***Machinery Lubrication and Reliability***

**By Dr. Trinath Sahoo**

**Bonus Website Material**

**125+ Practice Questions & Answers for the ICML Exam**

**1. Q: What is the first *Publicly Available Specification* for optimized management of physical assets?**

**A:** In 2002-2004, the *Institute of Asset Management* (IAM), in conjunction with the British Standards Institution (BSI) developed PAS 55, the first “Publicly Available Specification” for optimized management of physical assets.

**2. Q: From which standard are the ISO 55000 series of international standards derived?**

**A:** The *International Standards Organization* (ISO) accepted PAS 55 as the basis for development of the new ISO 55000 series of international standards.

**3. Q: How many standards are there in ISO 55000?**

**A:** ISO 55000 is a set of three standards or documents, issued by the International Organization for Standardization, which covers:

1. [ISO 55000:2014](https://www.iso.org/obp/ui/#iso:std:iso:55000:ed-1:v2:en) Asset Management – Overview, principles, and terminology  
2. [ISO 55001:2014](https://www.iso.org/obp/ui/#iso:std:iso:55001:ed-1:v1:en) Asset Management – Management systems; Requirements  
3. [ISO 55002:2018](https://www.iso.org/obp/ui/#iso:std:iso:55002:ed-2:v1:en) Guidelines for the application of ISO 55001

**4. Q: What is the importance of connecting top management to the asset base, and how does the ISO 55000 standard provide for this?**

**A:** In any organization, top management may think they know about all the aspects of asset management, but, as defined by ISO 55001, it is a very rare organization that truly is driven by strategy, policy and plan for delivering value from their assets. This is achieved through an *Asset Management Strategy*, an *Asset Management Policy*, and an *Asset Management Plan*. These are written documents designed to be used within a reliability leadership culture.

Top management in your organization defines what value is and what risk is. Operational excellence at the Asset Management level means assuring that value can be delivered through the asset portfolio that is deployed.

**5. Q: Who is a leader, according to ISO 55000?**

**A:** Within ISO 55000, a leader is anyone who helps another person, machine or gadget do a better job, meaning that there is leadership at every level of your organization. It doesn’t mean only the CEO or Reliability guru or computer system analyst can lead, but rather that there is a need to engage *everyone* in the organization as a leader.

**6. Q: What is the feeling of regulators and insurance companies on implementing ISO 55000?**

**A:** Insurance companies insure against risk, and are pretty good at validating what the status of a risk profile is in an organization, not only from a health and safety perspective, but also in regards to the risk of business loss. In most industries, regulators are also going to come in and say, “Where’s your Asset Management plan? Are you working towards ISO 55000?” If you don’t have a plan, the regulators are going to leverage you in a very negative way.

**7. Q: Do you see municipalities heading toward these standards, as well as corporate entities?**

**A:** Energy, utilities and oil and gas, as well as rail infrastructure companies have been the first to adopt this standard, and it makes sense for them to do so. Those companies that work on the public good want it held in custodianship for them, as they would manage the process themselves. They want to make sure the stewardship and the value is there. PAS 55 (in the beginning, and ISO 55000 in the future) creates that framework to assure the people that are being served that their assets are being stewarded in a positive way.

**8. Q: How do decisions systems involving ISO 55000 asset management systems need to be?**

**A:** Decisions systems around asset management systems need to be *risk-based* according to ISO 55000. To evaluate risk around asset management, ISO 55000 specifically points out that top management needs to drive a risk-based system and that all stakeholders need to be involved. Again, the standard pushes top management involvement and cross-functional teamwork around asset management.

**9. Q: How can ISO 55000 asset management systems help organizations?**

**A:** ISO 55000 should ideally provide more involvement by top management in asset management, help establish asset management objectives that are aligned with business goals, and break down some silos between departments.

**10. Q: What are ICML 55 requirements, and why were they developed?**

**A:** The ICML 55 requirements publication, ICML 55.1, defines 12 interrelated areas of sustainable lubrication program plans. ICML began developing ICML 55 following the *International Organization for Standardization’s* publication of the ISO 55000 “Asset Management” standard in 2014. ICML saw the need for a highly tactical, lubrication-specific standard that would supplement the more general ISO document. With technical contributions from a team of over 40 experts, ICML 55 fills that gap with specific requirements and guidelines to establish, implement, maintain and improve consistent lubrication management systems and activities.

**11. Q: What are the 12 interrelated areas incorporated into any sustainable lubrication program plan, as per ICML 55?**

**A:**

1. **SKILLS:** Job Task, Training and Competency
2. **MACHINE:** Machine Lubrication and Condition Monitoring Readiness
3. **LUBRICANT:** Lubricant System Design and Selection
4. **LUBRICATION:** Planned and Corrective Maintenance Tasks
5. **TOOLS:** Lubrication Support Facilities and Tools
6. **INSPECTION:** Machine and Lubricant Inspection
7. **LUBRICANT ANALYSIS:** Condition Monitoring and Lubrication Analysis
8. **TROUBLESHOOT:** Fault/Failure Troubleshooting and RCA
9. **WASTE:** Lubricant Waste Handling and Management
10. **ENERGY:** Energy Conservation and Environmental Impact
11. **RECLAIM:** Oil Reclamation and System Decontamination
12. **MANAGEMENT:** Program Management and Metrics

**12. Q: What is an asset management *policy*?**

**A:** The asset management policy is a short statement that sets out the principles by which the organization intends to apply asset management to achieve its organizational objectives. The asset management policy should be authorized by top management and thereby demonstrate commitment to asset management.

Policy documents contain the following:

* Purpose statement
* Applicability and scope
* Effective date
* Responsibilities
* Policy statements

**13. Q: What are asset management *objectives*?**

**A:** Asset management objectives should be tailored to suit each organization’s needs, which may include addressing subsets of objectives (e.g. for the asset management system, asset portfolios, the asset system and asset level), and can vary for different functions carried out to meet stakeholder requirements. The organization should consider information or data from both internal and external sources, including contractors, key suppliers, regulators or other stakeholders. You cannot define your asset management objectives without knowing the risk management expectations of internal and external shareholders.

**14. Q: What is an asset management *strategy*?**

**A:** The asset management strategy defines how organizational objectives are to be converted into the asset management objectives. It should define what the organization intends to achieve from its asset management activities and when. This must cascade throughout the organization.

**15. Q: What is an asset management *plan*?**

**A:** An asset management plan should be documented at a level that is appropriate to the organization and the degree of sophistication in its asset management approach. There is no set formula for what should be included or how it should be structured. However, it is common practice for an asset management plan to contain a rationale for asset management activities, operational and maintenance plans, capital investment (overhaul, renewal, replacement and enhancement) plans and financial and resource plans, often based on a review of earlier achievements.

**16. Q: How important is the role of leadership in implementing an asset management system?**

**A:** Asset management leadership can be demonstrated by top management through positively influencing the organization. Top management may appoint an individual to oversee the development, implementation, operation and continual improvement of an asset management system. However, it is important that ownership and accountability for asset management remains at the top management level.

**17**. **Q: What does a strong reliability culture look like?**

**A:** All employees are keen to participate in teams to improve processes in their area, e.g., members of the purchasing department working to improve the efficiency of the tendering process, or operations staff supporting equipment reliability improvement work;

Team members working to improve the relationships between their group and an outside department with whom they have to interact, e.g., operations staff working with project team members to improve project definition or sign-off; and

Operators and technicians paying close attention to the condition of an equipment item by observing operating parameters such as temperature, pressure, sound, production rate and reporting any significant changes.

**18. Q: What are the elements that drive a reliability culture?**

**A:** Two critical elements that can drive reliability cultural change are:

1. A clear purpose
2. A reliability framework

**19. Q: To create a positive reliability culture, what are the key elements an organization should focus on?**

**A:** The three key elements an organization should focus on to create a positive reliability culture are:

1.Mindset

2. Values defining the purpose

3. Implementing a reliability framework

**20. Q: How does one resolve the reliability culture issue?**

**A:** This is not something that is available from the dashboard, so those who are immediately next to top management have to take it upon themselves to find such incidences or deviations. Then, the chain of command continues until reverse communication (i.e., bottom to top) gets completed to give the light of day to such a critical issue.

## **21. Q: Why is operations-owned reliability so important?**

**A:** An important aspect of achieving reliability excellence is transferring the ownership of reliability to the asset owners. Key managers are coached on the specific actions that they would need to take to accomplish this culture change.

