PLAINTIFF'S
EXHIBIT
CHV-458

MAY 27 2011JK

SPECIFICATION NO. SS-2502

REFRACTORY LINING FOR REGENERATED CATALYST U-BEND IN THE FCCU

1. GENERAL

1.1 This Specification covers requirements for materials, installation, curing, repairing, testing, and inspecting a cast 4-5/8 inch thick monolithic refractory lining. The lining shall contain 1.2 volume percent stainless steel fiber reinforcement in a 48 inch diameter U-bend (per Drawing SD-120612) and be suitable for 1300°F operating temperature.

1.2 CONTRACTOR shall provide and install all materials required following good workmanship practices. All work shall be free from injurious defects.

2. MATERIALS

2.1 Refractories

2.11 The "castable refractory" shall be a 130-140lb/ft^3 density ASTM C-401 Class C refractory Resco RS-17E. No substitutes will be accepted.

2.12 The "erosion resistant refractory," shall be a 160-170lb/ft^3 density acid bonded refractory Resco AA-22. No substitutes will be accepted.

2.2 Stainless Fibers

2.21 The stainless fibers shall be AISI 302 or 304 stainless steel, and shall be made by the melt extraction process. Fibers made of chopped wire shall not be used.

2.22 Stainless fibers mixed into the castable refractory shall have an average length of 1 3/8 inches, and an equivalent diameter of 0.018 to 0.020 inch.

2.23 Stainless fibers mixed into the erosion resistant field joint refractory shall have an average length of 3/4 inch, and an average diameter of 0.018 to 0.020 inch.

2.3 Hexmesh

304 SS

2.31 The hexmesh shall be 3/4 inch thick, 14 gauge AISI ~~405 or 410S~~ (low carbon) stainless steel.

2.32 The hexmesh shall be 1 3/4 inches across the flats, welded or riveted (not clinched), and shall have two "prongs" extending into each hex.

2.33 The hexmesh shall be Bufnel Lance Grid, or COMPANY approved equivalent.

2.4 Anchors

2.41 Castable refractory anchors shall be 3½ inches tall, 3/16 inch diameter, AISI 304 stainless steel V-studs.

2.42 Hexmesh supports shall be ¼ inch diameter AISI 304 stainless steel Nelson studs welded on 2 inch by 2 inch by ¼ inch AISI 304 stainless flats.

3. INSTALLATION

3.1 Anchors

3.11 V-studs for the castable refractory shall be installed in staggered alternate rows 8½ inches apart and oriented per Drawing SK-RCC-FCC-8.

3.12 Nelson studs for the hexmesh shall be installed and oriented per nozzle detail SK-RCC-FCC-8.

3.13 Nelson and V-studs shall be welded to the inside of the U-bend using E-309-15 welding electrodes.

3.14 The entire inside surface of the U-bend shall be grit blasted to a commercial blast finish (SSPC-SP6), and shall be cleaned of all grit, dust, rust, scale and grease before welding in the studs.

3.2 Hexmesh:

3.21 The hexmesh shall be rolled the "hard way" (with the axis of the roll and axis of the rivets parallel) and installed in accordance with Drawing SD-120612.

3.22 The hexmesh shall be welded together and to its supports in accordance with Drawing SD-120612 using E-309-15 welding electrodes.

3.23 The hexmesh shall be thoroughly cleaned and all grease and oil removed before welding.

3.3 Refractories

3.31 The entire inside surface of the U-bend shall be cleaned of all grit, dust, rust, scale and grease before applying any and all refractory. All refractory anchors and hexmesh shall be thoroughly cleaned and all grease and oil removed before applying any and all refractory.

3.32 The U-bend metal temperature, surrounding air temperature, and refractory temperature shall be maintained between 50°F and 90°F throughout refractory mixing and application operations.

3.3 All refractories shall be properly proportioned and thoroughly mixed in accordance with the manufacturer's instructions and specifications.

a. Each batch of similar type refractory shall be mixed to the same consistency and workability established by CONTRACTOR and approved by COMPANY.

1. CONTRACTOR shall submit for COMPANY approval the ASTM C860 Ball In Hand Test range at which the castable refractory will be cast.
2. CONTRACTOR shall submit for COMPANY approval the ASTM C181 Workability Index range at which the AA-22 erosion resistant refractory will be rammed.

b. Within the manufacturer's recommended water limits, only enough water shall be added to the refractory to achieve the approved application consistency and workability.

1. For the castable refractory, no more than 20 cups of water shall be added per 100 pounds of refractory without COMPANY approval.
2. For the erosion resistant refractory, no more than 6 cups of water shall be added per 50 pounds of refractory without COMPANY approval.

c. All refractories shall be poured or placed within the manufacturer's recommended time limitations. Refractory not used within the recommended time shall be discarded, and not remixed.

