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INFLUENCE OF MANUFACTURE OF THE WINDOW AND THE FITTINGS USED ON THE FINAL QUALITY OF THE WINDOW

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ABSTRACT

The window as a product used in construction aims to provide natural light and the possibility for ventilation in the building where it is placed, but at the same time to protect the room from external influences such as wind and rain and to prevent uncontrolled cooling or heating of the building it is built-in. Given the purpose, a quality window is one that protects against air penetration, water penetration and it ensures wind resistance. The window is a complex product that is composed of different parts that can be made of different materials. As part of this research, windows made by different manufacturers and made from different materials will be tested, but they are with profile identical to the profile used for the frame and the window sash. The main goal is to prove whether the construction of the window and the fittings used have an impact on the final quality of the window. In order to do the research, ten windows will be tested in accordance with the European norms EN 1026: 2016 (test method for air permeability), EN 1027: 2016 (test method for water permeability), EN 12211: 2016 (test method for wind resistance).

Key words: construction carpentry, window, air permeability, water permeability, wind resistance, PVC profiles.

1. INTRODUCTION

The quality of a product is a characteristic worth being considered when it is proved that the product meets the needs it is produced for. Having in mind that the purpose of one window is to provide light and desirable ventilation of a room, and, at the same time, to protect the object from external influences such as air permeability, water tightness and resistance to wind, we state that the window is of a higher quality as much as it can guarantee all these conditions. The window as a product is of complex content from diverse materials and parts. As different parts of the window we list the following ones below:

- Frame – the frame is a construction of the jamb and the construction of the side jamb.
- Glass – the content of the construction that can be made of glass and glass packet.
- Hinge – design, window handle, window lockers which offer the sliding of the window, meaning, the possibility for its opening and closing.

Throughout the production of window parts, different types of materials are used:

- Frame – wood profiles from different types of wood, PVC profiles, aluminum profiles, as well as a combination of these materials.
- Glass – one glass (4mm, 6mm), glass packet out of two, three or four glasses with different combinations of glasses layered with different protective paints.
- Fittings – metal, plastic, rubber.

The field in which this research is directed is a current topic that is of great importance for analysis, especially in the field of energy efficiency. Heating and cooling of one object is enabled through the energy consumption. The energy efficiency policy is an integral part of the politics in the field of energetics, economy, sustainable development and protection of the environment, and it is conducted through measures and activities for efficient energy use. When choosing windows, a great attention is dedicated to how much they are going to protect the object from external influences and how much energy they are going to save.

2. MATERIALS AND METHODS

As a subject of research, the windows from different manufacturers that use diverse types of fittings are going to be taken into consideration, yet, they are made of identical profile of case frame and side jamb. The windows shall undergo research in terms of the quality. So as to gain sufficient number of results which can be compared, the research will be conducted on ten windows made by different manufacturers. There are ten samples and they all have to be made of PVC brand profile ALUPLAST, model IDEAL 4000.