Before, plant leaders held the operations groups accountable for key performance indicators (KPIs) like tons produced, quality and safety, among other aspects. The maintenance groups were responsible for KPI’s like maintenance costs, PM compliance, schedule compliance, safety and overall reliability of the equipment.

The plant leaders changed this paradigm dramatically. Operations managers began to report a different set of metrics at weekly staff meetings. They were expected to create partnership agreements with maintenance and other key parts of the organization—so that success or failure would be shared.

## **22. Q: What is corrective maintenance?**

**A:** Corrective maintenance (also called *breakdown maintenance*) are maintenance tasks that are performed in order to rectify and repair faulty systems and equipment. The purpose of corrective maintenance is to restore broken down systems.

For example, during an emergency repair, as part of a routine inspection, or in the process of conducting preventive maintenance, a technician spots another issue that needs corrected before other problems occur.

Upon discovering an additional problem, corrective maintenance is planned and scheduled for a future time. During the execution of corrective maintenance work, the asset is repaired, restored, or replaced.

## **23. Q: What is condition-based maintenance?**

**A:** Condition-based maintenance (CBM) is a [*predictive maintenance*](https://www.fiixsoftware.com/maintenance-strategies/predictive-maintenance/) strategy where various elements of an operating asset are observed and measured over time to identify and prevent deterioration and possible failure at the earliest possible moment. Under CBM, maintenance only occurs when data indicates a decline in performance or the early warning signs of failure. This differentiates CBM from [*preventive maintenance*](https://www.fiixsoftware.com/maintenance-strategies/preventative-maintenance/), where tasks are performed at regular intervals.

The goal of condition-based maintenance is to uncover equipment failure *before* it happens, so maintenance can be done exactly when needed. Because CBM is based on collecting and analyzing data, it can be used to identify trends in asset performance and assess where an asset is in its lifecycle. This makes it easier to make informed decisions on everything from scheduling and labor to budgeting.

## **24. Q: When should condition-based maintenance used?**

**A:** Although condition-based maintenance can be used on most assets, equipment must meet certain requirements for CBM to be used effectively.

First, as the name suggests, there must be a condition that can be monitored. If performance can’t be measured, you won’t be able to tell if there is a change in performance, which indicates the need for maintenance.

It is also crucial to be able to observe these changes in performance far enough in advance of failure so maintenance can be completed before the asset fails or deterioration affects production.

## **25. Q: What are the benefits of condition-based maintenance?**

**A:** There are several advantages to using condition-based maintenance on assets, especially in a production-intensive, equipment-heavy environment. Here are a couple of the major benefits that can be gained from CBM:

* It is much easier to predict failure and fix it *before* it occurs, which means CBM can help reduce unplanned downtime and labour hours while increasing throughput.
* The time between maintenance increases because repairs are only done on an as-needed basis. This means less downtime, reduced backlog, and fewer costs.

## **26. Q: How is vibration analysis used for predictive maintenance?**

**A:** Collecting data has to follow a specific pattern to be effective. The system measures known failure vibration frequencies and compares data taken at one time from another. Increasing vibration or its impact (how hard it vibrates) identifies a potential issue. This is why measuring at the same time is critical.

The data collected during the route is loaded into the VA database. The VA software helps to identify irregularities from previous data or is outside of a set parameter. The VA technician can take additional measurements and/or report the findings on a follow-up work order in the *computerized maintenance management system* (CMMS). The specific component requiring replacement or service can be made a part of the follow-up work if the technician is confident with the necessary steps.

**27. Q: How do ultrasound analysis instruments work?**

**A:** UA instruments take high-frequency sounds picked up by a sensitive microphone and convert them into audio and digital data that can be heard and used by humans and software. They can be used on a case-by-case basis or on a fixed frequency to collect data over a period of time.

PdM uses current measurements and applies them to known issues or past measurements. Change from these helps detect potential problems.

## **28. Q: What is infrared (IR) analysis?**

**A:** Infrared analysis uses infrared radiation to compare the difference in temperature between components in one view or multiple views over time. The temperature differences can indicate an asset’s condition or performance.

Radiation (IR) is the wavelength of light that is invisible to the human eye. The varying levels of light indicate an object’s temperature. Infrared analysis is a cost-effective way to identify imminent or existing problems with various types of assets, components, and materials. And unlike *oil analysis* and other types of predictive maintenance that require intense training, IR is relatively easy to adopt. For these reasons, organizations around the world are using IR to move from preventive maintenance to predictive maintenance and find existing failures faster.

**29. Q: What is the difference between predictive maintenance (PdM) and condition-based maintenance (CbM)?**

**A:** Predictive and condition-based maintenance are both maintenance types that occur *before* breakdowns happen. As such, they are both forms of proactive maintenance and are designed to increase reliability and decrease downtime.

The primary difference between them is the way in which maintenance is measured. Predictive maintenance relies on precise formulas in addition to sensor measurements (temperature, vibration, noise), and maintenance work is performed based on the analysis of these parameters. In this way, predictive maintenance is a very exact form of maintenance because it predicts future maintenance events.

On the other hand, condition-based maintenance relies only on *real-time* sensor measurements. Once a parameter reaches an unacceptable level, maintenance workers are dispatched. This means that condition-based maintenance systems perform work only in the moment it is needed.

**30. Q: How is oil analysis used for predictive maintenance?**

**A:** Predictive maintenance is an integral part of a company’s asset management strategy. It is considered to be the most advanced type of maintenance available. This type of maintenance aims to evaluate the condition of in-service equipment to estimate when maintenance should be performed. Oil analysis is just one of several types of predictive maintenance.

As previously stated, a significant amount of equipment failure has been found to be related to oil contamination.

**31. Q: Why is oil analysis performed ?**

**A:** Oil analysis can be used to determine the following:

1. **Fluid properties**: Evaluates condition of the lubricant which could affect oil change intervals
2. **Wear metal analysis**: Surface wear is considered to be the predominant threat to long-term equipment performance. Machine condition can be evaluated by measuring debris in oil
3. **Contamination**: Different types of contamination can affect equipment in different ways. For example, presence of air and water may affect fluid film required for surface separation. Presence of atmospheric and process chemicals can cause surface abrasion.

Although we have defined oil analysis as a means of predictive maintenance thus far, it can also be used as a tool to verify the effectiveness of a shop’s lubrication activities.

**32. Q: How can lubrication-related PM be optimized? What is it that we want to accomplish with PM optimization, and what is the expected outcome in order to sell the value of such an initiative?**

**A:**

* Improved wrench time through waste elimination. Wrench time will be improved when PM’s are optimized, freeing up your resources to complete more work.
* Increased OEE because of minimized mistakes. Mistakes will be minimized because you have a procedure to follow to complete the task.

With lubrication, the key is training, procedures, and lubrication maps. The lubrication route should be optimized as well. Movement is a form of waste that needs to be eliminated. The lubrication maps should reflect this.

Also, we have our operators lubricate some of their machines as a part of their start up procedures. We have grease gun meters with color-coded grease guns, and color-coded tags on the grease gun to match grease type. We also have lubrication maps and a lubrication schedule in place.

The key to PM optimization is to have a procedure in place for every activity, set standards, visual aids, and training, along with the expectation that they are followed. As a manager, you have to follow up as well. You will do this through auditing. It doesn’t have to be complicated.

## **33. Q: What is proactive maintenance?**

## **A:** Proactive maintenance is a maintenance strategy that corrects the source of underlying equipment conditions. The goal of proactive maintenance is to reduce unplanned downtime, equipment failure, and risks associated with operating faulty equipment.

## **34. Q: What is total productive maintenance?**

## **A:** *Total Productive Maintenance* (TPM) is the process of maximizing equipment effectiveness through the active involvement of all supporting departments. The goal of TPM is to improve overall productivity by optimizing equipment availability.

**35. Q: What is the 5S approach in TPM?**

**A:** The 5S approach provides a systematic approach to cleaning the workplace, thereby uncovering underlying problems and challenges:

1. **Sort** tools, equipment, and materials to identify which of these can be discarded.
2. **Straighten** and set things in proper order to reduce unnecessary motion and efficiently travel between working groups and locations.
3. **Shine** refers to performing necessary housekeeping to clean up the work area.
4. **Standardize** and schedule activities to systematically form the habits to keep the workplace organized.
5. **Sustain** the process and principles for long-term applications.

### **36. Q: What is autonomous maintenance?**

**A:** Maintenance tasks and caring for equipment should start with the people using the equipment. The empowerment of operators to work on small maintenance tasks effectively allows the maintenance teams to focus on more specialized assignments.

