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Technical paper on IMO regulations for fire protection of "plastic piping"

(Fire Testing According to IMO A.753 (18), L2/L2W)

Introduction

The purpose of this fire test must be to test the integrity of a "plastic pipe" when exposed to fire in respectively 30 and 60 minutes as defined in Appendix 1. **Favuseal AS** has conducted a series of fire tests at **SWRI, USA** and **SINTEF/SP** in Norway.

A majority of the test has been performed "to the letter" of the **IMO** test setup. During these fire tests (both **IMO L1** and **IMO L2**), a serious flaw in the test setup has been discovered that causes a disproportionate amount of fire protection in order to reach two "relatively" simple requirements defined as "no leakage" during fire testing (Nitrogen) and water pressure test at rated pressure after the fire test.

Integration and Customization

This inherent "flaw" is uncovered because **Favuseal AS** has, in consultation with **SINTEF/SP**, including a variety of temperature sensors that are not defined in the **IMO**. The inclusion of these additional temperature sensors does not inflict or impair the fire test performed. We have included these additional temperature sensors to get a deeper understanding of our revolutionary fire protection known in the marketplace as **Favuseal Fire Barrier System X3M**. **Favuseal AS** has installed 3 pcs. Temperature sensors on the surface of each **GRE pipe** tested. Consequently, we have monitored temperature rise in the furnace oven after the propane is turned off. We have done this to gain more information regarding the adverse contribution of any heat radiation caused by the oven after e.g. 30 or 60 minutes.

Our findings are striking, and the conclusion is clear. For "plastic pipes", as defined by **IMO**, to pass two relatively simple requirements and an excessive amount of passive fire protection needs to be used. As a consequence of this, the competitive edge of "plastic pipes", when compared with steel piping, is reduced heavily via the increased cost per m^2 of "plastic piping" compared to steel piping.

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What is Wrong in the Test Setup?

Assumption: In the next, **IMO L2** is discussed. However, the same argument is valid for **IMO L1**

The purpose of the **IMO** test setup is to do fire protection of a "plastic pipe" for 30 minutes under a Hydrocarbon Fire curve a defined in Appendix 1. The integrity of the plastic pipe is checked by implementing a pressure test (Nitrogen) during the fire test and the subsequent days when the pipe has cooled down at the "rated pressure".

The fire test is conducted on an "empty pipe" not allowing for flowing/still water inside of it. This is a logical, practical and replicates a "real-life" scenario. The criteria of failure for "plastic pipes" (loss of pressure and leakage) differs significantly from fire testing of steel piping where the criteria of failure are defined as a temperature more than 400°C. There is no requirement for pressure-testing afterwards when it comes to fire testing of steel piping.

As mentioned earlier, a few number of fire tests on "plastic pipes" has revealed a major weakness in the current test regime. It is an exogenous factor that plays a much bigger part than earlier anticipated. This factor is defined as the radiant heat from the furnace itself in the aftermath of the propane is turned off, and the flames are extinguished. The effect of radiation heat is much greater than expected.

A Fire Test According to IMO L2 with Real Numbers as Measured by SINTEF/SP

During the last fire test we did on a "plastic pipe", we required **SINTEF/SP** to keep measuring the temperature inside of the furnace oven after the propane and fire were extinguished. By doing this, we can quantify the radiant heat from the oven itself onto the fire protected "plastic piping" installed in the oven. A "plastic pipe" usually has a TG of +/- 170°C before the resin loses its integrity.

Consequently, a temperature of 170°C was defined as critical during the fire test. The same temperature was defined as the temperature inside the furnace oven where the radiant heat will not adversely affect the test results further. Keeping this mind, we know that the temperature in the 30th minutes is 1095°C and at 31th minutes, there is only the radiant heat affecting the temperature in the furnace as the propane was shut. As the temperature goes down, the same temperature (170°C) was defined as "zero" where the radiant heat does not yield a negative contribution to the "plastic pipes" any longer.

