

Methodology for the Diagnosis of Lubrication and Lubricants Management in an Enterprise

Metodología para el diagnóstico de la gestión de lubricación y lubricantes en una empresa

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ABSTRACT: The objective of this research was to carry out a diagnosis of the management of lubrication and lubricants in a company in Havana, Cuba. It was based on the tool proposed and validated by the Center for Maintenance Engineering Studies CEIM to evaluate the status of said management. For this purpose, techniques specific to the field of research were used, such as: bibliographic search, document review, group of experts, etc. The tool allowed to identify the deficiencies in the management of lubrication and lubricants, providing a number of strategies that contribute to increasing the reliability and availability of tangible fixed assets, as well as reducing the consumption of electric energy, lubricants and spare parts.

Keywords: Bibliographic Search, Maintenance, Document Review, Group of Experts.

RESUMEN: La presente investigación tuvo como objetivo realizar un diagnóstico de la gestión de la lubricación y lubricantes en una empresa de La Habana, Cuba. Se basó en la herramienta propuesta y validada del Centro de Estudios de Ingeniería de Mantenimiento CEIM para evaluar el estado de dicha gestión. Para ello se emplearon técnicas propias del campo de la investigación como son: la búsqueda bibliográfica, revisión de documentos, grupo de expertos, etc. La herramienta permitió identificar las deficiencias en la gestión de la lubricación y los lubricantes, arrojando un número de estrategias que contribuyan al aumento de la confiabilidad y disponibilidad de los activos fijos tangibles, así como la disminución del consumo de energía eléctrica, lubricantes y piezas de repuesto.

Palabras clave: búsqueda bibliográfica, mantenimiento, revisión de documentos, grupo de expertos.

INTRODUCTION

The adequate management of maintenance process ensure to fulfill the social object of enterprises; it constitute a fundamental factors to guarantee that the repairing cost could be reduce with no affect product quality nor equipment's availability.

Maintenance lubrication management allow guaranty reduction on friction and surface wear, lubrication failures, diminish energy consumption and no affect workers security. Actually is complete secure the Jost Institute study done, that estimated that losses due to no efficient lubrication management constitute 1, 60 % of world internal gross product (Deus *et al.*, 2022; García *et al.*, 2023).

The cost of lubrication is 3% the one of maintenance activity and the 80% of that are due to inefficient lubrication. This is most important on pharmaceutical enterprises which products are higher and complex, sometimes export products.

Nowadays science, technology and innovation are very important for the Social Economy Development (PCC, 2016). Also it is very important to consider maintenance active as an inversion and not as expenses

(Mora, 2006). CEIM research the good practices on lubrication on different development countries in different enterprises and on different national enterprises (Díaz, 2011; Rodríguez, 2017). That's why BIOCUBAFARMA enterprises was interested to adopt convenient strategies to guaranty its organizational exit.

DEVELOPMENT

Theoretical fundament

Methodology

Lubricants

Lubricants are substances that diminish friction on machine parts or on relative machinery movement. Lubricant is a third body on wear; not also reduce friction a wear but also facilitate heat transference that is generated on friction and allow wear particles movement that are generated. It is necessary that the third body had a low tangential stress movement opposition between parts on wear. Lubricants can be gaseous, liquid or solids (Marais *et al.*, 2013; Rodríguez, 2021)

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Additives are organic and inorganic components dissolve on base lubricants which function is to give new properties to basic lubricant, increase those properties or avoid not desirable's properties. Lubricants are chosen in accordance to desirable missions, in accordance to surface type, charge, temperature, lubrication system and substances in contact with the lubricant.

Lubrication

Lubrication is an essential aspect on maintenance to allow efficient functioning. It is very important to reduce costs, to increase useful life and an efficient production (Balliache, 2015; Martínez, 2017; Hernández, 2020).

When there are failures on lubrication, metals and other materials could be destroying, causing no repairable damages and materials, heat (Salazar *et al.*, 2015). Efficient lubrication is the one that where it is applied an adequate lubricant, when are done or necessities actions (require quantities of lubricant, adequate and prepare workers) (Chávez, 2014).

Lubricant and lubrication management

Management of lubrication activities is a complex process. Very important are the use of modern technologies on lubricants selection, application and analysis (Ramírez, 2012). All these is the guaranty of equipment availability.

