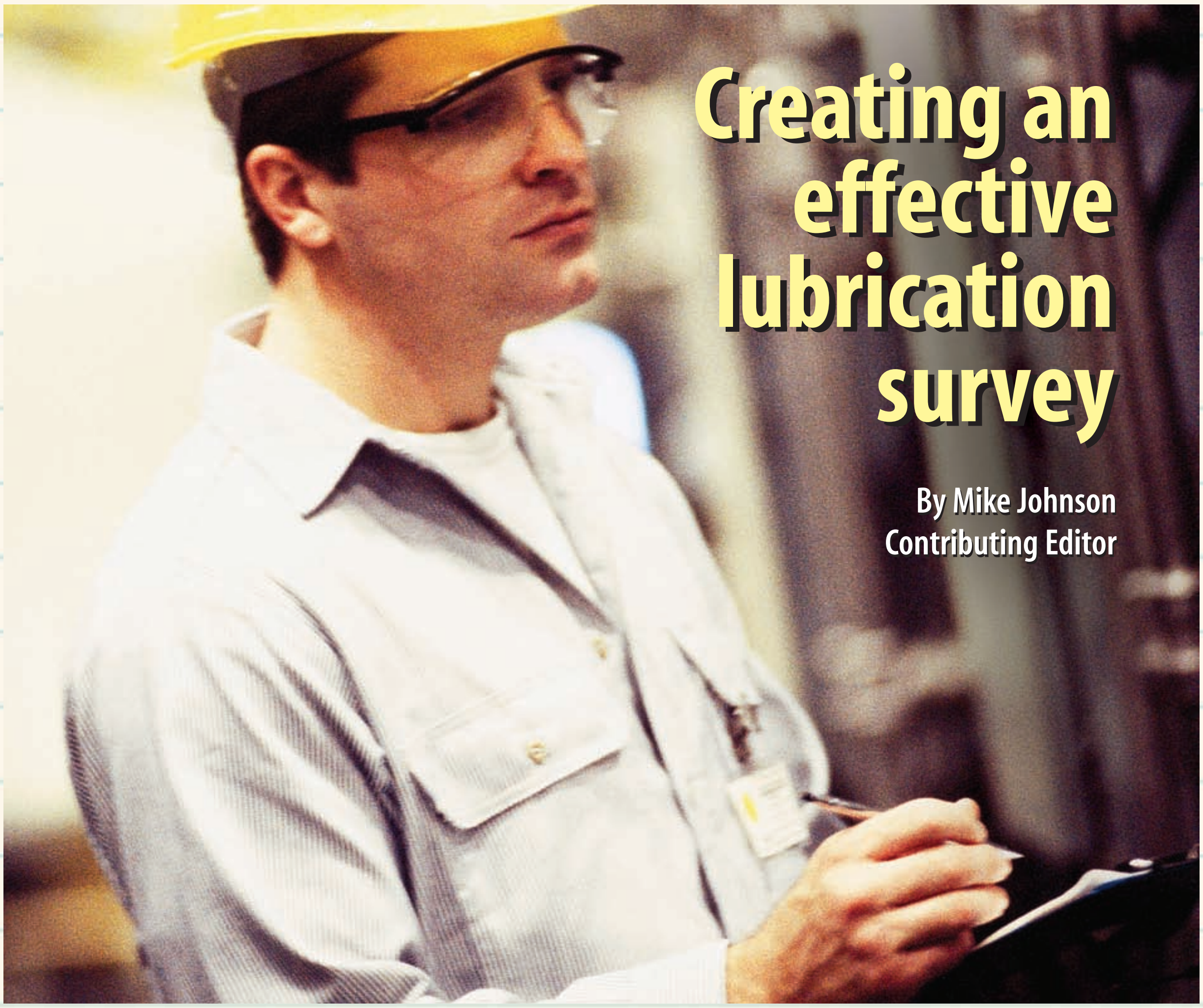

Creating an effective lubrication survey

By Mike Johnson
Contributing Editor

You start with a criticality assessment, an in-depth analysis of the key operating factors and environment of a plant's machinery.

