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The assessment of preventive maintenance activities in relationship with the electrical equipments of Northwestern Anatolian electricity power network

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ABSTRACT

Northwestern Anatolian Electricity Power Network (NAEPN) preventive maintenance activities are achieved annually in time. These activities are intended to increase the reliability of the equipments and power network. These activities which related to the circuit breakers, protection relays and measurement transformers are done in all substations and transmission lines in NAEPN. In this study, initially the reported data of fault occurrences in the electrical equipments of the NAEPN are analyzed and then by drawing the diagrams of association between the equipments failure and the time interval from the previous preventive maintenance, the performance of the preventive maintenance group is analyzed. The results of assessments include crucial information that indicates the significance of this research.

Keywords: preventive maintenance, protection relay, measurement transformer, circuit breaker, NAEPN

Kuzeybatı Anadolu elektrik güç şebekesinin elektrik teçhizatları ile ilişkisindeki önleyici bakım faaliyetlerinin değerlendirilmesi

ÖZ

Kuzeybatı Anadolu Elektrik Güç Şebekesi (KAEGŞ) önleyici bakım faaliyetleri yıllık bir şekilde zamanında gerçekleştirilir. Bu faaliyetler teçhizatlar ve güç şebekesinin güvenilirliğini arttırmaya eğilimlidirler. Kesiciler, koruma röleleri ve ölçü transformatörleri ile ilgili bu faaliyetler KAEGŞ'deki tüm trafo merkezleri ve iletim hatlarında yapılır. Bu çalışmada, ilk olarak KAEGŞ'nin elektrik teçhizatlarında arıza olaylarının raporlanmış verileri analiz edildi ve sonrasında teçhizatların yetersizliği ve ilk önleyici bakım zamanı arasındaki ilişkinin diyagramları çizilerek önleyici bakım grubunun performansı analiz edildi. Değerlendirmelerin sonuçları bu araştırmanın önemini gösteren hayati bilgiler içerir.

Anahtar Kelimeler: önleyici bakım, koruma rölesi, ölçü transformatörü, kesici, KAEGŞ

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1. INTRODUCTION

From 1930 until now, the changes in the maintenance activities of the system can be expressed as follows. In the years before World War II, the industries were not in today's modern mechanical form, and consequently the sudden machine failures and stoppages do not cause serious problems. That is to say, the failure prevention was not significant for most managers and engineers. In the meanwhile, the system maintenance was achieved after machine failure, to return it to its functional state. This kind of maintenance was called the "Breakdown Maintenance" [1].

The years after 1950 were the period of manufacturing of mechanical machines. These years can be counted as the dependency of mechanical equipments and industries to the automation. With the growth of automation, the issue of equipment disabilities and failures became another challenge and affected the quantity and quality of products. With the continuation of this problem, the managers and experts think about different alternatives and appropriate solutions to prevent from the unavoidable system failures. To overcome this trouble, preventive maintenance of systems as a suitable solution developed and implemented in the United States of America [2-3].

Preventive maintenance methods are activities which balance maintenance assessments against the impact of electrical equipments failure. With regard to [4-5], it notes that many preventive maintenance methods or activities have been improved chiefly based upon time for doing preventive maintenance, quality of maintenance, complexity and sophistication of electrical equipment and value of total assets. According to [6], the targets of preventive maintenance management activities is to increase the electrical equipment reliability, diminish production downtime, increase life expectancy of assets, develop safety and quality conditions and optimize the use of available funds, staff and facilities.

According to [7-8], it describes six types of maintenance strategies, namely: no maintenance, active maintenance, preventive maintenance, predictive maintenance, proactive maintenance and self- maintenance. With the growth of investment on machinery and industrial automation, the managers and industrial owners think about providing effective solutions to increase the equipment lifetime and system reliability [9].

These efforts lead to some new achievements such as condition based maintenance and reliability centered maintenance. NAEPN is one of the electricity regions of Turkey. NAEPN is connected to Bulgaria power network via Maritsa and Plovdiv post by 400 kV transmission lines, to Greece power network via Nea Santa post by 400 kV transmission lines [10]. Also, this power network connects to Babaeski through Unimar, and through Hamitabat to Alibeyköy by the 400 kV transmission line to global power networks of Turkey. NAEPN single line electricity diagram is given in figure 1.

