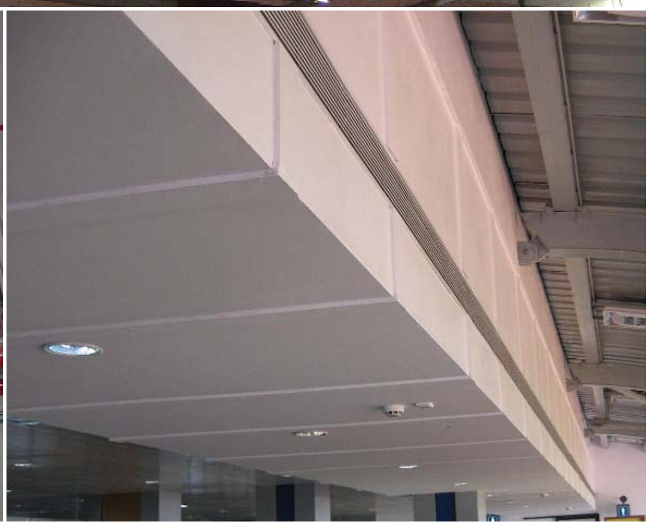
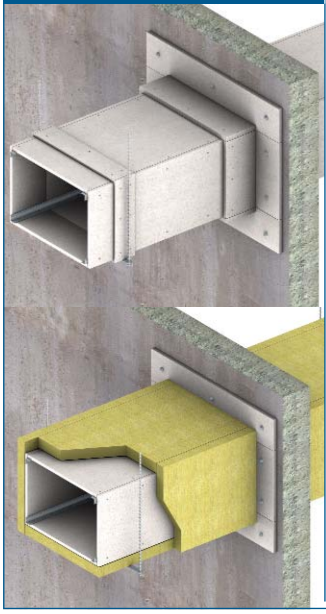
Promat

PROMATECT®-H / PROMATECT®-L
Self-supporting Ducts



Type of self-supporting ducts	System code	FRL	Board thickness	Duct type	Mineral wool	Maximum dimension	Tests and assessments standards/labs	Page no.
	**PL 43.12**	120/120/-	25mm	A B	Not required	3000mm x 1250mm	**BS476: Part 24 and AS1530: Part 4 Report no.** • BRE CC82043D • BRE CC88388 • BRE CC82101 • WFRC C134133	6
	PH 43.12	120/120/-	12mm	A B	Not required	10,000mm x 3000mm		
		120/120/120	15mm	A B	100mm x 140kg/m³	6100mm x 3000mm		
	PH 43.18	180/180/90	20mm	A	Not required	10,000mm x 3000mm		
	PL 43.24	240/240/-	25mm	A B	Not required	3000mm x 1250mm		
	PH 43.24	240/240/30	25mm	A B	Not required	3000mm x 1250mm		
			20mm	B	Not required	10,000mm x 3000mm		
		240/240/240	25mm	A B	100mm x 140kg/m³	6100mm x 3000mm		

NOTE: For ducts exposed to external fire (Duct type A) the insulation can be measured inside the duct, inside the fire compartment or outside the duct on an adjacent compartment. All the above provide similar levels of insulation to that listed, when the insulation is measured outside the duct. For details of insulated ducts exposed to external fire where insulation is required inside the duct, or inside the fire compartment, please consult Promat Technical Department. Different performance requirements may occur under the Builder Code of Australia (BCA), please consult Promat for clarification if necessary.

The relative complexity of any ductwork system which is passing through different fire compartments and the relevance of the system's function in ambient as well as fire conditions can make the selection of a suitable ductwork system difficult.

This section of the handbook aims to give some guidance on the fire performance requirements of ductwork and offers a wide range of solutions for the protection of steel ductwork and for self-supporting systems using PROMATECT®-H, and PROMATECT®-L500.

For particularly onerous conditions, e.g. where high impact strength is required or for use in aggressive environments, Promat have developed a range of systems using the PROMATECT®-S high impact board.

Fire Testing Methods

To determine the fire resistance of ducts (without the aid of fire dampers) passing through or between compartments, the system should normally be tested or assessed in accordance with BS476: Part 24 or AS1530: Part 4. These standards have been written specifically for ventilation ducts, but guidance is also given in these standards on the performance requirements for "smoke outlet" ducts and "kitchen extract" ducts.

