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ANALYSIS OF TRANSFORMER, MOTOR AND OTHER TYPES OF OIL FLOW IN ELECTRIC POWER DISTRIBUTION SYSTEM IN DEVELOPING COUNTRIES

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Abstract: Flows of transformer, motor and other types of oil in electric power distribution system require certain analyses over the safe handling and efficient management of oil flow in the above mentioned system for not only the purpose of environmental protection but the integration with other forms of protection and the implementation of adequate protection measures. The set of system activities is to be realized in the distribution of electrical energy and other complex activities, which includes continuous education of all participants in charge of monitoring, control and management of various types and quantities of the flows of waste and new oils, creation and update of the internal documents, collection and temporary storage of waste oils within the organizational units and final disposal of waste. The study presents the analysis and treatment of transformer, motor and other oils in the MH "ERS" ZEDP "Elektro-Bijeljina" joint-stock company Bijeljina, which shows the types, quantities and flows of oil, treatment and solution methodologies, including other activities to be implemented in the electricity distribution system in developing countries.

Keywords: transformer oil, motor oil, electricity (power) distribution, analysis of material flows, waste, environmental protection, safety and health at work, fire protection

INTRODUCTION

A set of activities undertaken during the handling of new and waste oils, as well as directing and control of oil flows must be carried out in order to have the least impact and acceptable level of risk to the environment and human health, reduce the use of natural resources, minimize the waste, reduce its adverse impact on the environment and enable reuse and recycling of waste and safe waste disposal. Transformer, motor and other oils are being generated in the processes of maintenance, reconstruction, replacement of power equipment, motor vehicle maintenance and other activities, as well as other various types of waste for which the enterprises belonging to the electricity distribution system are obliged to undertake appropriate protection measures and activities in order to control and manage the aforementioned, in the manner prescribed by laws and bylaws.

MATERIAL AND METHOD

Oils used in electric power distribution system

Regular or periodic replacement or control of oil quality is conducted for the transformers (as shown in Figure 1) and other electric appliances, machines, tools and/or vehicles, which operate by using oil as a lubricant, insulation or heat transfer. The same is also conducted during the regular maintenance and planned overhaul.

Different types of oil are used in electric power distribution systems: insulating oil (transformer oil and oil switches), hydraulic oil, gear oil, motor oil [1]. These types of oil may be of mineral or synthetic

Figure 1: Transformer connected to the electrical grid in substation 35/10 kV [1]

origin. Choosing the type of oil for individual devices, tools and vehicles depends on the nature and working conditions, status and degree of wear.
Waste - used oil includes all priory mentioned mineral or synthetic oils that are either used and/or contaminated by physical or chemical impurities.

Waste insulating oil (transformer oil and oil switches)

Of all the stages in the life cycle of transformer oil, the longest is the stage of use [2]. Waste transformer oils and other wastes are being generated from the complex process of reconstruction, overhaul, maintenance, replacement of power equipment, as well as other activities of electrical distribution companies. Processed insulating oil in the switches is collected by a substation electrician who fills the Record on replacement based on which the keeper of either central or working unit's warehouse completes the form Entry of waste materials into warehouse and performs temporary storage of insulating oil and other waste [1], as shown in Figure 2.

Figure 2: Storage of oily waste [3] and containers for oil safe disposal

Waste motor, hydraulic and gear oils

Changing of motor, hydraulic and gear oil in vehicles and operating machines is done in authorized institutions or workshops within the electrical distribution company. If the oil is changed in an authorized institution, the waste oil management is the responsibility of the institution. Changing of motor, hydraulic or gear oils is based on the proceedings initiated of by a clerk in charge of car park.