1. Castable refractory not applied within 25 minutes after the addition of water shall be discarded, and not reused.
2. Erosion resistant refractory not applied within 15 minutes after the addition of water shall be discarded, and not reused.

d. Refractory should be mixed only long enough to produce a uniform mix. Under no circumstances shall refractory be mixed longer than 5 minutes after the addition of water.

e. Only fresh, unused, non-recovered refractory shall be used.

f. Only clean, fresh, nonpolluted water suitable for drinking and free from injurious amounts of organic matter or other deleterious substances shall be used.

g. Refractory mixers shall be cleaned, and free of any contaminant, before mixing each batch of refractory.

3.4 Six pounds of clean, oil-free stainless fibers shall be mixed into every cubic foot of castable refractory (1.2% fibers by volume). The stainless fibers shall be screened to breakup knotted fiber and thoroughly mixed into the castable refractory to achieve a uniform distribution of randomly oriented fibers.

3.5 The castable refractory shall be vibration cast into each U-bend segment in one continuous operation in accordance with manufacturer's instructions and specifications.

a. Each U-bend segment shall be poured as a single continuous casting. If more than one pour is required to complete a U-bend segment, the time between pours shall be minimized and shall not exceed 30 minutes.
b. Sufficient vibration shall be applied to the U-bend to achieve a dense, uniform casting free of vapor pockets and voids.
c. Casting forms and molds shall be treated or coated to prevent premature loss of moisture during refractory curing, and to minimize refractory adhesion to the forms.
d. Within 30 minutes after completing a U-bend segment casting, all exposed refractory surfaces shall be coated with a color tinted curing compound approved by the refractory manufacturer.

3.6 The erosion resistant refractory shall be rammed into each hexmesh section in accordance with manufacturer's instructions and specifications.

a. Underlying castable refractory shall be clean and free of any contamination that would adversely affect adhesion.
b. Sufficient ramming and hammering shall be applied to the erosion resistant refractory in each hexmesh section to achieve a dense, uniform "biscuit" free of air bubbles, pocket and voids, and completely filling the hexmesh.
c. If a batch of refractory should stiffen before placement in the hexmesh, to the point where it is not binding together, the batch shall be discarded. Under no circumstances shall more water be added or the refractory remixed.
d. The erosion resistant refractory shall not be coated with a curing compound without COMPANY approval.

4. REFRACTORY CURING

4.1 All refractory shall be cured and dehydrated in accordance with manufacturer's instructions and specifications.

4.2 Prior to the installation of any refractory, CONTRACTOR shall provide, for COMPANY approval, a planned curing and dehydration schedule showing hold times, temperatures, and heating rates. The COMPANY approved schedule shall be followed for all refractory curing and dehydration.

4.3 All refractory shall be hydraulic cured at least 24 hours (or at least 48 hours if the temperature is below 65°F) before removing the casing forms.

4.31 The castable refractory shall be kept moist throughout hydraulic curing. A fine water (suitable for drinking) spray shall be applied to exposed refractory surfaces and casting forms as necessary to keep the castable refractory moist during hydraulic curing.

4.32 The erosion resistant refractory shall not be moist cured without COMPANY approval. Water or water spray shall not be applied to the erosion resistant refractory during curing. Erosion resistant refractory shall not be cooled from direct contact with the atmosphere.

4.33 Surrounding air temperatures shall be maintained between 50°F and 80°F during all refractory hydraulic curing.

4.34 After removing the casting forms, all refractory shall air dry at least 24 hours before heating for dehydration.

4.4 All refractory shall be thermally dehydrated to 600°F at a rate slow enough to prevent steaming. As a maximim, all refractory shall be dehydrated no faster than the following, with additional holds as necessary to prevent steaming.

4.41 Heat from ambient temperature to 250°F at no more than 25°F per hour.

4.42 Hold temperature at 250°F for at least 12 hours.

4.43 Heat from 250°F to 600°F at no more than 50°F per hour.

4.44 Hold temperature at 600°F for at least 6 hours.

4.45 Temperatures above are curing gas temperatures; not refractory or metal temperature.

4.5 The thermal dehydration of all refractory shall be done using only the convection heat of hot circulating gases. No portion of the refractory shall be subjected to flame impingement or direct radiation at any time during the thermal dehydration.

4.51 The gas temperature shall be continuously monitored and recorded throughout the dehydration procedure with at least 3 thermocouples, one at the middle and each end of each U-bend segment.

