MSHA Approval Number 120M-14.0
120 PSI Reinforced Wall Seal
Installation Manual
For Seals Up to 12 Feet in Height

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Strata Mine Services, Inc.
Seal Installation Guidelines for
120-psi Reinforced HIGH STRENGTH STRATACRETE Seal

1.0 SITE SELECTION AND PREPARATION

1.1 This seal is designed to be used in a mine opening up to 12 feet in entry height and 16 feet to 40 feet in entry width. Please see the Seal Design Table for specific dimensions at varied heights and widths of entry.

1.2 It is recognized that conditions such as pressure piling, risks of spontaneous combustion, and detonation in the area to be sealed, etc. may require seals with more than the 120 psi design strength. Under those conditions, this seal is not applicable.

1.3 Any loose roof, floor, or rib material shall be removed with various means prior to seal installation.

1.4 Soft floor or soft fireclay that will compromise the integrity of the seal will be removed to competent material.

1.5 The seal shall be located at least 5 feet from the corner of any pillar, but preferably 10 feet from the corner of any pillar. If located less than 10 feet from the corner of the pillar, ribs will be reinforced by the application of Gunite or Shotcrete, or equivalent, a distance of 10 lineal feet along the ribs. If on the inby side of the seal, this will be done before the seal is installed. If outby the seal, this can be done before or after erecting the seal. The governing enforcement district may require any additional reinforcement or remediation they deem necessary.

1.6 Roof or rib support bolting and bearing plates shall be left in place at the seal location. Metal objects such as roof mesh, straps, rails that extend into the seal will be removed.

1.7 This design uses transfer of shear to the surrounding strata as part of its ability to withstand a 120 psi overpressure. The roof and floor need minimum shear strength of 400 psi. It is imperative the surface is clean and all unstable material is removed.

1.8 No standing water shall be present inside the seal footprint when the pumping of the seal starts. Area may be damp. Puddles may be dried by the application of dry Block Bond. Water shall not be deeper than the invert of the water system in that seal during the initial curing of 24 hours.

1.9 Standing water shall be pumped from the seal location. Flowing water shall be diverted around the seal location or collected and pumped from a sump to prevent the area of seal construction from becoming a collecting point for water during the initial curing of 24 hours.

1.10 Supplemental roof support is not required in the seal design. Supplemental roof support will be installed inby and outby the seal area to meet the roof control plan of the mine.

1.11 The strata at the seal perimeter should be as rough as practically possible and smooth surfaces shall be minimized. Surfaces with roughness less

than 1 inch per 4 linear feet must be mechanically roughened to increase the shear resistance at the seal interface. Alternatively, undulations may be cut into the strata to increase the shear resistance along the plane. The 120psi STRATACRETE REINFORCED WALL SEAL is a symmetrically designed seal.

1.12 The mine opening geometry in the area of the seal shall be inspected to ensure the rib, roof, and floor lines do not deviate significantly from parallel through the seal area. The rib lines and the roof and floor lines shall be roughly parallel. Diverging surfaces may significantly reduce the shear resistance along the plane, in the event of an explosion and depending upon the location of the explosion. In areas where the floor, roof, or rib lines diverge, the area in contact with the seal shall be excavated to create a surface that is roughly parallel to the opposite side.

1.13 A Professional Engineer (P.E.) will certify the areas are applicable for this reinforced seal. Rib, roof, and floor must be deemed competent by the P.E.

1.14 Roof, ribs and floor need to be cleaned to at least 3 feet inby and outby the seal.

2.0 PULL TESTS

2.1 This design requires anchoring of rebar. Rebar will be as per Seal Design Table. All vertical rebar will be Grade 60 and of the size #9 as listed in the Seal Design Table. Rebar will meet specification ASTM A615/ A615M. Boreholes for rebar will be a minimum of 24 inches in depth.

2.2 Pull tests will be conducted on site in areas representative of the seal locations, verified, and certified by the certified person designated by the mine operator to directly supervise construction of the seal. An acceptable depth of hole is one that gives an anchorage of 90% of the #9 rebar's yield (54,000 psi).

2.3 Borehole diameters will be as recommended by the grout manufacturer.

2.4 Commercial grout formulations such as FASLOC or MINOVA Lockset suitable for bar/hole size will be used. Rebar will be free of surface dirt and loose scales. Minor surface rust will be acceptable.

2.5 Test holes will be drilled in the roof and floor a minimum of 2' for testing.

2.6 Adequate resin will be inserted into the hole to ensure the hole is fully grouted.

2.7 Rebar will be installed and rotated in the hole according to the manufacturer's recommendations.

2.8 Resin should set in accordance with manufacturer's recommendations.

2.9 A pull test will be performed until 27 tons is reached. If the hole will not develop the required anchorage, additional holes will be tested at increased depths until the required anchorage is reached. This will be done on the roof and the floor of the area.

2.10 Results will be recorded and the test area will be marked for future observation.

2.11 The certified person designated by the mine operator will supervise the anchorage test and furnish these results to the certifying Professional Engineer.

3.0 PREPARATION OF INDIVIDUAL SEAL AREAS

3.1 If poor ground conditions (e.g., severe cutter roof, floor heave, bedding separation, rib slough age, etc.) are present, then remediation or an alternate location shall be selected for the seal(s). Areas with roof, floor, and rib fissures are not appropriate for installation of this seal. If water accumulation is possible at the seal location, floor strata that can be affected by water, such as fireclay, shall be removed down to competent rock. The seal shall not be located where a geologic feature, such as a fault or open joint, would compromise the performance of the seal.

3.2 Any loose roof, floor, or rib material shall be removed prior to seal installation.

3.3 All floor accumulations between the seal and the weir will also be removed from the floor of the area. Examples of material removed are loose coal and roof, soft or broken floor or fireclay, thick rock or coal dust, and oily residue. This can be accomplished with approved use of hand tools or with machinery, as needed, in accordance with approved state and federal mining plans.

3.4 All debris will be removed 50 feet inby and outby the seal location.

3.5 Soft floor or soft fireclay that will compromise the integrity of the seal will be removed.

3.6 The seal shall be located at least 5 feet from the corner of any pillar, but preferably 10 feet from the corner of any pillar. If located less than 10 feet from the corner of the pillar, ribs will be reinforced by the application of Gunite or Shotcrete, or equivalent, a distance of 10 lineal feet along the ribs. If on the inby side of the seal, this will be done before the seal is installed. If outby the seal, this can be done before or after erecting the seal. The governing enforcement district may require any additional reinforcement or remediation they deem necessary.

3.7 Roof or rib support bolting and bearing plates shall be left in place at the seal location. Metal objects such as roof mesh, straps, and rails that extend into shall be removed.

3.8 This design uses transfer of shear to the surrounding strata as part of its ability to withstand a 120 psi overpressure. The roof and floor need minimum shear strength of 400 psi. It is imperative the surface is clean and all unstable material is removed. If roof and floor strata is unstable, the seal will be moved to an alternate location.