Material Flow Analysis – MFA method

The MFA is a systematic approach to displaying the material flows and stocks within the spatial and temporal limits of the system. The MFA locates materials through a restricted system. Therefore, it connects the sources, pathways and interim or final disposal sites. The MFA takes into account the principle of mass balance based on the law of conservation of matter. The balancing of all the input and output components enables the forecasting of critical statuses of either discharge or accumulation [4].
Stock and flow diagrams enables insights into flows relevant to resources and environmental aspects in order to choose the most efficient strategies for reduction and prevention of oil. [5]
Application of the MFA procedure offers the possibility to develop ways to reduce the problem of independent pollution. As a result, the MFA reveals possible problems in terms of current and future legal frameworks. It enables immediate detection of problems that may arise in the future. The MFA is a method which may provide a detailed review of the material and substances in the organization's flows thus provides environmental management system.
The spatial limit (boundaries) of the system is determined by the scope of this study, which is mainly engaged in the distribution of electricity. Accordingly, the limit (boundary) is defined area of real (fixed) infrastructure, including the environment. The relevant processes taking place on site are included.
Due to the specific structure and business activities of the company itself in the electric power distribution system, as well as the business operation method, one-year time limit has been adopted for the purpose of this analysis.
When it comes to defining the process within the electric power distribution system in order to have a more comprehensive overview of the entire situation, the process has been defined at the appropriate levels. The appropriate level means defining of all distribution units - working units under the Elektro-Bijeljina company as separate processes or as independent portions of organizational complex. Spatial limits (boundaries) of these distribution units are the geographical boundaries of their organizational units.

RESULTS AND DISCUSSION

Flow analysis of insulating oil (transformer oil and oil switches), motor and other oils, including waste oils, and its management must be carried out in an appropriate manner in order not to jeopardize human health and to prevent environmental pollution. The MFA is the basis for the monitoring of material and generated waste flows.

After the completion of the oil public procurement, the selected bidders deliver oil to the central warehouse, where the oil is distributed from to the working units' storages. Oil procurement depends on the need for topping up, sampling, oil changing and other regular and extraordinary activities, thus the terms of procurement are usually not uniform. Process of generating waste oil and other hazardous waste is a particularly problematic stage because of the complex organization of analyzed system for monitoring the quantitative and qualitative variations within the general trend of the generated waste movement, as well as the establishment of efficient control mechanisms. Waste oil generation is caused by: the analysis of the transformer oil sample - if it results in an unsatisfactory quality, the replacement with new oil follows; if the oil leaks as a result of damage to the transformer, motor vehicle, operating machine or any other device in either regular or extraordinary circumstances, then the refilling of oil or replacing it with new oil follow. [1]

As a logical continuation, the temporary storage usually comes after the generation of hazardous waste, which means storing hazardous waste on its way to the waste treatment plants and final disposal. The capacities of temporary storage facilities have to meet the existing requirements, so while designing, the calculations are made for twice the amount of hazardous waste than the one which is usually generated between the two cycles of treatment, i.e. the transport. [6]

Waste oil is collected in the containers or other appropriate packaging and shipped to a warehouse of a working unit. Due to the accumulation of large quantities of hazardous waste in one place, this stage is a major challenge in terms of organization in order to prevent possible accidents. For this reason, the constant control is necessary, not only by immediate responsible participants, but also by regulatory authorities.

In case of changing oil during the transformer overhauling in authorized institutions, the waste oil management is the responsibility of the institution. If the institution does not operate in accordance with standard ISO 14001, it is the obligation of power distribution company to manage the waste oil [1], [7].

Results of the waste oil analysis in the "Elektro-Bijeljina" joint-stock company Bijeljina show that the share of the amount generated in the waste oil flow per working unit is: 43% in Vlasenica, 33% in Bratunac, 20% in Bijeljina and 4% in Zvornik, as shown in Figure 3.