Sometimes it happens that are not obtain good results on lubricants weariness and that Is not due that was bought a bad quality lubricant, but because was not done a good application and the conditions of technological equipment. (Gamez, 2015).

Development studies realized by different companies of the world that had been evaluated by STLE (Engineers and Tribology's on Lubrication) established that more than 50% of wear of rollers are caused by inefficient lubrication and 80% of wear is caused by contamination of lubricants and that 30% of lubricants are replaced when is possible to continue their work (Torriente, 2016).

Characteristics of lubricants and lubrication on pharmaceuticals enterprises

On pharmaceutical enterprises lubrication have a specific characteristic because systems could not contaminate the used prime materials on medicaments production and because failures on actives due to failures on lubrication affect quality of final product and production plan. Different machinery employ in pharmaceutical require periodical lubrication such as colloidal mill, pressed for tablets and the mixer-granulator. On sterile ambient, lubricants could be source of microbial contamination and is a risk for quality and efficiency.

Taking that on account it is only allow the use of lubricants capable for the contact with foods and has to be certified by ISO 21469. Fabricants had to be registered by National Sanitation Foundation (NSF) H1. This category

is one of the three existed in lubricants, besides are used lubricants classified H2 to work on parts no exposed to product. ISO 21469 require that lubricants producers developed hygiene strategy for chemist, physical and biologic risk in context of the use of lubricants.

Employed weapons on research

Management maintenance process has important and powerful weapons for research that help to decide actions to take in the presence of different situations that help to maintenance personal.

Selection of the group of experts

Most analysis and comparison tools require the criteria of "experts" to be fully developed. Given the use of these tools in research, it is necessary to select a group of experts to argue them.

This method allows consulting a set of experts to validate the proposal based on their knowledge, research, experience, bibliographic studies, etc. (Hurtado, 2012; Cabrero, 2014)

The level of competence of the experts is evaluated by the competence coefficient (K), which is calculated according to established rules; which were fulfilled in the present research. (Martínez, 2017).

Tools for the evaluation of lubrication and lubricant management

The tool to diagnose lubrication and lubricant management used in the research was the one designed and validated by professors from the Center for Maintenance Engineering Studies (CEIM). It is a tool that, unlike other similar ones, allows a natural work team of the organization to self-assess the management of lubrication and lubricants with a concurrent approach using inspection and diagnostic technologies in an integrated manner, which contributes to continuous improvement. It is a tool that allows all aspects of lubrication management, lubricants and human resources associated with it to be addressed in an organized and thorough manner. The tool makes it possible to locate the sectors with the greatest potential for change, which makes it easier to carry out a comparative analysis after its successive application, which shows the trends of change and constitutes the basis for continuous improvement.

Characterization of the current maintenance situation

The maintenance activity is carried out by the Maintenance Group subordinate to the non-functional Engineering Department, the latter answering directly to the General Manager.

The maintenance carried out is planned preventive (MPP) and, to a greater extent, reactive, with the former not reaching the desired effectiveness, resulting in the need for large inventories of resources in the warehouses to be able to carry out the interventions. Although the maintenance staff has some diagnostic equipment, it is not used, so condition-based maintenance is non-existent.

The maintenance process is not certified and is considered support within the Integrated Quality Management System.

The production plants have a maintenance specialist who focuses on the activity with the support of a mechanic and an electrician. The lubrication activity is carried out in a shared manner, the part of the equipment that has direct contact with the product is lubricated by the operator and the part considered dirty or that has no contact with the raw material and the packaging material is carried out by the mechanic.

The lubricant used is purchased partly from the equipment manufacturer and the other part from Cuba Lub, with the Marketing Department taking charge of the logistics.

The maintenance activity does not have the staff covered nor the human capital fully trained to satisfactorily carry out the tasks inherent to the process.

98% of the electrical and electronic components and 90% of the spare parts used are imported due to the impossibility of manufacturing or purchasing them in our country due to the characteristics of the equipment, a situation that causes delays in maintenance plans and is one of the causes of unforeseen breakdowns and failures.

Outsourcing, in the case of maintenance, has a great impact since, for the most part, it is carried out by foreign companies

Their control systems are considered complex, so they must have high availability since any failure or breakage implies a loss of raw material and packaging material, as well as the consequent environmental and human risks.

