SPECIFICATION FOR STEEL VESSELS TO BE LINED WITH BRICK

1. SCOPE

1.1 This specification is meant to provide general guidelines for good brick lining practice when used in a steel vessel to receive a brick lining. It is not meant to be all-inclusive nor take priority over specifications of designers skilled in the science of process vessel design.

2. *VESSEL DESIGN GENERAL COMMENTS*

2.1 Vessels which will be inner lined with acid proof brick may need to conform to certain requirements such as ASME's Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1. Consult Armor for further information.

3. MEMBRANES

3.1 The membrane provides protection for the steel vessel and differential movement of the brick lining without damaging the vessel and must be considered.

3.2 When the vessel membrane lining is rubber or other elastomer, consult with Armor regarding the possible requirements of an intermediate layer between membrane and brick. Maximum service temperature of the membrane lining must be considered in designing the brick thickness.

3.3 Where lead is used as a barrier membrane, the selection of the type of lead and of its thickness, and whether hung or homogenous shall be determined by the designer, based on service conditions. In general, the lining inside the lead shall be designed to provide adequate thermal drop to keep surface temperature of the lead at 165˚F (74˚C) or lower, and to prevent scarring or rupture by differential movement of the brick lining.

4. ACID PROOF BRICKWORK

4.1 Acid proof brick shall be produced in accordance with ASTM C-279, latest revision. The designer shall determine which type of brick he desires, and any variations permitted from this standard. Selection should bear in mind the availability of shapes and sizes to be required.

4.2 The following mortars are suitable for acid and/or alkali service depending on specific conditions to be expected:

CE-128 Furalac™ Green Panel and CE-206 Furalac FN Mortars (furan resin)
CE-254 Asplit™ CN Mortar and CE-290 Asplit Special Mortar (phenolic resin)
CE-250 Pennchem™ Mortar and CE-255 PC1000 Mortar (vinyl ester resin)
CE-276 Penntrowel™ Novolac Brick Mortar (high functional novolac epoxy resin)
CE-231 Penntrowel Vinyl Ester Carbon Mortar (vinyl ester resin)
CE-204 HES™ Cement, CE-207 HB™ Mortar, CE-208 K-14 Mortar, CE-281 Corlok™ B Mortar inorganic mortars

4.3 Selection of the most suitable mortar for the anticipated conditions should be made by consultation with Armor, their representative or its approved contractor.

4.4 All joints must be completely full. The narrower the joint, normally the stronger the brickwork. Unless otherwise specified a nominal joint thickness of 1/8" (3 mm) is specified, with a maximum width of 3/16" (4.5 mm). Joints between courses and layers shall be staggered for maximum strength and to eliminate any possibility of straight-line penetration from interior directly to vessel wall.

4.5 Cutting of brick shall be done with a brick saw, outside of the vessel to be lined so that no fragments may be embedded in the floor or membrane. Cuts shall be smooth and straight to give good bond, and all residual water from the saw shall be removed with a dry rag and brick allowed to fully dry before use.

4.6 Adequate thickness of brickwork shall be computed and designed into the tank lining to provide insulation sufficient to maintain the temperature at the surface of the membrane below its maximum thermal limit. After computing this thickness, the elongations and stresses of each layer of brick shall determine the suitability of the lining under the following three conditions:

a) Maximum internal operating temperature at minimum external temperature
b) Maximum internal operating temperature at maximum external temperature
c) Shut down conditions at lowest external temperature

4.7 From these calculations shall be determined (1) any corrective action that must be taken to keep all forces in the brickwork (in all three conditions) within 50% of the maximums for the material (2) any additional strength required in the steel and, (3) whether at least 50% of the total lining is in compression.

4.8 If at least 50% of the lining is not in compression, elongation figures must be worked out against temperatures at the time of the brick installation to bring 50% of the brickwork into compression. In computing this, the compressive or stress-absorbing qualities of the ceramic fiber layer should be considered and made part of the overall design. From these figures it shall be determined to what temperature the steel must be heated at time of the installation to bring 50% of the brick lining into compression at the poorest condition.

