MSHA Approval Number: 120M-10.1
120 psi MINOVA MAIN LINE TEKSEAL®
ENTRY WIDTHS GREATER THAN 30 FT
Minova USA Inc.
For information, contact Dr. Steve Tadolini, PhD at (740)359-4076 or Jason Tinsley, P.E. at (618)663-7937

SEAL INSTALLATION GUIDELINES FOR THE MINOVA MAIN LINE TEKSEAL

A. Site Preparation:

1. Tekseal is palletized 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, entry stability, and seal location shall be judged by the Certifying Professional Engineer *(CPE)* prior to seal installation. A CPE must determine if the strata surrounding the proposed seal possess minimum shear strengths of at least 72 psi prior to seal installation. If geologic anomalies, such as joints, cracks, faults, weak coal in the pillar, or other discontinuities within the proposed seal location would compromise the performance of the seal, and if removal of weak material, or installation of mechanical reinforcement is not acceptable, then a new seal location must be found. 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®, Teknite, Tekcrete Fast®, shotcrete, gunite, or other, similar material. (If this occurs on the inby side of the seal, this will be done prior to seal installation.) If the seal is to be located less than 10 feet from the corner of the pillar, a plan must be submitted to the respective MSHA District for approval of the proposed rib reinforcement measures.

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. The prepared entry dimensions, to the extent practical, must be approximately perpendicular to the rib-line across the depth of the seal, and from either the inby or outby direction. If a CPE determines that the floor consists of water sensitive material, the material must be removed to competent strata. The seal can be constructed on the competent strata, or as an alternative, a base can be constructed in the excavated area with Tekrok or concrete to the approximate original floor level. The seal can then be constructed on the newly established base under the direction of the CPE.

   The base construction material must have an unconfined compressive strength equal to or greater than 1,000 psi. A minimum of nine (9)

samples from each base must be taken, as follows: The first three (3) samples from the bottom must be taken once the entire floor is covered; the next three (3) samples must be taken from the middle once the base material reaches half the height of the base; and, the last three (3) samples must be taken from the upper third of the base height. Sampling for the test specimens must be performed in a completely random and unbiased manner. Samples must be tested from the base material to determine the unconfined compressive strength. The minimum average unconfined compressive strength of the base material must be 1,000 psi with not more than two (2) samples testing below 1,000 psi, and no samples testing below 750 psi.

Each of the samples in the testing stages outlined above must be taken directly from the material discharge as it is placed into the base excavation. Samples must be placed into Minova-supplied containers. Each sample must be filled to the top of the supplied container. Samples must be tapped and/or stirred to make 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 near the base in the mine or in an upright position in closed sample containers near the base (sample container types specified by Minova). The location, base identification, and date must be marked on each sample with a permanent marker. While in the mine during the curing period, the samples must be readily able to be inspected. The samples are to remain in the mine to cure under approximately the same conditions as the base. If an evaluation of the design strength is required at an earlier curing time, additional samples, per the sampling protocol, may be taken.

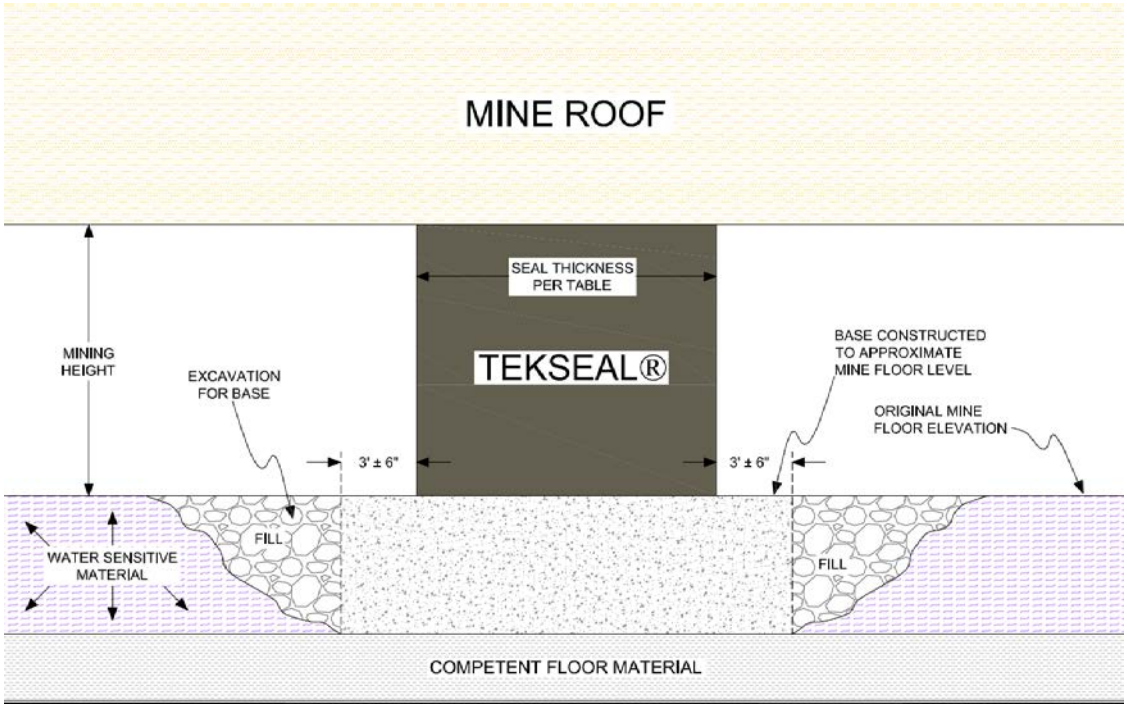
To minimize moisture loss during curing, the top surface of the base should be covered with plastic sheeting, mine curtain, or materials specified in ASTM C 171. The top surface of the base should be as rough as practically possible, minimizing smooth surfaces. Surface roughness must not be less than 1 inch per 4 feet. This can be established by placing a 4-foot long straight edge against the top surface of the base and measuring the surface variation perpendicular to the edge. Surfaces smoother than this requirement must be mechanically roughened, at the designation of a CPE, prior to the seal installation. Seal construction may not begin on the constructed base until the material has reached the average minimum required UCS as determined through sample testing.

