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uPVC PIPE FIRE COLLARS – HISTORY

Fire and Security Consulting Services (FSCS) is frequently consulted on where and when fire collars are required in buildings. Note that Rick Foster was with Fire Control Pty Ltd from 1968 until 1977 and was involved with the development of passive systems including the design of fire doors.

To understand the regulatory process under which uPVC piping was allowed for waste, soil and rainwater piping systems in buildings, it is important to understand the history of Building Codes in Queensland. Accordingly it is recommended that readers consult the companion paper to this paper entitled "Alterations to Existing Buildings in Queensland" by FSCS.

This paper is the result of research by FSCS including personal recollections and records from Fire Control Pty Ltd, Fire Research Pty Ltd, web searches, Queensland Legislative records of the Building Act and a paper by H. Vormelker from Adelaide City Council.

If any reader has additional information, please submit it to FSCS I the interests of further expanding this paper.

Prior to 1975

The years before 1975 saw a significant advance in the methodology and materials used in building construction in Australia. The advances were driven primarily by Companies responding to Developers' and Builders' requirements for less costly and more efficient building processes. Additionally Architects demanded more aesthetically acceptable finishes for prestige buildings.

Two product areas with potential fire safety implications were targeted by industry, namely:-

1. Replacement of the traditional metal (copper, steel or cast iron) waste, soil and rainwater pipes with uPVC which significantly reduced costs and improved longevity of the systems. These were introduced by Iplex, Vinidex, Humes and Hardie in association with overseas product developers; and
2. Development of timber veneer (with timber hinge and lock stiles) fire doors up to 3 hour rating by Fire Control Pty Ltd.

These and other responses by industry were a significant influence on the newly formed "Australian Model Uniform Building Code" (AMUBC), which struggled to keep up with industry developments. However AMUBC did respond and amendments to the Code were forthcoming several time a year.

Until 1975, some builders were using uPVC pipe in waste, soil and rainwater systems, possibly contrary to the local building Regulations. Fire spread by these systems was not universally recognised nor were the local Building Inspectors aware of the implications.

An industry that did recognise the implications was the then flourishing shipbuilding industry. Shipbuilding standards in Australia were controled by the Commonwealth Department of Shipping and Transport under the International SOLAS (Safety of Life at Sea) Convention. SOLAS had mandated specific requrement where the use of (lightweight) uPVC piping was to be used and recognised the effectiveness of intumescent materials which could crush the softened (due to fire) walls of uPVC pipe and thus seal them. In 1971, the Commonwealth Experimental Building Station (EBS) under the forward thinking of Jack Keough tested an intumescent fire damper for Whyalla Shipbuilding and Engineering.

This, and further tests were the basis of possibly the first Alternative Solution for uPVC systems to be used in the Grenfell Centre and Stock Exchange Plaza in Adelaide between 1971 and 1973.

With this test data, Industry, at the behest of AMUBC, commenced research on cost effective methods of using intumescant materials for sealing uPVC pipe penetrations.

Another documented use of uPVC pipe in a multi-storey building was the Norwich Union Centre at 53-79 King William Road in Adelaide in August 1974, As a portion of the plumbing installation was already completed, the Architect appealed to the referees under section 24 of the Building Act to permit PVC plumbing piping in the two buildings. The main installation of pipes was confined in the Ladies and Men's toilets and the vertical piping from the roof mounted condenser to the plant room and the ground floor. The Architect maintained that In these buildings the PVC piping was generally confined and constituted a low fire hazard, Toilet areas were bounded by a 1hour fire rating and access to the men's toilets was through a 1 hour fire rated door from the enclosed fire rated staircase.

