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RESEARCH OF PORTABLE DATA STACK HOLDER

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1. INTRODUCTION

Fire is a thermal decomposition of combustible materials that is uncontrolled in time and space. The basic physico-chemical process occurring in a fire is the oxidation reaction that proceeds at a high rate and is accompanied by the release of a significant amount of heat.

The state of the environment, of a burning building or vehicle, changes over time and varies from room to room to building part and to vehicle. This condition depends on a number of factors: the ability of the structure to bear loads in conditions of strong thermal effects, the properties of building partitions, spatial solutions, the type and amount of combustible materials stored, the type and arrangement of combustible building materials, as well as the installations placed in the building and used for damping fire (extinguishing systems) and limiting the spread of smoke (fire ventilation).

Fire development curves can be designed for each room in the building, which show the temperature course over time (Fig. 1.1). Such curves are a useful tool for building fire safety and fire safety design. During fire tests, building and vehicle elements are subjected to a thermal load which is determined by the standard fire development curve.

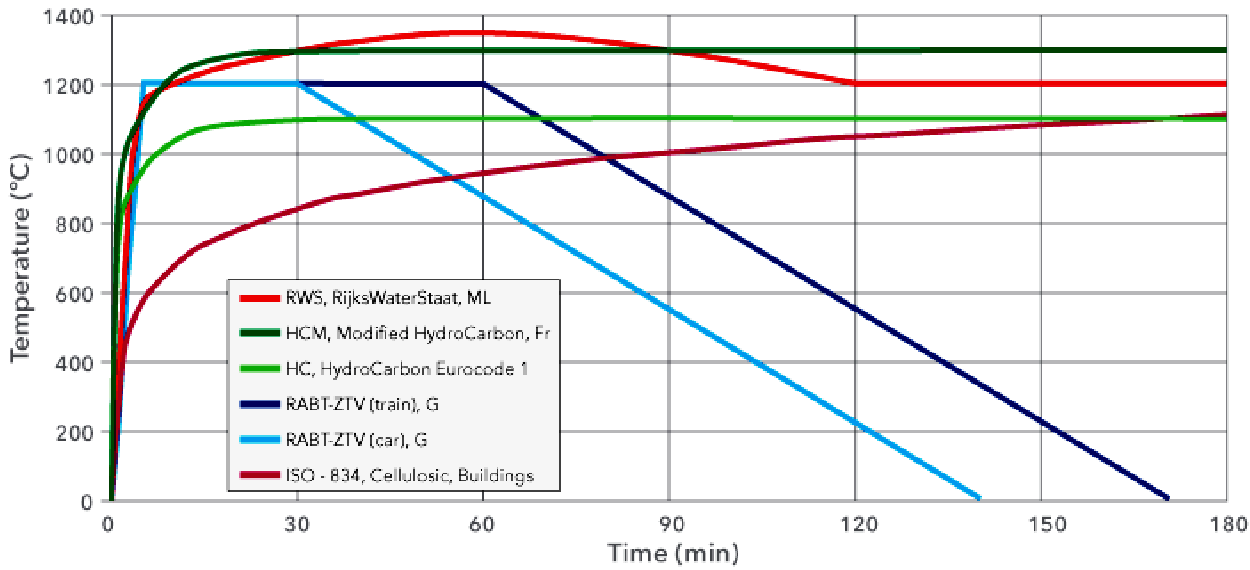

Figure 1.1. International fire development curves in fire tests

2. PURPOSE AND SCOPE OF RESEARCH

The aim of the research was to conduct laboratory fire tests of the Cryptosteel capsule. The tests were carried out with the use of a chamber furnace for heat treatment without a protective atmosphere. The tests were carried out at temperatures ranging from 1100-1400 °C. The temperatures were selected on the basis of international fire development curves, where the temperature of the burning vehicle (car, train) is 1200 °C, and the temperature of the burning building (depending on the structure of the building) is 1100-1350 °C. Additionally, in order to determine the melting point of the capsule, fire tests were used at 1400 °C, the temperature indicated as the melting point of steel, intended for the production of the tested elements. The tests consisted of placing the capsule in a furnace with a given temperature, holding it for 60 minutes, and cooling it in the air.