If the top surface of the base is higher than the approximate original inby floor elevation then the bottom of any drainage pipe on the inby side must be no less than 4 inches above the top surface of the base and no more than 12 inches above the original mine floor elevation. If the top surface of the base is lower than the approximate original inby floor elevation then the bottom of any drainage pipe on the inby side must be no less than 4 inches above the top surface of the base and no more than 12 inches above the top surface of the base.

Surfaces upon which the base is to be constructed can be damp but must be completely free of standing or running water. All debris, oil, and

unsound material must be removed and flowing water must be diverted or pumped away from the seal sites. The area excavated for the base construction must have a bottom minimum dimension of 3 feet ± 6 inches greater than the width of the proposed seal on both the inby and outby sides. A diagram of the typical base design and seal is shown below.

While constructing the base, the excavated area can be filled entirely with concrete or Tekrok. Formwork can also be used for construction of the base. If formwork is utilized for construction of the base, the formwork may remain in place or be removed once the base has achieved the minimum unconfined compressive strength per the sampling protocol. The excavated area can then be backfilled with material to the approximate original floor level.



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, prior to the seal installation.

6. Surfaces upon which Tekseal is to be placed can be damp but must be completely 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 must 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. As an alternative, Minova Tekpak or Tekcrib can be utilized if included in the respective approved plans.

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

9. All metal objects, mesh, straps, rails, etc. that extend through the seal location must be removed. Should objects be present that do not extend entirely through the seal, a clear space on each side of the object shall be provided to break the continuity of the conductive element beyond the seal face.

10. The mine must maintain appropriate documentation of entry conditions for the seal location as part of the seal plan. Documentation in the seal plan may include proposed removal of weak material, pillar reinforcement, or other site modifications, and proposed rib reinforcement measures if the seal is to be located less than 10 feet but not less than five feet from the corner of the pillar.

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”. If Wood and Brattice formwork is used for one wall and the opposite wall is constructed of Kennedy or CMU Block the minimum required thickness outlined in the “Form Thickness Specification Table - Wood and Brattice Forms” will be used.

   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. The seal minimum thickness, based on the maximum entry dimensions, can then be determined from the “Thickness Specification Installation Table – Wood and Brattice Forms

2. For wood and brattice seal formwork, vertical site specific posts and/or cribs shall be used. Posts must be 4” x 4” or larger and shall be installed in each wall on typical centers of thirty (30) inches ± 6 inches. Cribs shall be a typical 6” X 6” X 24” 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. As an alternative, Minova Tekpak® or Tekcrib® can be utilized if included in the respective approved plans.

3. Rib-to-rib fly boards (1"x 6" ± 2 inches or equivalent) will be horizontally attached to the inner face of the posts or cribs on centers of 18 inches ± 6 inches. For the top 12 inches of the inby formwork of the seal, the top two fly boards will be butted or the top fly board doubled to prevent blowout during pressurization of fill pipes near the roof. The reinforcing lap boards added will be on the outside of the form and no adjustment to the measurement of the minimum required seal thickness is needed.

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 ± 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.

   The outby brattice cloth formwork will have a double thickness curtain installed during the construction and the curtain installed in a manner that the brattice cloth seams are offset. At the discretion of a CPE, it may be necessary to provide an additional barrier to permanently seal the formwork. The outby side of the framework, curtain, and seal perimeter can be sealed with a cementitious coating such as Tekflex®, Teknite, Tekcrete Fast®, gunnite, shotcrete, or other approved sealant with no structural function. It may be necessary to pre-install sampling ports prior to permanently sealing the outby formwork or creating ports while applying the coating to allow for seal certification testing. Once the seal has been certified, the sampling ports must then be permanently sealed. If subsequent testing requires removal of the coating material, then the coating must be removed in a manner not to damage the Tekseal® material and the testing area must again be permanently sealed.

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.

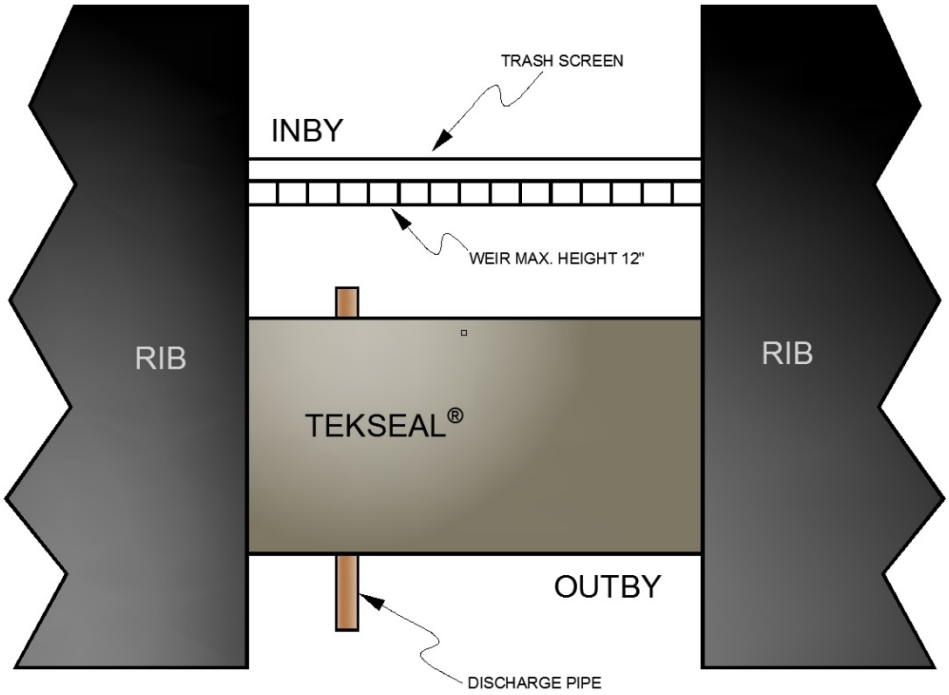
6. A water drainage system must be installed during seal construction in the lowest elevation seal(s) of the set. This seal is not designed to impound water, other than to a minimal, unavoidable depth. The actual size and number of pipes must be determined by a CPE and based on the anticipated maximum flow rate at the seal location. The maximum number of drainage pipes cannot exceed six (6) per seal. Pipe sizes will range between 4 inches minimum and 8 inches maximum 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 (Example: 4 inch diameter pipe –

