Guide for

EXISTING ALTERNATIVE SEALS

(Alternative Seals Built Prior to the Issuance of Program Information Bulletin (PIB) No. P06-16, Dated July 19, 2006)

October, 2006

Mine Safety and Health Administration

Introduction

On July 19, 2006, MSHA issued a Program Information Bulletin (PIB) No. P06-16, titled, "Use of Alternative Seal Methods and Materials Pursuant to 30 CFR 75.335(a)(2)." PIB No. P06-16 requires that new alternative seals be designed and built to reliably withstand an overpressure of at least 50 pounds per square inch (psi). Alternative seals built prior to the issuance of this PIB had to comply with existing 30 CFR § 75.335(a)(2), which required that alternative seals withstand a static horizontal pressure of 20 psi. The purpose of this guide is to provide information to assist in the inspection of existing "alternative seals" that were constructed as per 30 CFR § 75.335(a)(2), prior to the issuance of Program Information Bulletin (PIB) No. P06-16.

Background

Prior to the issuance of PIB No. 06-16, existing seals were required to be constructed in accordance with the requirements prescribed in 75.335(a)(1), or according to the alternative seal requirements in 75.335(a)(2). For alternative seals, the requirements were stated as follows: "Alternative methods or materials may be used to create a seal if they can withstand a static horizontal pressure of 20 pounds per square inch provided the method of installation and the material used are approved in the ventilation plan."

To determine whether an alternative seal met the 20 psi requirement of 75.335(a)(2), MSHA and seal manufacturers worked with the National Institute for Occupational Safety and Health (NIOSH) to have testing performed at NIOSH's Lake Lynn Experimental Mine. Alternative seals were constructed in the Lake Lynn Mine and subjected to a side-on or static pressure of 20 psi from a methane explosion. Following the test, air leakage across the seal was measured to determine whether the seal met post-test leakage requirements. The seals described in this guide were found to withstand the 20-psi static pressure requirement and meet the post-test leakage criteria.

The Lake Lynn facility is a limestone mine and the test seals were built in mine openings that were 18 to 20 ft wide and 6.5 to 7 feet high. The test locations have a limestone roof and ribs and a concrete floor, providing essentially unyielding or stiff strata surrounding the seals. As a result of the test conditions, NIOSH, through the Lake Lynn testing, could not address the issues of: degradation in seal performance as a result of convergence; long-term durability of the seal materials; size scaling (requirements for higher or wider seals than those tested); weaker or less rigid strata-seal interface; quality control of the construction and materials in mines; and similar issues regarding installation in an underground coal mine.

This guide provides information on how the seals that passed the 20-psi testing were constructed. This guide can be used when inspecting existing alternative seals to help determine if they were constructed in the same manner as the seals that were tested at Lake Lynn. In addition to the information provided in this guide, standard engineering

construction practices, such as for material tolerances, plumbness, etc., should always be followed in seal construction.

The method of installation and the materials for alternative seals are approved by MSHA in the mine's ventilation plan. To deal with variable mining conditions, MSHA has approved seals with minor variations from the heights and widths of the seals tested at Lake Lynn. Any seal that is not constructed according to the approved plan must be corrected or replaced.

Replacement alternative seals must be constructed to meet the requirements of PIB No. 06-16. As indicated in PIB No. 06-16, new alternative seals must have an engineering design certifying that the seal will reliably withstand an overpressure of 50 psi. In addition, for new alternative seals the ventilation plan must provide that a senior mine management official certify that the construction, installation, and materials used were in accordance with the approved plan. To meet this requirement, seal construction should be supervised, by a person(s), designated in the ventilation plan, who is knowledgeable of the seal construction techniques and who will assure that the seal is constructed in accordance with the approved plan and that quality-control requirements for materials and construction procedures are met.

Convergence of an amount that compromises the function of any portion of a seal will require that the seal be replaced or repaired. In mines subject to convergence, mine operators should provide engineering analysis to MSHA to substantiate how much convergence the seals can withstand and the initial height of the openings where these seals are constructed.

Information is provided on the following seals:

Additional details on seals can be found in the publications listed in the Appendix.

TEKSEAL AND CELUSEAL PUMPABLE CEMENTITIOUS SEALS

Pumpable cementitious seals with a thickness of at least four feet, and compressive strength of at least 200 psi, have withstood 20-psi explosion testing conducted at NIOSH's Lake Lynn Mine. Seals in this category are constructed with either Tekseal or Celuseal products. Seals constructed in the same manner as the tested seals meet the requirement for an alternative pursuant to § 75.335(a)(2).

