

MSHA Approval Number: 120M-03.0
120 PSI BHP Billiton Concrete Main Line Plug Seal
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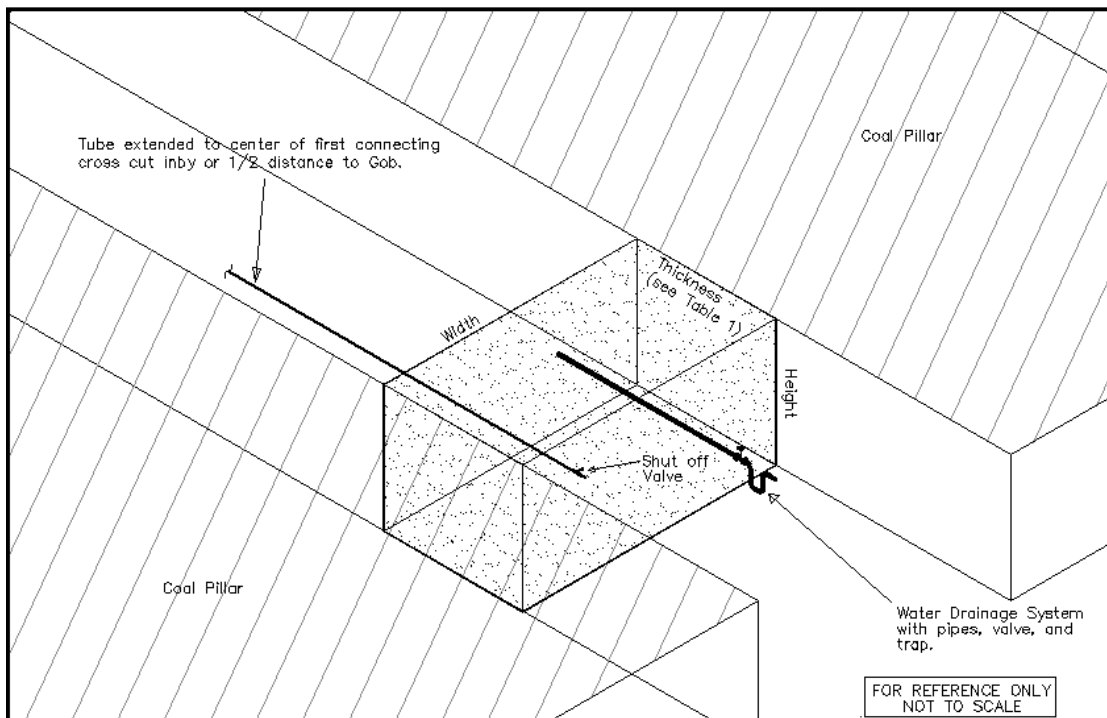
Seal Installation Guidelines for the BHP 120 PSI Concrete Plug Seal

Introduction

These instructions are a summary of the installation procedures related to concrete plug type seals. Figure 1 shows the general layout of the concrete seal as it exists inside of the form walls.

In general, concrete is pumped through a borehole to the mine or from an underground pumping location and distributed laterally through pipes to the seal location where it is poured into the seal forms.

Figure 1. General Layout of Concrete Seal without forms shown.



Work Place Inspection:

Work place inspection involves several steps:

1. Make sure an adequate pre-shift has been performed for the work area.
2. Examine the area for hazards such as water, loose roof and ribs, etc., and take action to remediate any hazardous conditions found.
3. Take account of the tools and materials used and make sure adequate supplies are present to complete the work.
4. Inspect all tools and equipment for safe operation and compliance with applicable standards.

Site Preparation:

Seal construction sites will be prepared in the following manner:

