

**MSHA Approval Number: 50M-02.0**  
**50 psi MINOVA MAIN LINE TEKSEAL®**  
**Minova, USA, Inc.**

**For information, contact David Himes at (800) 626-2948**  
**Or, for customers west of the Mississippi, contact**  
**Joe Burdette at (970) 245-4007**

**SEAL INSTALLATION GUIDELINES FOR THE MINOVA MAIN LINE TEKSEAL**

**A. Site Preparation:**

1. Tekseal is palleted in polyethylene-lined bags, or as a bulk pack. The entire pallet is then covered with an impervious plastic wrap, or raincoat, which completely covers the pallet. This packaging enables outside storage in all conditions. Bagged material must not be stored directly on the ground in areas with standing water.
2. The seal must be located in stable conditions. Pillar stability shall be judged by the Certifying Professional Engineer (*CPE*) during the seal installation. To minimize air leakage, Minova recommends that the seal shall not be located less than 5 feet from the corner of any pillar. If the seal is to be located less than 10 feet from the corner of the pillar, Minova recommends that the ribs be reinforced with Tekflex® or some other, similar material. (If this occurs on the inby side of the seal, this will be done prior to seal installation.)
3. The ribs, floor, and roof will be scaled to competent strata prior to placement of the seal. All loose material must be removed from the seal location for a distance of 3 feet ± 6 inches on each side of the seal.
4. Rock dust should be removed from the strata within the seal form by compressed air, high pressure water, or mechanical means.
5. The strata at the seal perimeter should be as rough as practically possible, minimizing smooth surfaces. Surface roughness should not be less than 1 inch per 4 feet. This can be established by placing a 4-foot long straight edge against the strata and measuring the surface variation perpendicular to the edge. Surfaces smoother than this requirement must be mechanically roughened, at the designation of the CPE, during the seal installation.
6. Surfaces upon which Tekseal is to be placed do not have to be dry but must be reasonably free from standing or running water. All debris, oil, and unsound material must be removed, at the designation of the CPE, during the seal installation. Flowing water will be diverted or pumped away from the seal sites.
7. Supplemental roof support must be provided by the mine operator, consistent with any approved plans on both the outby and inby sides of the seal.

8. Good housekeeping practices should be observed, such as removing any debris within 50 feet of the area being sealed.

**B. Form Sequence Guidelines – Wood & Brattice:**

1. Each pair of forms shall be constructed to ensure the minimum thickness of the Tekseal, as indicated in the table titled "Form Thickness Specification Table – Wood and Brattice Forms". The minimum seal thickness is based on the maximum height and width of the entry after loose strata has been removed. When the opening height or width is between values on the appropriate design table, the next larger thickness should be used. The forms can be constructed to any thickness, as long as it meets the minimum required thickness outlined in the "Form Thickness Specification Table - Wood and Brattice Forms".

The minimum thickness of the seal and the formwork is based on the maximum height and width of the entry once the area is prepped for construction, subject to the judgment of the CPE, during the seal installation.

2. For wood and brattice seal walls, vertical site specific posts and/or cribs shall be used. Posts should be 4" x 4" or larger and shall be installed in each wall on typical centers of thirty (30) inches  $\pm$  6 inches. Cribs shall be a typical 6" X 6" X 30" or larger and installed with no more than 36 inches from crib to crib. Minova recommends using cribs for wall supports but understands that it may not be practical in all circumstances.
3. Rib-to-rib fly boards (1"x 6"  $\pm$  2 inches or equivalent) will be horizontally attached to the inner face of the posts or cribs on centers of 18 inches  $\pm$  6 inches.
4. For wood frame and brattice cloth walls, a brattice cloth shall be hung over the interior of the formwork, leaving no more than a 3-inch  $\pm$  1 inch overlap on the roof, rib, and floor.