3. SUBJECT OF RESEARCH

The subject of the research were Cryptosteel capsules made of austenitic acid-resistant steel of AISI 303 grade (outer casing) and AISI 304 (core, tiles, separators, fasteners) (Figs. 3.1-3.3). After laboratory fire tests, the capsules were subjected to macroscopic observation using the OPTA-TECH stereoscopic microscope.

The images were recorded by a Visitron Systems digital camera coupled to the microscope with the NIS Elements BR software. In order to perform macroscopic examination of the core and tiles, the capsules after the fire tests were cut along the axis of the element with the use of an oil-cooled precision cutter.

The capsule tested at 1100°C was additionally subjected to microscopic examination. Observations of the microstructure were carried out using the NIKON ECLIPSE MA200 light microscope with the use of NIS Elements BR software, image recording was made with a Nikon DS-Fi1 CCD camera, at magnification: 100x, 200x, and 500x. Microscopic examination was performed in the etched state, 10% oxalic acid was used as the etching agent. The samples were electrolytically etched for 90 seconds at the voltage of 5.4V and the intensity of 1.4A.

Figure 3.1. General view of the delivered test samples

Figure 3.2. General view of the Cryptosteel capsule, visible outer casing and the core with tiles and separators

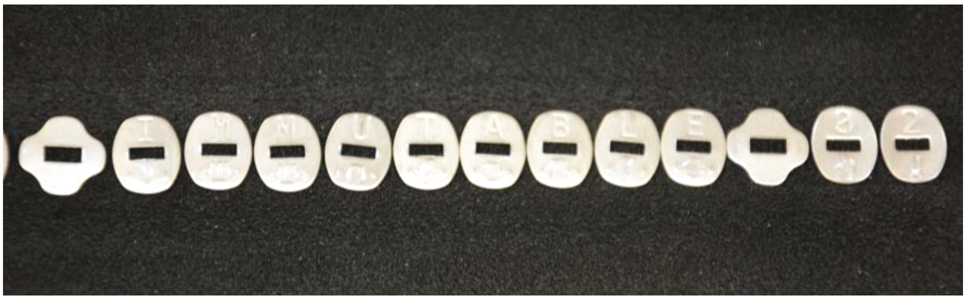

Figure 3.3. General view of the tiles with visible embossed letters

4. RESEARCH RESULTS

4.1. Fire test at a temperature of 1100 ° C

The laboratory fire test of the Cryptosteel capsule No. 02 was carried out at 1100 ° C for 60 minutes (Figures 4.1 and 4.2). Macroscopic observations immediately after the fire test showed that the capsule surface had oxidized but did not lose its continuity (Fig. 4.3). Moreover, it has been found that it is possible to open the sample by unscrewing the nut, but a great force is required to do so. Observations of the capsule core showed no thermal damage to the elements and that it was possible to read the information written on the tiles inside the capsule (Figures 4.4 and 4.5).

Figure 4.1. General view of sample No. 02 in the furnace at 1100 ° C

Figure 4.2. General view of sample No. 02 after its removal from the furnace at 1100 ° C

Figure 4.3. General view of sample No. 02 after fire test at 1100 ° C, visible oxidation of the outer casing surface

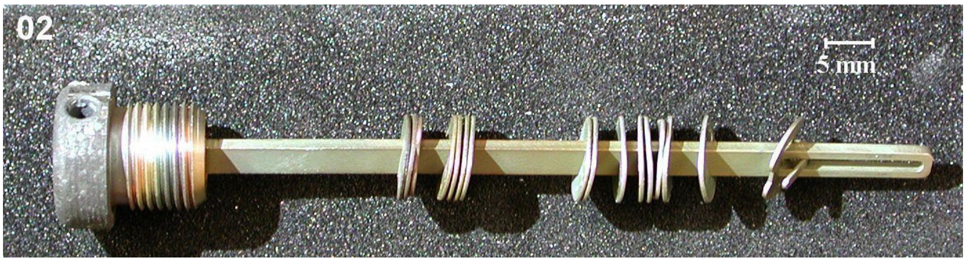

Figure 4.4. General view of the sample core No. 02, mandrel, tiles and separators undamaged