1. Remove excess debris and material from the seal pour location and for 3 feet on the inby and outby side of the seal forms location.
2. Remove any metallic conductors such as roof or rib mesh, cables, roof mats, truss cables, or pipes that would extend through the seal location. Any metallic conductors that extend across the form walls will be noted within the seal documentation as not passing through the body of the seal. If removal of roof mesh or other metallic roof control measures will create a hazard to miners during construction of the seal, the metallic roof control measures will be removed for 1 foot on either side of the form walls. This removal will be noted in the seal documentation.
3. Seals shall be constructed at least 5 feet from the corner of any pillar. If a seal is to be located less than 10 feet from the corner of a pillar, the rib will be reinforced by Shotcrete, Gunnite, or manually applied cement mixtures.
4. Scale the roof and ribs in the seal location.
5. Remove soft floor or mud from the seal location down to competent strata.
6. If necessary, a "footing" or slab of concrete with at least the same materials specifications used in the seal may be poured. This footing will be at least 2 feet in thickness and will extend a minimum of 1 foot past the footprint of the seal on both the inby and outby sides. If reinforcement is used, it will be of a non-conductive type such as fiberglass or equivalent construction. The surface of this footing will be roughed up to a minimum of ½ inch to promote adhesion and will be covered to reduce moisture loss during curing for a minimum of 7 days or until the seal is placed. Forms for this footing will be constructed to be mortar tight and will be placed in such a manner as to allow proper leveling of the slab to within 4 inches from side to side and from front to back.
7. A minimum roughness of 1 inch over a distance of 4 feet along the rib line inside the seal forms must be maintained. If this minimum is not met, mechanical means may be employed to create this roughness through rib material removal.
8. A maximum divergence of the rib lines will be 4 inches over a distance of 10 feet. If divergence is found to be in excess of this limit, the ribs shall be examined by a certified Professional Engineer to determine if the variation of the rib lines creates enough resistance to movement to maintain the

functionality of the seal. This may be accomplished at the point when the certified Professional Engineer certifies the seal location as adequate for use with this type of seal. A mechanical means may be employed to create a hitch in the ribs to more tightly restrain the seal from movement. The minimum hitch will be 12 inches in width and 6 inches deep from roof to floor on both sides of the seal.

9. Use pumps or dams to prevent water from accumulating at the seal location. Remove water to a maximum depth of no more than 2 inches anywhere in the seal footprint. Flowing water will be diverted from the seal location.
10. A certified person shall supervise or examine the construction site to ensure that the site is in accordance the Approved Ventilation Plan and the Seal Approval and make the appropriate records of such examination.
11. Remove piles of rib slack or accumulations. Minimal amounts of material need not be removed.

Form Walls:

Form walls will be constructed in the following manner:

- 1) Select a forms spacing from Table 1 (at the back of this document) appropriate for the height of the seal. If the locations height or width is between the foot by foot ratings in the table, use the next greater height or width to determine the appropriate spacing. When using Table 1, find the maximum seal dimensions from the seal location. Use this dimension to select a seal form spacing, not an average or minimum measurement.
- 2) When working between the form walls, the atmosphere will be continually monitored for methane and oxygen content.
- 3) Place forms as tight as possible to the ribs at the seal construction site.
- 4) Forms shall be placed as vertically as possible to within 2 inches of plumb and as straight as possible from side to side to within 4 inches.
- 5) Forms shall be constructed to maintain the minimum seal thickness throughout the seal as listed in Table 1.
- 6) Forms are to be sealed to prevent leakage of concrete during pouring. Forms can be made mortar tight by applying appropriate mine sealant or with brattice cloth.
- 7) When building wood forms:
 - a) Select wood members that are nominally straight and flat.
 - b) When re-using form materials, they are to be cleaned of excess materials such as concrete and sealant, etc.
 - c) Trim flat wood sheeting to conform to the contours of the roof, ribs, and floor.
 - d) Wood sheeting will be a minimum of $\frac{3}{4}$ inch in thickness and overlapped and at least two layers thick. Overlaps will be at least 12 inches.
 - e) Flat sheeting will be fastened together and to any support members with screws or nails to prevent movement.
 - f) Joints in the flat sheeting can be glued or sealed in addition to the screws or nails to make them mortar tight.
 - g) The edges of flat sheeting will be sealed to the roof, ribs, and floor with an MSHA approved mine sealant, brattice cloth, or plastic sheeting.