The conclusion from fire tests performed is surprising. The graph below shows the temperature on the surface of **GRE pipe** as measured based on three additional

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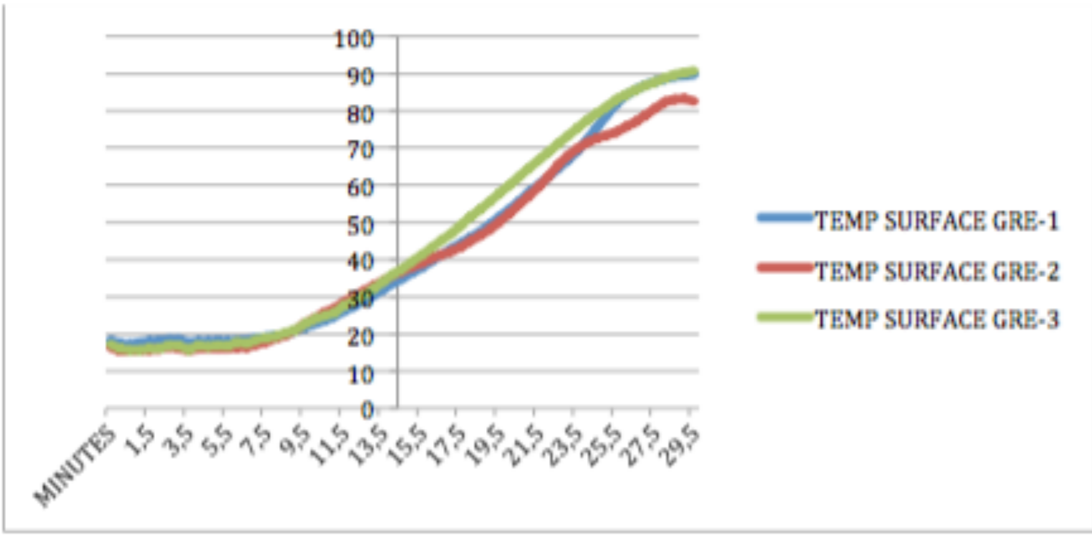
temperature sensors described earlier. The placement of the three temperature sensors are as follows:

- One temperature sensor on top of the joint connection (glued)
- One temperature sensor 0.6 meters to the right placed in the bottom of the pipe
- One temperature sensor 0.6 meters to the left placed on top of the pipe.

All of these additional temperature sensors were placed on the surface of the pipe that was tested.

When looking at the graphs below, it may be noted that the ambient temperature was about 18°C, so the delta is much lower (about 75°C) for a 30 minutes **HCF** scenario.



Based on these results, one would think that **GRE pipes** will pass fire test with "flying colors" as the **TG** of the pipe wall is defined at 170°C. Unfortunately, that was not the case. The fire test failed when we did water pressure test the subsequent day. The reason lies in the contribution of radiant heat after 30 minutes.

<u>Negative Effect of Radiant Heat beyond 30 minutes</u>

To measure this, we instructed **SINTEF/SP** to keep measuring the heat inside of the furnace oven after the fire was extinguished by turning off the propane in the 30th minutes. This result will give evidence of the period that the furnace itself gives and adverse contribution to the "plastic pipe" that is tested. As earlier described, the definition of the adverse contribution of radiational heat is defined as a temperature more than 170°C inside the

