THE FOURTH INTERNATIONAL CONFERENCE ON FRACTURE MECHANICS AND ENERGY,
"TRENDS ON THE FRACTURE AND ENVIRONMENT" FRACT'4, 2018
November 26-29, 2018 Chlef, Algeria

FIRE PROTECTION DURABILITY OF INTUMESCENT COATINGS AFTER ACCELERATED AGING

R. Thabet [1], A. Benarous *[2,3], L. Mesquita [4]

[1]Mechanical Engineering department, Faculty of Technology, Hassiba Benbouali University of Chlef (UHBC), Po Box 151, Chlef, Algeria, rida.thabet93@gmail.com
[2]LCEMSM Laboratory, UHB Chlef, Algeria, abenarous@yahoo.fr
[3]Mechanical Engineering department, Faculty of Technology, Saad Dahlab University of Blida (USDB), Soumaa, Algeria
[4]ISISE, Polytechnic Institute of Bragança, Campus Sta Apolónia Apartado 1134, 5300-857 Bragança, Portugal, lmesquita@ipb.pt

Introduction

- Intumescent coating is a reactive chemical material, which is used as the main fire protection material to steel structures.
- When intumescent coating is exposed to fire, the chemical components in the intumescent coating react to cause the coating to swell forming a lightweight flame-retardant char to protect the steel substrate from excessive rise in temperature.
- However, exposure to long-term environmental conditions can cause the intumescent coating to lose some of the reactive materials, thus reducing the effectiveness of the intumescent coating over time.
- Because fire safety requirement is throughout the entire life of a building structure, which may last many tens of years, it is important to understand the long-term protection performance of intumescent coating under exposure to environmental conditions, [1].

Experimental setup

To assess the performance of a commercial water- based intumescent paints a set of experimental tests was performed in a cone calorimeter before and after have been exposed to an accelerated aging, see Table 1 and Table 2, respectively.

- The steel plates are 100 mm squared and with 5, 8 and 14 mm thick, coated on one side with different dry film thicknesses (DFT) and tested in a cone calorimeter as prescribed by the standard ISO5660, [2], with two heat fluxes 35 and 75 KW.m^{-2}.
- Steel temperatures are measured by means of two thermocouples type k, welded to the plate surface on the heating side and on the opposite side.

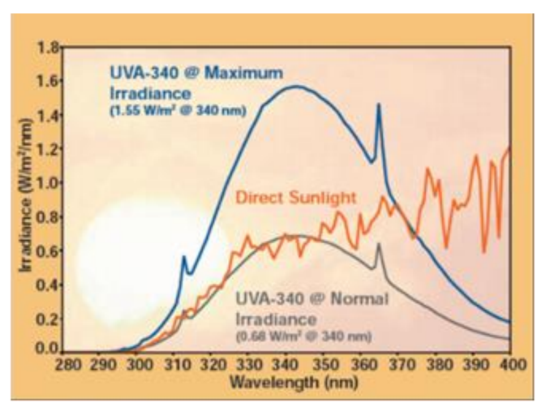
Table 1: Set of experimental tests without aging.

specimens	Heat flux [KW.m^{-2}]	ds [mm]	Nominal DFT [µm]	X DFT [µm]	Initial Mass [g]
P1	75	14	500	483	1161.39
P2	75			606	1120.28
P3	35			628	1140.6
P4	75	14	1000	831	1155.73
P5	75			833	1127.6
P6	35			1107	1122.2
P7	75	5	500	751	407.9
P8	75			705	414.9
P9	35			589	449.6
P10	75	5	1000	1171	431.1
P11	75			1298	436.1
P12	35			886	512.8
P13	75	8	1000	943	639.7
P14	35			602	650.2
A1	75 35	14	--	--	1145.1
A2	75 35	8	--	--	636.7
A3	75 35	5	--	--	492.3

--: The plates are not coated.

- To perform the coating accelerated aging test, a QUV Accelerated Weathering Tester were used. This equipment reproduces the damage caused by sunlight, rain and dew.
- The accelerated aging test was performed according to the European technical approval guideline N° 018, [3]. In this guidance, four types of environmental exposure are simulated: type X, Y, Z1 and Z2.
- The accelerated aging test reported in this work adopted exposure condition **Z1**.
- In this work it couldn't follow exactly the condition type Z1 according to the ETA Guideline, so the cycle was changed as follow:

8 hours at 40 [°C] and 16 hours at 30 [°C] with condensing humidity in all cycles.