minimum distance between pipes and ribs = 4 inch dia x 2½ = 10 inches). Pipes must be installed as low as practical, to minimize the depth of water against the inby side of the seal. The bottom of any drainage pipe on the inby side must be no less than 4 inches above the floor and no more than 12 inches above the mine floor.

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. No alterations from the manufacturer's design or strength reducing modifications may be made to pipe and pipe fittings for water drainage pipes.

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.

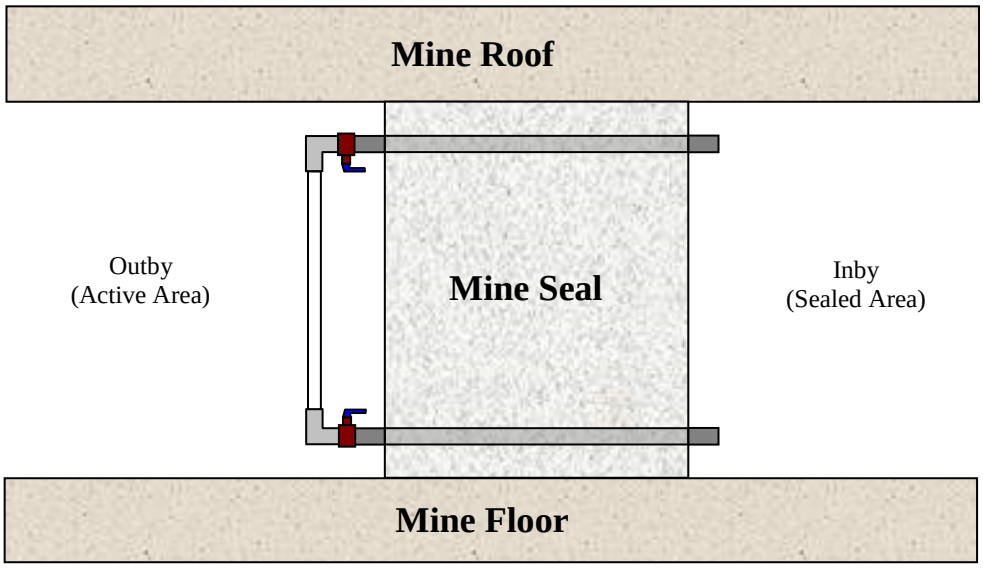
A low weir catchment, no more than 12 inches high, must be constructed across the total width of the entry inby all seals equipped with drainage pipes. The weir can be constructed of concrete or cement block and will be approximately and to the extent possible level with the bottom of the inby ends of the drainage pipes. A trash screen must be installed inby the weir that is twice the height of the weir. A generic typical drawing of a weir follows.



If a new seal is placed on the outby side of an existing seal equipped with a water drainage system, the existing U-trap must be removed, the existing valve must be removed or placed in a fully-open position, and the drainage pipes must be extended through the new seal with a new valve and U-trap installed as required and meeting required specifications discussed in this section.

a. <u>Water Height Measuring System</u>

If required by the District and if water accumulation in the sealed area is likely based on past mine experience, a water height measuring system, incorporating a sight tube shall be installed, if included on the MSHA approved mine ventilation seal plan. As shown below, the water height measuring system shall consist of two horizontal 1 inch to 1.25 inches inside diameter non-metallic, corrosion resistant, pipes installed through the seal. The lower pipe shall be securely installed through the seal at the approximate height of the top of the water trap ± 2 inches. The upper pipe shall be securely installed through the seal close to the mine roof at a distance of 6 inches ± 2 inches. 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 not less than 240 psi. Two 90 degree elbows shall be installed on the outby end of each valve and pipe after the valves are in place. A clear plastic tube shall be securely placed between these elbows for viewing of the water elevation inby the seal, as shown below.



As an alternative water height measuring system, a one inch diameter non-metallic, corrosion resistant, pipe with a valve shall be installed through the seal at the approximate height of the top of the water trap ± 2 inches. The pipe will be equipped with a pressure gauge with markings for depth of water behind the seal. The gauge should be limited to reading between 0-5 psi but no more than 0-10 psi so that the mechanical resolution of the gauge is great enough to show depth changes. (27.71 inches of water = 1 psi on the gauge) When calibrating the markings, add the distance in inches between the level of the gauge and the floor inby the seal to accurately report the water levels

inby the seal. The shut-off valve and pipe extending through the seal must have an internal pressure rating of not less than 240 psi. The shut-off valve must be opened during weekly examinations. It must be noted in an examination book whether or not the pipe discharges. If the pipe discharges, the valve must be closed and a reading of the pressure and/or water level must be recorded in an examination book.

7. Each newly constructed seal shall have one (1) non-metallic corrosion-resistant 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 must be between ¼ and 1 inch diameter, with a pressure rating of 240 psi. The inby end of the sampling tube must be placed at not more than 18 inches from the roof.