**37. Q: How many pillars are there in TPM?**

**A:** 8 pillars.

**38. Q: What is RCM?**

A**:** Reliability-centered maintenance was a product of airline maintenance schedules which are among the most intensive of any industry. Airlines have to undergo extensive servicing for safety but these services must be balanced with the need for the airline to generate revenue and continue operating. Balancing these two elements are difficult as machinery (i.e. airplanes) becomes increasingly complex and has multiple possible failure modes.

**39. Q: Which seven questions are normally asked in RCM?**

**A:**

1. What is the item’s purpose (main action) and performance standards?
2. What are ways it can fail to perform its main action?
3. What events are the cause of each failure?
4. What happens when each failure occurs?
5. How does each failure impact the system?
6. What task can be performed proactively to prevent, or lessen the impact of failure?
7. What actions must be taken if a preventive task can’t be found?

**40. Q: What is the Stribeck curve?**

**A:** The *Stribeck curve* is a fundamental concept in the field of [*tribology*](https://en.wikipedia.org/wiki/Tribology). It shows that [*friction*](https://en.wikipedia.org/wiki/Friction) in fluid-lubricated contacts is a non-linear function of the contact load, the lubricant viscosity and the lubricant entrainment speed. The discovery and underlying research is usually attributed to [Richard Stribeck](https://en.wikipedia.org/wiki/Richard_Stribeck) and [Mayo D. Hersey](https://en.wikipedia.org/wiki/Mayo_D._Hersey), who studied friction in journal bearings for railway wagon applications during the first half of the 20th century.

For a contact of two [fluid](https://en.wikipedia.org/wiki/Fluid)-lubricated surfaces, the Stribeck curve shows the relationship between the so-called *Hersey number*, a dimensionless lubrication parameter, and the friction coefficient. The Hersey number is defined as:

Hersey number = η ⋅ N P , {\displaystyle {\begin{aligned}{\text{Hersey number}}={\frac {\eta \cdot N}{P}},\end{aligned}}}

where *η* is the dynamic [viscosity](https://en.wikipedia.org/wiki/Viscosity) of the fluid, *N* is the speed of the fluid, and *P* is the normal load per length of the tribological contact. Hersey’s original formula uses the rotational speed (revolutions per unit time) for *N* and the load per projected area (i.e. the product of a journal bearing’s length and diameter) for *P*. Thus, for a given viscosity and load, the Stribeck curve shows how friction changes with increasing velocity. Based on the typical progression of the Stribeck curve, different [lubrication regimes](https://en.wikipedia.org/wiki/Lubrication#Lubrication_Regimes) can be identified.

## **41. Q: What is boundary lubrication?**

**A:** Boundary lubrication is associated with metal-to-metal contact between two sliding surfaces of the machine. During initial start-up or shutdown of some equipment (e.g., journal bearings) or under heavily loaded conditions (pins and bushings of construction equipment), the metal surfaces in a lubricated system may actually come into severe contact with each other. If the oil film is not thick enough to overcome the surface roughness of the metal, boundary lubrication occurs. We generally want to avoid boundary lubrication wherever possible.

## **42. Q: What is mixed lubrication?**

**A:** Generally speaking, boundary lubrication is dramatically reduced as sliding speed increases, creating a wedge of lubricant film between the surfaces in motion. As the potential for asperity contact is reduced and film thickness is increased, the coefficient of friction drops dramatically to the condition known as *mixed lubrication*.

Some metal-to-metal asperity loading is still occurring combined with loading (lift) on the lubricant. This is an intermediary condition between boundary and hydrodynamic/elastohydrodynamic lubrication regimes, the gray area between them. As the oil film thickness increases further, the system now moves into full film lubrication, either elastohydrodynamic or hydrodynamic lubrication.

## **43. Q: What is hydrodynamic (HD) lubrication?**

**A:** HD lubrication occurs between sliding surfaces when a full film of oil supports and creates a working clearance (e.g., between a rotating shaft and journal bearing). This lubrication regime condition occurs after a machine has begun to rotate and the speeds and loads are such that a wedge of oil has been formed between the shaft and bearing surfaces. For hydrodynamic lubrication to be effective, the oil’s viscosity must be such that the hydrodynamic condition will be maintained under every operating condition, such as high speed and high load, low speed and high load, low speed and low load, etc. If the operating conditions cause the working clearance to be reduced too much, metal-to-metal contact between the metal high spots or asperities may occur.

## **44. Q: What is elastohydrodynamic lubrication (EHL)?**

**A:** Elastohydrodynamic lubrication conditions occur when a rolling motion exists between the moving elements, and the contact zone has a low degree of conformity.

Examples of machinery applications that operate under EHL are rolling element bearings, gear teeth and cam contacts (rolling) where high rolling contact loads occur. If operating conditions such as speeds, loads, and temperatures are not exceeded, asperity contact may never occur because of this remarkable characteristic of lubricant and metal.

## **45. Q: What is abrasive wear in a lubricated surface?**

**A:** [*Abrasive wear*](https://www.machinerylubrication.com/Read/31684/know-abrasive-wear) is estimated to be the most common form of wear in lubricated machinery. Particle contamination and roughened surfaces cause cutting and damage to a mating surface that is in relative motion to the first.

## **46. Q: What is adhesive wear in a lubricated surface?**

**A:** Adhesive wear is the transfer of material from one contacting surface to another. It occurs when high loads, temperatures or pressures cause the asperities on two contacting metal surfaces, in relative motion, to spot-weld together then immediately tear apart, shearing the metal in small, discrete areas.

The surface may be left rough and jagged or relatively smooth because of smearing/ deformation of the metal. Metal is transferred from one surface to the other. Adhesion occurs in equipment operating in the mixed and boundary lubrication regimes as a result of insufficient lube supply, inadequate viscosity, incorrect internal clearances, incorrect installation or misalignment. This can occur in rings and cylinders, bearings and gears.

## **47. Q: What is *moisture corrosion* in a lubricated system?**

**A:** Moisture corrosion involves material removal or loss by oxidative chemical reaction of the metal surface in the presence of moisture (water). It is the dissolution of a metal in an electrically conductive liquid by low amperage and may involve hydrogen embrittlement. It is accelerated, like all chemical reactions, by increased temperatures. No metal-to-metal contact is needed. It will occur with a full-oil fluid film. Corrosion is often caused by the contamination or degradation of lubricants in service.

**48. Q: What is meant by “electrical pitting”?**

**A:** Electrical pittingis caused by a high electrical current or amperage passing through only a few asperities on the metal. Voltage builds up and then arcs, causing localized heating/melting and vaporization of the metal surface. This causes deep, large craters or pits in the metal surfaces, which may correspond to the spacing between the rolling elements of the bearing. It can sometimes be a result of welding in the area and inadequate grounding or insulation. It may also be referred to as electrical pitting, arcing or sparking.

## **49. Q: How does erosion takes place in a lubricating system?**

**A:** Erosion could be considered a form of abrasive wear. It occurs principally in high-velocity, fluid streams where solid particle debris, entrained in the fluid (oil), impinges on a surface and erodes it away. [*Hydraulic systems*](https://www.machinerylubrication.com/Read/277/hydraulic-systems-fluid) are an example where this type of wear may occur. Flow rates have a significant influence on these wear rates, which are proportional to at least the square root of the fluid velocity. Erosion typically occurs in pumps, valves, and nozzles.

## **50. Q: How does cavitation occur in a lubricating system?**

**A:** Cavitation is a special form of erosion in which vapor bubbles in the fluid form in low-pressure regions and are then collapsed (imploded) in the higher-pressure regions of the oil system. The implosion can be powerful enough to create holes or pits, even in hardened metal if the implosion occurs at the metal surface. This type of wear is most common in hydraulic pumps, especially those which have restricted suction inlets or are operating at high elevations.

Restricting the oil from entering the pump suction reduces the pressure on the oil and, thus, tends to create more vapor bubbles. [Cavitation](https://www.machinerylubrication.com/Read/380/cavitation-wear-hydraulic) can also occur in journal bearings where the fluid pressure increases in the load zone of the bearing. No metal-to-metal contact is needed to create cavitation.