Article highlights:

- Peter Jost's potential savings from better lube practices
- Elements of a machine criticality assessment
- Evaluating the key components

A technically precise machine relubrication plan is one of the more important functions that plant management can provide to protect plant productivity. Proper installation, alignment and balancing of production machinery also are cornerstones of an effective machine reliability practice. Fortunately these functions receive significant attention during machine design installation and routine maintenance phases of plant development.

Machine lubrication, however, is often an afterthought. In far too many facilities machine lubrication receives little or no thought at all.

The value of precise machine lubrication is poorly understood by most machinery operators. Among the practices that are far too prevalent in these facilities:

- Lubricants are shopped out as though they were just another commodity raw material.
- Poorly designed and scheduled lubrication practices receive blame for machine failures well after an appropriate opportunity for meaningful corrective action has passed.
- Lubrication technicians—a term that is rarely used—often are plant old-timers resting in day-shift jobs just before retirement and are characteristically not expected to 'think' during the fulfillment of their tasks.
- Lubrication program management is considered an entry-level supervisory task and is assigned to incoming maintenance supervisors or engineers.

These common traits are troublesome. Regardless of the lubricant brand used, practices that are poorly designed and left to the interpretation of untrained personnel will be poorly executed and deliver marginal value.

In the mid-1960s British professor and researcher Peter Jost organized and led a seminal study for the British Ministry of State for Education and Science on the influence of poorly executed lubrication practices in Great Britain. His research team delivered conclusions about the potential that could be gained from improvements in lubrication practices. These are summarized in Figure 1.

These potentials are representative of modern conditions as well. If there is a flaw in Dr. Jost's findings for today's manufacturing world, it is that they underestimate the impact for improvement that currently exists when precision is designed into work practices.

Figure 1. Peter Jost's predictions of potential for improvement from precise lubrication practices.

Savings on maintenance and repair costs:	20%
Savings in lube buys:	20%
Labor savings from reduced repairs:	0.13%
Savings from utilization and efficiency:	1%
Savings on new machine purchases:	.5%
Less energy use from friction control:	7.5%

Precise machine lubrication practices

A lubrication best practice incorporates details about machine design, construction, installation and operating mode (speed, load, environment, duration). Some of the specific things to keep in mind while building precision lubrication practices include:

Enjoy this new TLT feature!

Best Practices Notebook is TLT's newest editorial component and is designed to address the practical needs of reliability engineers. This article is the first of 22 in a monthly series focusing on designing and implementing machine lubrication procedures that meet or exceed industry standards and, therefore, can be labeled "best practices." Each article addresses the next step the practitioner should follow to establish effective, methodical machine lubrication practices. This inaugural article addresses how to draft a lubrication survey, the first step in creating effective machine lubrication practices. Feel free to clip these articles, but don't worry if you miss an issue or two. When all 22 articles are completed, TLT will reprint them in a special, stand-alone publication that will be an ideal resource for neophytes and veterans to the world of lubrication engineering. STLE members also can access these articles monthly at **www.stle.org**.

— Dr. Maureen Hunter
Editor

- Machine criticality and operating environment.
- Lubricant type, quantity and frequency requirements.
- Contamination control requirements.
- Oil analysis requirements.
- Activity sequencing.
- Planning and scheduling management.

Each of these factors, and likely others as well, influence product selection, product application volume and frequency, machine-specific tests and alarm settings and the use of automatic systems that apply and purify the lubricant in support of the process.

The scope and complexity of each activity could be the same but probably should vary according to the importance of the machine's function within the plant. Machines with highly critical functions should benefit from a rigorous application of engineering and reliability standards and attention to detail. Machines with low criticality should have practices optimized to the machine's relative state of importance.

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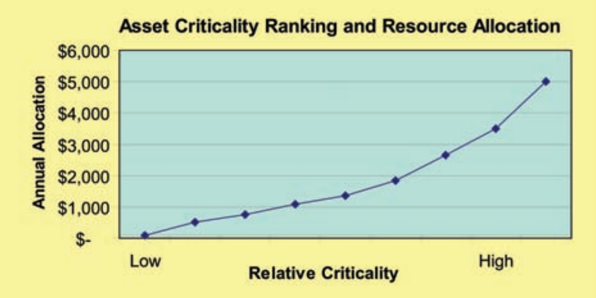
Step 1.