4.52 The temperature difference between thermocouples in a U-bend segment shall be minimized and not exceed 50°F.

4.53 The record of the thermocouples' temperatures shall be given to the COMPANY.

4.6 The U-bend metal temperature shall be continuously monitored and recorded throughout the dehydration procedure with at least 2 thermocouples evenly spaced on each U-bend segment.

4.61 The record of the thermocouples' temperatures shall be given to the COMPANY.

5. REFRACTORY REPAIRS

5.1 All refractory that does not meet all the requirements of this Specification shall be replaced or repaired, at CONTRACTOR's expense, in accordance with this Specification, including refractory mixing, application and quality control.

5.2 CONTRACTOR shall provide for COMPANY approval a planned curing and dehydration procedure for all repaired areas. Repaired areas shall be cured and dehydrated in accordance with the COMPANY approved procedure.

5.3 Small voids and large cracks in the castable refractory shall be chiseled out to sound adjacent refractory, and repaired with rammed Resco AA-22 or COMPANY approved equivalent.

5.31 Repair areas less than 1½ inches deep or covering less than 50 square inches shall be considered small.

5.4 Moderate sized voids and defective areas in the castable refractory shall be completely removed down to the U-bend exposing at least one entire V-stud.

5.41 The sidewalls of the repair area shall be angled outward 15-25 degrees such that the repair area adjacent to the U-bend is larger than the outer surface of the repair area.

5.42 Repair areas with only one exposed V-stud shall be rammed with fiber reinforced Resco AA-22 or COMPANY approved equivalent.

5.43 Repair areas with 2 to 4 exposed adjacent V-studs shall be re-cast with fiber reinforced castable refractory.

5.44 Repair areas with more than 4 exposed adjacent V-studs shall be considered major repairs.

5.5 Major voids and defective areas in the castable refractory shall be completely removed down to the U-bend in a band 360 degrees around the U-bend exposing at least two rows of V-studs. The removed refractory shall be re-cast with fiber reinforced castable refractory.

5.6 Defective erosion resistant refractory biscuits in the hexmesh shall be completely removed, and replaced with rammed erosion resistant refractory.

6. QUALITY CONTROL

6.1 Testing

6.11 Refractory studs:

All Nelson and V-stud attachment welds shall be hammer tested. All loose studs, bent over studs, and studs with cracked or partial attachment welds shall be removed, replaced, and retested.

6.12 Refractory Mix:

a. Each lot of refractory shall be pretested to determine the amount of water necessary to obtain the COMPANY approved consistency and workability. This water content shall be reported to COMPANY (as cups of water per 100 pounds of refractory) along with the refractory lot identification.

b. For every batch of refractory mixed, the total amount of water (in cups) and refractory (in pounds) added to the mix shall be reported to the COMPANY along with the refractory lot identification.

c. Every batch of mixed refractory shall be ASTM C860 and ball-in-hand tested for proper consistency and workability before casting or ramming.

6.13 Refractory Cure:

a. Each lot of refractory shall be pretested in accordance with ASTM C268 to determine its modulus of rupture with the specified reinforcing fibers. All refractory lots with an average modulus of rupture after thermal dehyration less than 1500 psi, or a single test valve below 1000 psi shall be rejected and not used.

1. CONTRACTOR shall provide COMPANY certified ASTM C268 test results for each thermally dehydrated test brick from every refractory lot tested. The test report shall also indicate the refractory dry weight (to the nearest 100 grams) of the test batch, and the amount of water added (to the nearest milliliter).

2. The ASTM C268 test batch of refractory shall be mixed using the amount of water necessary to obtain the COMPANY approved consistency and workability.

3. The five thermally dehydrated ASTM C268 test bricks shall be dehydrated at 1200°F rather than one of the ASTM C268 heating schedules.

4. The five, hydraulically cured only, ASTM C268 test bricks shall be clearly identified with the refractory lot number, and provided to COMPANY for information only.

C. The cold crush strength of each batch of mixed refractory shall be determined in accordance with ASTM C133 modified as follows:

1. A 2 inch by 2 inch by 2 inch cube test specimen shall be used instead of the ASTM C133 specimen.
2. Nine specimens shall be tested from each batch of refractory mixed.
3. The refractory specimens shall be hydraulically cured 24 hours and thermally dehydrated 18 hours at 250°F before testing.
4. CONTRACTOR shall report all cold crush test results (to the nearest 10 psi) to COMPANY, along with the required water content report. In addition, the location of each batch within the U-bend segments shall be reported to COMPANY.