   If the new seal is placed on the outby side of an existing seal, non-metallic corrosion resistant 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 240 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 a CPE, inertization pipe(s) may be installed during construction 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, and a design will be submitted to MSHA for approval. A maximum of two inertization pipes can be installed in each seal and the pipes size can range between 1 inch in diameter minimum and 4 inches in diameter maximum. If more than one inertization 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 inertization pipes shall not be less than 2 ½ times their diameter (Example: 4 inch diameter pipe, then minimum distance between pipes and ribs = 4 inches diameter x 2½ = 10 inches).

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 ± 2 feet and as close to the roof as possible. The two (2) remaining fill pipes shall be placed 3 feet ± 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. One row will extend 2/3 ± 1 foot into the seal, and the other row will terminate 1/3 ± 1 foot into the seal from the front/outby wall.

9. Approved PUR/foam pack, cementitious coating, sealant, or equivalent can be used around the perimeter of the brattice cloth, any joints or seams of the brattice cloth, sampling ports, and pipe annular openings in curtain to minimize leakage during the material pressurization.

10. An example of construction documents that may be used by the designated person is provided during training by Minova. A construction checklist must be completed by the designated certified person and kept on record at the mine.

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". If Wood and Brattice formwork is used for one wall and the opposite wall is constructed of Kennedy or CMU Block the minimum required thickness outlined in the "Form Thickness Specification Table - Wood and Brattice Forms" will be used.

2. For Kennedy forms, install horizontal rails no more than 24 inches apart or away from floor or roof. The top rail in the rear of the seal must be placed no more than 6 inches from the roof to prevent blowout during pressurization of fill pipes near the 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.

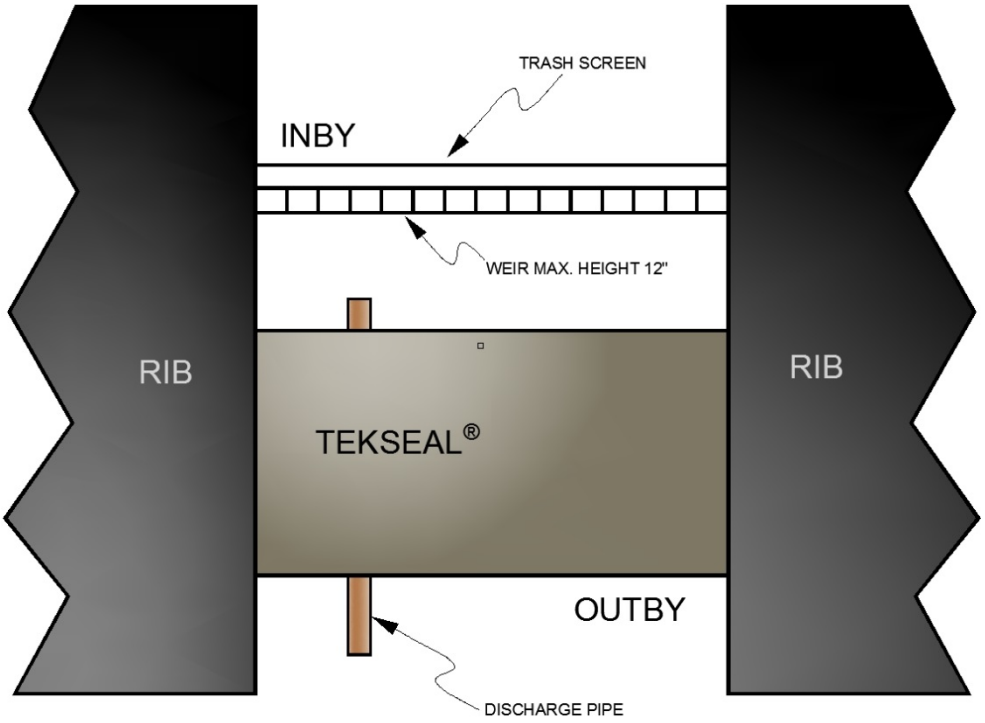
   Form ties can be used as long as they are non-conductive. Standing support on the outside of the seal is a good alternative to form ties, as long as the standing support will resist any form movement. At the discretion of a CPE, it may be necessary to provide an additional barrier to permanently seal the formwork. The outby side of the formwork and seal perimeter can be sealed with a cementitious coating such as Tekflex®, Teknite, Tekcrete Fast®, gunnite, shotcrete, or other approved sealant with no structural function. It may be necessary to install sampling ports prior to permanently sealing the outby formwork to allow for seal certification testing. Once the seal has been certified, the sampling ports must then be permanently sealed. If subsequent testing requires removal of the coating material, then the coating must be removed in a manner not to damage the Tekseal® material and the testing area must again be permanently sealed.

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 determined by a CPE and based on the anticipated maximum flow rate at the seal location. The maximum number of drainage pipes cannot exceed six (6) per seal. Pipe sizes will range between 4 inches minimum and 8 inches maximum 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 (Example: 4 inches diameter pipe – minimum distance between pipes and ribs = 4 inches dia x 2½ = 10 inches). 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. The bottom of any drainage pipe on the inby side must be no less than 4 inches above the floor and no more than 12 inches above the mine floor.

   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. No alterations from the manufacturer's design or strength reducing modifications may be made to pipe and pipe fittings for water drainage pipes.

   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.