Machine criticality and operating environment

The amount of resources dedicated to machine care must be allocated according to each machine's importance to the production process. As the importance ranking increases, resource allocation also should increase, as illustrated in Figure 2.

The ratio of high-to-low criticality ranking for a given facility should follow a standard distribution curve with 20% rated as highly critical, 20% rated as non-critical and the remaining 60% falling into a somewhat-critical classification. Each production facility must decide for itself where each production machine falls in the criticality ranking list.

Figure 2. Annual lubrication cost commitment by machine criticality status.



As a general rule, machines are considered highly critical when human health and safety is at risk with failure, when environmental safety is at risk, when the cost of production time is very high and/or cannot be replaced and when the cost of machine repair is particularly high.

Conversely, machines can be categorized as subcritical if they are involved in processes that pose no risk to human health, safety or the environment, and/or are not central to production and/or are built with high service factors (i.e., built to withstand physical stresses several times greater than the actual production stress imposed on the machine) and/or are considered to be disposable.

As service factors fall (machines are less rigorously constructed) the relative care and attention applied to a given machine will necessarily rise in order to sustain equivalent production levels. The process for grading the machine's importance relative to the production requirements is called criticality assessment.

An effective criticality assessment will consider various measurable parameters for each machine. Assessment parameters could include such factors as:

- Machine failure risk to employees or customers.
- Machine failure risk to the environment.
- Machine failure risk to production quality.
- Machine durability (rate of failure, mean time between failures, operating cycle standard deviation, etc.).
- Machine function.
- Hourly value of machine function.
- Speed of failure.
- Cost of machine repair.
- Operating environment severity.

The operating environment also will influence the degree of detail that the relubrication procedure should entail. Machines operating in a benign environment, such as a semiconductor manufacturing facility, for example, will require less attention for contamination control features than equipment operating in a steel mill melt shop.

Operating environments that influence lubrication plan development include factors such as:

- Atmospheric temperature.
- Atmospheric humidity.
- Atmospheric dust and dirt exposure.
- Machine direct exposure to production chemicals, moisture or solid contaminants.
- Machine stability (vibration from external sources).

If a machine has both a high criticality ranking and a high environmental influence, then the relubrication practice needs to reflect these realities through adjusted (shortened) relubrication frequencies, adjusted volumes and greater use of automatic application methods. Additionally, the plan should include measures to minimize the risk that the environment poses to machine health.

The skilled reliability engineer should be able to provide guidance for the amount of detail that each machine requires based on the selected criticality rating and the operating environmental risks.

Step 2.

Organizing the collection of machine details

Once a concise list of machines has been established and prioritized from most to least critical, the reliability engineer can begin focusing on the task of collecting the many details required for accurate practices. Regardless of the size of the facility, an orderly and methodical process will reduce the size and complexity of the task into manageable segments.

Each asset must be observed, and the technical details of each characteristic (environmental and operating) must be recorded as completely as possible. Some of the machine- and component-specific details may reside in a computerized maintenance management system and may be quickly accessed. Alternately, the details should reside in an OEM's operations and maintenance catalog. It is likely that the reliability engineer will have to depend upon multiple resources to complete this task.

For instance, a machine's electric motor builder, size, type, horsepower ratings and other similar details may be reflected in the OEM records. Over a period of time, however, electric motors are repaired or moved to other service areas, and the original record may not reflect the "as is" state. With that expectation in mind, it is necessary to conduct a physical review of each asset to verify existing criteria.

Conducting the physical review of the machines can become a detail-intensive process and therefore must be highly organized before any physical observations begin. There are several ways to organize the data collection activity.

Batch process: Environments that are batch oriented sometimes expand in a piece-meal fashion. The manufacture of consumer machines (automobiles, refrigerators, washing machines, etc.) occurs in a batch process with the forming, shaping and/or molding of multiple components occurring simultaneously in multiple locations and eventually arriving at a common area for assembly.