Due to technological costs, the basic equipment is unique (Preparation, Encapsulation, Filling, Microdosing and Cross-Body) and when it fails, it stops the entire technological flow; therefore, it requires high operational safety since it is the one that fundamentally causes contamination and affects workers, which is why they are exposed to rigorous controls.

Tool for assessing lubrication and lubricant management

The tool for diagnosing lubrication and lubricant management used in the research was designed and validated by professors at the Center for Maintenance Engineering Studies (CEIM).

Definition of the components and sub components of the weapon

The weapon possesses three components. They are shown on Fig. 1; they will be later defined.

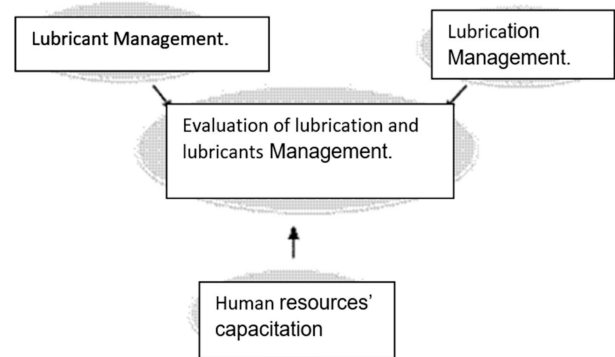


FIGURE 1. Components of the weapon for evaluate lubrication and lubricants management (Perdomo *et al.*, 2019).

The weapon for evaluation of lubrication and lubricant management have the shown general characteristics (García *et al.*, 2019).

General Characteristics

- State of lubrication and lubricant management (Five level values 1, 2, 3, 4, 5)

Components 3

- Lubricant management
- Lubrication management
- Human resources management and capacitation

Sub components 60

These subcomponents were defined and approved by experts. On table 1 are shown dimensions of lubrication and lubricant management.

Explanation of each element

- I. **Lubricant management:** Process of planning, control, execution and implementation of continue improve on selection, purchase, storage, manipulation and distribution of lubricants.

TABLE 1. Dimensions of lubrication, lubricant and human resources' management

State of lubrication and lubricant management		
Lubricant management	Lubrication management	Human resources management
Purchase (2)	Lubrication study (6)	Capacitation (3).
Reception (4)	Methods or systematization of lubricants. (4).	Security and health (2).
Quality control (4)	Optimization (3)	
Storage (11)	Filtration and leakage control (4)	
Use and management of use lubricants (2)	Cleanness (2)	
	Inspection and diagnostic technologies (6).	
	Oil analysis (5)	
	Reengineering (4)	

II. **Lubrication management:** Process of planning, execution, control and improve of lubrication; considering systems of quality, security, behavior and energy efficiency on context.

III. **Human resources management:** Management of human resources referred of lubrication activity, motivation, recognition, capacitation, certification and security.

Lubricant management. Subcomponents:

- Lubricants purchase: Guarantee that lubricants purchase cover demand, considering production value, lubrication study and minimum needs. (Milton, 2012; Gamez, 2015).
- Lubricants reception: Adequate reception of lubricants with no harm on them. Avoid humidity or damage on transportation (ICONTEC., 2000; Milton, 2012; Gamez, 2015).

Lubricant quality control:

- Verify that the invoice and the received product match and comply with the quality specifications agreed with the supplier or are accompanied by a batch quality control certificate.
- The lubricant received must be checked to ensure that it complies with the quality specifications agreed with the supplier (ACP, 2006).
- Ensure that the tanks or drums and other lubricant containers are properly organized within the warehouse with the required protection conditions, with their respective outlet valves or keys and have moisture and particle filters installed (Piloto, 2022).
- Check that the used oil reaches its final destination; that the used lubricant tank is painted, identified and clean on the outside, separated and labeled so that it is not confused with the others.

Lubrication management

Guarantee that all maintenance areas have lubrication study in all equipment's.

- Guarantee that methods and lubrication systems tend to increase its application (Díaz, 2011).
- Organize lubricants in a form that permit t
- o selects the correct one and it is the more adequate for it purpose.
- Reduce to minimum leakage that reduce loses on lubricants and the probability of failures.
- Obtain an integral inspection and technology system, controlling measure of temperature, noises, lubricant analysis and energy consumption.
- Increase the technology and equipment's for lubricant control and improve lubrication program.
- Create conditions to increase equipment's for lubrication operation.

