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COMPLETE ARTICLE
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The First Principles Concept of
Rainscreen Façade Fire Protection
Geir Jensen, FSS AS
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The First Principles Concept of Rainscreen Façade Fire Protection

Geir Jensen
Manager Application Research and Product Development at FSS AS

Preamble

I reveal disruptive facts not yet picked up by media or the Grenfell Inquiry, some of which industry are desperate to hide. I explain how todays messy rainscreens evolved, why current facades still endanger residents and how to cure it by startling simplicity: Back to basics.

I paint the broad picture. I live outside the box and got enabled to dissect and detect the devilish details.

Please check any headline you find interesting - or digest them all.

I owe this to Grenfell victims. Tenants and owners of similar blocks should pay attention. This is serious matter.

TAKE YOUR STANCE

Please read and sort out your role whether you are a building owner, tenant, official person or part of industry. Rethink what action or position yourself or your organization ought to take to replace the inferior practices. It is a global issue. We are in for a paradigm shift in the facade industry - or we continue to suffer.

Summary

I point at the goals and explain the mess of rainscreen practices. I propose what is required to clean up. I do it from insight, not by abstract political terms. I offend no person, industry expert or official institution. I make no preference to any type of material, combustibility or specific designs. The article is limited to **rainscreen systems** which are the most common in high-rise, are common elsewhere and strongly favored within building physics.

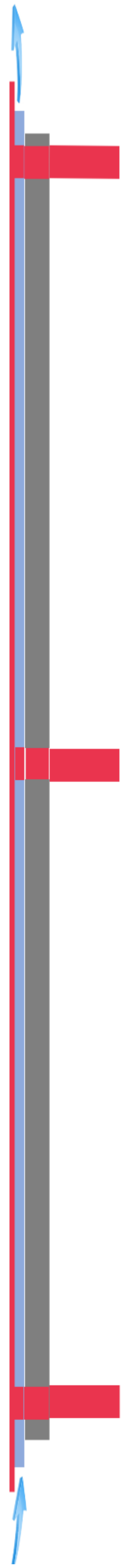
The calamity seems to have evolved rather than being governed by intention. Not anyone's fault except all victims of a sort of groupthink within the realm of manufacturers and laboratories 2000-2020. I explain and conclude how most of today's rainscreen systems are misconceived, unsafe, overly complicated, compromising building physics, vulnerable and sensitive to testing. Install practices lends themselves to err, not to fail-safe.

I explain how open source robust rainscreens can be possible and simple while complying to concept by code. No exclusivity or monopoly. Expensive tests can become rare. Compliance can become a breeze.

Unexpectedly to some, UK's MHCLG Approved Document B Vol 2 (ADB 2), CWTC standards and guides as well as the BR 135 document turns out satisfactory as in fact they are authored based on the first principles concept. BS 8414 and equivalent methods need specific change regarding exposure to test specimens. The parts and criteria in the former documents including ADB 2 need mere subtle adjustments to align with new BS 8414 series and ensure correct interpretation. This affects rainscreen (ventilated) systems, **not** the other type of facades.

The Concept

CHAPTERS



Smoke or heat from exterior fires shall not penetrate cladding to prevent occupation or evacuation or to allow fire spread between indoor fire compartments during the fire resistance rating period. Exterior fire damage shall be an acceptable risk or adequately insured.

That, condensed, is the world-wide obective and concept of exterior fire protection.

The strategy to achieve this is to design a cladding with a burn-through time or fire resistance class. Typically this involve limiting the area of damage, proving selfextinguishing after the fire source has burned-out or at least leave but a manageable residual fire to the rescue service.

Non-cavity facades, such as rendered or ETICS systems, are readily verified by a full scale façade fire test. Rainscreen systems are most common and have air cavities. Cavities need to be sub-divided or compartmentized. This article deals with the rainscreen facades only.

The concept and compartmentation of rainscreen systems is pure sense. It is best laid out in UK by ADB 2 and CWCT publications, despite glitches. These documents are widespread and applied in UAE and Australia among others. So far so good.

Then trouble starts.

The façade system designs by the industry, test methods, criteria, reliability, safety performance and practice are not at all adequate. Gone are functional requirements, cavity compartmentation and burn-through performance. The facades fail easily and horrendously. The article describes a multitude of missteps by industry last 20 years.

Find description, figures and comparison to current rainscreens at end of article.

A A Messy State

Rainscreen Facades under Scrutiny - Background

Debates in media on façade fire protection tend to miss context. The state of the current norm is messy. We need a common ground to make facades reliable in fire.

I will attempt to explain the logical and non-compromising concept of rainscreen facade protection. My insight comes from performing realistic exterior and laboratory fire tests while studying research and code literature of ventilation and draining as well as fire mitigation. My approach is reasoning from first principles as best I can.

The article comes in five chapters A-E and sets out to bypass the tweaking of code language, irrevocable statements, prejudice, industry dead-ends, political interests, skewed marketing, product shortcomings, fire design shortcomings and the «keep as is» attitude. It aims at getting back to basics to review the facts and functional requirements on how to ideally protect building exteriors from fire. Facade fires are proof we have got it wrong.

Facade designs are governed by architecture, building physics and fire safety in that order. Ideal rainscreens are preferably without projections. Air gap ventilation is limited by width, depth and volume. Cavity compartment is limited by volume, area, orientation and locations. Draining and air inlet and outlet gap sizes on sides, top, bottom or panel joints to compartments are all set by building physics. This leaves little leeway and lots of traps for fire protection design.

I frequently find post-Grenfell debates narrow: The greater perspective of façade fire protection include cladding as well as cavity and more. You can hardly discuss one element without the rest. This point is one of those missed by most parties involved, from owner to regulator. Façade fire protection has gone astray and have immense implications. You may be in for multiple surprises.

A current issue – flimsy panels

I am puzzled how one can assess cladding panels by reaction to fire properties and filler mass only; that is, without considering deflection, movement or crumpling that cause integrity failure of cavity compartmentation.

The governing concept of façade fire compartmentation: Extent of fire spread on outer surface and in cavity shall ideally be limited to the exterior profile of interior fire compartmentation. This is globally applied and laid out clearly by the ADB 2 and CWCT and perhaps best researched in Canada by NRC. So far so good. Verification by BS 8414/BR 135 is a test-feasible interpretation of the concept. Although, codes and test methods do suffer serious flaws as well, to be covered in later part of this series.

The major critical event in façade fires are integrity breach of a cavity compartment. The worst way this occur is by burn-through or deflection of cladding that expose and invalidate cavity barriers one by one, so fire escalate across stories. This often means cavity becomes a virtually open path for fire which then exits at top of building and at windows along its track. So, it is reasonable to focus on the cladding because a failure renders the panels and cavity barriers useless at the same time, i.e. a serious, irreversible event.

The other critical event is fire either starting inside cavity or fire penetrating a cavity barrier and becoming a concealed fire inside the cavity compartment. This is a less severe issue as long as fire do not penetrate the cladding panels. It takes time for a hidden and often oxygen-starved fire to pass barriers at each level. This allow reasonable time for rescue service to intervene.

Between 01.23.36 and 01.26.37 the rate of fire spread accelerated from approximately two storeys per minute to approximately four storeys per minute. At the start of this period the fire extended to the top of floor 15; after 60 seconds it had reached the top of floor 17; after 120 seconds it was at the top of floor 19; after 180 seconds it was in the middle of floor 23.[184] By 01.26 the fire had spread 19 floors in approximately 14 minutes. The following series of images captures that sequence:[185]

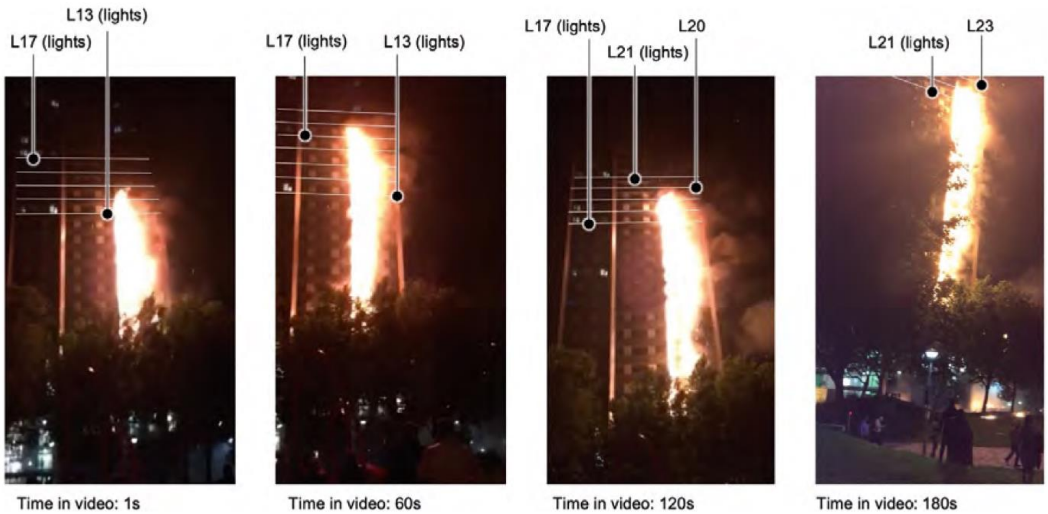


Figure: **Grenfell - Rainscreen Speed of Fire**

At the mean fire spread rate: each fire stops at floors bypassed in 2.6 seconds.
Up to four story's per minute.

Takeaways

Burn-through time is generally the most important fire parameter of cladding. Reaction to fire properties of panels are less of a challenge as long as fire do not enter cavities. As long as cavity compartmentation is achieved cavity surfaces and wall insulation may even be combustible. See other sections or chapter E for more on this.

Cladding must support fire compartmentation. Prescribed compartment barriers are already EI 30 or E 30 I 15. Any cladding panels of inferior burn-through/deflection will decrease performance of compartments. Weak panels, combustible or not, are the likely main cause to excessive loss of most tall building façade fires.

Many are shocked to learn this. You don´t need to study formal investigations to agree. Just apply logic and watch videos of these fires. Grenfell you watched already.

A sigh of mine: Why rainscreens fail in fire

How could the bad practice of flimsy cladding evolve based on the robust concept of compartmentation? I believe it stems from the perceived "impossibility" of combining ventilation with firestopping in rainscreens. It likely got on the wrong track when someone said "rainscreens need be ventilated anyway so no need to make them fire resistant". As no solution could be accomplished way back then, code authorities succumbed to require E30 I15 to cavity barriers only. They have since remained silent about the importance of panel burn-through performance.

Today, venting and firestopping can be reliably combined but the regulators have backed into a corner, incapable of stopping the bad practice.

