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Influence of the Environmental Aspects on the Quality of the Activity of the Wastewater Treatment Plant from the Repairs Locomotives Industry

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Abstract— **The aim of this paper is to identify an engineering method to study and to optimize the process of treating the wastewaters from the repairs locomotives industry in terms of quality, cost and environmental impact. The main purpose of this paper is to show how the control systems allowed us to investigate the environmental aspects of a wastewater treatment plant. The final issue is to optimize the process in terms of quality which means to decrease the cost and environmental impact. There are few steps to obtain the final issue. The first step is to establish the flux diagram of the wastewater treatment plant activity in the context of repairing locomotives process. The second step is to define this activity as a sum of processes according with ISO 14001 Standard, aimed to identify the interaction between this processes. To do this must be described the control system of a wastewater treatment method based on Dissolved Air Flocculation (DAF), used to treat the waste waters results from the locomotive repairs activity. A case study was made on a pumping station to illustrate the influence of the control system on this activity. All these sentences were made with environmental tools like: ad-hoc methods and control list methods, Environmental Systems Analysis (ESA) tools, critical synthesis of the processes and theirs modeling, observation and the experiment and statistic calculus. The result of this work is a work procedure in the activity of control quality of the repairs activity, being a practical implementation. The theme is completely original and responds to an actual practice of Environmental Management System.**

I. Introduction

The subject proposed in this paper develops the theme built up in [1] about the treatment of the wastewater of the activities of repairing the locomotives.

As a short review, the aim of the repairing locomotives activities is to obtain new products by assembling new parts and used parts.

In railway repairing industry, the locomotives must be completely disassembled, cleaned and examined for wear and breakage. Worn out, missing or non-functioning components are replaced with new or rebuilt components.

Electrical parts, normally, need rewinding or rewiring. After this stage, the parts are reassembled and tested for compliance with performance specifications.

In terms of quality, the main environmental advantage of the repair locomotives industry is that it incorporates the saving of energy and resources. The energy and resources necessary to rebuild the different components are considerably less than those required to replace the entire unit. So this industry could be considered a way to save energy and resources and is important to upgrade and develop it [1].

In [1], a short review of the literature [2] , [3] shows that the repairing locomotives operations produce wastewater, which contains organic substance contaminating in solution (degreasers, engine cleaners, cleaning fluids, solvents, enamels, lacquers, epoxies, acids or alkalis), colloidal and particulate form. The composition of the wastewater depends on the volume of production and could have negative impact on the environments.

To eliminate the environmental risks, the operator must realize an analysis related to the repairs process of locomotives, and search out actions to improve the environmental management system of their activity. According with [9] the quality management system documentation will have five levels, similar to the structure of figure 1.

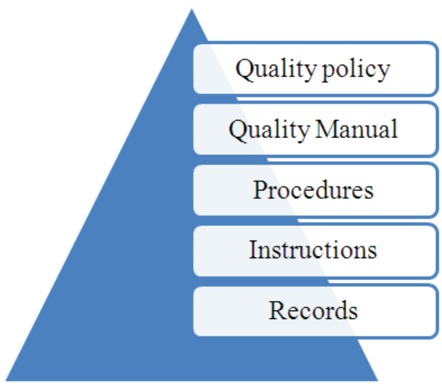

Fig.1. Levels of quality management system documentation

In terms of norms "Environmental Management System (EMS) is a set of management processes and operational procedures that allows to the organization to analyze, control and reduce the environmental impact of its activities, products and services, and operate with greater efficiency and control" [5].

In the context of EMS model, the mission of quality control is to identify and prioritize the environmental aspects following the steps from diagram figure 2.

Using ISO 14001 and EMS the organization can define environmental aspects as features of a society's operations, activities, products, or services that can have an impact (positive or negative) on the environment. Any change (good or bad) in the environment, caused by an environmental aspect, is an environmental impact (figure1).

In terms of quality, a main mission of the quality department in the activity of repairing locomotives is to establish and maintain procedures to identify the environmental aspects of the process.

