Technical Report
Comparison of Thermal Exposures in Fire Test Standards in the Context of Bolt Cap Protection Systems

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1 INTRODUCTION

Typhoon Performance Products Ltd. (Typhoon) produce a bolt cap protection system for the construction industry that provides protection from the effects of fire to bolts and nuts associated with bolted connections.

PFP Specialists Ltd. (PFPS) have been requested by Typhoon to provide an overview of the thermal exposures associated with common and globally recognised fire test standards. The purpose of this document is to provide assurance to potential end-clients of Typhoon or other project stakeholders that in the absence of a dedicated fire test standard for bolted connections, functionally equivalent testing can be considered as an acceptable alternative.

2 REGULATORY FRAMEWORK

Regulations associated with the fire resistance of steel structures around the world vary greatly. Fundamentally, a building code or design code will typically dictate the fire resistance period that the steel structure should withstand. This is described as a duration of time with respect to a degree of fire exposure. A complementary critical or limiting temperature that the steel should not exceed is defined by the project's structural engineer or is taken as an assumed and conservative value.

It is to note that building codes or design codes provide practical guidance on potential ways to achieve compliance with the requirements of the regulations. They often note that there may be other ways to comply with the requirements via some other acceptable means or method.

3 GLOBAL FIRE TEST STANDARDS

To demonstrate passive fire protection capability with respect to the requirements to meet the regulations, fire tests have been developed around the world. These subject materials to a fire test which serves as a common benchmark. Example fire test standards and their common geographical area of use are shown in Table 1 for cellulosic requirements and in Table 2 for hydrocarbon requirements.

Table 1: Example cellulosic fire test standards and their common geographical area of use

Fire test standard	Geographical area of use
ISO-834 [1]	Global
BS 476-20 [2]	UK, Middle East, India, parts of South America, South-East Asia, New Zealand
EN 1363-1 [3]	UK, mainland Europe, Australia
ASTM E-119 [4] / UL 263 [5]	North America, Middle East, parts of South-East Asia

Table 2: Example hydrocarbon fire test standards and their common geographical area of use

Fire test standard	Geographical area of use
BS 476-20 Appendix D [2]	Global
UL 1709 [6]	Global
EN 1363-2 [7]	Mainland Europe
ISO 22899-1 [8]	Global where jet fire is a requirement

The standards listed in the tables above are commonly globally recognised as fire test standards. While they are not completely identical, they can be considered as being functionally equivalent. They each expose an element of construction to a similar fire curve to represent a post-flashover fire scenario as depicted in Figure 1 for cellulosic fires or to a more severe fire scenario as depicted in Figure 2 for hydrocarbon fires.

While the fire test curves are similar within the cellulosic or hydrocarbon standards respectively, there are subtle differences in the test with respect to setup, furnace control thermocouples, steel thermocouple locations, assessment methods, etc. It is these differences which are typically deemed to account for minor differences in product thickness when the same product is tested to different fire test standards.

Nonetheless, each test standard aims to test either loadbearing or non-loadbearing steel with applied fire protection to demonstrate fire resistance (stability) for a given period of exposure time.

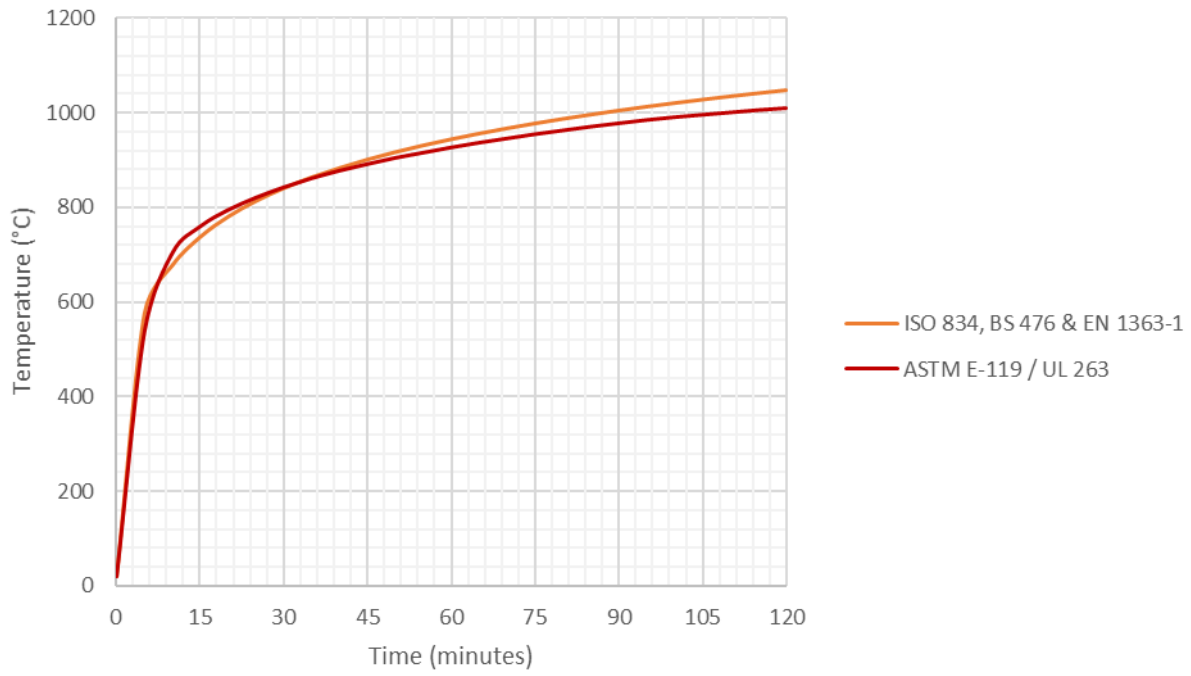

Figure 1: Comparison of furnace temperature heating curves for common cellulosic fire test standards