In NAEPN, there are four different transmission line voltage levels; the 400 kV, 170 kV, 63 kV and 36 kV. With the comparison between them, the lengthiest transmission line is for 170 kV with a length of over 13000 km, then the transmission line of 400 kV with the length of 4000 km, and then 36 kV and 63 kV [11]. There are twelve power plants in this region that can produce 4000 MW of power in table 1.

Table 1. The type and amount of produced power by NAEPN

Power plant name	Production amount	Voltage	Type of units
Ada DGKÇS I	1432 MW	380 kV	Gas-combine cycle
Ada DGKÇS II	722 MW	380 kV	Gas-combine cycle
Çolakoğlu	474 MW	154 kV	Steam-gas
Enerjisa	52 MW	154 kV	Steam-gas
Nuh enerji	68 MW	154 kV	Steam
Entek II	107 MW	154 kV	Steam-gas
Sarıyar	160 MW	154 kV	Hydroelectric
Yeni Çates	228 MW	154 kV	Thermic
Bozöyük Akenerji	132 MW	154 kV	Gas-combine cycle
Seyitömer	370 MW	154 kV	Thermic
Tutes A	125 MW	154 kV	Thermic
Tutes B	130 MW	154 kV	Thermic

The energy consumption in the typical days of the year is about 1800 MW and 2500 MW in the days that it reaches to the peak [12]. According to the above information, the production capacity of the power plants is more than the power consumption of the region and this extra amount of production is added to the global power network.

Therefore, any failure in the NAEPN has a significant influence on the reliability of the global power network and this fact indicates the importance of the preventive maintenance in NAEPN. It should be noted that preventive maintenance in NAEPN is based on the annual schedule. That is to say, the power network equipments are checked by the preventive maintenance group at a fixed time in each year.