Human resources management

Capacitation. Determine needs of capacitation and elaborate a capacitation program and certification of personal.

Security. Control security and health norms and identify risks to increase security and health of workers.

It is approved by expert's criteria for validation of lubricant and lubrication management that is shown on Table 2.

TABLE 2. Criteria for validation of lubricants and lubrication management

Criteria	Evaluation rank
5	Excellent
4 to 4,9	Very good
3 to 3,9	Good
2 to 2,9	Regular
1 to 1,9	Bad

Applied of the weapon. Obtained results. Analysis and discussion

Application of diagnostic weapon

To obtain diagnostic of all the management was solve a discussion with experts and approve. Results are shown on Table 3.

Where was applied the designed weapon were contained a media punctuation of 2, 1 that was equivalent of 42% of the total; resulting a qualification of regular for lubrication and lubricant management.

On Fig. 2 is shown the polar graphic of this result.

With previous results were done analysis of each component. On lubricant management in Fig. 3 are shown values for each subcomponent.

Considering results on radar graphic was conclude that evaluation of lubrication management component was 2, 6 points, equivalent to 52% of total value. Were evident more problems on subcomponents: lubricant purchase 1 point; quality lubricant control 2 points and use and management of lubricant 1 point; quality control of lubricant 2 points and use and management of lubricant one point.

Component and sub components of lubrication management are shown on Fig. 4.

With showed results was conclude that this component has the more influence on general evaluation, obtaining only 1,8 points equivalent to the 38% of total evaluation, Bad.

Subcomponents with worse results are: lubrication study 1, 3 points; inspection and technologic diagnostic 1, 6 points, lubricant analysis 1, 0 point and reengineering 1, 0 point.

Results of component and subcomponents human resources management are shown on Fig 5.

TABLE 3. Results of diagnostic weapon

Componentes	Evaluación				
	5	4	3	2	1
1. Lubrication management					
Lubrication buying					
1. ¿It is known that lubrication storage guaranty demand?					1
2. ¿ Person in charge with planning of lubrication volumen to buy take into account lubrication volumen, lubrication study and minimum of demand?					1
Lubrication reception					
3. ¿There are adequate dispositives to receive lubricants?			3		
4. ¿It is verified that tanks and drums are not damage (oxide, and others) when they are received?		4			
5. ¿It is controlled that tanks and others containers dont suffer damage when they are unloading?		4			
Lubricant quality control					
6. ¿It is verified that facture and received product are coincident?	5				
7. ¿It is verified that purchase and received lubricant has the specific quality?					1
8. ¿Purchase lubricant is received with the quality control certification?					1
9. ¿Exist a consecutive with certificates of received products?					1
Storage					
10. ¿Tanks and drums with lubricants are well organized on storage?		4			
11. ¿Tanks and drums in use are well mounted with respectives valves or keys?				2	
12. ¿Lubricants are well protected at contamination (rain, heat, dirt)?		4			
13. ¿Are verified the existence of all the recommended lubricants and greases by lubrication study?					1
14. ¿It is verified that all inventory cards are actualized?	5				
15. ¿Exist a system to identify all the lubricants by type and mark?					1
16. ¿It is control the outside cleanness of all lubricants containers?	5				
17. ¿It is control the existence of dispositives for the control of leakage?					1
18. ¿Exist dispositive to control fire on the place of store lubricants?	5				
19. ¿Pavements are clean and secure?	5				
Use and management of used lubricants					
20. ¿It is verify that used lubricants is transport to final place (lubricants processers)?					
21. ¿It is controlled that deposit of used lubricants is painted, identified and clean outside?					
2. Lubrication management					
Lubrication study					
22. ¿Does exist lubrication study realized by a capacity person?					
23. ¿Lubrication study is actualized for equipment's?					
24. ¿Lubrication study is actualized by study results to improve their content systematically?					
25. ¿Lubricant study is actualized for the use of better lubricants?					
26. ¿Lubrication study is use don lubrication work?					
27. ¿Exist lubrication plans that allow better control on lubrication work?			3		
Methods or systems for lubricants application.					
28. ¿It is controlled that bombs, etc. are adequate and protected against dirt and humidity?		4			
29. ¿It is controlled that each lubricant or grease have a lubrication employment?					
30. ¿Lubrication dispositive are well identified for type and lubricant mark?					
31. ¿Are used appropriate lubrication systems for each application?		4			
Optimization of lubricants.					
32. ¿It is selected lubricant for each application on base of requirements of the seller (viscosity, quantity, etc.) and operating conditions?.			3		
32. ¿It is selected lubricant for each application on base of requirements of the seller (viscosity, quantity, etc.) and operating conditions?.			3		
33. ¿It is used the more efficient lubricant for energy saving and it consume?.					1
34. ¿It is controlled for each application adequate lubricant quantity and for required conditions?			3		
Filtration a linkage control.					
35. ¿Used filters are of certificated quality?		4			
36. ¿Filters have with efficiency (beta) recommended for producer of the equipment?		4			
37. ¿Are dehumidifiers filters and for particles retained on reducers and other required equipment's?				2	
38. ¿Are losses of lubricant on dispositive (codes, retainers, etc.)?		4			