- h) Use a minimum of 2 horizontal reinforcement beams or “wales” to strengthen the forms. Such wales will be a minimum of 2 inch by 10 inch standard lumber dimensions.
 - i) If roof to floor supports are used to hold the form walls in place, a minimum of 5 supports will be placed evenly across each form wall.
 - j) If form ties are used to hold the forms, they will be of a non-conductive construction such as structural fiberglass.
 - k) If form ties are used to hold the forms, a minimum of 4 ties will be used per row along the wales.
 - l) If forms are to be left in place after construction of the seal, all exposed wood or flammable construction material surfaces will be coated with an MSHA approved mine sealant having a flame spread index of 25 or less.
 - m) If forms are removed after seal construction, patch or repair any material that may have been pulled loose by the removal of the forms with a cementitious grout or MSHA approved mine sealant.
- 8) When building metal forms:
- a) Select materials that are free from dents or deformations that may prevent sealing.
 - b) When re-using form materials, they are to be cleaned of excess materials such as concrete and sealant, etc.
 - c) Place forms tightly to the roof, ribs, and floor, trimming them if necessary.
 - d) Adequate edge re-enforcements will be used to make the forms mortar tight.
 - e) Form sheeting will be fastened to each other and to any support members to prevent movement.
 - f) Joints in the flat sheeting can be glued or sealed to make them mortar tight.
 - g) The edges of flat sheeting will be sealed to the roof, ribs, and floor with an MSHA approved mine sealant, brattice cloth, or plastic sheeting.
 - h) Use a minimum of 2 horizontal reinforcement beams or “wales” to strengthen the forms. Such wales can be beams, channels, or other structural shapes that will adequately support the concrete when poured.
 - i) If roof to floor supports are used to hold the form walls in place, a minimum of 5 supports will be placed evenly across each form wall.
 - j) If form ties are used to hold the forms, they will be of a non-conductive construction such as structural fiberglass.
 - k) If form ties are used to hold the forms, a minimum of 4 ties will be used per row along the wales.
 - l) If forms are removed after seal construction, patch or repair any material that may have been pulled loose by the removal of the forms with a cementitious grout or MSHA approved mine sealant.
- 9) Supplemental roof supports shall be installed inby and outby the seal in accordance with any approved plans.
- 10) Vent pipes, if needed, will be placed in high spots to allow the removal of air pockets at the top of the seal. If used, a minimum of 2 vent pipes will be installed. Vent pipes will be of a non-conductive construction such as PVC, ABS plastic, or equivalent or other non-conductive material. If the vent pipes fail to return material, they will be filled with an expansible grout or other material that is similar to the concrete of the seal or filled with an MSHA approved mine sealant. Closeable ports in the seal forms may also be used to visually verify the complete filling of the seal to the roof and to allow the removal of air pockets.

- 11) At least one non-metallic sample pipe with a minimum inside diameter of ½ inch and a maximum inside diameter of 1 inch with an appropriate valve and fittings for taking gas samples shall be installed through the seal body and shall extend into the first connecting cross cut in by the seal. If such an intersection does not exist, the pipe shall be extended half the distance of the open entry in by the seal. Sample pipes shall be labeled to indicate the location of the sampling point when more than one sampling pipe is installed through a seal. Each gas sampling pipe or extension shall be supported along its length with ties or straps at a maximum of 5 foot intervals and the in by end shall be hung no more than 12 inches from the roof.
- 12) The shut off valves for the sampling pipes may be extended downward on the fresh air side of the seal to allow safe access to the valves. Each pipe, fittings, and valve shall be ½ inch internal diameter and have a minimum internal pressure rating of 240 psi which is easily identifiable.
- 13) Install a corrosion resistant, non-metallic water drainage pipe with water trap and valve(s) all having a 240 psi pressure rating through the seal body. This will be located as close to the lowest point in each set of seals as possible but located at least 36 inches from the rib to prevent damage from rib sloughage or floor heave. The U portion of the water trap may have to be recessed into the floor. The pipe shall be a minimum of 4 inches and a maximum of 8 inches inside diameter.
- 14) When an existing seal is used as a form wall for another seal, the site for the new seal will be cleaned and prepared in the same fashion as for any seal (i.e. removal of loose roof, floor, and rib material, removal of conductors, etc.). The water drainage system and gas sampling pipes will be connected through the new seal and new valves and fittings will be placed on the out by face of the new seal.
- 15) An existing seal used as a form wall for another seal will be cleaned of loose roof, rib, and floor material. Excess forms material left from the first seal will be removed. Existing supplemental roof to floor support will be removed only if it does not pose a safety hazard to miners working in the area. If existing supplemental roof to floor supports cannot be removed safely, they may be enclosed in the body of the new seal as long as no support is closer than 12 inches from the new form wall on the out by face of the seal. Metallic conductors such as roof mesh shall be severed and removed to a minimum distance of 12 inches from both sides of the new form wall on the out by face of the seal. Remove accumulations of dust and dirt from the existing seal. Minimal amounts of materials such as rock dust or fine coal dust need not be removed as they will be encased or displaced by the concrete.
- 16) Dirt, dust, and debris will be removed from the seal pouring area prior to concrete placement. Piles of material such as rib slack will be removed with hand tools or other mechanical means. Minimal amounts of materials such as rock dust or fine coal dust need not be removed as they will be encased or displaced by the concrete.
- 17) When using external shoring, place a minimum of three roof to floor supports across the face of the seal with one at either side and one in the middle. Supports will be placed plumb to the face of the forms and wedged tight to prevent movement of the forms when pouring concrete. Angled shoring for the roof to floor supports may be added to brace the forms. This additional shoring will be placed to prevent movement of the supports when under load.
- 18) When using form ties, the ties will be installed to prevent deformation of the forms with excess tension.