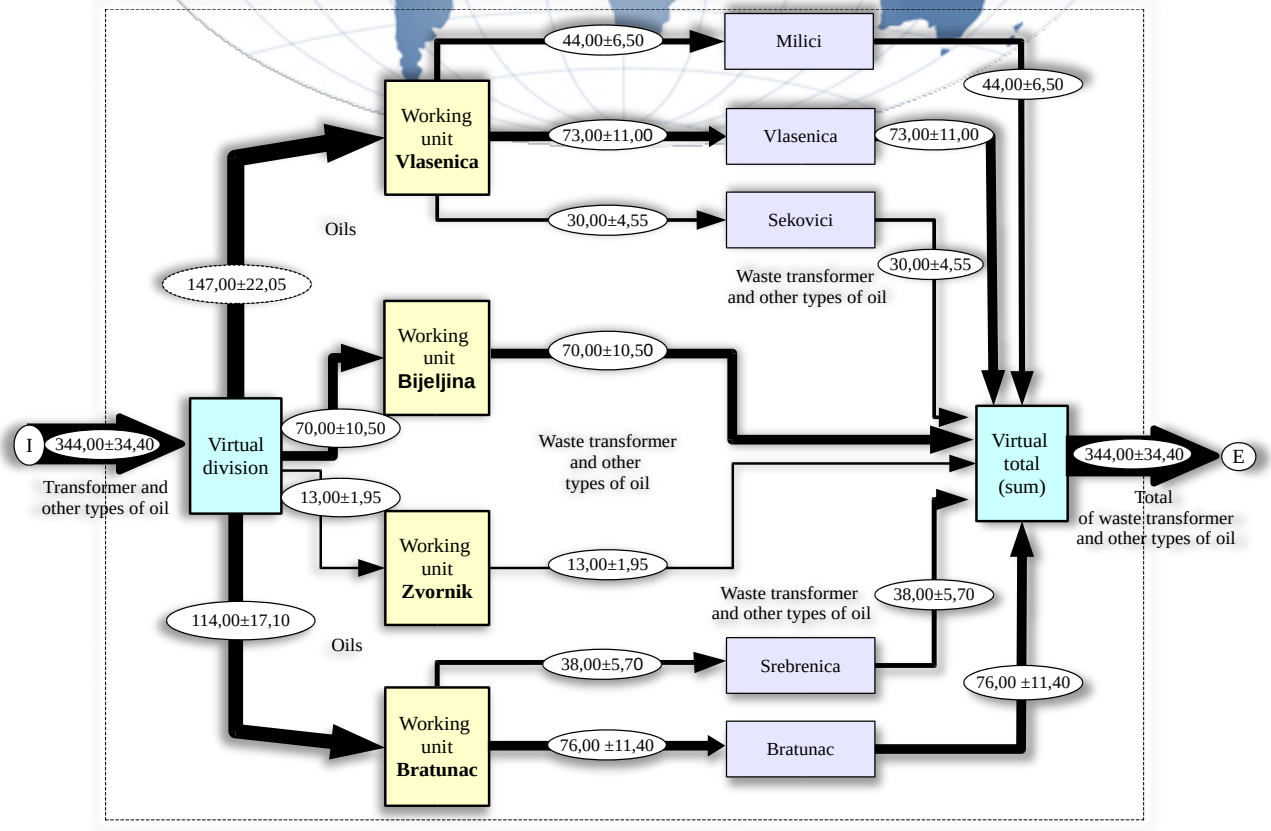

Figure 3: Analysis of oil flows in working units under the "Elektro-Bijeljina" Company (l/year).

The aforementioned waste oil analysis results are logical, given that the overhauls, repairs and reconstruction of certain power units, which belong to the above mentioned working units, most

intensely in Vlasenica, Bratunac and Bijeljina, were done in the period analyzed. The management of waste oils generated in the working unit Ugljevik is the responsibility of an authorized institution, which does the oil change treating it further in accordance with the legislation.
At the level of enterprises belonging to the electricity distribution system, the short-term or long-term contracts are signed with authorized organizations dealing with the disposal of waste oils and thus solving generated waste issue.
Further movement of waste oil flows and operation of the oil management system include transportation to the waste treatment plants, which significantly increases the risk of accidents and threat to the population and environment in the broader areas, along the transport route to be used.
In relation to the above, all types of waste oil stored temporarily in the warehouses of the Company's organizational units are transported for recycling by the contracted authorized institution specialized in the management and disposal of waste oils.
Based on the collected various data, the analysis and its results, it was established that there is not always completely accurate record or information about how much oil is topped up into individual transformer and/or other devices, as well as the records on other possible activities. The mentioned facts make it difficult and limit detailed analysis of oil flows and waste materials.
In accordance with the above analysis results, Figure 4 displays the proposed monitoring of the flows of oil and information, as a form of the enhancement and achievement of the necessary level of material flows monitoring in order to improve the existing recording, for the aim of more efficient environmental protection.

