

# Measurement of flow and pressure characteristics of combustion engine oil filters

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**Abstract.** For the purpose of measuring the flow and pressure characteristics of oil filters used in vehicles with internal combustion engines, a laboratory test equipment was used, which was designed at the Department of Transport and Handling of the Slovak University of Agriculture in Nitra. The target information from the given measurement is the obtained data on the change of flow and pressure, based on the type of oil filter used. The contribution of this paper is information that can be used in the future in the design of new filtration equipment, as well as the creation of a system for evaluating the technical life of motor oils, in order to extend the service intervals of motor oil, monitored set of motor vehicles.

## 1 Introduction

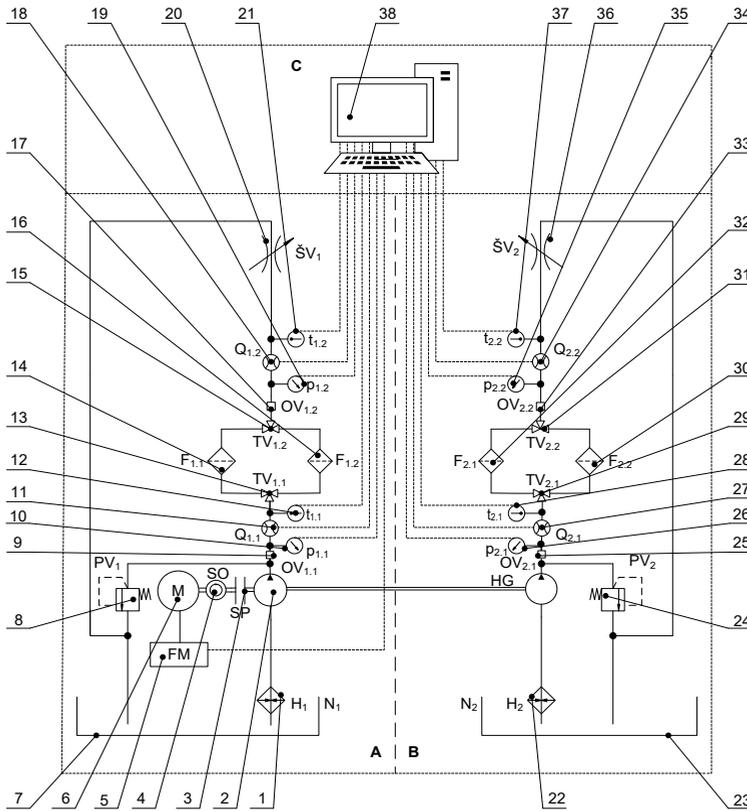
Today, more and more attention is paid to maintaining and protecting the quality of the environment, and this trend has not escaped even specific industries such as lubricant manufacturers. During production, they meet the requirements of constantly improving the quality of their products, but more importantly, to ensure that their impact on the environment is reduced. Fulfilling both requirements in practice means that the complexity of production and the price of a given product will increase [1]. In the case of solving the problem of working fluids, we consider motor oils, which are commonly used in internal combustion engines, to be the most demanding lubricants in terms of the choice of base oils and suitable additives [2]. As it is an important part of the whole system, oil pollution is one of the most common reasons for machine failure[3,4]. The engine oil is subjected to very high temperatures during operation, when, for example, the oil fill temperature reaches a temperature of up to 150 ° C. The measurement of flow and pressure characteristics was performed by means of a laboratory test equipment, the design of which was performed based on technical characteristics of oil filters, hydraulic elements used in the circuit and calculations performed at the Department of Transport and Handling [5,6,7].

## 2 Material and methods

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The influence of the lubrication system on the correct functioning of the internal combustion engine ensures the formation of a thin oil film on the friction surfaces, in order to cause the relative movement of the friction pairs in the form of liquid friction. Otherwise, there would be increased wear of the sliding pairs, and thus mechanical failures of the entire machine. With the given test laboratory equipment, the diagram of which is shown in Fig. 1, it is possible to evaluate the operation of the oil filter, monitor the size of foreign particles removed from the liquid through oil filters, but also monitor the expected life of the oil filter itself [6,8,9].



**Fig. 1.** Laboratory test equipment for measuring flow and pressure characteristics of internal combustion engine oil filters.