Preparation for Pouring the Seal Body:

Prepare for the pouring of the seal body in the following manner:

1. Install concrete pipes from the borehole bottom or underground pumping location using the proper couplers and installation procedures. Concrete pipes are specifically manufactured for the purpose of transporting concrete from a pump to the pour location and may be of rigid or flexible design.
2. Install a placement pipe or hose into the seal forms that will not allow the concrete to drop more than 5 feet.
3. Communications shall be established between the concrete pouring crew and the concrete pumping location.
4. Perform a final examination of the seal construction location including the pipe layout, the forms construction, and communications methods.
5. The concrete pump will be a positive displacement piston type or a pneumatic type.
6. The pump may be located on the surface for pumping through a borehole or underground near the seal construction site.
7. The pump shall be located to adequately transport concrete to the seal and according to the manufacturer's recommendation as to pumping distances.
8. When pumping distances exceed the capability of the pump, additional inline or transfer pumps may be used.
9. When pumps are used underground, they will be located in the intake air course. If pumps are to be used in areas that require permissible equipment, they shall be hydraulically or pneumatically powered or their power units will be in full compliance with MSHA requirements for permissibility.

Pouring Concrete:

Concrete shall be poured in accordance with the following procedure:

Note: The concrete will be of a minimum compressive strength of 3,000 psi. Admixtures may be added to address weather and other conditions. The slip or receipt provided by the vendor must note mix BHPSTC or mix SHOT.

1. Proper PPE shall be worn when in areas where the pouring of concrete could create splashing. This includes but is not limited to safety glasses, face shield or goggles, rain suit or coveralls, and gloves.
2. Communicate with the concrete pumping location and instruct them to start pumping concrete.
3. Continue to check the forms for leaks or bulges. Repair any leaks or bulges found.
4. If the seal is to be finished or “topped” at a later time, continue to pour the concrete until it is in proximity to the roof, nominally 2 to 6 inches. Allow the concrete to obtain an initial “set” strength, typically 4 or more hours.
5. Finish or “top” the seal with concrete or grout at a later time following point 7 listed below.
6. If the seal is to be finished in a continuous pour, continue to pour the concrete until it fills the forms.
7. Concrete or grout must return from the vent pipes to ensure good coupling with the roof. If the concrete or grout is of too low a slump to allow flow through the vent pipes, then the pipes must be filled with an expansive grout or withdrawn from the forms.
8. An inspection on each shift of seal construction shall be made by a certified person trained in the work being done. Proper records of such inspection shall be recorded in the appropriate locations.
9. Concrete is to be continuously poured. If a situation arises that requires pumping to be stopped for more than 4 hours, the surface of the concrete is to be roughed up using a rake or other suitable tool to a minimum of ½ inch before the concrete surface hardens.
10. The seal concrete material is a self consolidating, highly flowable material that does not require vibration or additional means of placement.

