DEVELOPMENT OF NEW DUTCH STANDARD FOR MID- AND LARGE-SCALE FAÇADE TESTING

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ABSTRACT

The fire safety requirements for facades are currently discussed in the Netherlands. For facades above 13 meters fire class B (in accordance to EN 13501-1) is required now [1]. With changing building trends and building use the probability of large incidents is increasing [2]. It is acknowledged that the current requirements will probably not be appropriate in the future. Therefore the Dutch regulations for facades are set to change and large and medium scale façade tests are introduced in the Dutch Standard NPR 6999. The tests included in this standard are the BS 8414-1/-2, DIN 4102-20 and a revised ISO 13785-1. The ISO-test is added to fill the gap in scale and costs between the DIN-test and the SBI and will be used as a basis for requirements at limited risk levels. In anticipation of this change, six façade systems were tested in both a revised ISO 13785-1 and the EN 13823 (SBI) to support drafting criteria for the ISO-test.

REASON FOR STRICTER REQUIREMENTS

International attention to façade fire safety increased significantly following the tragic fire at the Grenfell Tower in London in June 2017. This incident has led to the revision of fire safety regulations—not only in the United Kingdom but also in other countries. More recent events, such as the façade fire in Valencia in February 2024, further underscore the risks associated with façade fire safety. While such incidents strengthen the call for action, there are also other factors contributing to the urgency of tightening regulations in the Netherlands. Especially because of the growing number of high-rise buildings in the Netherlands.

In recent years, the design of (high-rise) buildings has evolved. High-rise developments have become more complex, with increasing use of new, lighter, and sometimes more flammable materials. While these materials align with modern architectural trends, they also elevate the risk of façade fires. Additionally, the energy transition and more ambitious sustainability goals are driving new façade concepts, including those with bio-based materials and integrated PV panels. These innovations support environmental sustainability but also present new fire safety challenges.
At the same time, building usage is changing. The Dutch society is aging, and more elderly people are living independently in apartment complexes and care facilities.

To maintain an acceptable level of safety in buildings, stricter fire safety requirements for façades are therefore necessary. It is undesirable to conclude in the near future that many relatively new or recently renovated buildings fail to meet acceptable safety standards. When a major incident occurs, public unrest often makes it difficult to carry out a balanced risk assessment, potentially resulting in overly stringent measures. This can be avoided by proactively tightening the requirements now.

NEW REGULATIONS

DGMR conducted several studies for the ministry to develop a balanced adjustment of the requirements. These studies resulted in a proposal that aligns the increased requirements with the Dutch context, avoiding excessive restrictions. For example, high-rise facades do not need to meet class A2 (with exemptions) or large scale test requirements in case of limited risk levels. This approach offers the Dutch construction sector flexibility in facade design.

The new regulations primarily focus on specific façades in new construction and renovation projects. The stricter requirements apply to:

- Façade sections above 50 meters in buildings where people sleep, such as residential buildings, care facilities, or hotels.
- Façade sections above 30 meters in buildings where less self-reliant individuals sleep, such as hospitals, particularly if the stairwells are not adequately shielded from a façade fire.

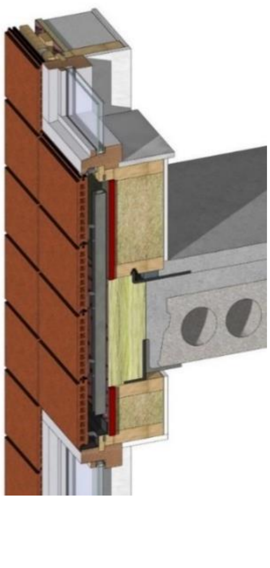
The new regulations in the Netherlands apply only to higher facades compared to several neighbouring countries. However, developments in construction methods, building use, and fire incident case studies will be monitored in order to make adjustments if necessary. The requirements give mainly cover reaction to fire aspects. Be aware that several fire resistance aspects of façade fire safety are covered elsewhere in the Dutch regulations, and those will be stricter too.