The referees ruled: -

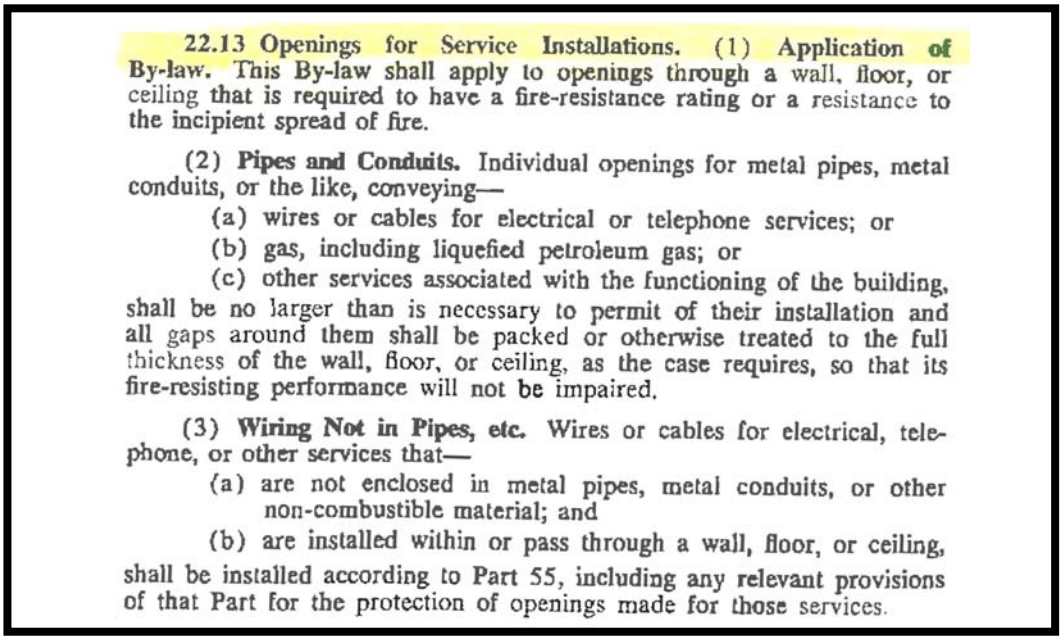
- To provide a fire door to the ladies ante room.
- To install air intake ductwork to the ladies toilet and provide fire dampers at penetrations of the walls.
- To enclose PVC plumbing fittings and runs below the first floor and vertical stack with 1 hour fire rating,
- Either enclose the condenser pipe with a 1 hour-fire rating, replace it in metal or insert a metal duct reflux valve closely to the penetration of the floor.

Clearly these were onerous requirements but at last someone had recognised the potential for fire spread up through uPVC pipe penetrations. However this recognition did not appear to have spread through the building and Regulatory community.

1975

In Queensland, the enactment of the Building Act on May 15th 1975 established Queensland's first formal regulatory system controlling the construction of buildings. This Act contained various appendices one of which was the "Standard Building By-laws" which adopted the technical requirements from AMUBC and which was regularly amended to reflect changes in the AMUBC.

The original Queensland 1975 Building Act, in Clauses 22 and 55.5 still read:-



22.13 Openings for Service Installations. (1) **Application of By-law.** This By-law shall apply to openings through a wall, floor, or ceiling that is required to have a fire-resistance rating or a resistance to the incipient spread of fire.

(2) **Pipes and Conduits.** Individual openings for metal pipes, metal conduits, or the like, conveying—

(a) wires or cables for electrical or telephone services; or

(b) gas, including liquefied petroleum gas; or

(c) other services associated with the functioning of the building,

shall be no larger than is necessary to permit of their installation and all gaps around them shall be packed or otherwise treated to the full thickness of the wall, floor, or ceiling, as the case requires, so that its fire-resisting performance will not be impaired.

(3) **Wiring Not in Pipes, etc.** Wires or cables for electrical, telephone, or other services that—

(a) are not enclosed in metal pipes, metal conduits, or other non-combustible material; and

(b) are installed within or pass through a wall, floor, or ceiling,

shall be installed according to Part 55, including any relevant provisions of that Part for the protection of openings made for those services.