Componentes					
Evaluación	5	4	3	2	1
Cleanness					
39. ¿There are knowing cleanness norms ISO 4406?					1
40. ¿Are applied and execute cleanness norms?					1
Inspection a technological diagnostic (integral)?					
41. ¿It is used technology for temperature measure?					1
42. ¿It is used technology for noise measure?					1
43. ¿It is have technology for diagnose lubricant analysis?					1
44. ¿It is a periodical control of lubricant and energy consume?	5				
45. It is used technology for vibration analysis?					1
46. ¿There are integrations of diagnostic techniques in actives on lubrication management?					1
Lubricant analysis					
47. It is known specimen procedure?					1
48. ¿There is a program of lubricant analysis for more critical equipment's?					1
49. ¿Exist installed on equipment's an adequate quantity for specimen points?					1
50. ¿Are used the results of lubricants analysis to improve lubrication program?					1
51. ¿Are known condemnatory parameters for each lubricant summited to analysis?					1
Reengineering					
52. ¿Where there are difficult Access on lubrication points are done modifications for making accessible?					1
53. ¿Are done modifications on equipment's on the base of results obtained by lubricant analysis or other diagnostic technics?					1
54. ¿Are done actions on equipment's to install dispositive to improve or maintained lubricant health?					1
55. ¿Are realized studies to implement a more confident lubrication system?					1
3. Human resources					
Capacitation					
56. ¿Are realized diagnostic for capacitation needs?					1
57. ¿Are realized designs for capacitation plans?					1
58. ¿Are certified the knowledge for capacitation personal?					1
Security					
59. ¿Are identified risks for security and workers health?	5				
60. ¿Are execute security and health norms?	5				

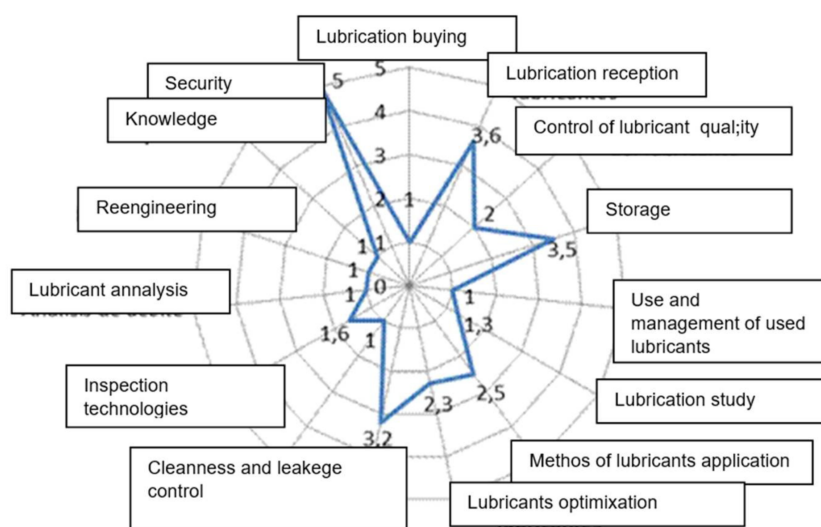


FIGURE 2. Behavior of lubrication and lubricant management (Polar graphic).

