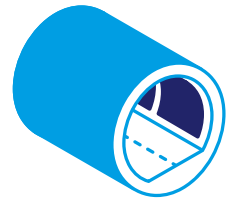


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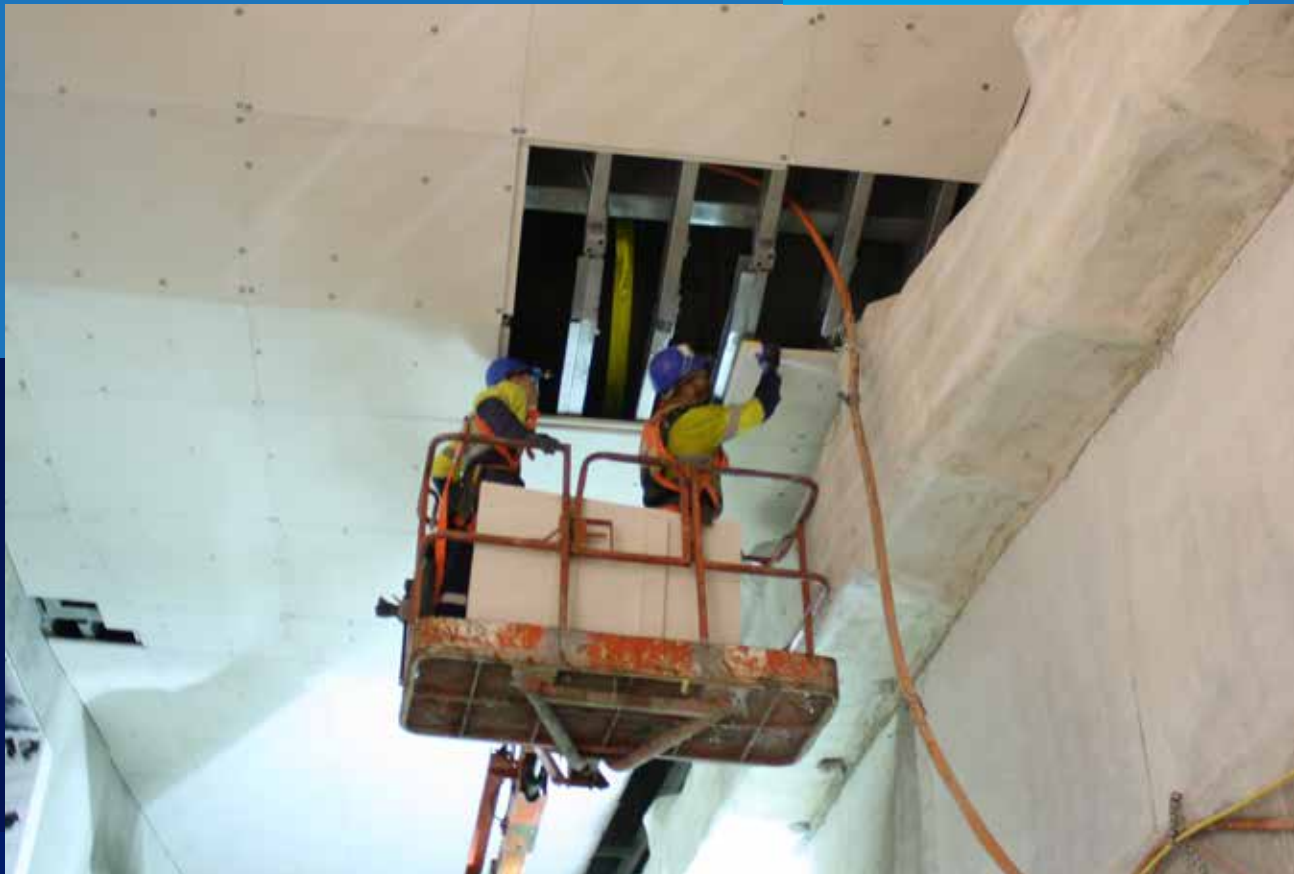


Tunnel

**Installation & Quality Audit Manual
for The Installation of**

PROMATECT[®] Boards **as a post cladding system**

Thermal Lining to Tunnel Concrete



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of living

Installation & Quality Audit Manual for the installation of PROMATECT® boards as a post cladding system (thermal lining to tunnel concrete)

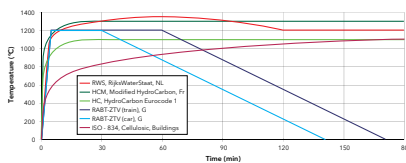
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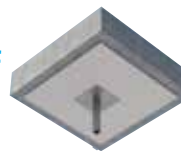
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Tunnel & underground structure fire protection introduction

The concrete cover for the steel reinforcement in a concrete tunnel lining provides structural fire protection for a certain length of time. Various reactions both physical and chemical take place in the concrete element as it heats up in a fire. It is the resultant pressure of such reactions that causes concrete spalling. Spalling of the concrete cover can have immediate and devastating effects on the reinforcement and the structural integrity of tunnels both during a fire condition and after (with regards to durability of the structure).

The loss of structural capacity due to thermal spalling in concrete tunnels exposes a string of life safety and property damage consequences. From structural collapse, inhibiting and endangering escape & rescue efforts, cost for structural remedial and repair works to the economic cost of any temporary or permanent closure of tunnel, are some of the consequences.

Installing a thermal insulating layer to prevent the concrete spalling in the form of PROMATECT® boards is one of the options that has a tested and proven track record for tunnels.

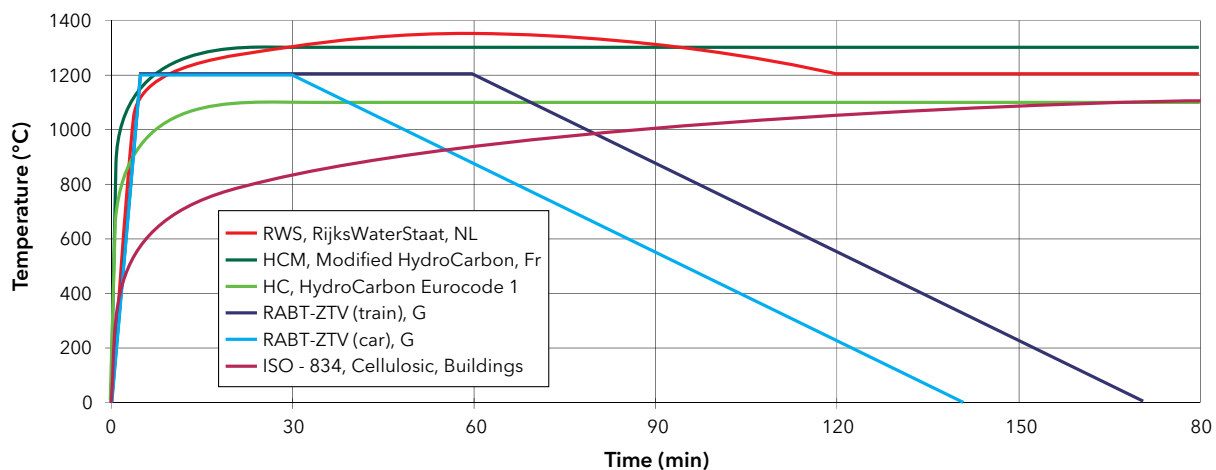
Tunnel Fire Curves

Figures above shows various internationally recognized time temperature fire curves that have been developed simulating tunnel fires. It also shows melting points of various materials.

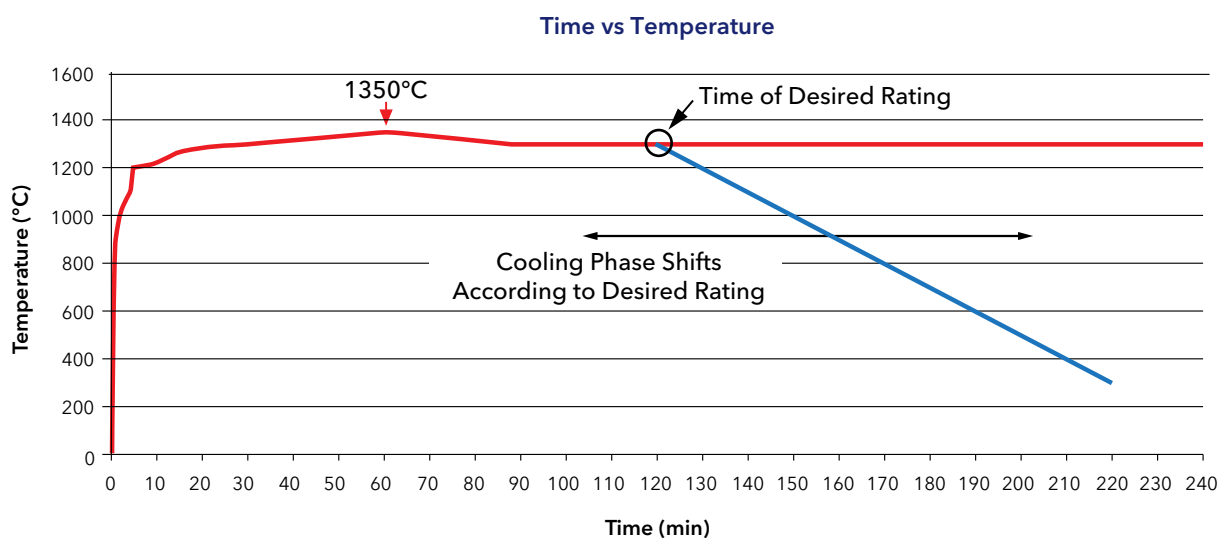
Over many years, a great deal of research has been undertaken internationally to ascertain the types of fire which can occur in tunnels and underground spaces. This research has taken place in both real tunnels, and under laboratory conditions. Because of the data obtained from these tests, a series of time/temperature curves for the various exposures have been developed and are detailed in. Whilst research in tunnel fire phenomena continues, it should be noted that existing data indices show that the severity of fires within tunnels is higher than would be experienced in open air