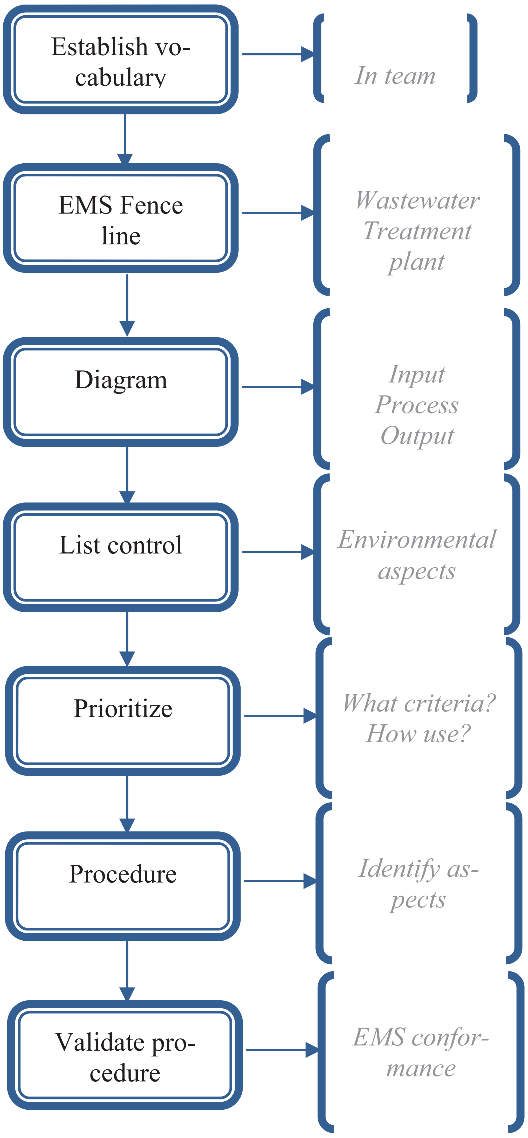

Fig.2. Method of work in EMS context

These analyze uses the ISO 14001 Standard and EMS model which is built on ISO 14001's Plan-Do-Check-Act (P-D-C-A). PDCA model help the organization to identify, control and monitor the environmental impact of the activity (figure 3).

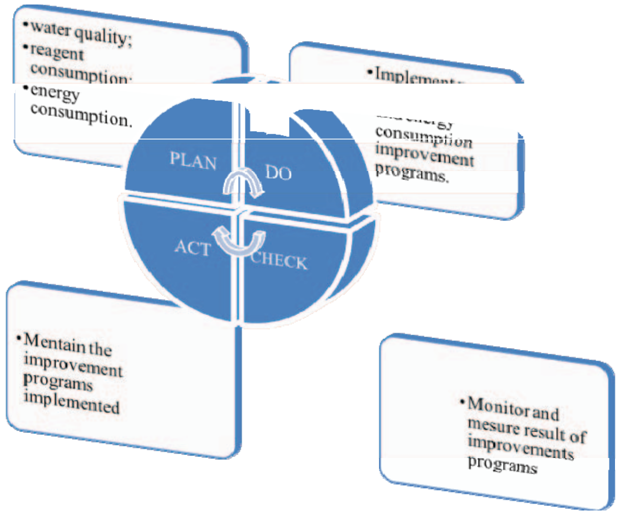

Fig. 3. PDCA model

II. WASTEWATER TREATMENT PLANT ACTIVITY

To establish the flux diagram of the wastewater treatment plant activities it must be knew the context of the industrial activity (figure 4).

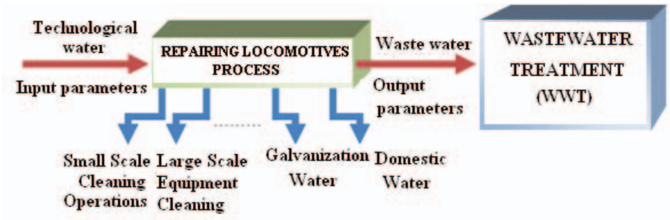

Fig. 4. Wastewater in the context of the industrial activity

A. *Sistem definition*

Flow of wastewater treatment plant is the sequence of logical operations that occur during the process of wastewater treatment. Flow shows the water line, and the command line sludge.

1) *Flow water line*

The filtered water is connected to the mixing tanks (7, 9). In studied case, the mixing tanks can store an amount of 60 m^3 of wastewater which allows maintaining a constant flow rate and a charge throughout the day. The fine bubble aeration by aerating elements (8,10) are distributed by flashing waste water, and maintaining the smoothness of a sufficient amount of oxygen dissolved in the water to prevent anaerobic biological processes which can release unpleasant odors.