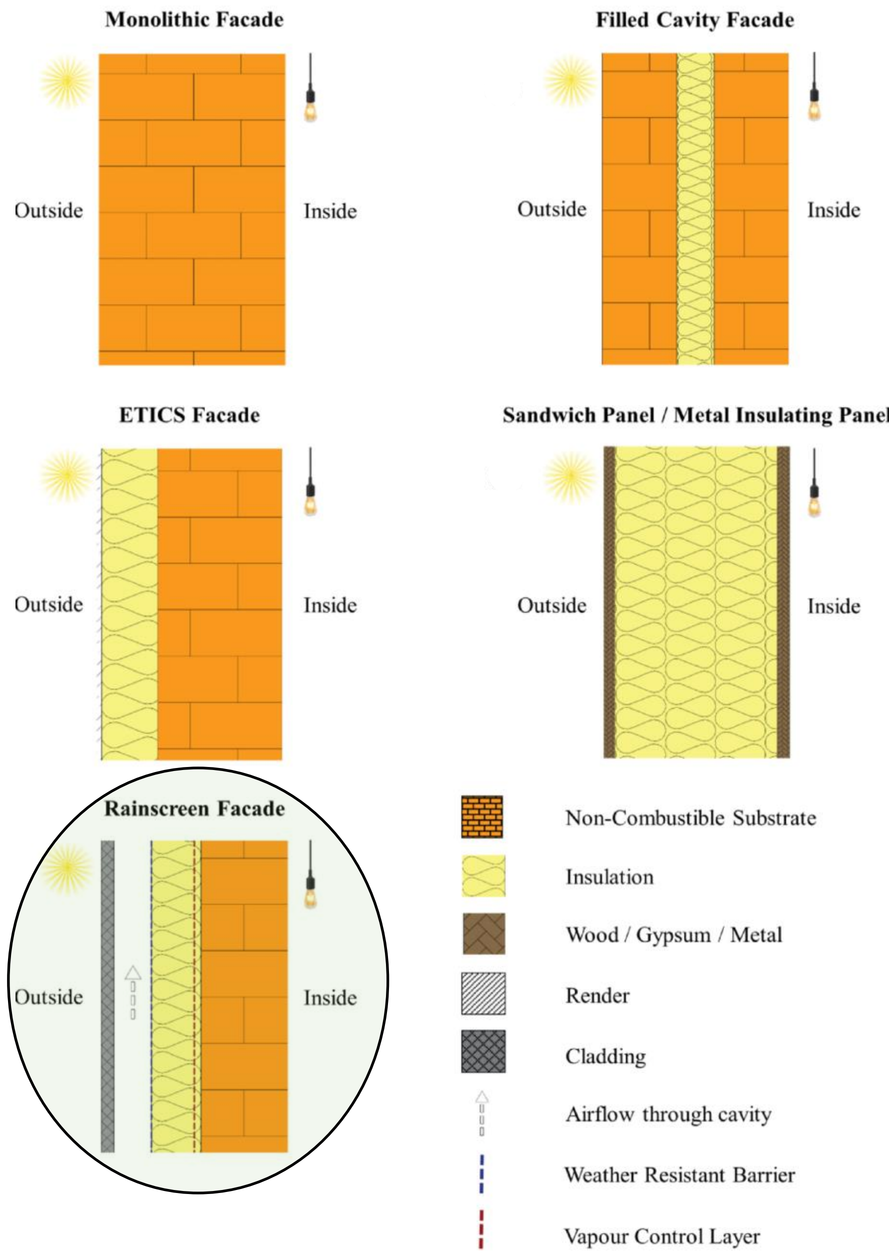


Figure: Common façade systems
- as simplified by Bonner and Rein (2020).

My article focuses on the rainscreen system (encircled) - the most common in high rise, common elsewhere and favoured by building physics engineers.

Rainscreen facades are frequently misunderstood or wrongly applied by professionals within building physics as well as fire protection.

B Are We Testing the Right Thing?

Most or all national functional requirements on facades have in common that they shall protect people from exterior smoke and heat, ensure evacuation if needed and keep structural loss at acceptable level.

A Chat with Myself

Do we test to verify compliance of functional requirements today? No. While testing in fire, do we record levels of smoke or heat ingress that may prevent occupation or evacuation during exterior fire? No. Do we test to verify fire resistance from exterior to interior? No. Do we test sensitivity and reliability, i.e. robustness of facades? No. Do we test propensity of facade elements to be installed in a wrong way? No.

Aren't those objectives obvious to verify that facades will prevent Grenfell happening again? Yes, of course. So, what are being done then to verify fire safety of facades? Since more than 20 years most countries still rely on full scale fire tests that simulate a room fire exposing a two or three level façade through an opening. It is a logic and really good idea, and it works fine with non-cavity facades. Pass criteria need be revisited though.

This article is about *rainscreen* facades however, which is another and uncomfortable story. Rainscreen cladding are the most common (Bonner and Rein) of larger buildings and well known from Grenfell and Dubai high-rise fires. Variations of such rainscreen facades do pass full scale tests. So why they failed? Full scale tests do not verify the vital properties and performances necessary to assess compliance with the functional requirements. Gosh! I will describe some of the decisive factors to explain this. Read on.

Functional Requirements Are Not Verified by Tests

The concept of fire protecting facades and the functional requirements are laid out in chapter A. This require to protect people from smoke and heat, ensure evacuation if needed and to limit structural loss at acceptable level.

It is traditionally and generally agreed that full scale fire test is a must to adequately assess exterior fire safety. This is not possible by the way rainscreen systems are made and the way specimens are exposed in tests today. Neither is it possible to verify facade fire protection by a full-scale test. Fire Safety Engineering (FSE) assessments must be added, and in doing so the full-scale test is no longer the alpha and omega of verification.

Verification of functional requirements is key as explained in chapter *A Messy State*. Robust systems according to the concept can be designed, tested and assessed very simple. I will return to this in several parts to follow.

Rainscreen Cladding do Not Conform to Concept of Approved Document B Vol 2

Rainscreen systems in the market typically have flimsy panels. They seldom differentiate between the widths of cavity air gaps and those of inlet/outlet gaps or simply look away from pressure equalized cavity compartment design rules where it is appropriate. Ventilating cavity barriers are typically not designed to keep expanded mass in place and rarely have any test evidence to prove fire resistance during the first five minutes of exposure.

This will be explained in detail further down - in the sections on issues of specimens and fire scenarios.

The current regime on how to comply with codes foster façade systems with ever more refined details. Attempts by fire protection engineers to avoid impacting the weather protection performance of the rainscreen facades enhance this. Collectively, all the modifications have removed whatever robustness was there from start. The manufacturers need to attend tests and oversee by utmost scrutiny that installation of test specimens is done correct, as minor defects otherwise may cause expensive tests to fail. However, that level of precision is hard to replicate in practice. Facades having passed tests may therefore become deadly prepared bonfires which kills.

A key to concept is to understand cavity compartmentation. A fire shall affect but one compartment, i.e. either burning through to it or start within it. However, current test criteria allow fire spread to one or even two compartments above to be accepted. This is because one cannot achieve to limit fire to first compartment with current façade systems.

Fire spread to another fire compartment is not acceptable inside buildings. Likewise, it should make no sense to allow minor defects in the façade to cause fire spread to multiple levels and compartments in ten minutes or so, once a fire breaks out. But they do. Such sensitivity is unheard of in indoor fire protection engineering based on 30 or 60 min compartments.

The concept is cavity compartmentation and limiting of the fire spread on face of façade to acceptable extent of damage. In that order. You see, fire spread is tolerated as long as it does not burn-through to cavities or to rooms inside. An exterior fire is what the building envelope protects against. Compare to room fire: As long as fire remains in the room of fire origin it is acceptable by the concept of indoor fire compartmentation. A full burn-out is accepted and that is indoor. This apply to the concept of facade as well, of course. Unfortunately, the crucial fire resistance is almost forgotten in current facade designs. Innocents are paying the price.

This indicates that robust safety designs are kept out of the market and innovation is stifled. The industry is in deep trouble, seemingly not aware. It keeps on bragging and protecting its fragile systems to the very end. The industry made the full-scale test methods. Surprisingly, post-Grenfell authorities seems most eager to defend them. After all ADB 2 has laid down the concept including compartmentation and 30 min integrity requirements. Are they governed or confused by the industry, or vice versa?

See following section for a sample case on this.

Best Fire Protection Rainscreens Fail in Valid Test Regime – Inferior Rainscreens Pass

Let me describe a case where the façade of a school building will never achieve a full-scale test. However, it offers 30 min fire resistance to any credible exterior fire, more than most buildings. The exterior wall is translucent, and the insulation of an extremely lightweight combustible (natural cellulose polymer) clad by thin polycarbonate. The inside is E30 wired glass. If ignited by a sufficient fire source the cladding and insulation in the affected cavity compartment burns off in 3-5 min and leave no combustibles. The 30 min glass easily resists such brief exposure.

That simple performance-based design (PBD) based on *fire resistance* is protecting people, robust and reliable. It is so efficient that reaction to fire properties of the outer façade become less important in this described case. Bravo; although of course it cannot pass a full-scale test to current criteria the way tests are done today. Read on.

The recent Norwegian NS 3912 standard “Exterior fire protection of buildings” supports the regulation and accepts full scale test results. However, it is based on burn-through time (smoke and heat) to protect life and property. That is, burn- through time is key when assessing fit for use in project-properties. Reaction to fire is assessed for the face of façade in regard to combustibility, expected loss, self-extinguishing and extinguishing.

At the same time, approved rainscreen systems may fail in the early minutes and lead to fatal incidents in real life. How this awkward situation has evolved and how it can be corrected will be explained in the following sections.

Figure: **Verified by performance-based design – not to BR 135 Criteria**

Robust translucent exterior wall offers 30 min verified fire resistance in furnace test – still cannot pass full scale test criteria BS 135 to BS 8414 which do not recognize fire resistance.

The Test Specimen Issue

Rainscreen façade specimens are not suited for full-scale tests applied to non-ventilating facades. I will explain.

Elements or modules of building bodies are tested in fire to prove their performances. Testing of larger interior elements is possible up to a limit only. Once they become too large to be prefabricated, or the interactions of its parts are no longer feasible to replicate in laboratories, e.g. multiroom layouts with corridors and shafts, we need to verify total performance by fire safety engineering (FSE) based on test evidence of the smaller parts and more.

Rainscreen facades have crossed this limit many years ago. Today, full scale testing is possible for simple ones, e.g. built to concept with cavity compartmentation. Most designs are not. They may come in too many variations and are generally expensive, complex, fragile or compromised. They are still tested according to code. If they pass, they are typically close to failure and extremely sensitive to deviations or errors when installed in practice. Worst of all are the failure modes that lead to uncontrollable fire spread escalation. Do I need mention Grenfell?

Building physics and fire dynamics

Fire protection engineers and fire laboratories, even façade designers, frequently seem to misconceive building physics of rainscreen facades. Tendency is to “ventilate and drain” which means a fixed air gap size from bottom to top. This often works adequately but are susceptible to draw in a lot of unwanted humid air in rainy climates which demands several days of good flow of dry air to dry out the cavity. It doubles as motorway for fire spread and for less well insulated walls it removes heat, i.e. loss of energy.

The appraised pressure equalizing rainscreens (PER) makes the best of both worlds, building physics and fire: Sealed panel facades should have inlet opening gaps that are less than 4-9 mm at bottom and top of each covered cavity volume. The cavity width in between should be the typical 50 mm. This restricts flow and makes the cavity act as a gas damper volume. Wind gusts set up same pressure in cavity as on face of cladding so very little air move in or out of the cavity and there is hardly any pressure acting that can push water against insulation. The pressure equalizing (or moderating) rainscreen enhances the performance of fire barriers at inlets where fire is most critical, reduces rear side exposure to cladding and reduces fire flow and fresh air flow into cavity.

How does building physics of rainscreens affect fire safety?

Developers of full-scale fire tests seem unaware of cavity implications. In two recent cases I noted developers suggest to firestop fully the cavity bottom opening from start of test. 15 years ago, I experienced a laboratory operator insisting to firestop both top and bottom ("we always do that"). A drawback of the superior PER design is the elaborated planning which deter competing manufacturers with cost concerns. However, if codes and regulations insist on requiring robustness, simple and passive modifications may be exploited to work wonders.

Benefits of optimizing building physics and fire protection is achieved by observing that the gaps for air inlets and outlets are narrow as per guides and observing compartmentation is done right. That will reduce energy loss, simplify barriers and make a robust way to allow use of combustible and environmental benign insulation etc.

Read more on how building physics can lower cost of protection in "*How to Verify Compliance to Code*".

