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PGH BRICKS™ TECHNICAL MANUAL

CSR

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1.1

BRICK PROPERTIES

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SECTION 1.1
BRICK PROPERTIES

1.101 INTRODUCTION

In construction, there is a hierarchy of minimum requirements for essential properties, designed to ensure that technical requirements do not provide barriers to new materials, techniques and designs. The New Zealand Building Code (NZBC) provides minimum performance requirements for all structures in New Zealand.

The NZS 4210 Masonry Construction: Materials and Workmanship provides the basic rules for the design and construction of masonry structures to meet the requirements of the NZBC.

All other standards covering the properties of building products such as bricks and blocks are written in such a way as to describe the properties of the materials concerned. They also provide test methods for the determination of those properties and set very low, or no, limits of performance. It is the designer's responsibility to specify the performance level required for the units selected for use in a given project.

In accordance with the general intent of NZS 4210 there are no specific performance requirements apart from some basic product requirements such as strength, dimensional deviations and integrity. If verification of the nominated values is required, it refers to AS/NZS 4456 which details the test methods for the determination of 17 different properties of masonry units and segmental pavers, as well as sampling procedures and the assessment of the mean and standard deviation of test results. Not all the tests described in this standard are rmandatory, NZS 4210 sets out the minimum compliance requirements of bricks, depending on application.

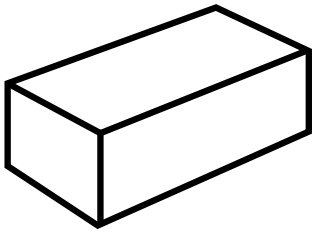
PGH Bricks™ manufactures all clay fired masonry products satisfying the requirements of AS/NZS 4455 – Masonry units, pavers, flags and segment retaining wall units. Products are tested to the Australian and New Zealand Standard AS/NZS 4456 – Masonry Units, Segmental Pavers and flags – Methods of Test. The testing is carried out in our PGH Bricks & Pavers™ NATA accredited laboratory (Accreditation No. 978) located in Schofields, NSW, Australia.

1.102 BRICK RANGES & DIMENSIONS

Extruded Common

Extruded
(Colour Through)

Extruded
(Surface Treated/Coated)



Standard
(230mm x 70mm x 76mm)

Used in all types of brick dwellings and structures. By far the most commonly used size. Can be cut and utilised across a variety of alternate bond patterns including flemish, half bond, stack bond etc.

1.103 BRICK DIMENSIONS

The work size of a brick unit is the manufactured size from which dimensional deviations (or tolerances) are measured in accordance with AS/NZS 4456.3 Determining Dimensions.

A traditional New Zealand clay brick has a work size of 230mm x 70mm x 76mm.

Depending on their deviation from the declared work size and the method by which compliance to a specification is determined (see Figure 01 Measuring cumulative dimensions), masonry units are divided into five categories as outlined in Table 01 Dimensional deviations of masonry units.

Due to the natural variation in the raw materials used, masonry units individual sizes may vary after they are fired, however size variation between units averages out when blended properly during laying.

Figure 01 Measuring Cumulative Dimensions

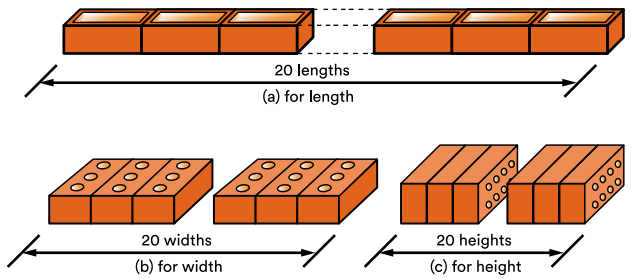


Table 01 Dimensional Deviations of Masonry Units

Category	Work size dimensions, mm		
	Under 150mm (for example, width & height)	150 to 250mm (for example, length)	Over 250mm (for example, length of modular bricks or blocks)
DW0	No requirement		
DW1*	±50	±90	±100
DW2*	±40	±60	±70
DW3	By agreement between supplier and purchaser		
DW4**	Standard deviation of not more than 2mm and the difference between the mean and the work size of not more than 3mm.		

* As determined by the cumulative method over 20 units
** As determined from the individual dimensions of 20 units (Method B of AS/NZ 4456.3)

1.104 WATER ABSORPTION

Cold Water Absorption (CWA)

The amount of water that a brick can absorb is measured by the water absorption test in accordance with AS/NZS 4456.14 Determining Water Absorption Properties.

There is no distinct relationship between water absorption and the water-tightness of walls, however, Cold Water Absorption can affect efflorescence and water penetration. The results of water absorption tests are used by the brick manufacturer for quality assurance.

Initial Rate of Absorption (IRA)

The Initial Rate of Absorption (IRA) is the amount of water absorbed in one minute through the bed face of the brick, which is a function of the units porosity, according to AS/NZS 4456.17 Determining Initial Rate of Absorption (suction).

The bond between the masonry unit and mortar is largely influenced by the capacity of the brick to absorb water and the ability of the mortar to retain the water that is needed for the proper hydration of cement. If the brick sucks the water too quickly from the mortar, the next course may not be properly bedded. If the mortar retains too much water, the units tend to float on the mortar bed, making it difficult to lay plumb walls at a reasonable rate. In either case, there will be a poor bond. Therefore the water retentivity of the mortar needs to be matched to the IRA of the bricks to ensure that a strong bond is formed.

There is no requirement that must be met for IRA, however the optimum range is between 0.5 and 1.5kg/m^{2}min.

In cases where the brick has a very low IRA, proprietary admixtures (in compliance with NZBC) often can be used with the mortar to combat the issues described above.

1.105 DURABILITY

Durability refers to the resistance of a masonry unit to weathering. The most common form of weathering is due to attack from soluble salts (commonly referred to as “Salt Attack”) but can also include other environmental factors including chemicals in the soil. The way in which soluble salts attack porous materials (such as clay units, concrete, mortars and some natural stone) is depending on the environmental conditions and the nature of the product, to which soluble salts can be absorbed into the unit. The salt concentration in the solution gradually increases as the material dries. Crystallisation beginning when the volume of water remaining cannot dissolve all the salts present. Considerable pressure is applied to the walls of the pores during this crystallisation. When this occurs near the surface of the unit, the pressure applied on the pore walls may exceed the tensile strength of the material and fretting will take place.