Legend: 1, 22 - heaters; 2 - tandem hydraulic pump; 3 - coupling; 4 - speed sensor; 5 - frequency converter; 6 - electric motor, 7, 23 - tanks; 8, 24 - safety valves; 10, 19, 26, 35 - pressure sensors; 11, 18, 27, 34 - flow sensors; 12, 21, 28, 37 - temperature sensors; 13, 15, 29, 31 - three-way valves; 14, 32 - original filter materials; 16, 30 - tested filter materials; 9, 17, 25, 33 - collection points; 20, 36 - throttle valves; 38 - Computer software; HG - tandem hydraulic pump; N<sub>1</sub>, N<sub>2</sub> - tanks; FM - frequency converter; SP - coupling; SO - speed sensor; PV<sub>1</sub>, PV<sub>2</sub> - safety valves; Q<sub>1.1</sub>, Q<sub>1.2</sub>, Q<sub>2.1</sub>, Q<sub>2.2</sub> - flow sensors; p<sub>1.1</sub>, p<sub>1.2</sub>, p<sub>2.1</sub>, p<sub>2.2</sub> - pressure sensors; t<sub>1.1</sub>, t<sub>1.2</sub>, t<sub>2.1</sub>, t<sub>2.2</sub> - temperature sensors; F<sub>1.1</sub>, F<sub>1.2</sub>, F<sub>2.1</sub>, F<sub>2.2</sub> - filters in circuit A and B; TV<sub>1.1</sub>, TV<sub>1.2</sub>, TV<sub>2.1</sub>, TV<sub>2.2</sub> - three-way valves; OV<sub>1.1</sub>, OV<sub>1.2</sub>, OV<sub>2.1</sub>, OV<sub>2.2</sub> - sampling point; M - electric motor; ŠV<sub>1</sub>, ŠV<sub>2</sub> - throttle valves

The laboratory equipment is divided into three circuits. Circuit A is a reference measuring circuit in which an uncontaminated liquid is used in the measurement. Subsequently, in

circuit B, in which a contaminated liquid is used in the measurement, it is called a test measuring circuit. The last of the main circuits is circuit C, which consists of a recording and evaluation unit. During the performed measurements, combined sensors were used, by means of which it is possible to simultaneously measure the pressure, temperature and flow of the working fluid. Another parameter that is suitable for monitoring for diagnostic reasons is the service life of hydraulic circuit elements, focusing on oil filters [10, 11]. FIG. 2a and FIG. 2b show HYDAC, SRN devices, by means of which it is possible to measure the flow in various ranges, the sensors are connected to a hand-held digital measuring device HMG 3010 (Fig. 2a).



**Fig. 2a and 2b.** HMG 3110 and pressure and flow sensor for HMG 3110.

These sensors, for the purpose of data acquisition and subsequent evaluation of the flow and pressure characteristics of the tested filtration devices, monitor the values in the test circuit. It is important to monitor changes in flow and pressure depending on the clogging of the monitored oil filters with impurities. The pressure change will be continuously monitored in the entire circuit, through a total of four pressure sensors. Monitoring of the working fluid temperature is provided directly from the circuit, or from the tank, in order to meet the requirement to ensure the temperature of the engine oil as during operation.

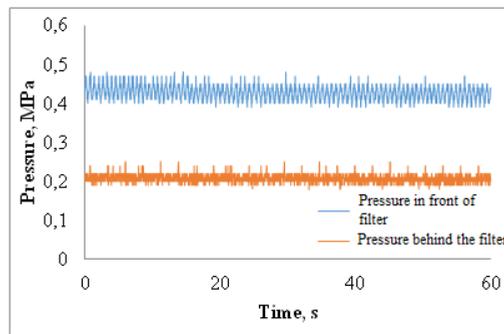
**Table 1.** Basic technical data for flow, pressure and temperature sensors.

Hydac flow sensor EVS 31 04-A-0060-000		
Parameters	Units	Values
<i>Power supply</i>	<i>V DC</i>	<i>10-32</i>
<i>Signal</i>	<i>mA</i>	<i>4-20</i>
<i>Fluid temperature</i>	<i>°C</i>	<i>-20÷90</i>
<i>Ambient temperature</i>	<i>°C</i>	<i>-20÷70</i>
<i>Measured flow</i>	<i>dm<sup>3</sup>.min<sup>-1</sup></i>	<i>6÷60</i>
<i>Max. working pressure</i>	<i>MPa</i>	<i>40</i>
Hydac pressure sensor HDA 4744-A-250-000		
<i>Power supply</i>	<i>V DC</i>	<i>12-30</i>
<i>Max. supply current</i>	<i>mA</i>	<i>100</i>
<i>Max. measured pressure</i>	<i>MPa</i>	<i>25</i>
<i>Measurement accuracy</i>	<i>%</i>	<i>≤±0.25</i>
<i>Safety type according to DIN 40050</i>	<i>IP</i>	<i>65</i>
Hydac temperature sensor ETS 4144-A000		
<i>Thermal range</i>	<i>°C</i>	<i>-25÷100</i>
<i>Working current</i>	<i>mA</i>	<i>4÷20</i>
<i>Working voltage</i>	<i>V</i>	<i>8÷32</i>
<i>Response time</i>	<i>1/s</i>	<i>4</i>