**51. Q: How can analyzing oil help?**

**A:** Oil analysis programs are designed to provide information about the state of the oil and condition of the machine. There is a wide array of testing used to deliver this type of information. The following are specific examples of how fluid properties, machine wear, and contamination can be tested:

1. *Particle counting (PC)*is a tool for determining overall cleanliness and contamination in used oil.
2. *Viscosity* is the most important property of a lubricant; it is what allows it to form the protective layer required for separating moving surfaces.
3. *Spectroscropy* helps monitor contaminant metals and enables analysts to look for species of molecules that don’t belong in the oil.
4. *Water content*, which, as the name suggests, measures presence of water. Water is a common contaminant that has potentially devastating effects including rust, increased wear rate, and loss of additive functionality.
5. *Neutralization* number measures a change in the concentration of acid in an oil that is indicative of oxidation, corrosion, or depletion of additive levels.

## **52. Q: What is FMEA?**

**A:** *Failure Modes and Effects Analysis* (FMEA) is a qualitative and systematic tool, usually created within a spreadsheet, to help practitioners anticipate what might go wrong with a product or process. In addition to identifying how a product or process might fail and the effects of that failure, FMEA also helps find the possible causes of failures and the likelihood of failures being detected before occurrence.

## **53. Q: Why should you perform Failure Mode and Effects Analysis (FMEA)?**

**A:** Historically, the sooner a failure is discovered, the less it will cost. If a failure is discovered late in product development or launch, the impact is exponentially more devastating.

FMEA is one of many tools used to discover failure at its earliest possible point in product or process design. Discovering a failure early in Product Development (PD) using FMEA provides the benefits of:

* Multiple choices for mitigating the risk
* Higher capability of verification and validation of changes
* Collaboration between design of the product and process
* Improved [*Design for Manufacturing and Assembly* (DFM/A)](https://quality-one.com/dfm-dfa/)
* Lower cost solutions

### **54. Q: How do you implement FMEA?**

**A:** You have a list of possible errors and their potential corrective actions. Armed with that information, you can assign responsibility to your team members to implement these actions so that the RPN of these errors can be reduced.

You will review them again after the corrective actions have been implemented to assess the effectiveness of an action plan. If necessary, a new FMEA will be generated to re-assess the risks and defects.

Use the [*Pareto Law*](https://pmstudycircle.com/2015/06/pareto-chart/) while using this technique. Focus on the minority of causes creating most of the issues or defects. This provides the most significant impact while using the least number of resources. You can take on the other defects, as resources permit, once these high-impact issues are resolved.

## **55. Q: What is Overall Equipment Effectiveness?**

**A:** OEE (Overall Equipment Effectiveness) is a “best practices” metric that identifies the percentage of planned production time that is truly productive. An OEE score of 100% represents perfect production: manufacturing only good parts, as fast as possible, with no downtime.

Simply put. OEE identifies the percentage of manufacturing time that is truly productive. An OEE score of 100% means you are manufacturing only good parts, as fast as possible, with no stop time. In the language of OEE, that means 100% quality (only good parts), 100% performance (as fast as possible), and 100% availability (no stop time).

## **56. Q: How do you calculate OEE?**

**A:** In simplest terms, OEE is the ratio of fully productive time to planned production time. In practice, this is calculated as:

OEE = (Good Count × Ideal Cycle Time) / Planned Production Time

Let’s define some terms:

*Good Count*: Pieces that are manufactured without any defects

*Ideal Cycle Time*: The theoretical fastest possible time to manufacture one piece

*Planned Production Time*: The total time that the production asset is scheduled for production

*Fully Productive Time*: Producing only good pieces, as fast as possible, with no stop time

### **57. Q: Why should you implement OEE?**

**A:** Overall Equipment Effectiveness is a universally accepted method for measuring the improvement potential of a production process—with one simple number. Measuring makes it easier to improve, and improving productivity (by eliminating waste) is the core objective of Lean Manufacturing. OEE also provides a critical link between measurement and improvement. It directly ties to the [six big losses](https://www.oee.com/oee-six-big-losses.html), which provide a practical and actionable roadmap for improving manufacturing productivity.

### **58. Q: Will OEE work with *my* process?**

**A:** The short answer is “very likely, yes.” OEE is most commonly applied to discrete manufacturing processes (i.e. processes that make individual parts). However, OEE can also be applied to continuous processes (e.g. refineries). The key thing to remember is that OEE identifies the ratio of fully productive time (actual output) to planned production time (theoretically possible output). The difference between the two is waste—lost time that could be used for manufacturing.

### **59. Q: My manufacturing process is mostly manual. Can I use OEE?**

**A:** Yes, but you may want to consider a variant known as *OLE* (*Overall Labor Effectiveness*). OEE is designed to measure equipment effectiveness. OLE is designed to measure labor (workforce) effectiveness. Another option is to simply measure labor productivity (parts per person hour).

**60. Q: What are the types of lubricants?**

**A:** Let’s look at the different types of lubricants:

***Gas lubricants*—Gas** lubricants (air, nitrogen, and helium) are often used in gas-lubricated bearings, though air is the most commonly employed.

***Liquid lubricants*—Also** known as *liquid oil lubrication*, where low viscosity oils have low fluid friction losses and hence results in low heat generation. The liquid can carry away heat. It has a high boiling point and low freezing point as well as high resistance to oxidation and wear. It has non-corrosive properties.

***Semi-solid lubricants*—Greases** are semi-solid lubricants. They are a black or yellow sticky mass used in the bearings for the purpose of lubrication. They have unique properties that include resistance to water, and withstanding harsh climates and conditions, important additives, thickeners, and more. The thickeners that are used can also be soap-based or non-soap based. It depends on the requirements.

*Solid lubricants***—**Graphite**,** hexagonal boron nitride, molybdenum disulfide and tungsten disulfide are examples of solid lubricants. Some retain their lubricity to very high temperatures. The use of some such materials is sometimes restricted by their poor resistance to oxidation.

**61. Q: How does viscosity affect the performance of lubricating oil?**

Viscosity indicates the resistance of a liquid to flow. There are several units for measuring viscosity. Formerly, the unit commonly used in America was *Saybolt Universal Second* (SSU), measured at 100°F or 210°F. In Europe, the former widely used unit was *Redwood I Second* (RWI), measured at 100°F or 210°F. At present, most countries have switched over to the metric system that employs the unit *Centistokes* (cSt), measured at 40°C or 100°C.

Oil with higher viscosity can stand greater pressure without being squeezed out of the lubricating surfaces. However, the high internal friction of the oil may offer greater resistance to the movement of the lubricating parts. An oil of lower viscosity offers less resistance to the moving parts but the oil can be easily squeezed out of the lubricating surfaces. It is therefore important to select a lubricating oil of appropriate viscosity to achieve optimum lubrication effect.

Viscosity changes with temperature. Hence, the measuring temperature must be specified whenever the viscosity of a liquid is stated. When temperature rises, a liquid becomes less viscous. Similarly, a liquid becomes thicker when temperature drops.

**62. Q. How does the viscosity index (VI) affect the performance of the lubricating oil?**

**A:** The*Viscosity index*is an indication of how the viscosity of a liquid varies with temperature. A high VI means the liquid does not thin out so much when the temperature rises. VI improver additives that are usually high molecular weight polymers can increase the VI of lubricating oil.

Increase in oil viscosity achieved by addition of polymers can be partially lost again through degradation of the polymer molecules by shear stress such as heavily loaded gears. Oil that can resist viscosity change due to shear are said to have high shear stability.

**63. Q: What is pour point?**

**A:** Pour point indicates the flow characteristic at a low temperature. This depends on the wax content of the oil.

**64. Q: What is flash point?**

**A:** Flash point measures the readiness of the oil to ignite momentarily in air, and is a consideration regarding the fire hazard of the oil.

**65. Q: What is oxidation stability?**

**A:** Oxidation of oil will produce resins and sludge that may plug filters and oil passages. Oxidation can also produce soluble organic acids that may cause corrosion of machine parts. A good lubricating oil should resist oxidation.

**66. Q: What is acidity and alkalinity (total acid number and total base number)?**

**A:** Highly acidic oil may cause corrosion of machine parts. Most engine oils show some alkalinity as a result of the addition of detergent type additives. This helps to neutralize any acid formed in the oil by oxidation.

After prolonged usage, lubricating oil may contain organic acids formed by oxidation. Therefore, a measurement of the acidity of an oil can reflect its degree of oxidation.

**67. Q: What is detergency?**

**A:** Most engine oils contain detergent and dispersant additives to prevent dirty particular produced by incomplete combustion from accumulating and plating metal surfaces.

**68. Q: What is meant by “anti-rust” property?**

**A:** Water may seep into the lubricating system and cause rusting of machine parts. Rust particles can act as a catalyst to accelerate the oxidation of the oil.

