Statistical Support System For Asset Management in Power Transmission Systems

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***Abstract*—The asset management in power transmission systems are one of the great issues in the current maintenance procedures carried out by power companies. With the aging of the devices, the development of optimized tools, capable of considering failure rates and regulatory/operational parameters, is increasingly mandatory. The purpose of this work is to present a statistics-based tool for optimized asset management.**

Keywords—Asset management, statistical analysis, power systems Statistics, Power Systems.

I. Introduction

In a modern electric utility, information management, asset maintenance, and remote diagnostics should allow security and better services for the customers. Since electric utilities are industries that have a significant impact on the environment and they are also strategic, modernization is crucial and can be achieved by a properly designed management system [1].

Many strategies have been proposed in the literature to increase the efficiency for an optimized asset management process, such as those based on reliability, since a database with information on age of the equipment, history of failures and predictive maintenance procedures be available [2-4].

However, to quantify the gains obtained with these tools a lot of effort is required because the heterogeneity of technologies, facilities and devices in the power transmission systems. On the other hand, some companies still carry out risk assessment annually, with many important variables being ignored due to massive volume of information to process [5].

Thus, the data science tools emerge as promising to act in the scenarios where amount of unknown information needs to be processed and analyzed [6].

Traditionally, efforts in power system have focused on the development of algorithms, even though, currently, an infinity of information on the assets of the electric system is now available, being, therefore, a new challenge to extract the characteristics of more significant interest.

In this way, more and more crucial data should be generated in large databases and critical analysis should be made in order to learn from data, otherwise, the equipment aging will not be properly taken account [7].

Thus, this work presents a tool for the estimation of failure rates in power transmission systems, using asset historical data, recorded operation events and health information, which is named Statistical Support System for Asset Management (3S-Asset).

II. Statistical Support System

In this study, a database composed of information regarding power transmission assets of a large Brazilian utility was used as a case study. The information was extracted from databases, where the variables were conditioned and processed, making statistical analyzes possible.

The raw information contained in the original database, such as technical information, operation data and inspection parameters from routine and special tests were processed to create the 3S-Asset database, as illustrated in Fig. 1.

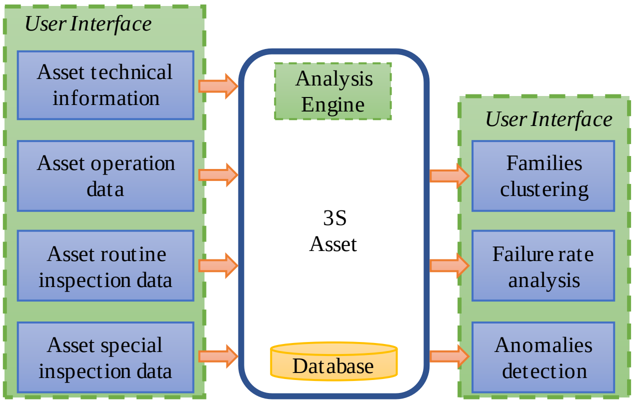

Fig. 1. 3S-Asset block diagram.

The "Analysis Engine" shown in Fig. 1 uses statistical analysis, relational graphs and probability distributions to create aging information, which are normalized and considering correction aspects based on the method proposed in [8].

Finally, the user can visualize the information clustered and normalized by equipment, as well as the failure information, such as those related to anomalies and failure rates.

The "Anomalies detection" module is based on the relationship between gases generated during the thermal decomposition process of the insulating mineral oil. This module aims to be preventive in the identification of failures, i.e., while conventional methods are oriented to identify faults already installed, the preventive analysis points out assets with a tendency to present faults in the future. In Fig. 2 is illustrated how this degradation is detected.

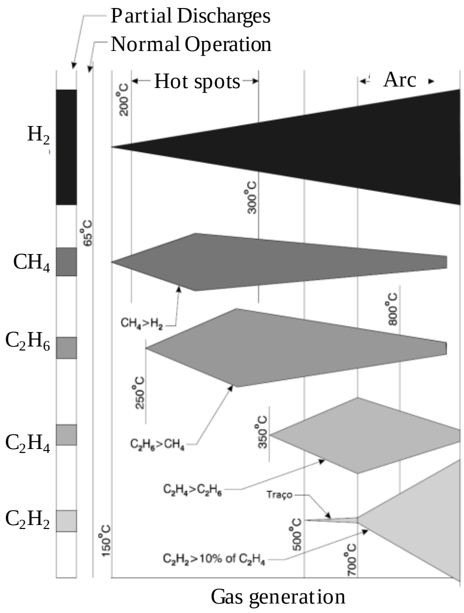

Fig. 2. Rate of gas generation as a function of temperature.