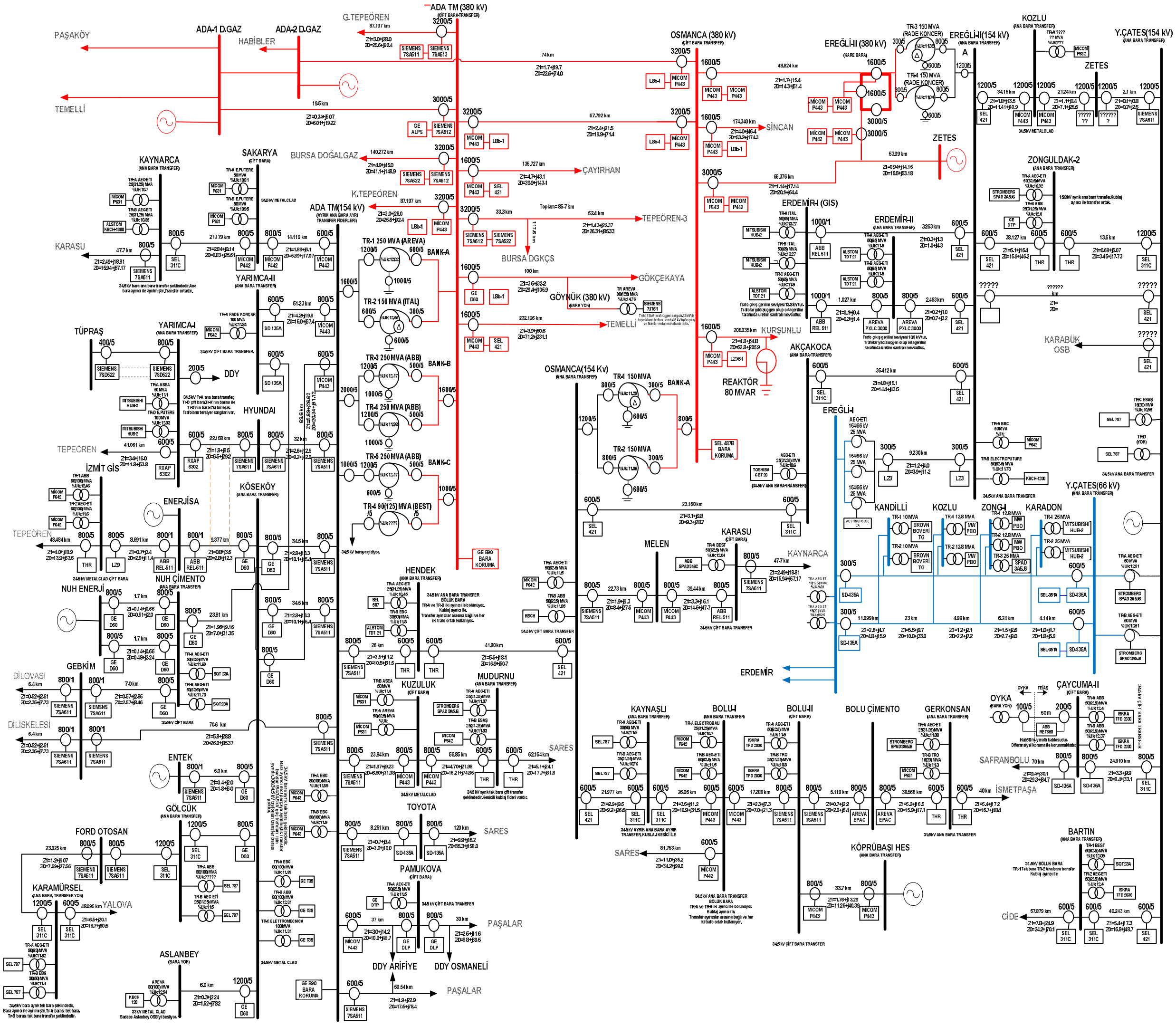

Figure 1. NAEPN single line electricity diagram

2. DATA ANALYSIS OF THE REPORTED FAILURES IN CIRCUIT BREAKERS AND RELAYS OF THE NORTHWESTERN ANATOLIAN ELECTRICITY POWER NETWORK

The reported failures are received from the database of the NAEPN [13]. This report relates to the years 2009 - 2012.

2.1. The Data Analysis of Circuit Breakers

In the first step, the power network circuit breakers are analyzed according to their producer companies. Table 2 shows the comparison between these companies according to the 2012 information. Figure 2 shows the information of table 2.

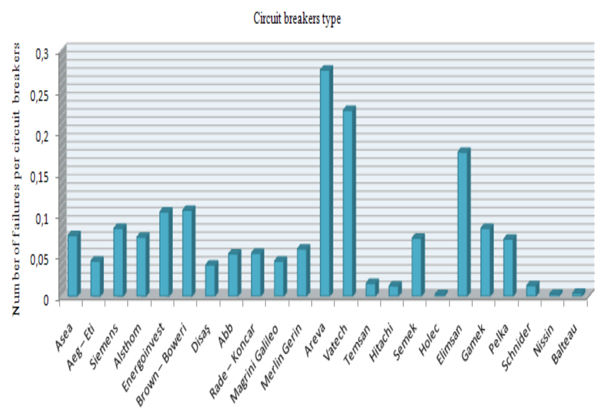

Figure 2. Performance of the circuit breakers in the NAEPN according to their producer company

Table 2. The performance of the circuit breakers in the NAEPN

The circuit breakers type	The number in the posts	The number of failures per circuit breaker
Asea	264	0.0743
Aeg – Eti	283	0.0432
Siemens	231	0.0830
Alsthom	62	0.0722
Energoinvest	29	0.1030
Brown – Boweri	16	0.1050
Disaş	137	0.0382
Abb	79	0.0520
Rade – Koncar	238	0.0529
Magrini Galileo	13	0.0430
Merlin Gerin	22	0.0580
Areva	26	0.2760
Vatech	21	0.2270
Temsan	11	0.0160
Hitachi	36	0.0010
Semek	34	0.0710
Holec	5	0.0023
Elimsan	53	0.1760
Gamek	7	0.0830
Pelka	14	0.0700
Schnider	17	0.0133
Nissin	3	0.0030
Balteau	4	0.0042

In this comparison, the statistics of the companies that the numbers of their circuit breakers are less than 100 should be neglected, because the population of their circuit breakers in the power network is few. After comparing different companies, they will be ranked as follows; Energoinvest, Aeg Eti, Magrini Galileo, Disaş, Brown Boweri, Asea, Hitachi and Rade Koncar. It should be noted, in this ranking the age of the equipments of the companies is neglected owing to the lack of existence of a scientific expression for the age effect. If this parameter is found, the Aeg Eti and Asea companies obtain better ranking than before. In conclusion, the circuit breakers of the Hitachi Company are more reliable than other circuit breakers, regarding the equipment age and the frequency of the fault occurrence.