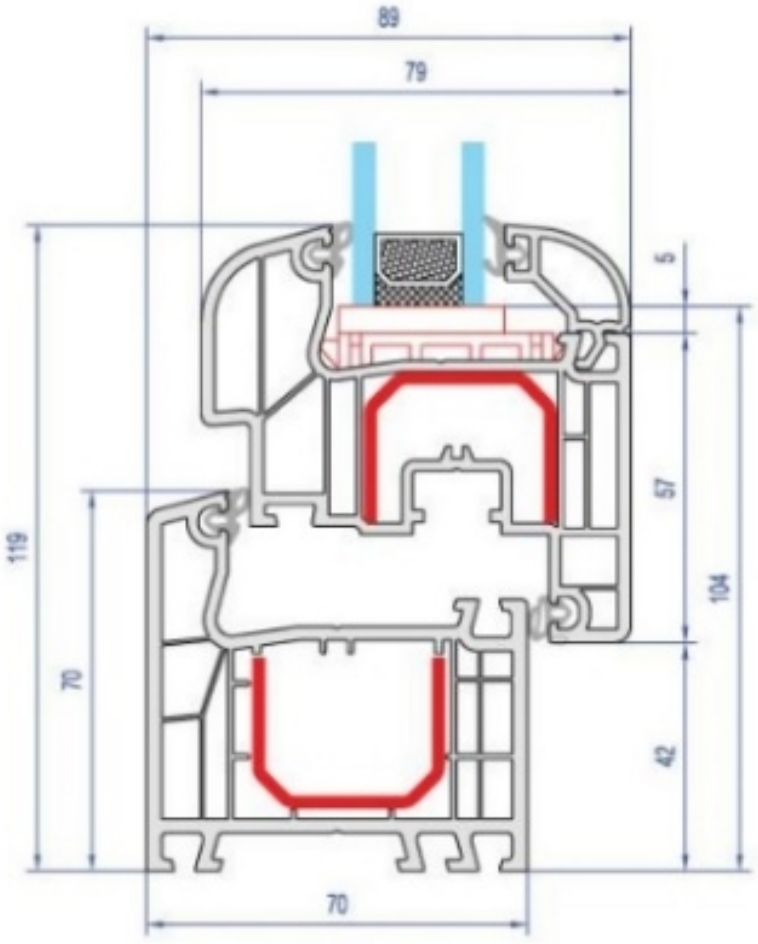

Figure 1. *ALUPLAST IDEAL 4000*

The samples which are subject of the research shall be tested on a device for testing windows by the manufacturer K. Schulten GmbH&Co.KG model KS 3040/650 PC-hr. The methods used for testing are "EN 1026:2016 Windows and doors - Air permeability - Test method" – meaning a method that proves how much air permeability there is on different force, "EN 1027:2016 Windows and doors - Water tightness - Test method" – i.e., a method that proves the strength of resistance to rainfall and "EN 12211:2016 Windows and doors - Resistance to wind load - Test method" – i.e., a method that proves the resistance while there is wind load.

3. RESULTS

3.1. Results – air permeability

Table 1. *Sample 1 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		49	100	150	200	250	302	453	600	
Air permeability	m³/h	15,88	24,81	33,03	42,15	52,42	64,59	113,69	175,56	General class
Seam length	m³/(h/m)	2,74	4,28	5,69	7,27	9,04	11,14	19,60	30,27	
Class		2	2	2	2	2	2	0	0	2
Window surface	m³/(h/m²)	8,49	13,27	17,66	22,54	28,03	34,54	60,79	93,98	
Class		2	2	2	2	2	2	0	0	2
										2

Table 2. *Sample 2 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		49	102	150	201	251	303	451	596	
Air permeability	m³/h	14,18	23,37	30,97	38,14	45,32	52,43	75,07	100,15	General class
Seam length	m³/(h/m)	2,26	3,59	4,71	5,80	6,90	7,98	11,43	15,24	
Class		2	2	2	2	2	2	0	0	2
Window surface	m³/(h/m²)	7,57	11,92	15,80	19,46	23,12	26,75	38,30	51,10	
Class		2	2	2	2	2	2	0	0	2
										2

Table 3. *Sample 3 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		51	101	149	201	251	300	451	598	
Air permeability	m³/h	14,82	23,20	30,78	38,14	45,33	52,45	75,30	100,38	General class
Seam length	m³/(h/m)	2,24	3,53	4,73	5,80	6,90	7,97	11,46	15,29	
Class		2	2	2	2	2	2	0	0	2

Window surface	m³/(h/m²)	7,55	11,90	15,78	19,46	23,12	26,76	38,33	51,13	
Class		2	2	2	2	2	2	0	0	2
										2

Table 4. *Sample 4 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		50	100	150	201	251	301	454	604	
Air permeability	m³/h	2,07	3,22	4,13	4,93	5,60	6,20	7,86	9,38	General class
Seam length	m³/(h/m)	0,50	0,79	1,01	1,20	1,36	1,51	1,92	2,29	
Class		3	3	3	3	4	4	4	4	3
Window surface	m³/(h/m²)	1,82	2,82	3,62	4,32	4,91	5,44	6,89	8,23	
Class		4	4	4	4	4	4	4	4	4
										4

