INSTALLATION SPECIFICATION - PENNGUARD™ BLOCK LINING SYSTEM

1. SCOPE

1.1 This specification covers the recommended installation, quality control, and inspection guidance for the successful installation of the PENNGUARD Block lining system on metal, concrete, brick and FRP/GRP surfaces.

2. GENERAL

2.1 PENNGUARD Block is a glass material that requires care during handling and installation to prevent damage.

2.2 When properly installed and cured, the lining system is very strong. However, excessive particulate loading, gas velocity exceeding 100 feet per second (30 m/s) and wear and tear associated with maintenance and inspection activity could cause mechanical damage. Although high gas velocity does not typically damage the lining when it is installed in the same direction as the gas flow, areas such as turning vanes and sharp changes of direction may require special treatment to optimize performance and longevity. Consult ErgonArmor with specific concerns.

2.3 When appropriate, the following sign shall be posted on the exterior of the structure during and after lining application. “LINED EQUIPMENT, NO WELDING OR BURNING”.

2.4 Do not impale the installed PENNGUARD Block Lining System with welding rods or other sharp or pointed devices as a convenient way to hang cords or wires for temporary lighting during outages or other maintenance activities.

3. EQUIPMENT AND SUPPLIES

3.1 To mix PENNGUARD Adhesive/Membrane, use a heavy-duty variable speed drill with a 3/4" (16-18 mm) chuck and sufficient torque to deliver a minimum speed of 230 rpm under load. The drill shall be fitted with a Jiffler mix blade, Model DC312, with 2 x 6.5" (165 mm) propeller blades. Use of any other equipment to mix PENNGUARD Adhesive/Membrane requires prior written approval from ErgonArmor, as incomplete mixing can prevent full cure and severely compromise system performance.

3.2 Insulation saws and rasps, to cut and sculpt the PENNGUARD Block.

3.3 Masons trowels of a size approximately 8" (200 mm) long x 3.25" (83 mm) at the heel with end blunt to approximately 3/4" (20 mm) radius to apply the adhesive.

3.4 Lanolin-based waterless hand cleaner.

3.5 4" (100 mm) wide stiff-bristled paint brushes, paper coveralls, Playtex dish-washing gloves, rags, wire brushes.

3.6 Mineral spirits to remove wet PENNGUARD Adhesive/Membrane from tools, such as trowels and mix blades, and loosen cured PENNGUARD Adhesive/Membrane.

3.7 Set of installation specifications, and latest product information sheets for all lining materials.

3.8 Dewpoint meter; electronic temperature meter; adequate lighting, especially in a dark chimney where application is taking place; surface thermometers; white (non-wax) marking chalk or white spray paint.

4. TEMPERATURES

4.1 The product and substrate temperatures are important. In cold, winter conditions, the product storage and construction areas shall be heated to achieve and maintain the temperatures outlined below.

4.2 At the time of mixing and application, the temperature of the components should ideally be 70°F (21°C).

4.3 The temperature of the prepared surface shall be at least 5°F (3°C) above the moisture dew point and between 50°F (10°C) and 95°F (35°C) at the time the PENNGUARD Block Lining System is applied.

4.4 The work site must be protected from precipitation. The cartons of PENNGUARD Block and containers of PENNGUARD Adhesive/Membrane and primer, shall also be protected.

5. SURFACE PREPARATION CARBON STEEL AND ALLOY SUBSTRATES

5.1 Steel and Alloy Surface Preparation, General

5.1.1 All welds shall be continuous. Intermittent or spot welding shall not be permitted.

5.1.2 All weld spatter slag and old anchor welds shall be removed from the substrate, and the area ground flush with the parent metal.

5.1.3 Gross pinholes, pits, blind holes, porosity, undercutting, or similar depressions should not exist in the finished surface of the weld before or after blast cleaning.

5.1.4 All edges and fillets and similar abrupt contours shall be rounded off smoothly by grinding or machining. A 1/8" (3 mm) radius is preferable. Smooth ripple finished welds are

acceptable.

5.1.5 Plates welded together shall be properly aligned; butt welded joints are preferred.

5.1.6 Lap welded joints should be avoided wherever possible. If lap-welded joints are used, they must be fully welded on the inside.

5.1.7 Connections of chimney sections can be joined by welding or flanging. It is important there is a full seal weld used when welding sections. All weld spatter must be removed.

5.1.8 Structural reinforcement members should be installed on the vessel exterior and must be installed before commencement of lining work.

5.2 Surface Profile

5.2.1 Unless otherwise specified in writing by ErgonArmor, a commercial blast finish (as specified by most current revisions of SSPC-SP6, NACE #3, or SA 2.0) is required for preparing carbon steel surfaces to receive the lining.