2.2. The Relays Data Analysis

By analysis and classification of the NAEPN reports, the proper performance of the relays according to their voltage levels, in which they have been installed, are depicted in figure 3. As it can be seen in the figure 3, the performance of the relays of the transmission lines 400 kV and 170 kV is already suitable, but the relay performance in other levels of voltage is not good enough. In this diagram, the equipment age and the producer company of the equipment are not considered, but it is obvious that the preventative maintenance group should pay more attention to the relays of the transmission lines 36 kV and 63 kV.

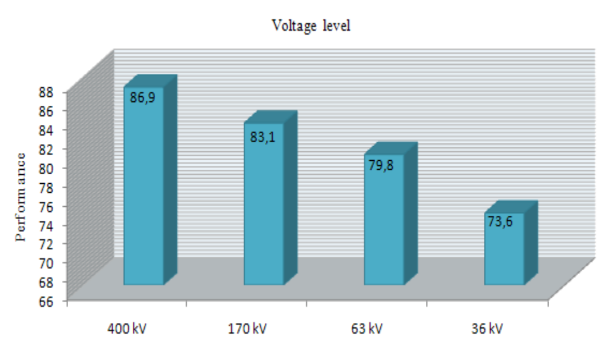

Figure 3. The correct percentage of the relay performance with respect to the voltage levels

In figure 4, it has been shown that the frequency relays have better efficiency with respect to the other kind of relays. They are used for warning if the frequency varies from 50 Hz. The over voltage, buchholz and distance relays have a satisfactory performance, but others relays do not have desirable accuracy. Differential, earth fault, and reclose relays had the worst performance in the power network. One reason for their bad performance is because of their internal defects that show the lack of attention to the preventive maintenance, although all the relays are subject to the annual maintenance program. Another reason is because of their inaccurate settings [14].

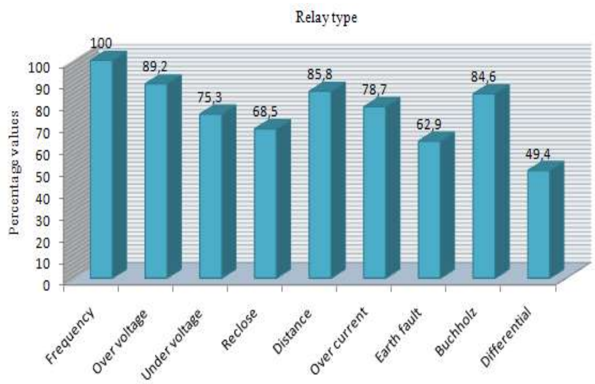

Figure 4. The correct percentage of the relay performance with respect to the relay type

The power network expansions as well as the lack of attention to the relays settings have affected the performance of the relays. This subject will be discussed more precisely later on. Figure 5 shows the main reasons for the incorrect performance of the power network relays.

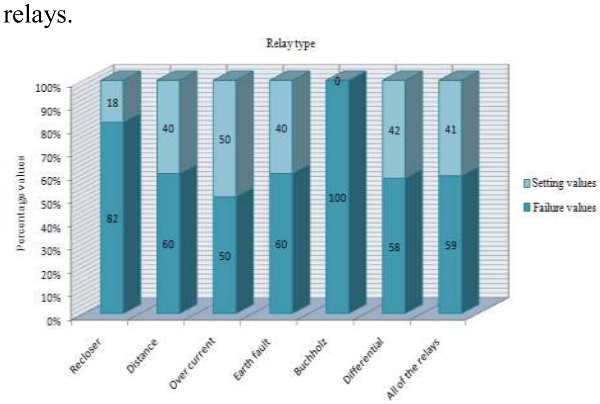

Figure 5. The incorrect percentage values all of the relays

Figure 5 includes two distinct parts; the upper part shows the incorrect performance of the relays because of their inappropriate settings, and the lower one shows the incorrect performance of the relays due to their internal defects. As it can be seen in figure 5, except buchholz relays and recloses that the performance of reliant group in order to relay settings is acceptable for them, other relays have unsuitable settings.