The brattice cloth overlap must be kept to a minimum, in order to maximize contact of the Tekseal with the strata. The brattice cloth and framing shall be maintained in place for the duration of the seal life. In the event the brattice cloth is damaged to the extent that the Tekseal material is visible, it will be the responsibility of the operator to replace the damaged cloth.

5. The front/outby wall shall have one or more temporary hatches that will allow access to the inside of the forms during the construction process.

6. A water drainage system must 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 actual size and number of pipes must be based on the anticipated maximum flow rate at the seal location. Recommended pipe sizes will range between 4 inches and 8 inches in diameter. The pipes used must be non-metallic and corrosion resistant and have an internal pressure rating of at least 240 psi. If more than one drainage pipe is installed in the seal, the horizontal distance between the pipes must not be less than 2 ½ times their diameter. The distance between the ribs and the drainage pipes shall not be less than 2 ½ times their diameter. Pipes must be installed as low as practical, to minimize the depth of water against the inby side of the seal. A minimum of 4 inches will be maintained between the bottom of the pipe and the floor. The actual height of the pipe in the seal will depend upon the gradient of the floor and allow gravity drainage of water inby the seal.

Pipe sections must be joined in accordance with the pipe manufacturer's installation recommendations. Pipe joints and couplers must have resistance to internal pressure of at least 240 psi.

The drainage system must be equipped to prevent the exchange of air through the pipe(s). A water trap and valve will be installed on the outby side of each drainage pipe. The valve and its connections must have blast resistance equivalent to at least 240 psi. The valve must be installed on the inby side of the water trap. Water traps must be U-shaped, and the vertical depth of the U-portion of the trap must be large enough that a sufficient quantity of water 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 to minimize the depth of water against the seal and to strengthen its blast resistance.

A low weir catchment, no more than 12 inches high, must be constructed across the total width of the entry.

7. Each newly constructed seal shall have one (1) non-metallic sampling tube, extending into the next connecting crosscut, as described in 30 CFR §75.337(g)(1). The diameter and material for the sampling pipe will be submitted to the MSHA District Manager by the mine operator in the Mine Ventilation Plan, and it will be between ¼ and 1 inch diameter, with a pressure rating of 240 psi. The inby end of the sampling tube will be placed at not more than 12 inches from the roof.

If the new seal is placed on the outby side of an existing seal, non-metallic gas sampling pipes, rated at 240 psi, shall be connected to each sampling pipe in each seal. The new gas sampling pipe will have a new 50 psi shutoff valve installed outby the seal. If there is any space between the new and existing seal, that area will also be provided with a sampling pipe of the same specifications.

At the discretion of the mine, inertization pipe(s) may be installed for injecting an inert gas into the sealed mine area. If inertization pipes are used, the CPE shall specify the size, rating, location and spacing of such pipes in the seal.

8. Three (3) pressurization fill pipes, 1¼-inch diameter PVC, shall be inserted through the brattice cloth and/or fly boards. The first will be located in the center of the seal  $\pm$  2 feet and as close to the roof as possible. The two (2) remaining fill pipes shall be placed 3 feet  $\pm$  1 foot from each rib and as close to the roof as possible.

Bleeder pipes, 1¼ inches to 2 inches in diameter, can be used to confirm complete filling of any roof void greater than 2.5 feet in height. The bleeder pipes will be plugged with rags after the material flow is evident and prior to final pressurization.

Any seal that exceeds 10 feet in thickness, based on the "Form Thickness Specification Table - Wood and Brattice Forms", shall have six (6) pressurization fill pipes in two rows of three. Each row will terminate  $\frac{2}{3} \pm 1$  foot and  $\frac{1}{3} \pm 1$  foot of the thickness from the front/outby wall.

9. Approved PUR/foam pack or equivalent can be used around the perimeter of the brattice cloth and pipe annular openings in curtain to minimize leakage during the material pressurization.