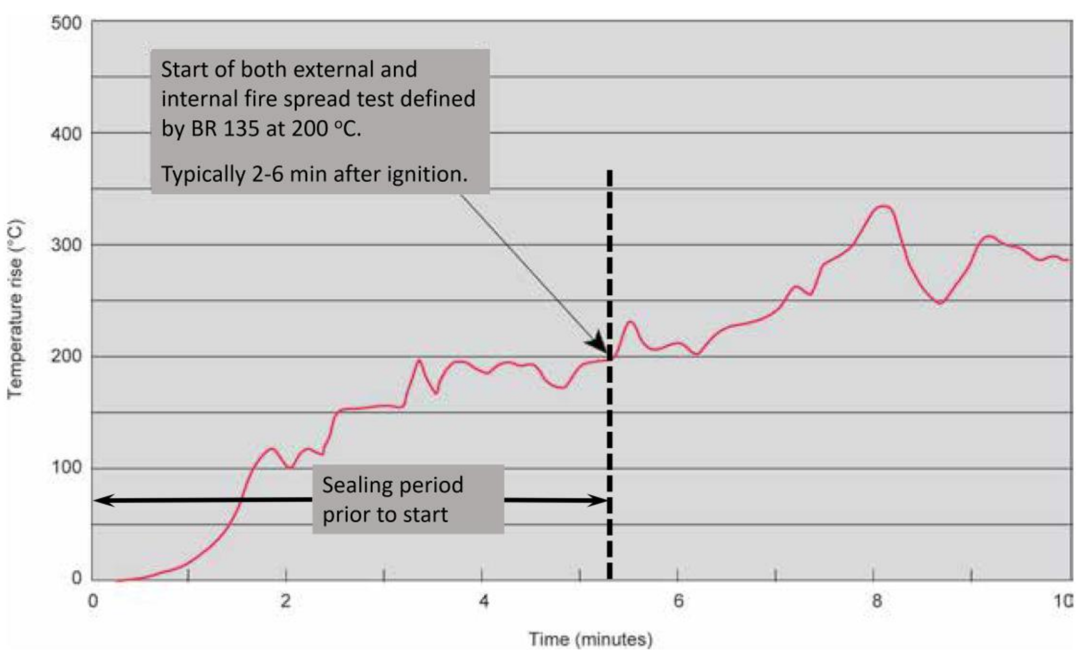
The Test Fire Scenario Issue

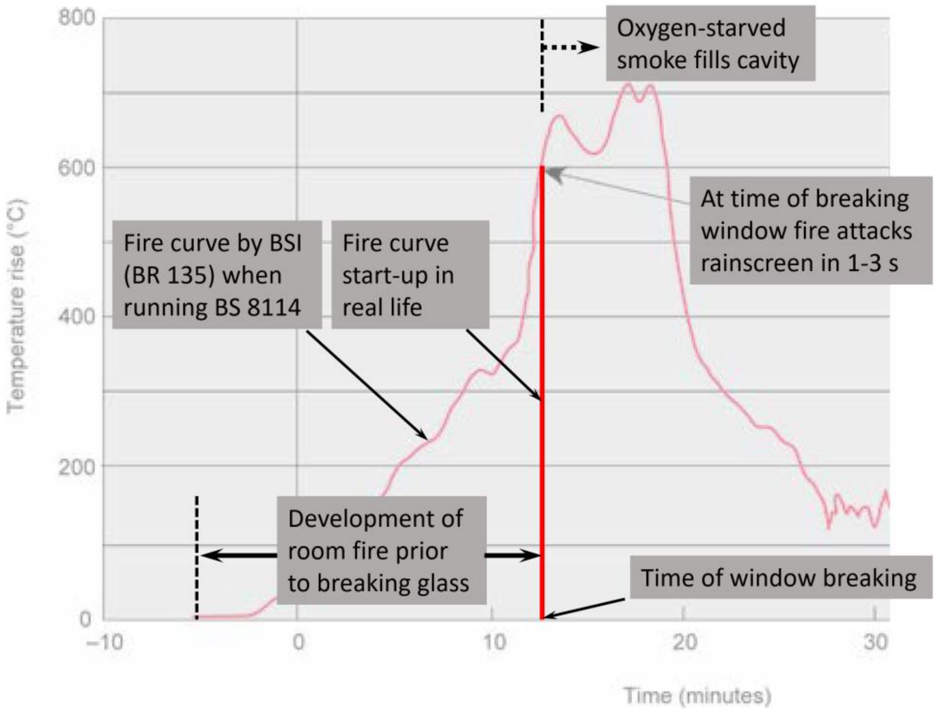
Fire sources of full-scale tests do not expose rainscreen specimens the way they need to. Currently, façades may pass test and fail in practice. I will explain.

The fire exposures are criticized for duration, irrelevant flue characteristics, low heat release rate, badly simulated fire-room volume plus geometry and lack of window glazing in front of room on fire and at the level above.

Full scale fire tests do not replicate real life fires. They do *not* simulate the breaking window scenario which is almost always the case (Hungarian test MSZ 14800-6 the single exception). Instead they expose the façade to a slow growth enclosure-fire exiting through an unprotected opening – i.e. simulating a fully open, large window in a very small room. This makes sense to assess exterior façade fire spread (non-cavity façade systems) but not to determine if there are any burn-through into cavity compartments or concealed fire spread which are the most critical and sometimes fatal events.

Why is it so? Explanation and consequences of this are explained in the article *"See-Through Fire Protection".*





Two figures above (adapted from two background diagrams by BRE in BR 135):

Pre-sealing prior to start of test: Intumescent expansion during preheating to BS 8414. Time of zero, start of fire, is defined as t_s. At t_s (i.e. 2-6 min after ignition as temperature reach 200 °C) all cavity barriers are perfectly sealed by ideal pre-eating. This is because there is no breaking window or slide off-shield to simulate breaking window. This can result in two-sided direct flame exposure to cladding panels and potentially a pop-pop-event as observed at Grenfell, unless quick barriers are in place – see also next figures.

If instead windowpane or removable shield is provided panels and barriers are exposed to realistic flame attack.

0 s **Window cracks** | **1 s** **Window breaks up** | **2 s** **Flames attack cladding above** | **3 s** **Steady flame column**

This series of snippets is from LPC test video of a typical office room fire. It shows why passive ventilating cavity barriers need to react instantly to prevent flame transfer to cavity above. The common types of intumescent cavity barriers applied 2000-2020 in the UK are not fully sealed until 25-50 s after flame attack. Cavity barriers to ASTM E2912 react instantly or quick.

(An insulated cable bundle with test sensors is seen right in front of the facade conection to floor slab above the room of fire)

Figure above:
Most common fire attack on rainscreen facades: Show sequence of 1-3 s as room fire breaks glass.

Figures at right: **Real life "behind the scenes"**

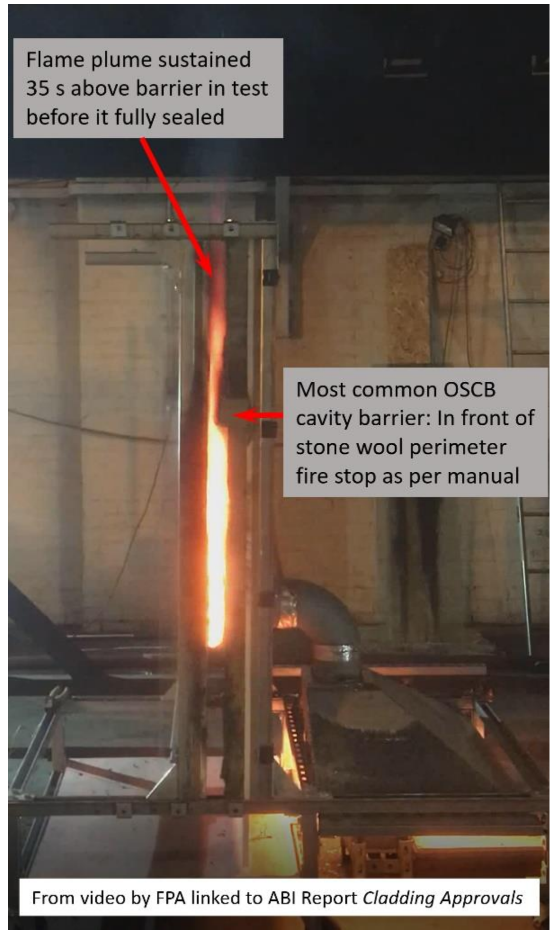


Image show what happens when rainscreen panels are subject to flame attack from behind (Grenfell and similar – tell-tale witness observations Phase 1 Vol 2 and 4 Reports (Sir Martin Moore-Bick). Image is from video of an ABI/FPA test. Sustained flaming above the barrier in 35 s before becoming sealed. Direct flame impact may ignite combustibles in 1-3 s only.

In real life copious amount of oxygen starved smoke fills the cavity as well – and will flare up when penetrating open panel joints or any deficiencies in façade - a common view in façade fires. The hot smoke and flaming of cavities are the reason cladding is subjected to the dreaded two-way exposure.

The figure below shows a typical scenario of flaming from open panel joints. A mockup fire test relevant to Grenfell facade by Efectis (ISO 13785-1), 3 min after ignition (Guillaume).

See also next to figures.

Does the Pre-heating Issue Affect BS 8414?

Yes. In fact, BS 8414 is the benchmark for full scale test being developed by the European Commission in view of an EN standard Neither is allowed to be improved by raising the bar.

Anyway, rainscreen or other ventilated façade systems cannot be tested with a pre-heating phase. Existing facades having passed BS 8414 or new ones in replacement schemes risk two-side exposure of panels that leads to the pop-pop escalation mode and early failure similar to what appeared at Grenfell. Unless the windows are fully open at the time of fire starting, which is highly unlikely. See more on this in next sections.

Important: This is not to say the facades are proven to fail in fire. Research to check the validity is yet to be done. Once industry and authority read this, they will consolidate. They will either explain convincingly that the present test method is OK for rainscreens after all or will research or perform comparison tests to prove me wrong. However, confirmations so far are in my favor: The ABI test, developing tests on ASTM E2912 and witnessed industry product tests by Exova Warrington. An EC mandate to CEN TC 127 and interpretation document decades ago was recently reiterated by TC 127 Resolution 778: It states that working groups on fire resistance standards *shall take into account reactive products open from start*.

Incidental research test results further confirm: In some tests, no fire appears in cavities without barriers, while others quickly spread fire. It appears those tests that avoids fire in cavity operates with virtually premixed flame fire sources that fill cavity with inert smoke, like BS 8414. This is accomplished by a fire source that is not in an enclosure that can accumulate oxygen starved smoke and not having any glass or protection in the façade opening from start. Easily done at testing but dangerously unrealistic. It is hard to break windows prior to fire attack, "to make fire fit the test method in real life", at least not at Grenfell where there was no time at all for preheating.

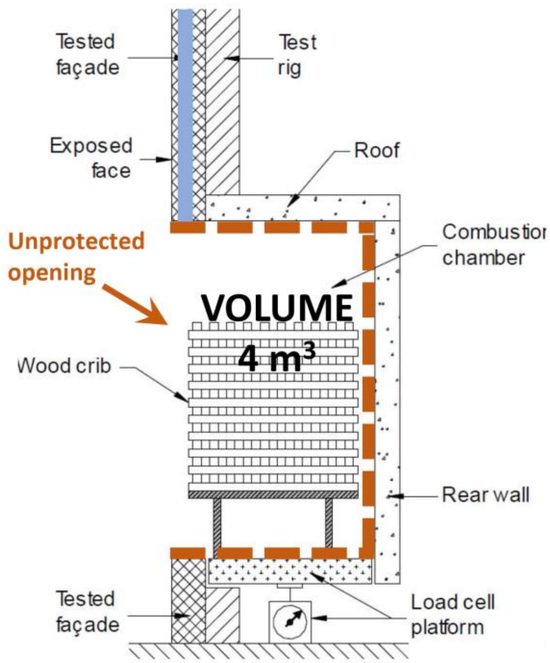


Figure: **BS 8414 or new EC Test Method**
Premixed flaming from 4 m^3 fire room fill *inert* smoke slowly into cavity (fuel-controlled fire – front wall open from start).