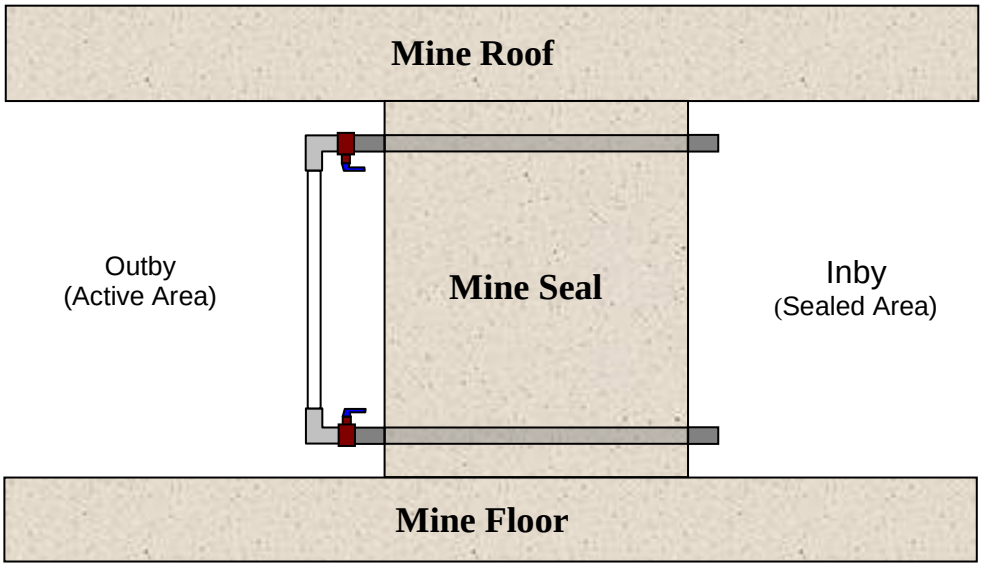
   A low weir catchment, no more than 12 inches high, must be constructed across the total width of the entry inby all seals equipped with drainage pipes. The weir can be constructed of concrete or cement block and will be approximately and to the extent possible level with the bottom of the inby ends of the drainage pipes. A trash screen, twice the height of the weir, must be installed inby the weir. A generic typical drawing of a weir follows.



If a new seal is placed on the outby side of an existing seal equipped with a water drainage system, the existing U-trap must be removed, the existing valve must be removed or placed in a fully-open position, and the drainage pipes must be extended through the new seal with a new valve and U-trap installed as required and meeting required specifications discussed in this section.

a. <u>Water Height Measuring System</u>

If required by the District and if water accumulation in the sealed area is likely based on past mine experience, a water height measuring system, incorporating a sight tube shall be installed, if included on the MSHA approved mine ventilation seal plan. As shown below, the water height measuring system shall consist of two horizontal 1 inch to 1.25 inches inside diameter non-metallic corrosion resistant pipes installed through the seal. The lower pipe shall be securely installed through the seal at the approximate height of the top of the water trap ± 2 inches. The upper pipe shall be securely installed through the seal close to the mine roof at a distance of 6 inches ± 2 inches. 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 not less than 240 psi. Two 90 degree elbows shall be installed on the outby end of each valve and pipe after the valves are in place. A clear plastic tube shall be securely placed between these elbows for viewing of the water elevation inby the seal, as shown below.



As an alternative water height measuring system, a one inch diameter non-metallic corrosion resistant pipe with a valve shall be installed through the seal at the approximate height of the top of the water trap ± 2 inches. The pipe will be equipped with a pressure gauge with markings for depth of water behind the seal. The gauge should be limited to reading between 0-5 psi but no more than 0-10 psi so that the mechanical resolution of the gauge is great enough to show depth changes (27.71 inches of water = 1 psi on the gauge). When calibrating the markings, add the distance in inches between the level of the gauge and the floor inby the seal to accurately report the water levels inby the seal. The shut-off valve and pipe extending through the seal must have an internal pressure rating of not less than 240 psi. The shut-off valve must be opened during weekly examinations. It must be noted in an examination book whether or not the pipe discharges. If the pipe discharges, the valve must be closed and a reading of the pressure and/or water level must be recorded in an examination book.

4. Each newly constructed seal shall have one (1) non-metallic corrosion-resistant 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 18 inches from the roof.

   If the new seal is placed on the outby side of an existing seal, non-metallic corrosion resistant 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 240 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 a CPE, inertization pipe(s) may be installed during construction 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, and a design shall be submitted to MSHA for approval. A maximum of two inertization pipes can be installed in each seal and the pipes size can range between 1 inch in diameter minimum and 4 inches in diameter maximum. If more than one inertization 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 inertization pipes shall not be less than 2 ½ times their diameter (Example: 4 inch diameter pipe, then minimum distance between pipes and ribs = 4 inches diameter x 2½ = 10 inches).

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 ± 2 feet and as close to the roof as possible. The two (2) remaining fill pipes shall be placed 3 feet ± 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 ± 1 foot, and the other row will terminate 1/3 ± 1 foot into the seal from the outby wall.

   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. An approved PUR/foam pack, cementitious coating, sealant, or equivalent can be used around the perimeter, any joints or seams, sampling ports, and pipe annular openings to minimize leakage during the material pressurization.

7. An example of construction documents that may be used by the designated person is provided during training by Minova. A construction checklist must be completed by the designated certified person and kept on record at the mine.

D. Tekseal Placement:

1. 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.

   Only properly trained personnel are to operate the placer equipment and place Tekseal® from the end of the hose into the seal formwork. Installers must complete installation training by qualified trainers prior to installing any seal. Written certification of training must be issued to each trained

individual and kept on record by the trainer and on site. All personnel shall wear appropriate personal protective equipment (PPE) during installation.

2. Prior to placement of the Tekseal material in between the prepared forms, the Minova Tekplacer will be calibrated in accordance with the following procedure using 45 pound bags of Tekseal® (The Tekplacer calibration is always performed using 45 pound bags of Tekseal® when utilizing either Tekseal® bulk packs or 45 pound Tekseal® bags to construct the seal):

   Prior to the placement of material into each seal formwork, after any interruption in pumping, and at approximately midshift (if only one seal is pumped in a single shift and the pumping exceeds four hours then a calibration will be performed at the approximate mid-completion of the seal), the Tekplacer machine must be calibrated to ensure that the Tekseal® material is proportionally correct. The water to powder ratio must remain between 1.1 and 1.25 at all times during pumping. Tekseal® output temperature must remain between 65º and 85º at all times during pumping. Water supply must be heated or cooled as needed. Inlet water flow must be adequate to support the required water to powder ratio (1.1 to 1.25) at all times during seal installation. The nominal inner diameter of the hose is 1.25 to 1.5 inches and the minimum length of the hose is no less than 600 feet to allow for proper mixing of the water and powder. Maximum hose length is 2,500 feet from the placer machine. Any hose distances greater than 2,500 feet must be reviewed and approved by a Minova Installation Technician. Recommended bag mixes (bags/yd^3) for curing times less than 28 days may be provided by a Minova representative. The following is an example of some of the information that will be documented during the calibration process.