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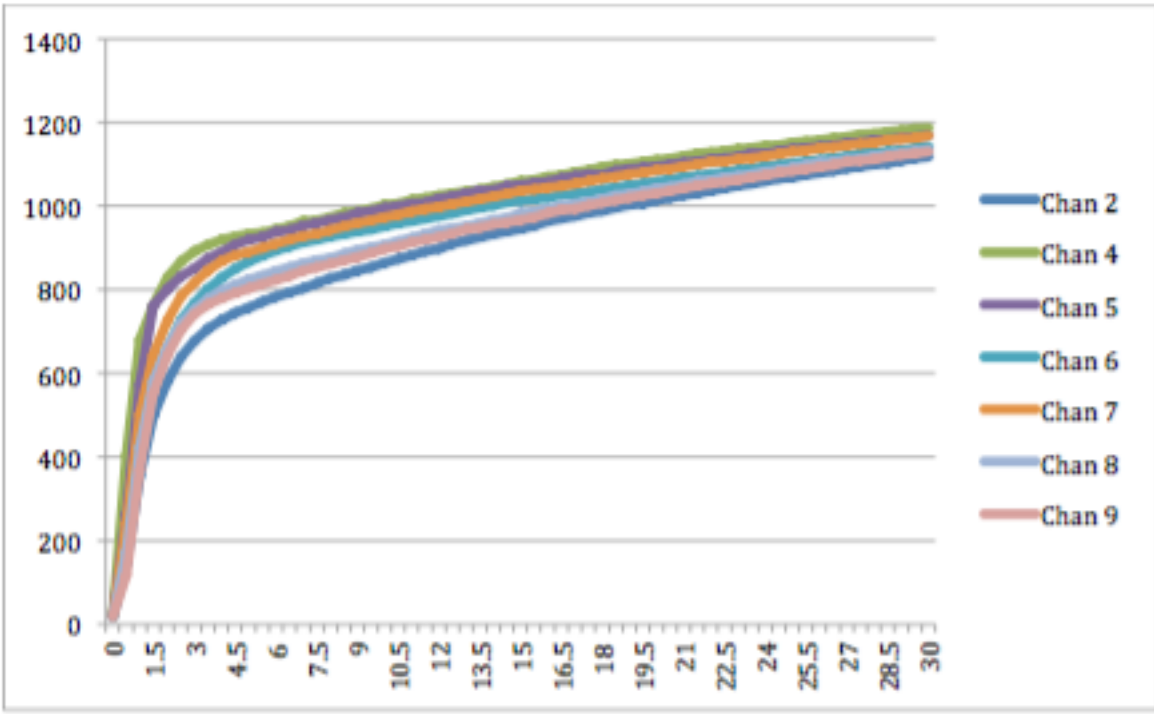
furnace. The adverse contribution of radiant heat was defined as the 31st minutes and until the actual furnace temperature drops below 170°C.

The next graph shows the temperature curve as defined by **IMO A.753 (18)** Appendix 1 during the actual fire test:



As shown by the next graph, the contribution of radiation in the furnace itself is much greater and lasts much longer than what one might think.