III. General Graphycal Analysys

In Fig. 3 is shown the general view of the 3S-Asset, which was developed all oriented to towards WEB presentation and based on the adoption of Self-service Business Intelligence (SBI) tools.

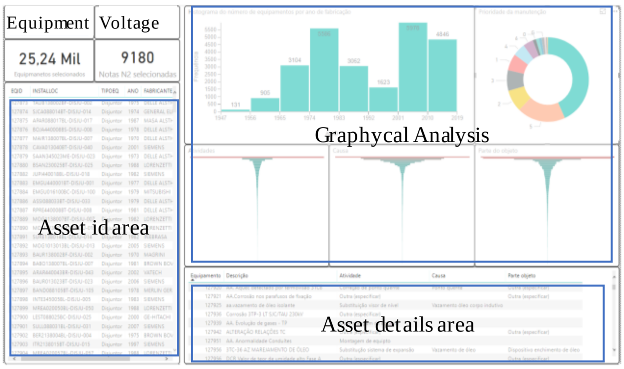

Fig. 3. Main graphycal interface.

In "Equipment" tab, the user can access functions for switches, circuit breakers, power transformers, current transformers, potential transformers and reactors. In "Voltage Classes" tab can be selected voltages, such as 138, 230, 345, 440, 500 kV, etc. This combination results in 25.24 thousand equipment's and over 9 thousand maintenance records in the 3S-Asset database. By selecting any asset, the histogram related to number of assets is presented, based on the year of manufacturing, as can be visualized from Fig. 4. For the maintenance records highlighted in Fig. 5, we present the percentage of each maintenance record priority by type, for the equipment's of the 1980s, allowing a comparison with all other equipment. In addition, Fig. 6 shows the number of maintenance records by age in relation to the selected asset.

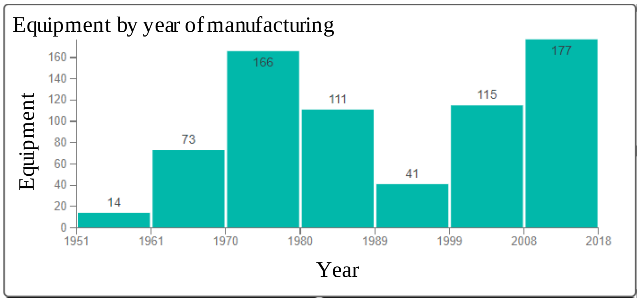

Fig. 4. Histogram of the number of power transformer with a voltage class of 138 kV or more, depending on the year of manufacture.

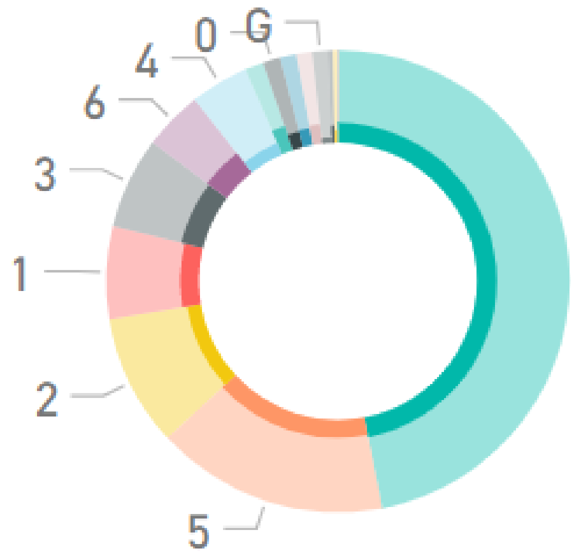

Fig. 5. Corrective maintenance priority of power transformer with a voltage class of 138 kV or greater, manufactured in the 1980s.