This summary provides information on how the seals that passed the 20-psi explosion testing were constructed, and on other good practices that should be followed during seal construction. In addition, standard engineering construction practices, such as those related to material tolerances, plumbness, etc., should always be followed.

Seal Material

Celuseal, manufactured by R.G. Johnson of Washington, Pennsylvania (724-222-6810) and Tekseal, manufactured by Minova of Georgetown, Kentucky (502-863-6800) are two cementitious materials that have been tested. These seals are constructed by pumping the cementitious material between two forms, located at least 4 feet apart, to completely fill the full height and width of the opening between the forms.

Tekseal and Celuseal are both lightweight, noncombustible cement-based products. Cementitious powder, water, and air are metered into a continuous mixer and then pumped between the forms. The amount of cementitious material used per cubic yard of seal determines the density and strength of the seal material.

Conditions for Test Seals

The seals that passed the 20-psi explosion test had an average compressive strength of 200 psi. The seals, which were not hitched, were tested in entries with maximum widths and heights of 19.5 feet and 7.25 feet, respectively.

Additional seal construction considerations/requirements

The four-foot minimum seal thickness has been approved for mine openings that are up to eight feet in height. For mine openings exceeding 8 feet in height, seals have been approved on the basis of the seal thickness being increased to at least one half of the measurement of the height. However, case-by-case evaluations should be made for any opening over 12 feet in height or over 20 feet wide.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

All loose or broken material is to be removed from the ribs, roof and floor in the immediate construction area. Cementitious seals can be built in dry, damp, or wet conditions, but not in standing water. Cementitious seals built in the same manner as the tested seals do not need to be hitched into the floor or ribs. Seals should be constructed using a continuous pour so that a solid plug, with no joints, is obtained.

Storage, transportation, mixing and pumping of all seal materials are to be according to the manufacturer's specifications. Cementitious material should not be used beyond the manufacturer's specified shelf life. Material should be stored in a dry place. A visual check of the material should be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers operating the pump and any other workers involved in the injection process.

Two support walls need to be constructed. These walls need to have sufficient strength to resist the pressure from the uncured material and can be constructed of concrete blocks or wood framing and brattice cloth. Wood framing can be installed as follows:

(a) Wooden timbers (minimum 4" x 4") should be installed as uprights on three (3) foot centers across the entry;

(b) Wooden boards (1" x 6" or equivalent) should be nailed horizontally across the timbers on not more than two (2) foot centers;

(c) MSHA approved brattice material should be nailed to the inside of the back wall with an overlap of approximately 4 inches onto each rib, the roof and floor. The overlaps should be secured to the ribs, roof and floor.

The front wall should be constructed following the steps outlined above or a method should be used to form containment using concrete blocks. Injection ports and hatch openings should be placed in the front wall to allow direct placement of the material. Boards should be installed covering the hatch when it is no longer needed. Internal support wires may be installed to keep the seal forms from kicking out.

In openings up to 20 feet wide, there should be a minimum of three (3) injection ports incorporated into the top of the formwork to assure uniform distribution of the cement grout. These ports should be installed as to have approximate equal horizontal spacing between them. They should be angled upward and secured into place. The pumped material should be directed through the hatch as long as possible. The remaining material should be pumped through the injection ports until the seal is completed. It is important to make sure the top cavities are filled with material.

In seals where a brattice is not used (i.e., concrete block forms), a minimum of two (2) bleeder pipes should to be angled upward to the highest points of the seal along the roof. This is because direct observations of the level of fill are not possible with such a form. The seal should be considered to be topped off when the seal material runs out of both of these pipes. These pipes are separate from the pipes used for injection of the cementitious material.

The forms are not intended to add structural strength to the seal. The forms may be removed after a curing time of 28 days or may be left in place. If a form is removed, or

any deterioration of a form occurs, an MSHA-approved general purpose sealant should be applied to the exposed face of the seal.

Samples should be collected during seal construction to assure that the seal material has the required compressive strength. At least nine samples of the cementitious material, representative of the pumped material, should be collected from each seal. Three samples should be taken during the pumping process from the bottom of the seal, three from the center of the seal and three from the top of the seal. The samples should be taken from material as it is being pumped into the seal. The samples should be collected in cylindrical containers three inches in diameter and six inches long. These samples should be tested for compressive strength 28 days after pouring, by the manufacturer or an independent laboratory, and the test results should be made available. The test results of these samples should have an average minimum compressive strength of 200 psi. None of the tested samples should have a compressive strength of less than 100 psi. Any test revealing insufficient compressive strength or other insufficiency should be investigated and appropriate corrective measures should be taken. Samples should be permitted to cure for 24 hours before transporting. The samples should be stored underground or in a moisture-controlled environment similar to the mine conditions where the seals are located. The samples should be labeled as to their collection location. ASTM or other applicable sampling and testing procedures should be followed.

