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SOME KNOWLEDGE FOCUSED ON THE POLYETHYLENE IMITATORS USED FOR THE NEUTRON WELL-LOGGING METHODS

NĚKTERÉ ZKUŠENOSTI ZAMĚŘENÉ NA POLYETYLENOVÉ IMITÁTORY POUŽITÉ PRO NEUTRONOVÉ KAROTÁŽNÍ METODY

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Abstract

This paper describes knowledge of standardization of neutron logging through polyethylene imitators presenting rock environment. Studied relation between deflections on output of registering instrument what is measured value and wetness of the around environment what presents quantity of hydrogen has parabolic shape. It is determined with two characteristic boundary points: the value evoked with dry air presenting 0% of wetness and the value being measured for infinity-powered thickness of polyethylene cylinder making possible to count the value of fresh water what is 100% of wetness.

Abstrakt

Článek popisuje zkušenosti standardizace neutronové karotáže pomocí polyetylénových imitátorů horninového prostředí. Zkoumaná závislost mezi výchylkami na výstupu registračního zařízení, což je měřená hodnota, a vlhkostí okolního prostředí, což představuje obsah vodíku, má parabolický tvar. Je určena dvěma charakteristickými krajními body: hodnotou vyvolanou suchým vzduchem, která odpovídá 0% vlhkosti, a hodnotou měřenou pro nekonečně silnou stěnu polyetylénového válce, která umožňuje stanovení výchylky pro nemineralizovanou vodu, což odpovídá 100% vlhkosti.

Keywords

polyethylene cylindrical standard, neutron characteristics versus wetness of rock environment

Klíčová slova

polyetylénový válcový etalon, neutronové charakteristiky versus vlhkost horninového prostředí

1 Introduction

This paper is about process of standardization for the neutron well-logging methods when as a standard was used a coaxial cylinder manufactured from polyethylene. It is too about construction of such cylinders and the needed principles for comprehension. Problem of standardization for three different equipments of Russian provenience had been solved in years 1980- 1982 and successfully.

2 Factors influencing registration

The signal being on the output of well-logging tool, originally expressed in counts per seconds [c/s] and afterwards transformed into contracting units [SJ], is affected with two basic factors. The first is quantity of polyethylene depending on the wall thickness of the polyethylene cylinder and, simultaneously, on its length, too. Polyethylene contains big amount of hydrogen and its density is relatively high in comparison to air. It makes the deflection registered on the output of tool is low and this is very well visible for bigger quantity of polyethylene around of well-logging tool. The second factor is quantity of air in the near surroundings of tool. This depends on dimension of the air gap being between the tool and the inner wall of cylinder. The air has a tiny amount of hydrogen in comparison to polyethylene and its density is low too. Consequence of that is the growing of deflection registered on the output of tool. The more the air gap is, the bigger that deflection is.

Thanks to combination of the wall thickness, the length of cylinder and the dimension of the air gap we are able to create an arbitrary deflection on the output of tool. The above deflection is limited with two boundary values; by the deflection in air and by the deflection in polyethylene, for both on condition that the thickness of material is infinite. The real recorded deflections vary somewhere in between both limits.

I can say, if we have the neutron source ^{241}Am/Be and the high-pressure polyethylene type SA-200-22, having density 0.92 g/cm^3 , the wall thickness of the cylinder being 150 mm is all enough for exclusion of the influence of surroundings behind the wall of cylinder. That means the outer effect is suppressed. And the length of cylinder being 900 mm helps to exclude that outer effect, as well. Here I ought to refer to RYŠAVÝ, (1993) publishing the way making possible completely exclude the outer effect. So we can use the cylinder having the wall thickness lower than 150 mm and, in spite of that, we receive by extrapolation of curve the needed deflection being free of outer effect.

Besides the high-pressure polyethylene there exist, too, the low-pressure polyethylene having its density that varying in the interval 1.9 –9.3 g/cm^3. BROŽ, J. et al. (1980). Moderator of fast neutrons with such density is extremely powerful, much more than the high-pressure one, because it can not only moderate neutrons but too intensively absorb the gamma-photons. Further, the polyethylene cylinders do not serve as standards only. They can successfully simulate an influence of the rock models; therefore they are denoted as imitators.