conditions as well as normal buildings. By comparing heat release rate (HRR) data (understood by many to be a good measure of fire severity) from tests carried out on different vehicle types, wooden crib fires, fuel oil tray experiments etc and comparing the results from tests within tunnels to those with the same tests carried out in the open air, the conclusion is that a tunnel can increase the HRR for a given fire load by up to four times. Further experimentation shows that the increase will vary with the ratio of the fire width to the tunnel width in a cubic manner.

The methods of ventilating a tunnel can also have a marked effect on the HRR of the burning items and should be factored into any proposals when designing the type and period of fire protection being specified.



Tunnel Time Temperature Curves



ASTM E3134: Alternative curve or "MOAC" (Mother-of-all-curve), combining RWS, UL 1709, German RABT, French Hydrocarbon

Promat thermal lining systems

Lost Formwork Method



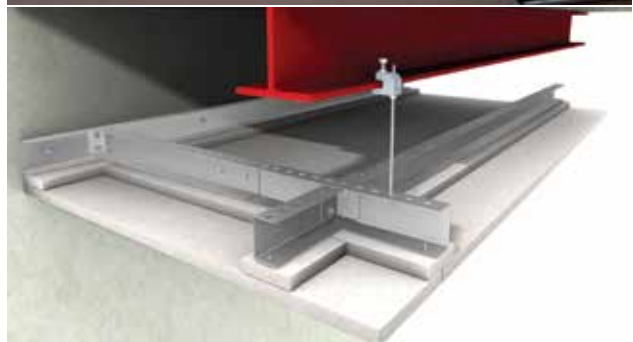
Post Cladding Method



Faceted Lining Method



Suspended ceiling Method



PROMATECT® Product Information

PROMATECT®-H RWS/HCM

PROMATECT®-H RWS/HCM is a calcium silicate-based fire-resistant board used for many applications where high levels of fire protection are required.

PROMATECT®-H RWS/HCM board is off-white in colour. The front face is smooth and is suitable for any forms of architectural/finishing treatment; the reverse face is sanded.

PROMATECT®-H RWS/HCM board is resistant to effects of moisture and will not physically deteriorate in a damp or humid environment. Whilst its performance characteristics are not degraded by moisture or aging under normal tunnel operating conditions, PROMATECT®-H RWS/HCM board is not designed for application in areas subject to continual damp or high temperatures.

PROMATECT®-H RWS/HCM is suitable for post cladding, faceted lining - cable ducts, electrical pit covers, suspended ceilings, diaphragm walls, however, not suitable for curving to a circular tunnel shape.

Physical properties are found in the Appendices.

PROMATECT®-T

PROMATECT®-T board is off-white in colour. The front face is smooth and is suitable for any forms of architectural/finishing treatment; the reverse face is sanded.

PROMATECT®-T board is resistant to effects of moisture and will not physically deteriorate in a damp or humid environment. Whilst its performance characteristics are not degraded by moisture or aging under normal tunnel operating conditions, PROMATECT®-T board is not designed for application in areas subject to continual damp or high temperatures.

PROMATECT®-T is suitable for post cladding cable ducts, electrical pit covers, suspended ceilings, diaphragm walls and faceted lining - it is also suitable to follow the curve of the tunnel, please see matrix with diameter to thickness ratio in appendices

Physical properties are found in the Appendices.

PROMATECT®-TFX

PROMATECT® TF-X is the latest addition to the PROMATECT® family of high- performance tunnel boards. This new generation of board is produced using FiBeCop™ technology, a new and exclusive manufacturing process that allows production of mono-lithic homogenous Calcium Silicate boards with thickness up to 40mm. FiBeCop™ produced boards can guarantee stable performance under the most extreme conditions and in most cases only require single layer.

installation where previously double layers would have been applicable.

This leads to a series of time and cost saving benefits.

Designed to provide fire protection solutions for use within the most severe fire scenarios including RWS and the latest M.O.A.C Time/ Temperature Curve.

Fire protection requirements are often defined in the owner operator's performance specification or local standards for example: NFPA502.

PROMATECT®-TFX is suitable for post cladding, cable ducts, electrical pit covers, suspended ceilings, diaphragm walls and faceted lining - not suitable for curving to a circular tunnel.

Physical properties and product data are found in the Appendices.

Quality assurance

All Promat products are manufactured to stringent quality control systems to assure that our customers receive materials made to the highest standards. Operating to these standards means that all activities which have a bearing on quality, are set out in written procedures.

Systematic and thorough checks are made on all materials and their usage. Test equipment is subjected to regular checks and is referred back to national standards.

The information given in this manual is based on actual tests and is believed to be typical of the product. No guarantee of results is implied however, since conditions of use are beyond our control.

The PROMATECT® Post cladding system

The PROMATECT® tunnel fire protection lining system for post fixing deals with the following subsections and note that all three PROMATECT® boards are suitable to use for post cladding onto concrete or a steel subframe.

PROMATECT® Coating Information

The PROMATECT® board systems provide the requisite fire performance without any coating. Should the contract require the surface of the fire protection panels to be painted this is easily achieved with a wide variety of paints and coating including Acrylic, solvent and epoxy-based coating. For specific details please contact your Regional Tunnel Manager in conjunction with the local paint manufacturer.

Thermal lining Schedule

A module for installation of the PROMATECT® panels is developed based on the following:

- the survey plans of the tunnel as provided by the Main Contractor.
- the route, layout and fixing configurations of electrical and mechanical systems within the tunnel.

Electrical and mechanical systems

The electrical and mechanical systems may include the following:

- Ventilation
- Fixed Fire Fighting Systems (FFFS)
- Linear heat detectors
- Tunnel lighting
- VMS
- Comms LCX cable
- CCTV

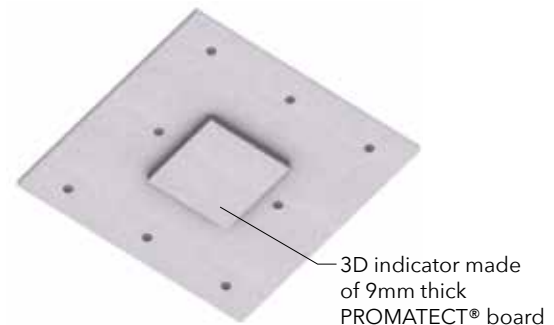
Installation sequence

The installation of the PROMATECT® panels shall be before the installation works of the electrical and mechanical systems.

Panels for water seepage Inspection

- High frequency water seepage inspection locations may be required to be pre-determined. Possibly grout tube locations, construction joints and movement joints might be classified as such locations.

- To facilitate identification of these locations after completion of PROMATECT® installation, a 3D indicator is prefixed to every Active panel that falls within these locations. See Figure below of the 3D indicator.



- Typical panel installation at a high frequency water seepage inspection location.

Site Preparation

- Concrete substrate preparation
- With the exception of cast in supports for axial fans, no electrical and mechanical systems installations (including supports and brackets) shall be installed prior to the installation of the PROMATECT® boards.
- Prior to the installation of the fire protection boards, the main contractor shall handover the tunnel for its installation having the following preparation in place
- Tests to ascertain the verticality of the walls (if required)
- Carry out concrete integrity tests - inspected and certified free of major crack lines, honeycombs or water seepage or other encumbrances
- Concrete level and concrete surface - made flat and smooth within the flatness tolerances in accordance with the Authority's Design Criteria, Materials and Workmanship Specifications"
- Any large holes or gaps shall be filled or repaired such that the panels are fixed to the surfaces as close as possible
- Concrete surface shall be made free of dirt and debris
- [Installation Procedure Flow Chart](#) on page 15 provides recommendation for PROMATECT® board installation where the flatness tolerance as specified above is not entirely met with

On-Site Storage and Handling

All Promat boards are supplied with a protective plastic sheet wrap. This protection should not be removed until the boards are ready for use. In general, the following steps should be taken to ensure that the boards remain in good condition during storage.