Roof sag or floor heave, occurring after seal construction, can result in failure of the form walls. If this occurs, the face of the seal should be coated with an MSHA-approved sealant.

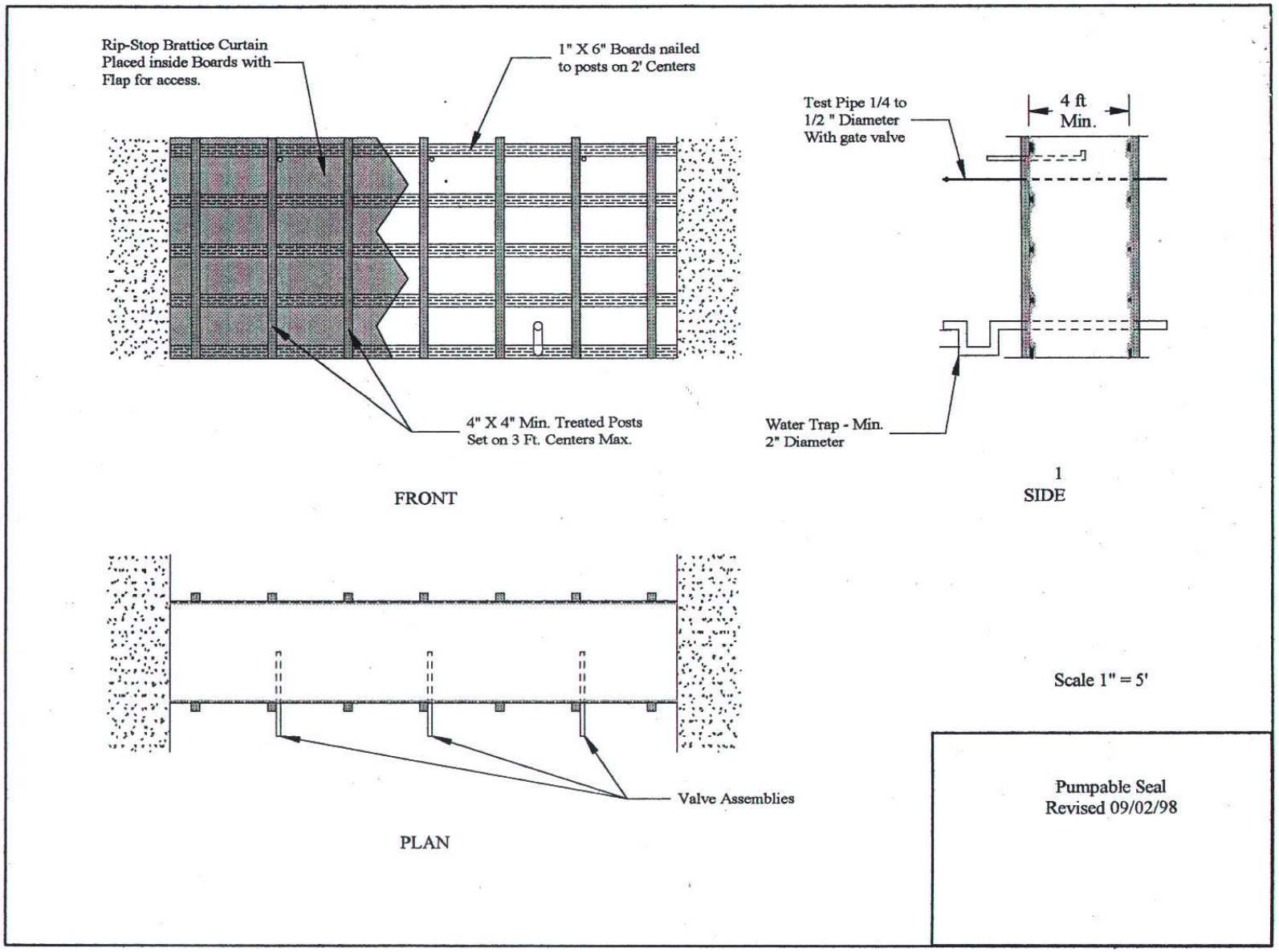
Convergence of an amount that compromises the function of any portion of the seal will require that the seal be replaced. In convergence conditions, mine operators should provide information to MSHA to substantiate how much convergence each seal can withstand and the initial height of the opening where these seals are constructed.

