Corrosion Engineering™	
AN ERGONARMOR COMPANY	**TECHNICAL INFORMATION**

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CORROSION ENGINEERING SPECIFICATION FOR INSTALLATION

SPECIFICATION FOR STEEL VESSELS TO BE LINED WITH ACID PROOF BRICK

1. VESSEL DESIGN

1.1 Vessels which will be inner lined with acid proof brick must conform to ASME Boiler & Pressure Vessel Code, Section VIII, Division 1, and in particular conform to design to Paragraph UG-22, Item 4, which states that, in lined vessels, loading due to the lining (such as weight and stresses) must be taken into account in determining wall thickness, and supports. In figuring the extra thicknesses required, the designer should also take into account any additional requirements resulting from Paragraph 3.4 in the "Acid Proof Brickwork" section below.

1.2 The code stipulates (paragraph UG-80) an out of roundness maximum of 1% variation of lengths of all diameters from the nominal diameter. This may not be exceeded in vessels to be brick lined.

1.3. The code (paragraph UG-81) permits a 1¼% out of roundness of the flanges, but does not mention out of roundness of the bodies of nozzles themselves. In the case of brick lined vessels, the nozzles of which must be sleeved, the out of roundness must be limited to 0.4%

1.4. Supports must be so located as to support the vessel and its extra weight uniformly and completely without distortion of the vessel. Thus:

A. If vessel is conical or dome headed, and support legs are used, they should be centered under the brick lining column, tangentially to the vessel body.

B. If vessel is conical or dome headed and supported by a continuous skirt, the skirt should be centered directly under the brick column, and

should be vented to provide adequate ventilation under the vessel.

C. If the vessel is flat bottomed, the bottom must be so constructed and supported as to be completely rigid, and well ventilated from the sides and underneath. This may usually be provided by cribbage or I beams. Supports should not be placed so as to rest directly against bolted sections or other points of weakness.

2 MEMBRANES

2.1 Membranes and semi-membranes must provide protection for the steel vessel and permit differential movement of the brick lining without damage to the vessel or to its lining.

A. 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. The lining inside the lead shall be designed to provide adequate thermal drop to keep surface temperature of the lead at 165°F or lower, and to prevent scarring or rupture by differential movement of the brick lining.

A 1/8"' layer of ceramic fiber paper shall be bonded to the surface of the lead with CORLOK® B Solution. This will provide for differential movement of the brick against the lead, and will provide accommodation for irregularities in the lead surface. This layer has a compressibility factor of 20%, a K factor of 1.37 per inch of thickness, a modulus of elasticity appropriate to this inner space between lead and brick and a Poisson's ratio of over 1.0

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

3. ACID PROOF BRICKWORK

3.1 Acid proof brick are covered by 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.

3.2 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" is specified, with a maximum width of 3/16". 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.

3.3 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 wiped off with a dry rag.

3.4 Adequate thickness of brickwork shall be computed and designed into the tank lining to provide insulation sufficient to bring the temperature at the surface of the membrane below the maximum thermal limit. After computing this thickness, the elongations and stresses of each layer of brick shall be computed, using the mathematics of Dr. Werner Matz and Diploma Ingineer Walter Fuller to 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.

From these calculations shall be determined (1) any correction 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.

3.5 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 the time of the installation to bring 50% of the brick lining into compression at the poorest condition.

3.6 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 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 that it does not shear outlet sleeves. Irreversible growth of domestic fireclay and shale brick (but not carbon brick) of 0.16% of any dimension maximum need not be taken into account 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 handled easily in vessel design. However, where the bottom is flat the brick will not be in arch and in diameters greater than 10', this growth will eventually cause the floor to heave. Corrosion Engineering drawing CED 1025 details a “squeeze joint” design to permit the relief of built up stresses in flat bottoms under these conditions without heaving.

4 INSTALLATION OF BRICKWORK

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

4.2 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 nor more than 85°F.

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

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

4.5 No brick will be laid when the temperature is less than 5°F above the moisture dew point, and during winter time all work areas shall be kept at a minimum of 70°F day and night until the mortar has set.

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

5. CLEANUP

5.1 All waste material, spoil, and unused brick and mortar will be removed from vessel interiors. If silicate mortars are used, requiring acid treatment, instructions for this treatment will be rigidly followed before any hydraulic or other testing is conducted or the vessel is placed in service.

6. STARTUP

6.1 Before starting up check with Corrosion Engineering for specific instructions regarding the first chemical exposure of the vessel surface.

6.2 Avoid rapid heating or rapid application of pressure on the first cycle and until the vessel has been in hot service for a week.

6.3 Avoid excessive thermal shock, such as the addition of ice water to a boiling charge, or water to concentrated sulfuric acid. If this sort of shock is anticipated it must be designed for.

6.4 Avoid rapid changed in pressure. If this sort of shock is anticipated it must be designed for.

6.5 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 important with silicate based mortars.

7. RECTANGULAR STEEL VESSELS

7.1 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.

7.2 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 arch, and *never* in reverse arch. (See Corrosion Engineering specification CES 301 for concrete Vessels, which explains this requirement). 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.

7.3 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 taken into account in design.

7.4 There must also be provision for irreversible growth in designing & sizing all expansion joints. (See paragraph 4 in section "Acid Proof Brickwork" above).

8. DISCLAIMER

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8.2 Please contact Corrosion Engineering for specific recommendations at +1-610-833-4000 or fax +1-610-833-3040.

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