The main conditions required for salt attack to occur are:

- Presence of salts
- Water ingress
- Drying/Evaporation of the water

Without these conditions, salt attack will not occur.

Bricks must be classified based on their ability to withstand the effects of these environments.

Building sites shall be classified as being in sea spray zone, or zones 1,2,3 or 4 depending on the severity of exposure to wind driven sea salt or to geothermal gases. NZS 4210 shows a corrosion map for zone idenfication.

For areas classified as seaspray zones and geothermal hotspots, it is required to use Exposure grade bricks. For Zone 1 & 4, at least general purpose grade bricks are needed. For other applications, Protected grade bricks can be used.

Bricks are classified by the manufacturer/supplier in accordance with Table 02 Durability Categories.

Table 02 Durability Categories

Grade	Requirement/description
Exposure	(a) Supplier’s experience according to which it is possible to demonstrate that the product has a history of surviving in saline or severe marine environments (b) Less than 0.4 g mass loss over 40 cycles when tested to AS/NZS 4456.10
General Purpose	(a) Supplier’s experience according to which it is possible to demonstrate that the product has a history of surviving under non-saline environmental conditions similar to those existing at the site considered. (b) Less than 0.4g mass loss in 15 cycles when tested to AS/NZS 4456.10.
Protected	Usually units in this grade would suffer substantial and early failure in less than 15 cycles when tested to AS/NZS 4456.10. Normally, suppliers will nominate to units that does not comply with general purpose or exposure grade.

Figure 02 Effects of salt attack on the bricks and mortar

Figure 03 Effects of salt attack on the bricks and mortar

1.106 COMPRESSIVE STRENGTH

The ultimate compressive strength of brickwork (f'_m) is a combination of the strength of the mortar, the characteristic unconfined compressive strength (f'_{uc}) of the bricks, their bond as well as the aspect (height-to-thickness) ratio.

The test method AS/NZS 4456.4 Determining Compressive Strength of Masonry Units, involves subjecting a brick unit to increasing load by compressing it between two (2) metal platens in a compressive testing machine. The test method also requires a correction factor (based on the aspect or height-to-thickness ratio) be applied to test results. The 'unconfined compressive strength' (in MPA) is then calculated.

Characteristic Unconfined Compressive Strength (f'uc)

The determination of the characteristic unconfined compressive strength (f'uc) is statistical based calculation and provides a level of certainty for the compressive strength of the product. This means that there is a 75% certainty that the strength of 95% of the units in the lot is greater than the characteristic unconfined compressive strength.The characteristic unconfined compressive strength (f'uc) is used to determine the ultimate compressive strength of brickwork (f'm), which is used by Engineers in equations to determine the strength of a wall.

Figure 04 Compressive Strength Testing

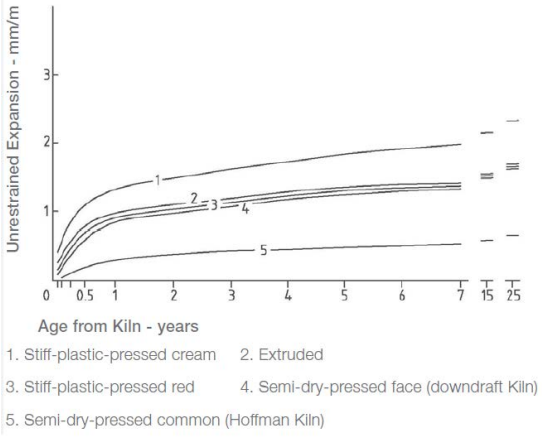
1.107 MOISTURE EXPANSION

Moisture expansion, or brick growth, is a property of all fired clay products (not just masonry) which are subject to reactions that cause them to expand in both horizontal and vertical directions. The amount of long-term permanent change in unit dimensions depends upon the material from which the units are made and how well that material was fired. The reactions begin from the time the masonry exits the kiln and cools, and continues at a reducing rate for the life of the unit.

Expansion over time is not uniform, it is in fact logarithmic, with the majority of the expansion occurring within the first six (6) months. Refer to Figure 05 *Typical expansion rate due to moisture in masonry units.*

For design purposes (size and spacing of expansion joints), the coefficient of expansion (e_m value) is used as a measure of the expected growth (mm/m) over 15 years, and is determined by the method of test given in AS/NZS 4456.11 Determining Coefficients of Expansion.

Figure 05 Typical Expansion Rate Due to Moisture in Masonry Units



Characteristic expansion can be classified as:
Low – up to 0.8mm/m
Med – 0.8 – 1.6mm/m
High – greater than 1.6mm/m
However, it must be remembered that there is no pattern in characteristic expansions based on clay masonry unit colour or manufacturing methods.
Due to variations in the manufacturing process, the characteristic expansion can vary considerably between batches, even within a single masonry type.
For those reasons designers should obtain current expansion data from the manufacturer for the specific unit they propose to use.

Moisture expansion must be considered when designing and constructing a clay masonry structure, in order to locate expansion and articulation joints which in turn reduce cracking in the masonry units and wall.

Control Joints
Control joints are required in clay masonry to relieve the effects of long-term expansion of the units. The detailing of these joints is similar to that for articulation joints.
Control joints must be inserted to absorb expansion, both horizontally and vertically, to avoid damage to the masonry. The problem is well understood, and when the long-term expansion value (em) is known, suitable control joints can be designed.

Corners are particularly prone to damage as the growth occurs in orthogonal directions in the two intersecting walls. For this reason, a control joint should be located at or near a corner if long lengths of brickwork are involved.
Where articulation is required for other reasons, the articulation joints can also be designed as control joints.

Articulation Joints
Articulation joints are used in conjunction with a foundation to control the effects of ground movements. The joints articulate the masonry components of the building into separate elements, which undergo rigid body rotations as the footing deflects, without causing distress in the masonry. The more flexible the footing, or the more susceptible the surface finish is to cracking, the closer the required spacing of the joints will be. Articulation not only limits cracking of walls, but also avoids the potential jamming of windows and doors caused by foundation movement.

1.108 EFFLORESCENCE

Efflorescence is a soluble salt that deposits on the surface of masonry after evaporation of water. These deposits can either be loose crystalline salts or amorphous films. The majority of soluble salts that cause efflorescence come from sources outside the masonry unit such as ground water, sea spray, acidic atmospheric gases, mortar ingredients and other materials in contact with the units.