3.9 No standing water shall be present inside the seal footprint when the pumping of the seal starts. Area may be damp. Puddles may be dried by the application of dry Block Bond. Water shall not be deeper in depth than the invert of the water system in that seal during the initial curing of 24 hours.

3.10 Standing water shall be pumped from the seal location. Flowing water shall be diverted around the seal location or collected and pumped from a sump to prevent the area of seal construction from becoming a collecting point for water during the initial curing of 24 hours.

3.11 Supplemental roof support is not required in the seal design. Supplemental roof support will be installed inby and outby the seal area to meet the roof control plan of the mine.

3.12 The strata at the seal perimeter should be as rough as practically possible and smooth surfaces shall be minimized. Surfaces with roughness less than 1 inch per 4 linear feet must be mechanically roughened to increase the shear resistance at the seal interface. Alternatively, undulations may be cut into the strata to increase the shear resistance along the plane. The 120psi STRATACRETE REINFORCED WALL SEAL is a symmetrically designed seal.

3.13 The mine opening geometry in the area of the seal shall be inspected to ensure the rib, roof, and floor lines do not deviate significantly from parallel through the seal area. The rib lines and the roof and floor lines shall be roughly parallel. Diverging surfaces may significantly reduce the shear resistance along the plane, in the event of an explosion and depending upon the location of the explosion. In areas where the floor, roof, or rib lines diverge, the area in contact with the seal shall be excavated to create a surface that is roughly parallel to the opposite side.

3.14 The width, height, and setbacks must be re-measured after all preparation work is complete to determine if the seal is applicable for the location and to determine the correct thickness and rebar spacing of the seal. Strata in roof and floor after cleaning should be the same type of strata in which pull tests were conducted.

3.15 The location of the proposed seal must be marked.

4.0 MATERIAL LIST

4.1 MSHA approved sealant.

4.2 HIGH STRENGTH STRATACRETE mix (3,700 lbs/yd^3).

4.3 HIGH STRENGTH STRATACRETE mixer and pump.

4.4 BASF Meyco 364 Flex Urea Silicate Grout

4.5 Foam Kits for perimeter sealing (example: Fomo Silent Seal 20 psi Comp. Strength).

4.6 Grout pumps.

4.7 Grade 60 rebar and accessories.

4.8 16 Gauge Tie Wire

4.9 Shotcrete or Gunite and machine (optional)

4.10 Shotcrete Mix or Gunite Mix (optional)

5.0 MATERIAL STORAGE, HANDLING AND QUALITY CONTROL

5.1 The HIGH STRENGTH STRATACRETE mix, if delivered underground in bags, shall be delivered in sealed bags, preferably on pallets or other means and should be kept from direct moisture.

5.2 The cementitious materials shall be stored in weather-tight containers and hardened material will be discarded. Adequate quality control measures will be taken by the manufacturer to ensure the consistency of the STRATACRETE Mix. Testing will include sieve analysis, compressive strength tests, flowability tests and unit weight tests. Any material that does not meet minimum standards as established by the manufacturer shall be discarded.

5.3 Admixtures which have been in storage at the project site for longer than 6 months, have an expired use date or which have been subject to freezing shall not be used unless they are retested by the manufacturer and proven to meet the specified requirements as set by the manufacturer. A record will be made and maintained of the date the admixture was received at the site. Admixture will be stored in a location not subject to freezing in the warehousing area or in the underground location. If suspect admixtures are not tested, they will be discarded.

5.4 HIGH STRENGTH STRATACRETE may be delivered via mixing truck from a local concrete plant and delivered underground through a borehole(s) near the construction site. If mixed at a concrete plant, Strata representatives will instruct the concrete plant personnel to ensure accurate and repeatable HIGH STRENGTH STRATACRETE batches are consistently produced. Records of material used in individual batches will be kept.

5.5 Concrete blocks, if used for formwork, will be delivered in pallet form. The certified person designated by the mine operator to directly supervise construction of the seal will certify the materials are of the same quality and type as per design.

6.0 REINFORCEMENT CONSTRUCTION

6.1 Vertical rebar spacing will be 12 inch centers with a tolerance of -2 inches as specified in the seal design table.

6.2 If vertical spacing is greater than specified, an additional vertical rebar may be placed between the ones with the excess spacing. Roof to floor offset tolerance will be 3 inches.

6.3 Anchorage hole depths and diameters will be according to the results of the pull tests.

6.4 The edge of the hole closest to the face of the seal shall be spaced 2 ½ inches from the face of the seal with a tolerance of +/- 1/2 inch. Rebar in the roof and floor will be coupled using couplers and or spliced with the required lap as specified in Seal Design Table to form a continuous tie vertically for each set of vertical reinforcements on the inby and outby

faces of the seal. Couplers shall be threaded onto each dowel rod until either it is threaded at least one half of the coupler length or until it bottoms out on the centering pin. Information for couplings is given in 17.1. Tie wire will be 16 gauge or larger.

6.5 This seal design does not require hitching.

6.6 This seal design does incorporate internal reinforcement. The vertical members will be the same rebar specified above that is anchored into the roof and floor. The horizontal members will be of the grade, specification, and diameter as specified in the Seal Design Table.

6.7 Horizontal spacing will be as specified in the Seal Design Table with a tolerance of -2 inches. Because of different void heights, some vertical spacing may be closer than the table measurements. All laps and intersections will be tied with #16 gauge or larger tie wire. Horizontal members shall be between 6 inches and 2 inch of ribs. Coupling and splices are installed as to be staggered and not aligned in a plane. All rebar shall have at least 2 inches of concrete coverage.

6.8 Roof and floor holes can be drilled with a hand held drill or a roof drill in accordance with approved state and federal mining plans. Holes will be drilled at least 2 feet deep or the depth that achieved adequate anchorage from the pull tests, whichever is greater.

6.9 Resin will be installed in the hole. Rebar will be inserted through the resin and rotated the recommended time and speed as specified by the manufacturer of the resin.

6.10 Care will be taken to ensure the roof holes and the floor holes are within the required tolerance for offset.

6.11 Couplers will be added to the vertical members to add additional rebar.

6.12 Top and bottom rebar will overlap a minimum of 32 inches with at least 3 tie wires per lap. Horizontal rebar will be lapped a minimum of 21 ½ inches and tied with #16 gauge tie wire. Vertical rebar will have extensions coupled to them to lap a minimum of 32 inches. Tie wire will be #16 gauge or larger.

6.13 After all of the vertical rebar on a side of the seal is installed, the horizontal rebar will be installed. Rebar will be tied to the vertical rebar each time they cross.

6.14 The same installation procedures will be done on the other side of the seal.

6.15 The certified person designated by the mine operator will recheck the reinforcement and certify the reinforcement is as designed before the seals are completed.