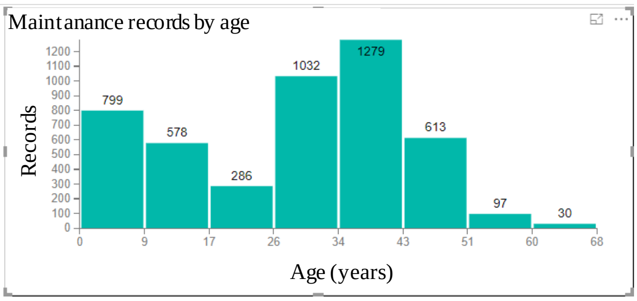

Fig. 6. Histogram of the number of equipment maintenance records for power transformer with a voltage class greater than or equal to 138 kV with respect to age.

IV. Health Analysis For Power Transformers and Reactors

The chromatographic analysis tests is one of the basic tools for health evaluation of power transformers, reactors, autotransformers and several other equipment's immersed in insulating mineral oil [9].

Considering the equipment's of voltage classes greater than or equal to 138 kV, the number of power transformers in each category of the IEEE Condition is then presented in

Fig. 7, where condition 1 is considered full operational and condition 4 is in eminent failure [10].

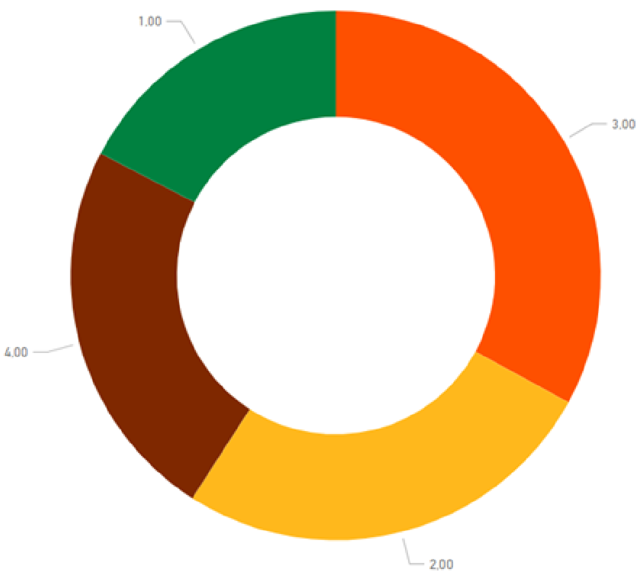

Fig. 7. IEEE condition for power transformers of voltage class greater or equal to 138 kV.

In Figs. 8, 9 and 10, the user can contemplate the historical evolution of gas concentrations in the chromatographic tests in order to identify tendencies.

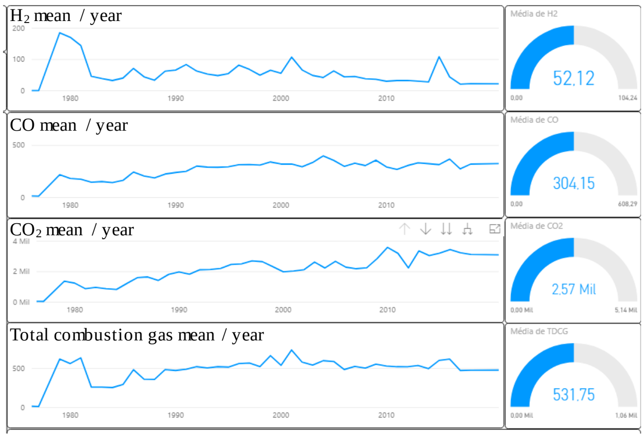

Fig. 8. H_2, CO, CO_2 and total combustion gas evolution.

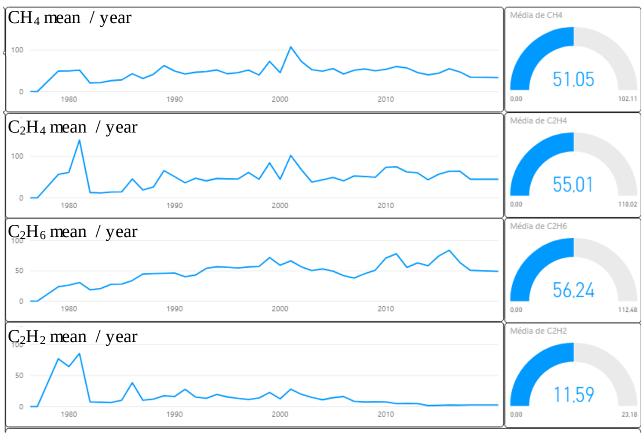

Fig. 9. CH_4, C_2H_4, C_2H_6 and C_2H_2 gas evolution.