3 Manufacture of cylinders

The first way was reeling of the polyethylene folio on a tube. Such manufactured cylinders were not too good; because of air bubbles.

The single beds of folio slipped one to other. Between them there were formed air bubbles. Therefore those cylinders could not be used as standards; however, like imitators they were sufficient.

The better cylinders were manufactured by pouring of the melted polyethylene granulate into the cylindrical mould. The final cylinder of the length of 900 mm consisted of three cylindrical semi-products had to be combined together by warming up of the contact faces. The so-formed cylinder was turned up for reaching of the final shape. Such cylinders were used like imitators but, mainly, like standards having contracting units [SJ] for all three equipment of Russian production denoted as DRST-3, SP-62 and DRSA. There was formed domestic metrological net; the main standard was the one for DRST-3 and both next standards for SP-62 and DRSA had been derived by repeating registration. The main standard presents value 1638 SJ for all three ones. This way of determination for all deflections in [SJ] was applied for all resting cylinders serving like imitators only.

I should like to remark something about the mentioned ones used for registration of gamma-photons only. For DRST-3 the outer diameter of tool was 90 mm, the tool of SP-62 presented its outer diameter like 95 mm and the tool diameter of DRSA only 36 mm. It ought also to be said the density of polyethylene is often very different. The higher density is, the more the fast neutrons are moderated. In the contrary of that the weight of standard is growing.

For first cylinders it held that their inner diameter and their length were estimated in random. However, we very often have to manufacture cylinders for the in-advance-determined deflections. Then it is significant to enumerate certain dimensions.

4 Theory of the apparent thickness of the cylindrical wall

The apparent thickness H taking account of different numeric characteristics of imitators and neutron tools is defined as follows:

$$H^2 = h^2 \times \frac{(D/h)}{(L/D)} \times \{1 - (d_s/D)\}, \qquad (1)$$

where H = the apparent thickness of the cylindrical wall of porous rock [mm],

h = the real thickness of the cylindrical wall [mm],

D = the inner diameter of cylinder [mm],

L = the length of cylinder [mm], and ds = the diameter of tool [mm].

The ratios are interpreted like this: (D/h) is the bore-pipe ratio, (L/D) presents the slenderness ratio and $\{1 - (d_s/D)\}$ is the air-gap ratio. The mentioned formula (1) can be also expressed like ratio of the cross-section areas.

$$H^2 = \frac{1}{\pi} \times \frac{S_1}{S_2} \times h^2 \times \{1 - (d_s/D)\}, \qquad (2)$$

$$S_1 = \pi \times D^2 \text{, and} \qquad (3)$$

$$S_2 = h \times L, \qquad (4)$$

where S_1 = the sectional area of the transversal cross-section of the inner aperture for cylinder [mm^2], and
S_2 = the sectional area of the longitudinal cross-section of cylinder [mm^2].

Now, it is time for fast analysis of the written formulas. You need to distinguish two cases; for thick tool when $d_s = D$ and for thin tool when $d_s \ll D$. The case of thick tool presented with condition $(d_s/D) \to 1$ has $H^2 \to 0$. The case of thin tool when $(d_s/D) \ll 1$ you can use a simpler formula:

$$H^2 = \frac{1}{\pi} \times \frac{S_1}{S_2} \times h^2 \ . \tag{5}$$

If you wants to get $H^2 \to 0$, it will hold that $S_1 \ll S_2$. For condition $S_1 \gg S_2$ when holds $H^2 \to H^2_{max}$, the cylinder must be short and thin with very big inner aperture. Simultaneously it holds condition $d_s \ll D$. Then the cylinder has very large the air gap. This allows us to have high deflections in [SJ] being typical for middle and low values wetness below 50% what presents real values wetness and porosity.

5 Investigation of relation between deflections and the squared apparent thickness of wall

You took a notice that the above formulas used the square of H. This will be important for definition of constants for relation $I = f(H^2)$. Tab.1 presents basic data of seven imitators manufactured by me and my fellows. Three of them served simultaneously like standards for older Russian equipments DRST-3, SP-62 and DRSA. The equipments were set different detectors of counts with different sensitivity. Their tools were different too with their dimensions. It was about the neutron – gamma method with registering of gamma photons for all three equipments.