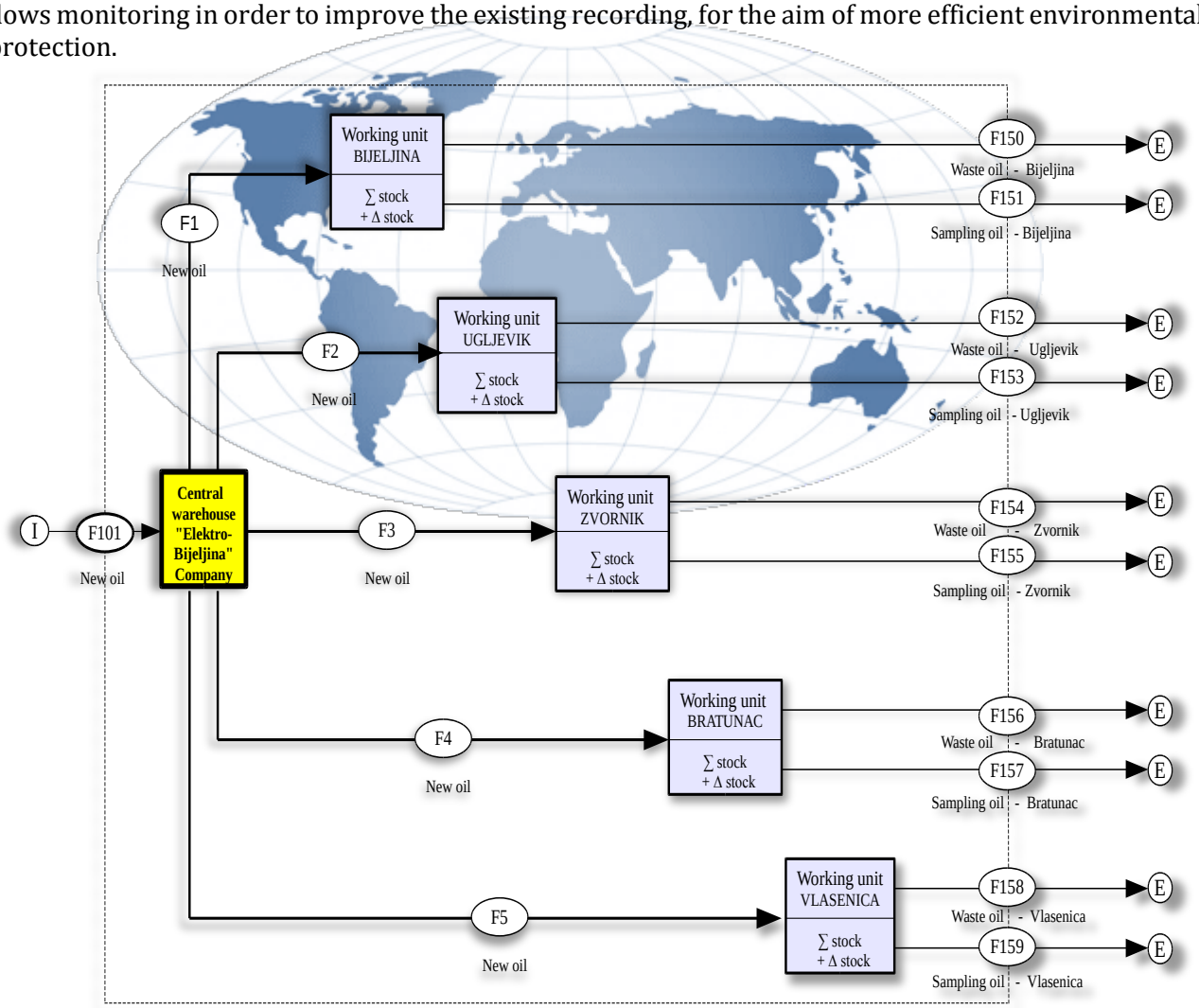

Figure 4: Diagram of proposed monitoring of flows of materials and informations

If the transformer, motor and/or other oils are unwillingly and uncontrollably discharged (spilled) into the environment (soil, groundwater or surface waters), the corrective measures are required to be implemented, which involve the collection of oil, safe disposal and rehabilitation of the consequences. The oil collected while taking samples or overflowing is categorized as waste oil [8].

Material flow analysis is the basis for the hazardous waste management [9]. The obligations and requirements for environmental protection are met by analyzing the flows of new and waste oil and implementing waste management procedures.