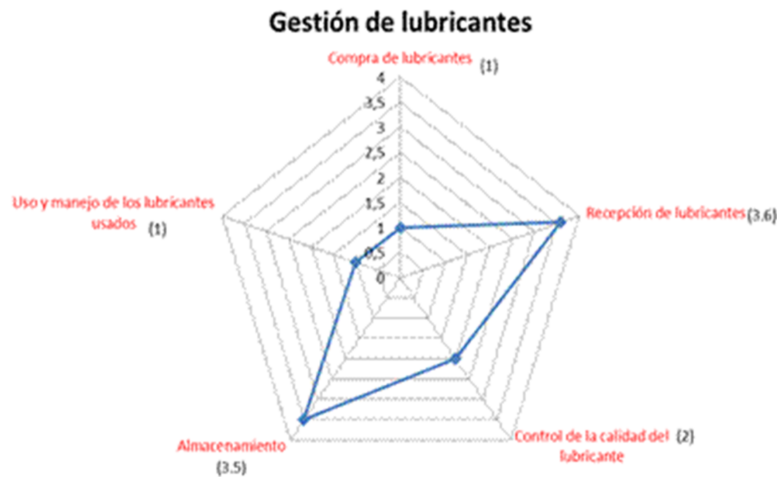


FIGURE 3. Radar graphic of subcomponents of lubricant management.

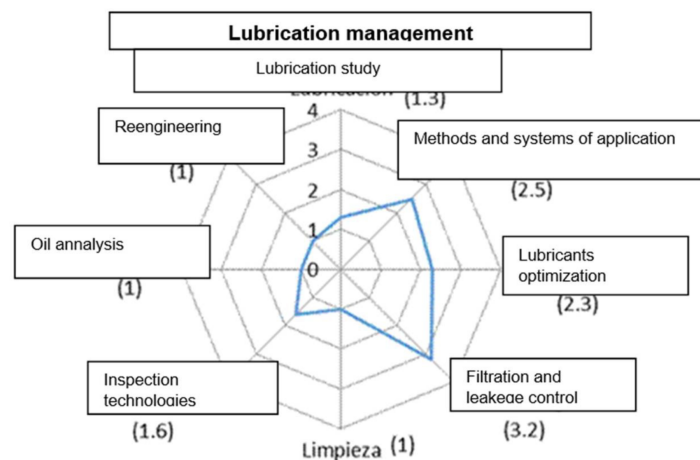


FIGURE 4. Radar graphic of subcomponents of lubrication management.

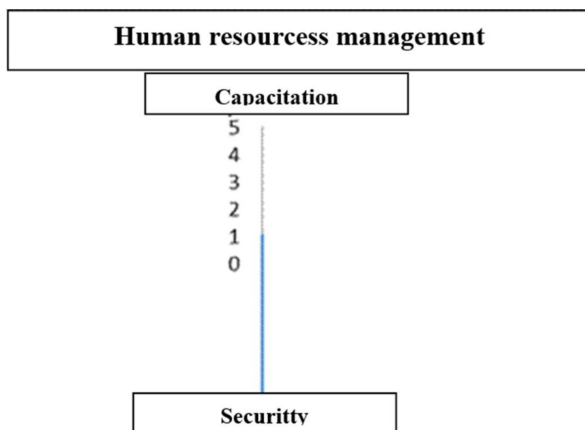


FIGURE 5. Subcomponents of human resources management.

General evaluation for component human resources management was regular 2, 6 points; equivalent to 52%. Was evident that mayor problems were on capacitation with 1 point, bad.

Improved proposals:

- I. Capacitate all the personal that work on lubrication activity (specialist, mechanics and technics).

- II. Certificate periodically the personal that work on lubrication activity.
- III. Employed on integrated form diagnostic technics to improve lubrication management and to identify on time causes of the root cause that can generate problems.
- IV. Implement and realize procedures for a trusty lubrication system.
- V. Contract specialist or specialized center to realize a lubrication study to 100% of equipment's.
- VI. Implement and realize procedures for a specimen procedure to equipment's.
- VII. Realize modifications to equipment's that present difficult lubrication access for the guaranty of a correct lubrication.

CONCLUSIONS

- As a result of research work was applied a structure weapon of 3 groups or components and subcomponents to diagnose a better form for lubrication and lubricant management.

- Were recommended 7 proposals to improve to improve lubricants and lubrication management.

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