   Tekseal® Outlet Temperature: 65 ºF - 85 ºF
   Hose Length: 600 feet – 2,500 feet (or as approved by Minova)
   Hose Diameter: 1¼" - 1½"
   Number of Bags/yd^3: 11.5 – 17

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^3

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

Output (volume ÷ time): 5.93 **ft^3/min**

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

Mix Strength = (lbs/yd^3) ÷ (45): 12.4 **bags/yd^3**

An example of a Calibration/Shift Production Report that may be used by the designated person is provided during training by Minova. The reports must be filled out, signed, and dated by the person performing the calibration each time it is necessary to re-calibrate the machine. A copy of the completed calibration sheet must be kept on record at the mine.

3. The existing mine water supply provided must be sufficient to maintain the correct water to powder ratio. A water source will be subjected to compatibility testing if Minova Tekseal® has not been installed during the preceding three years, if there has been a change in the water source since the last use of Tekseal®, or if a new chemical conditioner is being added to the water since the last use of Tekseal®. Compatibility tests will be completed by Minova using the Tekseal® Manufacturing Quality Control procedures. If the compatibility test meets the requirements, the mine water can be used as it is. If a change in supply or quality is noted during the pumping process, the water must again be evaluated for compatibility with Tekseal®.

   Water sources requiring liquid defoamer will undergo compatibility testing to determine the proper dosage levels by Minova. Once this dosage level has been determined, compatibility testing by Minova using the Tekseal® Manufacturing Quality Control procedures.

   In the field, the liquid defoamer will be dosed at the predetermined controlled rate into the inlet port of the pump suction housing of the Tekplacer.

4. 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, the roughness of the cold joint must be visually inspected. If the surface roughness is less than 2 inches over 4 feet, measures will be taken to mechanically roughen and clean the surface of the cold joint.

   Pumping interruptions should be documented as well as surface roughness and any surface preparations and modifications required.

5. 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.

6. A minimum of nine (9) samples from each seal will be taken, as follows: The first three (3) samples from the lower third of the seal height; 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 must 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 container. Each sample must be filled to the top of the supplied container. Samples must be tapped and/or stirred to make 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 near the seal in the mine or in an upright position in closed sample boxes near the seal (sample box types specified by Minova). The location, seal identification, and date must be marked on each sample with a permanent marker. While in the mine during the curing period, the samples must be readily able to be inspected. 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, additional samples (minimum nine (9)) can be taken and tested at the desired time period. If required by the respective MSHA District, a target cure time must be stated in the approved Seal Ventilation Plan.

i. All samples must be tested within 8 days from being taken from the seal area 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.

ii. Under the direction of a CPE, a non-destructive testing (*NDT*) method for measuring the strength of cured seals to determine if its strength had exceeded the design strength must be conducted on each seal after the curing period is reached. Testing must be performed by a trained person designated by a CPE.

    Sampling ports may be installed during the construction of the formwork to reduce the opportunity of surface air drying effects or air degradation (an example of a sampling port can be explained by a Minova representative). If a sampling porthole requires affixing a part or component of the porthole to the inside of the formwork on a Kennedy or CMU block form, then the design thickness of the seal will be the minimum required by the thickness specification tables plus the depth of the protruding part of the sampling porthole.
    Tests may be taken at the designated cure time stipulated or proposed by a CPE or up to the maximum of 60 days.

    Sampling ports or any other methods used for testing must be permanently sealed at the completion of the final testing so that the formwork is intact for its original purpose and to avoid any further opportunity of surface air drying effects or air degradation. Sampling ports must be sealed with a permanent, non-permeable coating such

as concrete, Tekflex®, Teknite, Tekcrete Fast®, or an approved PUR/foam pack.

a. A penetration test will be conducted on each seal installed after the designated curing period using a Minova approved penetrometer. The penetrometer is fitted with a probe having a surface area of 1/20 (0.05) square inches and is designed to penetrate up to ½ (0.5) inch into material by observing the scribed indicator. For an average entry height of 48" or less, six (6) areas on the seal will be tested. The seal will be divided into six approximately equal areas with three areas above the mid-height of the seal and three below. Tests will be conducted at a location within each of these six areas where the formwork will allow. For an average entry height greater than 48", nine (9) areas of the seal will be tested. The seal should be divided into nine approximately equal areas with three areas in the upper 1/3 of the seal, three in the lower 1/3 of the seal and the remaining three at the center 1/3 of the seal. Tests will be conducted at a location within each of these nine areas where the formwork will allow. For "Kennedy" and concrete block type formwork, sampling ports and/or holes can be fabricated into the formwork of the seal and the inby side of the sampling port covered with brattice cloth or similar material during pouring. If potential air degradation is observed when a sampling port is exposed, a CPE should examine the seal to determine the path, extent, and impact of the air degradation across the surface of the seal. At the discretion of a CPE, an alternate location can be selected for testing.

   After the test, the exposed area must be covered and permanently sealed to protect the area tested from exposure to the mine air. A passing test will be when the average of readings indicate a minimum average of 400 psi compressive strength with no more than two (2) measurements below 400 psi (a reading of 80), and no measurements below 300 psi (a reading of 60) will be accepted. The test results will be submitted with the compressive strength poured samples for certification. If a test does not meet the minimum 400 psi strength requirement, additional penetrometer tests can be conducted at a later date. If a seal does not meet these strength requirements within 60 days after the initial pour, the seal will need to be replaced.

b. Alternate methods may be implemented if approved by MSHA.