- All Promat pallets should be stored on covered and dry level ground, away from the working area or mechanical plant.
- Pallets should be stored safely on firm level ground. If two or more pallets are stacked, the following guidance as well as local legislation and regulations must be observed. The number of pallets per stack is mainly determined by site conditions such as ground conditions, flatness and load capacity of the ground. Maximum number of pallets stacked one above the other under warehouse conditions: All boards must be protected from inclement weather. Cover protection is essential for stacked boards.
- All boards must be stored under cover. Complete protection for stacked and covered boards in storage. Ensure that the immediate area is not used for the storage of materials such as steel, concrete, piping or bulk materials so as to avoid a situation where the transporting of such bulk materials pose a risk of damage to the PROMATECT® panels.
- Only unpack the panels when ready for installation. Any leftover boards removed from the pallets shall be well protected. While the PROMATECT® panels are water tolerant and essentially unaffected by water, the material is water permeable and can be soaked. The PROMATECT® panels shall always be sheltered from external elements. Should any be wet, the panels shall be allowed to dry out prior to installation.

Loading and unloading boards

Promat boards are supplied on pallets suitable for unloading by forklift. If off-loading by crane and slings is envisaged, care should be taken to avoid damaging the edges of the boards. All pallets and crates can be safely handled by using a forklift or hoisting equipment and straps. Steel cables or chains should not be used as they will damage both the pallet and the boards.

Where crates are removed from a box container, care should be taken not to subject crates and pallets to any impact shock, as this could result in cracking of the boards.

Always drive the delivery vehicle as close as possible to where the boards are to be used. When transporting the boards, it is essential to secure the pallets to prevent sliding. If the boards are subsequently moved around the site, they should be placed on a rigid base suitable

for lifting by forklift. Promat boards should always be stored on a rigid base.

Handling

The following recommendations must always be taken into account when handling all Promat boards:

- Wherever possible, always lift boards from the stack rather than slide board on board. This will prevent damage or scratches occurring to the face of the lower boards.



- Always carry the boards on edge but do not store on edge. Board carriers with wheels as shown below will make this process much simpler



Components, Tools & Accessories

- PROMATECT® boards
- 6mm impact anchors with 30mm diameter washers. If fixing to steel framing, drill tipped, hexhead screws to be used
- PROMATECT® T compound
- Anchor marking templates
- Masonry Drill bit - 6mm
- HSS drill bit - 7mm
- Heavy duty impact hammer drill
- Panel lifting device
- Hammer or pneumatic hammer
- Diamond or widia tip blade circular saw
- Vacuum exhaust accessory for high speed saw
- Approved Scaffolding or elevated working platform
- Permanent site marker / carpenters' pencil



Post clad tunnel installation with PROMATECT® boards

Flat surfaces

It is possible that the concrete to which the PROMATECT® boards is being fixed would not be completely flat. Care needs to be taken when fixing the boards to ensure the removal of any large nibs of concrete. In addition, the bolts fixing the boards should be carefully tightened to avoid overturning and cracking of the boards where positioned on uneven surfaces.

Bolts should be installed a minimum of 100mm from edges of the boards and should not be located directly in the corners of the boards. Bolts should be offset to avoid cracking or breakage at the corners.

Bolts used in the installation of PROMATECT® boards should be used in conjunction with washers of a minimum of 20mm diameter, or should have their own integral washer, to prevent the heads of the bolts being driven into the surface of the boards. These washers should be manufactured of the same material type as the bolts to ensure that corrosion does not occur.

Gaps

Care must be exercised to ensure that the butt joints between boards are as close as possible. Visually judged gaps of 1mm to 3mm are acceptable. Gaps shall not exceed 3mm. Where gaps cannot be kept within the maximum due to site discrepancies, a proprietary tunnel joint compound should be used where necessary to make good any minor joint misalignment up to 10mm. PROMATECT®-T Compound TDS is in Appendices

Application of framed sections

PROMATECT® boards do not necessarily need to be fixed directly to the concrete soffit of the tunnel. It is feasible for some fire resistance performance requirements to use steel framing members. It should be noted that although the performance of galvanised steel sections is adequate under fire conditions, the aggressive environment encountered within tunnels suggests that the use of stainless-steel framing members is preferable. Both figures here show the PROMATECT® boards fixed either directly to the soffit or onto top hat sections. The dimensions of the steel sections and the centres of positioning are dependent on a number of factors, e.g. the fire resistance performance, the installation span, the board thickness, the type of concrete etc. Figures below show board lining through flat tunnel concrete slab, PROMATECT®-T boards can be supplied as flat sheets and can be curved on site. Care should be taken to ensure that the PROMATECT®-T board thickness is commensurate with the diameter of the tunnel lining. If the diameter is too tight, refer to page 26, it may be necessary to install in a double layer of thinner boards rather than one single board thickness. Please consult Promat for further details.





Minimum requirements for fixing anchors:

- M6 in diameter.
- Made of stainless steel of 316 grade or higher.
- Minimum 30mm anchor depth penetration into the concrete.
- Expansion action of the anchorage shall be within the concrete, not within the PROMATECT® boards.
- Can be supplied with a nut and washer head to facilitate removal of the PROMATECT® boards when required.
- Suitable for use in tension zone of concrete, e.g. cracked concrete etc.
- Suitable for use where anchors will be subject to positive and negative pressure fluctuation, e.g. dynamic loads
- The proposed anchors that meets the above criteria is a stainless-steel impact anchor. Some examples of anchor manufacturers previously used include Fischer, Wurth, Hilti, Kunkel, MKT, Heco and Powers, among others. See some examples below. Note, all anchors will need a 30mm diameter washer to ensure the head does not impact on the board.



Thickness and dimension audit

Prior to processing the PROMATECT® boards for installation, a random check of the thickness and dimensions of the board shall be made. A random selection plan of one panel per ten pallets of boards shall be selected for checking.

- Thickness check
 - Verify panel thickness in accordance with the tolerances in the technical data sheet
 - Equipment: Vernier Gauge or other appropriate measuring device.
- Dimension and squareness check of regular panels
 - Verification in accordance with the tolerances in the technical data sheet
 - Equipment - good condition tape measure
- A sample of the audit check record is in Appendices.
- Boards found to be non-conforming shall be reported to the supplier for further investigation and instructions.

Board preparation

Wherever possible, PROMATECT® boards shall be processed and made ready for installation when delivered to installation site proper. The preparation works shall be carried out in a suitably equipped workshop either at an off-site location or as the site conditions permits, at an on-site location. However, provision for remedial work shall be made available at the installation site proper should there be necessity to make dimension and edges changes. The board preparation works include the following:

Cutting PROMATECT® panels

A few general rules that should be observed when working with boards:

- For workshop cutting and to extend the cutting life of tools, working with diamond tipped saws is recommended.
- Experience shows that tools with Tungsten Carbide teeth (TCT) provide a more than adequate cut for on-site activities.
- High speed electric tools generate very fine dust. Inhaling fine dust can be harmful to health. Thus, dust extraction equipment is necessary, as the alternative technology of wet cutting cannot be recommended. Although Promat boards contain no harmful fibres, inhalation of excessive nuisance dust can be detrimental to health. It is also recommended that when cutting or processing any Promat products, appropriate face masks and personal protection equipment (PPE) should be worn.
- Refer to safety data sheet for further detail.

Static Circular Saws

Industrial machines are used for continuous cutting over long periods of time, for large quantities and for improved efficiency.

We recommend the use of diamond based tipped blades for the cutting of Promat boards. There are many suppliers of professional sawing machines, your Promat partner will support you in making the right decision of equipment.

Recommendations for the cutting blades:

- Diameter of the blade 300 - 400 mm depending on the tool
- Speed approximately 500 - 1000 rpm
- Number of teeth: 36 - 56 per blade



Cutting with hand circular saws

The use of a Tungsten Carbide-tipped saw blade is recommended. The cutting is carried out in a dry state so dust extraction is essential. The Tungsten Carbide teeth of the saw have a shorter life span than diamond tipped blades but they can be sharpened by a skilled professional. The riving knife adjustment and fixing must be checked and if necessary adjusted. Set the intended depth of cut, the saw blade protruding some 15 mm below the material - an optimal setting guarantees long life of the circular sawing blade.