(4) **Ventilating and Air-Conditioning Ducts.** Openings for ventilating or air-conditioning ducts or other equipment shall be protected as required by Part 55 (Specification No. 7).

(5) Other Services. Openings for other services not mentioned in subclauses (2), (3), and (4) shall be protected in an approved manner.

22.13a Other Openings. Openings in floors, walls, and roofs, not provided for elsewhere in these By-laws, shall be protected in an approved manner to resist effectively the spread of fire and the products of combustion, and shall be of such approved dimensions and construction as not to endanger persons using the building.

55.5 Openings in Fire-Resisting Construction. (1) **Wires and Cables.** Wires or cables for electrical, telephone or other services that—

(a) are not enclosed in metal pipes, metal conduits or other noncombustible materials; and

(b) pass through a wall, floor or ceiling required to have a fire-resistance rating,

shall comply with subclauses (2) and (3).

(2) **Packing of Holes.** The space between any wire or cable referred to in subclause (1) and the inside faces of the holes in the walls, floors, or ceilings through which they pass, including the inside faces of sleeves or the like that may be inserted to carry them, shall be packed solid with gypsum-vermiculite plaster, asbestos, or other approved non-combustible material.

(3) **Area of Holes Limited.** The total cross-sectional area of any holes for the accommodation of wires or cables referred to in subclause (1) in any 10 m² section of a floor or ceiling required to have a fire-resistance rating shall not exceed 7×10^3 mm².

This clearly did not yet recognise the use of uPVC pipe in buildings.

In July 1975 the Experimental Building Station carried out tests of copper, cast iron and PVC piping penetrating a concrete slab. The experimental studies by the EBS indicated that services installed in metal pipes, conduits or metal ducts in accordance with the regulations may not maintain the fire rating of the wall or floor penetrated but are deemed to meet the requirements of the Regulations.

Regulation 55, 5(3) of the Act permits a $7x10^3$ mm^2 cross sectional area of plastic insulated wire or cables to penetrate any $10m^2$ of floor area and also covers single penetrations of that above size in a $10m^2$ area.

EBS carried out tests using plastic insulated electrical cables of uPVC piping, 45, 50 and 60mm diameter cables. In all cases, the uPVC piping insulated above the floor commenced to burn between 95 and 105 minutes and penetrated the floor slab in 130 minutes.

Observation of testing for copper and cast iron pipes indicated satisfactory performance for a period of fire exposure of 62 minutes. The maximum allowable temperatures rise of 180^oC above the initial temperature was exceeded at 27 minutes, 44 minutes and 56 minutes, as measured by a thermocouple located at 50 mm above the concrete box enclosed on the 102 mm copper pipe, on the 76 mm copper pipe and on the 80 mm cast iron pipe respectively, The pipes remained stable throughout the test, which was terminated at 1 hour and 2 minutes.

These tests confirmed the adequacy of electrical cables and copper and cast iron pipes for a period of one hour.

However the uPVC pipe tests prompted the following observations from the EBS.

(Apologies for the quality of the reproduction – the originals are very old.)

When heated, plastics soften at 80 to 105°C. As temperature increases, vapour containing a high percentage of hydrogen chloride is given off, the rate of vapour emission is proportional to the temperature increase and the duration of heat exposure. If external flame makes contact with the plastic, and there is sufficient oxygen present, ignition occurs at 250°C, but flames are extinguished once the external flame is removed.

Since plastic is a good insulator, the time required to cause burn-through or collapse of a pipe during E.B.S. studies is longer than that indicated by the softening and ignition temperatures. In B.B.S. tests plastic pipes with top and bottom ends open burned through on the non-fire exposed face after 10 minutes, by which time the furnace temperature had increased from 10 to 700° C.