The next table, tab.2, carries data of factors H^2 and I for each of ones. Relations $I = f(H^2)$ are depicted in fig.1. Some of points presented are more dispersed. This was caused by that not for all cylinders the tool was well centred. But, the above relation for all three events had been distinctly proved and I should it classify like the fundamental technical characteristic of all registering equipment.

It is relation expressed like an interval of parabola: $I = c + b \times \left(H^2 \right) - a \times \left(H^2 \right)^2$,... for $c \rangle 0$ and $0 \langle \left(H^2 \right) \langle H^2_{\max}$, (6)

where c = deflection evoked only with the high-pressure polyethylene cylinder in SJ-units [SJ],
b = the flux of gamma-photons coming to detector expressed through SJ-units and made with air gap and steel tube [SJ/mm^2],
a = the unit quantity of all gamma-photons expressed through SJ-units being not registered by detector [SJ/mm^4].

The mentioned technical characteristics have the following form:

$$I = -0.0011 \times \left(H^2\right)^2 + 7.2705 \times \left(H^2\right) + 150.2 \text{ ...for DRST-3}, \tag{7}$$

$$I = +7.8959 \times \left(H^2\right) + 390.3 \text{ ...for SP} - 62, \ a = 0, \tag{8}$$

$$I = -0.0008 \times \left(H^2 \right)^2 + 2.8045 \times \left(H^2 \right) + 144.4 \text{ ...for DRSA}. \tag{9}$$

It is always finite real value when it holds that a→0, never that a = 0. Unfortunately in some cases the linear relation can be more correct than the parabolic one, see equipment SP – 62.