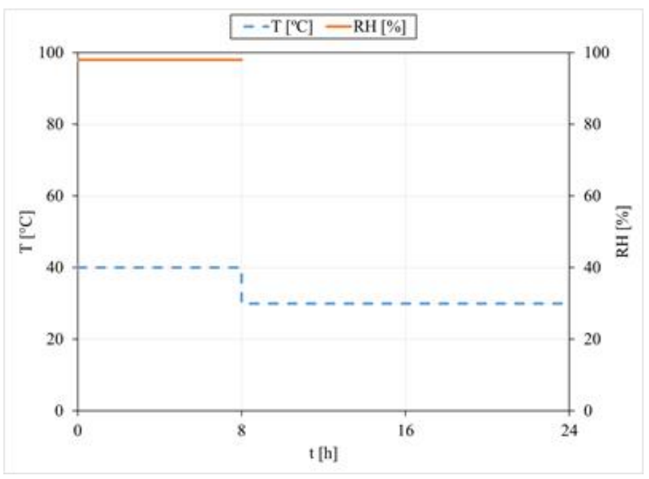


Table 2: Set of experimental tests after hydrothermal aging.

specimens	Heat flux [kw/m^2]	ds [mm]	Nominal DFT [µm]	X DFT [µm]	X DFT after aging [µm]	Initial Mass [g]
S1	75	14	500	625	647	1149.3
S2	75			599	529	1134
S3	35			436	362	1155.3
S4	75	14	1000	1359	*	1075.3
S5	75			733	708	1166.8
S6	35			625	579	1158.7
S7	75	5	500	795	778	423.9
S8	75			712	696	407.2
S9	35			689	694	398.57
S10	75	5	1000	1580	1990	429
S11	75			1312	1530	419.6
S12	35			951	904	425.2
S13	75	8	1000	947	994	650.4
S14	35			752	695	648.8

*The protection was damage after the hydrothermal aging.

Results

1. Steel temperature evolution

compared to specimens without aging, there is a sharp increase in steel substrate temperature after the accelerated hydrothermal aging test, where the temperature evolution of the steel plates with protection is very close to the plates without protection.

Coated steel plates before and after accelerated aging, with fixed thermocouples. Tested samples at 35 and at 75 KW.m^{-2}.