From the mixing tank the water is pumped by means of two centrifugal pumps (6) to the next stage of the treatment.

Water pumped from the mixing tanks is subject to a process of coagulation - flocculation.

The separation of the colloidal suspension is carried out in the flocculating pipe (14). This transformation is the result of two different actions: the stabilization, which is achieved through the addition of chemical reagents; and the colloids agglomeration resulting from various forces of attraction between particles on contact.

Balancing pH is suitable for flocculation. The next step is flotation own – itself (20) and the elimination of treated water (21).

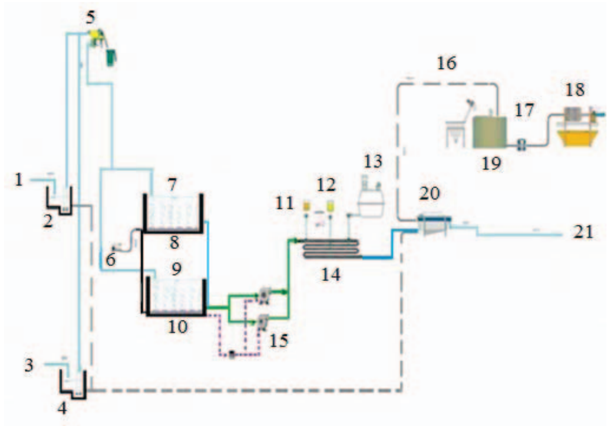

Fig. 5. Process diagram of the DAF wastewater treatment plant

2) Flow sludge line

Materials collected by scraper cleansing of the screen are stored in a tank located at its base.

The foam is removed with scraper blades. The sludge is evacuated from the flotation unit. The next step is the treatment and disposal of sludge.

3) Flow Control

Pumping station pump control is given by the information received from sensors located inside the basin level. The pumps operate by rotating, so a pump is in operation while the other is in standby.

Aerated water pumping is controlled by level sensors installed in pools. Pumping flow is constant. Zone flow and total flow is indicated by an electromagnetic flow meter installed before the piping enters the flocculation. An important step in control system is the control assay reagents.

Control and automation station pre - treatment is performed using a programmable PLC SIEMENS S7 200 CPU 224 and a 5.7'' touch screen, monochrome you can: view online station status, alarm status and can apply the option to configure TIMES desired.

B. Methodology to identify environmental aspects

The methodology aims to identify environmental aspects in two stages. First is identifying the environmental aspects at the level of operational activities (production, technical services, etc.).

This stage refers to the design of products. Second is collecting information about environmental sensitivity. Since the definition of an environmental aspect is open to interpretation, the reasoning used is about cause and effect.

C. Identify the environmental aspects

On the basis of the description of the treatment plant activity, have been identified the sub-processes and the interaction between them, and are placed in the process flow diagram (figure 6).