4.9 Expansion joints are not necessary in cylindrical vessels as in rectangular vessels, in closed dished head vessels where all brickwork can be kept in compression, and where design strength of the steel has taken the masonry lining into account. Except in certain cases of mortar growth, etc., expansion joints are required only sparingly. In open top cylindrical vessels, it is necessary to design for the vertical expansion of the brickwork, so it does not shear outlet sleeves. Irreversible growth of domestic fireclay and shale brick (but not carbon brick) of up to 0.16% of any dimension maximum need not be considered in cylindrical walls, dished and cone heads, and other sections where brick is restrained in arch. Growth pressure is not great enough to rupture the brick and can be accommodated in vessel design. However, where the bottom is flat, the brick will not be in arch and in diameters greater than 10' (3m), this growth will eventually cause the floor to heave. Consult Armor drawing D1025 which details a “squeeze joint” design to permit the relief of built-up stresses in flat bottoms under these conditions without heaving.

5. INSTALLATION OF BRICKWORK

5.1 The contractor shall have a minimum of five (5) years of experience in this specialized field and provide evidence of satisfactory completion of at least three (3) jobs of similar nature.

5.2 All materials must be kept dry, and stored at the job site. Prior to use, both brick and mortar materials must be stored for not less than 24 hours at not less than 70˚F (21˚C) nor more than 85˚F (29˚C).

5.3 All mortar mixes shall be made in the proportions indicated by applicable data sheets and specifications, and no water, solvent or other foreign matter shall be added to the mix.

5.4 Mortar that has passed its working life and started to set will be discarded and no attempt be made to reclaim it.

5.5 No brick will be laid when the temperature is less than 5˚F (2˚C) above the moisture dew point, and during wintertime all work areas shall be kept at a minimum of 70˚F (21˚C) day and night until the mortar has set. If temperatures may fall outside of this range, consult with Armor.

5.6 All joints shall be made full and tight, the brick buttered on three sides and pressed into place. Cut excess mortar cleanly cut off with the trowel, care being taken to prevent smearing and to leave a neat appearance.

6. RECTANGULAR STEEL VESSELS

6.1 The paragraphs above on vessel design which are unrelated to configuration or internal pressure also apply to rectangular or straight side configuration vessels, as do also the sections on membrane and on installation of brickwork, cleanup, and startup.

6.2 In construction of rectangular vessels it is vital to be certain that any deviation from a straight line is outward at the center, so that all brickwork is kept in an arch configuration, and *never* in reverse arch. Any irregularity that can cause the brick lining to arch inward can be a cause of failure. Stiffeners must be supplied to keep all walls rigid and to prevent flexing.

6.3 Anticipated thermal expansion must be carefully computed and provided for with expansion pads at the ends (in the case of relatively small tanks). Vertical movement can crush or shear sleeves through outlets and this must be considered in the design.

6.4 There must also be provision for irreversible growth in design & sizing all expansion joints. Consult Armor if unsure.

7. CLEANUP

7.1 All waste material, spoil, and unused brick and mortar will be removed from vessel interiors.

7.2 Consult mortar technical data sheet for the suggested cleaning solvent for trowels.

8. VESSEL STARTUP

8.1 Before starting up check with Armor for specific instructions regarding the first chemical exposure of the vessel surface.

8.2 Avoid rapid heating or rapid application of pressure on the first cycle and until the lining is fully cured.

8.3 Avoid excessive thermal shock, such as the addition of ice water to a boiling charge, or the adding of water to concentrated sulfuric acid. If this sort of shock is anticipated, consult Armor.

8.4 It is good practice, when not in service, to leave vessels full of weak acid to overcome any tendency to develop shrinkage. This is particularly advisable with silicate-based mortars.

9. SAFETY PRECAUTIONS DISCLAIMER CONTACT INFORMATION

9.1 Consult current Safety Data Sheets before commencement of work.

9.2 Mixes and applications of this product present a number of hazards. Read and follow the hazard information, precautions and first aid directions on the individual product labels and safety data sheets before using. While all 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

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9.3 Please contact Armor for further information at +1-877-98ARMOR (982-7667) or customerservice@armor-inc.com.

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