**C. Form Sequence Guidelines – Kennedy & CMU Block:**

1. Position form walls to insure the minimum thickness stated in the table, "Thickness Specification-Installation Table - Kennedy or Block Forms". This is achieved rib to rib and floor to roof.

The minimum thickness is based on the maximum height and width of the entry, once the area is prepped for construction.

The forms can be constructed to any thickness, as long as it meets the minimum required thickness outlined in the "Thickness Specification-Installation Table - Kennedy or Block Forms".

2. For Kennedy forms, install horizontal rails no more than 24 inches apart or away from floor or roof.

Install panels on rails, again insuring the seal's interior thickness meets or exceeds the minimum thickness requirement.

Leave desired number of Kennedy panels lowered from the roof to be used as a window for filling the seal.

Form ties can be used as long as they are non-conductive. Standing support on the outside of the seal is a good alternative to form ties, as long as the standing support will resist any form movement.

3. A water drainage system must 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 actual size and number of pipes must be based on the anticipated maximum flow rate at the seal location. Recommended pipe sizes will range between 4 inches and 8 inches in diameter. The pipes used must be non-metallic and corrosion resistant and have an internal pressure rating of at least 240 psi. If more than one drainage pipe is installed in the seal, the horizontal distance between the pipes must not be less than 2 ½ times their diameter. The distance between the ribs and the drainage pipes shall not be less than 2 ½ times their diameter. Pipes must be installed as low as practical to minimize the depth of water against the inby side of the seal. A minimum of 4 inches will be maintained between the bottom of the pipe and the floor. The actual height of the pipe in the seal will depend upon the gradient of the floor and allow gravity drainage of water inby the seal.

Pipe sections must be joined in accordance with the pipe manufacturer's installation recommendations. Pipe joints and couplers must have resistance to internal pressure of at least 240 psi.

The drainage system must be equipped to prevent the exchange of air through the pipe(s). A water trap and valve will be installed on the outby side of each drainage pipe. The valve and its connections must have blast resistance equivalent to at least 240 psi. The valve must be installed on the inby side of the water trap. Water traps must be U-shaped, and the vertical depth of the U-portion of the trap must be large enough that a sufficient quantity of water 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 to minimize the depth of water against the seal and to strengthen its blast resistance.

A low weir catchment, no more than 12 inches high, must be constructed across the total width of the entry.

4. Each newly constructed seal shall have one (1) non-metallic sampling tube, extending into the next connecting crosscut, as described in 30 CFR §75.337(g)(1). The diameter and material for the sampling pipe will be submitted to the MSHA District Manager by the mine operator in the Mine Ventilation Plan, and it will be between ¼ and 1 inch in diameter, with a pressure rating of 240 psi. The sampling tube will be placed at not more than 12 inches from the roof.

If the new seal is placed on the outby side of an existing seal, non-metallic gas sampling pipes, rated at 240 psi, shall be connected to each sampling pipe in each seal. The new gas sampling pipe will have a new 50 psi shutoff valve installed outby the seal. If there is any space between the new and existing seal, that area will also be provided with a sampling pipe of the same specifications.

At the discretion of the mine, inertization pipe(s) may be installed for injecting an inert gas into the sealed mine area. If inertization pipes are used, the CPE shall specify the size, rating, location and spacing of such pipes in the seal.

5. Three (3) pressurization fill pipes, 1¼-inch diameter PVC, shall be inserted through the Kennedy panels. The first will be located in the center of the seal  $\pm$  2 feet and as close to the roof as possible. The two (2) remaining fill pipes shall be placed 3 feet  $\pm$  1 foot from each rib and as close to the roof as possible.

Any seal that exceeds 10 feet in thickness, as required by the "Thickness Specification-Installation Table - Kennedy or Block Forms", shall have six (6) pressurization fill pipes positioned in two rows of three. One row will extend 2/3 into the seal  $\pm$  2 feet, and the other row will terminate 1/3 into the seal  $\pm$  2 feet.