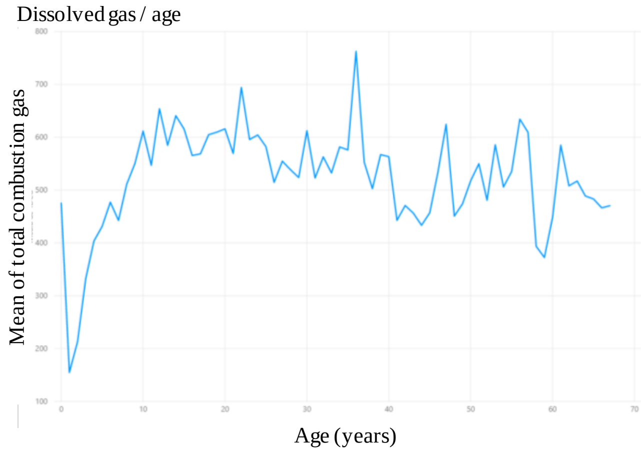

Fig. 10. Mean of total gas combustion by age of power transformer.

V. Maintanance Analysis For Power Transformers and Reactors

The information about corrective maintenance records can be also accessed by graphical analysis. In this case, the user can navigate by the reports showed in Figs. 11 and 12, which illustrate the normalized data from number of corrective maintenance records by asset age, as well as normalized records from assets by age.

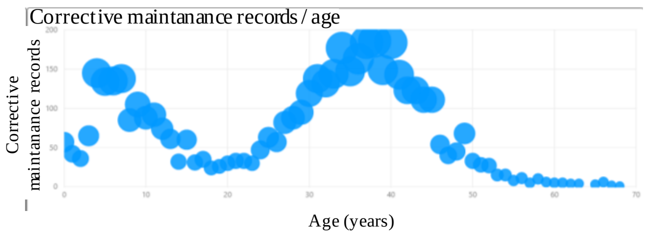

Fig. 11. Corrective maintanance records by age of asset.

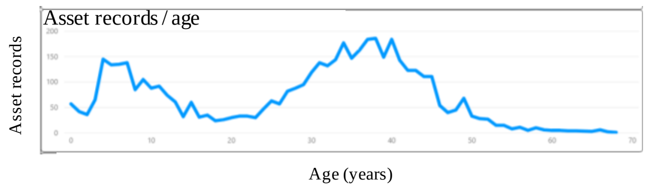

Fig. 12. Asset records by age of asset.

In Fig. 13 it is possible to follow the tendency line that maps the mean of corrective maintenance records per year, according to the age of the assets.

When a point on this tendency line is selected, the mean of corrective maintenance records/year and age are indicated, as well as updating the list of equipment under such circumstances.

Another possible tendency line analyses the rate of corrective maintenance occurrences by the age in the corrective maintenance records, as shown in Fig. 14.

The combination of the statistical analyzes of corrective maintenance records along with the health information of the assets allows to infer about the IEEE condition of the assets by means of a location map, as shown in Fig. 15.

Finally, an individual graphical analysis over the failure of each asset can be also visualized, as illustrated in Fig. 16.

In this figure, the failure rate estimation is normalized by the life cycle of all family assets, which localizes the real lifespan based on the statistical analysis realized in the raw database, as well as provides the normal failure rate by year expected by the asset.

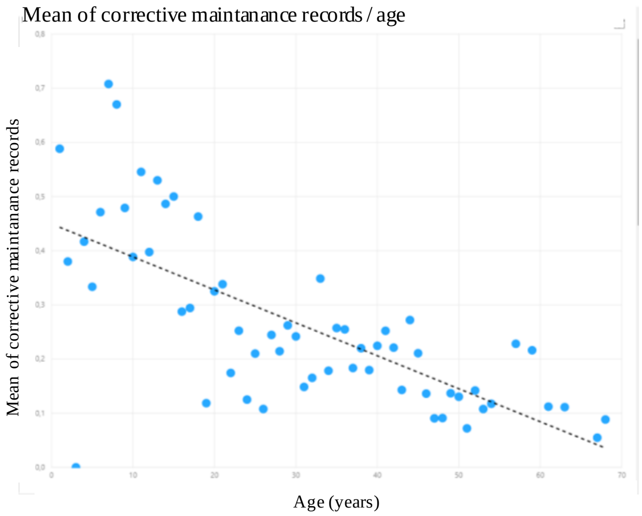

Fig. 13. Tendency line between statistical data of corrective maintanance records and asset age.