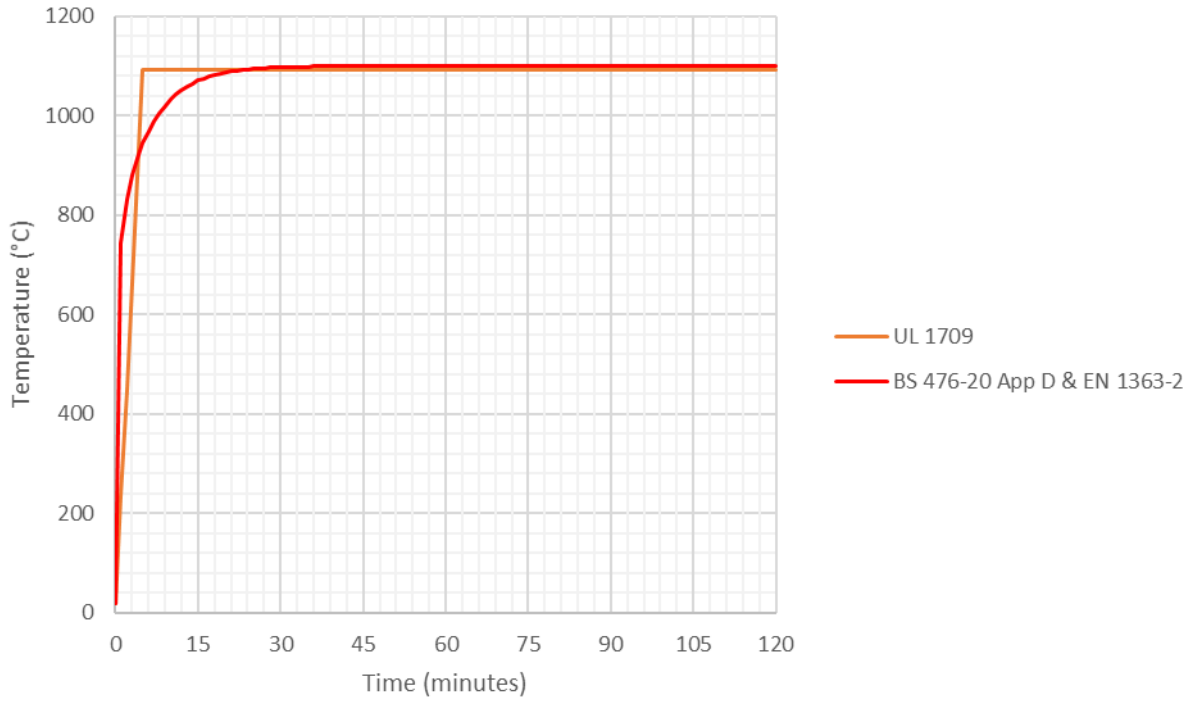

Figure 2: Comparison of furnace temperature heating curves for common hydrocarbon pool fire test standards

Manufacturers of passive fire protection material will test their products to characterise performance and to ascertain thicknesses of material to meet steelwork specifications. Typically, a selection of beam and column sizes are used, and the resulting matrix of specimens leads to an assessment of data to enable tabulated thicknesses relevant to massivity of steel and limiting steel temperature.

Product certification is based on testing and assessment to an appropriate test standard by a recognised test house or accredited certification body such as a classification society or notified body.

There is no dedicated fire test standard or assessment protocol for bolted connections, let alone for components of connections, i.e. a bolt cap. As such, bolt cap certification for fire resistance is not possible. Where no dedicated standard exists, then manufacturers will undertake ad-hoc fire testing to produce an indicative assessment report. Such testing will often be done in accordance with the intent of the principles of a recognised fire test standard. A corresponding indicative assessment report will then be produced, which although does not constitute product certification, it can be used to provide confidence in the performance of a product.

Many building codes and design codes will request materials used on a project demonstrate compliance in accordance with a recognised fire test standard. However, they also make allowances for alternative solutions which meet the intent of the fire test standard. The acceptance of such an approach is therefore subject to confirmation by the project design team, approving authorities or other stakeholders as appropriate.

4 SUMMARY

A high-level overview of the thermal exposures defined by common fire test standards shows that their respective time-temperature curves are similar when considering either cellulosic or hydrocarbon scenarios. Although each standard has subtle differences which can account for difference in product thicknesses, they can all be considered as functionally equivalent, i.e. they expose a passive fire protection material to a fire to enable its performance to be characterised.

There is no dedicated fire resistance test standard for bolted connections or their components. As such, product certification is not possible.

In the absence of a fire test standard however, a manufacturer will choose to undertaken ad-hoc testing to the principles of a recognised test standard. This can permit an indicative assessment report which demonstrates the capability of the product and can be used with the project team's stakeholders to consider its acceptance and use.

5 REFERENCES

[1] ISO 834-1: 1999, Fire-resistance tests - Elements of building construction. General requirements. International Standards Organisation
[2] BS 476-20: 1987, Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles). BSI
[3] EN 1363-1: 1999, Fire resistance tests, Part 1 - General requirements.
[4] ASTM E119-18ce1, Standard Test Methods for Fire Tests of Building Construction and Materials, ASTM International, West Conshohocken, PA, 2018, www.astm.org
[5] UL 263 Fire Tests of Building Construction and Materials.
[6] UL 1709 5th Edition, February 24, 2017. UL Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel.
[7] EN 1363-2:1999 Fire resistance tests – Part 2: Alternative and additional procedures
[8] ISO 22899-1:2007 Determination of the resistance to jet fires of passive fire protection materials. Part 1: General requirements.