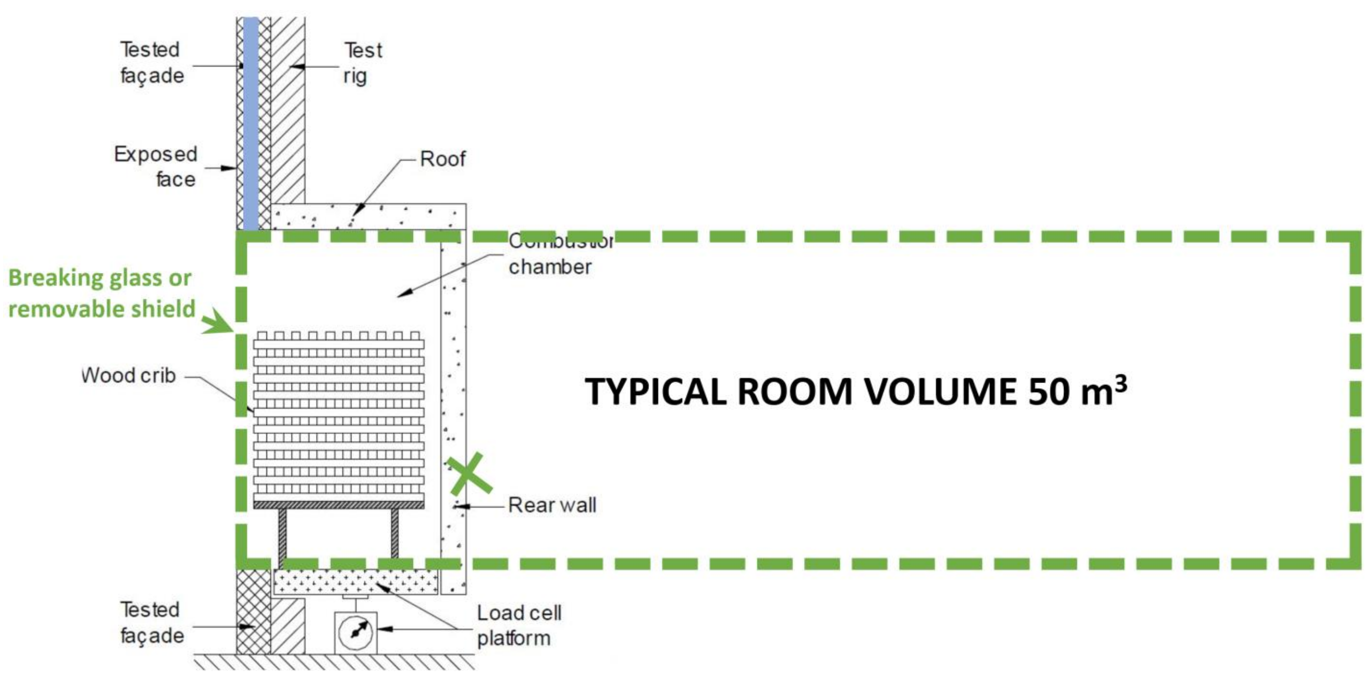


Figure: **Real Life Scenario**
Ventilation controlled fire abruptly fills cavity with copious amount of *combustible, oxygen-starved* smoke from a 50 m^3 fire room (fire breaking window scenario).

ASFP TGD 19 Product Standard: Why is It Not Endorsed by the ADB 2?

The TGD 19 test was developed by the industry in UK at the same time as CEN worked on the prEN 1364-6. This is a breach of contract between UK and the EU – work on test method for the same application, in this case cavity fire barriers, cannot be done at the same time.

Both proposed methods address cavity barriers in facades. The prEN 1364-6 describe two tests, one for barriers subject to enclosure fires (in rooms) and one for applications where sudden flame impact are anticipated, such as the cavity barriers in rainscreen facades. The latter method is in accordance with CEN TC 127 Resolution 778 which states that fire test methods to deal with intumescent seals must address fir resistance in the open state.

The TGD 19 method were published with the text copied in prEN 1364-6 that describes the method for room applications despite the fact TGD 19 is dedicated to cavity barriers only. TGD 19 applies a standard room fire exposure that preheats barriers very well to 538 °C (well beyond the 200 °C necessary to expand the seals) over 5 minutes without any window to separate fire from facade. Then, at 5 min the start of fire is defined, similar to BS 8414. This means: Products passing the test can perform if there is a pre-heating period before fire impacts the facade only. Incidentally open window is a rare occurrence in real life fires.

Other EU member state delegates disagree to adopt the English TGD 19 for cavity barriers in facades. The work progress on prEN 1364-6 is therefore halted since 2018. Pending confirmative research on the risk of flaming that pass barriers during their open state as window breaks, it currently remains allowed to use these by both English standards TGD 19 and BS 8414/BR 135. It is potentially a very high risk to existing building blocks and blocks listed for upgrading to continue use of open state barriers that allow fire to penetrate cavity compartments for the first five minutes from start of a fire.

See preceding sections "*Does the Case With Full Scale Testing Affect BS 8414*? and "*The Test Fire Scenario Issue*" for in depth discussions and indicative evidence at Grenfell regarding this.

Why ADB 2 does not refer to TGD 19? See footnote in section "*Scandal is Imminent. Industry Trumps it?*"

Why the EU Commissioned Test Method and Revised BS 8414 Do Not Add Safety

Yes, new EC method and revised BS 8414 may indeed serve a level playing field for vendors in the market as is the idea of EU CEN standards in general. However, it introduces less or nothing to increase fire safety of facades. The standard developments will not be led by authorities which govern by regulations except led by the industry itself. Homeowners and tenants in high-rise residential blocks in focus post-by Grenfell are not crying out for a level playing field. They are crying out for life safety. That is so important I need to emphasize:

Many expected that the EU Commission initiated a full-scale test method to address fire risk of facades based on updated knowledge on façade fires. I do not. It shall not fix discrepancies of current test methods. The EC has instructed an international task group to make sure the method *do not* add or change anything that raise safety level criteria of specimens compared to current national test methods.

To make clear: The new method shall become a mean of the European national methods (in excess of 10) by adjusting German and English existing methods DIN 4102-20 and BS 8414 so that façade systems tested today do not need re-testing or develop new designs when the new method become valid. EC do not allow task group to change the method towards increased safety. The current practices and national regulations, good or bad, shall be carried over to the new method. That is a revelation to some.

So full scale testing will never be a way to address façade system properties like susceptibility for shoddy work-manship which we all now know is the elephant in the room. Neither can changes to EC test method lead to specimen being adequately exposed by simulated attack from oxygen starved smoke at the moment room fire breaks windowpanes. Breaking of window is broadly accepted as most common initiation of severe façade fire incidents but no full scale test simulate this (except Hungarian MSZ 14800-6), they all apply a small open niche without any window, thus ensuring slow build up and fully pre-mixed flames.

Typically, there is no provision to observe and record two-sided fire exposure to panels, so fire spread in compartments cannot be properly assessed in test reports. By the way, unlike real fires the barriers get pre-sealed in current tests which effectively prevent any fire in cavities. Read more in "*The fire scenario issue*".

By CEN policy there is no way EU member states can agree on how to set safety levels such as a set of criteria on façade fire protection performance. The levels of safety are always up to member state regulators. The new full-scale standard will not increase safety nor ensure the safety one expect it to have. A member state cannot just raise its pass/fail criteria when the test itself has fundamental flaws. This is not sufficiently recognized by our professional communities or the public. The blind belief that full-scale testing will save residential building blocks is a fire risk of catastrophic proportions by itself.

It is Not OK to Pre-Seal Rainscreen Cavity Before Start of Test. So Why is It Done?

We just explained in previous section that rainscreen cavities get "plugged" by laboratories prior to start of test, by slowly preheating barriers in order to ensure they are fully sealed and to improve repeatability of test method. Laboratories and manufacturers developed the test methods - it is a written procedure. In real fires the barriers are bypassed and escalating fires in cavities can be fatal. How come? Let us have a look at the recent history:

Twenty years ago, there were no choice, barriers just needed preheating for 5 min to be able to stop fire spread in cavity. So preheating was allowed. No other measure was required to compensate. It is assumed that at the time one simply forgot that a breaking window is the design scenario, not an open window scenario.

Around 2000-2004 US and European ventilating products emerged that could block flame attacks while in their open state. In 2013 ASTM issued the E2912 standard for such. Prior to this, Americans did not accept intumescent barriers due to reliability and lack of fire stopping performance during their open state.

France adopted E2912 standard in façade guide 2016 while awaiting work on a European standard initiated 2014. UK made their own test standard TGD 19 while the CEN work was ongoing, however. TGD 19 recycled the idea of compromise that allows a period of 5 min preheating before any fire passing the barrier shall be recorded. Of course, this is a provoking way of testing since in real life there is no preheating when a window breaks in fire.

So, TGD 19 allows open state cavity barriers (OSCB) to have no fire resistance for the first 5 min of exposure. The only "justification" for this was that windows are always open (they rarely are, though) so they can be subject to an enclosure fire, i.e. a relatively slow, typical room fire. In practice, windows break near the time of flashover and expose façade to severe direct flame impact in 1-3 s while massive amounts of oxygen-starved gas fill the cavity.

Do we have evidence from real fire incidents? Let us look at Grenfell. At first impression the failure of the flimsy panels bypassed barriers so made them ineffective. But videos, later research and inquiry records indicate quite clearly that panels succumb to two-sided fire exposure. If barriers performed from start (such as in test where they are preheated) panels would be subject to exposure from outside only and could perform better.

In Phase 1 Vol 2 Report (Sir Martin Moore-Bick) witness accounts and videos constitute convincing evidence that cavity barriers were bypassed before they sealed, thus allowed two-sided exposure to the flimsy panels which in turn caused them to detach prematurely and to let next barrier to be bypassed quickly and so forth.

The vertical speed of flaming fire was about 1 min per level, or a mean of just 2.6 s to pass a 100 mm high barrier that need 30 s or more to effectively seal. Cavity barrier failures appear to be caused by many being poorly fitted

or partly dropping out in addition to expansion gaps remaining open while impacted by flames. Lack of robustness and inadequate fail-safe property could still have been mitigated by extreme caution by the installer.
The two-sided panel exposure and open state flame penetration plus the susceptibility of expanded material to fall out at movements, however, is what adds up to fatal escalations when rainscreen cladding is involved in fire.

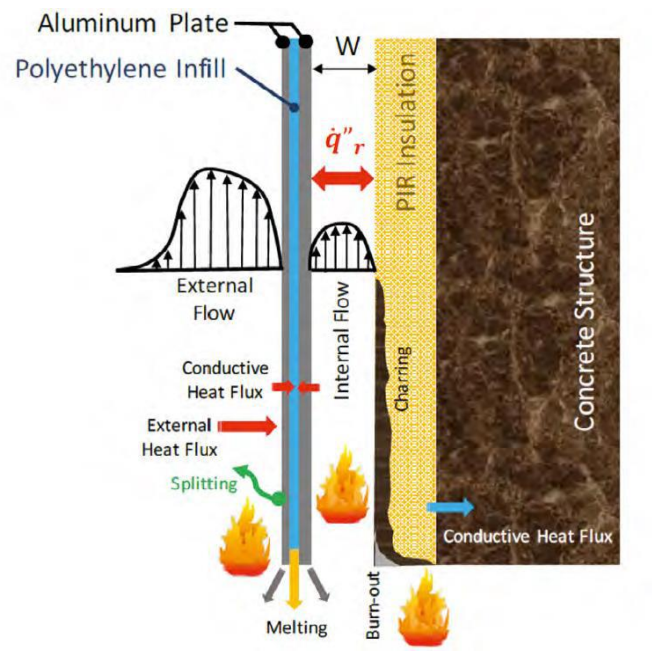


Figure: **Two-sided exposure to cladding panels at Grenfell**

Cavity barriers were bypassed or ineffective in preventing cavity fire. The drawing illustrates the situation where no surfaces are protected (warped panels or filed barriers) and get exposed by fire. See also figures in chapter C: One true to concept versus the flawed, common one installed at Grenfell, UK, UA, Australia.
(Drawing is by Torero in Grenfell Inquiry: Phase 1 Reports, Chapter 23).

"Chimney Façade"-Design is a Risk

Attempts have been made to accept rainscreen façade systems, even with open joint panels, without compartmentation - because "it is non-combustible so fire cannot spread". Truth is, this would be like a chimney with none or inadequate fire resistance. Fire out of window will attack panels from two sides or even six-sided by 600-900 °C smoke and flaming combustion. Flame can protrude from joints all over the façade. Even non-combustible panels crump le. Fire can expose windbreaker and insulation at any location on the façade, fueled by ample amount of air. BR 135 warns strictly against this in several paragraphs and make clear that vertical fire spread in cavities are up to 5 times higher than on the outer face of cladding, despite non-combustible surfaces.

This became utterly clear by statements of director at Arup, Dr Barbara Lane during Phase 2 2020 Grenfell Inquiry: "*It doesn't matter if the insulation is combustible or not, you are required to provide cavity barriers*". She added: "*You need cavity barriers on the floor lines and around the windows and the top of the wall. It doesn't matter what insulation or anything else you've selected for the columns or between the areas between the columns*".

It is most worrying that instead of testing for hidden fires some laboratories and standards actually tends to seal up inlet openings to cavity in front of the fire chamber to achieve "good reference test" or improve repeatability, as explained in the previous section. They simply do not understand how rainscreen facades differ from others.

"Chimney"-design is a severe high-risk misconception. The 18 m rule is no allowance to drop compartmentation.

Reaction to Fire? Combustibility? Fire resistance? Burn-trough time? – What Counts?