There are three possible approaches to meet the new fire safety requirements for high-rise façades:

1. **Facade construction in compliance with fire class A2**
   The entire façade assembly must comply with fire class A2 in accordance with NEN-EN 13501-1. This means that only (virtually) non-combustible materials may be used throughout the entire façade system.
   An exemption of 5% remains in place. Windows, doors, frames, and foils may comply with the lower fire class B as specified in NEN-EN 13501-1.
2. **Protection of combustible materials**
   Combustible materials may be used if they are shielded by fire-resistant cladding that provides at least 15 minutes of fire resistance (classified EI15) or $K_2$30 fire protection. Any unprotected materials must meet fire class A2.
3. **Large-Scale Façade Testing**
   A third option to comply with the stricter façade requirements is by testing the façade assembly in accordance with one of the (medium or large-scale) fire tests specified in NPR 6999. This offers manufacturers an alternative pathway by allowing for compliance through improved detailing or features such as cavity barriers.
   This method may allow for compliance even in cases where the external façade materials do not meet fire class A2—for instance, façades that incorporate PV panels.

An example of option 2 is shown in the figure below. The façade materials on the exterior and within the cavity are non-combustible. If timber-frame panels (with insulation that does not meet fire class A2) are shielded by cement-bonded board, the façade can still meet the requirements. For example bio-based insulation materials, which typically do not meet fire class A2, can be used in this way.

Figure 1. Combustible materials protected by EI15-rated cladding (see cladding marked in red).



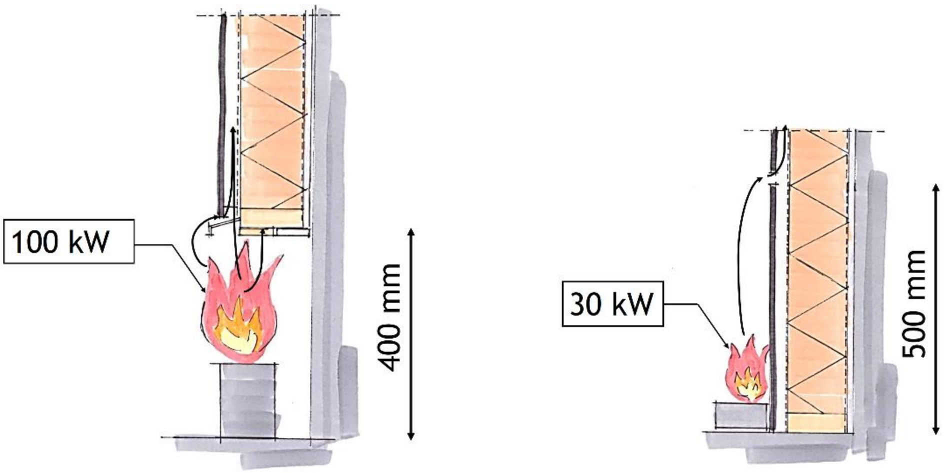
WHY THE ISO 13785-1?

In practice, large-scale façade tests are associated with long lead times and high costs. However, the impact of these requirements on the construction process is not always proportionate to the actual risk of a façade fire that these tests aim to mitigate. The regulator therefore wants to retain the option to limit the impact on construction processes and the tightening of requirements for high-rise façades with lower fire risks.

For many years, several European countries have imposed performance requirements for façades based on large-scale fire testing, in addition to the requirements set out in EN 13501-1. Two commonly used tests are the British BS 8414 (Parts 1 and 2) [3] and the German DIN 4102-20 [4]. Due to their larger scale and the use of a more substantial ignition source, these tests provide far better insight into the real-world fire behaviour of façades compared to the 'SBI test' EN 13823 [5], which determines the B-class rating.