Generally, efflorescence does not damage the brickwork and can naturally disappear over time, or may be brushed off. Persistent efflorescence may be a sign of water entering the brickwork and if allowed to continue the salts carried to the surface of the brickwork may eventually attack the bricks.

AS/NZS 4456.6 Determining Potential to Effloresce classifies the potential of a masonry unit to effloresce as one of the following five categories as seen in Table 05 - Definitions of Efflorescence.

Table 03 Definitions of Efflorescence

Category	Definition
Nil	No observable efflorescence
Slight	Not more than 10 percent of total external above-water surface covered by a thin deposit of salt
Moderate	More than 10 percent of one external above-water surface but not more than 50 percent of the total external above-water surface covered by a thin deposit of salt
Heavy	A deposit of salt covering more than 50 percent of the total total external above-water surface
Severe	Any efflorescence that is accompanied by powdering and/or flaking of the surface of the specimen

Figure 06 Effects of Efflorescence

1.109 LIME PITTING

If the raw material used for brick-making contains particles of limestone (calcium carbonate) these can be converted to quicklime during firing in the kiln. If the fired unit is exposed to moisture, the quicklime converts to hydrated lime and in this process expands. If lime particles are sufficiently large and sufficiently near the surface they 'pop' off a piece of the brick, leaving a generally circular pit.

Table 06 Pitting due to lime, categories and definitions summarises the requirements of AS/NZS 4456.13 Determining pitting due to lime particles.

Improved production techniques have resulted in the number of cases of lime pitting drastically reducing.

Table 04 Pitting Due to Lime: Categories and Definitions

Category	Definition
Nil	No visible pits
Slight	Up to five pits, none over 8mm diameter
Moderate	No pit over 10mm diameter
Severe	Pits or pits over 10mm diameter

These definitions refer to pits on one face and both ends of a brick or the face of a paver.

Figure 07 Lime Pitting

Figure 08 Lime Pitting

1.110 SOLAR ABSORPTANCE

Solar Absorptance is a measure of how well a material absorbs heat from the sun (the remainder is reflected). Solar Absorptance is based on colour, rather than material used, and is reported as a number from 0 to 1. Light materials have a lower Solar Absorptance and will reflect more heat, while dark materials have a higher Solar Absorptance and will absorb more. Unlike many other materials, clay masonry units absorb and release heat almost equally well.

PGH Bricks™ & Solar Absorptance

PGH Bricks™ manufactures bricks varying from light to dark. Specific solar absorptance information for all bricks is available in product brochures or by request.

Thermal Mass

Thermal mass is the ability of a material to retain heat energy when subjected to a temperature differential and to slowly release it back into the environment as the conditions change. Structures with high thermal mass can reduce the transfer of heat by absorbing the heat energy flowing in from the outside. This process is slow and results in a delay called thermal lag. The ability to absorb large quantities of heat energy combined with the thermal lag effectively increases the thermal performance of a material. Heavy walling systems like brickwork coupled with concrete floors combine to produce relatively high thermal mass. From a sustainability perspective, high thermal mass is ideal as such buildings need less dependency for artificial heating and cooling, meaning less energy use and improved thermal comfort for building occupants.

R-Value

The thermal resistance value or R-value of brick contributes to the thermal efficiency of a building or structure.
While insulation in external walls is essential, the R-value is a static parameter which alone does not predict the energy used in maintaining internal temperature in real-life dynamic temperature environments. Consequently, it also does not reflect the true superiority of clay masonry which is due to its inherent thermal mass.

1.111 NATURAL COLOUR VARIATION

PGH bricks are made from natural clays, fired at extreme temperatures creating products of enduring colour and character. The natural variation in both clay and firing process means textures, composition, size and colour including the appearance of flashing, will vary from batch to batch. Often the character created by this variability is the very reason bricks are desirable.

1.2

BRICKLAYING & CLEANING

PGH

1.201 MINIMISE CLEANING

Consideration should be given during design and construction to the following matters to avoid or minimise clay masonry cleaning problems.

Bricklaying

Mortar extruded from masonry joints during laying should be cut off with a trowel. In this way a clean cut can be made with little smearing of the unit face.

On completion of laying and joint tooling, mortar smears on the work face should be removed by dry brushing.

Wet sponging of the mortar joints is a common practice with smooth face bricks. Although this creates a smoother joint finish, it smears a cement-rich mortar film over the brick face that often develops into staining.

Cleaning Cavities

Cavities can be cleaned by hosing at the end of a day's work. Temporarily leave bricks out at the wall base to enable mortar to be hosed clear of the cavity.

Take care to ensure that mortar does not set on masonry below the base of the cavity. This is best done by thoroughly hosing the masonry below.

Concrete Droppings

Masonry supporting reinforced concrete slabs and beams is frequently disfigured by droppings and spattering from the concrete pour. If these deposits are allowed to set it is sometimes impossible to rectify the damage. Protection is best achieved by covering the walls with plastic sheeting. Where this is not done, any deposits on the wall must be thoroughly hosed off before they set.

Copings, sills, weathering

Stormwater should be shed so as to clear the masonry immediately below. Copings and sills should project at least 10mm beyond the wall face at the underside of the sill or coping. Sills should be angled to properly shed water.

Where downpipes have not been installed water from the guttering should be diverted away from the brickwork.

In-built Elements

In-built elements should slope away from masonry. The soffit of major elements such as balconies should be provided with a drip mould. It is desirable for all roofs to be provided with sufficient overhang to protect the wall below.

Mortar Additives

Some mortar additives if used incorrectly may create problems during the brick cleaning process, examples being:

- Air-entraining agents used to improve the workability of mortar. Overuse creates a highly porous mortar that is easily eroded during cleaning.
- Water modifying agents used to retard the absorption of water from the mortar into the brick are extremely difficult to remove from the brick if left on for more than one to two weeks.
- Excessive clay content in mortar (around 15%) is detrimental to the mortar as excessive shrinkage will occur, creating cracks within the mortar and at the mortar/brick interface.

Paint Overspray and Splashing

Extreme care is needed to avoid paint and timber stains being splashed onto masonry. Dried paint is extremely difficult to remove, therefore prevention is the best cure.

Rain interruption

When rain interrupts bricklaying – or is expected overnight – protect the top of the newly laid wall with plastic sheeting.