Figure 4.5. Tiles from the core of sample No. 02, no thermal changes in the material, visible embossed letters and numbers

4.2. Fire test at a temperature of 1200 ° C

The laboratory fire test of the Cryptosteel capsule No. 05 was performed at 1200 ° C for 60 minutes (Figs. 4.6 and 4.7). Macroscopic observations immediately after the fire test showed that the capsule surface had clearly oxidized and peeled off (Fig. 4.8). Moreover, it was found that it was impossible to open the sample by unscrewing the nut, it was necessary to use a cutter. Observations of the capsule core showed thermal deformation of the stem and no thermal damage to the remaining elements (Fig. 4.9). It was possible to read the information written on the tiles inside the capsule (Fig. 4.10).

Figure 4.6. General view of sample No. 05 in a furnace at 1200 ° C

Figure 4.7. General view of sample No. 05 after removal from the furnace from the temperature of 1200 ° C

Figure 4.8. General view of sample No. 05 after the fire test at the temperature of 1200 °C, visible oxidation of the outer casing surface.

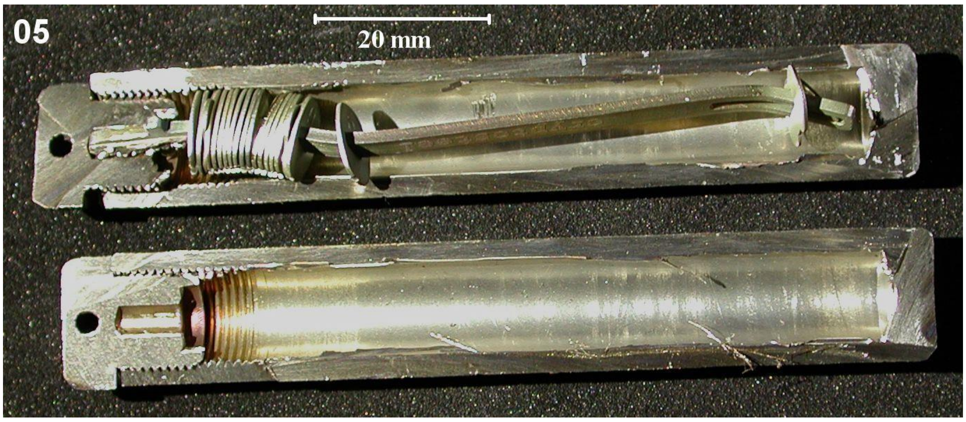

Figure 4.9. General view of the sample core No. 05, thermally deformed pin, tiles, and separators undamaged.

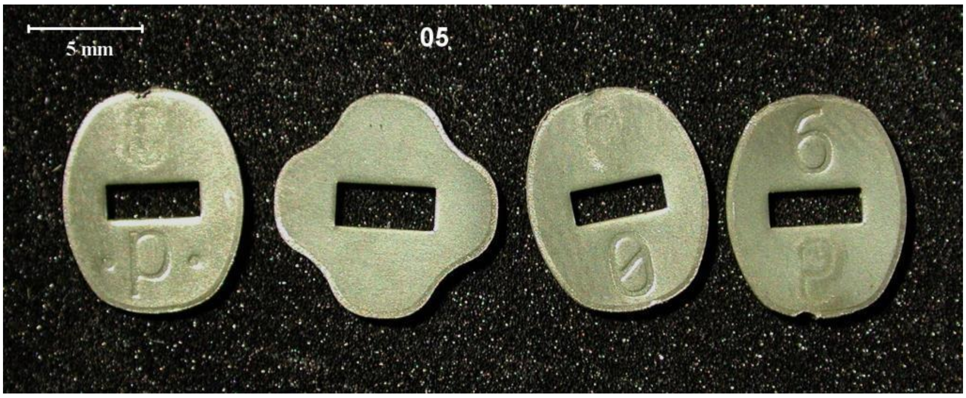

Figure 4.10. Tiles from the core of sample No. 05, no thermal changes of the material, visible embossed letters and numbers.

