# ASFP Advisory Note 24

## ASFP Position Paper on the use of Yellow Book Critical Temperatures for the UK (or equivalent) Market

### Background to Yellow Book

The ASFP publication "Fire protection for structural steel in buildings" better known as the Yellow Book has been used as the industry leading guide for those involved in the manufacture, test, specification and use of passive fire protection for structural steel.

First published in 1976, the 5th Edition was published in July 2014.

The 5th Edition of the Yellow book was published to enable adoption of new European testing and assessment methods – alongside amendments to the pre – existing UK test and assessment methods. The UK amendments were needed to keep pace with steel design practices such as adoption of the Steel Eurocodes and use of Multi-Temperature Analysis (MTA) and Structural Fire Engineering.

Using Eurocode for steel design allows for a fire engineering approach which can be used to calculate the critical temperature of structural steel members. However, the practice of carrying out such a structural analysis is not common in the UK market. The UK construction industry has traditionally worked with a series of default temperatures. As part of this update, in 2014, the ASFP introduced 3 new tables of default temperatures in the Yellow Book, covering both the historical BS5950 and newer Eurocode design scenarios. These tables were accompanied by a flow chart to help specifiers chose the correct table.

Recently we have become aware that the tables and flow chart are considered over complicated, and the underpinning assumptions are not clear. As a result, we have reviewed both the tables and the flow chart to produce a clearer and easier to understand guidance.

### Default Temperature Guidance.

Table 16 covers designs done in line with the Eurocodes – EN1993 & EN1994 (often referred to as Eurocodes 3 & 4). The design process when using Eurocodes is more complex than the historical way in which BS5950 was used. Despite this complexity, the ASFP and members worked together to provide some reasonably practical yet safe "default" critical temperatures.

To keep the reasons behind the development of the Table 16 values simple, the Eurocodes have introduced factors of safety that are applied in fire and these factors are dependent on the use (or

occupancy type) of the structure. Table 16 represented that simplified approach, even though it introduced three scenarios, when we historically only used one – see below. However, the most common scenario used by construction is “Office”.

Various assumptions were made in compiling the table below (See Appendix). These assumptions can be shown to cover most cases in structural design. It is the responsibility of the steel designer / engineer to determine whether these assumptions are appropriate for a particular structure.

## Table 16 - Eurocode Default temperatures (˚C) reproduced from the Yellow Book

| Usage Type | Non-Composite 3-sided Beam | Composite 3-sided Beam | I section Column / 4 sided I beam | Hollow Column |
|---|---|---|---|---|
| **Office / Domestic / Traffic Ramps etc** | 603 | 576 | 563 | 547 |
| **Congregational, Shopping and Car Parks** | 583 | 553 | 539 | 521 |
| **Storage,**<br>**Default if occupancy not known** | 576 | 544 | 530 | 512 |

Whilst Table 16 is based on Eurocode designs, Table 18 covers the design scenarios using the historical British Standard – BS5950. Although BS5950 has been superseded in Standard development work, it is still a legitimate practice to design structures according to BS5950. Many modern buildings are designed in accordance with this standard today.

## Table 18 - BS5950:2003 Default temperatures (°C) reproduced from the Yellow Book

| | Other | Offices |
|---|---|---|
| Hot rolled H sections in compression with $\lambda \leq 70$ | 540 | 580 |
| Hot rolled H sections in compression with $\lambda > 70$ | 510 | 545 |
| Non-composite beams carrying concrete floor slabs | 620 | 650 |
| Beams not carrying concrete floor slabs | 555 | 585 |
| Composite beams supporting steel deck floors | 580* | 610* |
| Hot finished/formed hollow sections in compression | 520# | 520# |

*Assumes that the deck voids are filled. See A.3.5
# Typically this is 520°C although different manufacturers state different temperatures based on the testing and assessment for certain products

$\lambda$ is the slenderness, which is defined as the effective length divided by the radius of gyration. If it is not known it should be assumed to be > 70.

Historically, temperatures of 620°C for Beams carrying a concrete slab and 550°C for Columns exposed to 4-sided heating have been used. Despite the publication of Table 18 in the Yellow Book 5th Addition, most manufacturers have continued to present their product thickness tables for these "defaults". These values were based on a series of assumptions, notably how much applied load existed in the fire situation (See Appendix showing assumptions that were applied). It is acceptable to continue to use these default temperatures if the structure is designed within the parameters of the engineering assumptions.

Table 18 has therefore been revised here to include 620°C for Beams carrying a concrete slab and 550°C for Columns exposed to 4-sided heating to cover the most common usage type – "Office". The revised table also provides a modified set of default temperatures for building uses other than Offices and an additional set to cover occupancy type storage / stair or lobby.

It should be recognised that structural engineering assumptions have been made in order to derive these temperatures (See Appendix). It is the responsibility of the design engineer to ensure that these assumptions are appropriate to the building design.