Bleeder pipes, 1¼ inches to 2 inches in diameter, can be used to confirm complete filling of any roof void greater than 2.5 feet in height. The bleeder pipes will be plugged with rags after the material flow is evident and prior to final pressurization.

6. For best results, use approved foam pack or equivalent to seal the perimeter and seams.

#### **D. Tekseal Placement:**

Minova's Tekplacer is the only machine currently approved for placement of Tekseal, and no alternative pumps may be used for the placement of Tekseal without Minova's prior approval. Additionally, Minova reserves its right to introduce new or modified equipment for the purpose of Tekseal placement.

1. Prior to placement of the Tekseal material in between the prepared forms, the Minova Tekplacer will be calibrated in accordance with the following procedure:

During the initial start-up of the seal project and the start of each pumping sequence, the Tekplacer machine will be calibrated to insure that the Tekseal material is proportionally correct. The following is an example of the information that will be documented during the calibration process.

Water Temperature: 69.4 °F  
Hose Length: 600'  
Hose Diameter: 1¼"

### **Calibration**

Time to dump 5 bags (min & sec): 1 min 50 sec = min + (sec/60) = 1.83 min  
(powder pounds = 5 x 45 lbs = 225 lbs)

**Throughput** (powder pounds ÷ time): 123.0 **lbs/min**

**Water to Solids** (lbs/min X 1.25 for Tekseal divided by 8.34 = 18.4 **gpm**

Drum Dimensions (Dia" x H"): 20" x 30" Volume = (Dia. x Dia. x H) ÷ (2,200): 5.46 ft<sup>3</sup>

Time to fill drum (min & sec): 55 sec = min + (sec/60) = .92 min

**Output** (volume ÷ time): 5.93 **ft<sup>3</sup>/min**

Powder pounds per Cubic Yard = (throughput ÷ output) x (27): 560.0 lbs/yd<sup>3</sup>

**Mix Strength** = (lbs/yd<sup>3</sup>) ÷ (45): 12.4 **bags/yd<sup>3</sup>**

2. The existing mine water supply of at least 25 gpm at 50 psi is sufficient for the preparation of the Tekseal material. Should there be concerns about the quality of the mixing water, Minova will evaluate it to ensure compatibility with Tekseal and make chemical adjustments to the water if necessary.

Should the mixing water show excessive foaming when tested with Tekseal, then the amount of liquid defoamer required to reduce foaming to a normal level will have to be determined. Once this dosage level has been determined, the standard Tekseal QC test procedure will be carried-out using the mixing water dosed with an appropriate level of defoamer.

In the field, the liquid defoamer will be dosed at the predetermined controlled rate into the mixing water prior to its contact with the Tekseal.

3. The hose will be moved and positioned, as necessary, during placement, to provide uniform and complete filling of the form. Care must be taken to direct the flow of Tekseal along the back of the form wall and into the corners of the formed area to assure complete filling against the formwork and at the roof and rib contacts.

Tekseal's unique design allows for cold joints due to pumping interruptions. In the event pumping is interrupted for more than eight (8) hours, the roughness of the cold joint will be documented. If the surface roughness is less than 2 inches over 4 feet, measures will be taken to mechanically roughen the surface of the cold joint.

4. A minimum of nine (9) samples from each seal will be taken, as follows: The first three (3) samples from the bottom will be taken once the entire floor is covered; the next three (3) samples will be taken from the middle once the Tekseal material reaches half the height of the seal; and, the last three (3) samples will be taken from the upper third of the seal height. Sampling for the test specimens must be done in a completely random and unbiased manner.

Each of the samples in the testing stages outlined above will be taken directly from a tap on the seal manifold or the end of the material discharge hose and placed into a Minova-supplied testing cup. Each sample will be filled to the top of the supplied cup, making sure that large air pockets are not entrapped during the sampling process. Any excess material will be screed off with a straight edge, the lid will be secured in place, and the sample stored in an upright position. The samples are to remain in the mine to cure under approximately the same conditions as the seal for 28 days.