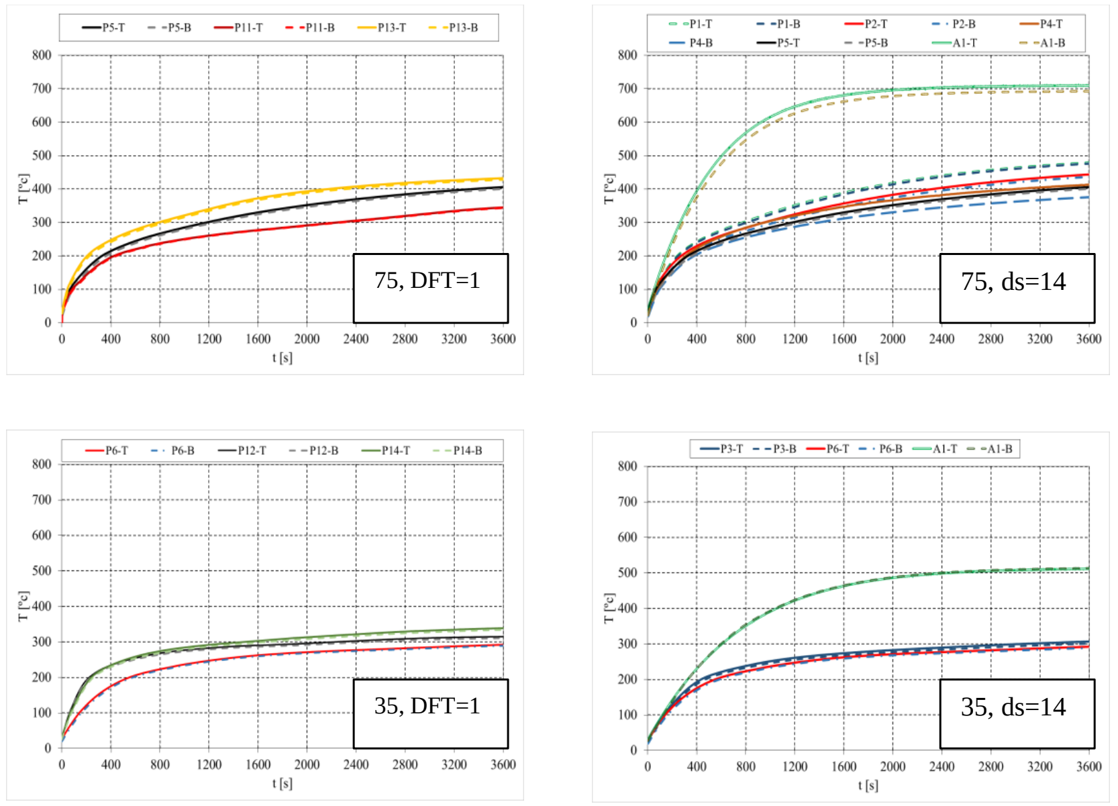


Figure 1: Measured temperature in the steel plates for a radiant heat flux of 35 and 75 kw.m^{-2} before the hydrothermal aging test.

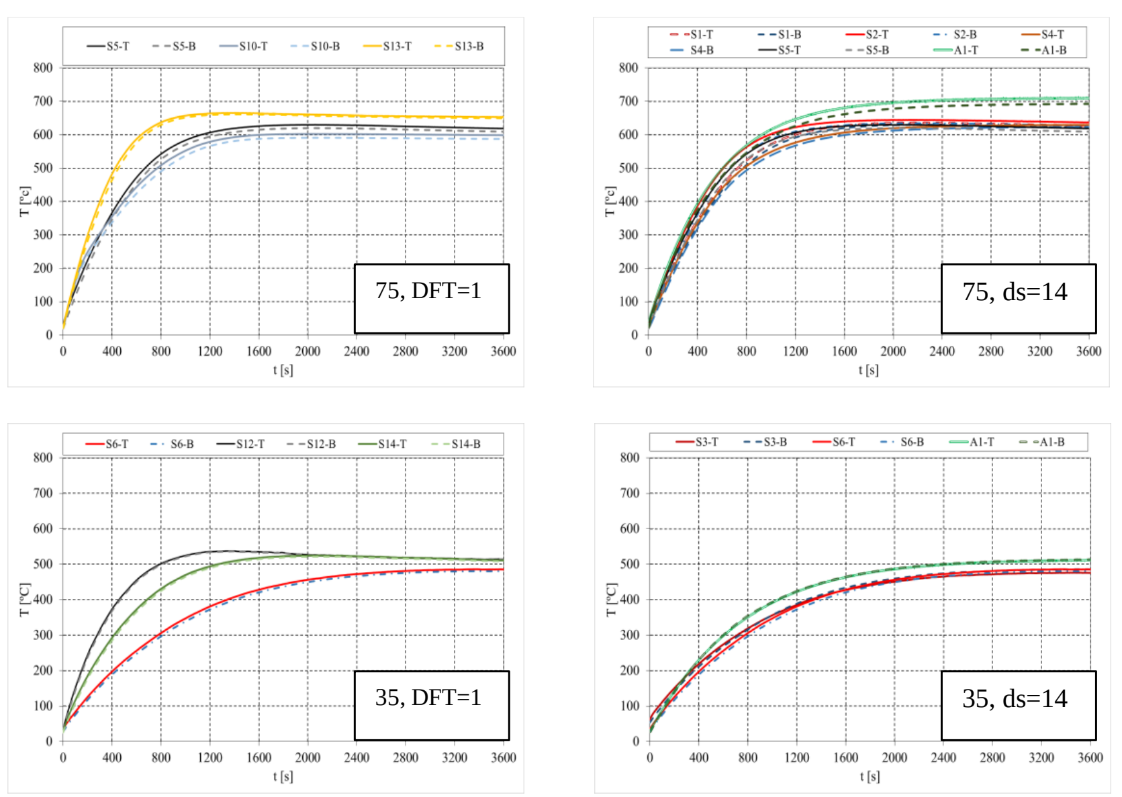


Figure 2 : Measured temperature in the steel plates for a radiant heat flux of 35 and 75 kw.m^{-2} after the hydrothermal aging test.