Table 5. *Sample 5 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		50	101	150	200	251	301	452	604	
Air permeability	m³/h	7,23	10,77	14,09	16,66	18,92	21,00	26,25	30,97	General class
Seam length	m³/(h/m)	1,29	1,93	2,52	2,99	3,39	3,76	4,70	5,55	
Class		3	3	3	3	3	3	3	3	3
Window surface	m³/(h/m²)	5,56	8,28	10,84	12,81	14,55	16,16	20,19	23,82	
Class		3	3	3	3	3	3	3	3	3
										3

Table 6. *Sample 6 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		52	102	150	202	251	302	451	604	
Air permeability	m³/h	1,31	2,10	2,78	3,41	4,00	4,55	6,20	7,87	General class

Seam length	m³/(h/m)	0,36	0,57	0,76	0,93	,09	1,24	1,70	2,15	
Class		4	4	4	4	4	4	4	4	4
Window surface	m³/(h/m²)	1,37	2,19	2,90	3,55	4,17	4,74	6,46	8,19	
Class		4	4	4	4	4	4	4	4	4
										4

Table 7. *Sample 7 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	General class
Pa actual		50	100	150	201	251	300	453	601	
Air permeability	m³/h	3,15	4,93	6,51	8,56	10,76	13,46	26,25	43,81	
Seam length	m³/(h/m)	0,86	1,34	1,77	2,33	2,93	3,67	7,15	11,94	
Class		3	3	3	3	3	3	0	0	2
Window surface	m³/(h/m²)	3,28	5,13	6,78	8,91	11,21	14,02	27,34	45,63	
Class		3	3	3	3	3	3	0	0	2
										2

Table 8. *Sample 8 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	General class
Pa actual		50	100	150	202	251	302	453	603	
Air permeability	m³/h	0,88	1,65	2,20	2,66	3,07	3,47	4,58	5,93	
Seam length	m³/(h/m)	0,22	0,41	0,54	0,66	0,76	0,86	1,13	1,46	
Class		4	4	4	4	4	4	4	4	4
Window surface	m³/(h/m²)	0,78	1,47	1,96	2,37	2,74	3,10	4,09	5,30	
Class		4	4	4	4	4	4	4	4	4
										4

Table 9. *Sample 9 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		51	100	151	201	251	303	451	603	
Air permeability	m^3/h	2,20	3,42	4,41	5,20	5,92	6,55	7,96	8,84	General class
Seam length	$m^3/(h/m)$	0,78	1,20	1,55	1,83	2,08	2,31	2,80	3,11	
Class		3	3	3	3	3	3	3	3	3
Window surface	$m^3/(h/m^2)$	3,49	5,42	6,99	8,26	9,39	10,40	12,64	14,04	
Class		3	3	3	3	3	3	3	3	3
										3

Table 10. *Sample 10 – air permeability*

Pa normal		50	100	150	200	250	300	450	600	
Pa actual		50	100	150	200	250	301	451	603	
Air permeability	m^3/h	1,45	2,40	3,14	3,80	4,39	4,95	6,72	9,02	General class
Seam length	$m^3/(h/m)$	0,38	0,63	0,82	1,00	1,15	1,30	1,74	2,37	
Class		4	4	4	4	4	4	4	4	4
Window surface	$m^3/(h/m^2)$	1,30	2,14	2,80	3,39	3,92	4,42	6,00	8,06	
Class		4	4	4	4	4	4	4	4	4
										4

3.2. Results – water tightness

Table 11. *Sample 1 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	200	00:05:00	00:00:00	00:01:17	**NOT OK**

Table 12. *Sample 2 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	200	00:05:00	00:00:00	00:00:00	**OK**
A6	250	251	00:05:00	00:00:00	00:00:00	**OK**
A7	300	352	00:05:00	00:00:00	00:00:37	**NOT OK**

Table 13. *Sample 3 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	200	00:05:00	00:00:00	00:00:00	**OK**
A6	250	251	00:05:00	00:00:00	00:04:12	**NOT OK**

Table 14. *Sample 4 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	149	00:05:00	00:00:00	00:00:00	**OK**
A5	200	200	00:05:00	00:02:12	00:00:00	**NOT OK**