See also 1.302 Calcium Stains.

Retaining Walls

The rear face of retaining walls should be waterproofed by such methods as cement rendering, use of a plastic sheet or applying a bituminous coating. This will prevent the migration of soluble salts through the wall. Proper drainage should also be provided behind the wall.

Scaffolding

Scaffolding planks should be laid at least 150mm clear of the wall, allowing mortar droppings to fall clear instead of building up on the plank and disfiguring the wall. At the end of each day's work – or when rain interrupts work – the plank nearest the wall should be propped on edge to prevent mortar which may have collected on it being splattered onto the wall.

1.202 A CLEAN START

The cleaner the bricklayer leaves the wall the easier the cleaning task will be. The majority of mortar residues and smears should be cleaned before they set. However, in most cases some additional cleaning will be required to completely remove the mortar residue.

1.203 ACIDS – THE BASICS

Safety Requirements

All acids and proprietary cleaners are dangerous. Users are required by law to:

- Obtain a copy of the manufacturer's Safety Data Sheet (SDS) for every chemical used in the conduct of their work and to only use the product in accordance with the instructions in the Safety Data Sheet (SDS).

In particular you are reminded that hydrochloric acid is classified as a corrosive S6 poison. All steps should be taken to comply with the requirements for its use in the Safety Data Sheet (SDS).

To avoid personal injury users should always:

- Wear all necessary safety equipment detailed in the Safety Data Sheet (SDS) including but not limited to goggles or face mask, gloves, and protective clothing as advised.
- Pour acids into water – this avoids splashes of highly concentrated acid onto the operator.

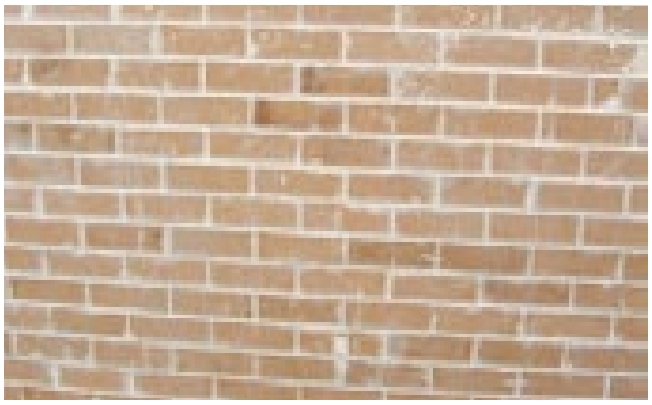


Figure 56 Typical wall after bricklaying

- If an acid or proprietary cleaner is splashed onto the skin, it should be immediately washed thoroughly with clean water or a solution of bicarbonate of soda and water that will neutralise the acid. Medical attention should be sought with respect to any injury arising from the use of chemicals. Chemical spills are required to be treated in accordance with the advice contained in the Safety Data Sheet (SDS).

Acid Concentrations and Cautions

The traditional masonry cleaning chemical is hydrochloric acid, (also known as muriatic acid or spirits of salts). Its main function is to put portland cement into solution, that is, dissolve the cement in the mortar mix. It has few other uses and in many stain situations SHOULD NOT BE USED.

The recommended maximum strength for light coloured clay bricks is 1 part acid to 20 parts water, and the recommended maximum strength for all other clay bricks is 1 part acid to 10 parts water.

Note: This point must be strictly adhered to particularly for bricks manufactured in Queensland. Their raw materials naturally contain large amounts of iron oxide, sometimes just below the surface. The use of acid solutions stronger than 1 part acid to 20 parts water can dissolve these particles and create iron oxide staining. Removal of these stains is treated in Section 1.501.

Proprietary masonry cleaning solutions are available. The manufacturer's recommendations must be adhered to strictly.

1.204 CLEANING – THE BASICS

Cleaning techniques may involve high-pressure water jet equipment or hand methods. Both are detailed later in this section. Whatever technique is used, the following requirements must be observed to ensure that additional staining problems are avoided:

Saturate the Wall

The brickwork must be thoroughly wetted by hosing before any acid solution is applied and kept wet ahead of the acid application. The area to be cleaned must be saturated as well as all brickwork areas below. The hose should be trained upon the wall until the brick suction is exhausted.

If the wall appears to be drying on the surface, reapply water until ready to apply the cleaning solution.

Failure to completely saturate the wall is a major cause of cleaning stains. Cleaning solutions containing dissolved mortar particles will be drawn into a dry masonry wall, causing further staining. Furthermore saturating the wall keeps the acid solution on the face of the masonry where the mortar smears are present.

Recommended acid strengths are based on application to a saturated wall and it is a myth to consider that pre-wetting 'weakens' the acid.

Note: This point must be strictly adhered to for bricks manufactured in Queensland. Failure to saturate the wall allows acid solutions to react with the iron oxide and create iron oxide staining. Removal of iron oxide stains is treated in Section 1.3.

Acid Application

Apply the acid solution and leave to stand on the wall to allow the chemical action to take place, this could take up to 3 to 6 minutes, however for bricks manufactured in Queensland and Western Australia a lesser time is advised or secondary staining can occur.

Hose Off

If the acid is left on the wall too long it can be absorbed into the brickwork and may cause staining.

It is extremely important to thoroughly hose off the wall as the work proceeds. The acid solution and debris cleaned off the wall must not be allowed to dry on the wall. Weather conditions, location of the masonry, and the suction of the bricks will affect the timing of the hosing off. Generally two to six square metres should be treated at a time.

1.205 PROCEDURE FOR HAND CLEANING

Hand cleaning is appropriate for small jobs, or where the use of high pressure water jet equipment may cause further problems.

1. Wait for mortar to harden. It is possible to start cleaning 24 to 36 hours after completion of masonry work, depending on the type of brick and the weather (drying) conditions.
2. Remove large mortar particles with hand tools before applying water or cleaning solutions. This 'pre-cleaning' is an important part in cleaning new masonry. Don't expect acid and/or water alone to remove large particles of hardened mortar.
3. Mask and otherwise protect adjacent materials such as metal, glass and wood, as recommended by product manufacturers.
4. Care should be taken to identify and remove any vanadium staining on the brickwork prior to applying the solution of hydrochloric acid, as it may turn the vanadium black and make it more difficult to remove. For further information regarding removal of vanadium stains refer to Section 1.303.
5. Thoroughly wet the face of the wall with clean water. All areas to be cleaned must be saturated as well as masonry areas below.
6. Use a brush or spray to apply the acid solution to the saturated wall. Start cleaning at the top of the wall. Cover a small area.
7. Allow the solution to remain on the wall for sufficient time for the reaction to take place. This could take up to 3 to 6 minutes. Then scrub vigorously with a scrubbing brush. Scrub bricks not joints.
8. Rinse thoroughly as small areas are being cleaned. To slow evaporation, work ahead of sunshine. These ideal conditions allow walls to dry soon after being washed, permitting the operator to observe if all stains are being removed before moving too far ahead.

