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METAL MATERIALS FOR THE SAFETY OF GOODS AND PEOPLE

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Abstract: Metallic materials can be used in the field of safety of goods and people, provided that they ensure, due to their technical qualities, but also through the way of use, the necessary parameters to ensure compliance against exposure to risks, such as those of a thermal nature. The lack of ensuring some technical characteristics, necessary for the response to the risk, can lead to major losses, for human safety and the goods. For checking the resistance of materials subjected to thermal action, by any analytical method, are based on the results of experimental tests. Sheets used as metal screens for protection against thermal action are made of alloy steels. The tests were performed for galvanized sheet with a thickness of 0.5 mm. The experiments that will be presented were carried out in the laboratories of the Faculty of Materials Science and Engineering Bucharest and at the research and testing laboratory on safety of constructions, INCD Urban–INCERC Bucharest.
Keywords: steel, protection, metallic material, safety

1. INTRODUCTION

Analytical methods for checking the resistance of metallic materials subjected to thermal action are general and particular, applicable to types of elements [1] [2] [3], specified by the constituent material [5]. Alternative methods for checking the resistance of materials subjected to thermal action, by any analytical method [4], are based on the results of experimental tests. In this field there are several types of metals and alloys used.

Sheets used as metal screens for protection against thermal action are made of alloy steels, and as the main alloying elements we can list: Cu, Si, Mn, P, S, Al, Ti, V, Cr, Mo, Nb. In addition, because of the application of the zinc layer, the galvanized sheet that we tested, acquires a series of attributes, such as durability and corrosion resistance. In the propagation of thermal action, convective-radiant processes predominate, an important role is played by the movement of gases and the resulting reactive products, vertically or horizontally [13].

The verification, if the accepted model exposed to thermal action, according to the temperature-time curve ISO 834 [14], can be done based on an analysis of the evolution of some physical parameters, which are monitored, so that the results can be compared with some safety terminals accepted for compliance, regarding the safety of goods and people [10] [11]. As an example, in the studies presented by Poh W. - Tenability in Building: Limits and Design Criteria, Australia, Spring, 2010 [6] [7] [8] [9], one of the performance criteria (tolerance) regarding life safety is "to ensure that the amount of radiant heat , the density of the radiant heat flux received, not to exceed the threshold of severe skin pain of 2.5 kW/m^2, within a height limit of 2 m above the floor level from the source. Also on this height limit, it is necessary that the temperature does not exceed 100ºC".

Figure 1. Experiment "0.5mm metallic protection sheet exposed to the action of temperature"

2. RESEARCH METHODOLOGY

The thermal action check, if the accepted model is the temperature-time curve ISO 834 [14], can be done based on an analysis of the evolution of some physical parameters that are monitored so that the results can be compared with some safety terminals accepted for compliance, as presented above.

The experimental stand, which we designed, in order to test the materials from which the screens used as

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safety are made, is composed of dismountable sub-assemblies, so that it can be easily transported at a distance. The experiments that will be presented were carried out in the laboratories of the Faculty of Materials Science and Engineering Bucharest and at the research and testing laboratory on safety of constructions, INCD Urban-INCERC Bucharest (Figure 1).

We propose to measure the density of the heat flow and the evolution of the temperature gradient, in the area protected by the tin screen, against the action of a thermal that can spread from inside the building, through the glazed area. The tests were performed for galvanized sheet with a thickness of 0.5 mm. The ambient conditions were, on 22.12.2023, humidity 71%, and temperature Tambient= 18.5^{0}C. The recorded temperature values and flow values appear in tables 1, 2 and 3.