4.3. Fire test at a temperature of 1300 ° C

The laboratory fire test of the Cryptosteel capsule No. 01 was carried out at 1300 ° C for 60 minutes (Figs. 4.11 and 4.12). Macroscopic observations immediately after the fire test showed that the capsule surface was strongly oxidized and the surface layer delaminated (Fig. 4.13). Moreover, it was found that it was impossible to open the sample by unscrewing the nut, it was necessary to use a cutter. Observations of the capsule core showed thermal deformation of the stem and no thermal damage to the remaining elements (Fig. 4.14). It was possible to read the information written on the tiles inside the capsule (Fig. 4.15).

Figure 4.11. General view of sample No. 01 in a furnace at 1300 ° C

Figure 4.12. General view of sample No. 01 after its removal from the furnace at the temperature of 1300 ° C

Figure 4.13. General view of sample No. 01 after a fire test at a temperature of 1300 ° C, visible strong oxidation of the surface and delamination of the top layer of the outer casing

Figure 4.14. General view of the sample core No. 01, the thermally deformed pin, tiles, and separators undamaged

Figure 4.15. Tiles from the core of sample No. 01, no thermal changes in the material, visible embossed letters and numbers

4.4. Fire test at a temperature of 1350 ° C

The laboratory fire test of the Cryptosteel capsule No. 04 was carried out at 1350 ° C for 60 minutes (Figs. 4.16 and 4.17). Macroscopic observations immediately after the fire test showed that the capsule surface was strongly oxidized and the surface layer delaminated (Fig. 4.18). Moreover, it was found that it was impossible to open the sample by unscrewing the nut, it was necessary to use a cutter. Observations of the capsule core showed thermal deformation of the pin, slight welding of the tiles, which gave way to the influence of mechanical pressure, and no thermal damage to the elements (fig. 4.19 and 4.20). It was possible to read the information written on the tiles inside the capsule (Fig. 4.21).

Figure 4.16. General view of sample No. 04 in a furnace at 1350 ° C

Figure 4.17. General view of sample No. 04 after removal from the furnace from the temperature of 1350 ° C

Figure 4.18. General view of specimen No. 04 after a fire test at 1350 ° C, visible strong oxidation of the surface and delamination of the top layer of the outer casing

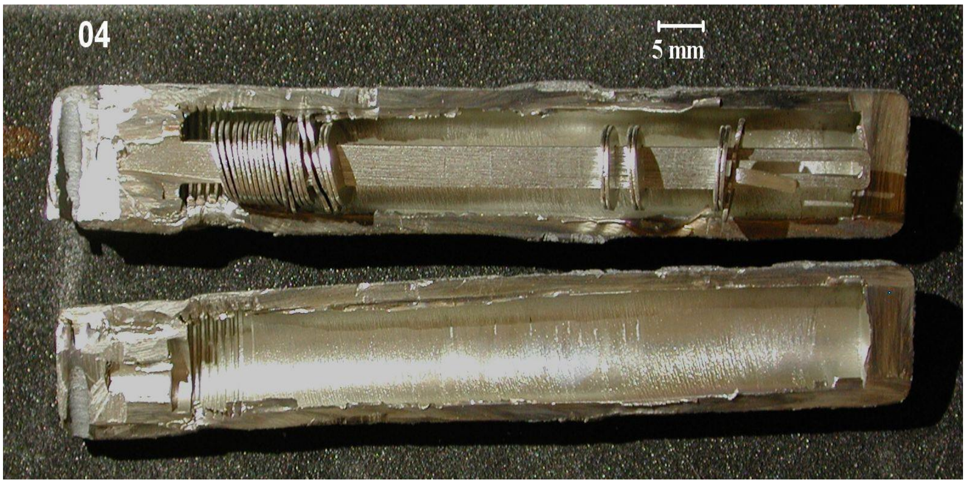

Figure 4.19. General view of the sample core No. 04, thermally deformed pin, tiles, and separators undamaged