Anti-rust additives can be absorbed onto metal surfaces and prevent moisture from coming into contact with the metal, thus preventing rusting.

**69. Q: What is corrosion inhibition?**

**A:** Acidic materials in oil can cause corrosion of machine parts. Corrosion can be minimized by the addition of a corrosion inhibitor that reacts with metal to form a protective layer, separating the acidic materials and the metal.

**70. Q: What is an anti-foaming property?**

**A:** Foaming reduces the lubricity of oil because the air bubbles in the foam create a barrier between the oil and the metal surface. Foam can also produce resistance to the movement of machine parts.

In a hydraulic system, foam will reduce the cohesive power of the oil, and cause the hydraulic pressure to drop. Good lubricating oil will not foam easily and can disperse foam quickly. Anti-foam additives can help to reduce the foaming tendency of oil.

**71. Q: What are emulsification and demulsification?**

**A:** Emulsification is the homogenous mixing of oil and water. Some oil requires high emulsibility so that it can mix with water easily, for example, some metal cutting oils. The emulsibility of oil can be improved by the addition of an emulsifying agent that has a strong affinity for both oil and water, thus holding the oil and water molecules together.

Some other lubricants require good demulsibility so that water can be separated from the oil easily, e.g., turbine oil. The demulsibility of an oil can be achieved by a good refining technique**.**

**72. Q: What is meant by “anti-wear” property?**

**A:** Some lubricating conditions may call for extremely light oil, an oil of lower viscosity than the load-speed relationship of the machine may indicate. Under such condition, wear of the metal surfaces may occur. Anti-wear additive forms a protective coating on the metal surfaces, allowing the surfaces to slide on each other with a minimum loss of metal.

**73. Q: What is the extreme pressure loading property (EP) of lubricants, and how does it affect lubricating oil performance?**

**A:** Heavy loading, extreme pressure and intense heat may cause machine moving parts to melt and weld together, hence interfering with motion.

The extreme-pressure additive in oil can react with metal to form a compound with a low melting point. The intense heat that develops as a result of the extreme pressure loading will be dissipated in the melting of the compound, instead of welding the two metallic parts.

EP properties are usually measured by the Timken method (ASTM D 2782). In the Timken method, a steel cup rotates against a steel block in a lubricant bath. The maximum load that will not cause scoring is considered OK.

**74. Q: What is meant by “tackiness” of lubricants?**

**A:** Tacky oils contain tackiness agents and will stick to the lubricating surface for a long time without being spattered. Lubricants used in textile machinery and wire ropes usually require a tackiness property.

**75. Q: How is grease formulated?**

**A:** Grease is a semi-solid formed by the dispersion of a thickening agent in a liquid lubricant (base oil). Other ingredients imparting special properties may be included. Greases have advantage over oils in some applications because greases stay at the point of lubrication and will rarely be squeezed out. Sometimes, greases can also be used to seal up machine parts to prevent the entry of moisture and dust.

Base oil viscosity, hydrocarbon type, and volatility can influence the structure stability, lubricating quality, low and high temperature performance, and cost of grease. The thickener is the principal factor controlling water resistance, high temperature qualities, resistance to breakdown through continued use, and ability to stay in place. To a large extent, the cost of grease is determined by the type of thickener and other additives. Thickeners can be divided into several categories; soap-type, inorganic type and synthetic organic type.

**76. Q: What is meant by “penetration” in grease?**

**A:** This indicates the consistency (hardness or softness) of grease. It is measured by dropping a pointed cone into the grease and seeing how far the cone penetrates into the sample. Different ranges of penetration are identified by the following National Lubricating Grease Institute (NLGI) Grade Numbers: 000, 00, 0, 1, 2, 3, 4, 5, and 6. Grade 000 is the softest, while Grade 6 is the hardest.

Most greases thickened with soaps become softer with an increase in temperature, but some greases become progressively harder upon exposure to high temperature. Non-soap thickeners, as a whole, show very little change in consistency with a rise in temperature.

**77. Q: What is meant by “water resistance” in grease?**

**A:** Greases with thickeners soluble in water will emulsify and fluidize if they come into contact with a relatively large amount of water. In general, calcium, lithium and aluminium soaps are highly water resistant, while sodium soap greases are soluble in water.

**78. Q: What is oxidation stability?**

**A:** Oxidation will cause the grease to harden, form varnish-like films, and eventually carbonize. Additives can improve the oxidation stability of grease.

**79. Q: What are lubricating properties in grease?**

**A:** Both the oil and the thickener in soap-type grease have lubricating properties. Inorganic non-soap thickener generally does not contribute to the lubricating of grease. The lubricating capability of the oil depends on its viscosity and viscosity index.

**80. Q: What is meant by the “anti-wear” characteristic of grease?**

**A:** Additives may be included in a grease to promote its anti-wear properties.

**81. Q: What is the extreme pressure capability (EP) of grease?**

**A:** Some grease contains special additives to fortify its load carrying capability so that welding and scoring of metal can be minimized.

**82. Q: What is the dropping point of grease?**

**A:** It is the temperature at which the grease is fluid enough to drip. Grease with a dropping point below the operating temperature would not provide proper lubrication. However, the converse is not necessarily true—a dropping point above operating temperature is no guarantee of adequate lubrication since there may be a change in consistency and deterioration in chemical properties of the grease at high temperatures.

**83. Q: What are the advantages of grease lubrication?**

**A:** Lubricating greases:

* Act as sealants, preventing ingress of extraneous particles and water;
* Stay better on an application and minimize the chances of a dry start;
* Are easy to mix with solid lubricants like moly, graphite, and other solid lubricants;
* Are used in more than 90% of machines with roller bearings.

**84. Q: How should you determine when to use oil or grease?**

**A:** In general, lubrication can either be achieved by lubricating oil (ﬂuid) or grease (semi-solid). Whether to use lubricating oil or lubricating greases is usually governed by its *DmN* factor, which can be calculated as follows:

DmN factor = N x (D + d) /2

Where

**D**=Bearing outer diameter, mm

**d**=Bearing bore diameter, mm

**N**=Bearing operating speed, rpm

If DmN factor is more than 1 million, oil should be used.

Lubricating greases are generally recommended up to 1 million DmN factor, barring a few exceptions. For lower DmN factors ranging from 100,000 to 500,000, mineral oil-based greases with suitable viscosity may be used. However, for higher DmN factors, synthetic oil-based greases are preferred. For all DmN factor beyond this number, oil lubrication is recommended.

### **85. Q: What qualifies as a lubricating grease?**

**A:** The grease as “a solid to semi-ﬂuid product of the dispersion of a thickening agent in a liquid lubricant.” The thickener provides it non-Newtonian nature by the dispersion of base oil in its gel-like structure, and acts like sponge. Lubricating greases basically consist of base oil (75-85%), thickener (10-15%), and performance additives. Both base oils as well as thickeners inﬂuence properties of lubricating greases. Performance additives are added to boost the certain desired performance label of lubricating greases.

### **86. Q: What does the base oil do in lubricating greases?**

**A:** Base oils in lubricating greases are present in the majority (> 80 %) of greases, and are responsible for the main function of lubrication carrying the oil and acting like a sponge, releasing the oil at the point of application. Base oils inﬂuence pumping and ﬂowability of lubricating greases. High-viscosity oil-based greases ﬂow/pump slowly compared to low-viscosity oil based greases.

### **87. Q: What does thickener do in lubricating greases?**

**A:** Thickeners are considered the backbone of greases. The thickener system may be a simple metal soap, a complex soap, a synthetic organic thickener, or inorganic gelling agents. Whatever the thickener type may be, many of the important properties and performance characteristics of the fully formulated grease comes from the actual thickener system. High-temperature capabilities of grease are a function of the thickener, though the base oil also does play some role. Water-resistant characteristics of grease are also controlled by type of thickener. For example, soda-based greases are poor for water resistance, whereas aluminum complex and sulfonate-based greases are known for their superior water-resistant properties.

### **88. Q: What do additives do in lubricating greases?**

**A:** An additive is any material added to a lubricating oil or grease formulation to improve that product’s ability to perform the task called for. In fully-formulated grease, the base oil imparts certain characteristics and thickeners also bring certain characteristics to the formulation. The additives doped in the formulation may either add to these characteristics, or may boost desired characteristics already present. These include pressure properties, corrosion and rust inhibition, water resistance, low temperature ﬂuidity, color and odor, etc.