To this end, a test has been added in the Dutch standard that bridges the gap between the two existing large-scale tests and the SBI test, both in terms of performance level and practical impact. This is a revised version of the ISO 13785-1 [6], hereafter referred to as the (ISO) mid-scale test. An important additional advantage of this test is that the vulnerable façade detail above an opening can be incorporated at the bottom of the test specimen (see following figures).

Figure 2 & 3. The difference in burner position between the ISO test (left) and the SBI test (right).



The ISO 13785-1 mid-scale test offers better insight into the fire behaviour of façades in practice compared to the EN 13823 SBI test. This is not surprising, considering that the SBI test was never originally designed for façade systems. Another important advantage of the mid-scale test is the ability to perform a heat release measurement. This allows the total heat output generated during the test to be determined, as well as the rate of fire growth.
However, the improved insight offered by the ISO test still comes with clear limitations. For instance, the ignition source used in the test is much smaller than some ignition sources encountered in real-life situations, such as flames from a fully developed fire or a large vehicle fire close to the façade. These are critical parameters for assessing the fire development of a test specimen.

Nonetheless, the ISO 13785-1 test provides significant advantages over the SBI test. The slightly larger scale and, more importantly, the inclusion of a critical façade detail above an opening are key improvements. This specific detail greatly influences both the likelihood and severity of fire spread within a structure, such as through a cavity.

INTRODUCTION OF LARGE-SCALE FAÇADE TESTING

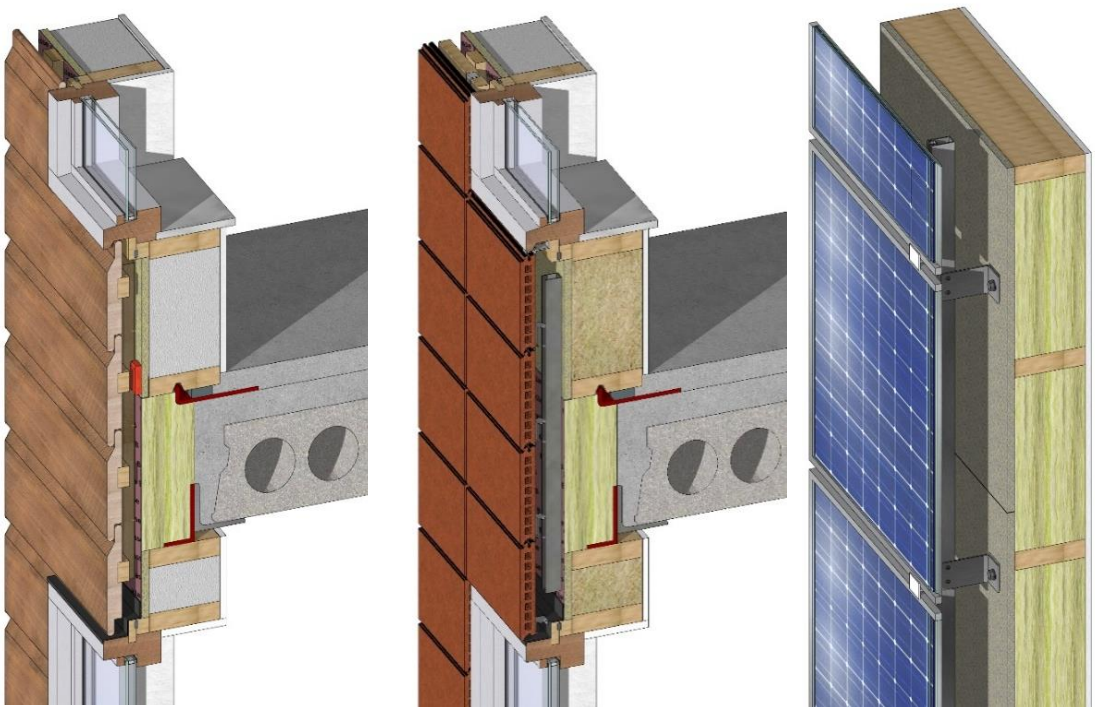
The introduction of large-scale façade testing is intended as an alternative to the fire class A2 requirement. The idea behind these tests is to evaluate façades in a more realistic and stringent manner than before with the SBI-test method. This approach allows façades that do not meet fire class A2—such as façades with integrated PV panels or other innovative products—to still be deemed safe if they pass the testing.
NPR 6999 specifies acceptance criteria based on the following three tests:

