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TRAFALGAR FIRE

WHERE **WOULD** CONSTRUCTION BE WITHOUT INTUMESCENT MATERIALS

WHERE WOULD CONSTRUCTION BE WITHOUT INTUMESCENT MATERIALS?

By John Rakic

INTRODUCING INTUMESCENT

It was around 30 years ago when I first heard the word “intumescent”.

Little did I know that day would change my working life. It took me ages to remember how to spell it and to pronounce it correctly.

“In-tyoo-mess-ent”.

If I’m honest, this word and the phenomena of intumescing has been a huge part of my working life. So, what is it? Simply put, to intumesce—the verb which comes from the Latin word “intumesco”—means to swell up (“I become swollen”).

Intumescence [in-too-mes-uhns, -tyoo-]

noun

1. A swelling up, as with congestion

2. The state of being swollen

3. A swollen mass

“An intumescent material is a substance that swells as a result of heat exposure, thus leading to an increase in volume and decrease in density. Intumescent materials are typically used in passive fire protection and require listing, approval, and compliance in their installed configurations in order to comply with the national building codes and laws.” (see source)

LATIN

Pronunciation

(Classical) IPA(KEY): /in.tu`me:s.ko:/, [intu`me:sko:] (Ecclesiastical) IPA(KEY): /in.tu`mes.ko/, [intu`meskc]

Verb

***Intumesco** (present infinitive **intumescere**, perfect active **intumui**); third conjugation, no passive, no supine stem*

1. I become swollen

2. I rise

IT IS FAIR TO SAY THAT PASSIVE FIRE PROTECTION (OR FIRE STOPPING) HAS ADOPTED THE WORD, AND INTUMESCENT MATERIALS ARE WELL KNOWN TO THOSE WHO WORK IN THIS FIELD.

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INTUMESCENT FOR THE LAYPERSON

An intumescent material swells up when it gets hot, and typically—in terms of passive fire protection—forms a large volume mass of burnt swollen material, called a char.

The intumescent materials can close off openings, and once closed, can protect against the spread of flames, hot gases and heat or temperature transfer from the fire side to the non-fire side for long periods of time.

HOW DOES INTUMESCENT MATERIAL WORK?

I like to say **"the heat of the fire makes the material swell up and close off an opening"** and leave it at that.

Sadly, the inquisitive nature of those who specify, buy, or approve passive products using intumescent materials want to know more. I have spent countless hours discussing intumescent materials with thousands of people over the last 30 years or so.

What temperature does it activate at?
How much force does it exert?
Will it swell up around a fire door so people cannot get out of their apartment?
Is the smoke toxic when it activates?
Is it expensive?
Does it have a shelf life?
Does it need to be replaced every three years in a building?

I hope after reading this article, I have answered the questions listed above and any other that come to mind for you.

A QUICK BUT IMPORTANT DIGRESSION

There are thousands of formulations of intumescent materials, so it makes no sense to talk in general terms about intumescent materials. The formulations or ingredients allow chemists and manufacturers to engineer their intumescent material to do the job they want them to do in the event of a fire.

To articulate my point, think of biscuits. Yes, those things we eat.

There are round ones, square ones, odd shapes, thick ones, thin one, sweet ones, savoury ones, creamy ones, coated ones, soft ones, hard ones. The variables are almost endless.

I am not saying for a minute you should try eating intumescent materials, but I think you can appreciate that every intumescent material is different based on its ingredients and how it is made.

Intumescent materials are proprietary; the manufacturer knows their secret herbs and spices, and this is their intellectual property.

BACK TO THE QUESTION, HOW DO INTUMESCENT MATERIALS WORK?

Simply speaking, just like self-rising flour in a cake, when put in the oven, the cake swells or rises to form a thicker volume of lighter density material.

Yes, a cake intumesces. Maybe that is why I chose biscuits as a useful analogy to help readers understand the variability of intumescent materials.

Let me get technical now, as many of you really know you want me to.