It is not reaction to fire. It is the *time to burn-through* from exterior to interior that decisively protects people from smoke and heat during occupation or evacuation.

Burn-through times are available from standard tests to determine burn-through times of products or claddings: ASTM E3048, CW Test Protocol of NS 3912, BS 2782:Part 1: Method 140C, ISO 10351 or EN 14135. Most practical is the ISO 834-based fire resistance tests. Those are based on enclosure fires were the heat energy is contained and re-radiation and convective accumulation of heat are at play. This does not occur in exterior fires so in general EI or even K classes make practical and conservative choices for exterior burn-through performance.

During 2020 several experts pointed at the bewildering focus on reaction to fire properties only being discussed in relation to façade fire safety. It kind of culminated by the statements of Dr Barbara Lane of Arup at the Grenfell Inquiry: She made clear that reaction to fire classification and tests of materials were designed for indoor applications. She further conveyed there is no rationale known to justify the application of reaction to fire performances almost exclusively in disfavor of fire resistance properties for facades. This is precisely one of my strong objections as well, against the current state of facade fire protection.

Give me a break: There is no sense in totally dismissing burn-through time in favor of the messy current rainscreen designs that is reaction-to-fire based.

The NS 3912 standard is just published and applies burn-through performance as key to assess all kinds of façade design applications. It incorporates an optional normative full-scale test, CW Test Protocol, to determine burn-through performance plus self-extinguishing and auto- or manual extinguishing properties of tall, combustible cladding. This first version of this standard also recognizes full scale tests and the fire code when verified by PBD.

(Exterior-relevant) Reaction to fire (RtF) properties of the outer surface of cladding remains a factor to determine property loss, environmental effects and effects on life safety of surrounding population. It is even paramount when fire safety strategies rely on fire brigade intervention or where the exterior fire may ignite other buildings.

The CEN mandate and interpretation documents from 1970-ies instructs standard developers to resolve the issue of reactive products being in an open state from start of fires which allow sudden flame impact to pass flames. CEN TC 127 reiterated the instruction in Resolution 778 in 2014 as a number of products in market had provided fire resistance in open state. Still, UK industry bluntly dismissed it. The UK delegation at CEN aggressively impose TGD 19 (allowing flames to pass) to replace prEN1364-6 which incorporate a normative method to test fire resistance in the open state. The industry and delegation have not presented any evidence in support of their actions. European industry questions what is going on. MHCLG has wisely not added TGD 19 as a valid standard in ADB 2.

Grenfell Witness Accounts Confirm Two-Sided Exposure Prior to Panel Distortion

As described above, witness accounts (Phase 1 Vol 2 Report) unanimously support the description of hidden fire spread due to failure of cavity barriers and subsequently exposing both sides of the flimsy panels. Flames were observed "rolling" in behind panels prior to flames protruding at joints, then distorting and consuming the panels.

This would not necessarily occur if the Grenfell façade was put on full-scale test with preheating, such as BS 8414. Then cavity barriers would be sealed before the flame attack. Exposure to panels from outside only could then delay time to distortion and perhaps allow next level cavity barriers to seal. Grenfell panel *could* pass BS 8414 (!).

However, as I explained previously, at Grenfell the mean speed of fire would make it pass barriers in 2.6 seconds and in real life most windows are closed and breaks in fire. So, even if installed meticulously according to install instructions the barriers and panels would likely fail. At best, they might retard the fire spread but slightly. Again, this is clear evidence that BS 8414 and similar methods cannot keep on testing rainscreen (ventilated) facades as if the window to fire room is open from start. Exposure must simulate windows breaking, as in real life.

C True and Flawed Interpretations of Concept

To recapitulate: The concept of fire protection to functional requirements on any type of facade is to allow time for occupants to stay put or evacuate and to limit damages to acceptable level. For rainscreen type in particular, compartmentation or sub-division of facade cavities is part of the general strategy to comply with the concept.

Global Interpretation of Concept Gone Horribly Wrong

For those of you that perhaps got startled or confused by the previous sections, read this focused summary:

There is no current code requirement of fire resistance from exterior to interior. Current requirements are on reaction to fire regarding vertical fire spread and no fire resistance requirement on fire cladding. The most disturbing fact is that fire resistance is required by cavity barrier and perimeter fire stops at floor edges only, and side by side with different performances in fire. This is close to ridiculous. When such designs pass a full scale test the cladding must have some fire resistance anyway.

Unfortunately, the cladding is most often finetuned to just pass test, no more. So, any minor design deviation or defect by installing can lead to catastrophe. The same apply indoor: What other than catastrophe and wasted money could we expect if room fire compartments of a building should each have one wall fire resistant only?

See figure below: "*Flawed Rainscreen 2000-2020*".

PS
It appears this is the type of rainscreen design being used for ESW 1 Form-selected building blocks for refurbishing in England. May I urge everyone with doubts to think twice?

The Straightforward and Correct Interpretation of the Concept

The ADB 2 require E 30/I15 to barriers only, according to the compartmentation concept. However, consider a code interpretation that (of course) states full cavity fire compartments shall be one-way fire resistant to E 30/I15 (or EI 30), i.e. cladding panels and barriers, to separate from exterior fire. Then, we could enjoy residential blocks being robustly safe.

Instead, the current interpretation in UK and countries adopting this practice is that just one of six sides of a compartment need be fire resistant. Who else than a competition-led industry can misinterpret code this way and conceive a ridiculous high-risk design? Then corporately endorse and defend it for 20 years?

The obvious cure is for national regulations to call for a compartmentation requirement of say EI 30 min. No need to specify fire resistance of cladding panels. Just make clear that test must prove fire resistance from exterior to the cavity/insulating wall for 30 min and let the industry design and compete with models that comply.

This will allow for furnace testing only to comply, rather than expensive full-scale testing. Those who can achieve this by cladding less than E 30/I15 or even by non-classified cladding can perform full scale tests if realistically designed for rainscreens and still comply. In any case this effectively excludes flimsy in adequate panels from passing test and prevents unacceptable levels of smoke or heat from filling cavities and threaten occupants during those 30 min.

See figure further down: "*Rainscreen True to Concept*".

Flawed: Common Rainscreen 2000-2020

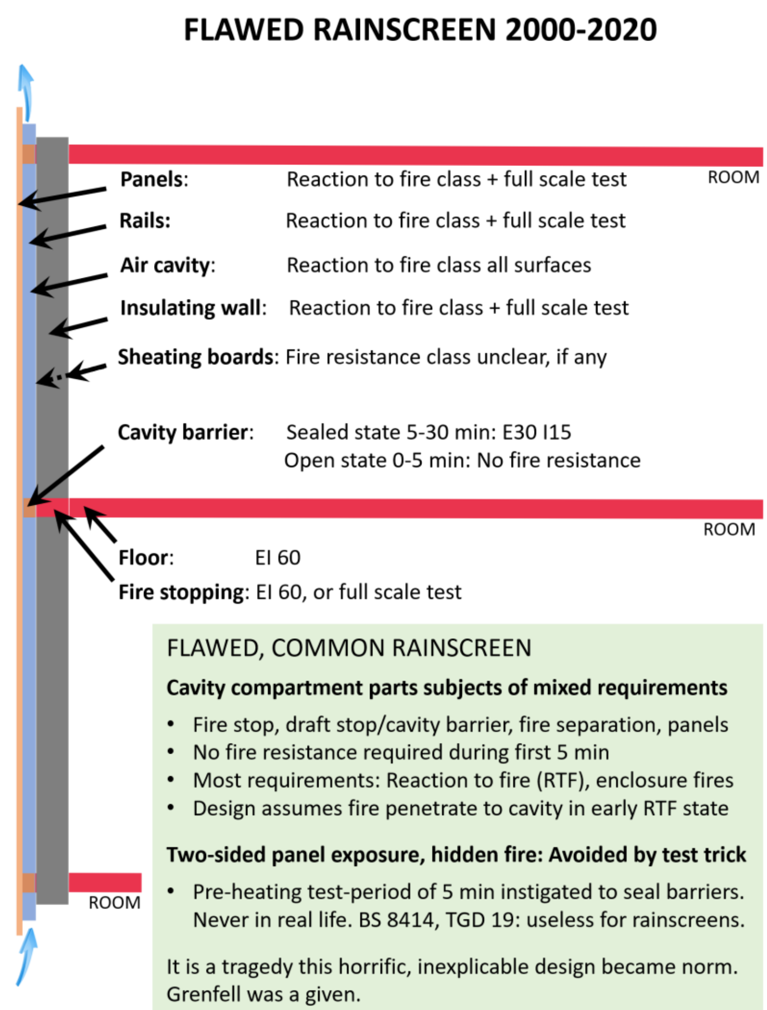
There is no rational or concept of fire protection accompanying the flawed designs. Usually vendor refer to having passed a national full-scale test, such as BS 8414 for UK. That's it. The design stands out as an extremely complicated and fail-prone interpretation of code. It seems to have evolved by groupthink within the realm of manufacturers and laboratories 2000-2020. All parties focused on self-interest and solving every challenge with introducing a new fragile detail. In the end this test method came to serve the specimens not vice versa.

Note that there is no clear logic in the drawing: Everything is designed to pass a test with pre-heating. There is no margin for error anywhere. This has left us with a messy and fragile construction that is difficult to install reliably. Even deviation of a few mm of any detail or of a closed window or fixed glazing, can jeopardize performance and lead to fatalities.

These rainscreen designs are most common and are the ones applied at Grenfell and most high-rise Dubai fires.

Grenfell inquiry Phase 1 reports are clear that poor workmanship of fail-prone designs allowed flaming fire to attack cladding from both sides and inside-out through panel joints.

Grenfell inquiry Phase 2 reports are clear that the concept-wise flawed rainscreen was the result of an industry collectively acting like criminals, claiming falsely panels and barriers were safe while exchanging internal emails bluntly contradicting it. Never did they make any attempt to improve safety. All was about making test methods to fit their products, to conceal negative facts and to compete on price.

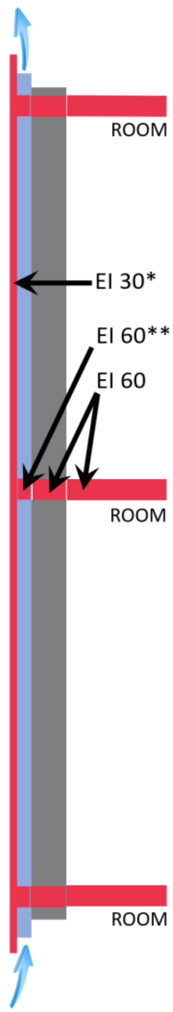


Rainscreen True to Concept

Designs to concept are unambiguous, simple and robust. See figure. This way serves the functional requirements of protecting people and minimizing loss. Façade installs reliably and verifiably using simple fail-safe instructions.

The performance is easy to verify by test of fire resistance classification or burn-through time. Reaction to fire tests are required for combustible cladding only, using full scale test.

RAINSCREEN TRUE TO CONCEPT



RAINSCREEN TRUE TO CONCEPT
FIRST PRINCIPLES CONCEPT OF ADB 2

Based on burn-through times or fire resistance classifications.

Provides time to occupy or evacuate.

Resists fire at any time - from broken window, hidden or exterior fires.

Robust, proven, simple and verifiable.

Optimizable drained and ventilated, or pressure equalized, rainscreen.

Cavity compartment part of room fire compartment.

Allows combustibles in cavity and insulating wall.

** Insulation wall fire class EI 15 allow cavity barrier EI 60 reduced to EI 30.

* Panel cladding less than EI 30 if verified by full scale test.

Allows simple and meaningful full scale tests: Failure criteria is burn-through of cavity compartmentation. Period.

Full scale testing limited to special configurations window, glazing, balconies.

Cost-effective planning and installation.

Note that room fire compartment volumes extend to include external wall and cavity: This means cavity barrier framing of windows may not be necessary. Combustible parts of insulation and cavity are part of fire compartment fuel load so less critical as well.

OPEN SOURCE: Anyone can apply the concept, the sub-division of cavities or the generic sample illustrated.
I am not yet familiar with a building facade conforming to concept shown - as minimalistic as in this sketch.