5.3 Primer for Carbon Steel Substrates

5.3.1 To prohibit the formation of re-rusting and rust bloom after blasting carbon steel should be primed with PENNGUARD HP Epoxy Primer.

5.3.2 Mix and apply Pennguard HP Epoxy Primer in accordance with Ergon specification CES-150.

5.4 For high nickel alloy and stainless steel substrates, consult ErgonArmor to discuss specific project details.

6. SURFACE PREPARATION CONCRETE AND BRICK SUBSTRATES

6.1 Concrete and Brick Surface Prep General

6.1.1 The surface condition of new and/or existing concrete and brick liners can vary greatly. The surface should be thoroughly inspected to identify the condition and suitability of the surface to accept the PENNGUARD Block Lining system. An assessment and evaluation of the suitability of the surface should precede quotations, procurement, or mobilization of installation crews. Any buildup, deposits, carry over, or mortar on concrete or brick faces must be removed.

6.1.2 When forms have been used for placing concrete, they should be designed to yield a smooth continuous concrete surface to which the lining will be applied.

6.1.3 Concrete floors should have a single pass troweled finish with special care being taken to avoid bringing laitance to the surface.

6.1.4 New concrete shall reach a minimum compressive strength of 3000 psi (20 MPa) and a surface tensile strength of 300 PSI (2.0 MPa) before the lining is applied. Curing compounds must either be removed or tested for compatibility before proceeding.

6.1.5 Before acceptance for lining, all form marks and protrusions, such as prominent aggregate exposure, tie wires, reinforcing wire, stirrups, etc., must be ground flush with the surface.

6.1.6 All cavities, stone pockets, honeycombing, and bug holes greater than 1/4" (6 mm) depth shall be filled by repairing with appropriate materials.

6.1.7 Damage to the existing structure such as cracks or other structural damage is to be suitably repaired prior to the application of the PENNGUARD Block Lining System.

6.1.8 For installations on brick liners, if the offset between adjacent bricks is greater than 1/8" (3 mm), the nature and size of the surface irregularity will dictate the action to properly prepare the surface. For a corbel area where individual brick courses are intentionally offset, consult ErgonArmor for specific details.

6.1.9 PENNGUARD Adhesive/Membrane can be used to fill mortar joints that are less than 1/4" (6 mm) wide though not completely full provided brickwork is structurally sound. Joints wider than 1/4" (6 mm) shall be appropriately addressed before proceeding.

6.1.10 Attachments to the brick substrate such as liquid condensate collection systems and stop-bars shall be installed without leaving any gaps in between the brick substrate and the attachment to be installed. A cementitious mortar shall be used to level the area behind attachments prior to final installation of such attachments.

6.2 Surface Cleaning for Concrete and Brick Substrates

6.2.1 The brick faces and mortar over which the lining will be applied must be high pressure water or grit blasted to yield a clean, hard and sound bonding surface. Contaminants must be removed, and the surface shall be pH neutral. Consult appropriate standards. The intent is to achieve a sound surface free of contaminants.

6.2.2 A concrete surface to which the lining is to be applied shall generally be prepared by abrading the concrete and have a resultant surface like a medium grit of sandpaper. The surface shall have a non-glazed appearance. The intent is to remove enough material to achieve a sound concrete surface free of laitance, glaze, efflorescence, and incompatible concrete curing agents or form release agents.

6.2.3 All prepared surfaces must be dust, dirt, and grease-free. Any foreign material which will interfere with adhesion must be removed. All abrasives and dust must be removed from the substrate in accordance with the most recent revision of ISO 8502-3 prior to priming. The use of a power vacuum is recommended.

6.3 Primer for Concrete and Brick Substrates

6.3.1 PENNTROWEL™ Epoxy Primer is the recommended primer for all concrete and brick liner surfaces. It serves to seal and promote adhesion of PENNGUARD Adhesive/Membrane. Consult Product Data Sheet CE-139 and Installation Specification CES-342 for complete product details.

7. SURFACE PREPRATION FRP/GRP SUBSTRATES

7.1.1 Avoid or remove wax on surfaces to be lined. This may require grinding or sanding with a suitable grinding disc until a whitish surface has been achieved. Do not aggressively grind surface so as not to alter the surface profile. All remnants of dust from grinding or sanding shall be removed.

7.1.2 All edges and fillets and similar abrupt contours shall be rounded off smoothly by appropriate means. A 1/8" (3 mm) radius is preferable.

7.1.3 A primer for FRP/GRP is not normally required, check with ErgonArmor for specific project requirements.

8. MIXING

8.1 Remove the lid from the PENNGUARD Adhesive/Membrane pail. Inspect for damage incurred during transit.

8.2 Insure that there are no leaks in the Part B Hardener container and that there is no water present on or in the Part A Base Resin.