Figure 3 depicts a non-sequential production process. In this type of environment one can collect drivetrain (production machine) data by each machine center or production department using plant location markers as geographical reference points. This process requires that someone within the facility (maintenance engineering or production planning) verify that each of the machines used in the manufacture of individual items is represented on a master list, and the master list is used to verify that each machine center has been reviewed and documented before the job is complete.

Continuous process: In linear production processes, raw materials must complete one process before they begin another. There may be slight variations in the manufacturer of a product, but the flow of materials through the machines is essentially the same regardless of slight variations. In this environment one may order the data collection activity to follow the flow of raw materials through the conversion process.

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Figure 3. Batch process plant overview/layout.

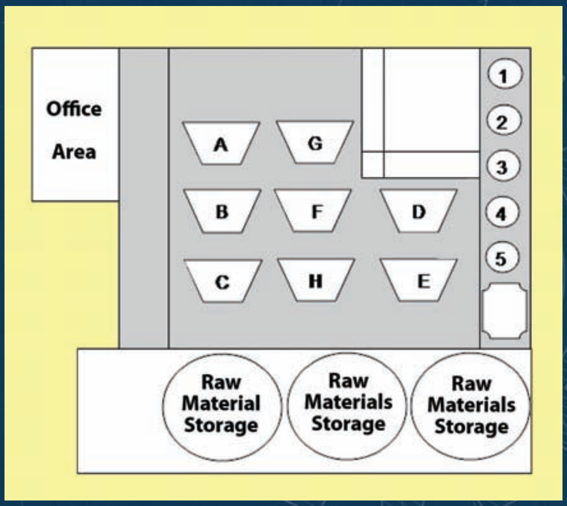
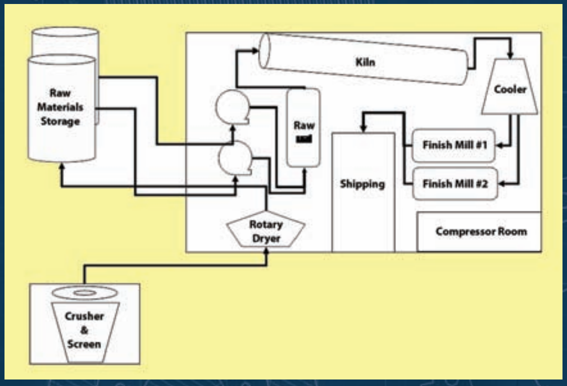


Figure 4. Linear production process flow diagram for manufacturing Portland cement.



Poorly designed and scheduled lubrication practices receive blame for machine failures well after an appropriate opportunity for meaningful corrective action has passed.

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Figure 4 (*on page* 29) shows a sequential view of the major processes for manufacturing Portland cement. Each individual section contains drivetrains operating in tandem or in sequence to the other drivetrains. Organizing drivetrain details by following the raw material conversion process also helps with the organization of lube points for a route plan.

Planned availability (production demand flow): Where there is a clearly defined safety or injury risk to personnel when the machine is operating, regardless of whether the production process is batch or linear, it is necessary to either catch the machine when it is idle or idle the machine at the point that the surveyor is ready to review the compliment of components. An electromechanical robot, or any other machine type operating behind a closed and locked or closed and posted safety barrier, falls into this category.

To minimize the amount of time that a machine is idle for lubrication survey purposes, the reliability engineer should review the fundamental machine components from the OEM installation and operation and maintenance manual and be relatively certain of the lubrication plan requirements prior to idling the machine. Once the expected lubrication plan is developed, the machine may be idled to confirm the reliability engineer's conclusions.

There is a strong likelihood that each of these three approaches will be required in unison for a modern manufacturing facility. The keys for successful completion of the organization of the collection process are:

1. Have a clearly defined machine set (list or catalogue) before the evaluations begin. This list defines the scope of the project. Maintain separate original (source) and working documents and use the documents to verify the completion of each machine set as the process unfolds.