In figure 5, it has been shown that the over current, differential, earth fault, and distances relay have the worst performance among other relays. Their deficiencies have caused a great damage to the equipments of power network. This huge amount of money should not be paid in normal situation but due to the weakness of the system and the lack of attention to the power network expansion is wasted. It should be noted that the earth resistance should be computed precisely in the setting of earth fault relays. Unfortunately, the earth resistance of all parts of the NAEPN in the land of Marmara is considered similar and this wrong assumption has lead to the wrong performance of the relays. Figure 5 shows by the accurate adjustment of the earth resistance the huge amount of money is saved without spending any cost.

2.3. Data Analysis of Reported Faults of Measurement Transformers in NAEPN

First, the power network transformers are analyzed according to their producer companies and a comparison between different producer companies is made according to the 2012 information. The results of this comparison have been shown in table 3. Figure 6 shows the information of table 3 for more comprehensible comparison. In this comparison, the statistics of the companies that the numbers of their measurement transformers are less than 25 should be neglected, because the population of their circuit breakers in the power network is relatively few.

Table 3. The performance of the measurement transformers in the NAEPN

The measurement transformers type	The number in the posts	The number of failures per measurement transformers
Alce	96	0.1740
Abb	28	0.0430
Emek	241	0.2310
Alsthom	24	0.0580
Siemens	19	0.0160
Elimsan	6	0.1050
Trench	13	0.0390

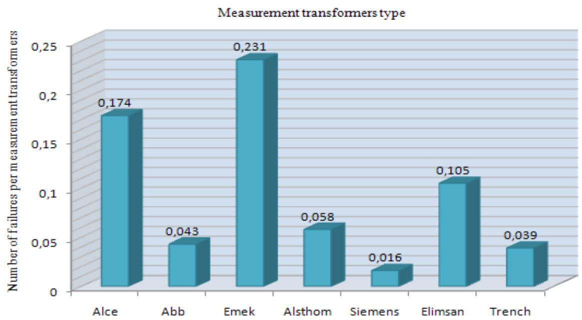

Figure 6. The performance of transformers in the NAEPN according to their producer company

After comparing different companies, they will be ranked as follows; Alce, Emek, Abb, and Trench. It should be noted, in this ranking the age of the equipments of the companies is neglected due to the lack of existence of a scientific expression for the age effect. If this parameter is found, the Trench Company obtains better ranking than before, because its equipments are older than others.

3. THE EVALUATION OF THE RELATIONSHIP BETWEEN EQUIPMENT FAILURES AND THE TIME INTERVAL FROM THE PREVIOUS PREVENTIVE MAINTENANCE

In this section, the relation between the relays failures and the time interval from the previous preventive maintenances is analyzed. Figure 7 shows relation between the relays failures and the time interval from the previous preventive maintenance. This figure is depicted on the basis of 2011 and 2012 information. Unfortunately, due to the lacks of information and knowledge about the number of power network relays, the normalization of this figure is not done. Therefore, it is not possible to compare this figure with the equipments like circuit breakers, and the importance of preventive maintenance in these equipments cannot be compared precisely.

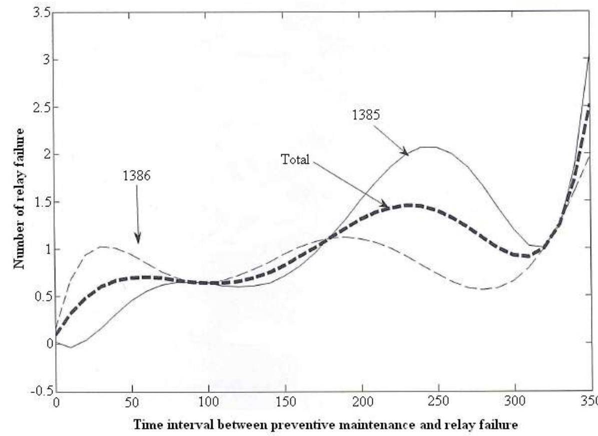

Figure 7. Relation between the numbers of relays failures and the time interval from the previous preventive maintenance

