Technical state of piezometers as an element of data quality in groundwaters monitoring

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Abstract: The PARAMEX method enables on-site determination of the basic hydrogeological parameters in the vicinity of the piezometer. It is also possible to assess the technical state of the piezometer. The indexes l and $h_{\%}$ of the piezometer technical state has been defined. It enables a simple and immediate quantitative assessment of the piezometer efficiency rate.

Key words: technical state of piezometer

The meaning of data credibility for groundwaters monitoring

It is noteworthy that an important factor which affects the quality of data in groundwaters monitoring is the technical state of the well or piezometer, which itself depends on the quality of the drilling works and the advance of the ageing processes. The technical state of the well can be assessed using the Jacob–Rorabaugh (1953) method, taking Walton's (1962) criteria into consideration. It is also possible to observe how the specific discharge of the well changes over time. We lack, however, a method enabling an evaluation of the technical state of piezometers, i.e., low-diameter hydrogeological boreholes. Three reasons of piezometers' faultiness can be indicated: drilling errors, natural ageing processes, damage.

The PARAMEX method

The PARAMEX method enables on-site determination of the basic hydrogeological parameters in the vicinity of the examined piezometer. Values of hydraulic conductivity coefficient and transmissivity of the aquifer can be evaluated. It is also possible to assess the technical state of the piezometer (Marciniak, 2001).

During the examination of the piezometer by means of the PARAMEX method water level motion is initiated by air compression or suction in the sealed over-well screen pipe. The rate of this motion depends both on the hydrogeological parameters of the aquifer and on the technical state of the piezometer. The aim of the measurement carried out during the examination is to record the function $s = s(t)$ of the water level motion in the piezometer during both compressing and sucking of the air. A typical example of such a function is shown in Fig.1. PARAMEX can be considered as an "express" method of determining the

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hydraulic conductivity coefficient of aquifers among the *slug-bail test* group (FETTER, 1994). During the examination of the piezometer by means of the PARAMEX method three phases of the water level motion can be distinguished: lowering, stabilization and free rise of the water level during air compression or raising, stabilization and free fall during air suction. Owing to bad technical state of the piezometer the function $s = s(t)$ is deformed in all the three phases. A detailed analysis of this deformation enables the identification of faultiness of various elements of a piezometer (MARCINIAK, 2002).

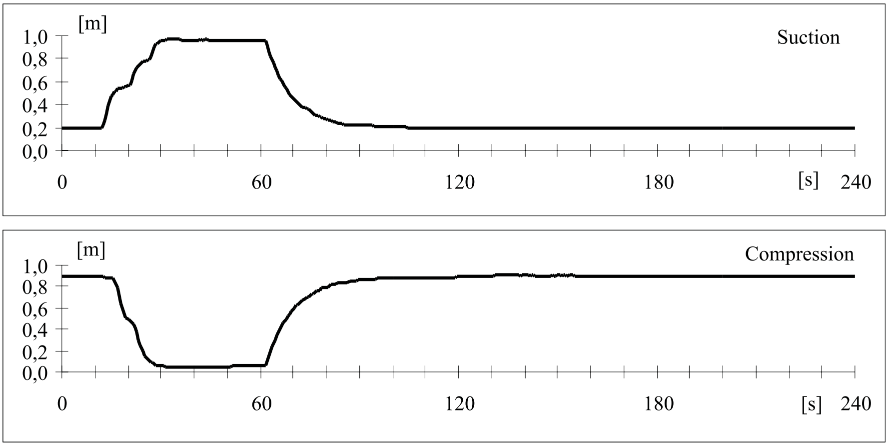

Figure 1. An example of the water level motion in the piezometer during examination by PARAMEX method. Aperiodic motion recorded in the piezometer III/1' at the Dębina intake in Poznań

THEORETICAL BASIS FOR EVALUATION OF TECHNICAL STATE OF THE PIEZOMETER

In earlier applications of the PARAMEX method the goal of identification was to determine the values of hydrogeological parameters of an aquifer. It was a priori assumed that the piezometer does not upset the identification experiment, i.e., that its technical state is good. In this paper it is he piezometer itself, which is the goal of identification (Fig. 2).