The answers come from combustion kinetics and thermogravimetry; it is the rate of heat (heating rates) and the amount of thermal energy an intumescent material sees that determines how quickly it reacts.

It is not the temperature of activation that is the way to describe the intumescent reaction, it is the amount of heat energy the material is exposed to that is important. Simply put, we need to know how thermally sensitive the intumescent material is.

Just like a sprinkler head, intumescent materials have a response time index.

The most commonly known measure of thermal sensitivity is the response time index (RTI). A standard-response element has a RTI of 80 (meters-seconds) 1/2 or greater, while a fast-response element has an RTI of 50 (meters-seconds) 1/2 or less.

So, what happens when we get enough heat into an intumescent material?

The material goes through an initial devolatisation stage where the release of water vapour, other chemicals in the binders and a gaseous mixture (from graphite, for example) occurs, chemically forming a char. The continuous application of heat and chemistry results in heterogeneous combustion of the active part of the intumescent char (in this example, the graphite).

Intumescent additives undergo a thermal degradation process on heating, which produces a thermally stable, foamed, multicellular residue called an 'intumescent char'. When these substances are added to a polymeric material which is later involved in a fire, they produce an intumescent char which accumulates on the surface, while the polymer is consumed, providing insulation to the underlying materials, and partially protecting it from the action of the flame.

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You asked for it. Heat, chemical reactions, and a fire or heat-activated char forms.

Manufacturers of passive fire protection systems engineer the type of intumescent, the quantity and its geometry to provide the reaction they are looking for in a fire to limit the spread of fire and heat.

It is quite scientific and often hundreds of formulations and iterations of quantity and geometry are required to achieve the performance you are looking for.

Sadly, many manufacturers make silly claims about the temperature at which their intumescent materials start activating at to try and suggest their material is better than another. I can say with confidence it is not temperature, but rather it is heat sensitivity against a known amount of heat of energy which is the real measurement for intumescent materials.

In practice, it is nice to know all the performance attributes and have quantified the response time behaviour of a material, but the really important factors are:

• Does it work how you want it to? And,

• For regulatory purposes, can it pass the fire test as part of a system and allow an FRL or fire rating to be achieved?

PERFORMANCE CRITERIA FOR INTUMESCENT MATERIALS

This might sound a bit funny, but more is not always better, nor is fastest and strongest!

There are many areas where intumescent materials are used in passive fire protection.

Some applications require fast and high expansion and a very strong and cohesive char whilst others require slower, marginal expansion and a weak char.

Can you think of where and why for both examples?

Fast, high expansion rate and strong char:

Example: A fire stop collar that needs to close off the opening formed by a softening plastic pipe.

Relatively slow, moderate expansion and softer char:

Example: An intumescent pad behind a hinge on a wooden door frame for a fire door, or the clear intumescent in laminated fire rated glass.

For those who wondered, it is the so-called baking powder or baking soda (acid salts) (or the secret ingredient in self-rising flour) that makes the cake rise or swell!

Both baking powder and baking soda are chemicals leavening agents that **cause batters to rise when baked**. One of the acid salts reacts with the baking soda and produces carbon dioxide gas. The second reaction takes place when the batter is placed in the oven. The gas cells expand causing the batter to rise.

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WHERE AND WHY DO WE SEE INTUMESCENT MATERIAL USED IN CONSTRUCTION?

The primary reason for requiring intumescent materials is the introduction and increased use of plastics in construction. These plastics are used for many or most of the services that we see in buildings today.

Whether it be, plumbing, electrical, communication/data, air conditioning or refrigeration, all these services contain some plastic materials.

Plastics shrink, shrivel up and melt in fire conditions, and the intumescent materials are used to swell up and fill the space left when the plastic melts.

Without intumescent materials, we could not stop fire spread when using plastic materials for our services.

ACRYLIC SEALANTS AND FIRE COLLARS

I am trying to decide which products or systems would cater for the most volume of intumescent material used in construction here in Australia. It would be close, but it would probably be acrylic or water based intumescent sealants.