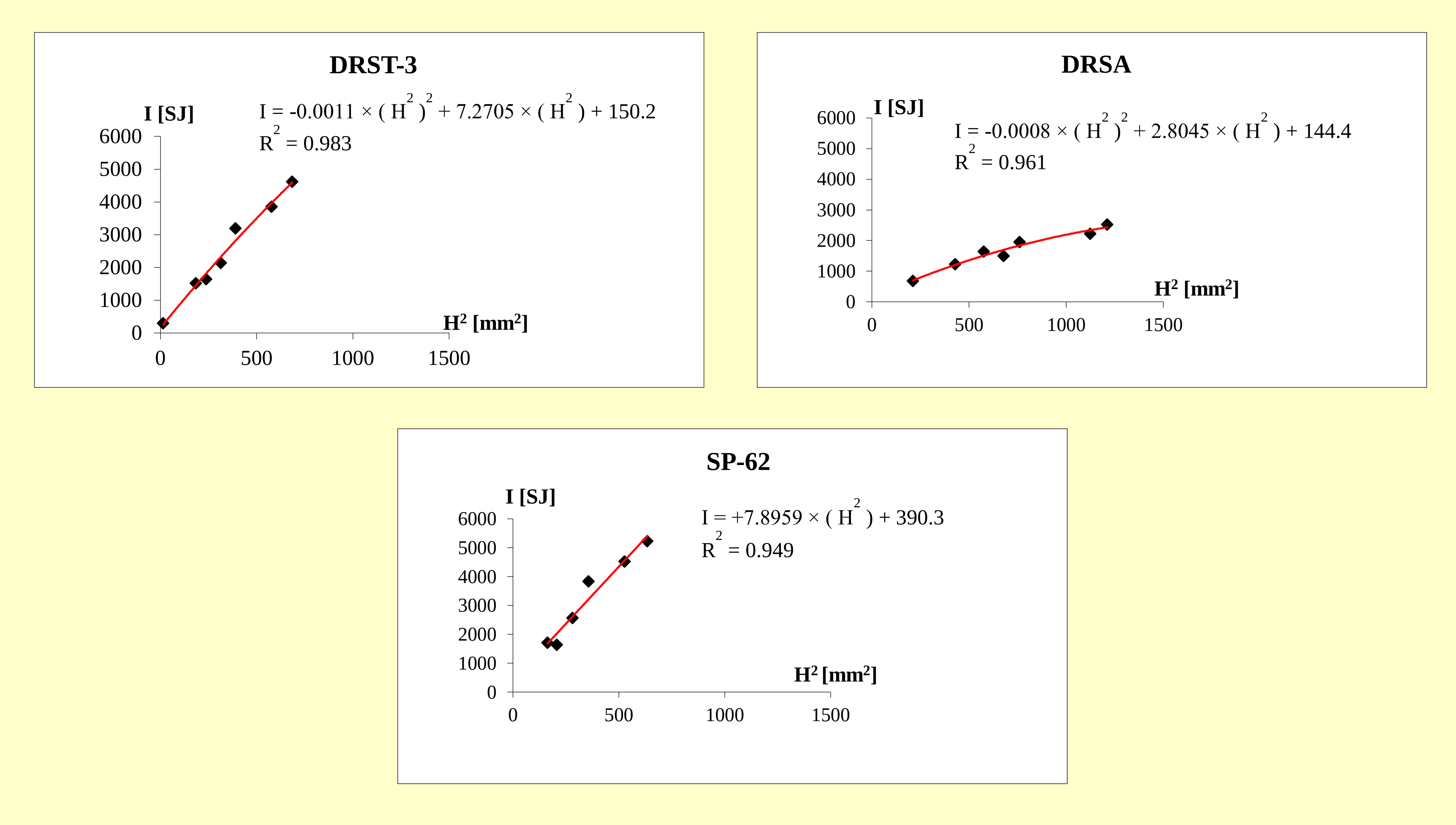

Fig.1 Relations $I = f(H^2)$ for DRST-3, SP-62 and DRSA

Tab.1 Basic data of imitators used

Imitator	L [mm]	D [mm]	h [mm]
N. 1	900	147	42
N. 2	900	147	62
N. 3	900	131	31
N. 4	900	160	55
standard DRST-3	900	128	44
standard SP-62	900	137	44
standard DRSA	900	94	35

Tab.2 Function I = f (H^2) for DRST-3, SP-62 and DRSA

	DRST-3		SP-62		DRSA	
Imitator	**H^2 [mm^2]**	**I [SJ]**	**H^2 [mm^2]**	**I [SJ]**	**H^2 [mm^2]**	**I [SJ]**
standard DRST-3	238	1638	207	1638	576	1638
standard SP-62	315	2136	282	2567	678	1498
standard DRSA	15	296	357	3830	212	678
N. 1	391	3191	527	4520	761	1946
N. 2	578	3849	163	1707	1124	2222
N. 3	185	1512	635	5222	429	1226
N. 4	685	4613			1212	2523

Tab.3 presents all technical constants needed for valuation of equipment. Thanks to that table and fig.1 you see very distinctly that SP-62 has linear relationship not parabolic one; in some cases it can be. It happened for the reason that there is absence of next needed points for higher deflections. This is handicap because we will not able to determine maximal value for dry air. When holds that a = 0, the before value is infinite. SP-62 carries a proof that the case of linear relationship occasionally can be too; however it is not any advantage.

Tab.3 Numeric values of constants for DRST-3, SP-62 and DRSA

Constants	DRST-3	SP-62	DRSA
a [SJ/mm^4]	0.0011	0	0.0008
b [SJ/mm^2]	7.2705	7.8959	2.8045
c [SJ]	150.2	390.3	144.4

Both equipment DRST-3 and SP-62 have almost identical steepness of curves. It is confirmed with constant b. However, SP-62 is a bit more sensitive. The equipment DRSA is characterized by lower steepness of curve. On the other side, constants **c** and **a,** are for DRST-3 and DRSA very close one other.

For all three ones the determination coefficients of correlation are these: $R^2 = 0.983$ for DRST-3, further, $R^2 = 0.949$ for SP-62 and, finally, $R^2 = 0.961$for DRSA. These data are high significant, because they confirm relations (7), (8) and (9). The numerically defined relationships make possible reversely manufacture such imitator for the in-advance-selected deflection. So for DRST-3 we want to have I = 3000SJ. In such case $H^2 = 418.5\ mm^2$. For D = 120 mm, L = 900 mm and for d = 90 mm I receive:

$$h = \frac{418.5 \times 900}{120 \times (120 - 90)} = 104\ \mathrm{mm}.$$

This formula presents relation (1). Due to adjustment we attain the following formula:

$$h = \frac{H^2 \times L}{D \times (D - d_s)} . \tag{10}$$

We are able to manufacture the standards characterized by the selected deflection. Here is opened way to use series of imitators simulating deflections of rocks. It is evident that the points are dispersed with certain errors around the trend curve. Their correct values can be enumerated with the help of formulas (7), (8) and (9).