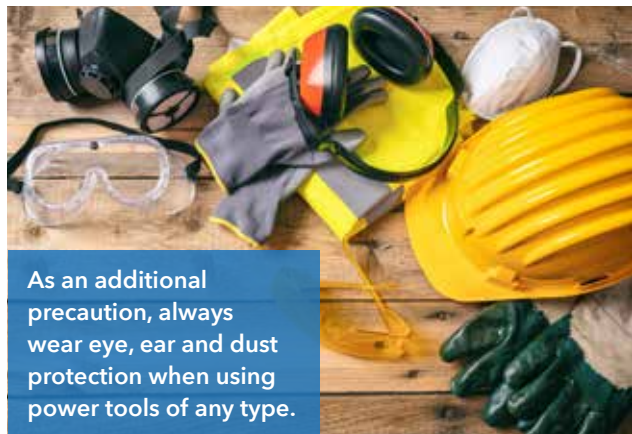
Recommendations for cutting tool:

- Diameter of the blade 180 mm but depending on the tool
- Speed approximately 3000 rpm
- Number of teeth: 36 - 56 per blade
- Feed speed: the saw is to be pushed evenly without stopping and without forcing the saw forward.



On-site machines

Sawing machines work best with a Tungsten Carbide tipped saw blade and mounted to move over a fixed working table, is a typical machine for occasional use on site and produces very good results. FESTO is a good example of the type of equipment used (see pic below) Dust extraction is recommended for use while cutting, especially when using power saws.



As an additional precaution, always wear eye, ear and dust protection when using power tools of any type.

While working with power saws, the following important points should be observed:

- Ensure that the boards to be cut are continuously and well supported on either side of the cut;
- A straight edge should be clamped in position to guide the cutting operation;
- Care must be taken to ensure the tool remains against the straight edge during the cutting operation;
- The cutting rate should be such that the blade is not labouring or over heating. Feed speed for calcium silicate boards is slower than for timber if you wish to prolong the life of the blade and achieve a good cut.

Promat

Jigsaw

This tool is applicable for panels up to 25 mm thick. Panels can be easily cut with a jigsaw to form various shapes. Blades with special hardened teeth are available for cutting Promat boards. As with all power tools, care should be taken to cut within the capacity of the tool and blade. Do not force the cutting speed.



Rasp / Surform

A rasp or surform can be used for edge finishing where necessary in order to trim away rough cutting. For optimum edge finishing, dress the edges with sand paper.



Drilling

Drilling can be carried out either by any conventional power or battery drill with or without dust extraction. For best results the boards should be firmly supported behind the location of the holes. Generally when working with Promat boards the use of drills with point angles of 60° to 80° rather than the more usual 120° type, are preferable and more efficient.



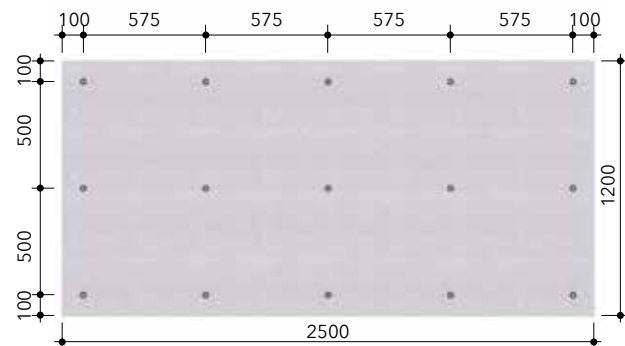
Promat strongly recommend an underlying support to avoid break out as the drill passes through the back face of the board.

Drilling into concrete will require the use of a hammer drill.

Templates

Suitably prepared templates shall be used to mark anchor positions on PROMATECT® panels. The

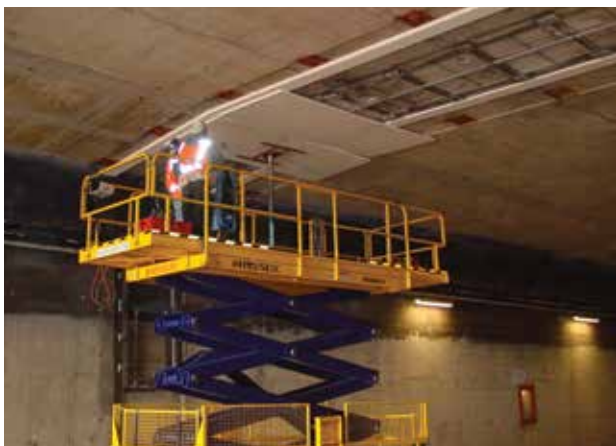
positions of holes for various PROMATECT® panels are predetermined according to the anchor layout plan. Figure 5 below shows the standard anchor layout for the panels used in the general soffit protection. PROMATECT® panels prepared in this way shall serve subsequently as drilling templates for the drilling of holes on the concrete substrate for anchors. We recommend using a 7mm diameter drill bit to predrill the holes in the boards for this purpose (see note below Fig 5) If a situation arises where it is impractical to use pre-drilled PROMATECT® boards, the template used for offsite drilling can be used to facilitate the simultaneous drilling of both the boards and the anchor positions. Thereafter secure the impact anchors as prescribed. Pre-cut or cut on site boards shall be prepared to suit site conditions for boards along the junction with tunnel walls.



Position of holes for anchors on standard panel full size board of 2500mm x 1200mm. the pattern for a half size board 1250mm x 1200mm would be different, please consult Promat for details. Note standard PROMATECT® board can also be supplied in 2440mm x 1220mm. Amend bolt pattern accordingly.

Scaffolding & Elevated Working Platforms (EWP)

All scaffolding and platforms shall be inspected and certified safe for use by a licensed scaffolding safety officer prior to use. Depending on the site there may be a requirement for induction training for EWP.



Marking of Substrate

Identify grout tube, construction and movement joint positions

Upon determining positions of the grout tube, construction and movement joint positions, a marking using red paint shall be made on the soffit, following the entire length of the tube joints. This marking shall facilitate the installation of Active panels with 3D for water seepage inspection. (if applicable)

Marking route of Electrical and mechanical systems

Electrical and mechanical systems contractors shall prepare markings on the concrete soffit indicating the route of their service.

Marking reflected ceiling plan

In accordance with the approved reflected ceiling plan the setting out points of lateral and longitudinal starting lines shall be determined by the main contractor. From hence, ink marking lines may be made on concrete substrate to facilitate actual panel installation for all panels.

Installing PROMATECT® panels

- Mark position of anchor points on PROMATECT® with template and predrill holes with 7mm diameter HSS drill bits. Multiple boards can be drilled at the same time
- Prior to fixing panels where required, select and install the 3D indicator (if required) for panels for the predetermined positions.
- With the smooth face of the PROMATECT® panels facing down, the panels are held in pre-marked positions flat against the substrate with suitable clamp and / or lifting equipment. See Figure below. 3D indicators of panels shall also face down.
- Drill anchor holes through boards prior to installation. Then drill into concrete when installing the boards, ensure adequate drill depth for fixings ensuring to comply with anchor manufacturer best practice
- Whenever required, a rebar detector shall be employed. Ensure hitting of reinforcing bars due to discrepancies in concrete cover is avoided. Anchor positions shall be adjusted to accommodate this situation. Quite often rebars are at a greater depth than the anchor length so not normally a problem. However, at all times, the required panel area to anchor ratio shall be maintained. If holes are drilled that are not used, they should be filled with PROMATECT® T compound. TDS is in Appendix



Clamp and drill into concrete substrate

- Insert anchors into predrilled holes and tap anchor into position until the washers are in tight contact against the PROMATECT® panel surface. If nut and bolt type, tighten nut to a maximum torque of 3Nm. See Figure above
- Visually inspect that the anchors are tight and secure. Any dislodged anchors shall be replaced.
- Care shall be taken not to over drive the anchor and damage the PROMATECT® panel.
- Place next PROMATECT® panel tightly butt against the installed panel and repeat process. Repeat installation of panels according to approved reflected ceiling plan.

- Care shall be exercised to ensure that the butt joints between panels are as close as possible. Visually judged gaps of 1mm to 3mm are acceptable. Gaps shall not exceed 3mm. Where gaps cannot be kept within the maximum due to site discrepancies, PROMATECT® T compound shall be used where necessary to make good the minor joints misalignment. Maximum gap size is 10mm. See Appendix for information on PROMATECT® T compound.
- Where discrepancies in substrate level occur such that the PROMATECT® boards cannot comfortably be laid in a flat manner to the soffit, refer to page 16.
- Irregular sized panels shall be prepared on site to suit certain site conditions such as angles, haunches etc.
- Installation procedure is same for panels at junction with tunnel wall. Figure below is a photograph of installation at the corner location.