ACRYLIC SEALANTS

Trafalgar Fire's FyreFLEX™ was the first one-part fire rated intumescent sealant launched in the commercial market. Before this, fire rated sealants were two-part polyurethanes, needing to be mixed, just like the old Araldite™ glue for those who remember mixing this up. The intumescent properties in acrylic sealant are important in fire conditions, as the char ensures the sealant does not fall out of the joint and allows less material to be used to provide the necessary fire rating, as the char or foam acts to stop heat conduction through the gap.

AUSTRALIAN MADE AND OWNED

NCC 2022 READY

FyreFLEX

CLICK TO LEARN MORE

FCO 1579 is available for download at tfire.com.au/Test_Reports

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FIRE COLLARS

The other high-volume application is fire collars which are used to protect openings through which plastic plumbing pipes pass through fire rated barriers such as floors, walls, service shafts and ceilings.

Put simply, we would have to go back to cast-iron, brass, and copper pipes and stop using PVC or plastic pipes for plumbing without intumescent materials. If my research is correct, Australia was the first country to commercialise the use of PVC, and the first fire collars were Trafalgar Fire FyreCHOKE™ collars.

To be fair, the early commercialisation of both FyreFLEX™ and FyreCHOKE™ were by Wormald International, but today these old trademarks and legacy is part of our Trafalgar Fire history, having acquired all the assets for the passive fire protection divisions more than 20 years ago now.

FyreCHOKE™ COLLARS SYSTEMS

FyreCHOKE™ Fired rated collars for passive fire protection of service penetrations.

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RECENT CHANGES OF NOTE AND WHY NEWER PASSIVE FIRE PROTECTION SYSTEMS HAVE BEEN INTRODUCED

The two main culprits for necessary change are probably the increased cost of copper and the energy provisions of Section J in the NCC.

COPPER

Services made from copper are expensive and we are seeing a shift away from copper.

Hot, cold water and gas pipes are changing to engineered plastic. Cross-linked and rigid polyethylene tubing, known as PEX pipes, have become very popular for the transfer of hot and cold water in our buildings. Gas reticulation needs to be pressure rated, so this is where PEX-AL-PEX pipes—a co-extruded aluminium composite cross linked polyethylene tube or gas pipes—have gone.

Both PEX and PEX-Al-PEX pipes require a very high performance and strong intumescent material to close them off in the event of a fire.

Fire tests we have done at Trafalgar Fire show that the aluminium in the PEX-AL-PEX and the thick wall PEX both conduct heat in fire conditions and often act similarly to a metal pipe in terms of heat transfer, including getting hot on the non-fire side. This means they often require wrap to achieve the insulation or temperature increase requirement.

Recent projects have also seen the introduction of aluminium core cables.

Copper pipes

PEX Pipes

ENERGY PROVISIONS

Section J requires the conservation of energy for reticulation of cold or hot gases or liquids. This means we are seeing increased use of combustible foam or insulation wrap around air conditioning and refrigeration pipes. As the R values increase, the thickness of insulation increases.

This requires again the use of high-performance intumescent systems with proven fire testing.

Intumescent

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NEW PRODUCTS OR SYSTEMS

What products and systems have we seen introduced to combat the new plastic materials we are seeing replacing copper and to deal with the insulation or lagging on pipes?

High Performance (HP) graphite sealants have become popular.

These sealants (or mastic if you prefer) are black as they are heavily laden with graphite intumescent. Trafalgar Fire's FyrePEX™ HP was aptly named as it was developed as a cost-effective solution to help with PEX and PEX-AL-PEX pipes.

The problem with these graphite intumescent sealants is that they require very exact hole sizes and annular space or gaps around the PEX pipe. This is hard to achieve in practice as some trades do not ready technical literature very well. It is not the cheapest option if you do the maths either, but we sell tonnes of it as Trafalgar Fire, notwithstanding the above. It works a treat in fire conditions.