It needs to add that constant **b** characterizes sensitivity of all equipment. Those having high value of **b** more sensitively distinguish changes between two different rocks. Constant **a** has again relation to the dead time of counter and the surface panel together. Constant **c** is also very important, because presents that value characterizing polyethylene when the air gap is zero and thickness of the cylinder wall is infinite.

6 Determination of wetness

Wetness of rocks/materials is defined like multiplication of the degree of water saturation and total porosity.

$$w = s_w \times p , \tag{11}$$

where s_w = the degree of water saturation, and

p = the total porosity.

Wetness of rocks varies between values 1 and 0. The value 1 is for fresh water, whereas, the value 0 presents completely dry rock/material. In this case it presents dry air. If you know deflections of fresh water and dry air, you will be able to determine **double factor of material** denoted as η_w after formula:

$$\eta_w = \frac{(I_a - I)}{(I_a - I_w)} , \tag{12}$$

where I_a = deflection of dry air [SJ],

I_w= deflection of fresh water [SJ], and

I = an arbitrary deflection being between I_a and I_w [SJ].

Both named deflections need to be enumerated. This is explained in the next chapters. Relation I = f (η_w) is depicted on fig.2. If you know the double factor, you will be very close to determination of wetness. Relation w = (η_w), can have various form. The simplest is relation being bounded by high values of wetness. It looks like that:

$$\eta_w = w .$$

However, exacter is relation holding for complete interval:

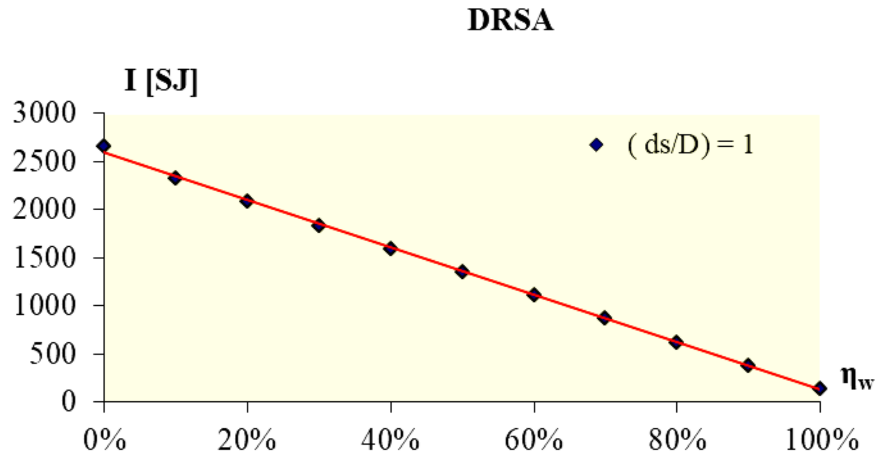

Fig.2 Relation I = f (η_w) for DRSA

$$\eta_w = \left(1 - \ln w\right)^{-1}. \tag{14}$$

Note, please, that by implication of approximate relation you receive formula (13) for high values. The relation is defined as:

$$\ln \eta_w \approx 1 - \frac{1}{w} \text{ for } w \to 1.$$

The before statement is true because holds:

$$\eta_w \approx \left\{1 - \left(1 - \frac{1}{w}\right)\right\}^{-1} \approx \left\{1 - 1 + \frac{1}{w}\right\}^{-1} \approx \left\{\frac{1}{w}\right\}^{-1} \approx w.$$

Both before mentioned relations are presented in fig.3. For direct evaluation of wetness is better to use the adjusted relation (14) what is formula (15) recorded in fig.3 as:

$$w = \exp\left\{-\left(\frac{1}{\eta_w} - 1\right)\right\} = \exp\left\{-\left(\frac{1 - \eta_w}{\eta_w}\right)\right\}, \text{for } 0 \le \eta_w \le 1. \quad (15)$$

Pay more attention to fig.3. The curve after equation (15) is placed between two lines. The first is the **line of fresh water**. It is the line in green described by equation (13). It is clear you can use such line only for values higher than 80% of wetness. The second line is the **line of the dry air**. This line is presented by horizontal x-axis with characteristic η_w. For condition $\eta_w < 20\%$ what is an interval of wet air, holds that wetness is almost zero. Thus, the red curve after formula (15) almost perfectly emerges from both deficiencies and covers completely all interval of wetness.