- **Mid-scale test (ISO 13785-1):** A test in which the façade assembly has a L-shaped specimen has a height of 2.4 meter, and wings of 1.2 meter and 0.6 meter width. Gas thermocouples measure the temperatures at the front and in the cavity of the specimen at a height of +1300 mm and +2300 mm above the bottom of the specimen [3].
- **BS 8414:** The British large-scale test, where a façade assembly with a height of 9.5 meters is subjected to a wood crib fire generating up to 3000 kW [4].
- **DIN 4102-20:** The German test, involving a façade assembly with a height of 5.5 meters and a 320 kW gas burner [5].

The mid-scale test is the most likely to be applied in practice for façades up to 70 meters in height. This test is relatively cost-effective, can be conducted at Dutch laboratories, and the test specimen remains of manageable size. The scale of the test roughly corresponds to the height of a single building storey. The detailing at the bottom of the test specimen must match the top of a window frame connection, which means that, unlike the current SBI test used for fire classification, flame penetration into the cavity is also assessed.

Three façade build-ups, likely to undergo testing due to their material composition and expected ability to meet the criteria, are illustrated with the following three examples.

Figure 4, 5 & 6. FR-Timber façade cladding combined with a non-combustible board and an intumescent cavity barrier, biobased insulation combined with a mostly non-combustible façade cladding and PV-panels mounted on a non-combustible backing board.



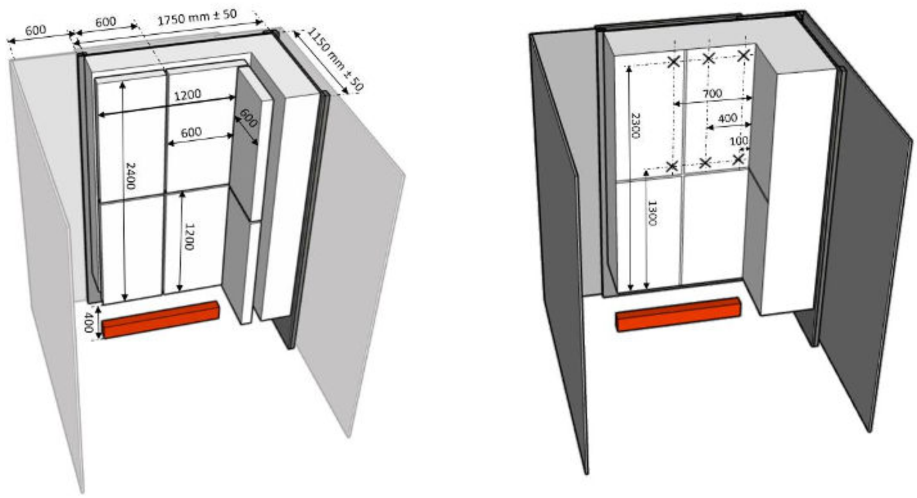
TESTING SETUP

A series of changes and additions were made to the ISO 13785-1, which lead to a Dutch revision of this international standard. In addition, some criteria relied on visual observations that were not easily reproducible. Instead of such observations, reproducible measurements are preferred.
As a result, the NPR 6999 introduces the following adjustments and additions to the ISO standard:

- Various visual observations have been removed;
- Power measurements and corresponding calibrations have been added;
- The position of the burner relative to the test specimen is now fixed;
- Gas temperatures are now also measured at the front side of the test specimen;
- Test instructions have been further detailed in many areas;
- A changed frame is added to be able to test element facades or curtain wall systems.