If the minimum 400 psi is required in less than 28 days, an additional nine (9) samples can be taken and tested at the desired time period.

All samples will be crushed to determine the unconfined compressive strength. The average compressive strength must be greater than 400 psi with not more than two (2) samples testing below 400 psi, and no samples testing below 300 psi.

5. Whenever possible, the Tekseal discharged from the hose should be observed. Any changes from the normal appearance and consistency are sufficient reason to cease pumping and investigate the cause of the change

**E. Time Required for Seal to Reach Design Strength:**

The standard Tekseal mixture (typically 517 lbs/yd<sup>3</sup>) will reach its intended strength (400 psi) after 28 days. Adding more pounds of Tekseal per cubic yard will achieve the minimum design 400 psi strength in a shorter time period. This is controlled by standard calibration procedures, as previously described. If an evaluation of the design strength is required at an earlier curing time, additional samples, per the sampling protocol, are necessary.

**F. Surface Drying Effects:**

The surface drying effects are only an issue if the brattice or form material is damaged and the Tekseal surface is exposed to the atmosphere. Drying effects are not rapid, and the weekly inspection cycles provide more than adequate time intervals to re-establish surface protection. Examiners will be instructed to verify the brattice is intact. If the brattice or form is damaged, or the Tekseal is otherwise exposed to the atmosphere, the brattice will be repaired or other measures will be taken to cover the exposed Tekseal.



**G. Seal Voids:**

If there is any loss of contact with the roof, rib, or wall, a direct Minova Field Repair certified technician will propose a repair procedure, which will be subject to MSHA's approval before its implementation. The procedure will specify that the voids shall be filled with a non-shrinking material, with a minimum cured strength of 400 psi. It will also state that, before injection, any dried Tekseal material must be removed from the vicinity of the void. The grout shall be pumped into the voids using open-ended injection pipes until it is apparent the void is filled, as witnessed by grout flowing back past the injection pipe. The seal shall then be checked for air leakage to ensure the void has been completely filled. This procedure is applicable to any size or position of a seal void.

If the leaks are determined to be only on the outby face of the seal, and there is no loss of contact with the surrounding rock or coal, the leak(s) may be filled with a low-density polyurethane foam, such as Silent Seal<sup>®</sup> or equivalent. The manufacturer's instructions shall be adhered to. Again, the seal must be checked for air leakage afterwards to ensure the job has been successful.

**H. Strata Fracture**

If the strata surrounding the seal are badly fractured, or other factors indicate the shear strength of such strata or coal is less than the shear strength of Tekseal, then reinforcement of the strata will be evaluated. The strata can be ring-grouted with a minimum 400 psi grout such as Minova's Tekgrout injection grout, an equivalent cement-based grout, or 20-70 lbs. per-cubic-foot density polyurethane grout. In addition, the strata can be reinforced with additional bolting or the seal should be hitched into the strata. Check the seal afterwards to ensure the grouting has been successful by the use of typical air leakage detection tools such as smoke tubes or other approved detection devices.

Sometimes it may be better to undertake seal voids and strata fractures as one repair project. The grout used to make seal repairs will migrate into the surrounding strata, sealing and strengthening it.

**I. Maximum Allowable Convergence:**

The Tekseal system was specifically designed for deep, high-convergence mines, and it has repeatedly demonstrated its ability to accept significant levels of entry closure. An independent laboratory confirmed, during the triaxial compression tests, that Tekseal exhibits increasing compressive and shear strengths as the confinement pressure is increased. Further, under confinement of less than hydrostatic pressure, Tekseal deforms through the development of micro-fractures and not along planes of weakness associated with the internal angle of friction. These ductile properties (deformation under load) indicate the seal could accept as much as 20% convergence (18% under laboratory tests) and possibly maintain shear, tensile, and compressive strengths above its unconfined values. Values of maximum acceptable convergence (roof to floor closure as measured vertically at the midpoint of the entry at the outby face of the seal) are shown in the attached tables for the various entry heights contained therein. The actual convergence may be measured at the outby entry using extensometers, "pogo" sticks or any other approved measuring device.