Fixing PROMATECT® at junction of soffit & tunnel wall

Fixing ratio

As a rule of thumb:

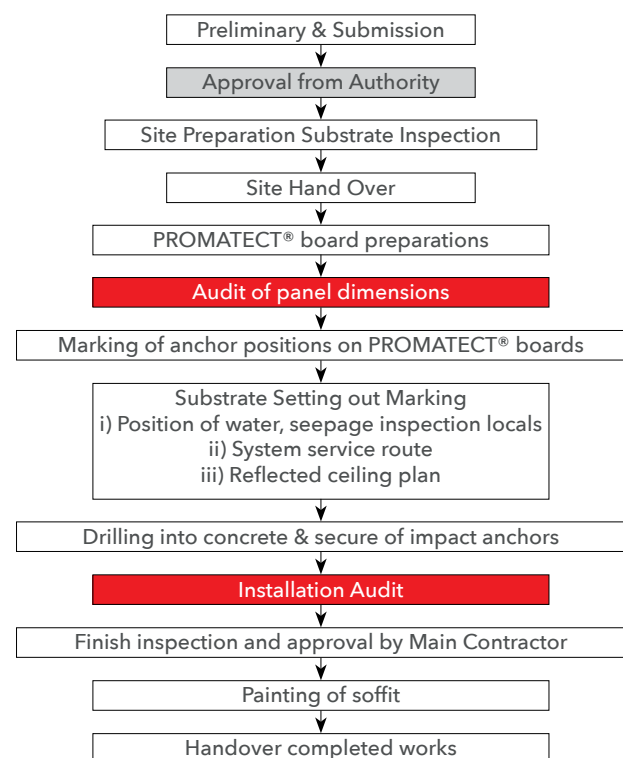
- the ratio of number of anchors to the area of the PROMATECT® panel is 5 per m²
- Anchors shall not be closer than 150mm apart and not closer than 100mm to the board edge

PROMATECT® board installation audit

- An installation audit shall be carried out during the installation of each zone as required by the contract QA for the tunnel
- Visual inspection shall be carried out on a selection of randomly chosen panels. Selected panels shall be identified, and reference recorded on the reflected ceiling plan. The inspection is on the following aspects:
 - All PROMATECT® boards shall be secured with the required number of anchors. Where non-standard panels are installed, the anchor ratio of 5 per m² shall be used to determine the appropriate number of anchors. If found inadequate, the anchor ratio shall be made good.
 - No dislodged anchors - dislodged anchors shall be removed and replaced.
 - Butt joints are kept tight and within the maximum allowable of 3mm. Where butt joints are unavoidable due site constraints, PROMATECT® T tunnel joint compound shall be used to make good the joints. See Appendix 3 for technical information on PROMATECT-T tunnel joint compound.
 - The installation audit shall be recorded in form IPA 01 and a copy shall accompany the handover submission to the main contractor. See Appendix 5 for a copy of Form IPA 01.

See Flow Chart on the right.

Installation Procedure Flow Chart



Process flow chart & audit checkpoints

Minor discrepancies in level of substrate

In general, where minor discrepancies in substrate level occur and the PROMATECT® boards can still comfortably sit in a flat manner; no specific remedial action is needed. Where the levelling discrepancies do not exceed 3mm, it is acceptable to observe a slight kink between two PROMATECT® boards. Figures below illustrate these conditions:



Impact anchors
Minor uneven levelling
PROMATECT®-H boards can still sit flat

Minor uneven levelling



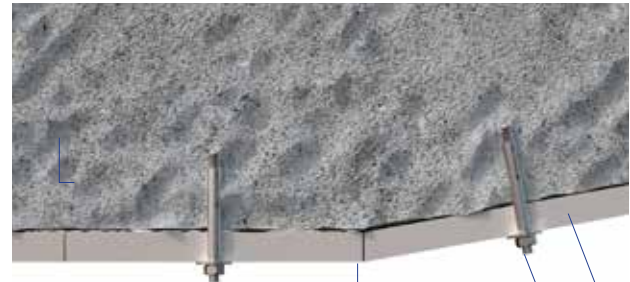
Impact anchors
Slight kink not more than 3mm at butt joint between two Promatect-H panels
PROMATECT®-H boards can still sit flat

Discrepancies not exceeding 3mm

Change in inclination of substrate

Where an inclination occurs in the soffit, a mitred joint shall be introduced. Figure below illustrates the mitred butt joint.

- Introduce a mitred joint where the change in inclination occurs.
- Bevelling shall be prepared to suit the angle of the inclination.
- The rule of thumb (5 anchors per m²) for anchors and positions shall apply.



Predetermined butt joint to be maintained
Introduce spliced joint
Impact anchors
PROMATECT®-H panels

Change in inclination

Interface with installations of Electrical and Mechanical systems

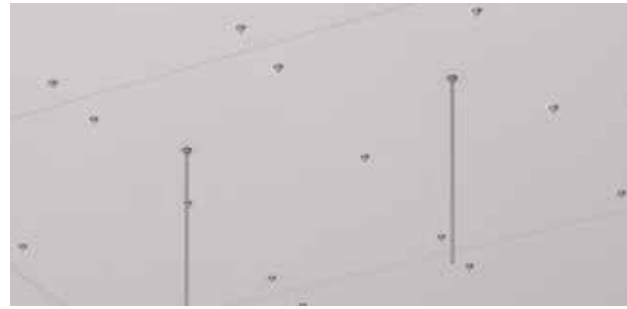
The following information and details of electrical and mechanical systems are to be collated for the development of the ceiling layout:

- dimensions of fixing brackets supporting the service element
- the running route of the service in the tunnel
- the clearance required on both sides of the service
- the position of their fixing elements
- the co-ordination between various electrical and mechanical systems
- Surface mounted fixing

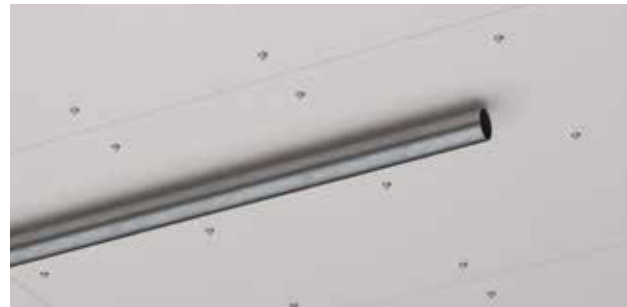
Electrical and mechanical installations will be surface mounted on the pre-determined locations. Figures on the right show typical service installations.

Note: any concrete anchors 6mm diameter or less are automatically acceptable to use. If there is a requirement to use larger diameter anchors it is recommended to install a PROMATECT® collar of the same material for 100mm around the anchor. In some cases, Promat will be able to prepare a finite element analysis to determine quantitatively the thickness required and the distance past the anchor required to reach a predetermined temperature at the interface of the anchor and the concrete. Contact your Promat Regional Tunnel Manager

- Do not fix any form of anchorage on butt joints of PROMATECT® boards
- Ensure the service elements, continuous or discontinuous mounting elements are fixed within the pre-determined panel locations.
- Ensure anchors are not spaced too closely together. Contact your regional tunnel manager for information.
- Holes drilled incorrectly shall be made good by sealing with PROMATECT® T tunnel compound. Where more than 3 holes are incorrectly drilled, fix a cover plate of the same thickness board over the top or replace PROMATECT® panel.



Installation of hanger rods on panel



Installation of continuous service element on panel



Installation of support brackets on panels



Base plates fixture on panels



Local thickening around penetrants

Guide for Retrieval and re-installation of PROMATECT® panels

Where a situation arises where PROMATECT® panels need to be removed, the following instructions serve as a guide for the removal and replacement process:

- Ensure elevated working platform to access location is safe and secure, and certified where necessary.
- Provide support for the panel to be removed
- Unscrew nuts from threaded section of the impact anchor.
- Carefully release PROMATECT® panel from position.
- Where more than one panel is retrieved, ensure the panel identification number is on the back face of the panel and on the concrete soffit, to facilitate re-location of original panel position.
- To reinstall, carefully sleeve the panel through the anchors. Secure nut to threaded shank and tighten to a maximum torque of 3Nm.
- Should a replacement panel be necessary, mark position of anchors and drill holes on panel accordingly.
- Carefully sleeve anchors through pre-drilled holes; secure nut and tighten to maximum torque of 3Nm

On site safety practices

At all times, on site safety practices shall be adhered to strictly during the entire duration of the installation works. Particularly relating to PROMATECT® panels installation, the following serves well for good practice.

Dust extraction equipment shall always be installed and activated during cutting and drilling of PROMATECT® panels.

Protective apparels such as dust masks, gloves, goggles shall always be worn during the cutting and drilling work on the panels.