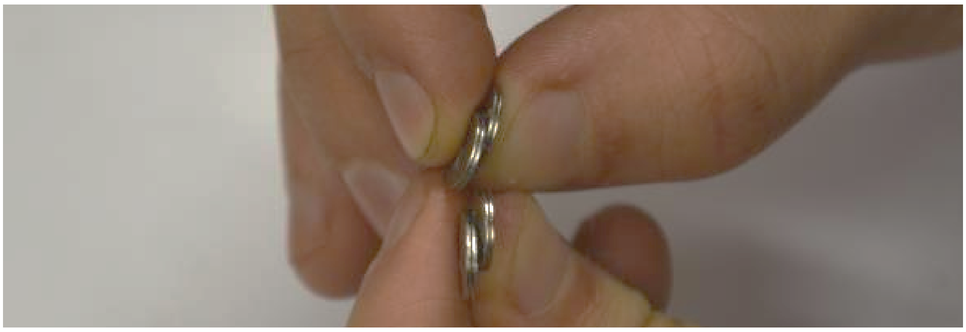

Figure 4.20. View of the thermally welded tiles

Figure 4.21. Tiles from the core of sample No. 04, no thermal changes in the material, visible embossed letters and numbers.

4.5. Fire test at a temperature of 1400 ° C

The laboratory fire test of the Cryptosteel capsule No. 03 was carried out at 1400 ° C for 60 minutes (Fig. 4.22). Macroscopic observations showed that the capsule material completely melts at this temperature (Figs. 4.23 and 4.24).

Figure 4.22. General view of sample No. 03 in a furnace at 1400 ° C

Figure 4.23. General view of sample No. 03 after its removal from the furnace at 1400 °C

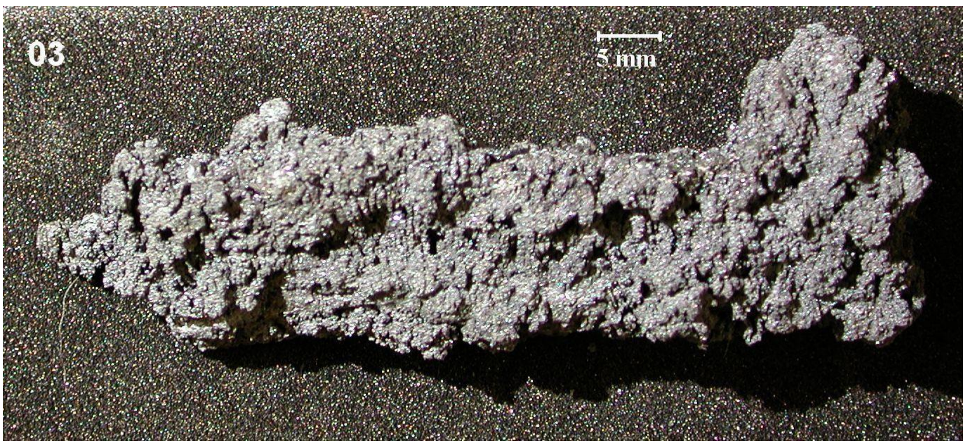

Figure 4.24. General view of sample No. 03 after the fire test at 1400 ° C, visible melting of the capsule material

4.6. Microscopic examination of the sample after the fire test at 1100 ° C

A laboratory fire test of the Cryptosteel No. 02 capsule at 1100 ° C showed that it was possible to open and reseal the sample by unscrewing the cap, indicating the possibility of further use of the capsule. In order to find the influence of the applied temperature on the structural properties, closely related to the mechanical properties of the material, additional microscopic examinations of the outer casing material were performed.

Figure 4.25. Sample material No. 02 after fire test at 1100 ° C, visible fine-grained structure typical of austenitic acid-resistant steel. Light microscopy, etched state.