To make it easier and to assist with what we called visible compliance, we introduced our FyreSHEATH™ to alleviate the issues with incorrect holes sizes and having to do a destructive test to check as installed thickness, which has proven very popular. In essence, you are building your own fire collar of sorts on site.

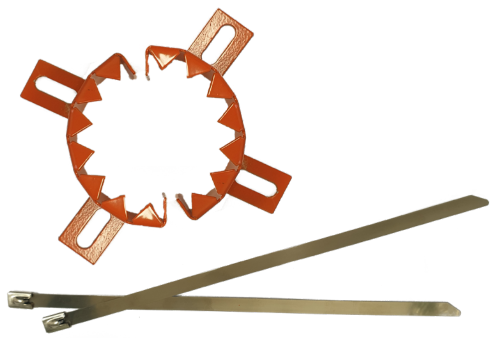
FyrePEX HP

CLICK TO LEARN MORE

FyreTest- FyrePEX™ HP: Pair coil and plastic pipe services.

FyreSHEATH

CLICK TO LEARN MORE



NCC 2022 READY

FyreSHEATH secured to concrete or masonry wall using M6 masonry anchors.

FyrePEX™ HP applied to depth of at least 60mm from top side of the wall.

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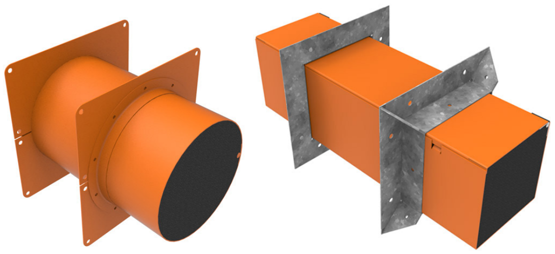
FyreBOX™ SMALL MULTI-SERVICE TRANSITS, AKA FyreBOX™ Mini

The most fire tested solution—especially for multiple PEX pipes and some additional services like pair coils, PVC drains, cables and other services—is our FyreBOX™ Mini. Previously known as a FyreCLAMP™, these were introduced 15 years ago for data and electrical cables and were commonly referred to as a CT or Cable Transit.

FyreBOX MINI

NCC 2022 READY



FyreBOX

CLICK TO LEARN MORE

FyreTest- Single Layer Plasterboard Wall

MULTI-SERVICES FIRE COLLARS

Due to popular demand, Trafalgar Fire has recently conducted numerous fire tests to allow the use of our conventional FyreCHOKE Premium Hinged Retrofit Fire Collars for use with more than just plastic plumbing pipes.

FyreCHOKE MIXED SERVICES COLLAR

CLICK TO LEARN MORE

REAL WORLD SERVICE APPLICATIONS

Personally, after 20 years or more, I got tired of trying to educate trades to not bundle multiple services together in one opening.

I wanted designers to plan for passive fire protection; they said they could not do it in practice, or no one wants to pay for this service.

I smiled and gritted my teeth. Hadn't we successfully managed to stop core holing concrete slabs for plastic plumbing pipes with the advent of the cast-in fire collar?

"Please make your life lives easier and plan your passive fire protection" I heard myself saying as we had to help get things fixed days before the building had to open. This happened building after building. Don't people learn from their mistakes? It seems not!

ENTER MY PATENTED FyreBOX™ SYSTEMS

Why not put the fire stopping in before the wall or floor is built? We do it for fire collars, granted for a single service, but why not for multiple services?

The advances in intumescent materials made a larger opening and high-performance solution possible in my mind. The rest is history. Six years, several patents, a few million dollars of development and nearly 50 fire tests later, the evolving Trafalgar FyreBOX™ range—locally invented by yours truly, made right here in Australia, by Australians—is seeing orange FyreBOX™ units on many building sites.

It has not been without challenges. A nuisance and poor copycat with some interesting fire, smoke and acoustic claims have distracted us in part, but notwithstanding this annoyance, we have soldiered on with the development of more systems and educating the market on the benefits of using Trafalgar FyreBOX™ range of systems.