How to Get It Right

It is simply about a fire resistant envelope around the building made up by panels and barriers. Combustible parts in cavity and even fire spread on the outer face become less critical, just like combustibles in a neighboring room to a fire compartment. This remains the robust, logic and obvious concept that should never again be breached.

See figures above and other parts of article on how to profoundly improve rainscreen designs and verify compliance. Teaser: ADB 2 by MHCLG and CWCT guides have done their parts well, just miss clarifications. BR 135 guides are very good overall as well, though the BS 8414 description and its criteria need revisiting.

We need to scrap all vulnerable parts of facades in favor of simple robustness. Codes, standards and project specifications need to link every bit by logic connection to the concept. Codes must make clear what is the concept and what are acceptable fulfilling interpretations.

Cavity Compartmentation Versus Room Compartmentation: Same Rationale?

Yes. Functional requirements are the same: Contain fire to compartment where it settles first. Allow burn out of content while not allowing fire spread to other fire compartments during the time of fire resistance.

The time of compartment fire resistance shall enable evacuation and firefighting operations. Interior or exterior. Robustness apply in any case: If fire spread to another compartment it is not critical since time to evacuate is passed by then. Fire fighters easily handle two compartments in fire operations, as they occur in sequence, the second 30 or 60 min after the first. Again, interior or exterior.

Bonuses apply for true cavity compartmentation:

Since cavity fire compartmentation is configured to fit the profile of room compartmentation any combined cavity and room compartment share the same volume. Therefore, the insulated external wall behind cladding does not require fire separating function. Fires in either cavity or room are extinguished by fire fighters accessing the room. No need for exterior firefighting at façade.

The cavity is still ventilated and drained or pressure moderated/equalized as normal, except the cleaner design may allow more predictable results for building physics engineers.

Wall insulation, windbreaker, studs and sheathing - now being part of the compartment fire load volume shared by cavity and room(s) - can now be 'green' or even combustible as long as it does not exceed fire load limits by code.

We cannot leave this topic without commenting on role of the ADB 2:

It is utterly satisfying that BRE's Rogowski (1988) and Connolly (1994) noted that surface spreading is not the same as fire resistance: it is a mere pathway for fire, fire resistance eventually must protect people inside. It is satisfying that it was eventually carried through as cavity compartmentation by Colwell et al (late 1990ies) and the term subsequently manifested in CWCT Standard and ADB 2 (sub-division, fire separation, fire barrier, fire stop).

It is then unbelievable how the industry's interpretation developed (see *Flawed Rainscreen*) and how authorities got to accept it. Children can see the error. It is not at all compartmentation (or the most fragile ever made), Grenfell was not at all unexpected and the flawed type of rainscreen is on its way to be installed in ESW projects.

Protection or Insurance?

Even non-combustible panels get damaged in fire and a cavity compartment fire calls for repair or replacement. It does not make sense for a society to pay more for fire protection of facades than estimated insurance losses. This should be considered regarding choice of materials for exterior (surface) fire spread.

However, true to concept-designs are estimated to cost less than flawed ones so we may enjoy both fire safety and reduced insurance premiums.

D How to Verify Code Compliant Performance?

Guides like ADB 2 and the CWTC standard and guides are based on functional requirements of national building regulations and apply the first principles concept of cavity compartmentation. That concept and the BSI's PD 7974 series and BS 9414 set the stage to verify compliance to code by performance-based design (PBD) as well as by prescriptive engineering. Let me explain why and how.

The following text will explain that it is a greater challenge to design fire protection of facades than the building itself. Therefore, PBD is either required or just make more sense as PDB can optimize towards robust and reliable designs while being transparent for QA and make sure no risk is overlooked. You will also get that full scale testing to BS 8414, or to the EC method being prepared, is basically a sound idea, though currently not fit for rainscreen facades. We need the full-scale tests to verify what we cannot verify by single product testing, and need to amend them to run without pre-heating, i.e. they must simulate fire attack from breaking window.

ADB 2 and CWCT OK as Is – Need Subtle Rewording to Ensure Correct Interpretations

Since Grenfell, CWTC joined with SFE and have published but one guide, of 47 pages. The file name is "*CWCT/SFE Fire Guidance, Issue 1, September 2020*" (The front page title is however: "*The Building (Amendment) Regulations 2018 - Regulation 7(2), Regulation 7(3) and Requirement B4 - Technical guidance for interpretation in relation to the external walls and specified attachments of Relevant Buildings in England*"). That is a thorough and good guide as most from CWCT. Scope is limited though:

In good tradition of the industry the guide is concerned with reaction to fire of materials applied in facades only. Nothing about concept, functional requirements or compartmentation. It is much appreciated that the publishers point it out themselves: "*This guidance document is solely focused on the combustibility of materials. Other measures such as compartmentation will also be required to limit fire spread in external walls. These issues are not discussed here.*"

Apart from that guide, deafening silence remains at MHCLG, BSI, BRE and CWCT. No reminders to observe the concept, functional requirements and compartmentation. Yes, they have indeed based and described their codes and guides well on the concept, but as interpretation and practices by the industry are off track, those organizations ought to provide explanations and direction signs. Unfortunately, they appear consider having themselves screwed up in a corner. I think they should not. Concept is there, just need to improve interpretation. So those institutions need a push by owners and tenants of residences affected by Grenfell to address these revelations.

The 18 m rule to ban on combustibles are enforced by MHCLG. However, RtF is not the problem, so less helpful.

Facades More Complicated Than Building Bodies

Facades are complicated configurations of interacting building elements that must be designed by engineers of building physics and fire safety (FSE). So that is where the verification of compliance must be made. I will explain.

Think of a residential block or office building to undergo FSE. The job is fairly straightforward and fire compartmentation of rooms apply as standard. You don't fire test a mockup of the building. A rainscreen façade can be more challenging. Still, today a majority seems to call for full scale fire testing of the façades and seems more inclined to prohibit FSE than demand it.

Luckily, some experts are objecting: Dr Evans and others referenced in "*Do I Have Support to Disrupt the Regime*?

Note: Fire Safety Engineering (FSE) and performance-based design (PBD) are misinterpreted as “desktop studying” post-Grenfell. The Grenfell meaning is “a quick assessment” by non-professionals, not by FSE/PBD engineers.

New thinking is now expressed by several experts (see more on this further down). They all seem to agree that competent FSE assessments are required in addition to any full-scale test, and also accept that full scale tests are not always necessary. May I stress that the more robust concept the less is the demand for full scale testing.

FSE shall apply relevant test evidence. FSE shall *add* to test evidence, not replace it. See support for this by Dr Evans and others in a later section.

Just like room compartmentation: Usually there is no need to do extensive FSE work to verify it, nor full scale test, even if the compartment arrangement is different in each project. The basic concept of fire protecting rainscreen facades include cavity compartmentation. If adhered to no further test or extensive FSE may be required to verify.

How to Verify Workmanship in Compliance?

Workmanship is not tested. Facades are built up by 5-10 operators on site which install many elements by multiple vendors. The full-scale tests shall simulate “facades as installed”, something everyone agree to. However, façade system elements are often intricate to fix and join. Typically gaps kin joints leave pathways for fire spread.

Studies that include reliability of workmanship typically point at barriers being fitted in the wrong location or not butting tight or not coping with panel and structure movements. Grenfell appears to have suffered from these, and some where even fixed upside-down.

Ideally, elements of façade systems therefore ought to be "click to fit" or modular prefabricated to avoid wrong installs, not the least when rehabilitating facades. This is referred to as “fail-safe fixing methods” and it demands that the design supports it. Today, we lack criteria that encourage designs and assessment methods that provide fail-safe install practices and simplicity that increase reliability.

Increasing reliability by developing codes, tests or guides towards improved designs and fixing methods is a must.

How Can Test Methods Become Useful?

How can a single test method properly cover ETICS, double facades, curtain walling and rainscreen categories of facades? It can’t. One factor is to make them test breaking window scenario, not open window scenario. Another factor is the need to cater for variations, so you do not require a new 400-600 EUR test for each new project due to deviations from the first design tested.

Dr Jonathan Evans makes a well-conceived plan for verification of facades in a FPA presentation, which I endorse:

> “What is the way forward
>
> - A ‘suite’ of tests that provide the answers we need
> - Realistic tests of the individual or interdependent elements of a façade, including modular/MMC
> - New standards to support that – cavity barriers, penetrations, windows
> - Added measurements of smoke, toxicity, debris, damage
> - Classification standard that differentiates the key performance criteria of systems
> - Research to show in what situation might a full façade test be required.”

That said, this is in order to correct the current sad state of practices. Anyway, by sticking to the simple and basic concept which I elaborate in this article a lot of those measures may not be necessary at all.

Think Tank Turned into Echo Chamber – Competition on Price Overrule Intent

Competition is a favored mechanism to improve inferior performance of fire safety measures. In the case of rain-screen facades it has become clear in last 20 years that manufacturers of façade systems do indeed compete.

However, they compete on minimum cost to pass full scale fire tests. They have also started to put resources in getting a level playing field via the new EU test method. I have shown in previous chapters that neither efforts will improve the situation. As a strong advocate of testing and especially full scale, I regret that the most popular and effective facade, the rainscreen, cannot be tested to BS 8414 or similar, while the method is perfect to the non-ventilating types of facades.

To exploit competition the industry should instead compete on achieving best performance to meet functional requirements. That could well transcend to the basic first principles concept based on cavity compartmentation. Personally, I think the ADB 2 calls for this, as is. The reason industry got off track and offer inadequate facades is likely caused by authorities allowing inferior designs and interpretations to be developed. Apparently, from the start no one detected that rainscreens passed because test method is preheating barriers to seal. The industry itself or authority should have responded to fix it. Now it is too late. It has gone too far. Everyone is to blame.

Most infuriating: The EU commissioned development of a test method prohibits any such change to the method. Because it shall not raise the bar. Because it shall ensure level playing field to compete only. National regulations can raise the bar any time - except, that is not possible when test method is fundamentally wrong for rainscreens.

See section on Groupthink explaining further how the façade industry's think tank turned into an echo chamber.

CE Marking of Rainscreen Systems? Forget It.

As a consequence of the issues we laid out above plus the many technically detailed issues within the laboratory environment, CE-marking is not viable. The test method is at least two years from completion and the product and classification standards that is required for CE-marking are now 10+ years further on. By the time we get there no one will for sure accept the result unless it is assessed by FSE. Supporting product tests of elements of the façade system may be required as well before a façade comply to code. Many are now pointing at this.

CE marking is simply not a viable future for rainscreen facades. We need to bring in FSE and provide engineers with product data for elements of facades, just like we do for fire protection engineering on building interiors. Read more in "How to verify compliance to code".

Why Shall Windows be Framed by Cavity Barriers?

Again, an obvious glitch by the industry. It is assuming that floor level barriers that frame indoor fire compartment in façade are not sufficient, i.e. that barriers fail. That is not to concept and makes no sense. Yes, it is promoted by the ADB 2 as well, but a lack of common sense can hit us all. I suspect it is related to the awkward distinction in ADB 2 between fire stops and cavity barriers. The concept is fire compartmentation, and all enclosing element should have same classification, so framing windows by barriers should not be required. Why it is done I believe is remnants from bygone times when choice of materials was less, and cost prohibited overall fire resistance. Today this is turned around: Same fire resistance to all fire separating elements of compartment is more cost effective.

May I suggest Grenfell incident would not happen without the ridiculous operation of mixing panels verified by full scale with cavity barriers to product standard, fire stops to other standard plus reaction to fire prescribed to windbreakers and panels etc? A senseless mess.
See chapter E and its figures on how simple the basic cavity compartmentation designs according to concept are.

Explanation: A fire protecting window frame inside another fire protecting frame hardly make sense. Effectively like a fire compartment inside a fire compartment. I suspect someone has told MHCLG that OSBC cavity barriers cannot be relied upon for first minutes, therefore fire can spread out of the first compartment. So, barriers around openings became prescribed in ADB 2 9.3 and diagram 9.2. It is true that OSCB barriers to TGD 19 performance have no test evidence to be fire resistant during their open state, unless tested to cavity barrier test in prEN1364-6 Appendix D. The industry has kept this a hidden fact for MHCLG. The MHCLG do not reference TGD 19 (good) but industry still apply it (bad). True to concept façade designs do not require fire barrier framing of windows.