At the request of the Netherlands, ISO has also initiated a revision of the standard. It is expected that the updated ISO version will largely align with these modifications.
The ISO 13785-1 Medium scale façade test uses as heat source a 100 kW propane gas line burner with flames against the bottom side and along the front of the façade specimen. The L-shaped specimen has a height of 2.4 meter, and wings of 1.2 meter and 0.6 meter width. Gas thermocouples measure the temperatures at the front and in the cavity of the specimen at a height of +1300 mm and +2300 mm above the bottom of the specimen.

Figure 7 & 8. Changed setup with Dutch revision of ISO 13785-1 with on figure 5 the dimensions of a specimen and on figure 6 the positions of thermocouples on the surface an in the potential cavity.



The following major adjustments and additions to the BS 8414 standard:

- Curtain walls are not within the scope of BS 8414-1 and BS 8414-2. However, in this NPR, BS 8414-2 is also made applicable to curtain walls, but only when combined with specified additions;
- The test must not be conducted outdoors;
- A cavity barrier and fire stop are only present in the test specimen where they would also be present in the intended practical application. This also applies to any vertical fire stops and cavity barriers around the opening of the combustion chamber.

The following major adjustments and additions to the DIN 4102-20 standard:

- The test must not be conducted outdoors;
- Measurements and observations conclude after 60 minutes.

Outdoor tests are insufficiently reliable and reproducible for supporting a classification due to weather influences.

TESTING PROCEDURE

In anticipation for this change in regulations revised ISO 13785-1 medium-scale tests were performed combined with EN 13823 SBI tests [6] on the same products to set criteria for compliance when using the revised ISO test. The manufacturers were especially asked for specimens with flammable components, the façade designs tested are not used in the current building designs. Due to limited budgets the medium-scale façade tests were performed only once per type of specimen, the SBI test were performed three times.

The following facades are tested:

- Reinforced cement plaster, EPS insulation and a 250 mm mineral wool fire barrier on the bottom of the specimen.
- Bamboo façade cladding, plastic fixing, calcium silicate panel and wooden framework.
- ACM-FR aluminium cladding, aluminium fixing, thermoset insulation fire class C with cavity barrier on top of specimen.
- Element façade, aluminium elements, rubber connections, elements filled with PIR insulation and mineral wool in the panels.
- Non-combustible façade cladding, flame retardant battens, foil and wooden framework filled with biobased flax wool (fire class C).
- Flame retardant wooden façade cladding, flame retardant battens, calcium silicate panels protecting the wooden framework filled with insulation (fire class C).
- Calibration of the test setup with only inert materials.

Figure 9 & 10. Results of test following the ISO 13785-1-NL-rev. On the left graph the temperatures in front and in the (potential) cavity. On the right graph the HRR and THR in the first 300 seconds.