Notwithstanding the above, the SDS should always be referred to for guidance



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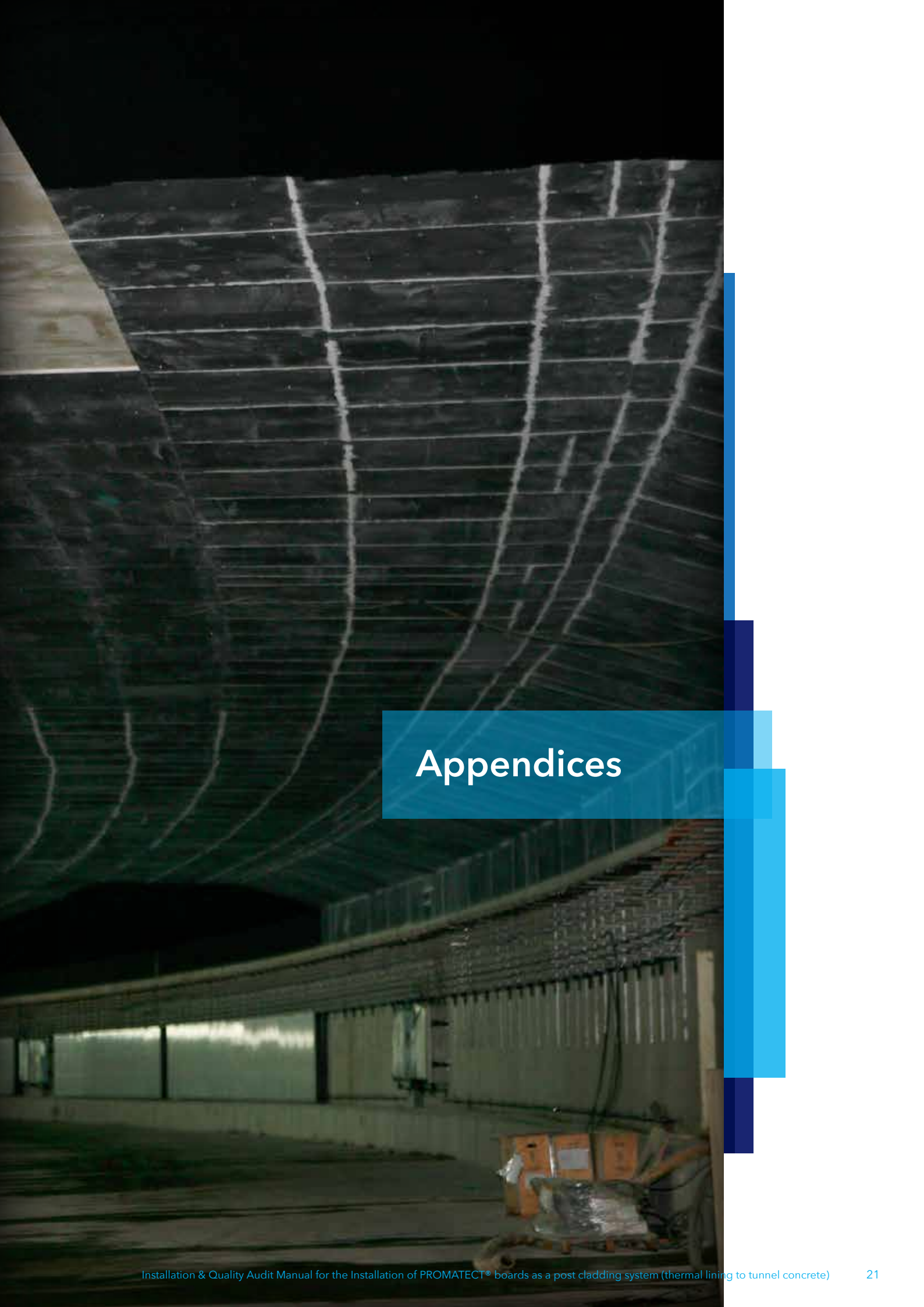
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If further copies of this manual are required, please forward a request in writing to

Etex Building Performance NV
Bormstraat 24
2830 Tisselt
Belgium





Appendices

PROMATECT®-H RWS/HCM

Matrix engineered mineral board



General Description

PROMATECT®-H RWS/HCM board is a matrix engineered mineral board reinforced with selected fibres and fillers. It does not contain formaldehyde or Magnesium Oxy-Chlorides.

PROMATECT®-H RWS/HCM board is off-white. The front face is smooth and is suitable for any forms of architectural/finishing treatment; the reverse face is sanded.

PROMATECT®-H RWS/HCM board is resistant to effects of moisture and will not physically deteriorate in a damp or humid environment. Whilst its performance characteristics are not degraded by moisture or aging under normal tunnel operating conditions, PROMATECT®-H RWS/HCM board is not designed for application in areas subject to continual damp or high temperatures.

Application

- Lining for tunnel structure fire protection
- Cladding to steel ducts, self-supporting ducts
- Cable and services enclosure
- Fire exit door

Material properties

| | |
|--|--|
| Generic description | PROMATECT®-H RWS/HCM matrix engineered mineral board |
| Surface condition | Front face: smooth Back face: sanded |
| Alkalinity | pH 12 |
| Coefficient of expansion | -6.4 x 10 ⁻⁶ m |
| Water diffusion resistance factor, μ | 5 |
| Thickness tolerance | ±0.5mm (standard thickness boards) |
| Dimension tolerance | ±3mm (standard dimension boards) |

Physical performance

| Property | Test method | Test results |
|---------------------------------|--|---|
| Density | BS EN 323 | Dry 105°C: 870kg/m ³ ± 15% 23°C, 50% RH: 940kg/m ³ ± 15% |
| Modulus of elasticity, E | BS EN 310 | Longitudinal 4995N/mm ² Transverse 4389N/mm ² |
| Flexural strength F | BS EN 310 | Longitudinal 10N/mm ² Transverse 6N/mm ² |
| Tensile strength T | BS 5669: Part 1 | Longitudinal 7.14N/mm ² Transverse 4.94N/mm ² |
| Compressive strength | BS 5669: Part 1 | 11.36N/mm ² |
| Combustibility | AS 1530: Part 1 DIN 4102: Part 1 EN 13501-1 (A1) | Non combustible |
| Surface burning | BS 476: Part 7 AS 1530: Part 3 | Class 1 Class 0,0,0,0 |
| Thermal conductivity | ASTM C518 | 0.242W |
| Moisture content | BS EN 322 | 6% |

| Fixing | |
|----------------------------------|--|
| Screw pull out resistance | RAMPA (Type B 3815) screw inserts Screw depth of 15mm on board face: 330N |
| Standard dimension | |
| Thickness | Length x Width |
| 8mm ± 0.5 | 2440mm x 1220mm, 2500mm x 1250mm |
| 10mm ± 0.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 12mm ± 0.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 15mm ± 0.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 18mm ± 0.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 20mm ± 0.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 25mm ± 1.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |
| 27.5mm ± 1.5 | 2440mm x 1220mm, 3000mm or 2500mm x 1250mm |

Disclaimer

PROMATECT®-H RWS-HCM board is used in the higher temperature tunnel fire curves such as RWS and HCM. Where the specification calls for lower temperature fire curves, e.g. RABT, HC and ISO, the board used is standard grade PROMATECT®-H.

Herein are mean values given for information and guidance only. If certain properties are critical for a particular application, it is advisable to consult Promat. PROMATECT®-H RWS-HCM board is manufactured under a quality management system certified in accordance with ISO 9001: 2008. The product has passed the site audit in accordance with the environmental standards of ISO 14001: 2004 and occupational health and safety requirements of OHSAS 18001: 2007.

Health and safety

When machining the PROMATECT®-H RWS-HCM product, airborne dust may be released, which may be hazardous to health. Do not inhale the dust. Avoid contact with skin and eyes. Use dust extraction equipment. Respect regulatory occupational exposure limits for total inhalable and respirable dust. Safety data sheet is available from Promat and, as with any other material, should be read before working with the product.

PROMATECT®-H RWS-HCM product is not classified as a dangerous substance so no special provisions are required regarding the transportation and the disposal of the product to landfill. The product can be placed in on-site rubbish skips with other general building waste which should be disposed by a registered contractor in the appropriate and approved manner.