8.3 Using drill mixer and mix blade specified in section 3.1, pre-mix Part A by itself for a minimum of one minute. If temperatures are below 65°F (18°C), first mix Part A for a minimum of 90 seconds.

8.3.1 A good manual mixing technique involves movement of the rotating blade within the pail. Move the blade around the base of the pail in a circular motion. Simultaneously lift the blade from the base of the pail without bringing the blade above the surface of the compound and continue the circular motion around the side of the pail. During mixing, hold the mix blade occasionally at a 30 degree angle within the mixture, to insure all contents of the pail are thoroughly mixed. Pay close attention to contact all surfaces of the sides of the pail with the mix blade. Make sure to mix in the corner of the pail.

8.3.2 Automated mixing machines specifically designed for this purpose can also be used to mix PENNGUARD Adhesive/Membrane. Consult ErgonArmor for more details.

8.4 Open Part B Hardener. While continuing to mix Part A Base Resin, take a full 15 to 20 seconds to slowly pour Part B into the vortex created by the mix blade in Part A.

8.5 When the material temperature is 65°F (18°C) or higher, mix for at least three (3) minutes using a good mixing technique to yield a uniform mix. When the temperature of the components is 60°F or

below (15°C), mix for at least four (4) minutes using a good mixing technique to yield a uniform mix.

8.6 PENNGUARD Adhesive/Membrane is ready for use immediately after mixing; however, as a thixotrope, it will thicken over time when allowed to sit after the components have been mixed.

8.7 Protect membrane components and mixed material from any contact with moisture or other contaminants.

9. INSTALLATION

9.1 Before applying block, the contractor shall check the flatness of the prepared substrate in any area which visually may indicate a seating problem. This shall be performed by taking a straight edge of the specified length of the block to be installed and placing it dry against the prepared surface in the orientation in which it will be installed. If there are any gaps between the substrate and the straight edge greater than 1/8" (3 mm) or if the straight edge rocks on a high point rather than sits firmly on the surface, properly mark the area. Either remove the imperfection in the substrate or cut the standard size block being used to minimize the effect of the substrate variation and allow a full bond of the block to the substrate using the adhesive. A comparable check shall also be applicable to lining curved surfaces.

9.2 Trowel apply a minimum 1/16" (1.5 mm) thickness of PENNGUARD Adhesive/Membrane onto the substrate with a suitable trowel as specified in section 3.3 carrying the coverage to approximately 2" (50 mm) beyond the area the PENNGUARD Block will cover when it is placed in position. The size of the area to which the PENNGUARD Adhesive/Membrane is applied at any one time shall be no greater than will allow the area to be lined with the block before the adhesive on the substrate loses its tackiness.

9.3 Trowel a minimum of 1/16" (1.5 mm) thickness of the PENNGUARD Adhesive/Membrane onto the back and all sides of the PENNGUARD Block to be installed. In positioning the block against the adhesive applied to the substrate surface, move the block back and forth at least 2" (50 mm) a couple of times as it is being slid into place against the adjacent block so as to remove voids between the block and the surface. Be sure to maintain a minimum of 1/8" (3 mm) thickness block to block, and block to substrate. Adhesive shall totally fill side joints and shall be seen to 'bead' along edges. Strike clean the surfaces of joints of adhesive squeezed out during placement of the block. Listen for the grinding sound of block scraping against block or the substrate. This is a sure indication of insufficiently filled side joints.

9.4 In placing successive blocks, it is acceptable to leave one or more sides without adhesive and subsequently apply the adhesive to these sides when they are on the substrate prior to placing the next block up against this block edge. However, the intent is to utilize a double buttering technique and no block surface is to be put into final position without adhesive applied with a trowel on that surface first.

9.5 It is very important that the block, coated with adhesive has full contact with the adhesive applied to the substrate surface, whether it be flat floors, side walls, overhead areas, curved surfaces, etc. No voids shall be left between the block and the substrate or between the layers of adhesive coating

them. Cut the block and create an extra joint when necessary or increase thickness of the adhesive back joint to exclude voids and gaps. Side and back joints must be full joints and shall not be less than 1/8" (3 mm) thick.

9.6 Side joints shall be struck clean after installation, with attention to removing excess material from the face of the block. Before moving to a new work area or at appropriate times such as shift changes or scaffold/platform movements, inspectors shall thoroughly inspect surface to detect presence of any excess adhesive and direct that it is to be removed promptly.

9.7 If the applied adhesive is still tacky enough to blacken a gloved finger when touched, additional material can be applied over it, to continue installing Pennguard Block. If it has cured beyond this stage and transfers no color to a glove when touched, it must be removed. This procedure is critical since wet adhesive will not bond well to cured adhesive.