CONCLUSION

Control of analyzed flows of transformer, motor and other oils is not fully functional and adequate for the existing record-keeping method, which requires improvement. Currently, waste water records are kept in accordance with organizational division of the Company, in amounts/quantities that are generated in different working units, often without defining the exact place or the process of waste generation (the power station and/or other type of facility). Therefore, such records are not always accurate, timely and/or complete, thus result in analysis quality loss.

The mentioned conclusion, among other things, is one of the disadvantages of different distribution systems, mainly in developing countries (economies in transit), and is an important parameter that needs to be improved in further work and system operation.

Work teams that carry out operational activities, interventions and maintenance of the power distribution systems, although they are continuously obliged, do not always submit report on the transformer topped up and the oil quantity used, and/or the returned amount of oil after taking samples. This prevents the possibility of precise record-keeping and quantification of waste, including the possibility of analyzing the generation place. Because of the above mentioned, there is not always complete records on the waste generation place and all generated waste flows.

By seriously applying the results of flow analyses of various waste oils, including synthesis of all the data analyzed in the company that was subjected to the research or similar enterprise in developing countries, the MFA may significantly contribute to the environment protection, better functioning and faster development of the electricity distribution system, through the increase in: the speed and quality of the necessary information circulation, the safety of all active entities, profitability, timely and comprehensive fulfillment of legal obligations, level of business image and general progress of the underlying system, thereby increasing the degree of positive impact on the entire social community, based on scientific grounds.

Based on previous statements and analyses, it is necessary to build, soon as possible, temporary storages for waste oils and other hazardous waste at the localities where missing, or expend storages in order to ensure a sufficient and safe space for temporarily storing the waste oils and other materials, which some localities lack at present.

Based on conducted research presented in the study and various analyses of transformer, motor and other oils, methods, and the synthesis of numerous data, it can be generally concluded that the described problem solving method, recommendations and other positive suggestions, as well as the optimal waste management methods, in addition to researched system, can be applied to most of the power distribution systems, particularly in developing countries for the purpose of environmental protection.

Note

This paper is based on the paper presented at The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, in Zrenjanin, SERBIA, October 13–14, 2016, referred here as [10].

References

[1.] Technical and other documentation of the MH “ERS” ZEDP “Elektro-Bijeljina” joint-stock company Bijeljina.
[2.] Ksenija R. Djurdjevic, Mirjana Vojinovic-Miloradov: The life cycle of transformer oils; NIS Novi Sad, Faculty of Technical Sciences Novi Sad, Faculty of Technology, Novi Sad, 2008.
[3.] Anita Petrovic Gegic, Dragan Zivkovic: Safe disposal of transformer oil; Higher Education Technical School of Professional Studies Novi Sad, Transmission System and Market Operator “Elektromreza Srbije” Belgrade, 2010.
[4.] Brunner, P. H. and H. Rechberger. Practical handbook of material flow analysis. Boca Raton, FL, USA: CRC Press, 2004.
[5.] N. Stanisavljevic, PH Brunner, Combinatin of material flow analysis and substance flow analysis: A powerful approach for decision support and waste management. Waste Management & Research, 2014.
[6.] Milena Panic: Hazardous waste management, planning, organisation, operation system; Special edition; Serbian Academy of Sciences and Arts, Belgrade, 2010.
[7.] Technical rules and manuals for the maintenance of power distribution plants and devices, MH “Electric power industry of Srpska", Banjaluka, 2008.

[8.] Bozena Musulin: Ecological aspects of use and disposal of transformer oil, Fourth counseling; Croatian Committee of the International Conference on Large Electric Systems, Koncar - Electrical Engineering Institute, Zagreb, 1999.
[9.] G. Vujic, N. Stanisavljevic, B. Batinic, D. Ubavin, S. Kovacevic: Material flow analysis as a basis for hazardous waste management in transition economies - power distribution company case study, 2. Hazardous and Industrial Waste Management, Crete: Technical University of Crete, pp. 55-56, 5-8 October 2010.
[10.] D. Djordjic, S. Djuric, M. Hadzistevic, Analysis of transformer, motor and other types of oil flow in electric power distribution system in developing countries, The VIth International Conference Industrial Engineering and Environmental Protection 2016 – IIZS 2016, University of Novi Sad, Technical Faculty "Mihajlo Pupin" Zrenjanin, Zrenjanin, SERBIA, 2016