An awakening now seems underway and should reveal it. FPA has published the "check list" IQ 7 which states: *"…provide evidence that any reactive (intumescing) cavity barriers can respond faster than the rate of vertical fire spread of the most onerous material in the void (i.e. vapor barrier/ membrane, insulation material)".*
This extends the CWCT recommendation of observing the slow response of barriers into a verifiable requirement. Verification of fire resistance in the open state is done by American ASTM E2912 (E2886) or European CEN prEN 1364-6 Normative Annex D standards. ASTM E2912 referenced in France as option until prEN 1364-5 is published.

Ventilating barriers with fire resistance in the open state perform equal to solid fire stops: Fire is blocked immediately or very quick, so no flames penetrate to ignite on the protected side, from start of fire and throughout.

Flimsy Panels Failing by Two-Sided Exposure

This is elaborated in other section of this article. What need to be said is that cavity barriers to BS 8414 test, the panels shall get one-sided exposure which is often required to avoid failure. In real life, most often a room fire breaks a window and exposes façade instantly, causing severe fire to spread in cavities prior to barriers becoming sealed. Then fire consume flimsy panels quickly from two sides, not in laboratories. Certificates cannot be trusted.

Full Scale Façade Tests Do Not Tell the Truth About Death Tolls

The utterly sad and bad state of fire safety verification has allowed a dangerous built environment, globally. This caused the death toll at Grenfell. This caused or impacted most of UAE tall facade fires.

This article explains why ongoing facade replacement projects have a high probability of carrying over some of the very discrepancies that allowed Grenfell to happen. A pandemic of virus-infected facade designs awaiting vaccine.

The cause of deaths is traced back to façade designs and test methods as described in other sections of article. A proper way to test or otherwise verify that facades provide protection has yet to emerge. We do not know of any ongoing efforts to get there. This article aims to show how to do it.

Groupthink and Inept External Governance Told us the Truth About Grenfell Death Toll

In human populations there is but a percentage of fair, bold and empathetic people. In an industry community driven by money and eagerness to pass tests with the least expensive products, the percentage is probably less. Then groupthink thrives.

Grenfell Inquiry confirms: It was all so evident that inside such a community you can speak out about weaknesses, unfounded claims, risk of death and receive nothing but deafening silence. You get no response. You want to keep your job or position and cannot make the threshold to go public or become an ombudsman-protected whistleblower. You are not sure your case qualifies. No objections or alternatives are aired by peers. So, the bad conditions prevail and lingers in the air as accepted. Culture develops. Borderline interpretations become facts and tweaked further at any opportunity. The echo-chamber effect is at work.

Add to this company arguments like "the code and test criteria is our framework; our job is to fulfill and comply". So, you will never question codes or standards. Still, as revealed in other parts of article, it is the community itself that developed BS 8414, TGD 19 and set the criteria to pass. Rules are made to what fits the major manufacturers.

This of course stifle innovation and prevents detecting and correcting weaknesses in codes and standards.

A major uncomfortable suspicion remains: It appears that even government, authorities, independent laboratories and experts are to some extent victims of the groupthink. Thus, they became parts of this evil, endless loop. In any case, why should building regulations adopt industry's current interpretation of façade compartmentation? What else than dictate by industry can make ADB 2 allow compromised compartmentation? This means avoiding burn-trough time requirements to cladding and means cheating by a pre-heating phase in test to avoid two-sided panel exposure? Further, to support the industry interpretation means accepting that some parts of a compartment shall be fire resistance rated and others not, assuming that barriers do not work and therefore require added barriers around windows (!). It means almost everyone have supported flawed barriers and also supported non-combustibility requirements which has nothing to do with simple fire compartmentation fire resistance.

Do I Have Support to Disrupt the Regime?

Yes. It feels good to read recent position statements by prominent research, associations and entrepreneurs. Referenced sources by Bonner and Rein, Messerschmidt, Dr Evans, Dame Hackitt and Dr Glockling all share in their recent publications a common thought. I skip citations and try to summarize (see references to confirm):

- Passing a full-scale test is no clearance to build by its own. Need to consider all relevant factors project by project. Current facades are complicated, need customized expert engineering or FSE/PBD; no size fits all.

So, there is now a clear reluctance to rely sightlessly on full scale tests. This article identifies severe shortcomings of current methods which accentuate this. See relevant sections in this article.

The Grenfell Inquiry has made a strong case for introducing tests procedures to assess *reliability of install and use*. Further support to clean up poor compartmentation, two-sided exposure to panels and uncontrolled fire spread:

Dr Lane with her strong presence at the Grenfell Inquiry points at a clear need of fire strategy for each building. Grenfell became proof that this was missing. She stressed need for correct barrier locations in cavity and install practices. She killed the common misconception that non-combustible cavities allow omitting barriers. Dr Lane also pointed at current regime rely heavily on RtF while hardly anything to configure compartments. More below.

ADB 2 conveys the concept - albeit not as a collected chapter. The strategy of sub-division of cavities (cavity fire compartmentation) comes across well. Where the ADB 2 details how to, influences by industry show through.

RISCAuthority makes following recommendation in their new check list dedicated to rainscreens (IQ7, Version 1, Nov 2020): "..*provide evidence that any reactive (intumescing) cavity barriers can respond faster than the rate of vertical fire spread of the most onerous material in the void (i.e.vapour barrier/membrane, insulation material)*".

CWCT points out the risk of sudden fire impact to open state barriers. "*…they (ventilating cavity barriers) may take a significant time to form a seal. This time delay may not be significant in a test where the cavity is empty".*

My comment: RISCAuthority and CWCT are now and then in conflict with BR 135 and Dr Lane's insistent message: Flaming or oxygen-starved hot smoke spread fire very quickly via non-combustible as well as combustible cavities.

Firedetails.co.uk describes in clear language the need for ventilating barriers to span the gap fully (as addressed in recent IQ7, RISCAuthority). Also describes "shaped semi-rigid cavity barriers" and "supported cavity closers" in order to contain loss of expanded mass.

Dr Jonathan Evans in recent FPA presentation makes a well-conceived plan for verification of facades. See Part D *How can Test Methods Become Useful*? **Principal Jan Gouws** of Kaneba Ltd, NZ, share similar thoughts in his blog.

Dr Lane pulled up this BS 476 text: "*The underlying philosophy is that, if a fire starts, its rate of growth should be such that there is adequate time for the building occupants to escape to a place of safety without being injured*".

This translates to need for *fire resistance by compartmentation*. No wonder ADB 2 demands sub-division of cavity and E30/I15 barriers. I wonder then, how can MHCLG accept the industry's flawed design of no fire resistance and less effective compartmentation?

Small free burning fire | Spread to nearby objects | Room fills with hot smoke; remote items ignite

© NIST, *Dry Scotch Pine Christmas Tree Fire*, Available at: https://www.youtube.com/watch?v=HJGjwo3MQ8g&ab_channel=RCFD0908

Figure above: **Sustained fire bypassing cavity barrier in 35 s** (ABI report): In lack of illustrations of chimney fire damage in combustible cavity, here is what may happen in a room fire in 32 s. Christmas tree fire By NIST, via Dr Lane presentation at the Grenfell Inquiry.

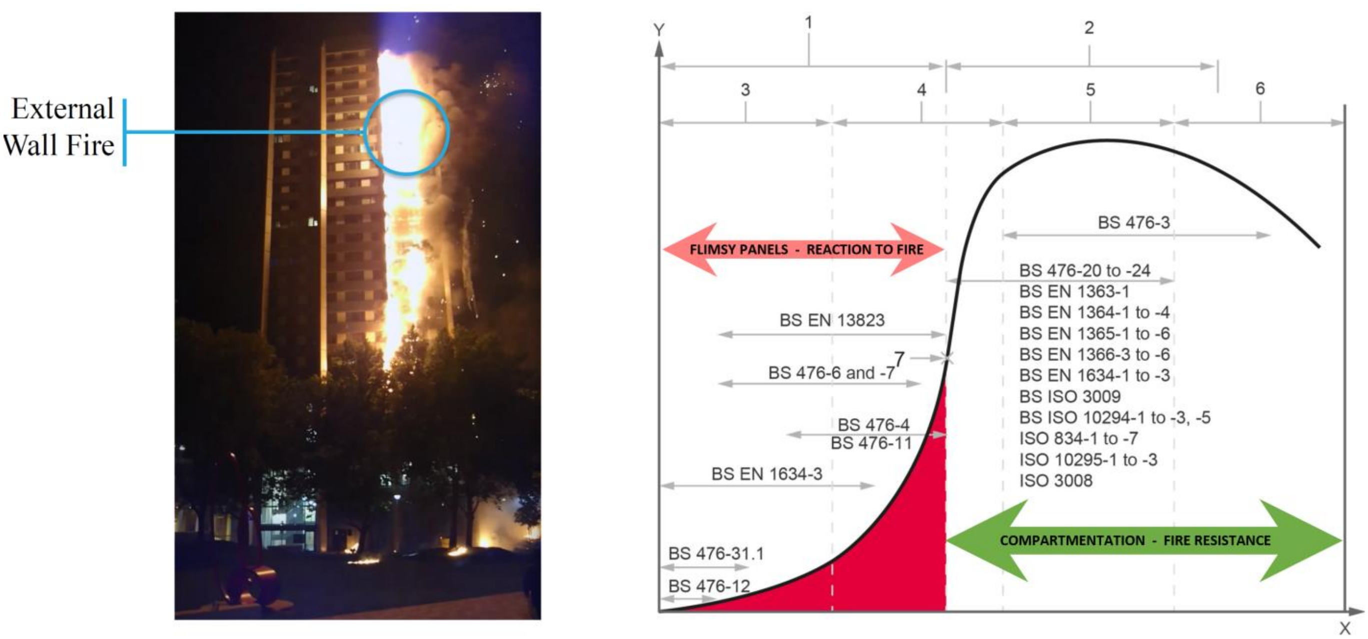


Figure above: **Industry obsessed by exploiting less-relevant façade properties only**: Red period of fire development is where reaction to fire (RtF) properties are relevant, except to *enclosed* fires indoor. However, what is relevant to rainscreen façades are functional requirements, life safety, compartmentation, time to occupy and time to evacuate. These factors are challenged in the post-flashover and decay phases (read: post-breaking window phase), governed by fire resistant compartments (sub-divisions) and marked green. – Again, superb figure by Dr Lane, span arrows added by me.

Messerschmidt in 2008 (Fireseat): "*Considering that the reference scenario for the Euroclass system is fire in a room it is only right to question the use of this for externally applied products*." (Dr Lane applied this reference).

Rogowski, BRE, 1988: Here is one of few statements by BRE on the purpose of reaction to fire requirements in facades. It is to avoid challenging the compartmentation (fire resistance): "*Control over the external surface of walls of buildings,particularly those of multi-storey flats, to avoid ignition and flame spread which might **endanger the lives of residents above by breaking down effective 'compartmentation'** is currently controlled by reference to tests specified in BS 476: Parts 6 and 7. However, these tests **only** provide information on surface fire behaviour*". So, the rationale behind the ADB 2, BR 135 and BS 8414 was (of course) that "effective compartment-ation" is assumed in place and the "only" purpose of RtF is to prevent undue exposure to it. The sad outcome of history since is that compartmentation is totally dismissed in practice, despite the very clear wording in ADB 2.

Scandal is Imminent. Industry Trumps it?

More than a dozen manufacturers and companies in UK thrive on selling or installing cavity barriers and depend on the ASFP TGD 19 standard to verify their performance. Remember, this is the one standard that do **not** verify blocking of fire for the first 5 min of exposure. The English representatives at CEN are keen to have this adopted as a EN standard for Europe. UK is the only member state advocating it. There is no consensus with other experts. UK recently attempted to bypass the process at CEN without notifying the task group. Germany and other states rejected it. Convenorship is English. Nothing done since.

During the 6 years of developing prEN 1364-6 only once did English representative comment on why they do not want to require fire blocking first 5 min: He responded to the CEN Technical Committee Convenor saying that "Well, anyone can set up a fire exposure to get the result one wants", implicating what his opponents attempt. That is the boomerang. That is what the industry did itself: Made sure the TGD 19 and the BS 8414 exposures are designed with a pre-heating phase to hide the lack of performance of cavity barriers, not to reveal it. The pre-heating of BS 8414 require that the fire room window is fully open from start, has a well pre-mixed flame source to produce inert smoke only. The pre-heating of TGD 19 is an enclosure fire, or room fire, which means a slow heat up to 538 ^{o}C during 5 min (flame temperature is reached at about 6 min). Not real life. Real fires often make their sudden massive attack on façades in 1-3 s only.