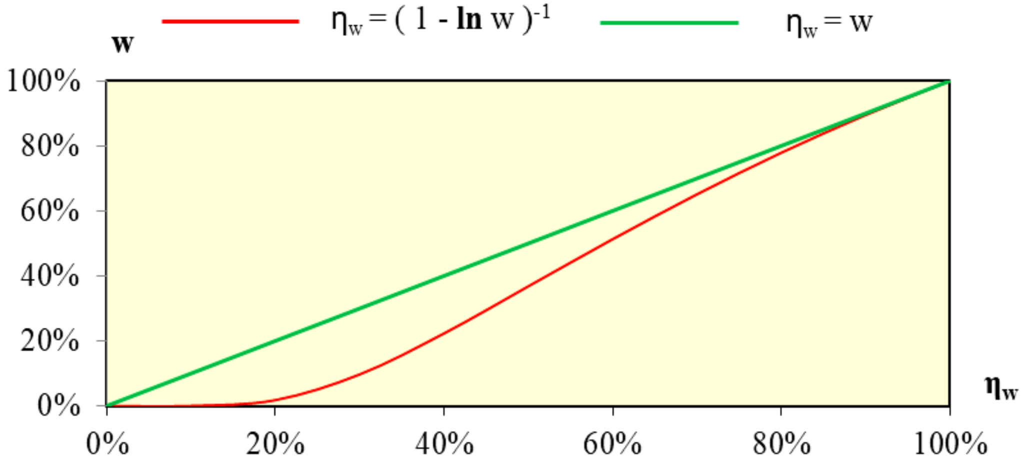

Fig.3 Relations $w = f(\eta_w)$

7 Determination of the dry air deflection

Let’s return to formula (6) again. Its first derivative is following:

$$\frac{dI}{d\left(H^2\right)} = -2a \times \left(H^2\right) + b. \tag{16}$$

On condition that formula (16) equals zero you attain new formula for maximal value of (H^2).

$$\left(H^2_{\max}\right) = \frac{b}{2a}; \text{ for a = 0 holds that } H_{\max} = \sqrt{\infty}. \tag{17}$$

By substitution of this expression into formula (6) I receive $I_a = I^{(\max)}$ which can be presented like the **deflection of dry air**. Formula of relation for dry air is following:

$$I_a = I^{(\max)} = c + \frac{b^2}{4a};\ \text{for } a = 0 \text{ holds that } I_a = \infty. \qquad (18)$$

Formula (18) expresses deflection of the dry air. Problems begin when holds that a = 0. Then maximal value equals to infinity what presents linear relationship. It is case of equipment SP – 62 in fig.1. Coefficient of linear correlation is really high; it makes $R^2 = 0.949$, whereas coefficient of polynomial correlation is significantly lower. However, linear correlation presents that detector registers all photons what is never true. And further. Deflection of the dry air is always finite, it is definitive number. Therefore is the best is to continue in modelling function $I = f(H^2)$ until you receive characteristic parabolic curvature and to use polynomial correlation of second degree even if can be worse than the linear. If holds that $a \to 0$ not $a = 0$ then you have not any problems.

8 Determination of the fresh water deflection

For $H^2 = 0$ you will receive that I = c. This expression presents the deflection of the high-pressure polyethylene. We can write that for $H^2 \to 0$ it holds that $I = I_p = c$, where I_p is deflection of polyethylene. However, polyethylene has not the same neutron characteristics like fresh water. It is all evident thanks to tab.4. The neutron source was ^{241}Am/Be. Calculation of the neutron characteristics was made according to the formulas published in RYŠAVÝ, (1985).