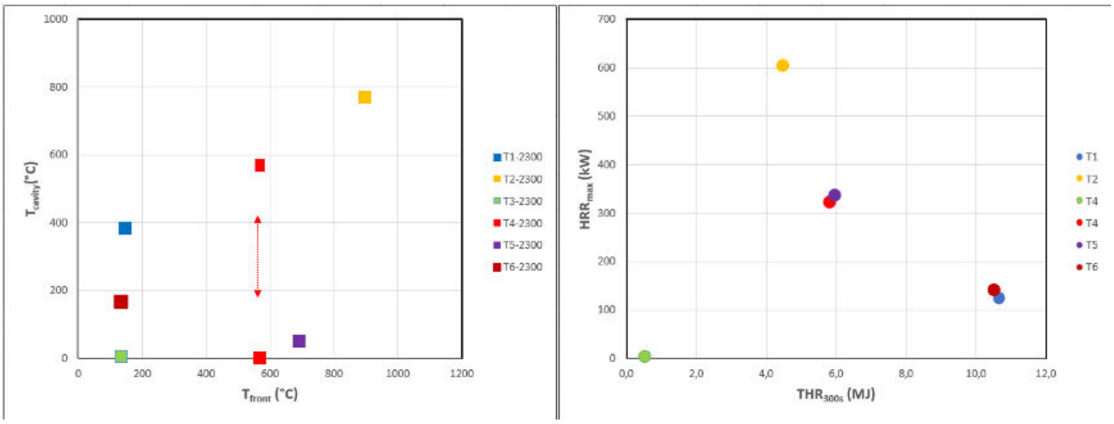
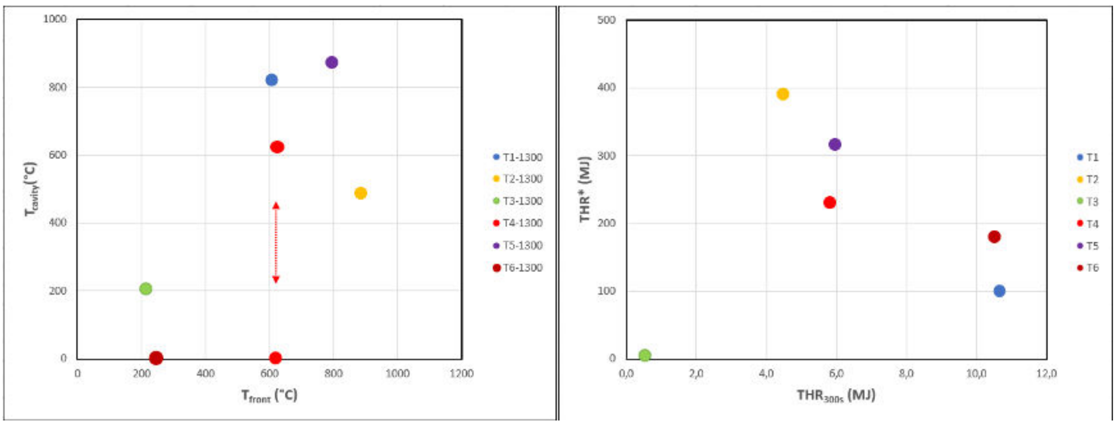


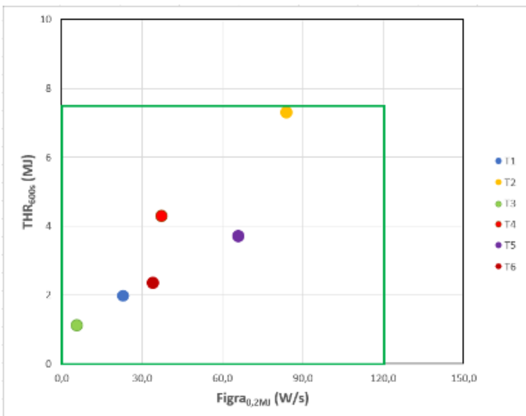
Figure 11 & 12. Results of test following the ISO 13785-1-NL-rev. On the left graph the temperatures in front and in the (potential) cavity. On the right the total produced Heat Release.



Measurements errors occurred in three of the test, which means that not all individual results are fully representative. However, the overall dataset still provides a reliable indication of the relationship between SBI tests and ISO mid-scale tests.

As previously noted, the façade assemblies were tested as part of the development of NPR 6999, in accordance with ISO 13785-1-NL-rev and EN 13823 (SBI test). All assemblies met the requirements of NEN-EN 13501-1 for Reaction to Fire Class B, as shown in the figure below. The criteria for the new Dutch ISO classification (NL-ISO) were deliberately set more stringently (i.e. with lower thresholds) than the values achieved by façade types 1, 2, 4, 5, and 6, since the observed and measured performance of these assemblies was considered not acceptable for the envisaged high rise facades. This means that the NL-ISO criteria impose stricter requirements than Class B under NEN-EN 13501-1.

