A NOVEL TABULAR METHOD FOR ESTIMATION OF WATER FLOW RATE AT THE HYDRANT NOZZLE

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Abstract: *In order to estimate the flow rate of water at the hydrant nozzle, the standards such as SRPS Z.C1.050:1989 and DIN 14 440 cannot be applied to all types of nozzles that obey the requirements of reference standards SRPS EN 671-1: 2015 or SRPS EN 671-2:2015. In this paper the authors present tables that can be used for estimating flow in function of pressure and flow characteristic of hydrant nozzle with orifice diameter of 8 and 16 mm.*
Keywords: Hydrant nozzle, Flow characteristic of nozzle

1. INTRODUCTION

The most important numerical parameters for fire hydrant operation are: water static pressure, dynamic pressure and flow rate. During hydrant periodic testing, that is mandatory to be carried twice per year, static pressure is measured at each internal wall-mounted hydrant cabinet. Dynamic pressure is measured at the cabinet with the most unfavourable hydraulic position (where the lowest pressure values are expected, i.e. on the highest floor or the most distant form water source), while for other cabinets dynamic pressure is calculated. Flow rate at each cabinet can be determined by calculation or measurement. In paper [1], the procedure for determining the mentioned hydrant parameters is presented, as well as the procedure for determining the flow characteristics of hydrant nozzle. Standards [5] and [6], which are mandatory for application in Serbia according to the rulebook [3], define the minimum flow characteristic depending on the nozzle diameter and the minimum flow rate at pressures of 2.0 bar, 4.0 bar and 6.0 bar. In Serbia, the standard [4] is used to calculate the hydrant flow rate. This standard is practically a translation of the standard [8], in terms of text, equations and symbols that are identical, while the tables and nomograms are different. The difference is that in the standard [8] the flow rates resolution in tables and nomograms equals to 1 l/min while in the standard [5] it equals to 5 l/min. Please note that before the adoption of harmonized regulations [5], [6] and [7], the nozzle geometry and the procedure of nozzle manufacturing were standardized, but not the nozzle flow characteristics.
In a series of measurements that were carried out at the Centre for Fire Protection Engineering of the Faculty of Mechanical Engineering in Belgrade, it was shown that the flow characteristics of nozzles that are offered in Serbian market and that meet the requirements defined by standards [5] and [6] are significantly different from the flow characteristics that are obtained according to standards [4] and [8]. In paper [2], it was stated that for nozzles with a nozzle diameter of 12 mm, which are prescribed by regulation [3] for mandatory use when testing internal hydrant installations, the flow characteristic determined by measurement ranged from 76 to 83, while the flow characteristic determined by procedure given in standard [4] equals to 96 and by using standard [8] equals to 94. Hence, it can be

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concluded that tables and nomograms given in standards [4] and [8] are not applicable for hydrant nozzles that are present on the market.
In paper [2], tables are given in which the flow rates of water at hydrant nozzle with a nozzle diameter of 12 mm are shown as a function of pressure, for different nozzle flow characteristics. In this paper, tables will be presented in which the flow rates of water at nozzles with nozzle diameters of 8 mm and 16 mm can be determined as a function of pressure, for different nozzle flow characteristics.

2. DETERMINATION OF NOZZLE FLOW CHARACTERISTICS

The procedure for determining the flow characteristic of the nozzle is given in detail in other paper [1]. Here it will be presented briefly. For the standard hydrant nozzle, which is shown in Fig. 1, the water flow rate through a constant nozzle orifice is directly proportional to the square root of the water pressure value. The proportionality coefficient is called the flow characteristic of the nozzle (*K*). Therefore, the relation can be expressed as:

$$Q = K\sqrt{P} \tag{1}$$

Where,
P – pressure [bar];
Q – flow rate [l/min];
K – flow characteristics [$l/(\min\sqrt{bar})$].

When determining the flow characteristic, a pressure gauge (manometer) is mounted between the hydrant nozzle and hydrant hose. The nozzle to be tested is directed outdoor or to a drainage pit. By adjusting the valve position at the hydrant cabinet, the pressure in the installation is controlled. The flow is measured with an ultrasonic flowmeter, which is placed at the water supply pipe to the hydrant cabinet. Pressure (*P*) is set at fixed values of 2.0 bar, 2.5 bar, 3.0 bar; 3.5 bar, 4.0 bar, 4.5 bar, 5.0 bar, 5.5 bar and 6.0 bar. The estimation of the value of the nozzle flow characteristic is determined by the application of the least squares method [1]:

$$K = \frac{\sum_i Q_i\sqrt{P_i}}{\sum_i P_i} = \frac{\sum_i Q_i\sqrt{P_i}}{36}. \tag{2}$$

Figure 1. Standard hydrant nozzle (orifice diameter 16 mm, hose connection flange Ø75mm - type B, length 410 mm, height 126 mm, weight 1.75 kg)
Source: https://tehnoprom.rs

3. TABLES FOR CALCULATING FLOW RATE AS A FUNCTION OF PRESSURE

In Table 1, results are presented for a nozzle with an orifice diameter of 8 mm. Such nozzles are used at the internal hydrant cabinets in accordance with the standard [4]. According to the rulebook [3], this type of nozzles can be installed on internal hydrant networks in residential and commercial buildings that have a maximum of 5 above-ground floors and the technological process category is K3, K4 or K5. For such hydrant installations semi-rigid hoses wound on a reel can be applied. Their advantage is that the maximum permitted distance from the point in the protected area to the hose connection in hydrant cabinet is 30 m, which is greater than the connections defined by the standard [5].