As an overall comparison, due to the greater number of relays in the power network than circuit breakers and also because the number of peak errors in the relays are fewer than circuit breakers, it can be said that the importance of preventive maintenance in the circuit breakers are more than relays. It should be noted in this figure, the failures that have been occurred in the interval of 10 day have been computed in the beginning of the interval.

Figure 7 shows that the number of the relay failures increased by increasing the days after the preventive maintenance. By accurate analysis of the graph, the importance of the preventive maintenance group will be achieved. The graph sharply increased in its early steps in 30 days after the preventive maintenance which shows the lack of attention of the preventive maintenance group in doing their duties, because only 30 days after their maintenances, the equipments are broke down or badly operated. Therefore, in order to reduce the initial peak of the graph, some solutions must be found for more accurate performance of the preventive maintenance group.

Before the second peak (around 200 days after the preventive maintenance), if the slope of the graph is suitable, the preventive maintenance group in the electric company has reached to their goal. If the slope of the graph is not suitable, in order to reduce both second (240 days after the preventive maintenance) and last peaks (350 days after the preventive maintenance) another preventive maintenance should be done 200 days after the first preventive maintenance. If this procedure is done and the initial slope of the graph is reduced, the behavior of the graph remains stable. Regarding the negative slope of the graph after the peak (the number of faults is decreased), it should be mentioned that this behavior is because the preventive maintenance has been done out of the predefined schedule after the equipment failures.

Figure 8 depicts the graphs of circuit breaker failures over days after the preventive maintenance.

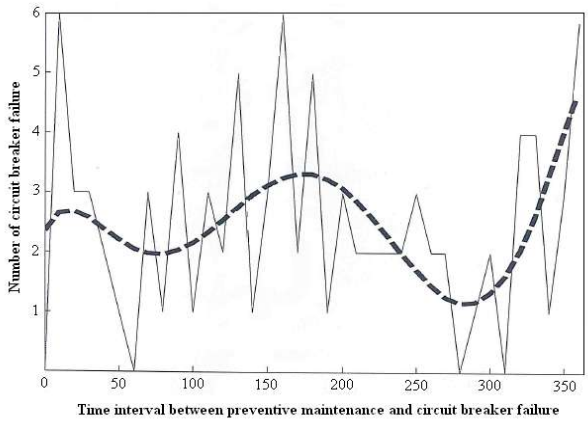

Figure 8. The number of circuit breaker failures over time after previous preventive maintenance

As it can be seen, the behavior of these graph is similar to the relay behavior; it has one initial peak 30 days after the first preventive maintenance and another peak around 180 days after that. Similar to the relay graph the slope is increased over time. If the value of the second peak between these two graphs (figure 7 and figure 8) is more than the desirable amount, it shows that the useful life of the preventive maintenance in the NAEPN is around 200 days. This low useful life is originated in the low quality of both preventive maintenance and equipments.

4. CONCLUSIONS

Preventive maintenance activities in the electrical transmission company greatly influence the way maintenance of electrical plant device and electrical transmission equipment is performed and its effects on factory performance. The study founded that robust electrical plant device and electrical transmission equipment maintenance strategies play a key role in the company performance. Preventive maintenance leadership was the most influential intervening variable to the way electrical plant device and electrical transmission equipment maintenance is managed. In this paper, based on the reports of failures and undesirable performances of the circuit breakers, relays, and measurement transformers of the NAEPN which obtained from Turkish Electricity Transmission Company, some new evaluations and suggestions have been made to improve the performance and reliability of the NAEPN. These suggestions include the precise tuning of the relays, buying high quality equipments, special attentions to the preventive maintenance in some voltage levels and in special conditions. In the final section of the paper, the time interval between the previous preventive maintenance and the first failure in the equipment is analyzed. This section proposed some new suggestions for increasing the quality of the preventive maintenance.

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