Figure 13. Results of the indicative tests for the NPR 6999 in the EN 13823 test setup.



The following parameters for criteria are used for classification:

- The test must not be terminated within the first 30 minutes.
- Total heat release (THR) during the entire test [MJ].
- Total heat release during the first 300 seconds of the test (THR300s) [MJ].
- Maximum temperature rise at a height of 2300 mm on the front side of the specimen [°C].
- Maximum temperature rise at a height of 2300 mm in the cavity [°C].
- Maximum temperature rise at a height of 1300 mm on the front side of the specimen [°C].
- Maximum temperature rise at a height of 1300 mm in the cavity [°C].
- Maximum temperature rise at the rear side of the specimen [°C].

The final criterion applies only to element façades. As these façades do not have a cavity, the temperature rise criteria in the cavity are not applicable.

A test specimen fails if any of the threshold values for the above criteria are exceeded. The laboratory technician may also terminate the test within the 30-minute duration if the specimen poses an excessive hazard. In such a case, the specimen is considered to have failed the test.

The reason for including both the THR and THR300s parameters is that THR provides insight into the total fire contribution of the specimen over the full duration of the test, but not into the early fire growth rate. Therefore, the THR300s is added to reflect heat release in the first 300 seconds. Due to the limited reproducibility of energy release measurements within the first 30 seconds after burner ignition, it was decided not to include a Figra-type parameter (as used in EN 13823 'SBI').

The reason for measuring both the front temperature and the cavity temperature is that flame spread via these two routes can differ significantly, and the fastest route is usually decisive in real-world situations. Additionally, temperature measurement at both 1300 mm and 2300 mm heights provides an impression of vertical flame spread beyond the area heavily affected by the burner flame.

The horizontal joint in the specimen, as shown in Figure 7, is located halfway up the specimen at a height of 1200 mm. The temperature at 1300 mm is measured just above this joint to assess the potential for flame penetration into the cavity. Temperature is recorded as the average from three thermocouples distributed across the width of the specimen.

The criterion for the rear surface temperature is based on standard fire resistance criteria rather than the single test conducted. This temperature has other implications than temperatures in the cavity or at the front. The rear of a unitised façade can be in direct contact with the building's contents and must remain well below the ignition temperature of common materials.

In principle, observations regarding the distance of flame spread across the specimen are relevant as an indication of fire behavior. However, such observations are not used for setting hard limits. In laboratory practice, consistently observing flame spread proves challenging due to rapid natural variations in flame volume and differences in human and camera light sensitivity. As a result, different observers frequently reach different conclusions regarding flame observations.

CONCLUSION

In light of recent international incidents façade fire safety has become an urgent priority for regulatory bodies worldwide. The Netherlands has responded by proposing a tightening of fire safety requirements for façades of high-rise buildings and those occupied by vulnerable populations. This regulatory shift is driven not only by the clear lessons from tragic fire events but also by the evolving nature of the built environment: architectural innovation, increased use of lightweight and bio-based materials, integration of renewable energy systems like PV panels. Also potential demographic shifts, such as the aging population and the rise of assisted living facilities, demand a re-evaluation of fire performance standards for building envelopes.

To address the fire safety of the facades, in the Netherlands a new regulatory framework will be introduced that allows for multiple compliance pathways. These include the use of non-combustible materials that meet fire class A2, protective cladding systems that shield combustible components, or proof of safety through mid- and large scale facade fire testing. This flexible approach reflects an effort to maintain high safety standards without unnecessarily limiting material choices or hindering sustainable building practices.