Table 15. *Sample 5 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	149	00:05:00	00:00:00	00:00:00	**OK**
A5	200	201	00:05:00	00:00:00	00:00:00	**OK**
A6	250	250	00:05:00	00:00:00	00:02:03	**NOT OK**

Table 16. *Sample 6 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	-15	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	101	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	201	00:05:00	00:00:00	00:00:00	**OK**
A6	250	250	00:05:00	00:00:00	00:00:00	**OK**

A7	300	302	00:05:00	00:00:00	00:00:00	**OK**
A8	450	449	00:05:00	00:01:12	00:00:00	**NOT OK**

Table 17. *Sample 7 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	-14	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:04	**NOT OK**

Table 18. *Sample 8 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	100	00:05:00	00:00:00	00:00:00	**OK**
A4	150	149	00:05:00	00:00:00	00:00:00	**OK**
A5	200	199	00:05:00	00:00:00	00:00:00	**OK**
A6	250	249	00:05:00	00:00:00	00:00:00	**OK**
A7	300	301	00:05:00	00:00:00	00:00:00	**OK**
A8	450	451	00:05:00	00:00:00	00:00:00	**OK**
A9	600	602	00:05:00	00:00:00	00:00:04	**NOT OK**

Table 19. *Sample 9 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	0	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	99	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	200	00:05:00	00:00:00	00:00:00	**OK**
A6	250	251	00:05:00	00:00:00	00:00:00	**OK**
A7	300	300	00:05:00	00:00:00	00:00:00	**OK**
A8	450	448	00:05:00	00:01:12	00:00:00	**NOT OK**

Table 20. *Sample 10 – water tightness*

Class	Pressure in Pa		Time	Water entrance		Observation
	Normal	Actual		Dripping	Flowing	
A1	0	-15	00:15:00	00:00:00	00:00:00	**OK**
A2	50	50	00:05:00	00:00:00	00:00:00	**OK**
A3	100	101	00:05:00	00:00:00	00:00:00	**OK**
A4	150	151	00:05:00	00:00:00	00:00:00	**OK**
A5	200	201	00:05:00	00:00:00	00:00:00	**OK**
A6	250	250	00:05:00	00:00:00	00:00:00	**OK**
A7	300	302	00:05:00	00:00:00	00:01:03	**NOT OK**

3.3. Results – resistance to wind load

Table 21. *Resistance to wind load*

	pressure					suction				
Class	1	2	3	4	5	1	2	3	4	5
Absolute pressure	600Pa	1200Pa	1800Pa	2400Pa	3000Pa	-600Pa	-1200Pa	-1800Pa	-2400Pa	-3000Pa
Absolute pressure actual Sample 1			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 2			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 3			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 4			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 5			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 6			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		
Absolute pressure actual Sample 7		1200 Pa					-1200 Pa			
Observation		**OK**					**OK**			
Absolute pressure actual Sample 8				2400 Pa					-2400 Pa	
Observation				**OK**					**OK**	
Absolute pressure actual Sample 9				2400 Pa					-2400 Pa	
Observation				**OK**					**OK**	
Absolute pressure actual Sample 10			1800 Pa					-1800 Pa		
Observation			**OK**					**OK**		

4. CONCLUSION

From the results analyzed and their comparison with the results of the special samples, one can confirm the following:

- The window construction, as well as the fittings used, have a significant influence on the air permeability of the window. Out of the tested samples that are made of identical profiles, the results obtained are very different, showing high, medium and low quality in terms of the air permeability of the window.

- The window construction, as well as the fittings used, have a significant influence on water tightness of the window. Out of the tested samples that are made of identical profiles, the results obtained are very different, showing high, medium and low quality in terms of water tightness of the window. From the presented results, it is obvious that some samples cannot withstand 20 minutes rain with 50 Pa pressure, while another sample withstands 50 minutes with 450 Pa pressure.

- The window construction, as well as the fittings used have a significant influence on resistance to wind. Out of the tested samples that are made of identical profiles, during the resistance to wind, certain samples withstand 1200Pa, and others 2400 Pa.

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