**89. Q: What is the dropping point in grease?**

**A:** Dropping point is an indicator of the heat resistance of grease. At or above the dropping point, a grease will act as a fluid. As the grease temperature rises, penetration increases until the grease liquefies, and the desired consistency is lost. Dropping point is the temperature at which a grease becomes fluid enough to drip, and indicates the upper temperature limit at which a grease retains its structure. It is not the maximum temperature at which a grease may be used. Some greases have the ability to regain their original structure after cooling down from the dropping point. The USACE recommends that the operating condition of the grease be at least 56°C or 100°F below the dropping point.

**90. Q: What is grease consistency?**

**A:** The consistency, or rigidity, of a grease is a measure of its resistance to deformation by an applied force and is, in most cases, the most important characteristic of a grease. A grease that is too stiff may not feed into areas requiring lubrication, while a grease that is too fluid may leak out. Grease consistency depends on the type and amount of thickener used and the viscosity of its base oil. In the United States, penetration classifications have been established by National Lubricating Grease Institute (NLGI) and range from 000 to 6.

**91. Q: What is the oxidation stability of grease?**

**A:** Oxidation stability is the ability of a grease to resist a chemical union with oxygen. The reaction of grease with oxygen produces insoluble gum, sludge, and lacquer-like deposits that cause sluggish operation, increased wear, and reduction of clearances. Prolonged high-temperature exposure accelerates oxidation in greases.

**92. Q: What is meant by the “pumpability” of grease?**

**A:** Pumpability is the ability of a grease to be pumped or pushed through a system at very low temperatures. More practically, pumpability is the ease with which a pressurized grease can flow through lines, nozzles, and fittings of grease-dispensing systems. An example of this is grease lines for miter gate pintle bearings and radial gate trunnion bearings. In northern climates, it is important that grease reach the [bearing surfaces](https://www.sciencedirect.com/topics/engineering/bearing-surface) of the pintles.

*Feedability* is a grease’s ability to be drawn (sucked) into a pump. Fibrous greases tend to have good feedability, but poor pumpability. Buttery-textured greases tend to have good pumpability, but poor feedability.

**93. Q: How does base oil viscosity affects grease properties?**

**A:** The base oil viscosity significantly affects grease [evaporation rates](https://www.sciencedirect.com/topics/engineering/evaporation-rate). Grease, by its nature, cannot dissipate heat by convection like a circulating oil. Consequently, without the ability to transfer away heat, excessive temperatures result in accelerated oxidation or even [carbonization](https://www.sciencedirect.com/topics/engineering/carbonisation) where grease hardens or forms a crust. Effective grease lubrication depends on the grease’s consistency and dropping point.

High temperatures induce softening and bleeding. If the temperature of a grease is lowered enough, it will become so viscous that it cannot lubricate properly. Pumpability suffers and machinery operation may become impossible because of torque limitations and power requirements. As a guideline, the base oil’s pour point is considered the low-temperature limit of a grease.

**94. Q: How does soap thickener affect grease?**

**A:** A soap thickener gives grease its physical character. Soap thickeners not only provide consistency to grease, they affect desired properties such as water and heat resistance and pumpability. They can affect the amount of an additive, such as a rust inhibitor, required to obtain a desired quality. The soap influences how a grease will flow, change shape, and age as it is mechanically worked.

Each soap type brings its own characteristic properties to a grease. The name of the soap thickener refers to the metal (calcium, lithium, etc.) from which the soap is prepared.

**95. Q: Which lubricants are used for vacuum applications?**

**A:** One problem with using greases and oils for lubrication in a vacuum is that they tend to “creep” away from where they are needed. This is especially a problem when it involves long-term service such as for space applications. One approach is to use low-shear-strength solid-film [lubricants](https://www.sciencedirect.com/topics/materials-science/lubricant). Solid film lubricants include graphite (which is not useable in a vacuum as it requires water vapor for its lubricity), sulfides (e.g., MoS2—electrical insulator), selenides (e.g., MoSe2—electrical conductor), and low-shear strength metals such as Ag, Sn, and In.

**96. Q: What are the advantages and disadvantages of oil and grease?**

**A:**

|  |  |  |
| --- | --- | --- |
| **Lubricant** | **Advantage** | **Disadvantage** |
| Oil | Easy to distribute, lubes other components, less drag, easier to drain out and change. Better for high temperature. | May leak (environmental concern), then no more lubrication |
| Grease | Remains in place, doesn’t leak out easily, improves sealing, and does not require monitoring. | Requires more labor to clean out and replenish. High temperature grease is very expensive. |

### **97. Q: Which oil contaminants affect lube oil?**

**A.** The lubricating oil properties are affected by any contaminants that may occur during motor operation. The effects of the contaminants are as follows:

*Water*: Even in small amounts, water causes rusting of iron or steel. The water also results in forming water sludge (emulsions), which may clog oil passages, pump valves and other oil handling equipment. Water also contributes to foaming problems.

*Solid particles of dirt, dust, grit and metallic fragments* *which were circulated by the* [*lubricant*](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/lubricant): These contaminants cause excessive wear, scoring of the bearing surface, and possible failure as a result of seizing of metal fatigue.

*Sludge and lacquers*: The sludge deposits clog small oil passages and clearances. Lacquers or varnish cause sticking of valves, and resist against the continuous operation of oil pump.

*Liquid contaminants such as unburned fuel from engines*: These dilute lubricating oil and possibly reduce their viscosity beyond a safe load. Contaminants of the lubricant with heavier oil increase viscosity and interfere with the oil circulation. This affects the lubricating valve and heat transfer capacity.

**98. Q: Why is new oil cleanliness so important?**

**A:** In many cases, new oil is the dirtiest oil in the plant. The containers used to store lubricants are often reused and may be subjected to many extreme conditions before they reach your plant. Currently, lubricant manufacturers are not required to ensure cleanliness of the lubricant they provide unless it is advertised as meeting a specified cleanliness rating, or cleanliness is written into the lubricant purchase specification.

Cleanliness of new oils typically ranges between ISO 4406 codes of 16/13 to 22/19. Considering most hydraulic and lubrication systems require ISO cleanliness of 17/14 or better, the new oil contamination level is frequently too high for immediate service without conditioning. Routine analysis of new oils should be employed to ensure effective contamination control.

**99. Q: Why is filtering of new oil required?**

**A:** Filtering new and used oil and keeping them clean of particulates and moisture will prolong the life of the oil and keep the equipment protected from wear. Studies have shown that as much as 70% of all premature machine failures can be attributed to contamination. The key is to purify the oil new as it comes into the facility and keep it clean throughout its operating life. By establishing an ISO code cleanliness goal and maintaining it you will extend the life of the oil and the equipment. Large and small particles are destructive and the enemy. By removing the particles, we can keep the equipment protected from abnormal wear.

If you are looking to improve your current lubrication reliability efforts, one tool that is a must-have is a portable or dedicated filtration system designed to screen the oil removing large particulates and clean the oil from small particulates.

**100. Q: Why is lubricant dispensing equipment important for contamination elimination**?

**A:** Lubricant dispensing equipment often lies at the root of cross contamination problems. By dispensing oil through equipment that was previously used with a different lubricant, the two fluids mix, potentially causing lubrication impairment. Cross contamination is also a trend-killer, reducing the effectiveness of oil analysis efforts. Equipment such as transport containers, hand pumps, transfer carts and filter carts should be labeled to match the lubricant with which it is to be used.

Where mixing is unavoidable, verify compatibility in advance with the lubricant supplier. Extend the identification process to the machine’s lubricant fill ports. Using identification tags or color-codes helps to ensure that the proper lubricant is added to the reservoir fitted with the proper dispensing tools. If dispensing equipment must be used for a variety of lubricants, employ a proper cleaning or flushing procedure that emphasizes the removal of the previous lubricant and other contamination to minimize risk.

**101. Q: How do varying temperatures** **affect lube oil?**

**A:** Temperature fluctuations will cause movement of air between the atmosphere and the head-space of the container (thermal siphoning). For partially full containers, with greater head-space, the air movement is increased. Although the drum is sealed and does not leak lubricant through the bung, a rigid container still inhales air when the temperature drops and exhales as the temperature rises. Along with the air, moisture and small airborne particles enter the oil container, potentially leading to degradation of the base stock and additives. Also, water might condense within the drum, drop to the bottom and get pumped to the machine during a top-off.