7.0 FORM CONSTRUCTION

7.1 Formwork shall withstand the forces resulting from the placement of wet STRATCRETE with minimal deflection. Form ties, if necessary, shall be of a non-metallic design, will not permit form deflection and will not spall concrete upon removal. Forms can be steel concrete block, plywood, or

wood board construction. An existing seal can also be used as one of the form walls for the new seal. If a form “kicks” during construction, remedial measures will immediately be taken to contain the pour. If it is determined and documented by a Professional Engineer that the seal integrity will not be compromised, the seal will be completed after corrections are made.

7.2 Forms shall be built as to maintain the minimum seal thickness throughout the seal.

7.3 Forms will be constructed plumb within 1/4" per foot. Seals constructed in highly pitching seams will be constructed perpendicular to the roof and floor.

7.4 Forms shall be mortar tight. This shall be done by installing plastic curtain material on the inside of the framework. Curtain material shall be lapped on roof, ribs, and floor between 2 inches and 4 inches.

7.5 Vent pipes shall also be provided to allow air within the forms to vent. The vent pipes shall be configured in an L-shape so the end of the pipe in the seal is positioned vertically and close to the roof. The diameter of the pipe shall be at least 1 inch in diameter and less than 3 inches in diameter to let the air vent and then the pipe to fill with HIGH STRENGTH STRATACRETE. The gap between the roof and the end of the pipe shall be adequate to allow the pipe to fill with HIGH STRENGTH STRATACRETE, but as close to the roof as practical to assure the air is completely evacuated, preferably about 1 inch. A minimum of 3 vent pipes will be used. They will be spaced approximately equally across the seal. This requires a minimum of 3 vent pipes and vent pipes in any void in the roof greater than 12 inches in diameter and 3 inches in depth. Valves shall be provided on the filling ports to allow the flow of HIGH STRENGTH STRATACRETE to be stopped without the loss of HIGH STRENGTH STRATACRETE through the filling port. The filling ports must be completely filled with HIGH STRENGTH STRATACRETE when the placement is completed. Caps or valves shall also be provided on the vent pipes so the vent pipe can be shutoff once the vent pipes are returning concrete. Where the roof is uneven such that it creates recessed pockets, a vent pipe shall be installed to allow air to evacuate and allow the HIGH STRENGTH STRATACRETE to contact the roof. Vent pipes shall also be placed wherever the roof line peaks or crowns.

7.6 Surfaces upon which HIGH STRENGTH STRATACRETE is to be placed against shall be free from dirt, debris, rock dust, oil, standing or running water, and unstable material.

7.7 Form ties, if used, shall be non-metallic and non-conductive. An example of this type of form tie is the structural fiberglass type.

7.8 The certified person designated by the mine operator will recheck the forms and certify the forms are as designed before the seals are completed.

8.0 GAS SAMPLE PIPES

8.1 Each seal shall have non-metallic, corrosive-resistant PVC pipe with metal valves for sampling gases behind the seal.

8.2 One non-metallic gas sampling pipe shall be installed in each seal that extends into the center of the first crosscut inby the seal. If an open crosscut does not exist, the sampling pipe shall extend one-half of the distance of the open entry inby the seal. The inby end of the pipe shall be up to 18 inches from the roof and shall be at least 6 inches from the roof and ribs when it is going through the seal. The pipes shall be supported by hangers or on cribbing.

8.3 The sampling pipes shall be ½-inch inside diameter with an internal pressure rating of 240 psi. Each sampling pipe shall be equipped with a shut-off valve, rated at strength to withstand a 240 psi overpressure, and appropriate fittings for taking gas samples. All connections shall be able to withstand a 240 psi overpressure.

8.4 One non-metallic gas sampling pipe rated at 240 psi shall be connected to each sampling pipe in each seal, if the seal is placed on the outby side of an existing seal. The new sampling pipe will have a new 240 psi shutoff valve installed outby the seal. If any space is between the new and existing seal, that space will also have a sampling pipe of the same specification. All connections shall be able to withstand a 240 psi overpressure.

8.5 If an existing seal is used for the back wall of this seal, air sample pipes will be connected to and extended through the new seal for sampling, if necessary. All connections shall be able to withstand a 240 psi overpressure.

9.0 WATER DRAINAGE SYSTEMS

9.1 The pipes used shall be corrosion resistant, have equivalent strength properties of a schedule 80 smooth wall steel pipe *(240 psi internal pressure rating*) and be non-metallic. The drainage system shall be equipped to prevent the exchange of air through the pipe(s). A water trap and valve shall be installed on the outby side of each drainage pipe. The valve and its connections shall have blast resistance equivalent to 240 psi overpressure.

9.2 The actual size and number of pipes shall be based on the anticipated maximum flow rate at the seal location. Five (5) drainage pipes will be the maximum in any one seal. The Drain pipes shall be positioned at least three (3) feet from the nearest rib. If more than one drainage pipe is installed in a seal, they shall be at least three (3) feet (-2”) from the nearest pipe (edge to edge measurement) with slight variations to miss steel reinforcement. Horizontal rebar can be cut to miss drain pipes. Pipes shall be installed as low as practical to minimize the depth of water against the seal with at least 2 inches of STRATACRETE between the floor and

the bottom of the pipe. Traps may be recessed in the floor. Pipe sections shall be joined in accordance with the pipe manufacturer's installation recommendations. Pipe joints and couplers shall have resistance to internal pressure which is equivalent to the pressure rating of 240 psi overpressure.

9.3 The drainage system shall be installed during seal construction in the lowest elevation seal(s) of the set. This seal is not designed to impound water other than to a minimal, unavoidable depth. The invert of the water drainage pipe is placed no higher than 12 inches from the mine floor. Water may accumulate up to 12 inches in depth against the seal before water is drained off the seal. Normal mine water will not adversely change the performance of the HIGH STRENGTH STRATACRETE Reinforced Wall Seal.

9.4 The water drainage system shall be checked at an interval specified by the governing enforcement district and used to ensure water, other than the depth to the bottom of the pipe invert, is not being impounded by the seal.

9.5 The minimum pipe inside diameter shall be 4 inches and the maximum pipe inside diameter shall be 8 inches. The pipes used shall be corrosion resistant, have equivalent strength properties of a schedule 80 smooth wall steel pipe *(240 psi internal pressure rating*) and be non-metallic. The valve and its connections shall have blast resistance of 240 psi overpressure.

9.6 The valve shall be installed on the inby side of the water trap. Water traps shall be U-shaped and the vertical depth of the U shall be large enough that a sufficient quantity of water or mineral oil can be maintained in the trap to prevent evaporation prior to the scheduled periodic examination. The U-portion of the water trap may be recessed into the mine floor, if necessary, to minimize the depth of water against the seal and to strengthen its blast resistance.