In reality, few if any façade fire incidents had their glazed portion or window removed at start of fire. Most often they involve copious amounts of oxygen-starved smoke from rooms that are 10-30 times the volume of BS 84134 "fire closet". The highly combustible smoke extends in cavities at high speed, passing ventilating barriers in 2.6 s and ignites wherever it encounters available oxygen (Grenfell).

Why not test to show current cavity barriers are inept? Or to word it in respect of the industry: Why not test to show current cavity barriers are adequate? Get it done? Nope. Locked in a corner, the industry trumps the facts. Blaming opposition, bypassing consensus group and making a standard of their own (TGD 19). Not offering any proof to support their view and rejecting facts listed in the previous section.

Am I building my argument on hypotheses rather than evidence myself? Not at all: Previous section listed some. The BR 135 describe the fire spread mechanisms. The developing tests to validate ASTM E2912 and prEN 1364-6 standards. The tests done by ABI at FPA (Dr Glockling). They are unanimous. The IQ 7 Check list by RISCAuthority just and CWCT T98 guide urge to make sure cavity barriers are quick enough to avoid ignition on unexposed side.

The ASTM E2912 and 'Method D' of prEN 1364-6 are meant for cavity barriers and similar applications by testing performance at sudden exposure. UK* prefer to use TGD 19 (same as the indoor product test of prEN 1364-6) that exempt the first 5 min and include pre-heating. Where is any argument for EU member states to join UK on this?

** Actually, the ADB 2 does not refer to TGD 19 or any cavity barrier fire performance standard at the time of writing. MHCLG has refrained from adding TGD 19 to the ADB 2 list of ASFP standards. Doing so would have breached the EU CEN agreement. The interesting side of this is "who is responsible for the use of cavity barriers in UK without any fire resistance verified for the first 5 min of fire"? It seems the MGCH has become aware of the situation and by not listing TGD 19 it makes sure responsibilities rest with the industry and BSI, both of which occupy CEN committees.*

E The Robust Concept Prompts Simple Design

The task is to protect people and building from exterior fire and the concept is simple: The basic solution for rainscreen is cavity compartmentation made up by fire resistance, e.g. EI 30 classified panels and fire barriers.

All rainscreen systems have air cavities which are either through-ventilated or have two-way air flow gaps for pressure equalization. The fire resistance-classified EI 30 cavity barriers are either solid or ventilating to withstand the breaking window fire scenario. That exposure shall cover all other credible fire exposures to façades.

Yes, it is very simple. It gets no better: EI 30 min protection overall. Fire spreads into the first cavity compartment in 30 min, to the next in 30 min and so on. That means, not 2 minutes for a fire to leap across two stories as it did at Grenfell but rather 2 hours when taking into account total burn-through time from room fire to cavity, from cavity to façade at the level of fire origin and then into level above via cavity before entering a room above, then a repeat to next level above and onwards. This “very slow leap-frogging” adds up to hours of life-saving time. If fire breaks into a cavity compartment it can be extinguished from room side. Easy to construct, easy to test, easy to inspect, fail-safe and no need for demanding PBD/FSE work. Simple, robust and fantastic. This is resilience.

A cavity compartment according to the concept is always part of the corresponding room fire compartment. A window and the cavity compartment it sit on is always part of the corresponding room fire compartment. That is why no window frame fire barriers are necessary. If 1 hour fire resistance is required between compartments, EI 60 barriers at the wall/floor perimeter apply – then you do not need any fire resistance of the insulation of the exterior wall.

In the latter case: The fire load of combustible wall insulation will add to the room compartment fire load. If the total load exceeds the permissible load of the compartment the wall may need to be non-combustible or protected by fire resistance classed sheathing. If you apply sheathing boards of say EI 15, the perimeter fire stops/barrier can be reduced from EI 60 to EI 30 since the total pathway of burn-through then become 15+30+15 minutes to make up the 60 minutes. EI 60 barriers are the simplest, most cost-efficient and most robust way, though.

(Remember: The current misconceived facades require reaction to fire classifications of each of multiple elements of the rainscreen, inside and outside of cladding panel, and require panels themselves verified by full scale tests. Those rainscreens allow fire to penetrate and spread in cavity (assumed by current regime) so require restrictions to parts in cavity. There is no proven fire resistance at all with those facades - as they may pass tests without any).

The concept of compartmentation allows combustible surfaces in cavity as long as the outer surface fire spread is checked, or you may still decide on non-combustible insulation for peace of mind. We are talking a really robust and simple concept here, with an abundance of safety margins.

You may wonder; as I did: As this is easy to do, even described in the prescriptive terms of UK’s ADB 2, why are common facades so fragile in fires? As explained in previous chapters the industry as a whole has gone astray. It has missed to build on functional requirements of rainscreens, on the concept of weather protection and on the concept of fire protection. Along the way common sense got lost. Individuals and manufactures are competing on making most inexpensive design to a flawed practice, led by the industry’s echo chamber in place of a think tank.

Confused? Just remember that what the concept involves is basically a cladding as fire separating element. Fire barriers are already fire resistance rated from ADB 2 requirement. Thus, cladding and barriers combine to make up cavity fire compartments. No reaction to fire requirements in order to protect people. The outer face of cladding may need specific reaction to fire. Although, to reduce repair cost it is relevant not necessary for life safety.

Windows should (regardless of any type of façade) have a burn-through time that equals or improves that of total burn-through time via other pathways of fire. The outer surface properties and spandrel height play a role her.

You may choose to strengthen spandrel areas or apply windows of sufficient fire resistance. The scenario is room breaking a window and spreading fire to break next window above. Most windows are multilayered so the added fire resistance class or equivalent burn-through property required of the windows can be moderate.

Summarizing figures below provide the details and fire properties that distinguish flawed from true rainscreens.

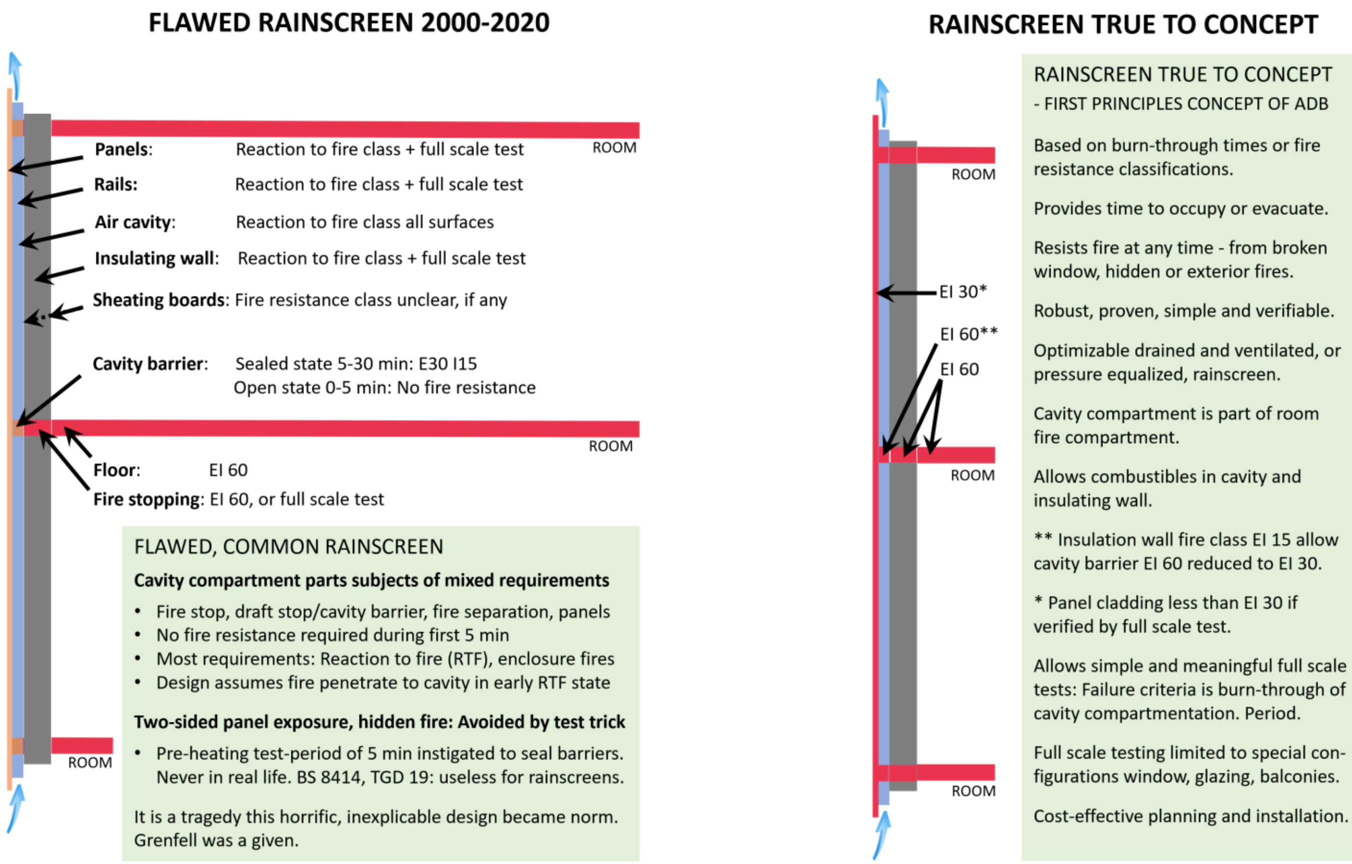
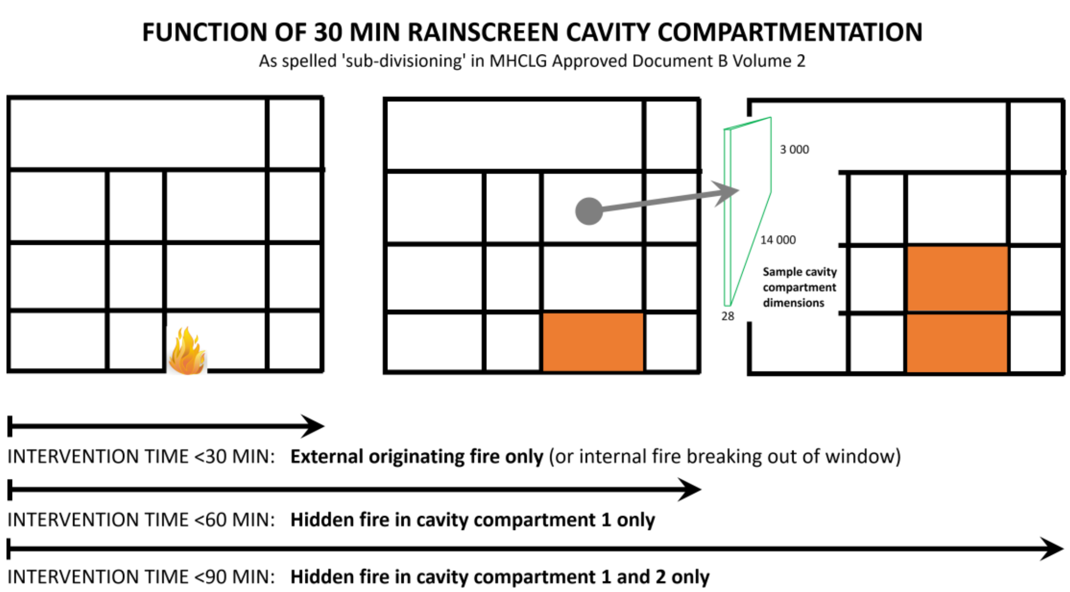


Figure above: **The Rainscreen Designs Compared**
Left: Flawed rainscreen, used *everywhere*. Right: Simple, safe and true concept conveyed in ADB 2, *not* used.



Going Forward

I expect my facts, revelations, hypotheses and rationale of this article to be largely ignored by industry, even by government. Both them and me out of fear, though. They may have to protect their earlier statements, products or prestige. They may be pushed to hide glitches. I prepare to yield if my hypotheses fail. I hope it turns out fair.

Landlords and tenants of affected buildings be aware.

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