**102. Q: How does dispensing affect lube oil contamination?**

**A:** The dispensing of lubricants includes the withdrawal of the lubricant from the oil house or other storage areas—the transfer of the lubricant to its point of use, and the application of the lubricant at the point of use. When lubricants are dispensed by methods other than completely closed systems, containers or devices used to move lubricants and related products should be kept clean at all times.

Each container or device should be clearly labeled for a particular product and used only for that product. The device used for the introduction of a product to the point of final use should be carefully cleaned before the filling operation is started. Also, sumps and reservoirs should be thoroughly cleaned and flushed before filling the first time and should be checked at the time of every refill.

**103. Q: How do storage and handling procedures affect safety?**

**A:** In a typical lubricant-storage facility, you will find many sources for potential injury or loss of life. Some examples are:

* Heavy forklifts and other machinery move in confined spaces and often carry heavy loads, posing safety risks to pedestrians as well as the machine operators.
* Weighty containers, such as pails of oil weighing almost 40 pounds and oil drums weighing nearly 450 pounds, could fall or roll onto unsuspecting individuals.
* Slippery lubricants may leak or spill, creating slip-and-fall and fire hazards.
* Some substances may cause physical harm upon inhalation, swallowing, or contact with skin or eyes.

### **104. Q: What can cause stored lubricants to go bad?**

**A:** Some of the most common causes of lubricant contamination and degradation include:

* Storage of a lubricant beyond its expected shelf life
* Damaged or improperly sealed containers
* Unclean dispensing equipment
* Inappropriate mixing of lubricants
* Ingression of moisture from humidity, condensation or precipitation
* A dusty or dirty environment
* Exposure to extreme heat or cold, or to fluctuating temperatures

Ensure that your storage and handling procedures safeguard against these and other contamination-causing circumstances.

## **105. Q: What is Root Cause Analysis?**

**A:** Root Cause Analysis (RCA) is defined as a systematic process for identifying the root causes of problems or events and an action plan for responding to them. Many organizations tend to focus on or single out one factor when trying to identify a cause, which leads to an incomplete resolution. Root cause analysis helps avoid this tendency and looks at the event as a whole.

**106. Q: How to you conduct a Root Cause Analysis (RCA)?**

**A:** Root cause analysis can be used in a variety of settings across multiple industries. Each industry might conduct the analysis in a slightly different way, but most follow the same general five-step process when investigating issues involving heavy machinery. This process was laid out by the United States Department of Energy (DOE-NE-STD-1004-92) back in 1992. Root Cause Analysis is commonly referred to as detective work at its finest. You’ll see similarities between how a detective works to solve a case and how manufacturers can figure out the root cause of an issue in the five-step process:

***Phase 1*—Data Collection**

***Phase 2*—Assessment**

***Phase 3*—Corrective Action**

***Phase 4*—Inform**

***Phase 5*—Follow-up**

**107. Q: What are Pareto charts?**

**A:** A Pareto chart combines both bar and line graphs, with bars representing individual values (lengths or costs) shown in descending order and lines used to illustrate the cumulative total. In quality control, a Pareto chart can highlight the most common sources of defects or the type of defect that occurs most frequently.

**108. Q: When should you use a Pareto chart for Root Cause Analysis?**

**A:**

* When looking at data on how often problems occur or the causes in a process
* When you want to weed out other problems and focus on the most significant
* When looking at broad or general causes by analyzing their specific components
* As a good communicative tool

**109. Q:** **What are the “5 Whys”**?

**A:** You can think of the 5 Whys method like a curious child continuously asking “why” until he or she receives a satisfactory answer. Each time you ask “why,” the answer produces another “why” question. It is a simple tool, so you shouldn’t use it to determine complex problems. However, it can be useful to help dive into the results from other methods like a Pareto chart.

An example of using the 5 Whys might look like the following:

* Why did machine A stop working? The circuit overloaded, causing a fuse to blow.
* Why is the circuit overloaded? The bearings locked up because of insufficient lubrication.
* Why was there insufficient lubrication on the bearings? Machine A’s oil pump isn’t circulating enough oil.
* Why is the pump not circulating enough oil? The pump’s intake is clogged with particulate.
* Why is the intake clogged? There is no filter on the pump.

You may need more or less than five questions to get to the root of your problem, but as long as your questions keep peeling away issues on the surface, the more likely you are to uncover your root cause.

**110. Q: What are fishbone diagrams?**

**A:** Sometimes called a cause-and-effect diagram, a fishbone diagram is helpful for sorting possible causes into multiple categories which all branch off from the original problem. The main categories addressed in this diagram are the six “Ms”—man, material, method, machine, measurement and Mother Nature (environment). A fishbone diagram can also have numerous sub-causes originating from each main category.

**111. Q: When should you use a fishbone diagram?**

**A:**

* To identify possible causes for an issue.
* When your team’s thinking and brainstorming tends to get stuck or stagnate.

Work the diagram right to left, having your team brainstorm possible causes of the problem and placing each idea in the appropriate category. Once the team is done brainstorming, rate the potential causes by level of importance and likelihood of contributing to the problem. From here, select which causes to investigate further.

In our example, the fishbone diagram includes a main problem, six factors contributing to the main problem, and potential causes of those factors branching off.

**112. Q: What is Failure Mode and Effects Analysis (FMEA)**

**A:** [FMEA](https://www.reliableplant.com/fmea-31611) is used to analyze and determine potential risks, failures and causes. The process looks at ways in which failures such as errors or defects might occur and then studies or analyzes those failures.

**113. Q: When should you use FMEA?**

**A:**

* During the design or redesign of a process, product or service.
* When applying an existing process, product or service in a new way.
* Before coming up with control plans for a new or modified process.
* When planning improvement goals for existing processes.
* When looking into failures of an existing process.

You can think of FMEA as more of a proactive tool rather than a reactive tool.

**114. Q: What is** **fault tree analysis?**

**A:** Fault tree analysis helps identify potential risks in a system or process before they happen. Sometimes called a “top-down approach,” this deductive process starts with a general conclusion and attempts to figure out the causes of the conclusion by making a logic diagram called a fault tree. The diagram utilizes shapes called “gates” to denote various interactions among contributing failure events.

The two most common gates are the “and” and “or” gates. When using these gates, consider two events: input events, which can lead to another event, referred to as an output event. If either of the input events causes the output event to occur, connect these events with an “or” gate. If both input events must happen for the output event to occur, connect them using an “and” gate.

A fault tree can be used to build a safety program, discover what went wrong in a process, or determine why employees may not be meeting company standards. For example, you can take a hypothetical incident like a lubrication spill, break down the contributing factors and see the chain of events or failures along the way. You can then choose safety procedures that help minimize these outcomes.

**115. Q:** **How should you dispose of used oil?**

**A:** Disposing the wrong way has the potential to pollute land, water, and wildlife. All used oils, including engine oil, machine oil, hydraulic oil, coolant oils and quenching oils, are classified as “prescribed industrial wastes.” As a result, it is illegal to dump waste oil into landfill or waterways. It is also illegal to send used oil filters to landfill in Victoria. All containers must be drained of all residue oil before they can be recycled. Wherever possible, you should endeavor to recycle waste oil.

**116. Q: How do I dispose of waste oil?**

**A:**

• Collect all waste oils in secure, clearly labelled drums or tanks that are stored in a bunded and undercover area.

• If stored in a double skinned tank, there is no need for bunding. However, if stored in a single skinned tank then the tank must be bunded.

• For oil filters, drain the oil and place the drained oil filters into a drum for collection by an EPA-approved transporter.

**117. Q: Why should you recycle your used oil after an oil change?**

**A:** Disposing of used oil the wrong way has the potential to pollute land, water and infrastructure, so we need to recover and recycle as much of it as possible. Consider that it takes only **one litre of oil to contaminate one million litres of water** and a single automotive oil change produces 4 to 5 litres of used oil. **Used oil, or “sump oil” as it is sometimes called, should not be thrown away.**

Although it gets dirty, used oil can still be cleaned and re-used. In fact, recycled used oil can be used as an industrial burner fuel, hydraulic oil, incorporated into other products or re-refined back into new lubricating oil.

Used oil disposed of inappropriately, dumped in a landfill, or stored on farms and in garages can cause harm to the environment, so it is important that we recycle as much of it as possible.

**118. Q: How can lubricants affect energy efficiency?**

**A:** Lubricants influence energy efficiency mainly by reducing energy losses, which include churning losses and friction losses in hydrodynamic, elastohydrodynamic, and boundary lubrication regimes. The total energy loss depends on lubricant viscosity and chemical composition. Different sources of lubrication-related power losses in industrial systems are described. The dependence of churning and friction losses on oil properties is analyzed.