If plastic is heated without flame contact, softening and the emission of vapour occurs as stated above. At 250°C carbonation commences after all vapour has been expelled from the heated plastic resulting in the formation of a soft carbon layer on the surface of the plastic, which acts as an insulating barrier and retards the rate of carbonation for the remaining plastic material. With continued heating all plastic is eventually converted to carbon, which undergoes a very slow rate of oxidation, with the production of carbon dioxide, when the surface exposed to air reaches 700°C. If air is allowed to pass through the hot carbon mass at a high rate, carbon monoxide is formed and ignites on emerging to free air.

Observations: Testing of P.V.C. piping in the furnace grouted with a 3:1 cement mix.

At 3 min from commencement of the examination some softening of the pipes above the concrete box enclosure was noted. At about the same time, heavy acrid smoke was observed issuing from the furnace flues. A blue haze of smoke surrounded the specimen at 5 minutes as can be seen in Fig 3 which shows also the softened and buckled pipe. As the examination progressed, the smoke density increased. Softening of the pipes also progressed, and at 10 minutes the pipe installed at location all burned through at the level of the upper surface of the concrete box and smoke issued through the opening. The smoke subsided in 20 minutes. At 30 minutes most pipes were burned through just above the concrete slab.

Considerable flaming was observed immediately after the furnace burners were extinguished at 1 hour and 2 minutes.

Another experiment was carried out by providing sleeves around P.V.C. pipes, the gap between them and the pipe was filled with rockwool. After 35 minutes the pipe above sleeve-fitting charred. The test terminated at 1 hour 2 minutes one minutes later the furnace was extinguished, air flow was maintained, the pipe above sleeve-fitting ignited.

The results of these examinations of approximately 1 hour duration lead to the following conclusions :-

1. The unprotected P.V.C. pipes would burn and if the upper ends are open they would act as flues discharging products of combustion from the fire-involved storey or compartment.

2. If certain lengths of P.V.C. pipes immediately past their penetration through the fire-rated slab were protected with special sleeve-fittings, the fire-resisting properties of the penetrated element of structure are likely to be maintained for periods of time dependent on the design of the sleeve-fitting.

3. The unprotected metal pipes will not be penetrated or damaged structurally by fire. However these pipes may become so hot as to exceed allowable temperature rise on the unexposed side to the fire side within 30 minutes.

4. The investigations covered certain aspects only of the performance under the conditions of the standard fire-resistance test of P.V.C. pipe installations that penetrate fire-rated elements of horizontal construction. Wider applicability of the findings is yet to be established.

As noted in the Experimental Building Station Technical Record, there are no established performance cirreria for evaluating the acceptability during fire exposure of pipe installations that penetrate fire resisting construction, other than the general stipulation that such installations should not influence detrimentally the level of fire resistance of the fire rated element penetrated.

The EBS conclusions for unprotected uPVC pipe were not favourable and it is thought that they led to the limitation of its use in the 1976 AMUBC reccomendations which were adopted in South Australia in May 1976 as follows:-

Openings in Floors for Certain Services

Metal pipes or ducts or fire-rated shafts required

22.11a (1) Subject to subregulation (2) hereof, in a *building required* to be of Type 1 or Type 2 *construction*, services associated with the functioning of a *building* and passing through a floor shall be in individual metal pipes, metal conduits, metal ducts, or the like, or be installed in *shafts* complying with Part 16.

Concession for P.V.C. plumbing

(2) Nothing in this regulation shall be deemed to preclude poly vinyl chloride pipes and fittings for plumbing from passing through floors or ceilings of *buildings required* to be of Type 1 or Type 2 *construction* where either—

(*a*) the *building contains* not more than two *storeys* and complies with the provisions of Part 19; or

(*b*) the floors passed through are those between sanitary compartments which—

(i) are separated from other portions of the *building* as though they were ventilating, pipe, garbage, or the like *shafts*, not intended for the discharge of hot products of combustion; and

(ii) have all doorways opening therefrom protected by *self-closing* one-hour firedoors,

and the openings for the pipes or fittings are no larger than is necessary to permit of their installation, and all gaps around them are packed or otherwise treated to the full thickness of the floor or ceiling, as the case requires, as prescribed in regulation 22.13 for metal pipes, metal conduits, or the like.