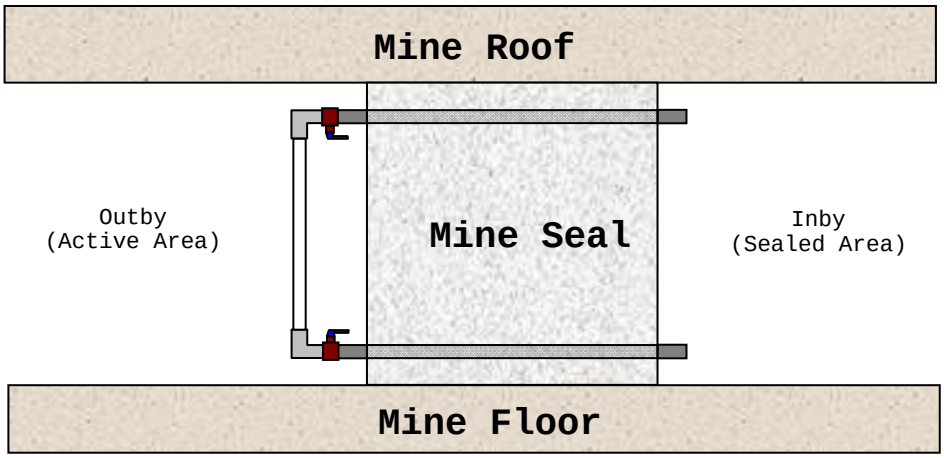
9.7 A low weir(s) or catchment, no more than 12" high, will be constructed across the entry inby the seal to trap sediment and debris that may clog the drainage pipe(s).

9.8 If seal is placed on the outby side of an existing seal, water drainage pipes connected to existing drainage pipes will have the water trap removed, non-metallic, corrosive resistant 240 psi pipe of an appropriate length added to the system with a 240 psi water trap and a 240 psi shutoff valve of the proper size added outby the new seal, if needed. The old shutoff valve will be opened before the seal construction is completed.

9.9 If an existing seal is used for the back wall of the new seal and water drainage pipes are present, they shall be extended, if necessary, with non-metallic pipe of the same size with an internal pressure rating of 240 psi. New traps, if necessary, will be installed.

9.10 Any individual seal with a water drainage system may also incorporate a water height measuring system. If used, this measuring system must be initially built into the seal in a manner that could establish the height of

water on the inby side of the seal. A water height measuring system, incorporating a sight tube as shown below, shall consist of two horizontal up to 1 inch inside diameter non-metallic pipes installed through the seal. One pipe shall be securely installed through the seal at the approximate height of the top of the water trap and the other pipe shall be securely installed through the seal as close to the roof as possible. On the outby side of each pipe, a shut-off valve shall be installed. Each shut-off valve and pipe extending through the seal must have an internal pressure rating of 240 psi. Two 90 degree elbows shall be installed on the outby end of each pipe after the valves are in place. A clear plastic tube shall be securely placed between these elbows for viewing of the water elevation. The elbows and the clear plastic tubing must only have strength that would allow them to perform the functions for which they were installed.



10.0 QUALITY CONTROL

10.1 Prior to the construction of the seal, the certified person designated by the mine operator to directly supervise construction of the seal shall:

a. verify the core of the seal is of the specified width;
b. check the cavity to be filled with HIGH STRENGTH STRATACRETE is free of loose material, dirt, debris, and rock dust;
c. ensure the formwork is compliant with the plan;
d. ensure the cementitious materials, water, admixtures, and pozzolans used in the concrete production are in accordance with the material requirements and mix design.

10.2 The certified person in charge of the construction of the seal will direct the construction project. All employees will be trained in their assigned tasks. Employees will be given a MSHA 5000.23 document showing their training. Questions and observations will be used to verify task training. A copy of the construction manual will be available at all times to the workers constructing the seal.

10.3 The STRATA 120 psi High Strength STRATACRETE Reinforced Wall Seal shall only be installed by personnel who either:
   a. have been trained on the installation of the STRATA 120-psi High Strength STRATACRETE Reinforced Wall Seal and are working under the direction of a Strata representative or,
   b. are trained Strata employees.

10.4 Materials used in constructing HIGH STRENGTH STRATACRETE seals are similar to normal underground concrete products, steel products and grout products. Normal precautions will be taken in the use and handling of such items. Personal Protective Equipment (PPE) necessary for safe handling of the material will be provided to the workers.

10.5 Concrete blocks, if used, for formwork will be delivered in pallet form.

10.6 Strength specimens shall be made to determine the unconfined compressive strength of the HIGH STRENGTH STRATACRETE. Test specimens shall be poured and cured in accordance with ASTM C31 and C31M standards and tested in accordance with C143 and C143M ASTM standards..

10.7 A minimum of two sets of testing cylinders shall be made per seal. If a seal is placed in more than one lift or pour, a set of specimens shall be made for each lift. A minimum of seven HIGH STRENGTH STRATACRETE cylinders shall be made per set, and shall be field-cured at the seal location. Three field-cured cylinders from each strength specimen set shall be tested at seven (7) days, and three (3) cylinders from each set shall be held in reserve in the event the seal does not reach the required minimum strength at seven (7) days. The sample cylinders will be three (3) inches in diameter by six (6) inches in length molds prepared in accordance to ASTM C 470-02a. The reserve cylinders may be used to verify the HIGH STRENGTH STRATACRETE strength at a later age to determine if the required minimum strength is achieved.

10.8 Samples will be cured underground at the seal site for a minimum of seven (7) days until shipped to the approved testing facility.

10.9 In accordance with ACI 318, the required minimum compressive strength of any tests shall be 4,600 psi to assure all HIGH STRENGTH STRATACRETE placed in the seal can reliably achieve the minimum design strength of 4,000 psi. The certified person designated by the mine operator to directly supervise construction of the seal will certify the samples are taken and cured as per design and delivered in a timely manner to the lab.

10.10 The seal should meet design strength in approximately seven (7) days after completion of construction. The samples shall be the final determinate for when the seals are acceptable.

10.11 If the first set of samples fails, in seven (7) days, the second set of samples will be tested. If these samples fail, MSHA will be notified and corrective measures up to replacing the seal will be performed according to measures approved by MSHA.

10.12 A certified independent lab, Geolab Material Testing of Lexington, Kentucky, or another certified laboratory approved by MSHA, will test the samples for strength and quality control.

10.13 At the appropriate time, the mine foreman or his designee will have the samples transported from underground to the certified testing facility for strength testing.

10.14 Seals are not considered to reach design strength until acceptable sample results have been received and approved by the MSHA District.

11.0 POURING OF THE HIGH STRENGTH STRATACRETE

11.1 A continuous water source will be provided to the seal site during pouring of STRATACRETE that is of a pressure and volume necessary to flush pump lines. Water will be the same quality as the mine fresh water system unless it is determined mine fresh water is detrimental to the production of concrete. Water will conform to ASTM C1602 / C1602M-06 –Standard Specifications for Mixing Water Used in Hydraulic Cement Concrete. If mine water is used for seal construction, it will be sampled to determine if it meets ASTM standard specifications. If HIGH STRENGTH STRATACRETE will be batched on site, the batch proportions shall be recorded to help ensure accurate and repeatable HIGH STRENGTH STRATACRETE batches are consistently produced.

11.2 Proportions of water, pozzolans, admixtures, and cement, as necessary, shall be identified on the data sheets. The amounts of each constituent used will be consistent with the laboratory tested material.