Tab.4 Neutron characteristics of fresh water and polyethylene

Material	**Formula**	**ρ[g/cm^3]**	**L_z [cm]**	**τ [μs]**	**D×10^5[cm^2/s]**	**L_d [cm]**	**L_M [cm]**	**L_γ [cm]**	**$L_{n,\gamma}$ [cm]**
Polyethylene	$(CH_2)_n$	0.92	9.1	173	0.26	2.1	9.3	16.5	18.9
Water	H_2O	1.00	9.5	205	0.32	2.6	9.8	15.2	18.1

We need to know how to transfer deflection I_p presenting polyethylene to deflection I_w presenting fresh water. It is possible thanks to formulas from (19) up to (21) and further formulas from (22) up to (24). Just these make us able to pass from system polyethylene – air to system fresh water – air being closer to natural environment. Polyethylene because having higher quantity of hydrogen than fresh water and its density being only tiny less than density of fresh water moderates and disperses neutrons more intensively than fresh water. It is nothing special. Methane having more hydrogen than freshwater moderates neutrons very badly as a gas. However, in the liquid phase with density equal to fresh water it would be very power moderator of neutrons, more powerful than water. This holds for equations (19) and (20).

$k_z = (I_w / I_p) = L_z^{(w)} / L_z^{(p)} = 1.0440 \ldots$ for NNM-E, epithermal neutrons. (19)

$k_M = (I_w / I_p) = L_M^{(w)} / L_M^{(p)} = 1.0538 \ldots$ for NNM-T, thermal neutrons. (20)

$k_{n,\gamma} = (I_w / I_p) = L_{n,\gamma}^{(w)} / L_{n,\gamma}^{(p)} = 0.9577 \ldots$ for NGM, gamma-photons. (21)

All other situation creates for gamma-photons having been formed after absorption of neutrons. Polyethylene is better permeable for gamma-photons than fresh water, because its density is lower than density of water. It holds that $L_{n,\gamma}^{(w)} < L_{n,\gamma}^{(p)}$ in tab.4; therefore coefficient $k_{n,\gamma} < 1$ whereas coefficients $k_z > 1$and $k_M > 1$ are. Deflections of fresh water we obtain with the help of formulas:

$I_w = k_z \times I_p \ldots$ for NNM – E, (22)

$I_w = k_M \times I_p \ldots$ for NNM – T, and (23)

$I_w = k_{n,\gamma} \times I_p \ldots$ for NGM. (24)

Tab.5 Deflections basic substances for DRST-3,SP-62 and DRSA

	DRST-3	SP-62	DRSA
I_p [SJ]	150	390	144
I_w [SJ]	144	374	138
I_a [SJ]	12164	∞	2602

Tab.5 carries three characteristics I_p, I_w and I_a. The last two of them make possible to count double factor η_w according to formula (12). Its scale is linear formed up with the help of two horizons; fresh water and dry air. Characteristics I_a and I_w present values typical for three different technical equipments using neutron source ^{241}Am/Be. The double factor makes too possible to go through double factor to wetness. The neutron logs are to be known that those registered by various well-logging companies are not same. It is caused by different calibration curves, because rock standards have different chemical composition and different matrix density, as well. Theoretically speaking, we would need to have for calibration the standards having absolutely the same chemical composition and the matrix density.

Such standards could have as the only variable their total porosity. Unfortunately, the nature does not make the rock standards which we need. We can only select such rock standards that are approximately similar one another as close as possible. And this is sometimes big problem.

Therefore the described way of construction of the calibration scale for wetness with the help of polyethylene imitators could fill those demands. Homogeneous polyethylene in combination with the air gap can present the way how to have identical surroundings for calibration. Relationship made in accordance to equation (12) for DRSA is depicted on fig.2, values of characteristic I in [SJ] are calculated after numerical data I_a and I_w for DRSA and neutron source Am/Be in tab.5. It holds that you have condition: $(d_s/D) = 1$.The characteristic denoted as d_s presents the diameter of tool; whereas, the characteristic denoted as D is not in such case the inner diameter of cylinder, but, the diameter of borehole. Transformation of the double factor to wetness is made after equation (15) depicted in fig.3.