Sampling Concrete:

1. Samples of the seal concrete will be taken only by persons trained to do so.
2. A minimum of 8 samples are to be taken for each lift in a seal. A lift is defined as a continuous pour of concrete that is not separated from another pour by more than 4 hours. The pouring of concrete is intended to be continuous as shown in the Pouring Concrete section above. If a delay is experienced (such as a mechanical breakdown of the pump) that stops concrete pouring for more than 4 hours, the next pour will be considered as an additional lift. The finishing or “topping” of a seal as shown in the Pouring Concrete section above is not considered as a separate lift.
3. Samples are to be stored at the seal location until the concrete has reached its design strength.
4. A slump test will be taken for each lift in a seal. The minimum slump will be 4 inches. Concrete that does not conform to the slump test will not be placed in the seal.
5. Place concrete samples in a location where they will not be in water or be damaged by rib sloughage or moving equipment.
6. Samples are to be tested after they have cured at the seal location for a minimum of 7 days.
7. At least 4 samples from each lift in a seal will be tested in compression. A minimum compressive strength of 3,000 psi must be achieved for a minimum of 4 samples tested in order to determine with a high degree of engineering certainty that the seal has cured to its design strength. If a sample should give results lower than the expected minimum, an additional sample from the same lift shall be tested to replace the failed sample.

Final Seal Work:

Final work associated with seal construction shall be performed according to the following:

1. When pouring is finished, remove and clean all pipes and fittings of concrete or grout.
2. Check the function of water trap and sample pipe valves.
3. Inspect all valves at seals for damage and replace if necessary and ensure the valves are closed.
4. Check that the vent pipes are either full of concrete or grout or are removed from the forms.
5. Remove any trash or material left over from seal construction that may impede inspection or the function of the water trap or sample pipe.
6. Install any necessary ventilation devices at the seal to prevent any accumulation of gasses or low oxygen.
7. Ensure that sampling pipes are properly labeled.
8. Install a convergence monitoring device on the seal.
9. During the regular inspection of the seal, the water trap will be opened to determine if water is accumulating behind the seal. Water will be allowed to flow out from behind the seal. If water is found to regularly accumulate behind the seal, the water trap will be left open and the trap filled with fire resistant oil after the water has finished flowing out. A one way check valve may also be used to prevent in-gassing at the seal when the valve is left in the open position. Unless a seal is noted to be in this condition, valves on water traps are to remain in the closed position.

Note: Convergence is a measurement of the distance between two known points at the seal. These seals are rated to withstand a convergence of .002 inch per inch of separation of the points. For example, if the two measurement points are 8 feet or 96 inches apart, 96 inches times .002 inch per inch is 0.192 inches that the points are allowed to converge. This distance is monitored with a convergence monitoring device installed at the seal and read from a scale on the side of the device. As all concrete experiences a minimal amount of shrinkage when it cures, the initial or baseline reading of the distance between the two points is measured after the concrete has reached its design strength after 7 days. Other options for monitoring this distance might include a device that can be moved from seal to seal to take the readings or one that remotely measures this distance or gives an indication that the maximum allowed convergence has been exceeded much like a "Tell Tale" measures roof sag.

Training:

1. All personnel involved in the construction of seals; including persons inspecting the seal sites before, during, and after construction, responsible persons, managers, and workers, shall be trained. This training shall include these installation instructions, familiarization with the Final Rule, and the requirements of record keeping.

Table 1. Required Concrete Plug Seal Thickness (inches) for 120 psi Seal.

		Width (feet)										
		16	17	18	19	20	21	22	23	24	25	26
Height (feet)	6	93	97	101	104	107	111	114	116	119	122	124
	7	97	101	106	110	114	117	121	124	127	130	133
	8	102	104	109	114	118	122	126	130	134	137	141
	9	113	114	115	117	122	126	131	135	139	143	147
	10	123	124	126	127	128	129	134	139	143	148	152
	11	131	134	136	137	139	140	140	141	146	151	156
	12	138	141	144	147	149	150	151	152	153	154	159
	13	143	148	152	155	158	160	162	163	164	165	166
	14	146	152	158	162	165	168	171	173	174	176	177
	15	148	156	162	167	172	176	179	182	184	186	187
	16	149	158	165	172	177	182	186	189	192	195	197
	17	158	158	167	175	181	187	192	196	200	203	206
	18	165	167	168	176	184	191	197	202	206	210	213
19	172	175	176	177	186	193	200	206	212	216	220	
20	177	181	184	186	186	195	203	210	216	221	226	