11.3 Water reducing and retarding admixtures shall conform to ASTM C494/494M, type A, B, D, F, or G, except that the 6 month and 1 year compressive and flexural strength tests are waived.

11.4 During the construction of the seal, the person certifying construction of the seal shall:

a. ensure the concrete is thoroughly consolidated, completely fills the void between the forms, and is tight against the ribs and roof;
b. verify all construction joints are cleaned and adequately prepared if the concrete is placed in multiple lifts.

11.5 Following the construction of the seal, the certified person designated by the mine operator to directly supervise construction of the seal shall ensure the HIGH STRENGTH STRATACRETE is properly cured using formwork, sheeting, and/or a sprayable curing compound.

11.6 Workers and other miners installing seals and materials will be furnished approved respirators, hearing protection, gloves, and other personal protective equipment necessary to ensure compliance with the standards affecting the health and safety of miners installing seals and handling seal material.

11.7 The concrete shall be covered for a minimum of seven (7) days to allow proper curing. The concrete can be covered by leaving formwork in place, by covering with impervious sheet materials conforming to ASTM C171, or

by using a membrane-forming curing compound conforming to ASTM C309. For concrete placed in multiple lifts or pours, the top surface of the lift shall be enclosed with formwork and shall not be covered with membrane-forming curing compounds. Membrane-forming curing compounds shall not be used on the top surface of lifts since this may interfere with the concrete bond between lifts. The forms shall not be loosened until the concrete has achieved adequate strength to prevent damage to the concrete. If the temperature during seal construction is below 32 degrees, measures shall be taken, such as use of a protective enclosure, to ensure the air temperature at the seal is kept above 40 degrees for at least 72 hours. Normally a seal form made of 3/4" plywood or concrete blocks will achieve this protection.

11.8 This is a high slump material and should not need vibration. A spread test will be used to determine if the material is fluid enough. A 3 inch by 6 inch cylinder will be filled and then removed from the STRATACRETE. A minimum of a 6 inch spread shall be observed. HIGH STRENGTH STRATACRETE will be worked into the corners of the forms without permitting the material to segregate.

11.9 HIGH STRENGTH STRATACRETE for the Reinforced Wall may be poured in multiple lifts or pours. STRATACRETE may be pumped through fill pipes or through doors in the forms. Multiple placements may be advantageous for controlling thermal and shrinkage effects, as well as minimizing the loads on the formwork. When the seal is placed in multiple lifts, the time between lifts should be at least 12 hours. HIGH STRENGTH STRATACRETE shall be supplied at a rate of at least 1 foot of depth per hour which will prevent cold joints. However, in the event a cold joint is unavoidable, the hardened surface shall be scarified and loose material shall be removed to ensure the lifts are adequately engaged.

11.10 HIGH STRENGTH STRATACRETE must be tight against the roof with no voids, pockets, gaps or separations. This will require the inby and outby formwork to be tight against the roof. Adequate access shall be provided through the formwork using windows and ports to place and consolidate the HIGH STRENGTH STRATACRETE so it is tight against the roof. At least 3 vent pipes will be spaced across the seal to allow for the tight placement of STRATACRETE to the roof. Pipes for concrete placement may be installed through the formwork so the HIGH STRENGTH STRATACRETE may be pumped into the form. The formwork must be adequate to support the loads imposed by the pumping. Strata experience has shown this requires either bolting form supports to the roof and floor and or using form ties from front to back at the top and bottom of each form support leg. If there is any loss of contact between the seal and the roof, floor, or ribs due to shrinkage, the voids shall be filled with BASF Meyco 364 Flex Urea Silicate Grout. If air leakage is determined to be only outby the seal and there is no loss of contact between the seal and the surrounding strata, a non-structural sealant may be used.

11.11 The spacing of the vent pipes shall be adequate to assure the HIGH STRENGTH STRATACRETE is placed the full depth and width of the seal to the roof. This requires a minimum of 3 vent pipes and vent pipes in any void in the roof greater than 12 inches in diameter and 3 inches in depth. This may require the outlet of the pipes to be staggered and the HIGH STRENGTH STRATACRETE placement through the pipes staged to ensure the HIGH STRENGTH STRATACRETE is placed in a continuous and uniform placement across the contact with the roof.

11.12 An alternative method of applying the HIGH STRENGTH STRATACRETE is spraying with a Gunite or Shotcrete Machine. Only a back form wall would be installed when spraying HIGH STRENGTH STRATACRETE. This formwork can be sheet metal. This material is a low slump material. When spraying HIGH STRENGTH STRATACRETE, vent pipes or filling ports wi**ll** not need to be installed. All other installation, safety, and testing procedures shall be followed.

11.13 The ambient curing temperature of the HIGH STRENGTH STRATA-CRETE is less than 215 degrees F at the c**o**re of the seal.

12.0 ALTERNATE INSTALLATION METHOD

12.1 If a Gunite or Shotcrete machine is used, all previous sections except section 7.0 FORM CONSTRUCTION and section 11.0 POURING OF THE HIGH STRENGTH STRATACRETE apply.

12.2 Only the back wall will be built for this method of construction. No vent pipes or supply pipes will be in the seal. Shotcrete or Gunite shall be tested by the manufacturer prior to shipment to insure the quality of the product.

12.3 A minimum of two test panels for each ventilation seal will be constructed.

- Each test panel is to be constructed in accordance with ASTM C1140 with no less than 14” Wide x 14” Length x 3 ½” Depth so to enable a **minimum of 2** (no less than 2” dia.) cores or 2 (no less than 2”) cube samples to be procured and tested from each test panel for compressive strength testing to the design strength minimum of 4,000-psi. ***Note**: ASTM C1140 allows for variant core size samples with correction factors to be used. Strengths for this test shall be a minimum of 4,600 psi regardless of specimen size.
- Each test panel is to be field cured in the mine at the seal location before being transported out of the mine for testing.

12.4 Shotcrete shall be placed into the forms using the dry-mix Shotcrete process. Material is fed into the Shotcrete hopper directly or with a pre-dampener. Compressed air conveys the material to the nozzle. Water is injected at the nozzle for placement or may be premixed before it is pumped to seal site.

12.5 Water will be the same quality as the mine fresh water system unless it is determined mine water is detrimental to the production of concrete. Water

will conform to ASTM C1602 / C1602M-06 – Standard Specifications for Mixing Water Used in Hydraulic Cement Concrete. If mine water is used for seal construction, it will be sampled to determine if it meets ASTM standard specifications.

12.6 All Shotcrete sprayers shall have had experience and/or training in the application thereof.

12.7 The ventilation seal must be Shotcreted in place with no less than 2" clear cover provided for the rebar.

12.8 If placement of Shotcrete is interrupted for more than 1-hr, the following steps will be completed before resuming the placement of Shotcrete:

- A rinse-coating of water will be applied as a bonding agent to the ventilation seal until the entire surface has a wet-shine appearance.
- A waiting period will be observed for the water to drain off or absorb into the ventilation seal surface before resuming the placement of Shotcrete.