Table 1. Recorded results for 0.5mm thick galvanized sheet

Time	Temp. contact metal sheet h=1,5m (°C)	Temp.1 (internal thermocouple 1) T1 (°C)	Temp.2 (internal thermocouple 2) T2 (°C)	Temp. (at dist. 200 mm ext. la h=1,5m) (°C)	Temp. ISO 834 (°C)	Temp. average = (T1+T2)/2 (°C)
12/22/2023 3:31:46 PM	224	343	343	32	349	343
12/22/2023 3:32:46 PM	356	488	569	57	445	529
12/22/2023 3:33:46 PM	345	607	604	76	502	606
12/22/2023 3:34:46 PM	328	632	622	78	544	606
12/22/2023 3:35:46 PM	323	632	648	87	576	640
12/22/2023 3:36:46 PM	331	656	663	87	603	660
12/22/2023 3:37:46 PM	323	670	681	96	626	676
12/22/2023 3:38:46 PM	346	687	694	98	645	690
12/22/2023 3:39:46 PM	343	701	706	101	663	703
12/22/2023 3:40:46 PM	332	718	709	106	678	713
12/22/2023 3:41:46 PM	344	729	726	112	693	727
12/22/2023 3:42:46 PM	612	740	737	118	705	739
12/22/2023 3:43:46 PM	359	748	744	121	717	746
12/22/2023 3:44:46 PM	358	757	756	126	728	757
12/22/2023 3:45:46 PM	343	767	760	136	739	764
12/22/2023 3:46:46 PM	339	774	774	134	748	774
12/22/2023 3:47:46 PM	327	782	776	133	757	779
12/22/2023 3:48:46 PM	325	791	789	140	766	790
12/22/2023 3:49:46 PM	335	796	792	145	774	794
12/22/2023 3:50:46 PM	344	802	799	146	781	801
12/22/2023 3:51:46 PM	343	811	809	91	789	810
12/22/2023 3:52:46 PM	252	650	653	51	796	652
12/22/2023 3:53:46 PM	186	526	536	43	802	531
12/22/2023 3:54:46 PM	145	451	463	34	809	457
12/22/2023 3:55:46 PM	120	400	411	29	815	406
12/22/2023 3:56:46 PM	108	362	373	26	820	367
12/22/2023 3:57:46 PM	98	333	343	32	826	338

Table 2. Recorded values of the heat flow for the 0.5mm metallic sheet, at a height of 1.5m and at a distance of 200 mm, in the area considered as an escape route

Minute	Termal Flux val. min.kW/m²	Termal Flux val. max. kW/m²	Termal Flux average kW/m²
1	0,02	0,02	0,02
2	0,53	0,55	0,54
3	1,83	1,87	1,85
4	3,25	3,26	3,25
5	2,99	3	3
6	2,91	2,94	2,92
7	2,99	3,01	3
8	3,24	3,25	3,25
9	3,3	3,3	3,3
10	3,91	3,92	3,92
11	3,52	3,54	3,53
12	3,6	3,61	3,6
13	4,32	4,33	4,33
14	4,37	4,37	4,37
15	4,4	4,42	4,41
16	4,78	4,8	4,79
17	4,98	4,99	4,99
18	4,93	4,94	4,93
19	4,91	4,94	4,92
20	5,17	5,19	5,18
21	5,45	5,45	5,45
22	5,58	5,61	5,59
23	4,23	4,35	4,29
24	1,37	1,39	1,38
25	0,87	0,88	0,88

Table 3. Recorded values of the thermal flow for 0.5mm metallic sheet, at a height of 1.5 m and at a distance of 200 mm in the vicinity of the sheet, in the area considered as an escape route, at decisive moments

Decisive moments	Val. flux Min. kW/m²	Val. flux Max. kW/m²	Val. average kW/m²
Start	0,02	0,02	0,02
For value of 1 KW/m²	0,99	1,01	1,00
For value of 2,5 KW/m² (<2minute)	1,47	1,51	1,49
For value of > 2,5 KW/m² (<10minute)	2,49	2,52	2,505
For value of 3 KW/m²(<10minute)	3,00	3,00	3,00
For value of 4,5 KW/m² (<16 minute)	4,49	4,50	4,50

3. THE RESULTS OBTAINED

As we observed above, in tables 4, 5 and 6, all the values determined after the test show us that the tested board does not fall within the safety limits.