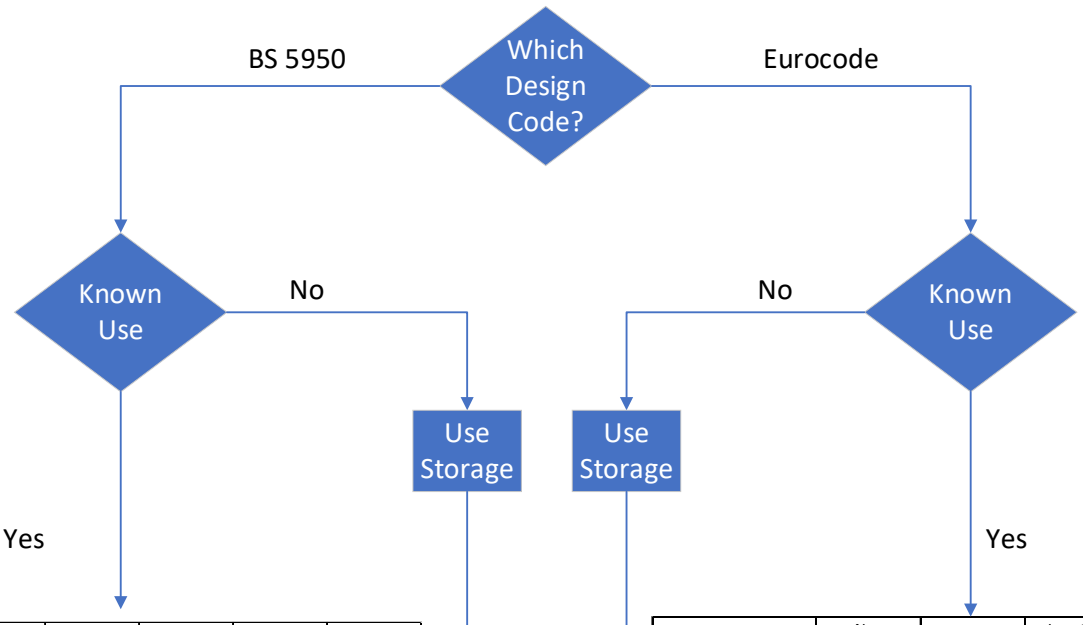
### Revised Table 18 - BS5950:2003 Default temperatures (˚C)

| Usage Type | Non-Composite 3-sided Beam | Composite 3-sided Beam | I section Column / 4 sided I beam | Hollow Column |
|---|---|---|---|---|
| **Office** | 650 | 620 | 550 | 520 |
| **Other** | 620 | 590 | 530 | 520 |
| **Storage / Stair / Lobby Default if occupancy not known** | 605 | 575 | 520 | 520 |

## Guidance where Building Type / Design Code is not known

Use of the Storage Category should be adopted when the actual occupancy type is not known. Where the Design Code is not known, then the Eurocode Temperatures from Table 16 should be used or Table 17 in the Yellow Book 5th Addition (2014). These have been chosen as they represent a conservative approach.

The flow chart over represents the process for selection of the correct critical temperature:




| Usage Type | Non Composite 3 sided Beam | Composite 3 sided Beam | I section Column / 4 sided I beam | Hollow Column |
|---|---|---|---|---|
| Office | 650 | 620 | 550 | 520 |
| Other | 620 | 590 | 530 | 520 |
| Storage, Stair, Lobby, Default where Occupancy not known | 605 | 575 | 520 | 520 |

**Revised version of Table 18 from Yellow Book**

| Usage Type | Non Composite 3 sided Beam | Composite 3 sided Beam | I section Column / 4 sided I beam | Hollow Column |
|---|---|---|---|---|
| Office / Domestic / Traffic Ramps etc | 603 | 576 | 563 | 547 |
| Congregational, Shopping and Car Parks | 583 | 553 | 539 | 521 |
| Storage, Default where Occupancy not known | 576 | 544 | 530 | 512 |

**Table 16 from Yellow Book**

## Concluding remarks

It is for the above reasons that ASFP Members will now seek to ensure they fully understand the Building Code and Category. This is significant for the end user to realise the importance of using the correct Codes & Occupancy (Building Category). These can have a significant effect on the Critical Temperature of a steel frame and consequently on the required thickness of Intumescent coating needed to protect it.

Several assumptions have been used in coming up with the limiting temperatures in the tables above. Users are advised to check that their structure is covered within the scope of the assumptions. If not, then structural calculations need to be done to establish the correct limiting temperatures for that structure.

Where a steel frame has been designed within the tolerances of our assumptions, if a user deviates to a different (higher) failure temperature than contained within this document, then concerns should be raised about the design liability. Someone in the contractual chain will need to take responsibility for that deviation, and ASFP recommends that this is not done lightly without the proper calculations being carried out.

Finally, we hope to move to a simpler position when Yellow Book 6th edition is published; however, it should be recognised that any such move for simplification, will also require a more conservative approach to be taken.

# Appendix

## Table 16 (Eurocode) Assumptions

The imposed to permanent load ratio ($Q_k$:$G_k$) was assumed as 1:1, and an effective length in fire for columns of 0.7$l_e$ also assumed.

## Table 18 (BS5950) Assumptions

In all cases, apart from the following, an imposed to permanent load ratio ($Q_k$:$G_k$) was assumed as 1:1, a Load Ratio of 0.5 and an effective length in fire for columns of 1.0$l_e$ was also assumed

“Office” Column assumes 1 (Qk): 2 (Gk), 0.57 load ratio in fire. Highly slender columns should be reviewed by the design engineer as this temperature may not be conservative.

“Other” NC & Composite Beam assumes 0.6 load ratio in fire.

“Other” Column assumes 1 (Qk): 2 (Gk), 0.64 load ratio in fire. Highly slender columns should be reviewed by the design engineer as this temperature may not be conservative.

“Storage” NC & Composite Beam assumes 2 (Qk): 1 (Gk), 0.65 load ratio in fire.

“Storage” Column assumes 0.67 load ratio in fire. Highly slender columns should be reviewed by the design engineer as this temperature may not be conservative.