12.9 If placement of Shotcrete is interrupted for more than 4-hrs, the following steps will be completed before resuming the placement of Shotcrete.

- The applied ventilation seal surface will be cleaned thoroughly with pressured air and water to remove any loose material. A waiting period will be observed for the water to drain or absorb into the ventilation seal surface.
- Another rinse-coating of water as a bonding agent to the ventilation seal will be applied until the entire surface has a wet-shine appearance.
- A waiting period will be observed for the water to drain off or absorb into the ventilation seal surface before resuming the placement of Shotcrete.

13.0 METHODS TO REDUCE AIR LEAKAGE

13.1 Seals shall be installed at least five feet from the corner of any pillar to reduce air leakage around the seal. Measures shall be taken to ensure the HIGH STRENGTH STRATACRETE is placed tight against the roof. If necessary to prevent leakage, the perimeter of the seal shall be ring grouted after the seal cures. Grout will be injected under pressure through pre-existing pipes or through in the strata around the perimeter of the seal. No seal will be drilled through unless approval is granted through the governing enforcement district. Grout will be either cementitious or two-part polyurethane or urea silicate. The certified person designated by the mine operator to directly supervise construction of the seal will certify the construction is as per design and materials are of the same quality and type as per design.

13.2 The seal shall be located at least 5 feet from the corner of any pillar, but preferably 10 feet from the corner of any pillar. If located less than 10 feet from the corner of the pillar, ribs will be reinforced by the application of Gunite or Shotcrete a distance of 10 lineal feet along the ribs. If on the

inby side of the seal, this will be done before the seal is installed. If outby the seal, this can be done before or after erecting the seal. The governing enforcement district may require additional reinforcement or remediation they deem necessary.

13.3 If shrinkage is encountered that causes the seal to not contact the roof or ribs, BASF Meyco 364 Flex Urea Silicate Grout will be installed during the curing process. No grout will be used that has an expired use by date unless recertified by the manufacturer. Ring grouting of the strata around the seal may be done after the seal has cured as this is not deemed a structural repair.

14.0 CONVERGENCE

14.1 Seals will be examined for convergence at the frequency set by the local MSHA District. If visible convergence is seen in the area, the area will be examined to see if maximum convergence is exceeded in the seal.

14.2 If convergence is suspected, a P.E. must be immediately contacted to evaluate the effects of the convergence. The P.E. will certify the structural integrity of the seal or determine the proper repairs and submit that information to the MSHA District.

14.3 The maximum allowable convergence this seal design can withstand before structural integrity of the seal is compromised is up the value listed in the table at the end of this section. This is the physical convergence of the seal and not the surrounding strata. The seal remains elastic if the maximum allowable convergence is not exceeded and continues to fulfill its designed purpose.

14.4 Pins may be installed in the center of the face of the seal for measurements to be taken. “Pogo” sticks or other acceptable measuring devices can be used in lieu of this. If convergence in the seal exceeds the value given in the table, a Professional Engineer will inspect the seal to determine if the integrity of the seal has been compromised. Seals will be evaluated on a case by case basis to determine the appropriate measures to take to correct the problem.

14.5 Convergence Table

Convergence With Safety Factor for Varying Seal Heights	
Safety Factor =	1.50
Seal Height (feet)	Allowable *Convergence* (inches)
3	0.10
4	0.13
5	0.16
6	0.19
7	0.23
8	0.26
9	0.29
10	0.32
11	0.35
12	0.39

15.0 CERTIFICATION OF SEALS

15.1 A Professional Engineer will certify the areas are applicable for this application and constructed as designed. The certification will state:

I the undersigned hereby certify, to the best of my knowledge and belief, and based upon:

a) my visits to the mine site; inspections of the seal site; inspecting the geology of the area; and review of documents and mine maps supplied by the mine operator; and

b) the representations and certifications of others outside of the control and direct supervision of this certifying engineer (with attachments)

c) the in-situ strata meets strength for which this design is to be used (400 psi minimum shear strength in the roof and floor).

that the construction, installation, and materials used in this seal construction were in accordance with the approved ventilation plan.

16.0 SEAL DESIGN TABLE

16.1 Thickness Table

Seal Design Table - 120 psi Reinforced HIGH STRENGTH STRATACRETE
For Seal 16 wide to 40 feet wide

Seal Number	Maximum Seal Height In Feet	Seal Thickness in Inches	Vertical Rebar Spacing Inches	Horizontal Rebar Spacing Inches	Face to Rebar Clearance Inches	Minimum Rebar Overlap Inches Vertical	Minimum Rebar Overlap Inches Horizontal
9	9	31	12	10	2.5	32	21.5
10	10	35	12	10	2.5	32	21.5
11	11	42	12	10	2.5	32	21.5
12	12	48	12	10	2.5	32	21.5

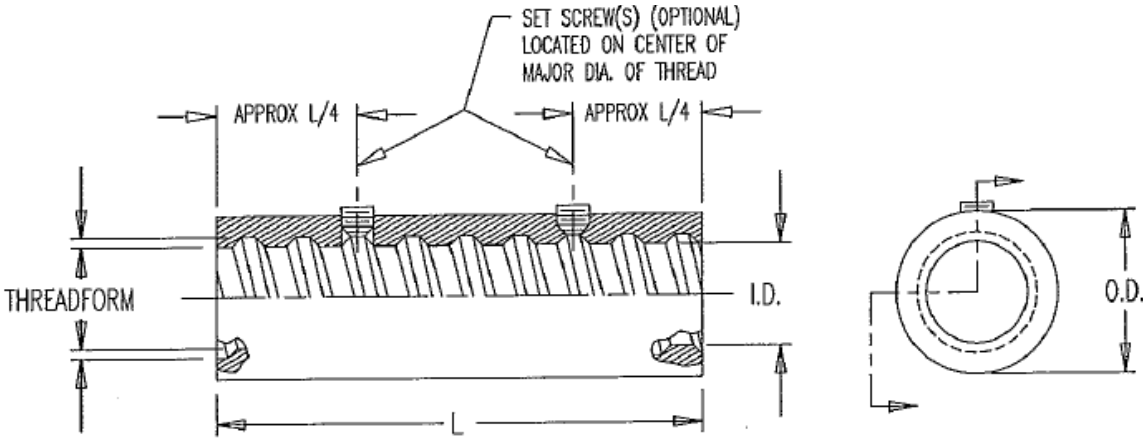
All Vertical Rebar is Grade 60 #9 Bar
All Horizontal Rebar is Grade 60 #6 Bar
HIGH STRENGTH STRATACRETE has a strength of 4,000 psi & a density of 138 pcf

Vertical rebar to be grouted into roof and floor a minimum of 24 inches to a depth required to develop 90% yield strength of bar in pull test