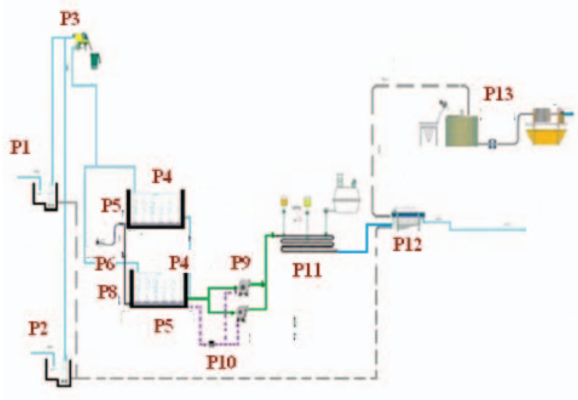

Fig. 6. Controlled process

TABLE I

ANALYZE OF DAF AS A SUM OF PROCESS AND INTERACTIONS

Simbol	Proces description	Interactions
P1.	Wastewater collected from sectors	iA1, iA2, iA3 - activities from sectors
P2.	Wastewater collected from sectors	iA4, iA5, iA6 - activities from sectors
P3.	Mechanical treatment	iA1, iA2, iA3, i3 – operating state
P4.	Mixing and aeration in basin1	i3.4 – quality of mechanical treatment i6.4 – quality of aeration i7.4 – quality of injection
P5.	Mixing and aeration in basin 2	i3.5, i6.5, i8.5 - quality of injector
P6.	Producing compressed air	i6 – operating state of the fun
P7.	Injecion of compresed air in basin 1	i6.7 – air presure
P8.	Injecion of compresed air in basin 2	i6.8 - air presure
P9.	Determination of hydraulic parameters for sending wastewater to the tubing	i9 - operating state of pumps i9.1 - pH
P10.	Pumps control	i10.1 - the state control loop
P11.	Floculation process	i11.1 - state injector for introducing coagulant, flocculant, acid / soda i11.2 – quality of waste waters i11.3 - hydraulic parameters of wastewater i11.4 - automatic control loop status
P12.	Flotation process	i12.1- scraper band operation i12.2 - hydraulic parameters i11.12 - quality flocculation / coagulation of tubing coagulation
$P_{13.}$	Sludge elimination	$i_{13.1}$ - the operating state of the system $i_{13.2}$ - quality stabilizers

III. CONTROL SYSTEM AND ENVIRONMENTAL ASPECTS

Using ad-hoc methods, control list methods, Environmental Systems Analysis (ESA) tools, critical synthesis of the processes and theirs modeling, observation, experiment and statistic calculus, have been identified the environmental aspects and the elements of system controls which influence it (table II, III).

Identification of environmental aspects for operation of the wastewater treatment plant control system allows adjustment both in terms of hardware and in terms of optimization programming.

TABLE II

ENVIRONMENT ASPECTS APPEARANCE

Aspects	Activity	Appearance
A.M.1.	Depreciation point loading effects (peak flow)	Basin homogenization/flow parameters
A.M.2.	Consumption of reagents (coagulant, flocculent, neutralizing)	Serpentine coagulation flocculation
A.M.3.	Overcoming limits discharged water quality parameters.	Serpentine coagulation flocculation
A.M.4.	Ensure fresh water mixtures, water and air recirculation optimal cohesion and formation of conglomerates of particles.	Serpentine coagulation flocculation
A.M.5.	The quality of the contaminated charges.	Rotating screen
		Flocculation unit
A.M.6.	The quality of pressurization	Pressurizing system
A.M.7	Energy consumption	Pumps/ compressors/ injection equipment/ etc.

TABLE III

EFFECT/CAUSE INTERACTION

Aspects	Effect	Rating / Cause
A.M.1.	Lack of flow and a constant load throughout the day (work pool homogenization procedure)	Homogenization inappropriate.
A.M.2.	1. Crystallization inadequate water; 2. Consumption of reagents. (Working procedure coagulation - flocculation).	Dosage control; Maintain the temperature at least 10 ° C to prevent crystallization of the soda.
A.M.3.	Defective function station pre - treatment (coagulation working procedure - flocculation).	Lack of supply of chemical treatment plant.
A.M.4.	No form conglomerates with a diameter of 250 - 300μm form clusters forming a solid unit - gas stable. (Working procedure coil coagulation - flocculation laminar)	1. Lack laminar flow conditions; 2. Corresponding flow rate; 3. Proper injection.
A.M.5.	The degree of removal of insoluble particles (working procedure rotating sieve).	1. Type of treated water.
	Shallow mud scraper removes less water when the float is down giving a higher concentration of sludge (working procedure for the installation of silt).	2. Concentration controlled by the water level float.
A.M.6.	Inadequate separation of the impurities that are in the air; Eliminating condensation The pressure value at the inlet of the air pump; Emergence of excessive pressure; Setting amounts of air injected into the pump pressurization production. (Working procedure pressurization system)	Operating status of pressurization system
A.M.7	Increase hydraulic load of the network, the cost of operation, etc	Inadequate pump control

IV. ANALYZING PUMP CONTROL

To exemplify this environmental analysis and its effect in an optimal operation was chosen the pumps control which regard the environmental aspect - A.M.7. The improvement of this aspect supposes an optimal programming of the pump operation, according with the volume of the productive activity. For this must be carefully analyzed the pumping system.

The wastewater plant is feed with wastewater through two pumping station, equipped with two submersible pumps. The pumps worked alternative and their command is given by level sensors (float switches) as in figure 7.