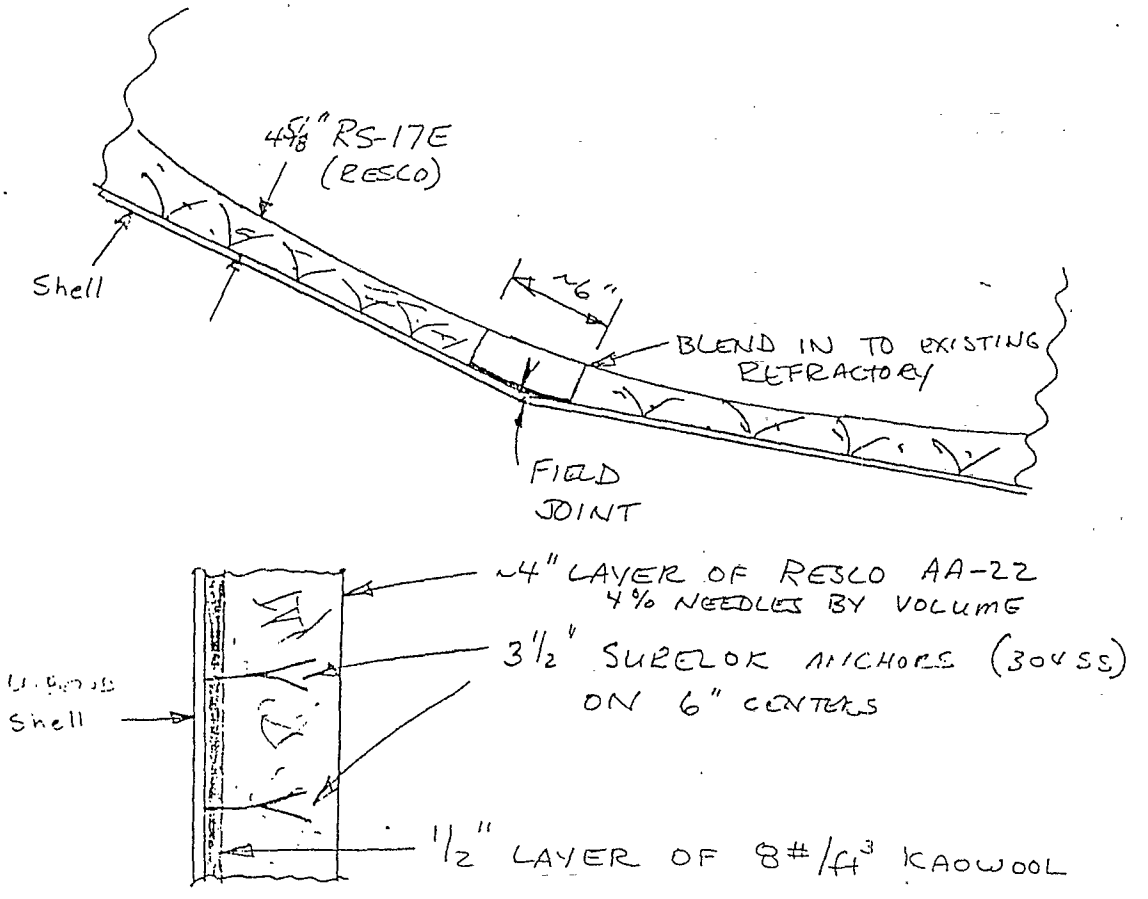
   All refractory batches with an average cold crush strength less than 8000 psi, or a single test valve below 5000 psi shall be rejected and replaced.

6.2 Inspection

6.21 COMPANY inspectors and representatives shall have access to CONTRACTOR's facilities to inspect the refractory during all phases of installation, including anchoring, mixing, application, curing, and testing.

6.22 CONTRACTOR shall visually inspect all exposed refractory, after it has been cured and thermally dehydrated, for cracks, voids, spalling, and unbounded material.

a. Cracks deeper than one inch or wider than 1/16 inch are unacceptable, and shall be repaired.
b. Voids and holes deeper than 3/16 inch or wider than ¼ inch are unacceptable, and shall be repaired.
c. Any and all spalling or blistering is unacceptable, and shall be repaired.
d. Unbounded or soft refractory more than 1/8 inch deep is unacceptable, and shall be repaired.
e. Erosion resistant refractory more than 1/16 inch below the hexmesh edge is unacceptable, and shall be repaired.
f. The refractory radial mismatch between adjacent U-bend segments shall not exceed 1/8 inch.
g. Segregation or preferential alignment of the reinforcing fibers is unacceptable, and shall be repaired.



DETAIL OF FIELD JOINT

REGEN U-BEND REFRACTORY

FIELD JOINTS

ECC