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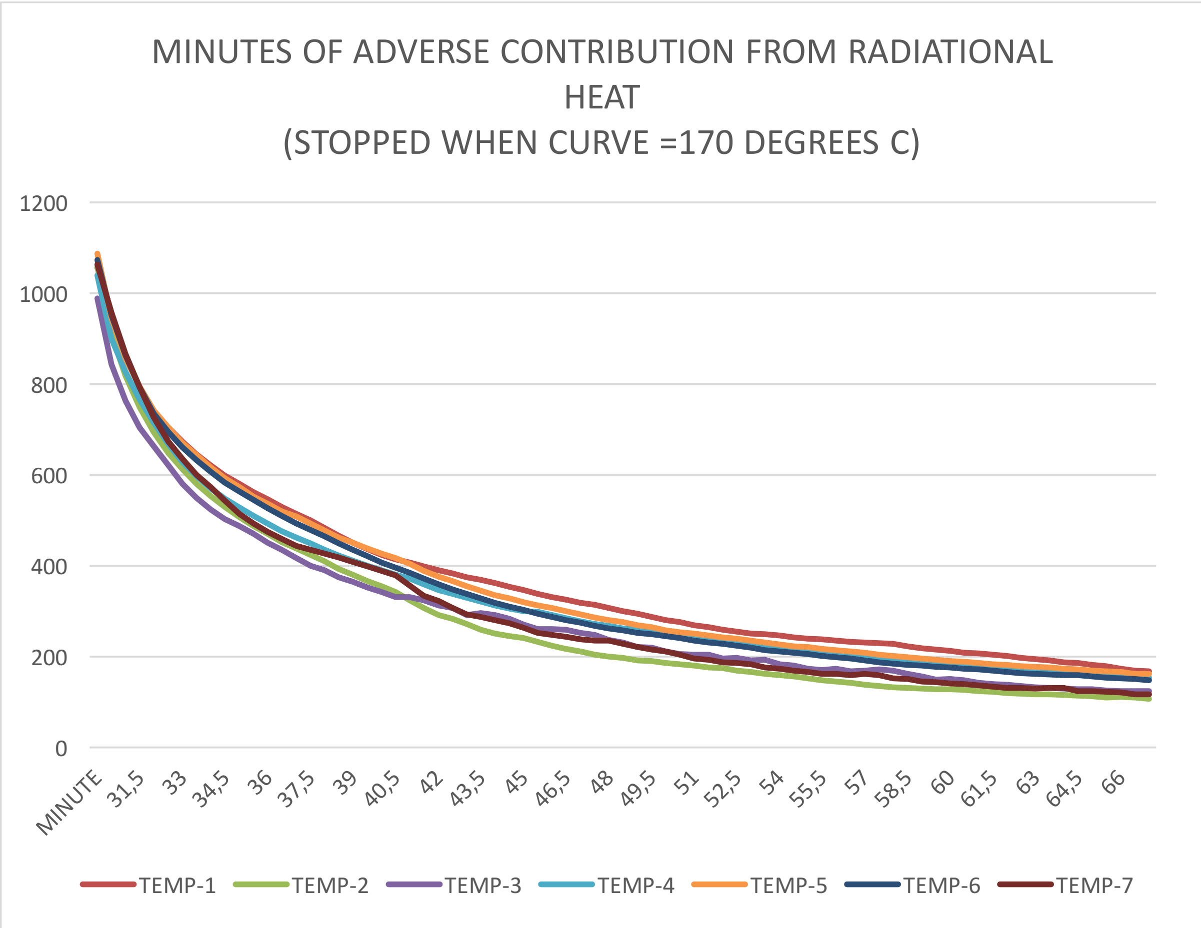

The adverse contribution of radiation heat gives an additional period of **37 minutes** of adverse effect. In practical terms, this means that an **IMO L2** test is not a 30-minute test, but rather a 67-minute test!

This will be even worse for an **IMO L1** test then it is likely that radiant heat will have a contribution beyond 37 minutes.

Conclusion and Solution

The contribution of radiant heat is significant and cannot be in the intent of the **IMO** committee. It is meant purely as a fire-test of “plastic piping”, where the contribution of radiant heat in all materials must cancel.

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There is only **one valid way** to remove this adverse contribution of radiational heat to the pipe. The same solution is also very close to a "real life" scenario.

IMO must make an amendment to its current test setup and allow for ambient temperature water to be injected into the pipes in the 31st minutes in order to **cancel out** the contribution of radiation into the tube as soon as possible after the fire test. It is the only way to weed out the radiant heat. A solution of physically removing the "plastic pipe" is a bad idea and poses a risk to the personnel of a fire lab.

Favuseal AS is a small technological company. We have now spent over **EUR 200.00** in fire testing according to **IMO L2** and **IMO L1**, with satisfying results. Alltough we have passed both IMO L2 and IMO L2W, we find it strange that IMO will not adapt and make amendments to their current test set-up in order to address the facts pointed out in this technical paper

Next step is to get type approval of the system adopted, but we do not want to undertake this with a sub-optimal solution that reduces the competitiveness of **GRE pipes** over steel because the unnecessary use of fire protection to allow for an exogenous factor that is not in the intent of the **IMO**.

Best regards

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