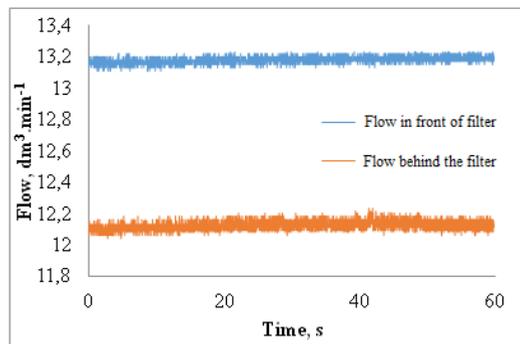
### 3 Results

The measurement of oil filters flow and pressure characteristics used in internal combustion engines was performed on a laboratory device designed for the evaluation of engine oil filtration. The great benefit of this device is the rapid reduction of time in the actual testing of the working fluid, as it is possible to simulate the real operating conditions of the vehicle in traffic. Measurements to determine the suitability of using different types of filtration equipment will be evaluated based on the effect of the contaminated fluid on the change in flow and pressure in the hydraulic circuit of the laboratory test equipment.

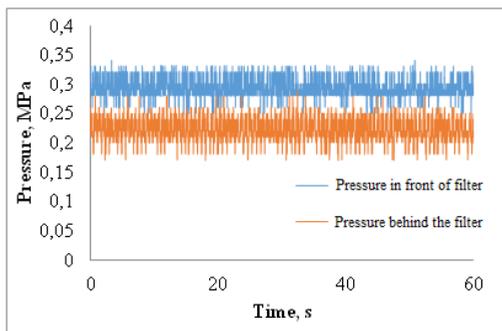
The working fluid 5W-30 URANIA FE LS and the oil filter device MAN W950 / 26 were used to measure the flow and pressure characteristics. The used oil filter is commonly used in vehicles used for intercity and urban public transport.



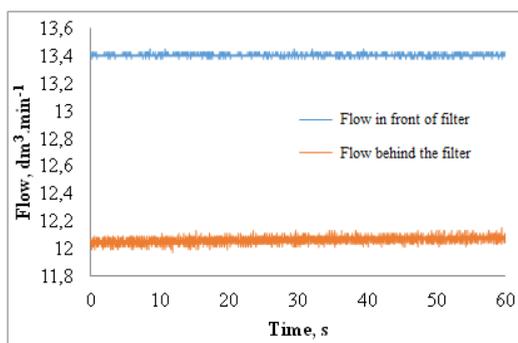
**Fig. 3.** Pressure profile when using uncontaminated working fluid.



**Fig. 4.** Flow profile when using uncontaminated working fluid.



**Fig. 5.** Pressure profile when using contaminated working fluid.



**Fig. 6.** Flow profile when using contaminated working fluid.

## 4 Conclusion

The measurement of flow and pressure characteristics of oil filters for internal combustion engines was performed on a specialized laboratory test equipment, created at the Department of Transport and Handling of the Slovak University of Agriculture in Nitra. The authors [12, 13], who dealt with this issue in their work, created a set of measuring laboratory equipment for testing hydraulic fluids, as well as individual hydraulic elements. The author [14] dealt with the analysis of oils by spectroscopy, which evaluated the state of oils based on the degradation of oils and changes in flow efficiency on a hydrostatic transducer. Through the given laboratory equipment, it is possible to obtain data that can be used in several industries in the future. As most transport companies own dozens of motor vehicles, reducing service costs for such companies can mean cost savings, both from an economic point of view and, last but not least, from an ecological point of view. Engine oils for extended service intervals, together with car service inspections, include a range of measures and checks to prevent unexpected engine failures and the failure of certain parts. It is important to note that the recommended oil change intervals given by the car manufacturer are the values achievable under optimal driving conditions. Service inspections at specified intervals should ensure the customer reliable operation of cars. In his work, the author [15] focuses on extending the engine oil change interval. The laboratory equipment allows testing the suitability of using filters with different filtration capacity while simultaneously testing in two separate hydraulic circuits with differently contaminated engine oil, without the risk of damaging the internal combustion engine. The extent of engine oil contamination prior to use in the test circuit shall be determined by evaluating the physicochemical properties of the oil used and the degree of contamination. The results of the evaluation of the filtering ability of oil filters can be used,

in addition to the already mentioned industries, for example, in the design of new filter materials.

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