PROMATECT®-T

Matrix engineered mineral board



Material properties

| | |
|--|---|
| Generic description | Calcium silicate-aluminate fire protective board with outstanding performance for protection of concrete and cast iron tunnels. |
| Surface condition | Front face: smooth, sanded Back face: lightly honeycombed textured Colour: greywhish white |
| Alkalinity | pH 10 |
| Coefficient of expansion α (20 - 100°C) | -8.3×10^{-6} m/mk |
| Water absorption | 0.60g/cm ³ |
| Water diffusion resistance factor, μ | 5 |
| Moisture movement (ambient to saturated) | 0.84mm/m |
| Dimension tolerance | ±0.5mm (standard dimension boards) |

Physical performance

| Property | Test results |
|--|---|
| Density | Nominal 900kg/m ³ |
| Bending strength | Longitudinal 4.5N/mm ² |
| Tensile strength | Longitudinal 1.2N/mm ² |
| Compressive strength (perpendicular to the surface) | 1% deformation: 1.2N/mm ² 10% deformation: 7.8N/mm ² |
| Combustibility EN 13051-1:A1 (Classification Report WFRGent 11536C) | Non combustible A1 |
| Thermal conductivity λ (ASTM C518-75) | 0.212W/m°K (at 20°C) |
| Thermal shrinkage | 1.7% (3 hrs 950°C) 4.0% (3 hrs 1250°C) |
| Typical moisture content (at EMC*) | 5% |

*EMC = Equilibrium moisture content

General Description

PROMATECT®-T is part of a new generation of high performance board products with multiple advantages for the protection of concrete structures and the protection of escape routes, fire doors, cable systems and ventilation systems.

Designed to provide protection solutions for use within the most severe of fire scenarios; as defined by the RWS fire curve; PROMATECT®-T provides not just a barrier to the passage of fire, but in a way that ensures the substrate being protected is kept cool in a controlled manner.

Simple and easy to install, PROMATECT®-T can be applied within existing tunnels without the need to completely close off all traffic lanes.

The engineered matrix of PROMATECT®-T provides a superior performance that allows for a reduction in the required fire protection thickness for equivalent concrete interface temperatures to much thicker competitor products and systems.

Fire protection thickness

Fire protection thickness requirements are often specified in the owner operator's engineering codes of practice. Alternatively, please consult Promat.

Advantages

- Easy to install, the application of PROMATECT®-T can be achieved on existing tunnels without total elimination of the traffic.
- The engineered matrix of PROMATECT®-T allows for reduced fire protection thicknesses (by up to 50%) for equivalent concrete inter-face temperatures.

Application

- Tunnel lining, concrete floor and wall upgrading
- M&E services enclosure
- Access panels and hatches, fire door

Fixing

Screw pull out resistance: screw into board surface quick fix screw - 5.0 x 50 20mm deep airdry: 657N
20mm deep saturated: 372N

Bolt pull through resistance (board thickness = 25mm) Bolt M8, washer diameter 30mm 3.220N

Additional data

Water permeability The standard board is impermeable according to EN 492 (DIN 492). If the board is continuously exposed to water, a special impregnation has been developed to prevent water absorption and the associated increase in board weight. Accidental exposure to water does not affect the characteristics of the board when dried afterwards.

Water absorption 0.6g/cm³

Moisture Movement
Air dry to saturated : 0.84mm/m
Saturated to oven dry : 1.06mm/m
Air dry to oven dry : 0.47mm/m
Oven dry to saturated : 1.19mm/m

Coefficient of Thermal Expansion 20°C to 105°C 8.3 x 10⁻⁶m/mK

Melting point >1,400°C

Abrasion Resistance (taber test - weight loss after 1000 turns) 4,600g/m²

Freeze/Thaw Resistance Using the method for accelerated ageing developed with the STUVA, consisting of 100 cycles of 24 hours per cycle of heat/rain and freeze/thaw, the board does not degrade and retains with its mechanical properties and performance characteristics. A slight flaking of the surface could be possible. If exposed to continuous water soaking and freeze/thaw, Promat recommend the use of impregnated boards. These boards are able to withstand the tests as described in the norm B3303 (designed to testing concrete to freeze/thaw cycles).

| Standard thickness | Standard dimension | Dry Weight | Weight (20°C, 65% RH) |
|--------------------|--------------------|---------------------------|---------------------------|
| 15mm | 2500mm x 1200mm | ca. 14.8kg/m ³ | ca. 15.6kg/m ³ |
| 20mm | 2500mm x 1200mm | ca. 19.8kg/m ³ | ca. 20.8kg/m ³ |
| 25mm | 2500mm x 1200mm | ca. 24.7kg/m ³ | ca. 25.9kg/m ³ |
| 30mm | 2500mm x 1200mm | ca. 29.7kg/m ³ | ca. 31.2kg/m ³ |
| 35mm | 2500mm x 1200mm | ca. 34.6kg/m ³ | ca. 36.4kg/m ³ |
| 40mm | 2500mm x 1200mm | ca. 39.6kg/m ³ | ca. 41.6kg/m ³ |

PROMATECT®-T board is used in the higher temperature tunnel fire curves such as RWS and HCM. Where the specification calls for lower temperature fire curves, e.g. RABT, HC and ISO, the board used is standard grade PROMATECT®-T.

Herein are mean values given for information and guidance only. If certain properties are critical for a particular application, it is advisable to consult Promat. PROMATECT®-T board is manufactured under a quality management system certified in accordance with ISO 9001: 2008. The product has passed the site audit in accordance with the environmental standards of ISO 14001: 2004 and occupational health and safety requirements of OHSAS 18001: 2007.

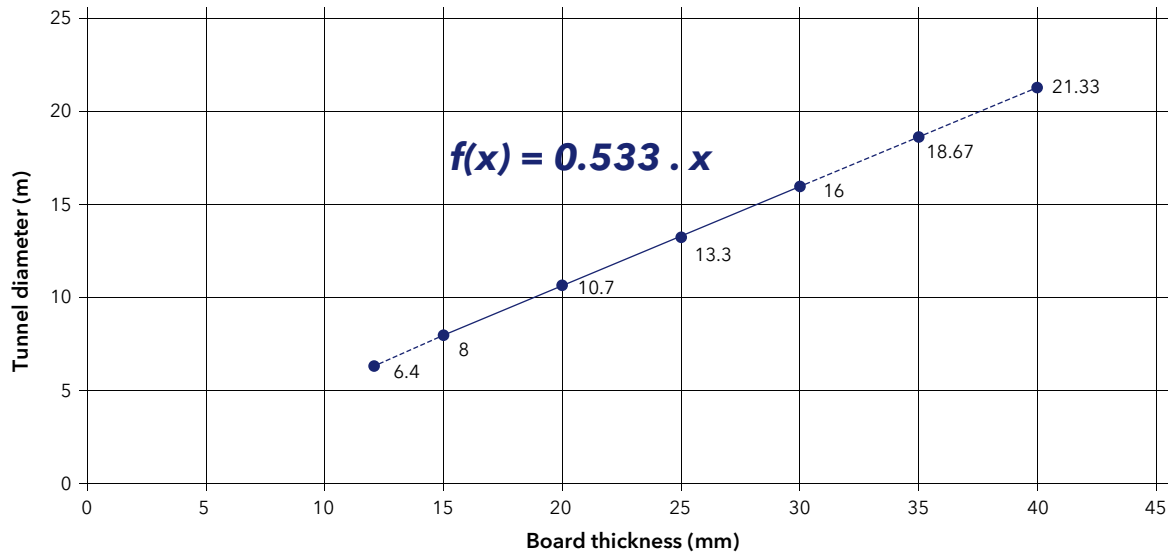
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PROMATECT®-T

Ratio of thickness to tunnel diameter



Thickness PROMATECT®-T vs tunnel diameter

PROMATECT®-TF-X

Matrix engineered mineral board

| Material properties | |
|---|---|
| Generic description | Matrix engineered mineral board for fire protection and high temperature insulation |
| Surface condition | Front and back face: smooth, sanded Colour: off-white |
| Alkalinity | pH 12 |
| Coefficient of expansion α (20 - 100°C) | 7.5×10^{-6} m/mk |
| Thickness tolerance | ± 1.5 mm double sided sanded |
| Dimension tolerance | ± 3.0 mm |
| Physical performance | |
| Property | Test results |
| Density | Nominal 950kg/m ³ $\pm 10\%$ |
| Bending strength | Longitudinal 8.0N/mm ² |
| Compressive strength | 12N/mm ² |
| Combustibility | Non combustible A1 |
| Thermal conductivity λ (ASTM C518-75) | 0.2W/m°C (at 20°C) |
| Thermal shrinkage | 1.6% (3 hrs 950°C) 4.0% (3 hrs 1250°C) |
| Moisture movement (ambient to saturated) | 0.2% |
| Typical moisture content, air dry at 20°C and 65% relative humidity | 5% |
| Water vapor transmission coefficient | 3.5 |
| Freeze thaw resistance | >100 cyc., category A |

| Standard thickness | Standard dimension | Dry Weight | Weight (20°C, 65% RH) |
|--------------------|--------------------|---------------------------|---------------------------|
| 20mm | 2500mm x 1250mm | ca. 19.0kg/m ² | ca. 20.0kg/m ² |
| 25mm | 2500mm x 1250mm | ca. 23.8kg/m ² | ca. 24.9kg/m ² |
| 30mm | 2500mm x 1250mm | ca. 28.5kg/m ² | ca. 29.9kg/m ² |
| 35mm | 2500mm x 1250mm | ca. 33.3kg/m ² | ca. 34.9kg/m ² |
| 40mm | 2500mm x 1250mm | ca. 38.0kg/m ² | ca. 39.9kg/m ² |