Although the following information refers to BS476: Parts 20 to 24, these details apply equally to AS1530: Part 4 in terms of the performance requirements. It should be noted, however, that there are substantial differences between the two standards in terms of testing methodology which greatly affect the results. It is not possible to simply transfer results from AS1530: Part 4 test to BS476: Part 24 due to this huge difference in testing methods.

A part of a standard fire test, duct systems are exposed to external fire (also known as Duct type A) and one sample to both external AND internal fire (also known as Duct type B). Fans create a standard pressure difference and air flow and the ducts fire performance is assessed in both fan-on and fan-off situations. When testing horizontal ducts, a run of at least 3000mm is located within the fire compartment (the EN and revised ISO standards required a 4000mm length exposed) and a further 2500mm outside the fire compartment.

BS476: Part 24 expresses the fire resistance of ducts without the aid of dampers, in terms of stability, integrity and insulation.

Stability failure occurs when the suspension or fixing devices can no longer retain a duct in its intended position or when sections of the duct collapse. This requirement does not apply to the length of the duct exposed to internal fire (Duct type B) within the fire compartment.

It should be noted that if a duct suffers extensive deformation, such that it can no longer fulfil its intended purpose, this would be classed as stability failure. For Duct type A, loss of pressure within the duct during testing is also construed as stability failure.

Integrity failure occurs when cracks, holes or openings occur in the duct or at any penetrations within walls or floors, through which flames or hot gases can pass. The effects on integrity of the movement and distortion of both restrained and unrestrained ducts are also included in the standard.

Insulation failure occurs when the temperature rise on the outer surface of the duct outside the fire compartment exceeds 140°C (mean) or 180°C (maximum). The guidance in the standard also states that ducts lined with combustible materials or coated internally with fats or greases, e.g. kitchen extract, should also have this criterion for the inner surface of the duct within the fire compartment when the duct is exposed to external fire (Duct A).

For smoke extraction, the guidance in the standard states that the cross sectional area of a duct required to extract smoke in the event of a fire should not be reduced by more than 25% for the duration of the fire exposure.

See **Penetration Through Walls & Floors** on opposite page.

General Design Considerations

The following points are some of the factors which should be considered when determining the correct specification to ensure a ductwork system will provide the required fire performance. Further advice can of course be obtained from the Promat Technical Department.

1. Required Fire Exposure

Ductwork systems which are located in more than one compartment should always be tested or assessed for their performance when exposed to the heating conditions described within BS476: Part 20. Reduced heating curves are generally only acceptable for certain of the systems components, e.g. the fan.

The performance of a ductwork system will vary depending on whether or not a fire could have direct access to inside the duct through an unprotected opening. If in doubt, one should assume direct access, i.e. the Duct B scenario described previously under Fire Testing Methods.

2. Required Fire Performance

It is a general requirement that the ducts must satisfy all the relevant performance criteria of stability, integrity and insulation (and cross sectional area if a smoke extraction duct). However, the approval authority may accept relaxations on occasion. For example, if no combustible materials or personnel could be in contact with the duct, the authority may accept a reduced insulation performance.

General Design Considerations

3. Supporting Structure

Care should be taken that any structural element from which the duct system is supported, e.g. a beam, floor or wall, must have as a minimum the same fire resistance as the duct system itself and must be able to support the load of the duct under fire conditions.

4. Hanger Support

The supporting hangers, supports and their fixings should be capable of bearing the load of the complete ductwork system including any applied insulation material or other services suspended from it. Chemical anchors are generally not considered suitable. It is normally not advisable to use unprotected supports if the stress exceeds the values given on page 5 and/or if hanger lengths exceed 2000mm. The hanger centres should not exceed the limits given in page 5.

5. Steel Ductwork

The steel duct must be constructed in accordance with the requirements of DW/144 – Specification for sheet metal ductwork – low, medium and high pressure/velocity air systems (published by the Heating and Ventilating Contractors' Association UK.), or equivalent specification, e.g. SMACNA. The steel ducts must be constructed with rolled steel angle-flanged cross joints. It is recommend that longitudinal seams be formed using the Pittsburgh lock.