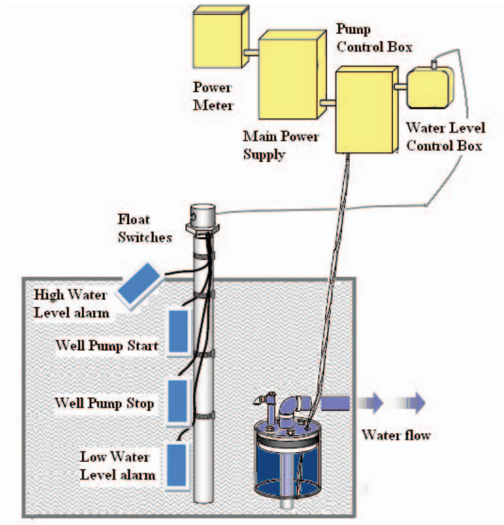

Fig.7. System characteristics [source 8]

The pumps are equipped with asynchronous motors with rotor in cage. To design a pumping system should be analyzed:

- the system characteristics – figure 7,
- the number of pumps – two pumps,
- how control water level – with float switches,

- the capacity of the pumping system – 80m3/h,
- the idea of the pump control system – figure 8,
- flow chart of the automatic level monitor – figure 9,
- the emergency measures for equipment failure,
- the power breakdown,
- the energy consumption.

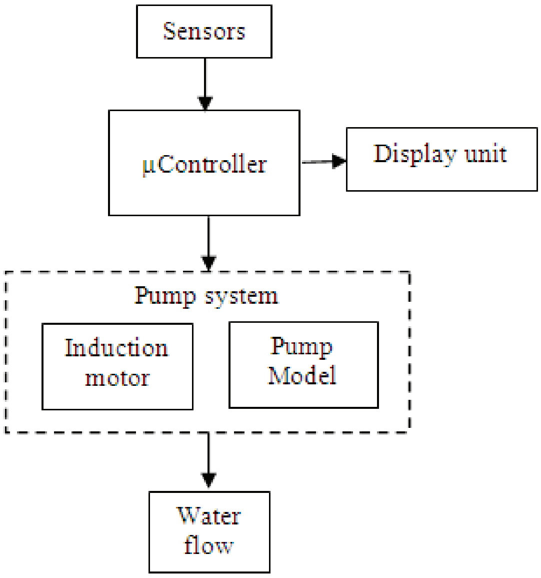

Fig. 8. Pump control system

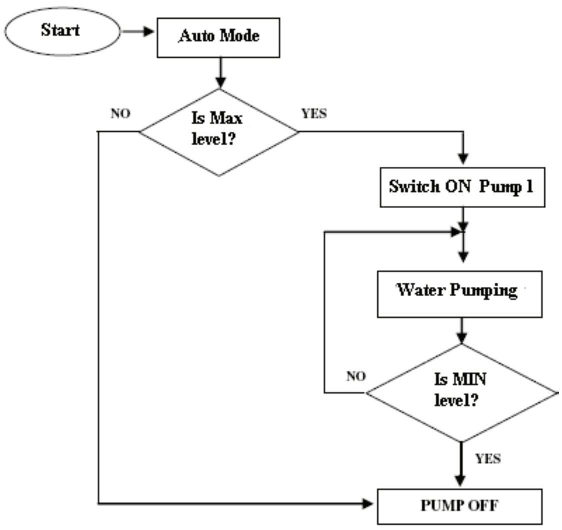

Fig. 9. Flow chart of the automatic level monitor

The control of water level monitor consists of the following major units: sensors, comparator circuit, microcontroller, display unit, and the pump and the core work of detecting the level of water is done by the comparator.

A. Case study: Motor and pump as a system

In [7] is underlined that about 18% of generated electrical power is used by three-phase-induction motors driven pumps in water pumping stations. The working conditions of these pumps are various: dynamic stresses in mechanical parts, high starting currents, energy saving problems. The optimization of this system means to find a way to improve the environmental aspects by decreasing the energy consumption and starts with mathematical modeling. To improve the energy consumption is imposed to improve the efficiency of the pumps. So, this is the objective of the modeling.