9.8 Cured adhesive that does not pass the gloved finger wet tack test must be abraded to roughen the surface and remove surface gloss using wire brushes as specified in section 3.5.

9.9 When work stoppage is anticipated, remove as much of the PENNGUARD Adhesive/Membrane as practical from the leading edge of the completed lining.

9.10 Do not install blocks that are cracked, gouged, or have other imperfections. Do not install blocks with chipped corners.

9.11 Staggered or broken bond construction is recommended to minimize four corners meeting and the possibility of a corner void.

9.12 If partial blocks are used, the minimum size shall be a one third (1/3) piece of block. If the remaining gap is less than a half block, reduce the dimension of the final two blocks to maintain this minimum block size.

10. CURING OF LINING

10.1 In general the lining may be placed into service after curing for 24 hours at 70°F (21°C).

10.2 Contact ErgonArmor for special cure schedules if down time does not allow enough curing of the lining as outlined above.

10.3 Consult ErgonArmor if initial startup temperatures may rapidly exceed 250°F (120°C).

11. INSPECTION AND QUALITY CONTROL

11.1 The mixing, curing, and adhesion characteristics of PENNGUARD Adhesive/Membrane shall be evaluated by applying it onto a test area of the same material and surface preparation of the production substrate. Work life and initial set time may be visually observed. Work life is the maximum time the PENNGUARD Adhesive/Membrane remains trowelable. Initial set time is defined as the time between mixing PENNGUARD Adhesive/Membrane and when it begins to

exhibit cohesiveness, i.e. the time when the surface of the PENNGUARD Adhesive/Membrane is no longer wet to the touch.

11.2 The installation procedure of the lining system shall be verified by using Cure Verification Cards as supplied for the project. Cards should be retained throughout the duration of the project to insure cure of all applied batches.

11.3 Inspectors shall determine the frequency of random site checks to determine back joints have complete contact by pulling random blocks while the adhesive is still wet and visually verifying the back joint and side joints are completely full.

11.4 Inspector shall sketch areas lined and which he inspected and note his observations.

11.5 A photographic history of surface preparation, primer application, adhesive application, and block installation is suggested.

12. REPAIR OF MECHANICALLY DAMAGED AREAS

12.1 Experience indicates that repair of an area smaller than a standard size block requires more effort than a larger area.

12.2 Cut out a minimum of a full block down to membrane on substrate. Remove remaining Membrane on substrate as best as possible to expose underlying substrate. Clean the PENNGUARD Adhesive/Membrane per Section 6. Reinstall block as outlined previously.

13. ABRASION RESISTANT TOPCOAT

13.1 Consult ErgonArmor for details on specifying additional topcoats on the block where abrasive environments are anticipated.

14. STOP BARS

14.1 The PENNGUARD Block Lining System should not be terminated with a free edge. It is recommended to install proper flat bars to protect leading edges. The height of the stopper should be the full lining thickness. The stop bar shall be of an alloy grade suitable for the anticipated service. Stop bars should be used if the PENNGUARD Block Lining System abuts manway openings, expansion joints, dampers, pipe stubs, sample ports, gunites, or castable linings.

15. EXTERNAL INSULATION

15.1 Do not apply external insulation on any structure being lined with PENNGUARD Block and Pennguard Adhesive/Membrane unless specifically authorized in writing by ErgonArmor. External insulation retains heat. That will overheat the adhesive and reduce its bond to the block.

15.2 Thermal gradient calculations are to be performed to determine the required thickness of block to maintain the temperature of the membrane substrate interface below the recommended levels.

16. FLOOR PROTECTION

16.1 PENNGUARD Block installed in areas such as horizontal ductwork may be subjected to mechanical damage caused by maintenance procedures such as removal of fly ash carry over. If this type of condition is anticipated, the floor area lined with the PENNGUARD Block Lining System may require a further protective layer installed over top of the it such as TUFCHEM™ Silicate Concrete or acid brick to minimize mechanical damage. Consult ErgonArmor for details.

17. DRAINS

17.1 Designs of horizontal ducting and chimney floors shall incorporate enough drainage to insure condensate is removed and be sized so that drains do not plug.

18. SAFETY PRECAUTIONS DISCLAIMER CONTACT INFORMATION

18.1 Consult current Safety Data Sheets (SDS's) before commencement of work.

18.2 While statements, technical information and recommendations contained herein are based on information our company believes to be reliable, nothing contained herein shall constitute any warranty, express or implied, with respect to the products and/or services described herein and any such warranties are expressly disclaimed. We recommend that the prospective purchaser or user independently determine the suitability of our product(s) for their intended use. No statement, information or recommendation with respect to our products, whether contained herein or otherwise communicated, shall be legally binding upon us unless expressly set forth in a written agreement between us and the purchaser/user. For all Terms and Conditions of Sale see ergonarmor.com.

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