gn. Mngr	Mnt. Mngr	Reliability	Mnt. Supv	Tech
		375	1095	1815	1695	1275
Reliability Centered Lubrication Strategies	45	Y	Y	Y	Y	Y
The Science behind Precision Lubrication	120	Y	Y	Y	Y	Y
Lubricant Construction	60	N	N	Y	Y	N
Performance Properties	120	N	N	Y	Y	N
Grease Lubricant Application	60	N	N	Y	Y	Y
Oil Lubricant Application	60	N	N	Y	Y	Y
Contamination Control	180	Y	Y	Y	Y	Y
Machine Design for Precision Lubrication	150	N	Y	Y	Y	Y
Reservoir Management	60	N	N	Y		Y
Lubricant Storage and Handling	30	Y	Y	Y	Y	Y
Lubrication PM Optimization and Design	360	N	Y	Y	Y	Y
Introduction to Oil Analysis	30	N	Y	Y	Y	Y
Properties Analysis	60	N	N	Y	Y	N
Solid Contaminant Analysis	60	N	N	Y	Y	N
Wear Debris Analysis	60	N	N	Y	Y	N
Test Slate, Alarms and Limits Development	60	N	N	Y	N	N
Oil Analysis Report and Data Interpretation	120	N	N	Y	Y	N
Methods /Process for Program Development	180	N	Y	Y	Y	Y

Figure 7 | Recommended knowledge levels necessary to achieve lasting improvement through changes in machine lubrication.

ment.

- Maintain up-to-date technical databases for products and procedures used in the program.

Maintenance supervision (if labor doesn't report to reliability management)

- Maintain weekly work schedules for all lubrication technicians.
- Support work schedule activities to assure 95% first-time compliance for all scheduled work.
- Provide weekly progress meetings for lubrication team.
- Provide tools and resources necessary to accomplish scheduled work.
- Provide ancillary support (air, electrical, cooling water provision, guard modifications, etc.) for contamination control improvements.
- Actively support program improvement through identification of machine operating conditions that compromise lubrication effectiveness and introduce defects.
- Participate as needed in planning sessions to coordinate between operations and lubrication group.

Technical labor

- Fulfill planned work at 95% or better.
- Keep management apprised of factors that limit fulfillment of plan.
- Participate in weekly progress meetings, training activities and pursue industry certifications from independent accrediting bodies (STLE, ICML, SMRP, etc.)
- Provide routine feedback from inspections to plan-

ning coordinator and recommendations for program improvement.

SUMMARY

Reliability centered lubrication requires a different perspective than is adopted based on lubricant selection experience alone. It is highly detailed and rewarding and is simple enough to be accomplished at any production site anywhere in the world.

There are seven steps that represent an efficient plan of attack. In June we covered Steps 1-3, while this article addressed Steps 4-7 of the RCL process, including establishing and managing work schedules, establishing machine health monitoring and program control plan via lubricant analysis, setting organizational knowledge (management and labor) expectations and developing a growth plan, and lastly tying program results to management performance evaluation.

Although detailed, these ideas are not highly complicated. A RCL plan requires five years of management engagement and support to succeed. Each level of work management, from the senior site management to the floor level technician, requires reeducation on what precision means and how it can be provided. Each level should also have accountability for supporting the program incorporated into annually performance objectives. **TLI**



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