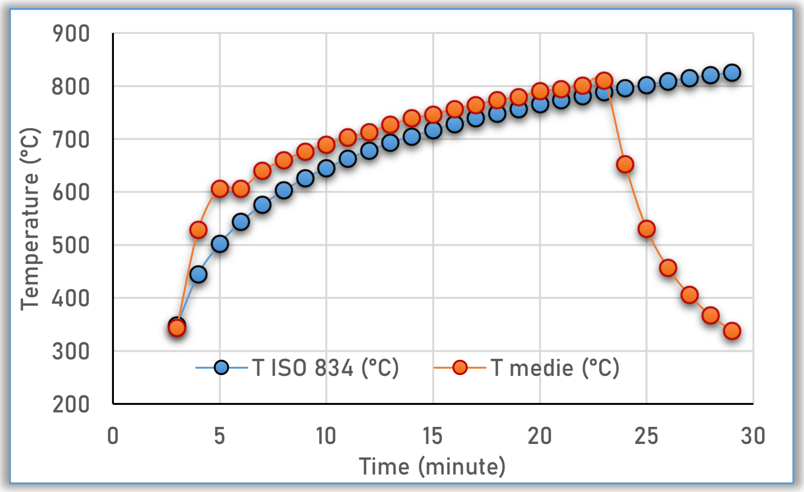

Figure 2. Temperature in oven inside / comparative with ISO 834 curve

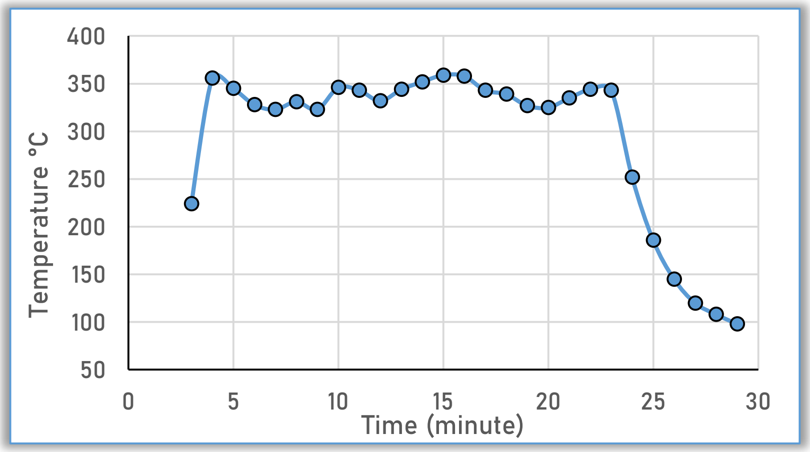

Figure 3. Temperature T (℃) at 1,5m h contact metal sheet

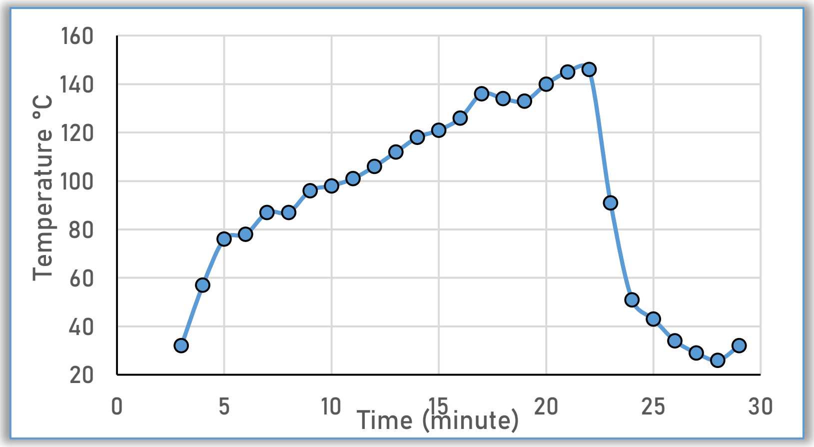

Figure 4. Temperature at a height of 1.5m and at a distance of 200mm outside

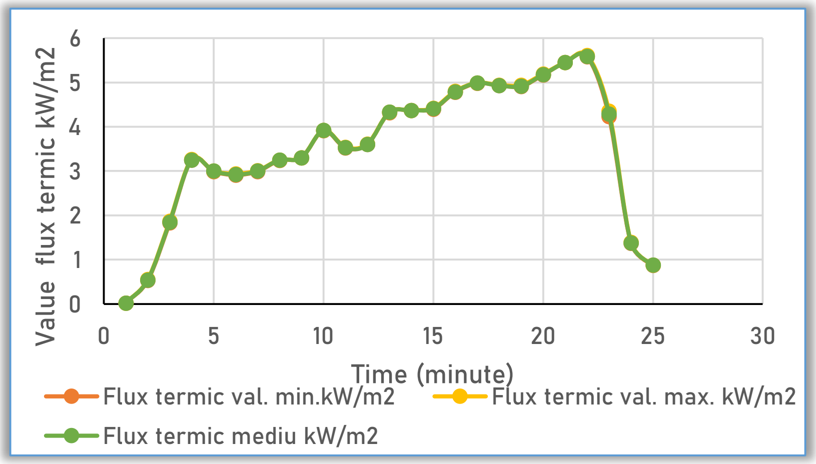

Figure 5 - The of the thermal flow for 0.5mm metal sheet

The results and their analysis are presented in tables 4,5,6 and 7:

Table 4. Framing for the value recorded by the thermocouple mounted at a height of 1.5m on a sheet with a thickness of 0.5mm, in minute 1

Reference value	Recorded value	Analyze the result
Temperature < 100oC	224°C	not comply
Height limit < 2m	1,5m	not comply
The accepted period of reaching the reference value - 10 minutes	1min.	not comply

Table 5. Framing for the value recorded by the thermocouple mounted to mounted at a height of 1.5m and at a distance of 200mm in the vicinity of the sheet, in the area considered as an escape route, in the 8th minute

Reference value	Recorded value	Analyze the result
Temperature < 100oC	101°C	not comply
Height limit < 2m	1,5m	not comply
The accepted period of reaching the reference value - 10 minutes	8 minute	not comply

Table 6. Monitoring of the heat flow value recorded for the 0.5mm thick sheet, at a height of 1.5m and at a distance of 200mm in the vicinity of the sheet, in the area considered as an escape route, at 3 minutes and 37 seconds

Date	Time	Flux Value Min. kW/m^2	Flux Value Max. kW/m^2	Average value kW/m^2
12/22/2023	15:32:37	2,49	2,52	2,505

Table 7. Classification of the heat flow value recorded for 0.5mm metallic sheet, at the height of 1.5 m and at the distance of 200 mm in the proximity of the sheet, at 3 minutes and 37 seconds

Reference value	Recorded value	Analyze the result
Temperature < 100°C	2,5 kW/m^2	not comply