7. The seal is not recognized as reaching design strength and performing as a seal until the quality control test results are accepted by the governing MSHA District as passing.

E. Time Required for Seal to Reach Design Strength:

The standard Tekseal mixture (typically 517 lbs/yd3) 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, may be taken. At the discretion of a CPE, it may be necessary to provide an additional barrier to permanently seal the formwork.

F. Surface Drying Effects:

The surface drying effects (air degradation) 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 must be instructed to verify that the brattice is intact. If the brattice or form is damaged, or the Tekseal is otherwise exposed to the atmosphere, the brattice must be repaired or other measures must be taken to cover the exposed Tekseal. The outby side of the framework and seal perimeter can be sealed with a cementitious coating such as Tekflex®, Teknite, Tekcrete Fast®, gunnite, shotcrete, or other approved sealant with no structural function.

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 (Concrete, Tekseal®, Carbothix, or Carbopur (polyurethane)), with a minimum cured strength of 400 psi and a minimum bond shear strength of 72 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 placed 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 perimeter of the seal, and there is no loss of contact with the surrounding rock or coal, the leak(s) may be filled with concrete, Tekseal, a low-density polyurethane foam, such as Silent Seal® or equivalent. The manufacturer's instructions shall be followed during application. Again, the seal must be checked for air leakage afterwards to ensure the job has been successful.

After the seal has reached design strength as recognized by the MSHA District, only non-structural repairs can be made to the seal. If deficiencies are determined by a CPE, a proposed repair plan will be submitted to the District for review.

Repairs prior to recognition by MSHA that the design strength has been reached or 60 days, whichever is shorter, include incidental void filling, surface repairs, grouting of ribs, roof, and floor, and must follow the procedures prescribed in 30 CFR 75.337.

H. Strata Fracture

During post-construction evaluations, if it is determined that air leakage through the strata surrounding the seal exists, ring-grouting can be performed. 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. The seal should be evaluated after grouting with typical air leakage detection tools such as smoke tubes or other MSHA-approved detection devices.

Prior to seal certification, post-construction seal voids and strata fractures can be grouted during the same repair project. The grout used to make seal repairs will migrate into the surrounding strata, sealing and strengthening it.

I. Maximum Allowable Convergence:

During post-certification evaluations, if 5 percent of actual convergence has been exceeded, a CPE must perform a structural evaluation as an additional safety precaution. If a CPE determines that the structural integrity of the seal has not been compromised and the seal can function as designed, a certified letter must be sent to the governing MSHA District with a CPE's assessment. If structural damage to the seal is detected by a CPE, the seal must be replaced as prescribed by Federal Regulations. The governing MSHA District will establish the measuring criteria and monitoring frequency of convergence after the initial 5 percent threshold is reached and structural damage has not been detected.

While the estimated convergence may be measured at the outby entry using extensometers, "pogo" sticks or any other approved measuring device, confirmation of the actual convergence of the seal can be measured by indicators established by a CPE only on the outby seal face.

J. Storage Conditions for Construction Materials:

Tekseal is palleted in polyethylene-lined bags, or as a bulk pack. 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 Dr. Steve Tadolini, PhD, (740)359-4076 or Jason Tinsley, P.E. at (618)663-7937, Minova USA Inc., 150 Summer Court, Georgetown, Kentucky, 40324.

Minova USA, Inc.

Thickness Specification - Installation Table - Wood and Brattice Forms

120-psi Blast Loading Seal – Entry Widths > 30 Feet

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

Entry Height, ft	Maximum Acceptable Convergence, in	Entry width, ft										
		30	31	32	33	34	35	36	37	38	39	40
4	2.40	9.5	9.5	9.6	9.6	9.6	9.6	9.7	9.7	9.7	9.7	9.8
4.5	2.70	10.4	10.5	10.5	10.6	10.6	10.6	10.7	10.7	10.7	10.8	10.8
5	3.00	11.4	11.4	11.5	11.5	11.6	11.6	11.6	11.7	11.7	11.7	11.8
5.5	3.30	12.3	12.3	12.4	12.5	12.5	12.5	12.6	12.6	12.7	12.7	12.8
6	3.60	13.2	13.2	13.3	13.4	13.4	13.5	13.5	13.6	13.6	13.7	13.7
6.5	3.90	14.0	14.1	14.2	14.2	14.3	14.4	14.4	14.5	14.5	14.6	14.6
7	4.20	14.9	14.9	15.0	15.1	15.2	15.3	15.3	15.4	15.4	15.5	15.6
7.5	4.50	15.7	15.8	15.9	15.9	16.0	16.1	16.2	16.3	16.3	16.4	16.5
8	4.80	16.5	16.6	16.7	16.8	16.9	16.9	17.0	17.1	17.2	17.3	17.3
9	5.40	18.0	18.1	18.2	18.3	18.5	18.6	18.7	18.8	18.9	18.9	19.0
10	6.00	19.4	19.6	19.7	19.9	20.0	20.1	20.2	20.3	20.5	20.6	20.7
11	6.60	20.8	21.0	21.1	21.3	21.4	21.6	21.7	21.9	22.0	22.1	22.2
12	7.20	22.1	22.3	22.5	22.7	22.8	23.0	23.2	23.3	23.5	23.6	23.7
13	7.80	23.3	23.6	23.8	24.0	24.2	24.4	24.5	24.7	24.9	25.0	25.2
14	8.40	24.5	24.8	25.0	25.2	25.5	25.7	25.9	26.1	26.2	26.4	26.6
15	9.00	25.7	25.9	26.2	26.4	26.7	26.9	27.1	27.3	27.6	27.8	27.9
16	9.60	26.8	27.0	27.3	27.6	27.9	28.1	28.4	28.6	28.8	29.0	29.2
17	10.20	27.8	28.1	28.4	28.7	29.0	29.3	29.5	29.8	30.0	30.3	30.5
18	10.80	28.8	29.1	29.5	29.8	30.1	30.4	30.7	30.9	31.2	31.5	31.7
19	11.40	29.7	30.1	30.5	30.8	31.1	31.5	31.8	32.1	32.3	32.6	32.9
20	12.00	30.7	31.1	31.4	31.8	32.1	32.5	32.8	33.1	33.4	33.7	34.0
21	12.60	31.5	32.0	32.4	32.8	33.1	33.5	33.8	34.2	34.5	34.8	35.1
22	13.20	32.4	32.8	33.3	33.7	34.1	34.4	34.8	35.2	35.5	35.8	36.2
23	13.80	33.2	33.7	34.1	34.6	35.0	35.4	35.8	36.1	36.5	36.8	37.2
24	14.40	34.0	34.5	35.0	35.4	35.8	36.3	36.7	37.1	37.4	37.8	38.2
25	15.00	34.8	35.3	35.8	36.2	36.7	37.1	37.6	38.0	38.4	38.8	39.1
26	15.60	35.5	36.0	36.5	37.0	37.5	38.0	38.4	38.8	39.3	39.7	40.1
27	16.20	36.2	36.7	37.3	37.8	38.3	38.8	39.2	39.7	40.1	40.6	41.0
28	16.80	36.9	37.4	38.0	38.5	39.1	39.6	40.0	40.5	41.0	41.4	41.8
29	17.40	37.5	38.1	38.7	39.3	39.8	40.3	40.8	41.3	41.8	42.2	42.7
30	18.00	38.2	38.8	39.4	40.0	40.5	41.1	41.6	42.1	42.6	43.1	43.5