2. Clearly document what, when and how the evaluation of a group of machines or a production process is to occur before beginning the evaluation.

3. Have a clear familiarity with plant's description of departments, process and machines before the collection process begins.

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	Falk	Type K
					Backstop	Falk	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
Trophing Rollers	Cont. Conv	78AH650-66G	192	3	Bearing	Timken	LM 11949
Return Roller Bearings	Cont. Conv	78AH650-66G	48	2	Bearing	Koyo	UCF208-24

Table 1. A typical list of components that are common to a simple conveyor. The assembly and integration of multiple components is called a 'Drivetrain.' Each individual lubricated component within the drivetrain must be accounted for.

Step 3.

Collecting machine drivetrain information

The lubrication survey/evaluation itself entails collection of information on every lubricated component on every drivetrain within the production system. Table 1 describes the type of component-by-component detail that is required to build an appropriate practice for a simple plant conveyor. The specific detail that must be collected depends on whether the lubricated component requires oil or grease.

Oil-based lubrication practices denote a fluid sump. The sump may or may not require sophisticated sealing materials to exclude contaminants, fittings to accommodate oil sample collection and fittings to accommodate contamination control requirements. Two identical machines may have appreciably different relubrication requirements at the time of data collection based on machine criticality, as previously discussed, but that criticality

> The amount of resources dedicated to machine care must be allocated according to each machine's importance to the production process.

requirement may change.

Table 2 offers a suggested level of detail for the collection of gearbox sumps. A similar level of system- and component-specific details is warranted for each lubricated component and integrated lubrication system for each machine in the evaluation.

Over time increased product demand can influence the criticality assessment, causing the criticality factor to both rise and fall. If the details collected are only sufficient to cover the immediate needs, then the process will unnecessarily have to be repeated at a later date. Sufficient detail should be collected to enable the development of a best practice even if all of the details are not used immediately.

Grease-based lubrication practices denote a grease sump. Relubrication of greased components requires a greater dedication to detail than is typically required for oil-lubricated components. Table 3 offers a suggested level of detail that should be captured for bearings, couplings, gears and other grease-lubricated components.

Grease sumps inherently require systematic refreshment/replenishment of the lubricant in the sump. The replenishment frequency may be long or short, depending on how the machine operates. The calculated relubrication interval (time between replenishment events) decreases as the machine speed, load and severity of the working environment increases. Calculating an acceptable operating-specific interval is detailed but not complicated. This will be addressed in subsequent articles.

Table 2. The level and type of detail that should be collected for each lubricated component.

Component	Make	Model	Details
Gear sump	Falk	2145 Y2B	Type of reductions
			Number of reductions
			Input speed
			Reduction ratio
			Bearing types
			Bearing sizes
			Stated AGMA lubricant grade
			Stated AGMA lubricant type
			Sump temperature
			Oil distribution method (bath or circulation)
			Presence of filtration
			Presence of vent breather
			Number and size of drain port openings

Table 3. Grease lubricated sumps require collection of some additional details.

Component	Make	Model	Details
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

Conclusion

Each individual lubricated working surface must be evaluated for the appropriate lubricant for the dynamic operating conditions. The vast majority of lubricated components that one will see during the evaluation process includes:

- Bearings (ball, roller, spherical, element thrust, plain, plain thrust, segmented thrust).
- Couplings (gear, grid).
- Gears (spur, helical, bevel, hypoid, herringbone and worm gear cases, spur and helical open gears).
- Pumps (hydraulic geared, vane and piston pumps; oil circulation geared screw and piston pumps; process vane, screw and gear pumps).
- Compressors (screw, centrifugal, axial flow (turbine type) and reciprocating piston compressors).

Each of the components has a wetted surface area, and for each surface area there is an appropriate lubricant (additive and base oil) type, an appropriate viscosity at normal operating temperature and a tolerance to contaminants that must be estimated.

A successful cataloging, categorizing, evaluation and tabulation of the machine component details is largely dependent on organization skills. If there is any question about how the information will be collected and tabulated, then it would be appropriate to continue the planning process until those questions are eliminated. TLT

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