Entry Dimensions	Thickness of Seal	Specified Minimum Unconfined Compressive Strength of HIGH STRENGTH STRATACRETE /Flyash Mixture	Steel Reinforcement	Strata Surrounding Seal
See Seal Design Table in Appendix A	See Seal Design Table in Appendix A (Note: Form wall thickness not to be included in the seal thickness provided in the Seal Design Table)	4,000 psi (Note: minimum strength of quality control samples to be 4,600 psi to assure 4,000 psi is achieved).	See Seal Design Table in Appendix A	Vertical rebar to be grouted into roof and floor a minimum of 24 inches to a depth required to develop 90% yield strength of bar in pull test

17.0 OTHER INFORMATION & DRAWINGS

17.1 Coupler Data



NOTE:
LEFT-HAND THREAD FOR #6,#7,#8,#9,#10 & #11,
RIGHT-HAND THREAD FOR #14 & #18

NOMINAL SIZE	#6	#7	#8	#9	#10	#11
PART NUMBERS	B06K70710	B07K70710	B08K70710	B09K70710	B10K70710	B11K70710
WITH 1 SET SCREW	B06K70711	B07K70711	B08K70711	B09K70711	B10K70711	B11K70711
WITH 2 SET SCREWS	B06K70715	B07K70715	B08K70715	B09K70715	B10K70715	B11K70715
O.D. (IN./mm)	1.218/30,9	1.406/35,7	1.592/40,4	1.790/45,5	2.015/51,2	2.245/57,0
I.D. (IN./mm)	.738/18,7	.864/21,9	.982/24,9	1.104/28,0	1.246/31,6	1.414/35,9
L (IN./mm)	3.120/79,2	3.725/94,6	4.030/102,4	5.020/127,5	5.700/144,8	6.370/161,8
SET SCREW SIZE	1/4"-20UNC	1/4"-20UNC	1/4"-20UNC	1/4"-20UNC	1/4"-20UNC	3/8"-16UNC

DYWIDAG POST-TENSIONING SYSTEMS

FULL LOAD COUPLERS
FOR GRADE 75 THREADBAR

DATE: 08-08-96 | DWG: G. MALECKI | CHK: | APP:

This drawing, the pertinent enclosures, descriptions, calculations etc. and their contents are the property of DYWIDAG SYSTEMS INTERNATIONAL, USA, INC. They are not allowed to be duplicated with-out our permission. They are also not to be shown or explained for any reason to a third party other than for reasons expressly intended by the original receiver. They have to be returned on request.

DIMENSIONS: INCH/mm
mm FOR REFERENCE ONLY

MATERIAL:
SEE PMK0070790T

SCALE
NTS

QUALITY PLAN NUMBER:
QB00030800S

REV.	DATE	NAME	
2	07-18-97	A.G.	PB-068
3	09-30-97	A.G.	
4	10-30-97	A.W.	
5	12-14-98	A.W.	
6	06-23-00	A.W.	
7	07-07-00	A.W.	
8	05-24-01	A.W.	