Today, FyreBOX™ is our biggest selling and my favourite product in the large portfolio of systems Trafalgar Fire offers in passive fire protection.

FyreBOX CAST-IN

FyreBOX MAXI

FyreBOX MINI

FyreBOX SLAB-MOUNT

FyreBOX SLAB-MOUNT BAMBINO

WHAT ABOUT SMOKE?

This is the reason why many fire engineers ask at what temperature does the intumescent activate.

If we have concerns over smoke early in a fire before a fully developed fire event (or if there is only a smouldering or incipient fire), **intumescent materials will do nothing**. Intumescent material comes into effect when serious heat passes through the opening and reacts as discussed earlier to form a char for fire resistance purposes and stopping excessive hot smoke only.

IT IS SMOKE THAT IS THE REAL KILLER

Sadly, Australian regulatory requirements ask for fire resistance only, not fire and smoke.

We do have some smoke walls in Class 9a and Class 9c building types, but nowhere do we need fire and smoke. It’s ironic as smoke is what kills most people, and is often remote from the seat of the fire. We all know smoke travels far and wide.

You might be thinking, what do we need to do for smoke?

Should we be trying to stop its movement through openings and around services where intumescent materials are used? The regulations do not require this at present. “Why?” you might ask yourself.

It is probably due to the age of the regulations. When all services were metal, we shoved non-combustible packing around them, and these as a rule provided both the fire rating and by default a decent smoke seal.

LEARN MORE ABOUT SMOKE.

TAKE A READ OR DOWNLOAD THE ARTICLE: SMOKE IS THE REAL KILLER IN FIRES

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THE DEVELOPMENT OF OUR FyreBOX™ RANGE

Fire resistance using intumescent materials was the relatively easy part for me in terms of the development of the Trafalgar FyreBOX™.

Knowing that the market I was targeting was corridor to apartment walls, the acoustic provisions were concerning and the biggest challenge to me.

I needed something to put in the ends of the box with the following attributes which could achieve the following performance:

- Relatively easy to cut and fit around services running through the FyreBOX™
- Ability to cater for movement of services as the building moves
- Ability to make it locally and in volume
- Acoustic or sound containment properties (low porosity)
- Smoke containment properties (which correlates well with acoustics aka porosity)
- Some fire performance attributes (fire resistance) as it takes as long as five to eight minutes for an opening to fully close around complicated services and across a large span of over 100mm.

It took a serious number of iterations to develop a graphite impregnated, non-porous foam insert material which could pass the fire test and provide a good acoustic and smoke seal.

The real technology in the Trafalgar FyreBOX™ is the graphite impregnated foam insert or plugs in the end of the box.

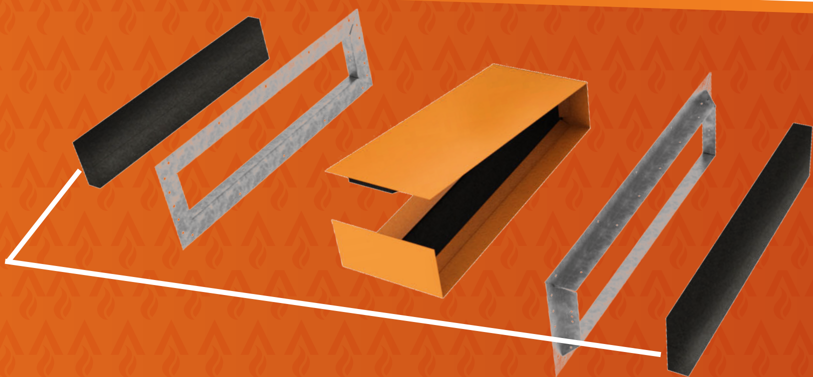
The FyreBOX™ cannot close quickly enough to pass the fire test empty of with only a sparse number of services without the foam. For the record, we tried brushes made from silicone rubber, but we could not achieve the acoustic requirements, we were worried about smoke and we could not pass the fire test.