The mathematical model of the pump is obtained from the equation of motion written for the motor-pump system:

$$J\frac{d\Omega}{dt} = T - \left(T_r - T_v\right) \tag{1}$$

$$\frac{d\Omega}{dt} = \frac{1}{J}\cdot[T - \left(T_r - T_v\right)] \tag{2}$$

where: J is the total moment of inertia [kgm^2], T – active torque [Nm], Tr-resistive/passive torque of the pump [Nm], Tv- viscous torque [Nm], Ω - angular speed of the rotors [rad/s]. The angular speed is given by (3):

$$\Omega = \frac{\omega}{p} \tag{3}$$

where: ω is the pulsation of rotor and p the number of poles. The viscous torque is given by (4):

$$T_v = B\cdot\Omega \tag{4}$$

where B is the viscous coefficient, [Nms/rad].

On the mathematical models could be proposed different strategies of control aimed to improve the performances of this system.

Figure 10 show two hydraulic characteristics of a pump: $H_p(Q)$ at rated speed ($n=n_N$); and a lower speed ($n<n_N$) and a hydraulic network features $H_R(Q)$.

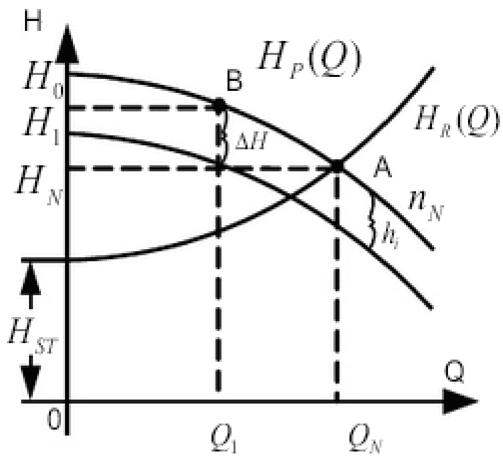

Fig.10. Hydraulic characteristics of a pump

The static point of operation is at the intersection of these characteristics, (H_i, Q_i), for a single debit $Q_p=Q_R=Q$. In the rated point A(H_N, Q_N) the efficiency of pump is maximal: $\eta_N=\eta_{max}=\eta$. If the debit of the hydraulic network decrease to Q_1 at constant speed, the pressure increase to B(H_1, Q_1) and increase the hydraulic losses in network direct proportional with differential pressure.

When the pump (P) is feed by a converter with variable frequency, controlled by a pressure regulator (PR) in the closed loop, the increase of the pressure couldn't happen because the pressure transducer and pressure regulator will control permanently the deviation from the prescribed pressure. This adjustment is known as rule of the constant pressure adjustments (fig. 11).

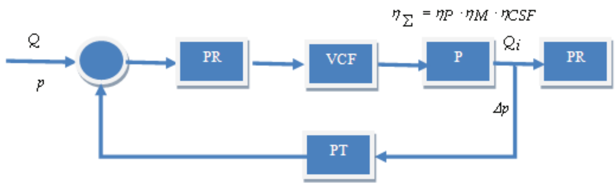

Fig. 11. Block diagram of pump adjustment at Δp=ct.

Reducing power (ΔP_C) and energy consumption (ΔW_C) are calculated with (5), (6).

$$\Delta P_{ci} = \frac{Q_i \cdot \Delta p}{\eta_\Sigma} \tag{5}$$

$$\Delta W_{ci} = \Delta P_{ci} \cdot \Delta t \tag{6}$$

where $\eta_\Sigma = \eta_P \cdot \eta_M \cdot \eta_{CSF}$ is the summary efficiency of the pump, motor and converter and Δt is the interval of time when the debit of the pump is Q in the 24 hour load diagram of the pump.

Finally, the reducing of energy is around 40-50% when it used a block diagram with frequency converter to adjust the pump. In context of figure 1 this analyzes was used to argue the stages of the working instructions of pumping system operation, implemented in daily functioning of the station.

All this analyzes is an original work and the results are the working instructions implemented in phase CHECK of PDCA method (figure 3).

V. CONCLUSIONS

The topic requires an interdisciplinary approach.

It is very important to analyze the efficiency of a process control system closely related to the identification of environmental aspects and analyze their impact. This can lead to incremental optimization of the system.

The automation of the pumping process leads to improve their performance and guides to a positive environmental impact.

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