1.206 HIGH PRESSURE WATER JET CLEANING

High pressure water jet cleaning can be used on clay masonry but the following simple precautions must be taken so that the bricks and the mortar joints are not damaged by the process.

Caution: Turbo or rotary head attachments damage brickwork and are not recommended.

Caution: Test clean a sample area to determine the effectiveness of the cleaning compound and the technique, and to check the wall for possible damage caused by the system.

Allow mortar to harden. Cleaning with high water pressure should not start before mortar is at least three days old.

1. Remove large mortar particles with hand tools before applying water or cleaning solutions. This 'pre-cleaning' is an important part in cleaning new masonry. Don't expect acid and/or water alone to remove large particles of hardened mortar.
2. Mask and otherwise protect adjacent materials such as metal, glass and wood, as recommended by product manufacturers.
3. Care should be taken to identify and remove any vanadium staining on the brickwork prior to applying the solution of hydrochloric acid as it may turn the vanadium black and make it more difficult to remove.
4. Thoroughly wet the face of the wall with clean water. All areas to be cleaned must be saturated as well as masonry areas below.
5. When the suction of brick is exhausted, apply the appropriate cleaning solution, starting at the top of the wall working in small areas. The solution can be applied to the wall with a masonry cleaning brush or soft broom.
6. Allow the cleaning solution to remain on the wall to allow the chemical reaction to take place, this could take up to 3 to 6 minutes, however for bricks manufactured in Queensland and Western Australia a lesser time is advised or secondary staining can occur.
7. Wash the wall with high pressure water from top to bottom so all dissolved mortar particles will be completely flushed from wall surfaces.

IMPORTANT

- **The maximum pressure at the pump should be kept low, around 7000 to 8000kPa (1000 to 1200 psi), to prevent damage to either the masonry units or the mortar.**
- **The concentration of power with which the water jet strikes the wall is a function of the flow in the hose, the pressure, the type of nozzle and the distance from the nozzle to the wall.**
- **A straight or zero degree water jet should never be used. A spray angle of 15 degrees, called a fan jet, will allow the operator to concentrate the pressure on the bricks and not on the joints. The jet should generally be 500mm from the wall and never closer than 300mm for localised patches.**
- **Pressure cleaning should be carried out in 'runs' from the top of the wall down, to rinse down debris during cleaning.**
- **The width of a run is usually 1 to 1.2 metres, and should only be as wide as the operator can clean while keeping full control of the pressure gun. The gun must be kept moving: surface abrasion will occur if it pauses in one spot.**
- **Turbo head water jets are not recommended as there is a high potential for damaging the bricks and/or mortar by the concentrated force of the water.**

Any lumps or smears remaining after initial treatment will require another scrape, followed by wetting, acid treatment and pressure cleaning. The patience of double cleaning on difficult stains will be rewarded with a first class finish. It also eliminates the risk of eroding bricks or joints, the main objections to the water-blast cleaning method.

When all cleaning is finished, go back and rinse loose sand and dirt from the eaves, walls and windows. Once the walls begin to dry, check to see if any further cleaning is required.

Caution: If the mortar joints or the bricks are being damaged, either the pressure is too high or the water jet is too close to the wall.

Caution: Before cleaning dry pressed bricks the manufacturers advice should be obtained as the use of high pressure water cleaning is not recommended.

Figure 57 Damage caused by incorrect high pressure water jet cleaning

Figure 58 Damage caused by incorrect high pressure water jet cleaning

Figure 59 Damage caused by incorrect high pressure water jet cleaning

1.207 CLEANING INTERNAL BRICKWORK

Using hydrochloric acid to clean mortar deposits on internal masonry requires special care. The work should be done before the building is enclosed to ensure maximum ventilation and exhaustion of acid fumes.

Frequently this procedure is not followed and the masonry is cleaned at the completion of the building, making it impractical to use large quantities of water. The result can be acid fumes flowing from the masonry for some time after occupation, attacking metal door furniture, light fittings, steel furniture, exposed metal grid ceilings and other metal components.

In addition to early cleaning, the following procedures are recommended when cleaning internal brickwork:

- Use a proprietary cleaner containing an acid inhibitor that reduces fumes from hydrochloric acid; OR
- After washing down, apply a neutralising wash consisting of 65 grams of Sodium Bicarbonate per litre of water.

Leave this on the wall. If acid fumes are suspected to be coming from the wall, test using litmus paper. Moisten a strip and apply it to the wall. If the blue paper turns red, acid is present and a neutralising wash should be applied.

Quite often stains occur on brickwork from the failure to follow correct cleaning procedures when removing mortar residue. Stains are aesthetic blemishes and do not affect the structural adequacy of the brickwork and are generally easily removed.

The correct identification of stains on brickwork is a first step in the removal process.

Testing on one or more small areas is the safest way to determine the correct chemical solution and technique to remove a particular stain. This must take place well ahead of final cleaning as it will usually not be possible to assess the effectiveness of the test clean until the masonry dries.

The cleaner the bricklayer leaves the wall the easier the cleaning task will be. The majority of mortar residues and smears should be cleaned before they set. However, in most cases some additional cleaning will be required to completely remove the mortar residue.

1.3

STAIN REMOVAL

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1.301 ACID BURN (IRON OXIDE STAINS)

This is a yellow, orange to brown rust-like stain. It is most obvious on cream bricks but can similarly occur on darker coloured bricks. Iron oxide stains frequently result from the incorrect use of hydrochloric acid on clay masonry.

This stain is commonly called 'acid-burn' because the reaction between hydrochloric acid and iron oxides in the brick and/or mortar sand causes the formation of iron oxide or rust on the face of the brick and can also leach into the mortar joint.