Today, we are proud to offer some brilliant fire, smoke and acoustic solutions which allows the Trafalgar FyreBOX™ to be installed early in the program, saving both time and money.

We are working through some seismic testing as I write this; so glad my design and performance attributes considered movement too.

THE FyreBOX™ DIFFERENCE

INTUMESCENT FOAM PLUGS PROVIDING ACOUSTIC AND SMOKE CONTAINMENT



DOES EVERY PASSIVE FIRE PROTECTION PRODUCT NEED TO BE INTUMESCENT?

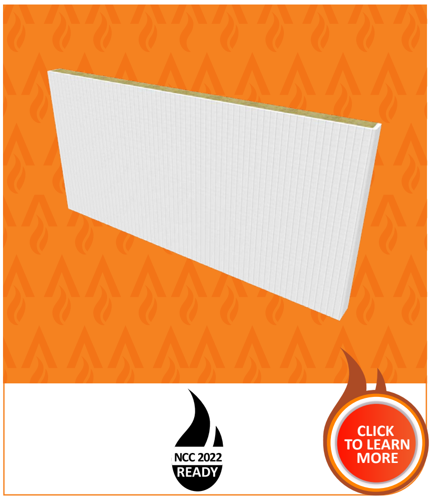
No, there are many non-intumescent products and systems.

At Trafalgar Fire, we sell many.

FyrePLUG™ fire pillows, FyreBATT coated stonewool slabs, FyreSET™ fire mortar and FyreBOARD Maxilite® fire boards and TWRAP™ insulation wrap for services are all non-intumescent.

Of course, where plastic services pass through there may need to be a secondary intumescent product used as part of the overall system, such as FyreFLEX® sealant as one good example.

FyreBATT



FyreBOARD MAXILITE

FyrePLUG

FyreSET

TWRAP

COMMONLY ASKED QUESTIONS ABOUT INTUMESCENT MATERIALS

WHAT TEMPERATURE DOES IT ACTIVATE AT?

If you must have a temperature, it is 100 degrees Celsius. This is where water turns to steam and the heat must be hot enough to start the chemical reactions and decomposition and create a char. The correct way of thinking about intumescent activation is energy or heat input.

HOW MUCH FORCE DOES IT EXERT?

This depends on the intumescent formulation and what you are using the material for in terms of a passive fire protection product and system.

WILL IT SWELL UP AROUND A FIRE DOOR SO PEOPLE CANNOT GET OUT OF THEIR APARTMENT?

By the time the intumescent activates there is no one alive in an apartment as a fully developed fire will be necessary to fully activate the perimeter around a fire door.

IS THE SMOKE TOXIC WHEN IT ACTIVATES?

Compared to the smoke generated in a building, it is insignificant and a silly question to ask.

IS IT EXPENSIVE?

No, for what it does it is amazingly cheap.

DOES IT HAVE A SHELF LIFE?

Not the good ones.

DOES IT NEED TO BE REPLACED EVERY 3 YEARS IN A BUILDING?

Not the good ones; they will last longer than the building.

The combustion kinetics of a laminate with intumescent behavior were determined by thermogravimetry for heating rates between 5 and 20 K/min and a final temperature of 873 K. The devolatilization stage consists of three consecutive first-order reactions that can be associated with the release of (1) water vapor (from aluminum trihydrate), (2) HCl (from polychloroprene), and (3) a gaseous mixture (from expansible graphite), followed by charring. The corresponding activation energies are 114, 140, and 83 kJ/mol. The second stage is the heterogeneous combustion of the active part of the intumescent char. This process is described by a one-step reaction whose rate presents a power-law dependence (n = 1.98) on the solid conversion and an activation energy of 182 kJ/mol. The thermal response of a composite system that uses the intumescent material as a coating for thin steel slabs was also investigated.