**J. Storage Conditions for Construction Materials:**

Tekseal is palletted in polyethylene-lined bags and then the entire pallet is covered with an impervious plastic wrap, or raincoat, which completely covers the pallet or as a bulk pack. This packaging enables outside storage in all conditions. Hardened material will be discarded. Bagged material must not be stored directly on the ground in areas with standing water. Tekseal has a shelf life of three months. A "use by" date of each batch is clearly indicated on each corresponding pallet. **Beyond this period, and depending on storage conditions, it may become a little slower to gel. Standard Tekseal QC test procedure will be carried-out on expired material to determine if it still passes all the tests, with the exception of the long-term strength test. Minova may grant shelf life extensions of 30 days beyond the "use by" date, depending on the results of those tests.**

**K. Contact Information**

For detailed information on the use and application of this seal, contact Mr. David Himes, Project Manager, Minova USA, Inc., 150 Carley Court, Georgetown, Kentucky, 40324, phone number 800-626-2948. For more detailed information for customers west of the Mississippi, contact Mr. Joe Burdette, Vice President – Sales Western Division, 2306 Highway 6 & 50, Grand Junction, CO, 81505, phone number 970-245-4007.



**Minova USA, Inc.**

**Thickness Specification - Installation Table - Wood and Brattice Forms  
50-psi Blast Loading Seal**

(Based on the seal design described in the Seal Approval Information Template)