The most common causes of incorrect hydrochloric acid cleaning leading to iron oxide staining are:

- Failing to thoroughly pre-wet the wall and keep it wet ahead of the cleaning operation.
- Failing to thoroughly hose down each four to six square metres of the cleaned area.
- Using a hydrochloric acid solution stronger than 1 part acid to 20 parts water on light coloured bricks, or stronger than 1 part acid to 10 parts water on other bricks.
- Too often the acid solution is not given sufficient time to act properly, usually resulting in the operator increasing the acid strength.

Pre-wetting and frequent washing off is designed to prevent undue penetration of the acid into the brick and mortar where further reactions and staining often occur.

Window sills and corners require particular attention with pre-wetting as the water readily runs off instead of being absorbed.

Removal Technique for Acid Burn

Phosphoric Acid

1. The application strength and duration will vary. As a guide, use a mixture of 1 part phosphoric acid to 6 parts water.
2. Apply by brush or spray to the dry wall and allow to stand until the stain disappears, usually within 30 minutes, but it can be up to 24 hours.
3. More than one application may be required. Mortar containing iron oxide colouring pigment will be lightened by this treatment.

To maintain a uniform appearance treat an entire wall or keep the phosphoric acid clear of the mortar.

Protection should be provided to powder-coated fixtures, painted surfaces and concrete coloured with oxides, such as paths and roof tiles, to prevent discolouration by the phosphoric acid solution.

Oxalic Acid

1. Use a solution strength of 20 to 40 grams per litre of water.
2. The method of application is the same as for the phosphoric acid treatment.
3. More than one application may be required.
4. Neutralise the oxalic acid by applying a solution of 15 grams of Sodium Bicarbonate per litre of water. Do not wash off.

Figure 60 Acid Burn

1.302 CALCIUM STAINS

Calcium stains appear as almost a milky film on the brickwork. These hard white deposits are invisible when wet but insoluble in water, unlike efflorescence which is water soluble.

Most commonly these stains arise from products of the setting reactions of portland cement and bricklaying sand containing clay. The combination of clay from the mortar with calcium and silica residues from the cement, form calcium silicate that produces the insoluble white scum. Calcium silicate is highly insoluble in most acids.

Kaolin, a clay mineral present in most bricklaying sands, can also form a hard deposit. It is insoluble in most acids except hydrofluoric acid.

Staining can occur in any of the following ways:

- Incorrect hydrochloric acid cleaning.
- When too much acid and too little water are used, the products of the reaction between the acid and the mortar are absorbed into the brick faces instead of being washed clear of the wall.
- When newly laid masonry is unprotected and saturated by rain, lime is put into solution either from the cement or hydrated lime in the mortar.
- By the interaction of lime leached by water from concrete elements or cement rendering.
- By the wet sponging of mortar joints that smears a cement-rich mortar film over the brick face.

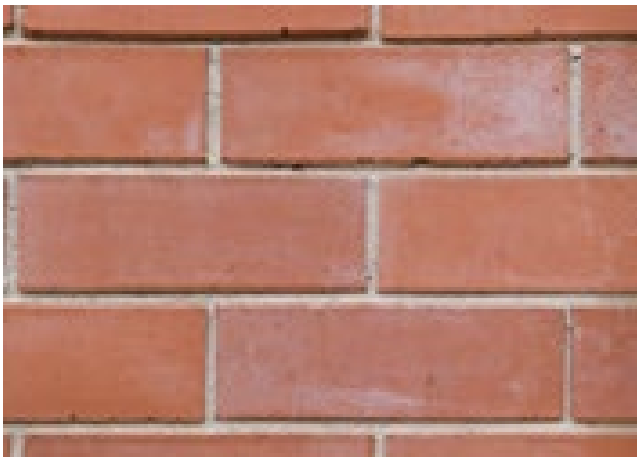

Figure 61 Calcium Stain

Figure 62 Calcium Stain

Removal Techniques for Calcium Stains

The application of some proprietary cleaners at full strength will usually remove these stains. In some cases, the reaction is immediate and should be followed by vigorous scrubbing. In others, the cleaning solution should be allowed to stand for some four to six minutes prior to scrubbing. A small test area should be used to determine the appropriate treatment technique. More than one chemical application may be required. The wall should be rinsed thoroughly after each treatment.

Note: The manufacturer's instructions and safety precautions must be followed when a proprietary cleaning product is used.

1.303 VANADIUM STAINS

Light-coloured clays often contain vanadium salt that are generally colourless, but under certain conditions may appear as a yellow, green or reddish-brown discolouration of the brick.

It is essential that any vanadium salts evident prior to the removal of mortar residue be removed, as the hydrochloric acid may turn the salt black and become difficult to remove.

Vanadium stains are often generated by the use of too strong a concentration of hydrochloric acid during the initial cleaning process, or from excessive water penetration.

Vanadium stains are neither permanent nor harmful and do not indicate a defect in the brick. Vanadium stains in exposed areas generally wash off in time but their removal can be hastened by chemical treatment.

After the initial removal of vanadium stains, more water on the masonry – even that used in the cleaning process – may induce further effloresing of the salts to the surface, depending on the amount within the brick.

Removal Techniques for Vanadium Stains

A number of chemical treatments are available to remove vanadium stains. It is best to test the efficiency of these chemicals on a test area to determine the most suitable treatment to use.

Sodium Hypochlorite

This is the active ingredient in household bleach and swimming pool chlorine. It is an inexpensive treatment for mild cases of vanadium staining. Simply spray or brush sodium hypochlorite onto the stain without pre-wetting, allow it to stand until the stain disappears, and then rinse.

Oxalic Acid

This is probably the best known chemical for removal of vanadium stains. However if used it must be followed by a neutralising wash. This action is commonly omitted and further staining of a serious nature can result. The correct procedure is:

1. Mix 20 to 40 grams oxalic acid per litre of water (preferably hot).
2. Apply to the stained bricks without pre-wetting.
3. Neutralise the oxalic acid by applying a solution of 15 grams of Sodium Bicarbonate per litre of water. Do not wash off.

Potassium Hydroxide or Sodium Hydroxide (Caustic Soda)

Mix 150 grams potassium or sodium hydroxide per litre of water and apply to the stained bricks. Leave on the wall until the stain disappears, then wash off. A white residue may appear after this treatment and this should also be hosed off. Extra care should be taken when using highly corrosive solutions such as these.