6. Penetrations Through Walls & Floors

Care should be taken to ensure that movement of the duct in ambient or in fire conditions does not adversely affect the performance of the wall, partition or floor, or any penetration seal. It should be understood that where a duct passes through any compartment wall or floor or other type of separating element, the aperture between the element and the duct must be sealed in accordance with the system approved for use with the duct. In general this requires the use of a penetration seal constructed from materials and in such a manner to match the system used in the duct test programme. Penetrations seals are part of the tested duct system and the use of untested third party products are not permitted.

7. Movement Joints

Movement joint details may be required for long lengths of duct, particularly where the duct spans across a movement joint in the floor or wall, or passes through floors and roof that may deflect at different rates. Please consult Promat Technical office for details of such joints.

8. Air Flow & Leakage

The design of some fire resisting duct systems may need modification to meet DW/144 performance standards. All Promat self supporting duct systems will meet the requirements of DW/144 to the highest levels, provided the correct board thickness is employed and all joints are correctly sealed in accordance with the system recommendations.

9. Ductwork Functions

Most ductwork systems can fall into one or more of the following categories:

- Ventilation and air conditioning;
- Natural smoke extract;
- Fan assisted smoke extract;
- Pressurisation of escape routes and fire fighting lobbies.

In the event of a fire, the function of a system can often change. For example, an air conditioning system could switch to become a fan assisted smoke extract duct. It is therefore essential that the performance requirements in both normal conditions and fire conditions are considered.

10. Other Requirements

Acoustic performance, thermal insulation, water tolerance, strength and appearance can also be important considerations (See BS8313: 1989 Code of practice for accommodation of building services in ducts).

Selection of Fire Protection System

Traditionally all ductwork was fabricated from steel which normally had to be encased in a fire protection system when passing through a compartment wall or floor without the aid of a fire damper.

In recent years, self-supporting systems without a steel liner have been introduced to extract smoke in the event of a fire through natural ventilation. Now some self-supporting systems, e.g. PROMATECT®-H, PROMATECT®-L500 and PROMATECT®-S are available which can match the leakage and air flow performance of steel ducts in accordance with the DW144 standard up to Class C.

To satisfy the wide range of requirements in the current market, Promat can offer no less than three products to protect steel ductwork and to fabricate self-supporting systems.

For any size of duct, the tensile stress in the steel hangers must not exceed 10N/mm^2 for fire resistance up to 120 minutes, or 6N/mm^2 for fire resistance up to 240 minutes. These figures are based on work carried out by Warrington Fire Research Centre (now Bodycote) in the UK and European research projects into the stress and strains of steel members under simulated fire conditions.

The stress reduction ratio factors mentioned below are based on BS5950: Part 1: 1990. Similar figures can be applied from AS4600.

The method to calculate whether the diameter of the threaded rod is within the permitted stress level is given below.

Fire resistance period	Approximate temperature	Maximum permitted stress	Maximum permitted centres
30 minutes	840°C	18/mm^2	2500mm
60 minutes	950°C	10/mm^2	2500mm
90 minutes	1000°C	10/mm^2	2500mm
120 minutes	1050°C	10/mm^2	2500mm
180 minutes	1110°C	6/mm^2	2000mm
240 minutes	1150°C	6/mm^2	1500mm

It should be noted that the stress levels referred to above apply to the threaded rod hanger supports themselves. The horizontal members have a differing level of applicable stress (see page 5). The maximum centres refers to the greatest allowable distance between hanger support systems. However it should be noted that in certain locations, bends for instance, additional supports at lesser centres should be considered.

Where the hanger support system may exceed the limits given in the table above the remedial options are as follows:

1) Increase the dimensions of the hanger support system, e.g. rod diameters etc,

2) Reduce the centres of the hanger support system,

3) Protect the hanger rods.

Hangers supporting steel ducts protected with Promat materials can be left unprotected providing the maximum stress on each hanger does not exceed the values given in the above table and importantly that their length does not exceed 2000mm. Where hanger rods exceed this dimension, there is a high risk of stability failure of the duct due to excessive expansion of the support system. If hanger rods exceed 2000mm, they should be protected at all times for all systems, regardless of system type or manufacturer.