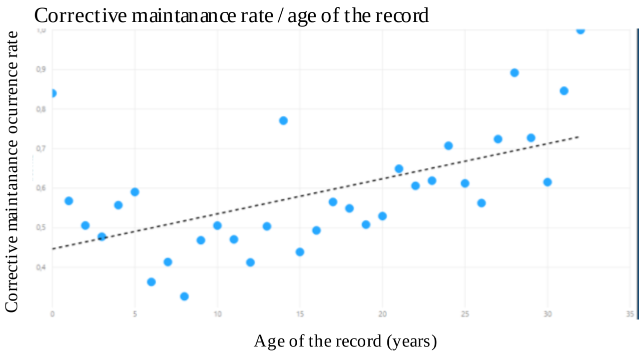

Fig. 14. Tendency line between corrective maintanance rate and age of the record.

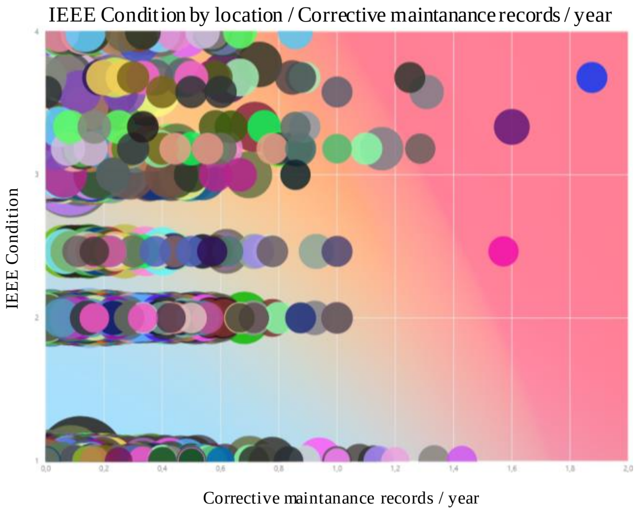

Fig. 15. Combined health and statiscal data analisys from asset.

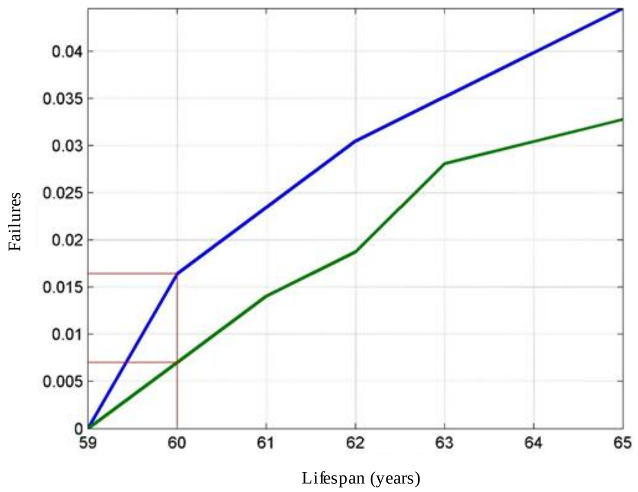

Fig. 16. Individual failure rate analysis for selected asset.

VI. Conclusions

In this work, we have presented the development of a method, based on database processing and statistical studies, which can help decision making on asset management for power transmission systems. Analyses through relational graphs and probability distributions were carried out considering the age of the assets and preventive maintenance practices. Our results are based on case studies of real databases of an electric utility. As the lifespan of equipment's become longer, it is then justifiable to develop methods to identify their health condition, considering not only historical data but also all available asset management tools, which companies currently own. The presented statistical analyses, combined with health information processed by means of graphical interfaces, can help companies to make decisions on maintenance procedures based on historical data and inspection tests.

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