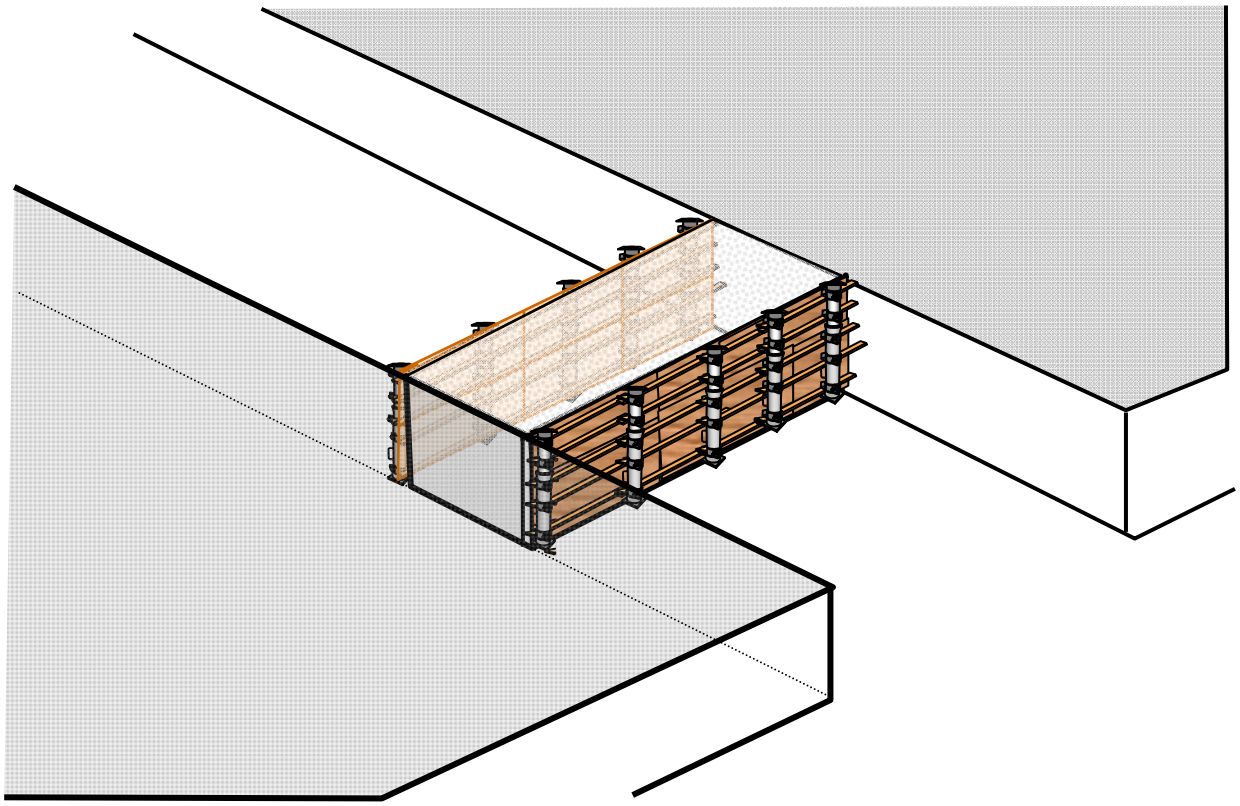
DRAWING NUMBER
B00K70710

DYWIDAG-SYSTEMS INTERNATIONAL, USA, INC. DSI

17.2 Lap Length Calculation Table

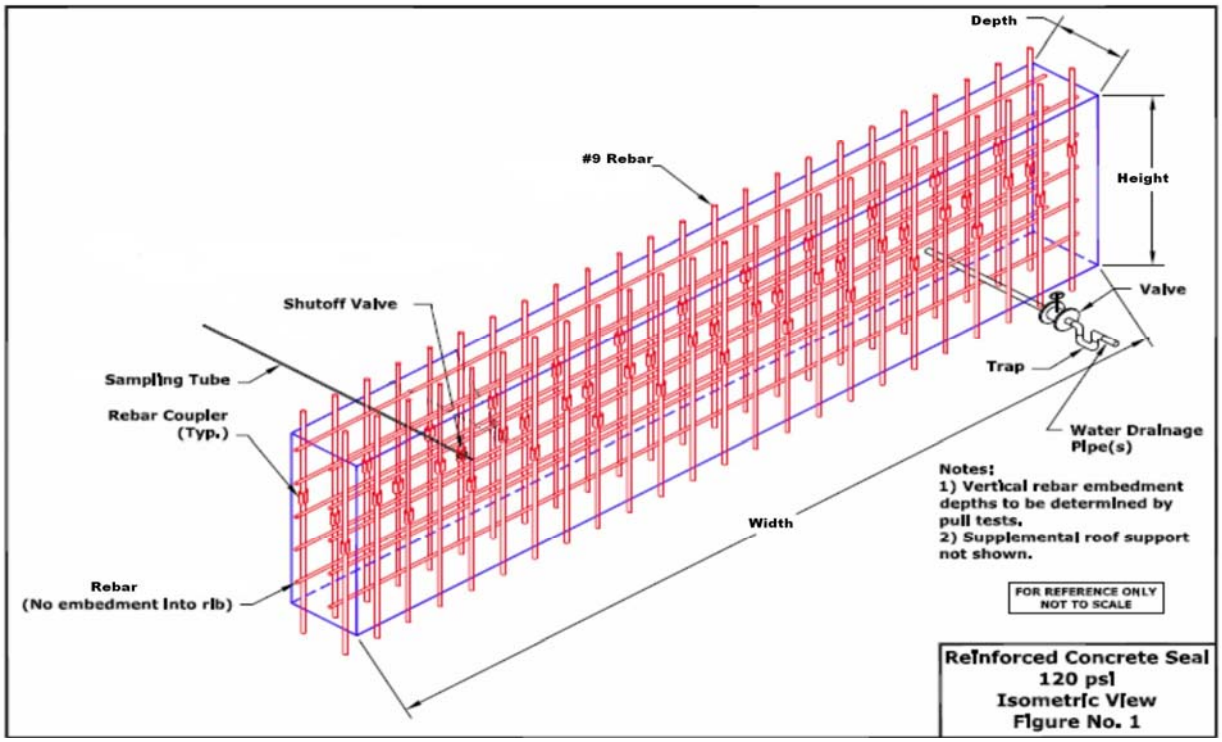
Rebar #	fy psi	fc psi	dbar in	c in	(c+Ktr)/dbar	default	ld in
6	60000	4000	0.75	2.88	3.83	2.5	21.35
9	60000	4000	1.13	3.06	2.72	2.5	32.02

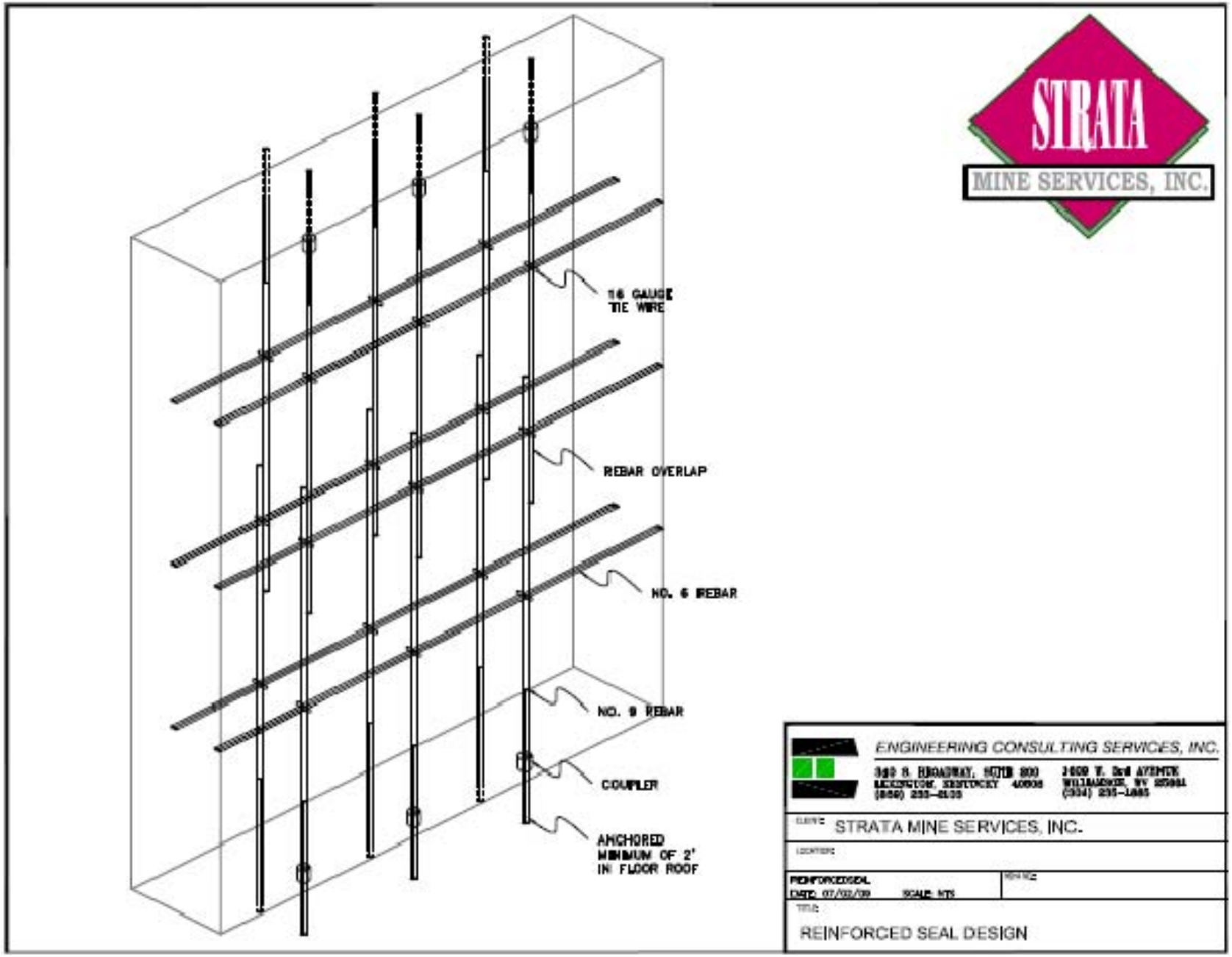
17.3 Typical Form Walls Constructed with Plywood & Rebar Drawing



17.3 Typical Form Walls Constructed with Plywood & Rebar Drawing

120 PSI REINFORCED CONCRETE SEAL –
MSHA SEAL APPROVAL NUMBER 120-75.336.1.07.01.0




16 GAUGE
TIE WIRE
REBAR OVERLAP
NO. 6 REBAR
NO. 9 REBAR
COUPLER
ANCHORED
MINIMUM OF 2'
IN FLOOR ROOF
STRATA
MINE SERVICES, INC.
ENGINEERING CONSULTING SERVICES, INC.
STRATA MINE SERVICES, INC.
REINFORCEDSEAL
SCALE: NTS
REINFORCED SEAL DESIGN