Proprietary Cleaners

These are general purpose cleaners that rapidly remove the stain. The manufacturer's instructions and safety precautions must be followed when using a proprietary cleaning product.

Figure 63 Vanadium as a green stain on light coloured bricks

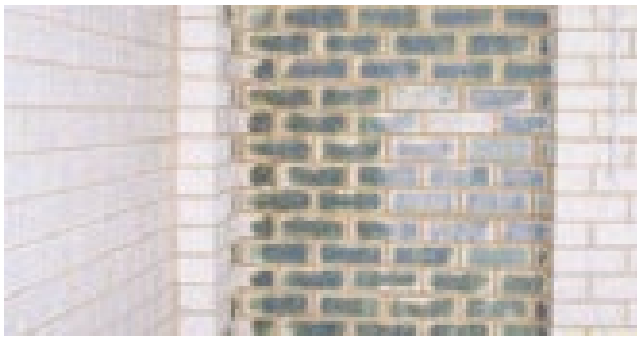

Figure 64 Vanadium stain not removed prior to hydrochloric acid application

1.304 EFFLORESCENCE

Efflorescence is not a stain, it is a powdery and sometimes 'fluffy' deposit that forms on the surfaces of porous building materials such as masonry units, mortar and concrete. The temporary appearance of efflorescence is common on new masonry.

The formation of efflorescence requires three conditions:

- The presence of soluble salts.
- Excessive amounts of water entering the masonry.
- The evaporation of water as the masonry dries out, depositing salts on the surface.

The soluble salts that appear as efflorescence can enter the wall from various sources:

- Mortar components, particularly cement.
- Soil or fill in contact with the wall.
- Sea spray in coastal areas.
- Masonry units, however this is not a common source.

Any situation that allows excessive amounts of water to enter the wall is likely to promote efflorescence. The most common causes are:

- Poor copings and flashings.
- The failure to protect new brickwork when rain interrupts bricklaying.
- Poor storage of masonry units on site. Before units are placed in the wall they can absorb ground salts and excessive water in the stockpiled masonry, and can mobilise latent salts if they are present in the masonry.

Persistent efflorescence may be a warning that water is entering the wall through faulty copings, flashings or pipes.

Removal Techniques for Efflorescence

Most efflorescence will naturally disappear over time, however its removal can be accelerated by brushing with a stiff dry brush. The use of a dust pan or vacuum cleaner to collect the salts after brushing is recommended as this will prevent salts from re-entering the brickwork or any porous paving materials below. After brushing and cleaning up, an absorbent cloth (wrung out until damp only) can be used to pick up any residue.

Frequent rinsing of the cloth in fresh water is advisable. Rinsing brickwork with water will only cause the salt to be reabsorbed into the bricks and reappear when dry.

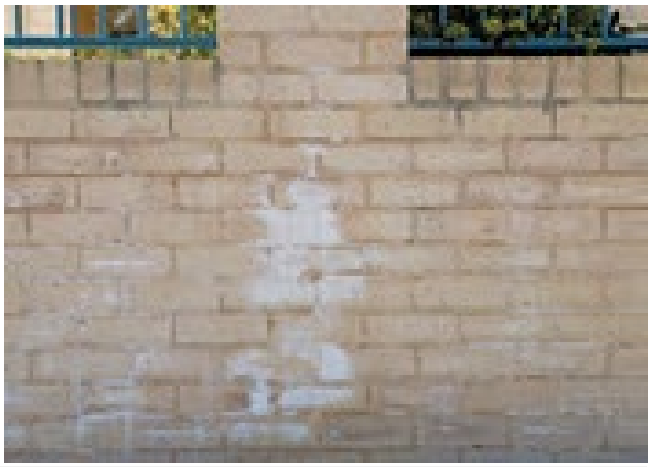

Figure 65 Efflorescence as seen on brick faces

Figure 66 Efflorescence from ground salts

SECTION 1.3
STAIN REMOVAL

1.305 GRAFFITI AND PAINT

Removal Techniques for Graffiti and Paint

For cleaning fresh aerosol paint, use a commercial paint remover in accordance with the manufacturer's instructions.

Oil-based Paints or Enamels

Burn off and follow with scraping and wire brushing ensuring not to damage the brickwork.

Dried Paint

1. Flood the stained area for a few minutes with a paint remover.
2. Scrub to loosen the paint film.
3. Flush with water to wash away the loosened paint.
4. Scrub with scouring powder until the stain is removed.

Poultice Method

If these methods do not remove all traces of the paint, it will probably be necessary to apply a poultice:

1. Mix a strong solution of sodium hydroxide (caustic soda) in an inert base such as diatomaceous earth.
2. Apply to a depth of about 5mm, and leave on the wall for at least 24 hours before hosing off.

1.306 IRON WELD AND SPLATTER

Where unprotected steel is built into masonry, unsightly rust stains may result on both bricks and joints. Similar stains will occur if welding is carried out too close to masonry.

Removal techniques for iron and welding spatter.

Phosphoric Acid

1. The application strength and duration will vary. As a general guide, use a mixture of 1 part phosphoric acid to 6 parts water.
2. Apply by brush or spray to the dry wall and allow to stand until the stain disappears, usually within 30 minutes, but can be up to 24 hours.
3. More than one application may be required.

Oxalic Acid

1. Use a solution strength of 20 to 40 grams per litre of water.
2. The method of application is the same as for the phosphoric acid treatment.
3. More than one application may be required.

Proprietary cleaners that are general purpose cleaners can rapidly remove the stain. The manufacturer's instructions and safety precautions must be followed when using a proprietary cleaning product.

1.307 OIL, BITUMEN AND TAR STAINS

These stains generally arise from the actions of other trades or due to a lack of care in protecting materials in the structure.

Removal Techniques for Oil, Bitumen and Tar Stains

1. Treatment with a commercial emulsifying agent (degreasing solution).
2. Mix an emulsifier with kerosene to move the stain. Clean the kerosene off with the emulsifier only mixed with water. Hardened oil must first be scraped off or free oil mopped up immediately with an absorbent, such as paper towels.

Wiping should be avoided as it spreads the stain and tends to force the oil into the masonry.

The area affected should then be covered with a dry absorbent material such as diatomaceous earth, hydrated lime, or whiting and the procedure repeated until there is no further improvement.