2. Intumescence development

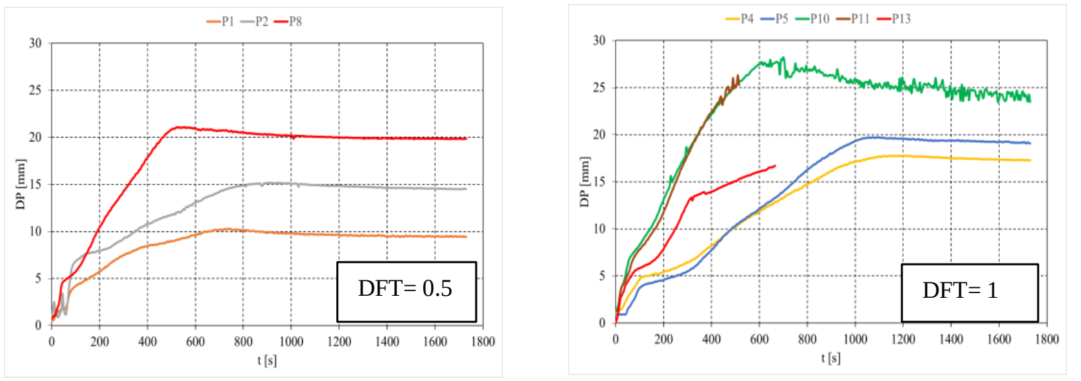


Figure 1: Intumescence expansion for a radiant heat flux of 75 KW.m^{-2}.

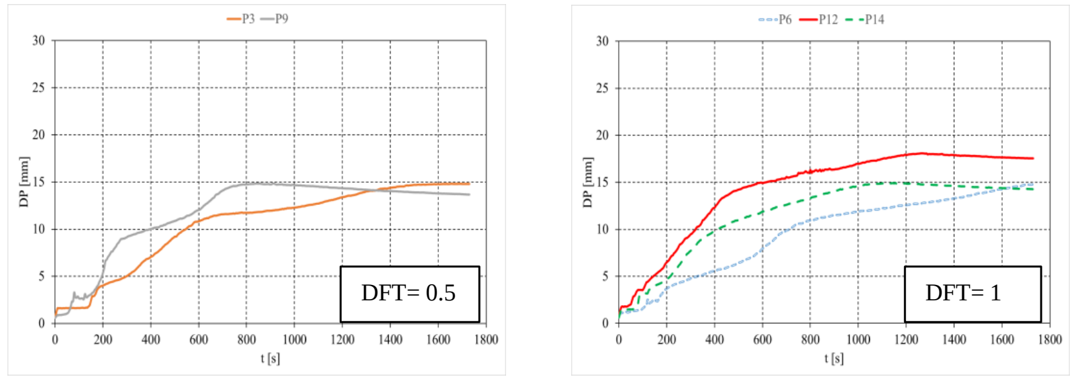


Figure 2: Intumescence expansion for a radiant heat flux of 75 KW.m^{-2}.

Conclusions

- The experimental tests show that the time to attain a specified temperature increases with increasing thickness of the coating (DFT) and by increasing the thickness of the steel plate.
- Intumescent coating has considerable reduction in performance after hydrothermal aging test. For example the steel plate temperature of specimen S2 was increased by about 270 °C compared to the steel temperature of P2 with fresh intumescent coating for the same conditions and an exposure time of 30 min.
- Intumescence development depends on the initial dry film thickness and on the incident heat flux, but the hydrothermal aging conditions damage its expansion capacity, leading to a drastic reduction of the intumescent coating fire insulation.
- It should be pointed out that the tests were performed without the use of a top coat, and this final coat can provide additional resistance to the weathering conditions and influence the long term fire insulation capacity.

References

[1]. Wang, L.L., et al., Thermal conductivity of intumescent coating char after accelerated aging. Fire and Materials, 2013. 37(6): p. 440-456.
[2]. STANDARD, I., ISO 5660-1: Reaction to fire tests ''Heat release, smoke production and mass loss rate''. Part 1: Heat release rate (cone calorimeter method). 2002.
[3]. EOTA, ETAG Nº 018: Guideline for European technical approval of fire protective products. PART2: REACTIVE COATINGS FOR FIRE PROTECTION OF STEEL ELEMENTS, European Organization for Technical Approvals, Editor. 2011, European Organization for Technical Approvals,: Brussels.