Viscosity shear-thinning and pressure-thickening effects and their dependence on base oil and viscosity index improver chemical composition are examined. The role of pressure-viscosity relationships has an important role, and some aspects of oil compressibility and viscoelasticity affect oil energy efficiency. The mechanism and role of friction modifiers in industrial oil formulations have an impact on energy efficiency.

Significant savings in machine energy consumption can be achieved by using energy-efficient lubricants.

## **119. Q: How can you reduce energy by using lubricating oil?**

**A:** Lubricant suppliers are increasingly pitching the importance of energy conservation when selecting lubricants. Lubricant users are also seeing increased corporate pressures to keep costs down and profits high. For many, this temptation has led them to take the plunge into energy-conserving lubrication.

There are many lubricant selection scenarios in which wear is reduced at the expense of greater energy consumption. This might occur when the viscosity selected is too high. To the other extreme, exceedingly low viscosity can periodically bring surfaces into boundary conditions (mechanical rubbing) and sharply increased sensitivity to particle contamination.

Fortunately, there are usually ways to reduce this risk. Begin with machines where the opportunity for reduced energy consumption is the greatest. Consider incremental changes in viscosity and VI for those lubricants that don’t have film-strength enhancing AW and EP additives.

Typically, viscosity is reduced and VI is increased in this strategy. However, in some cases, improvements are in the direction of viscosity increase. Take small steps, for example, in half-grade increments in ISO viscosity grades at a time (this is achieved by onsite blending).

### **120. Q: How can synthetic lube oil help in energy efficiency?**

**A:** When it comes to energy efficiency, some gear oils are more energy efficient than others because of their lower coefficient of friction. Polyglycols, for example, absolutely shine as the most efficient and lowest wear type of oils, particularly in high-sliding applications such as worm and hypoid gears. In these applications, PAGs offer a lower coefficient of friction within the gearbox, resulting in less power loss.

Synthetic oils are more energy efficient because they have better oxidation and thermal stability, which means the gear oil lasts much longer. One could expect to change a mineral oil every 5,000 hours, whereas PAOs or synthetic hydrocarbon oils can last approximately 15,000 hours before a change-out. In addition, PAGs can last as long as 25,000 hours at the same temperature.

Also, remember that oxidation causes degradation of oil over time. The Total Acid number changes, and the additives are being used up. While changing the gear oil replenishes these additives and removes wear materials, it also adds maintenance downtime to the equation. Choosing a high-performance gear oil from the start will automatically reduce the amount of oxidation within the oil and decrease the required number of oil changes and downtime for equipment maintenance.

**121. Q: How does Industry 4.0 helps in lubrication-related maintenance?**

**A:**

*By use of online sensors*

• Realtime measurement of key parameters

• Continuous determination of relative changes

*Central data base and data analytics*

• All data collected from traditional data sources and online sensors

• All data converted into a single format

• Data analysis and visualization

• Realtime evaluation of measured parameters as basis for decision making

*Immediate actions*

• (Automated) fluid adjustments

• Optimization of process parameters

• Preservation of process stability

• Avoidance of process break downs

• Prevention of health hazards

*Trend analytics*

• Comparison of current data with historical data to predict the remaining useful life

• Supports predictive maintenance approaches

• Identification of complex correlations

**122. Q: How can Industry 4.0 help lube oil analysis?**

**A:** Technologies in the Industry 4.0 sector consist of several major innovations in digital technology including advanced robotics, artificial intelligence, sensors, cloud computing, Internet of Things (IoT), data capture and analytics, software as a service (SaaS) and platforms that utilize algorithms to solve complex problems.

Understanding how to quickly and effectively implement Industry 4.0 techniques becomes increasingly important in an era when many maintenance programs are being downsized or cut because little value is seen in their role within the organization. Advances in software analytics that integrate the expert knowledge of the onsite equipment expert and lubricant analyst are now available to help maintenance professionals justify oil analysis programs within their facilities and maximize equipment life.

The programme is divided into three phases:

1. The first phase assesses the state of lubrication and the economic impact of lubrication on the industrial plant.
2. The second phase is geared towards the design of lubrication engineering in all the areas in which there is a need and opportunity to improve. Here the necessary resources to achieve good practices and excellence in lubrication are detailed.
3. And finally, the third phase covers the implementation of all the recommendations of the previous phase, the integration of all the information generated through the management system of the industrial plant in question, and the training of operations and maintenance personnel.

**123. Q: How can Oil Root Cause Analysis (Oil-RCA) help?**

**A:** Oil-RCAis a method to obtain a diagnosis and determine the origin, through oil analysis, of the problem affecting the equipment.

This method brings together the traditional RCA (Root Cause Analysis) methodology with the analysis of the lubricated system to identify the lubrication faults through oil analysis and to provide an effective solution for the lubricating system.

This approach enables the condition and action responsible for the fault to be identified. That way, corrective solutions designed to mitigate or eliminate the problems which have been spotted can be proposed. This will result in the increase in availability, reliability, extension of the active life of the asset and safety of the environment.

**124. Q: How can online oil monitoring help?**

**A:** The basic idea of some failure-detection lubrication oil condition-monitoring methods is the early identification of chemical aging of the lubrication oil and its additives under the influence of high- dynamic loadings in the wetted components such as bearings or gears.

Online methods can offer extremely important benefits. The online diagnostics system measures components of the specific complex impedance of lubrication oil. For instance, broken oil molecules, forming acids or oil soaps, result in an increase of the electrical conductivity, which directly correlates with the degree of contamination of the lubrication oil. For lubrication oils with additives, the stage of degradation of additives can also be derived from changes in online measurements such as the dielectric constant. The determination of the reduction in the lubrication oil quality by contaminations and the quasi-continuous evaluation of wear and chemical aging can be combined by the holistic approach of a real-time online monitoring.

Another concept is the online monitoring of wear debris in lubrication oil. Online sensors can effectively control the proper operation conditions of many critical machinery parts, for instance, bearings and gears.

**125. Q: What is wear debris analysis?**

**A:** It is a technique for analyzing the debris, or particles, present in lubrication oil that could indicate wear, particularly mechanical wear. This method provides microscopic examination and analysis of debris/particles found in a lubrication oil. These particles consist of metallic and nonmetallic matters. The metallic particles usually indicate a wear condition that separates different sizes and shapes of metallic dust from components like bearings, gears, and generally any components that can be wetted by lubrication oil. Nonmetallic particles may consist of dirt, sand, or corroded metallic particle. Analytical ferrography is one of the methods used in wear debris analysis; it’s among the most powerful diagnostic tools for condition monitoring.

When implemented correctly, wear debris analysis provides very useful information on machinery under operation. It’s not still in common use for all machines because of its comparatively high price and a general misunderstanding of its value. Wear debris analysis can also help with improving lubrication oil filtration efficiency and frequency for the lubrication oil cleaning and changeover. Machinery performance may be improved through proper filtration of oil. Clean oil lubrication is always more effective.

**126. Q: What is oil condition–based maintenance?**

**A:** A well-balanced oil analysis program can monitor machine wear condition, oil contamination and oil degradation at the same time. Key parameters are continuously tested and trending of those parameters is monitored. If a change of rate is accelerated or if a parameter exceeds an alarm limit, reliability engineers are alerted and maintenance actions may be required to resolve the potential problems.

**127. Q: What are the lubrication program development phases?**

**A:** The program is divided into three phases:

1. The first phase assesses the state of lubrication and the economic impact of lubrication on the industrial plant.
2. The second phase is geared towards the design of lubrication engineering in all the areas in which there is a need and opportunity to improve. Here the necessary resources to achieve good practices and excellence in lubrication are detailed.
3. The third phase covers the implementation of all the recommendations of the previous phase, the integration of all the information generated through the management system of the industrial plant in question, and the training of operations and maintenance personnel.

# 128. Q: Why is the Industrial Internet of Things (IIoT) important to the lubrication system?

**A:** Essentially, Industry 4.0 generates, analyzes, and manages data in real-time for operational planning, efficiency, and quality management. All the big data is optimized in an integrated network to provide valuable insights that improves productivity and equipment maintenance.

With their customers shifting towards the Industry 4.0 model, industrial lubricant and greases makers have realized they must help their customers improve processes and increase efficiencies too. This includes digitizing oil analysis data to simplify and improve a process that has traditionally been reliant on paper records. Digitizing this process and implementing IIoT therefore play important roles in streamlining this entire process.