The resulted data between units I in [SJ] and wetness you will find out in tab.6. They are counted with the help equations (14) and (12) for known I_a and I_w and wetness. Just this table makes to form the direct relation between wetness and deflections in units I in [SJ]. So you can construct function w = f (I) what means you can to each of polyethylene imitators to assign value in wetness, because you know its value I in [SJ]. Equation denoted as (25) makes possible to calibrate records directly in wetness and to determine values of standards used for controlling technical condition of equipments. The relation I = f (w) after tab.6 is identical in shape as curve in red in fig.3, however, turned about 90°.

$$w = \exp\left\{-\left(\frac{I-I_w}{I_a-I}\right)\right\} \approx \eta = \left(\frac{I_a-I}{I_a-I_w}\right) = -\left(\frac{1}{I_a-I_w}\right)\times I + \left(\frac{I_a}{I_a-I_w}\right). \qquad (25)$$

The polyethylene standards have too than its own value of wetness being typical for equipment and the neutron source used. It cannot be excluded that those common imitators used for three different equipments have then three various values of wetness. It offers too to calibrate apparatuses not in units I [SJ], but directly in wetness w after the known values characterizing polyethylene standards. Scale of the records in wetness after formula (25) can be either exponential or sometimes linear. Values of standards can be used for controlling of the selected scale after relation I = f (w). This is in tab.6**;** data of table join both boundary points for w = 0% and w = 100%.

I can give an example. All three equipments denoted as DRST-3, SP- 62 and DRSA have the load-bearing standard having the common value I =1638 SJ for all above mentioned equipments. This one is denoted as standard DRST-3. Apparatus DRST-3 has deflections I_w = 144 SJ and I_a = 12 164 SJ. After formula (12) you have η_w = 0.876 and thanks to formula (15) wetness is w = 0.868. Apparatus DRSA has other fundamental deflections: I_w = 138 SJ and I_a = 2 602 SJ. Then you receive η_w = 0.391, however, wetness is strong lower yet, because w = 0.211. For apparatus denoted as SP – 62 we are not even able to make such counting, because although I_w = 374 SJ, so the next value denoted as I_a is, however, infinitely high.

Tab.6 Basic data of DRSA for relation w = f (I)

DRSA	
w [%]	**I [SJ]**
0	2602
10	1855
20	1658
30	1483
40	1315
50	1146
60	971
70	786
80	586
90	372
100	138

9 Conclusions

- The relationship between the output deflection ISJ and the apparent thickness of porous rock of the squared cylindrical wall H^2 had been proved. Relation I = f (H^2) varies between two boundaries; it is the dry air and the fresh water points derived with the help of polyethylene standard.
- Owing to the mentioned relation it is possible reversely to calculate the thickness of wall of the cylinder for the known characteristics D, L and d_s. It enables us to present the series of cylinders having the in-advance-selected deflections covering large interval of ones. Such cylinders are denoted like imitators, because they simulate the deflections evoked of rocks.
- Relation I = f (H^2) reached with the help of imitators presents significant technical characteristic of the registering equipment. That relation is characterized with constants a, b and c characterizing fully the used equipment. Thus, you can calibrate different measuring instruments of various producers.

- Relation I = f (H^2) is always the polynomial of the second degree, can tend to linear one, however, never it is the real linear one. It results in that the constant, denoted as a**,** is very important; can be close to zero, but never equal to zero.
- Further to the preceding point; relation I = f (H^2) needs to have enough imitators making possible to model all relation as polynomial of the second degree which has typical curvature. Only in so way you can determine non-null value of characteristic a.
- The double factor of material denoted as η_w can be accepted like the characteristic making possible interpretation of the rock wetness. The scale of wetness can be linear, but more frequently non-linear; uses two basic points, the dry air one and the fresh water one.
- The point of dry air presents the maximal deflection of relation I = f (H^2); the point of fresh water is derived from deflection of polyethylene due to known relation I_p = c with the help of formulas from (22) up to (24).
- Thanks to tab.6 you can construct function w = f (I) making you to assign values of wetness to each of polyethylene standards. These can be then used for direct calibration in wetness and for values of standards serving for controlling technical condition of equipments.

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