Stress Calculation For Hangers

To calculate the stress in N/mm^2 on each hanger, the total weight of the ductwork and fire protection materials being taken by each hanger should be calculated in kilograms, converted to Newtons (N) by multiplying by 9.81 and then divided by the cross-sectional area of the hanger in mm^2. The cross-sectional area of a circular hanger is π x r^2 where r is the radius of the support rod. It should be noted that the root diameter of the threaded rod should be applied in this calculation, not the outer diameter of the thread. Please refer to the table below for details.

The method to calculate whether the diameter of the threaded rod is within the permitted stress level is given below.

Nominal outer diameter	Root diameter	Cross sectional area
6mm	5.06mm	20.10mm^2
8mm	6.83mm	36.63mm^2
10mm	8.60mm	58.08mm^2
12mm	10.36mm	84.29mm^2
14mm	12.25mm	117.85mm^2
16mm	14.14mm	157.03mm^2
18mm	15.90mm	198.55mm^2
20mm	17.67mm	245.20mm^2

The density of steel is approximately 7850kg/m^3, therefore the weight of steel (kg) = 7850 x surface area (m) x steel thickness (m).

The following example of calculating the stress of the support system is based on the use of PROMATECT®-H boards, however, this method would apply to all fire resisting systems.

Board thickness (mm)	=	12
Duct height (m)	=	1.0
Duct width (m)	=	1.0
Centres of hangers (m)	=	1.22
Area of boards	=	(Width x 2) + (Height x 2) x Centres of hangers
Weight of boards	=	Area x Thickness x Density (975kg/m^3)
Weight of angles	=	(Centres of hangers x 4) + (Width x 4) + (Height x 4) x 0.63kg/m
Section weight (kg)	=	68.62 (inclusive of angles)
Weight on one hanger	=	34.31
Total force (N)	=	336.58 (Weight (kg) x 9.81 = N)
Diameter of steel rod (mm)	=	8
Cross-section area (mm^2)	=	38.63
Stress (N/mm^2)	=	$\frac{F}{A}$ where F = force in Newton, where A = area of rod cross section
	=	8.71N/mm^2

Since the stress is less than 10N/mm^2 as set in the table above, an 8mm diameter rod is the minimum permissible for the duct of cross section 1000mm x 1000mm x 1220mm length constructed with a single layer of 12mm PROMATECT®-H. If cladding a steel duct, the weight of this has to be included within the total weight supported upon the hangers.

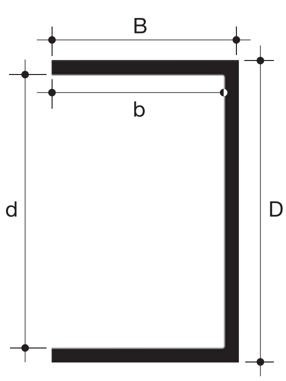
If these stress levels are exceeded then the size of the hanger members must be increased, or the centres of the hangers reduced or the hangers protected. The penetration of the hanger fixings into any concrete soffit should be a minimum of 40mm for up to 120 minutes ratings or 60mm for more than 120 and up to 240 minutes ratings.