Entry Height, ft	Maximum Acceptable Convergence, in	Entry width, ft																
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
4	9.60	4.0	4.0	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.2	4.2	4.3	4.3	4.3	4.3	4.3	4.3
4.5	10.80	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.5	4.6	4.6	4.6	4.6	4.7	4.7	4.7	4.7	4.7
5	12.00	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.9	4.9	4.9	5.0	5.0	5.0	5.1	5.1	5.1	5.1
5.5	13.20	4.8	4.9	4.9	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.3	5.4	5.4	5.4	5.5	5.5	5.5
6	14.40	5.0	5.1	5.2	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.7	5.8	5.8	5.8	5.9
6.5	15.60	5.3	5.4	5.5	5.6	5.6	5.7	5.8	5.8	5.9	5.9	6.0	6.0	6.1	6.1	6.2	6.2	6.2
7	16.80	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.1	6.2	6.3	6.3	6.4	6.4	6.5	6.5	6.5	6.6
7.5	18.00	5.8	5.9	6.0	6.1	6.2	6.3	6.3	6.4	6.5	6.6	6.6	6.7	6.7	6.8	6.8	6.9	6.9
8	19.20	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.8	6.9	7.0	7.0	7.1	7.1	7.2	7.2
9	21.60	6.4	6.5	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.6	7.7	7.8	7.8	7.9
10	24.00	6.7	6.9	7.1	7.2	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.3	8.4	8.5
11	26.40	7.1	7.3	7.5	7.6	7.8	7.9	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1
12	28.80	7.4	7.6	7.8	8.0	8.2	8.3	8.5	8.6	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	9.6
13	31.20	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.0	9.2	9.3	9.5	9.6	9.7	9.8	9.9	10.0	10.1
14	33.60	8.0	8.2	8.4	8.7	8.9	9.1	9.2	9.4	9.6	9.7	9.9	10.0	10.1	10.3	10.4	10.5	10.6
15	36.00	8.2	8.5	8.7	9.0	9.2	9.4	9.6	9.8	10.0	10.1	10.3	10.4	10.6	10.7	10.8	11.0	11.1
16	38.40	8.4	8.7	9.0	9.3	9.5	9.7	9.9	10.1	10.3	10.5	10.7	10.8	11.0	11.1	11.3	11.4	11.5
17	40.80	8.7	9.0	9.3	9.5	9.8	10.0	10.2	10.5	10.7	10.8	11.0	11.2	11.4	11.5	11.7	11.8	12.0
18	43.20	8.9	9.2	9.5	9.8	10.0	10.3	10.5	10.8	11.0	11.2	11.4	11.6	11.7	11.9	12.1	12.2	12.4
19	45.60	9.1	9.4	9.7	10.0	10.3	10.6	10.8	11.1	11.3	11.5	11.7	11.9	12.1	12.3	12.5	12.6	12.8
20	48.00	9.2	9.6	9.9	10.2	10.5	10.8	11.1	11.3	11.6	11.8	12.0	12.2	12.4	12.6	12.8	13.0	13.2
21	50.40	9.4	9.8	10.1	10.5	10.8	11.1	11.3	11.6	11.9	12.1	12.3	12.6	12.8	13.0	13.2	13.4	13.5
22	52.80	9.6	10.0	10.3	10.7	11.0	11.3	11.6	11.9	12.1	12.4	12.6	12.9	13.1	13.3	13.5	13.7	13.9
23	55.20	9.7	10.1	10.5	10.8	11.2	11.5	11.8	12.1	12.4	12.6	12.9	13.1	13.4	13.6	13.8	14.0	14.2
24	57.60	9.9	10.3	10.7	11.0	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.4	13.7	13.9	14.1	14.3	14.6
25	60.00	10.0	10.4	10.8	11.2	11.6	11.9	12.2	12.6	12.9	13.1	13.4	13.7	13.9	14.2	14.4	14.7	14.9
26	62.40	10.1	10.6	11.0	11.4	11.7	12.1	12.4	12.8	13.1	13.4	13.7	13.9	14.2	14.5	14.7	14.9	15.2
27	64.80	10.3	10.7	11.1	11.5	11.9	12.3	12.6	13.0	13.3	13.6	13.9	14.2	14.5	14.7	15.0	15.2	15.5
28	67.20	10.4	10.8	11.3	11.7	12.1	12.5	12.8	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.5	15.8
29	69.60	10.5	11.0	11.4	11.8	12.2	12.6	13.0	13.4	13.7	14.0	14.3	14.7	14.9	15.2	15.5	15.8	16.0
30	72.00	10.6	11.1	11.5	12.0	12.4	12.8	13.2	13.5	13.9	14.2	14.6	14.9	15.2	15.5	15.8	16.0	16.3

**Note:** Direct shear strength of grout on rock from lab test results as provided by Minova USA



**Minova USA, Inc.**  
**Thickness Specification - Installation Table - Kennedy or Block Forms**  
**50-psi Blast Loading Seal**  
(Based on the seal design described in the Seal Approval Information Template)