PROMATECT®-T compound

| Material properties | |
|----------------------------|--|
| Product description | Dry compound in powder form made from calcium-aluminium silicates and additives |
| Usage | Promatect® T compound is used as joint filler and repair-kits, suitable for the calcium silicate and calcium-aluminium silicate boards |
| Colour | white to off white |
| Mixing procedure | Mixer type: spiral mixer or double spiral mixer Water to solid ratio: 100 part by weight of solid to 70-73 part by weight of water Mixing time: 8-10 minutes |
| Application | The obtained paste can be applied on the desired spaces with a spatula |
| Surface preparation | Humidify the substrate before application. It is important to ensure that the substrate is be free of dust or grease dirt before application |
| Setting Time | Between 2 to 4 hrs at 20°C in open ventilated environment |
| Supply | In dry powder form to be mixed in desire quantities |
| Shelf life | approximately 6 months depending on storage conditions |

Form DAC 01

Fire Protection Enhancement to Tunnel Concrete

PROMATECT® Dimension Audit Checklist

To be checked in accordance with current technical datasheets (in appendices above)

| Pallet identification Batch no of panel | Date of check |
|--|---------------|
| Checklist | Check ✓ |
| 1. Thickness + 0.5mm | |
| 2. Dimension & Squareness | |
| a. Length +/-1.0mm | |
| b. Width +/- 1.0mm | |
| c. Squareness +/- 1.0mm | |

Name of checker: _____ Signature: _____

Name of installation supervisor: _____ Signature: _____

Date: _____

Non-conformance report submission to manufacturer required: Yes / No

Form IPA 01

Fire Protection Enhancement to Tunnel Concrete.

PROMATECT® Board Installation Audit Checklist

| Zone: | Panel reference no | | | | | | | | | | | | | | | | |
|---------------------------------|--------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|
| South / North Bound (select) | | | | | | | | | | | | | | | | | |
| Chainage: | | | | | | | | | | | | | | | | | |
| 1. Panel flatness | | | | | | | | | | | | | | | | | |
| 2. Anchor ratio | | | | | | | | | | | | | | | | | |
| 3. Anchor installation | | | | | | | | | | | | | | | | | |
| 4. Joint size/treatment | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 1. Panel flatness | | | | | | | | | | | | | | | | | |
| 2. Anchor ratio | | | | | | | | | | | | | | | | | |
| 3. Anchor installation | | | | | | | | | | | | | | | | | |
| 4. Joint size/treatment | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| 1. Panel flatness | | | | | | | | | | | | | | | | | |
| 2. Anchor ratio | | | | | | | | | | | | | | | | | |
| 3. Anchor installation | | | | | | | | | | | | | | | | | |
| 4. Joint size/treatment | | | | | | | | | | | | | | | | | |

Name of checker: _____ Signature: _____

Name of installation supervisor: _____ Signature: _____

Non-conformance report submission required: Yes / No



Headquarters – Belgium

Etex Building Performance NV
Bormstraat 24, 2830 Tiselt
T +32 15 718 100
F +32 15 718 109
E info@promat-international.com
info@promat.be

Australia

Promat Australia Pty Ltd
1 Scotland Road
Mile End South, SA 5031
T 1800 Promat (776 628)
F +61 8 8352 1014
E PAPT.mail@etexgroup.com

Austria

Etex Building Performance GmbH
St.-Peter-Straße 25 / Bau 39
4021 Linz/Austria
T +43 732 6912-0
F +43 732 6912 3740
E info.at@etexgroup.com
DVR-Nr.: 4011276

Chile

Promat Chile SA
Camino a Melipilla, Maipú
10803 Santiago
T +56 2 2391 2200
E contacto@promat.cl

China

Promat Shanghai Ltd
No.2, Tai Hua Street,
Yonghe Economic District,
511356 Guangzhou, Guangdong
T +86 20 8136 1167
F +86 20 3222 5275
E info@promat.com.cn

Colombia

Promat Colombia
Av. Kra 19 No. 120-71 Suite 506
110111 Bogotá D.C.
T +57 1 355 3500
F +57 1 355 1785
E info@promat.com.co

Czech Republic

Promat sro
Ckalova 22/784
16000 Praha 6 - Bubenec
T +420 2 2439 0811
F +420 2 3333 3576
E promat@promatpraha.cz

Denmark

Promat Nordic
Kometvej 36, 6230 Rødekro
T +45 7366 1999
F +45 7466 1020
E info@promat.nu

France

Promat SAS
Rue de l'Amandier, B.P. 66
78540 Vernouillet
T +33 1 3979 6160
F +33 1 3971 1660
E info@promat.fr

Germany

Etex Building Performance GmbH
Scheifenkamp 16
40878 Ratingen
T +49 2102 493 0
F +49 2102 493 111
E mail@promat.de

Hong Kong

Promat International (Asia Pacific) Ltd
Room 1010, C.C. Wu Building
302-308 Hennessy Road, Wanchai
T +852 2836 3692
E promat.hk@etexgroup.com

Hungary

Promat Hungary
(Division of Promat doo)
Pirosrozsza u. 32
1163 Budapest
T +36 1 317 5891
E info.hu@promat-see.com

India

Promat Fire & Insulation Pte Ltd
Unit 605, 6th Floor, Tower B
Global Business Park
Mehrauli Gurgaon Road
Sector 26, Gurgaon
122002 Haryana
T +91 12 4434 6865
E promatindia@etexgroup.com

Ireland

Promat Fire Protection
43 Fitzwilliam Square West
Dublin 2
T +353 1 676 5788

Italy

Promat SpA
Via Perlasca 14
27010 Vellezzo Bellini (PV)
T +39 0382 457 51
F +39 0382 926 900
E info@promat.it

Japan

Promat Japan Corporation
Pacific Marks Shinjuku
4-15-7 Nishi-Shinjuku, Shinjuku-Ku
160-0023 Tokyo
T +81 3 3377 2821
F +81 3 3378 2821
E sales@promat.jp

Kazakhstan

Promat Kazakhstan
(Representative office of SEIES Swiss
Eastern Investment Economical
Systems AG)
Prospekt Sheltoksan 37, Office 200a
050004 Almaty
T +41 71 666 6210
F +41 71 666 6211

Malaysia

Promat (Malaysia) Sdn Bhd
Unit 19-02-01, Level 2, Wisma Tune
19 Lorong Dungun, Damansara
Heights
50490 Kuala Lumpur
T +60 3 2095 5111
E promat.my@etexgroup.com

Netherlands

Etex Building Performance B.V.
Vleugelboot 22
3991 CL Houten
T +31 30 241 0770
F +31 30 241 0771
E info@promat.nl

Peru

Promat Peru
Jr. Republica del Ecuador 448
15079 Cercado de Lima
T +51 619 6400
E contacto@promat.pe

Poland

Promat TOP Sp zoo
Przeclawska 8
03-879 Warszawa
T +48 22 212 2280
F +48 22 212 2290
E top@promatop.pl

Singapore

Promat Building System Pte Ltd
10 Science Park Road
#03-14 The Alpha
Singapore Science Park II
117684 Singapore
T +65 6776 7635
E promat.sg@etexgroup.com

Slovenia

Promat doo
Kidričeva 56b
4220 Škofja Loka
T +386 4515 1451
F +386 4515 1450
E info@promat-see.com

South Korea

Promat International (Asia Pacific) Ltd
(Korea Branch Office)
#1104 Dong-a Building
117 Namdaemun-ro, Jung-gu
04522 Seoul
T +82 70 7794 8216
F +82 2 779 5566
E info@promat-ap.com

Spain

Promat Ibérica SA
C/ Velazquez, 41-2, Planta
28001 Madrid
T +34 91 781 1550
F +34 91 575 1597
E info@promat.es

Switzerland

Promat AG
Stationsstrasse 1
8544 Rickenbach - Attikon
T +41 52 320 9400
F +41 52 320 9402
E office@promat.ch

UAE

Promat Fire Protection LLC
Plot no. 597-921
Dubai Investment Park 2
PO Box 123945, Dubai
T +971 4 885 3070
F +971 4 885 3588
E info@promatfp.ae

UK

Etex Building Performance Ltd.
Gordano House
Marsh Lane, Easton-in-Gordano
BS20 ONE Bristol
T +44 800 373 636
F +44 1275 379 037
E marketinguk@promat.co.uk

USA

Promat Inc
1731 Fred Lawson Drive
TN 37801 Maryville
T +1 865 681 0155
F +1 865 681 0016
E sales@promat.us

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