(The selection of the absorbent material will be a function of the colour of the unit and the acceptability or otherwise of materials being trapped within interstices in the surface.)

3. Steam cleaning with a hot 10 percent sodium hydroxide solution may also be used but there is a risk of bleaching.
4. A further method is to apply a poultice of naphtha or trichloroethylene to the stained area.

1.308 ORGANIC GROWTHS

These are common where masonry is in contact with damp soil, such as flower boxes, retaining walls and in sunless spots. Some control of organic growth can be achieved by the use of water repellents or clear sealers. Flower boxes and the rear of brick retaining walls should be cement rendered with waterproof mortar or covered with heavy duty plastic sheeting to prevent water seepage into the wall.

It is also advisable to render the top of these walls or provide a brick coping, ensuring that a good cross fall is provided to shed water rapidly.

Removal Techniques for Organic Growths

As much growth as possible should be removed by vigorous brushing with a bristle brush. For heavy growth, scraping and wire brushing may be necessary.

After this dry cleaning, apply a proprietary weed killer or liquid chlorine that should be left on the surface for several days. Brush off and clean with hot water and detergent.

1.309 SMOKE STAINS

These stains vary from minor conditions around domestic open fireplaces to major problems of cleaning of face masonry in fire-damaged buildings.

The following chemical treatments may be supplemented by high-pressure water jet cleaning to scour the many small crevices on the masonry surface.

Removal Techniques for Smoke Stains

Minor Stains

Minor stains can be removed readily with sugar soap that is a highly alkaline mixture. Mix about 500 grams into 2 litres of hot water and apply liberally by brush. After the stains disappear scrub with a mixture of detergent and a household scouring powder containing sodium hypochlorite.

Smoke-damaged Buildings

The problems in fire-damaged buildings are usually complex, with widespread smoke stains and localised severe staining where highly-combustible materials have burnt. An initial treatment with sugar soap will remove some of the deposits. This can be followed by an application of sodium hypochlorite. The full strength chemical should be left on the wall for about 10 minutes before scrubbing and hosing.

Note: The manufacturer's instructions and safety precautions must be followed when using any chemicals or proprietary cleaners.

Severely-affected Areas

These may require a poultice treatment:

1. Use an inert filler material such as diatomaceous earth, mixed with sodium hypochlorite (bleach) to form a thick paste.
2. Apply to the stained areas by trowel or steel float to a depth of 5mm.
3. Leave on the wall 24 to 48 hours before removal by hosing and scrubbing.

1.310 SOIL AND GRIME

Base courses of masonry are frequently disfigured with splashing from adjacent soil. These deposits should be removed as soon as possible.

These stains arise from long-term airborne deposition. Grime is worst in industrial areas with heavy pollution problems. Special cases can arise, for example from bird fouling or proximity to railway lines.

Horizontal surfaces such as ledges, sills and raked masonry joints are the worst affected areas.

Removal Techniques for Soil and Grime

Scrubbing with a fibre or soft bronze bristle brush and a liquid detergent is usually effective. Steel wire brushes should not be used, to avoid rust staining from broken bristles.

Large jobs are usually carried out by specialist cleaners using high-pressure water and dry or wet sandblasting. Test cleaning should be carried out before the final cleaning technique is adopted.

1.311 TIMBER STAINS

These usually arise from water spreading tannin or resin stains on the wall, particularly from hardwoods. The stains are usually brown or grey and are present on both bricks and mortar.

Removal Techniques for Timber Stains

Normally timber stains will be removed by scrubbing with a solution of 20 - 40 grams oxalic acid per litre of hot water. Neutralise the wall after this treatment.

Where the stain is not removed by this solution, two other treatments can be used. One is to apply a bleaching solution containing sodium hypochlorite and allow it to dry on the wall. The other treatment is the same as that recommended for the removal of acid burn given in this section.

Note: The manufacturer's instructions and safety precautions must be followed when using any chemicals or proprietary cleaning products.

1.312 MANGANESE STAINS

A dark-blue brown discolouration may occur on bricks that have been coloured grey or brown by the addition of manganese during manufacture. The stain occurs most characteristically along the edges of the brick and is generally caused by excessive water penetration. In severe cases it may show as a stain across the face of the brick.

The problem with manganese staining is not so much the removal of the stain, as preventing its return in a short period by:

- Minimising water penetration into brickwork by ensuring all mortar joints are filled.
- Using ironed joints as they form a better weather-shield than other types.
- Ensuring copings at the top of the wall are effective.
- Covering all brickwork under construction during periods of wet weather.
- Insertion of effective damp proof membranes as brickwork progresses.

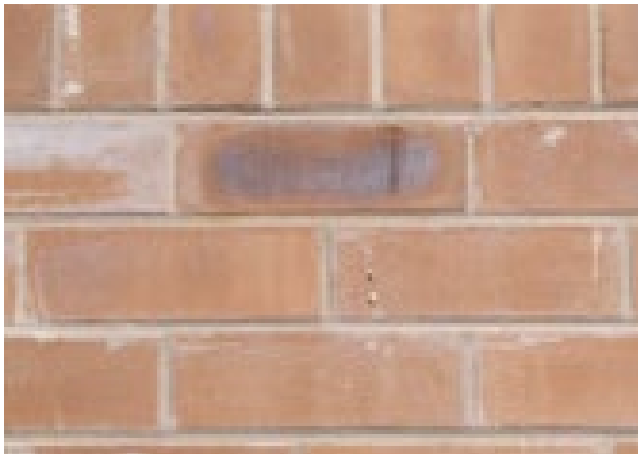

Figure 67 Signs of manganese staining

Removal techniques for manganese

stains Phosphoric Acid

1. Mix 1 part phosphoric acid to 6 parts water.
2. Apply with brush or spray to dry wall.
3. Avoid splashing any adjoining metal surfaces.
4. Reaction can take up to 24 hours and more than one application may be required.

Acetic Acid

1. Mix 1 part acetic acid (80% stronger) with 1 part hydrogen peroxide (30 to 35% concentration) with 6 parts water.
2. Apply with brush or spray to dry wall.
3. Avoid splashing any adjoining metal surfaces.
4. Reaction should be almost immediate however more than one application may be required.

1.4

IMAGE REFERENCE TABLES

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SECTION 1.401
TABLES LIST

SECTION 1.402
FIGURES LIST

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