Central to this regulatory update is the development and implementation of the revised ISO 13785-1 mid-scale test, now incorporated into the Dutch NPR 6999 standard. This standard will introduce large-scale façade test in the Dutch regulations. The medium-scale test bridges the existing gap between the limited relevance of small-scale EN 13823 (SBI) tests and the logistical and financial burdens of full-scale tests such as BS 8414 and DIN 4102-20. The Dutch revised ISO 13785-1 offers a more representative evaluation of façade systems by incorporating critical details such as window-head joints and by allowing for quantifiable, reproducible measurements, particularly those concerning front and cavity temperatures, total heat release (THR), and early fire development (THR300s).

This test method, while not as comprehensive as full-scale testing, significantly enhances the ability to predict real-world fire behaviour in façade systems, compared to the SBI-test. It supports a pragmatic regulatory strategy and it provides the construction industry with a viable route to demonstrate compliance when using façade assemblies that do not inherently meet class A2 standards but are considered to represent a limited fire risk.

Indicative testing conducted during the development of the NPR 6999 was used to set the new Dutch ISO classification criteria more stringently than the current class B under EN 13501-1. This reflects a precautionary principle, that only façade systems with limited fire risk pass the mid-scale test.

The updated approach in the Netherlands to façade fire safety provides a forward-looking framework that allows for design flexibility and material innovation, while ensuring a responsible level of fire protection suited to modern building challenges.

DISCUSSION

The evaluation of façade systems for fire safety has come under increased international attention following the fatal Grenfell Tower fire in 2017. The subsequent Grenfell Inquiry report emphasised that existing test methods such as BS 8414 are not without limitations. But no clearly superior alternatives are currently available. Large-scale façade tests, including BS 8414, are widely adopted across many European countries, largely due to the absence of harmonised European methodologies. In response, the Netherlands has introduced a Dutch modification of ISO 13785-1 as an intermediate solution, a medium-scale test method intended to serve as a provisional tool pending the development of a European large-scale test standard.

A key issue in the adoption of this new test method concerns its repeatability and reproducibility (R&R). This illustrates a well-known dilemma in the development of testing standards. Widespread adoption is hindered by the lack of proven reliability, while such reliability cannot be established without broader adoption. Consequently, progress is only possible if the acceptance of NPR 6999 is based on provisional judgments and practical experiences, supported by ongoing research.

Meanwhile, European efforts are advancing. The European Commission is funding the development of a harmonised large-scale façade test, featuring variants inspired by both the BS 8414 and DIN 4102-20 methodologies. While this forthcoming standard will eventually provide regulatory clarity, NPR 6999 is expected to play a critical role within the Dutch context during the interim period.
It is also important to emphasize the continued need for a mid-scale testing approach even after the introduction of a European large-scale standard. Such a scale would enable rapid and reproducible testing of commonly used façade systems, bridging the gap between small-scale laboratory methods and complex full-scale tests.

Another concern involves practical feasibility within the construction process. Due to time constraints and limited design flexibility, the prescribed SBI test is frequently bypassed. In practice, builders and designers often rely on expert judgment concerning the performance of individual components. This practice requires in-depth expertise, which is currently scarce, thereby increasing the vulnerability of the system to misinterpretation and inadequate risk assessment.

Given the current risk landscape and the operational realities of the construction sector, the Netherlands is proposing a modest increase in fire safety requirements. These revised requirements are based on test methods that are relatively easy to implement for standard applications, without significantly compromising the level of safety. The NPR classifications thus represent a deliberate compromise, more strict than Class B according to EN 13501-1, yet more practical for application within construction workflows.

However, it is recommended that the existing requirement for at least Class B performance in accordance with EN 13501-1 not be formally withdrawn until greater clarity is achieved regarding the practical implementation of NPR 6999. In the interim, equivalent safety performance may be demonstrated on a project-specific basis.

This discussion highlights that the Dutch model, with its emphasis on intermediate-scale testing and risk-informed regulation, could serve as a valuable example for other countries. The overarching challenge remains: to balance flexibility, feasibility, and safety, both in the current transitional phase and within the future European regulatory framework.

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