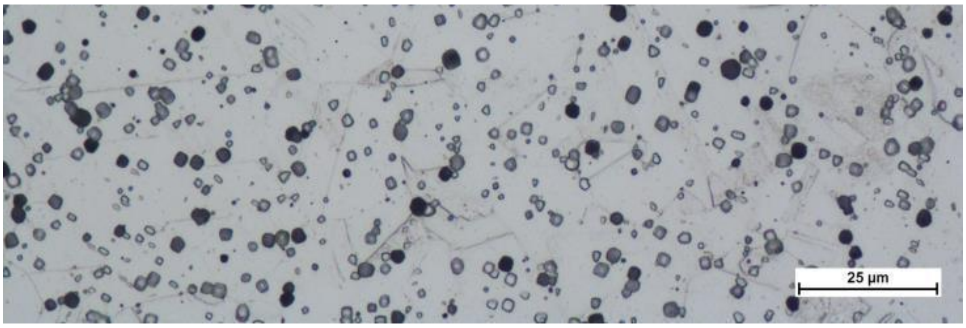

Figure 4.26. The enlarged area shown in Fig. 4.25, visible structure of austenitic acid-resistant steel with precipitates of chromium carbides. Light microscopy, etched state.

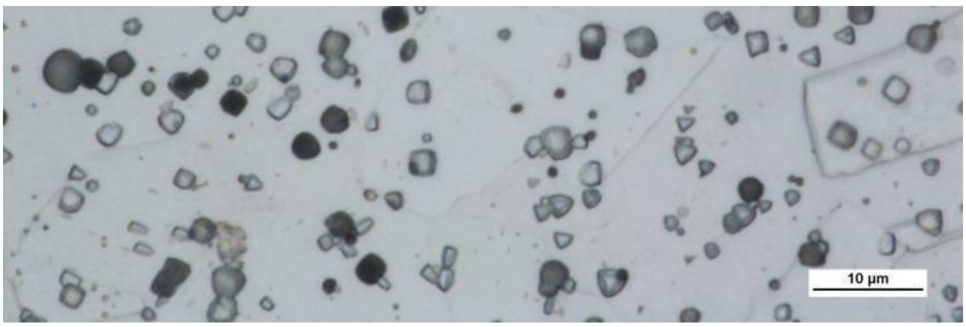

Figure 4.27. The enlarged area shown in Fig. 4.26, visible austenite grains with large precipitates of chromium carbides. Light microscopy, etched state.

Microscopic observations showed the presence of a structure typical of austenitic acid-resistant steel, confirming that AISI 303 stainless steel was used. The observed structure was fine-grained, i.e. there was no excessive and uncontrolled grain growth due to the high temperature applied. No negative influence of temperature on the mechanical properties of the element was shown. At the same time, a very large amount of chromium carbides was observed in the course of the research. The formation of carbides in the steel structure reduces the chromium content in the vicinity of the grain boundaries, changes the electrochemical potential, and thus reduces the corrosion resistance of the material.

5. SUMMARY AND CONCLUSIONS

Based on the research, the following conclusions were drawn:
- A laboratory fire test of the Cryptosteel capsule at 1100 ° C showed that it is possible to open and reclose the sample by unscrewing the cap. It was possible to read the information written on the tiles inside the capsule. This indicates the possibility of further use of the capsule.

- Microscopic examination of the capsule material after the fire test at 1100 ° C showed the presence of a fine-grained austenite structure with precipitates of chromium carbides. The results of these tests indicate no negative influence of temperature on the mechanical properties of the element, but the presence of chromium carbides in the steel structure may reduce the corrosion resistance of the capsule material.

- Laboratory fire test of the Cryptosteel capsule at temperatures in the range of 1200-1350 ° C showed that it is impossible to open and close the sample by unscrewing the cap. It was necessary to cut open the capsule. It was possible to read the information written on the tiles inside the capsule. This indicates that no further use of the capsule is possible.

- A laboratory fire test of the Cryptosteel capsule at 1400 ° C showed that the capsule material completely melts at this temperature.

In summary, the capsule material and construction are resistant and can be used up to 1100 ° C. The capsule material is resistant to temperatures up to 1350 ° C. It is possible to read the information on the tiles, but the thread design prevents it from being unscrewed. In order to open the capsule, it must be cut open. Based on the fire curves, it can be concluded that if a Cryptosteel capsule fails in a fire (building and/or vehicle fire), it will be possible to read the recorded data, but it will not be possible to further use the capsule.

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