Queensland adopted the AMUBC reccomendations in 1982 to the Standard Building By-laws Clauses 22.1 and of the 1975 Building Act. This clause was still in the 1984 By-Laws.

22.11a Openings in Floors for Certain Services. (1) **Metal Pipes, etc.** In a building of Type 1 or Type 2 construction, services associated with the functioning of a building and passing through a floor shall either be in individual metal pipes, metal conduits, metal ducts, or the like, or be installed in shafts complying with Part 16.

(2) **PVC Pipes, etc, in certain cases.** Notwithstanding the provisions of subclause (1) hereof in a building of Type 1 or Type 2 construction, plumbing services associated with the functioning of the building and passing through a floor may be in polyvinyl chloride pipes and fittings provided—

(a) the building contains not more than 2 storeys and complies with the provisions of Part 19; or

(b) the floors passed through are those between sanitary compartments which—

(i) are separated from other portions of the building as though they were ventilating, pipe, garbage, or like shafts, not intended for the discharge of hot products of combustion; and

(ii) have all doorways opening therefrom protected by self-closing one-hour fire doors,

and the openings for those polyvinyl chloride pipes and fittings comply with the provisions of clause 22.13 relating to openings for metal pipes, metal conduits, or the like.

Inserted by Order in Council published Gazette 15 May 1982, pp. 335-399.

55.5 Openings in Fire-Resisting Construction. (1) **Wires and Cables.** Wires or cables for electrical, telephone or other services that—

(a) are not enclosed in metal pipes, metal conduits or other noncombustible materials; and

(b) pass through a wall, floor or ceiling required to have a fire-resistance rating,

shall comply with subclauses (2) and (3).

(2) **Packing of Holes.** The space between any wire or cable referred to in subclause (1) and the inside faces of the holes in the walls, floors, or ceilings through which they pass, including the inside faces of sleeves or the like that may be inserted to carry them, shall be packed solid with gypsum-vermiculite plaster, asbestos, or other approved non-combustible material.

(3) **Area of Holes Limited.** The total cross-sectional area of any holes for the accommodation of wires or cables referred to in subclause (1) in any 10 m^2 part of a floor or ceiling required to have a fire-resistance rating shall not exceed 7 x 10^3 mm^2.

As amended by Order in Council published Gazette 15 May 1982, pp. 335-399.

Clearly the AMUBC reccomendations for fire rating of sanitary spaces above uPVC penetrated slabs was onerous but the EBS test findings warranted such measures.

Until 1981, no major changes occurred in the building industry in regards to the use of plastic plumbing.

In the City of Adelaide, various methods of fire-proofing uPVC piping were approved. Pipes were wrapped with wire mesh and sprayed with gypsum or concealed behind 1.5 to 2 hour fire rated ceilings without penetrating the same.

In 1981 , the Experimental Building station carried out test on uPVC with a fire stop collar, The collars are of various sizes in line with pipe diameters and with the collar (or canister made of galvanized steel) containing intumescent material with the following observations:-

At about 100^{o}C the intumescent lining material began to expand within the canister wall and against the penetrating pipe, As the temperature increases the pipe softens and the rapidly foaming lining material produces sufficient pressure to cause collapse of the pipe sealing of the opening.

The test specimen system incorporating 50mm-80mmand 100mm pipes was considered to have preserved the fire resistance of the concrete slab for a period of 2 hours.

The 150mm pipe failed in terms of the passage of flames of half an hour, and more test were carried out on fire stop collars for 150mm diameter with an additional guillotine cut off system.

In July 1982, the Building Advisory Committee of SA approved (with the data of the EBS) a system for a maximum 100mm diameter UPVC pipe penetrating a concrete floor with the following requirements:-

The pipe was wrapped with layers of Intumescent fibrous hydrated sodium silicate contained In a steel container designed to prevent swelling of the intumescent material, which is 20mm thick around 100mm pipes, 15mm on 80mm pipes and 10mm on a 50mm diameter pipe. All holes or openings in the pipe of the upper and lower storey sealed, which could permit smoke or hot products of combustion to enter or escape in the upper storey.