The water flow rate [l/min] is expressed as a function of the pressure (*P*) [bar] and the flow characteristics of the nozzle (*K*) as shown in Table 1. It was adopted that the pressure value should be regulated with step of 0.5 bar, which ensures an accuracy of 0.25 bar, because greater accuracy is not achieved even by measuring with standard manometers.

Table 1. Flow rate at nozzle [l/min] as a function of pressure *P* [bar] and nozzle flow characteristics *K* – for nozzle orifice diameter of 8 mm

Source: *original author's*

K/P	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
28	40	44	48	52	56	59	63	66	69	71	74	77
29	41	46	50	54	58	62	65	68	71	74	77	79
30	42	47	52	56	60	64	67	70	73	76	79	82
31	44	49	54	58	62	66	69	73	76	79	82	85
32	45	51	55	60	64	68	72	75	78	82	85	88
33	47	52	57	62	66	70	74	77	81	84	87	90
34	48	54	59	64	68	72	76	80	83	87	90	93
35	49	55	61	65	70	74	78	82	86	89	93	96
36	51	57	62	67	72	76	80	84	88	92	95	99
37	52	59	64	69	74	78	83	87	91	94	98	101
38	54	60	66	71	76	81	85	89	93	97	101	104
39	55	62	68	73	78	83	87	91	96	99	103	107
40	57	63	69	75	80	85	89	94	98	102	106	110
41	58	65	71	77	82	87	92	96	100	105	108	112
42	59	66	73	79	84	89	94	98	103	107	111	115
43	61	68	74	80	86	91	96	101	105	110	114	118
44	62	70	76	82	88	93	98	103	108	112	116	120
45	64	71	78	84	90	95	101	106	110	115	119	123

In Table 2, results are presented for a nozzle with an orifice diameter of 16 mm. This type of nozzles are defined by regulation [3] for mandatory use when testing external hydrant installations. The regulation also define minimum dynamic pressure at the connection of the external hydrant network of 3 bar and the flow rate of 5 l/s.

As in previous case the pressure values from 2.0 to 7.5 bar in Table 2 are with step of 0.5 bar, which ensures an accuracy of 0.25 bar, because greater accuracy is not achieved even by measuring with standard manometers.

Table 2. Flow rate at nozzle [l/min] as a function of pressure *P* [bar] and nozzle flow characteristics *K* – for nozzle orifice diameter of 16 mm

Source: *original author's*

K/P	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
170	240	269	294	318	340	361	380	399	416	433	450	466
171	242	270	296	320	342	363	382	401	419	436	452	468
172	243	272	298	322	344	365	385	403	421	439	455	471
173	245	274	300	324	346	367	387	406	424	441	458	474
174	246	275	301	326	348	369	389	408	426	444	460	477
175	247	277	303	327	350	371	391	410	429	446	463	479
176	249	278	305	329	352	373	394	413	431	449	466	482
177	250	280	307	331	354	375	396	415	434	451	468	485
178	252	281	308	333	356	378	398	417	436	454	471	487
179	253	283	310	335	358	380	400	420	438	456	474	490
180	255	285	312	337	360	382	402	422	441	459	476	493

181	256	286	314	339	362	384	405	424	443	461	479	496
182	257	288	315	340	364	386	407	427	446	464	482	498
183	259	289	317	342	366	388	409	429	448	467	484	501
184	260	291	319	344	368	390	411	432	451	469	487	504
185	262	293	320	346	370	392	414	434	453	472	489	507

4. CONCLUSION

In the former standards that were used before the adoption of harmonized regulations in Serbia in 2018, the geometry of the hydrant nozzle and the procedure of its production were standardized, but not the flow characteristics. In a series of measurements that were carried out at the Centre for Fire Protection Engineering of the Faculty of Mechanical Engineering in Belgrade, it was shown that the flow characteristics of the nozzles that are sold on Serbian market and that are in accordance with the harmonized regulations have lower flow characteristics than those for the nozzles defined by the standards [4] and [8]. Therefore, in this paper, tables are given in which the flow rate [l/min] through a nozzle with orifice of 8 mm and 16 mm in diameter is expressed as a function of the pressure [bar] and the flow characteristics of the nozzle. The use of these tables can significantly facilitate the work of engineers and technicians who carry out the initial and periodic testing of the performance of internal hydrant installations.

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