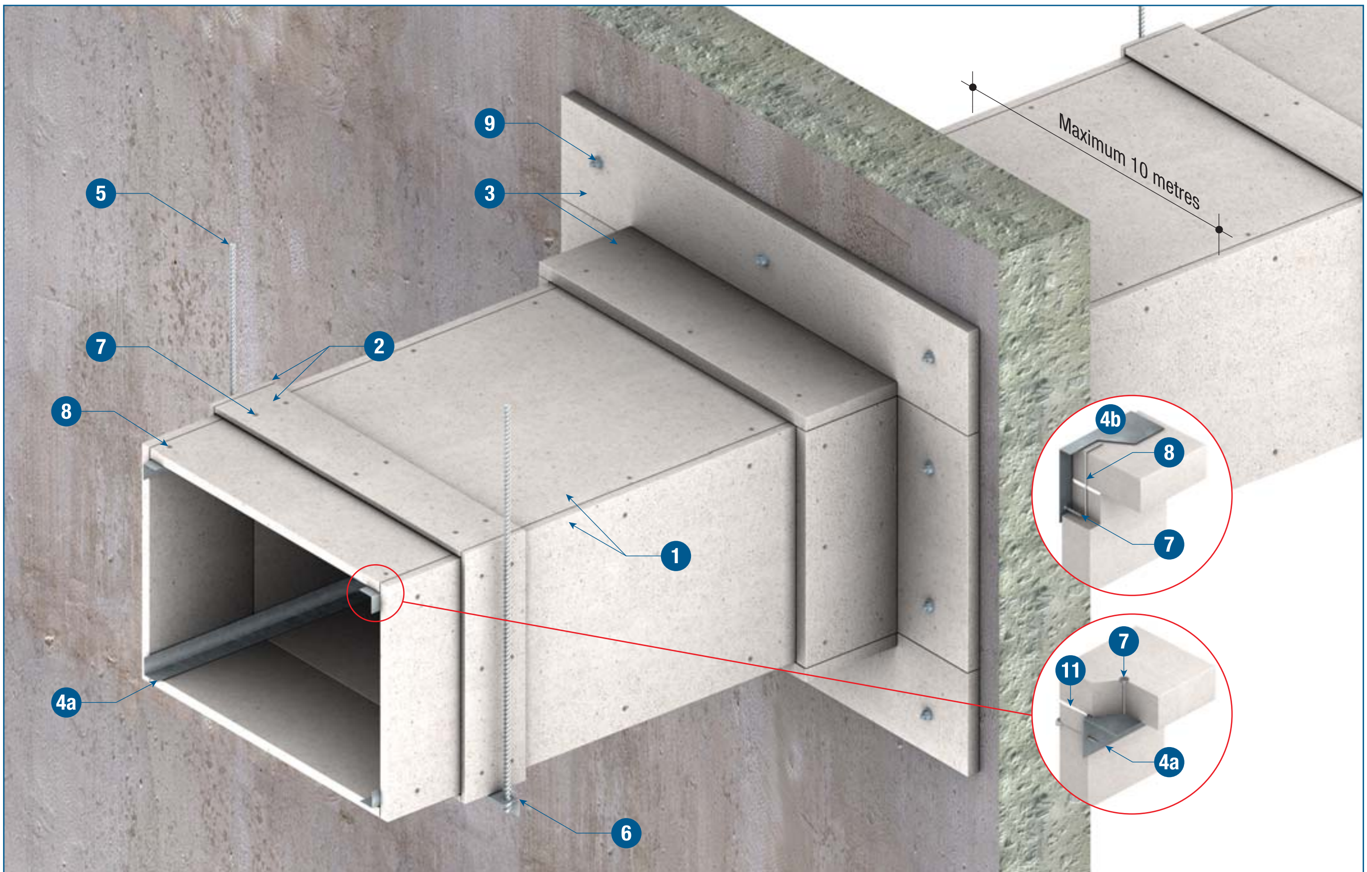
To calculate the stress of the horizontal supporting angle of channel, the following would apply.

Board thickness (mm)	=	12
Duct height (m)	=	1.0
Duct width (m)	=	1.0
Centres of hangers (m)	=	1.22
Area of boards	=	(Width x 2) + (Height x 2) x Centres of hangers
Weight of boards	=	Area x Thickness x Density (975kg/m^3)
Weight of angles	=	(Centres of hangers x 4) + (Width x 4) + (Height x 4) x 0.63kg/m
Section weight (kg)	=	68.62 (inclusive of angles)
Total force (N)	=	673 (Weight (kg) x 9.81 = N)
Maximum bending Moment, M	=	$\frac{W \times L^2}{8} = 101.79$
Stress, S	=	$\frac{M}{Z} < 19.5$ where Z is the section modulus in cm^3
Section modulus, Z	=	$> \frac{M}{19.5}$
Z	=	> 4.7cm^3

Using C-channels of uniform thickness in web and flanges, the dimensions of channel:

Breath of channel (cm)	=	3
Depth of channel (cm)	=	5
Thickness of channel (cm)	=	0.4
Section modulus	=	$\frac{BxD^2}{6} - \frac{bxd^2}{6}$
	=	4.9cm^3





TECHNICAL DATA

1. 1 layer of PROMATECT®-H or PROMATECT®-L board, see page 2 for details.