Height limit < 2m	1,5m	not comply
The accepted period of reaching the reference value - 10 minutes	3minute, 37secunde	not comply

4. CONCLUSIONS AND DIRECTIONS FOR ACTION

Analyzing the centralized data, mentioned above, we notice that there were inconsistencies in the results obtained from the tests carried out for the 0.5mm metallic sheet which is considered as a protective screen, compared to the limits mentioned as a reference value, for the human safety and the goods.

As the first general conclusion, the framing for the galvanized 0.5mm metallic sheet which is not considered as a protective screen as protection against the thermal action.

Therefore, it is necessary that the sheet metal screens, proposed for protection, be replaced with elements that ensure protection and that are certified in this sense. Practically, these elements must have minimum certification in the area of EI (tightness and thermal insulation), or EW (tightness and thermal radiation – W) for the indicated protection period.

It is necessary that when the steel sheets are used as protection screens against the thermal action, the elements from which they are made fall into the safety classes established according to the technical requirements, because these elements can be placed on the circulation paths that must to ensure the safety of people, and the design requirements impose this obligation;

These studies and researches, regarding the metallic thermal protection screens, can be completed with data resulting from the testing of several different types of sheets, in terms of type and chemical composition, which have different sizes and thicknesses. For a preliminary estimated of the sheets thermal protection, a simulation can be carried out using the calculation software for simulating the evolution of the heat flow (https://verificatorincendiu.ro/calcul-flux/) [6].

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