In December 1982 the EBS carried out more tests on uPVC pipes penetrating fire rated floors, using fire stop collars and a sliding blade guillotine device (the 'shut off device' system) in the 100mm and the 150mm pipe which satisfied a fire resistance test of more than 2.4 hours.

With the above fire stop collar and 'shut of device' system now on the market and the cost of each of the devices in various sizes ranging from $25-$70 (32-150mm) It was comparable with copper and cast iron installation in multi storey buildings and became common place. The first of the new units on the market did fail on building sides when they became wet and had to be replaced.

In 1985 Dow Coming introduced the 2 hour fire rated "Intumescent Wrap Strip 2002" but it failed and it was taken of the market. In 2001 Promat introduced the "Promastop Unicolour" which was tested for uPVC in Australia and New Zealand for pipes up to a size of up to 100mm diameter.

In April 1986 Fire Research Pty Ltd introduced a new range of fire collars with up to 4 hours fire rating and tested to AS1530.4, meaning that uPVC pipes rising from car parks in multi-storey building could successfully be protected.

Formal Adoption of Fire Collars

FSCS has been unable to source documentary evidence regarding the date formal adoption of a Deemed to Satisfy (DtS) system of fire stop collars based on testing.

It is known that AS1530.4 was used to test fire collars from about 1986 and from BCA90, tested fire collars were able to be used provided *the method and materials used were identical with a prototype assembly of the service and building element which has achieved the required FRL or resistance to the incipient spread of fire*; or these in Class 2 and 3 buildings. In 1995, AS4072.1 was specifically developed to test service penetrations and superseded AS1530.4 for those elements of construction.

Summary

From the above, it is considered that in examining a building for compliance of service penetrations, that:-

1. In buildings constructed prior to 1975, uPVC piping systems penetrating fire rated elements of construction were not officlally allowed but may have been approved by the Regulatory Authority.
2. If buildings constructed prior to 1975 have evidence of uPVC piping systems penetrating fire rated elements of construction, the systems may have been retrofitted at a later date. Prior to 1975 it is not known if there were any Transitional Provisions allowing approval under prior Regulations. However if the penetratiing pipes are fitted with compliant collars, approval may have been granted by the Regulatory Authority.
3. In buildings constructed between 1975 and 1982, piping systems penetrating fire rated elements of construction would not have been formally approved.
4. If buildings constructed between 1975 and 1982 have evidence of uPVC piping systems, the systems may have been:-
   - Specifically approved by the Regulatory Authority and only between sanitary compartments protected with fire rated construction; or
   - Retrofitted at a later date. Even the 1975 Building Act Transitional Provisions allowing approval under prior Regulations would not have permitted their installation. However if the penetratiing pipes are fitted with compliant collars, approval may have been granted by the Regulatory Authority.
5. In buildings constructed between 1983 and 1986, uPVC piping systems penetrating fire rated elements of construction would not have been formally approved unless between sanitary compartments protected with fire rated construction.
6. If buildings constructed between 1983 and 1986 have evidence of uPVC piping systems, the systems may have been retrofitted at a later date. Even the Building Act Transitional Preovisions allowing approval under prior Regulations would not have permitted their installation. However if the penetratiing pipes are fitted with compliant collars, approval may have been granted by the Regulatory Authority
7. In buildings constructed between 1986 and 1995, uPVC piping systems penetrating fire rated elements of construction require fire collars compliant with AS1530.4 for compliance.
8. In buildings constructed after1996,uPVC piping systems penetrating fire rated elements of construction require fire collars compliant with either AS4072.1 or AS1530.4 for compliance.

I trust that this paper provides information that you will find helpful.

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