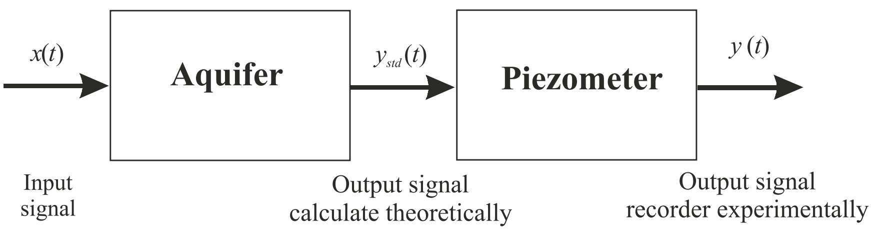

Figure 2. The piezometer as an identification object

When approaching evaluation of the technical state of a piezometer it is assumed that the hydraulic conductivity coefficient k_{std} of the filtered aquifer is known. The experiment consists in acting on a piezometer with an input signal $x(t)$, which causes a reaction $y(t)$ of the piezometer-aquifer system. The output signal $y(t)$ is the function of the water level motion in the piezometer $s(t)$, which has to be recorded experimentally. On the basis of the mathematical model describing the water level motion in a piezometer a theoretical shape of the function $y_{std}(t)$ can be computed. Comparison of the theoretical function $y_{std}(t)$ with the recorded function $y(t)$ is the basis for evaluating the technical state of the piezometer.
The function $y_{std}(t) = s_{std}(t)$ reflects changes in water depression in the piezometer over time. In general, $s_{std} = s_0 \exp(\gamma t)$ is an exponential function, where s_0 is the initial depression and the exponent γ can be computed knowing the construction parameters of the piezometer and hydrogeological parameters of the aquifer (Marciniak, 2002).

The index λ of the piezometer technical state is defined as:

$$\lambda = \frac{k_P}{k_{std}} \tag{1}$$

where: k_p - the hydraulic conductivity coefficient obtained using the PARAMEX method,
k_{std} - the hydraulic conductivity coefficient obtained from hydrogeological reconnaissance.
The technical state index λ of a piezometer defined above ranges from 0 to 1. The closer its index λ value is to one, the more properly functioning the piezometer is. Its computation index λ is possible only after interpreting the results of piezometer examination using the PARAMEX method.

Percentage index $\eta_{\%}$ of the piezometer technical state is defined analogically to the efficiency indices used in physics:

$$\eta_{\%} = \left(1 - \frac{\left|s_{std}(t) - s(t)\right|}{s_{std}(t)}\right)\Bigg|_{t=t_{cr}} 100\% \tag{2}$$

where: $s(t)$ - the actual depression measured in the moment t [m],
$s_{std}(t)$ - the depression computed theoretically [m],
t_{cr} - the critical time [s].
The percentage technical state index of the piezometer ranges from 0 to 100 %; the closer it is to 100 %, the more properly functioning the piezometer is.
Determination of the value of the index $\eta_{\%}$ defined by formula (2) requires theoretical computation of the depression value $s_{std}(t)$ at the moment t_{cr} and experimental measurement of the depression $s(t)$ at the same moment t_{cr}.
The time t_{cr} can be arbitrarily defined as the time after which the depression s_{std} decreases to half its initial value:

$$\frac{s_{std}(t_{cr})}{s_{std}(0)} = \frac{1}{2} \tag{3}$$

Taking the exponential nature of the water level motion into consideration we obtain:

$$t_{cr} = \frac{\ln 0{,}5}{\gamma} = \frac{-0{,}69315}{\gamma} \quad (4)$$

This arbitrary selection of the time t_{cr} can be justified by practical reasons. On the one hand, after such time the dynamics of the water level is well seen, so measurement errors are small; on the other hand, the examination of the technical state of the piezometer does not take too long.

EVALUATION CRITERIA

After many years of experience, distinction of three categories of technical state of piezometers has been proposed: **category A** - faultless piezometers, **category B** - partially faulty piezometers and **category C** - faulty piezometers. The limit values of the technical state index for these categories are:

category A	$\lambda \in \langle 1 \div 0{,}5)$	$\eta_{\%} \in \langle 100 \div 60)\%$
category B	$\lambda \in \langle 0{,}5 \div 0{,}1)$	$\eta_{\%} \in \langle 60 \div 20)\%$
category C	$\lambda \leq 0{,}1$	$\eta_{\%} \leq 20\%$

Obviously every user of a piezometer network can individually adapt the proposed limit values of the indices λ and $\eta_{\%}$.

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