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

120-psi Blast Loading Seal – Entry Widths > 30 Feet

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

Entry Height, ft	Maximum Acceptable Convergence, in	Entry width, ft										
		30	31	32	33	34	35	36	37	38	39	40
4	**2.40**	8.8	8.9	8.9	8.9	8.9	9.0	9.0	9.0	9.0	9.1	9.1
4.5	**2.70**	9.8	9.8	9.9	9.9	9.9	10.0	10.0	10.0	10.1	10.1	10.1
5	**3.00**	10.7	10.8	10.8	10.9	10.9	10.9	11.0	11.0	11.0	11.1	11.1
5.5	**3.30**	11.6	11.7	11.7	11.8	11.8	11.9	11.9	12.0	12.0	12.1	12.1
6	**3.60**	12.5	12.6	12.6	12.7	12.8	12.8	12.9	12.9	13.0	13.0	13.0
6.5	**3.90**	13.4	13.4	13.5	13.6	13.6	13.7	13.8	13.8	13.9	13.9	14.0
7	**4.20**	14.2	14.3	14.4	14.4	14.5	14.6	14.7	14.7	14.8	14.8	14.9
7.5	**4.50**	15.0	15.1	15.2	15.3	15.4	15.4	15.5	15.6	15.7	15.7	15.8
8	**4.80**	15.8	15.9	16.0	16.1	16.2	16.3	16.4	16.4	16.5	16.6	16.7
9	**5.40**	17.3	17.4	17.6	17.7	17.8	17.9	18.0	18.1	18.2	18.3	18.4
10	**6.00**	18.8	18.9	19.0	19.2	19.3	19.4	19.6	19.7	19.8	19.9	20.0
11	**6.60**	20.1	20.3	20.5	20.6	20.8	20.9	21.1	21.2	21.3	21.5	21.6
12	**7.20**	21.4	21.6	21.8	22.0	22.2	22.3	22.5	22.7	22.8	22.9	23.1
13	**7.80**	22.7	22.9	23.1	23.3	23.5	23.7	23.9	24.1	24.2	24.4	24.5
14	**8.40**	23.9	24.1	24.3	24.6	24.8	25.0	25.2	25.4	25.6	25.8	25.9
15	**9.00**	25.0	25.3	25.5	25.8	26.0	26.3	26.5	26.7	26.9	27.1	27.3
16	**9.60**	26.1	26.4	26.7	26.9	27.2	27.5	27.7	27.9	28.1	28.4	28.6
17	**10.20**	27.1	27.4	27.8	28.1	28.3	28.6	28.9	29.1	29.4	29.6	29.8
18	**10.80**	28.1	28.5	28.8	29.1	29.4	29.7	30.0	30.3	30.5	30.8	31.0
19	**11.40**	29.1	29.5	29.8	30.1	30.5	30.8	31.1	31.4	31.7	31.9	32.2
20	**12.00**	30.0	30.4	30.8	31.1	31.5	31.8	32.1	32.5	32.8	33.1	33.3
21	**12.60**	30.9	31.3	31.7	32.1	32.5	32.8	33.2	33.5	33.8	34.1	34.4
22	**13.20**	31.7	32.2	32.6	33.0	33.4	33.8	34.1	34.5	34.8	35.2	35.5
23	**13.80**	32.5	33.0	33.5	33.9	34.3	34.7	35.1	35.5	35.8	36.2	36.5
24	**14.40**	33.3	33.8	34.3	34.7	35.2	35.6	36.0	36.4	36.8	37.1	37.5
25	**15.00**	34.1	34.6	35.1	35.6	36.0	36.5	36.9	37.3	37.7	38.1	38.5
26	**15.60**	34.8	35.4	35.9	36.4	36.8	37.3	37.7	38.2	38.6	39.0	39.4
27	**16.20**	35.5	36.1	36.6	37.1	37.6	38.1	38.6	39.0	39.5	39.9	40.3
28	**16.80**	36.2	36.8	37.3	37.9	38.4	38.9	39.4	39.8	40.3	40.7	41.2
29	**17.40**	36.9	37.5	38.0	38.6	39.1	39.6	40.2	40.6	41.1	41.6	42.0
30	**18.00**	37.5	38.1	38.7	39.3	39.8	40.4	40.9	41.4	41.9	42.4	42.9

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