Entry Height, ft	Maximum Acceptable Convergence, in	Entry width, ft																	
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
4	9.60	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
4.5	10.80	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.1	4.1	
5	12.00	4.0	4.0	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.5	
5.5	13.20	4.1	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.8	4.8	4.8	
6	14.40	4.4	4.5	4.5	4.6	4.7	4.7	4.8	4.8	4.9	5.0	5.0	5.0	5.1	5.1	5.1	5.2	5.2	
6.5	15.60	4.6	4.7	4.8	4.9	5.0	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.5	5.6	
7	16.80	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.5	5.5	5.6	5.6	5.7	5.7	5.8	5.8	5.9	5.9	
7.5	18.00	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.8	5.9	6.0	6.0	6.1	6.1	6.2	6.2	6.3	
8	19.20	5.3	5.4	5.6	5.7	5.8	5.9	6.0	6.0	6.1	6.2	6.3	6.3	6.4	6.4	6.5	6.5	6.6	
9	21.60	5.7	5.9	6.0	6.1	6.3	6.4	6.5	6.6	6.7	6.7	6.8	6.9	7.0	7.0	7.1	7.2	7.2	
10	24.00	6.1	6.3	6.4	6.6	6.7	6.8	6.9	7.1	7.2	7.3	7.4	7.4	7.5	7.6	7.7	7.7	7.8	
11	26.40	6.4	6.6	6.8	7.0	7.1	7.3	7.4	7.5	7.6	7.8	7.9	8.0	8.1	8.1	8.2	8.3	8.4	
12	28.80	6.7	6.9	7.1	7.3	7.5	7.7	7.8	8.0	8.1	8.2	8.3	8.4	8.6	8.7	8.8	8.8	8.9	
13	31.20	7.0	7.3	7.5	7.7	7.9	8.0	8.2	8.4	8.5	8.7	8.8	8.9	9.0	9.1	9.2	9.4	9.4	
14	33.60	7.3	7.5	7.8	8.0	8.2	8.4	8.6	8.8	8.9	9.1	9.2	9.3	9.5	9.6	9.7	9.8	9.9	
15	36.00	7.5	7.8	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.6	9.8	9.9	10.0	10.2	10.3	10.4	
16	38.40	7.8	8.1	8.3	8.6	8.8	9.0	9.3	9.5	9.6	9.8	10.0	10.2	10.3	10.5	10.6	10.7	10.9	
17	40.80	8.0	8.3	8.6	8.9	9.1	9.3	9.6	9.8	10.0	10.2	10.4	10.5	10.7	10.9	11.0	11.2	11.3	
18	43.20	8.2	8.5	8.8	9.1	9.4	9.6	9.9	10.1	10.3	10.5	10.7	10.9	11.1	11.3	11.4	11.6	11.7	
19	45.60	8.4	8.7	9.0	9.3	9.6	9.9	10.1	10.4	10.6	10.8	11.0	11.2	11.4	11.6	11.8	12.0	12.1	
20	48.00	8.6	8.9	9.3	9.6	9.9	10.1	10.4	10.7	10.9	11.1	11.4	11.6	11.8	12.0	12.2	12.3	12.5	
21	50.40	8.8	9.1	9.5	9.8	10.1	10.4	10.7	10.9	11.2	11.4	11.7	11.9	12.1	12.3	12.5	12.7	12.9	
22	52.80	8.9	9.3	9.6	10.0	10.3	10.6	10.9	11.2	11.5	11.7	12.0	12.2	12.4	12.6	12.8	13.0	13.2	
23	55.20	9.1	9.5	9.8	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.2	12.5	12.7	12.9	13.2	13.4	13.6	
24	57.60	9.2	9.6	10.0	10.4	10.7	11.0	11.4	11.7	12.0	12.2	12.5	12.8	13.0	13.2	13.5	13.7	13.9	
25	60.00	9.3	9.8	10.2	10.5	10.9	11.2	11.6	11.9	12.2	12.5	12.8	13.0	13.3	13.5	13.8	14.0	14.2	
26	62.40	9.5	9.9	10.3	10.7	11.1	11.4	11.8	12.1	12.4	12.7	13.0	13.3	13.5	13.8	14.0	14.3	14.5	
27	64.80	9.6	10.0	10.5	10.9	11.3	11.6	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.3	14.6	14.8	
28	67.20	9.7	10.2	10.6	11.0	11.4	11.8	12.2	12.5	12.8	13.2	13.5	13.8	14.0	14.3	14.6	14.8	15.1	
29	69.60	9.8	10.3	10.7	11.2	11.6	12.0	12.3	12.7	13.0	13.4	13.7	14.0	14.3	14.6	14.8	15.1	15.4	
30	72.00	9.9	10.4	10.9	11.3	11.7	12.1	12.5	12.9	13.2	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.6	

**Note:** Direct shear strength of grout on rock from lab test results as provided by Minova USA