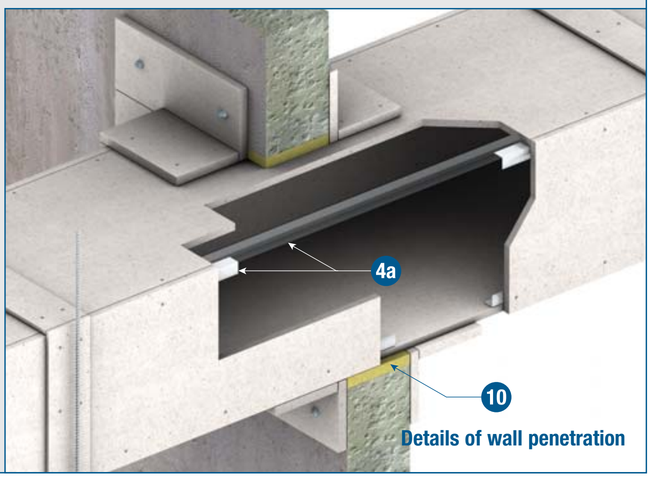
For FRL of 120/120/-	12mm thick PROMATECT®-H or 25mm thick PROMATECT®-L
For FRL of 180/180/90	20mm thick PROMATECT®-H (Duct type A)
For FRL of 240/240/-	25mm thick PROMATECT®-L
For FRL of 240/240/30	20mm (Duct type B) or 25mm thick PROMATECT®-H
For FRL of 120/120/120	15mm thick PROMATECT®-H with 1 layer of mineral wool 100mm x 140kg/m³ clad externally (not shown above)
For FRL of 240/240/240	25mm thick PROMATECT®-H with 1 layer of mineral wool 100mm x 140kg/m³ clad externally (not shown above)

2. 1 layer of PROMATECT®-H cover strips, 100mm wide x board thickness according to the desired FRL.
3. 1 layer of PROMATECT®-H collars, 150mm wide x board thickness according to the desired FRL, fitted around the duct on both sides on the wall forming an L-shape.

4a. Steel angles 30mm x 30mm x 0.6mm thick or

4b. Steel angles 40mm x 20mm x 0.6mm thick

5. Duct hanger system, stress calculation according to page 5.
6. Steel angles minimum 30mm x 30mm x 3mm thick according to duct weight and size and maximum permitted stress levels
7. No.8 self-tapping screws at nominal 200mm centres or steel wire staples at nominal 150mm centres
8. Staple boards face to edge using steel wire staples 63/10/2mm at nominal 150mm (for boards 15mm or greater thickness)
9. M6 anchor bolts at nominal 600mm centres
10. 1 layer of mineral wool tightly packed into aperture between substrate and the surface of the self-supporting duct
11. PROMASEAL® AN Acrylic Sealant at all board joints



Details of wall penetration

Self-supporting ducts provide an economical and fire safe method of constructing natural and mechanical smoke extract and ventilation ductwork without a steel lining. Lengths of the system can be prefabricated off-site or constructed on site using the applicable board type. This ensures that time spent on site is kept to a minimum, with little or no disruption to other trades.

For selection of board thickness, it will not only depend on the required fire performance but also on the internal cross section of the duct and the operating pressure(s). With large ducts and medium to high operating pressures, internal stiffeners may be required.

The above construction of self-supporting fire resistant encasements around is up to 10m wide in accordance with the criteria of BS476: Part 24 and AS1530: Part 4, exposed to external and internal fire. Please consult Promat Technical Department for duct width over 12m.

For impact resistant systems in accordance with the criteria BS5669: Part 1 exposed to external and internal fire, 20mm or 25mm thick PROMATECT®-H boards are required. Insulation will be as Duct type B (exposed to internal fire).

For latest information of the Promat Asia Pacific organisation, please refer to www.promat-ap.com

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