Where the ribs, roof, or floor are smooth at the seal location, measures should be taken by the mine operator to increase the shear bond between the seal and the surrounding strata. This may include such measures as notching the seal into the smooth surface, or bolting an angle to create an artificial hitch effect.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Tekseal and Celuseal Seals -- Summary of Features	
Thickness in inches	48
Pilaster Size	None
Hitching Requirement	None
Average Compressive Strength	200 psi
Minimum Compressive Strength of any sample	100 psi
Outby-side coating	Leave brattice cloth; apply sealant to exposed material.
Maximum height/width	Over 8 feet in height, thickness increased to at least one-half of the height. Seals in openings with heights over 12 feet or widths over 20 feet should have case-by-case evaluations.
Sampling Requirements	9 samples; three from top, three from middle; and three from bottom portion of pour - for testing to verify compressive strength.


Rip-Stop Brattice Curtain
Placed inside Boards with
Flap for access.
1" X 6" Boards nailed
to posts on 2' Centers
4" X 4" Min. Treated Posts
Set on 3 Ft. Centers Max.
FRONT
Test Pipe 1/4 to
1/2 " Diameter
With gate valve
4 ft
Min.
Water Trap - Min.
2" Diameter
1
SIDE
Valve Assemblies
PLAN
Scale 1" = 5'
Pumpable Seal
Revised 09/02/98

INSTEEL 3-D SEALS

The Insteel 3-D seal is manufactured and distributed by Precision Mine Repair of Eldorado, Illinois (618-273-2017). The Insteel 3-D seal consists of a three-dimensional welded wire space frame encased in concrete. The reinforcement modules are placed in position and concrete (Pak Mix Pro Line concrete mix) is applied from the outby side. The final seal is at least 11.5 inches thick. This seal withstood 20-psi explosion testing conducted at NIOSH's Lake Lynn Mine. MSHA will accept a seal constructed in the same manner as the tested seal as meeting the requirements for an alternative seal under 75.335(a)(2).

Insteel 3-D seals have been approved in openings with heights up to 8 feet and widths up to 20 feet. Seals for larger opening sizes need to be evaluated on a case-by-case basis. Insteel 3-D seals do not need to be hitched into the floor or ribs, but the seal is anchored to the surrounding strata by steel reinforcement grouted into the roof, ribs, and floor.

SEAL CONSTRUCTION

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Insteel 3-D panels are trimmed to fit dimensions of openings where they are to be installed. They are laid horizontally and permanently fastened together by clips on 12" centers. This first set of panels is designated as the main panel.

A form is installed on the inby side of the main panels as a backing for spraying the concrete from the outby side. Holes are drilled in the roof and floor for #8 rebar dowels. Two rows of dowels are installed. These dowels are 36 inches long. Holes are a minimum of 12 inches deep and are evenly spaced across the entry on not more than 2-foot centers. The end dowels should be equally spaced from the closest rib. Dowels are epoxy grouted in place. The main panel is positioned across the opening with the stay-form backing on the inby side. Number 8 dowels are tied in place vertically between corresponding roof and floor dowels, using pre-formed clamps. The main panel is fastened to the dowels and horizontal reinforcement (No. 3 rebar, evenly spaced) is installed as shown on the attached drawing.

A second set of Insteel 3-D panels is assembled in the same fashion as the main panel except that this panel does not have a stay-form backing. These panels are positioned on the outby side of the main panel. The second row of dowels is epoxy grouted in place; these dowels are offset from those previously installed. Number 8 dowels are tied in place vertically between corresponding roof and floor dowels, using pre-formed clamps. The second set of panels is fastened to these dowels.

Three holes are drilled a minimum of 12 inches deep on 24 inch centers into each of the ribs for grouting #8 dowels. Number 3 dowels are tied in place horizontally from rib to rib, using pre-formed clamps. These #3 dowels are not fastened to the #8 dowels grouted into the ribs. Placement of reinforcement is shown in the attached drawing.

At Lake Lynn Experimental Mine, over 12 tons of Pak Mix Pro Line concrete mix was applied from the outby side of the seal with a gunite machine, at a pressure of 100 psi. The panels are completely filled with gunite. This material hardens within 15 minutes and is nearly fully cured within 24 hours.

All loose or broken materials should be removed from the roof, ribs, and floor back to competent, solid strata. No hitching is necessary. Unstable ground and mid-seam partings should be scaled back. These seals can be built in dry, damp, or wet conditions, but not in standing water.

Storage, transportation, mixing and pumping of all seal materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life. Material should be stored in a dry environment. A visual check of the material shall be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

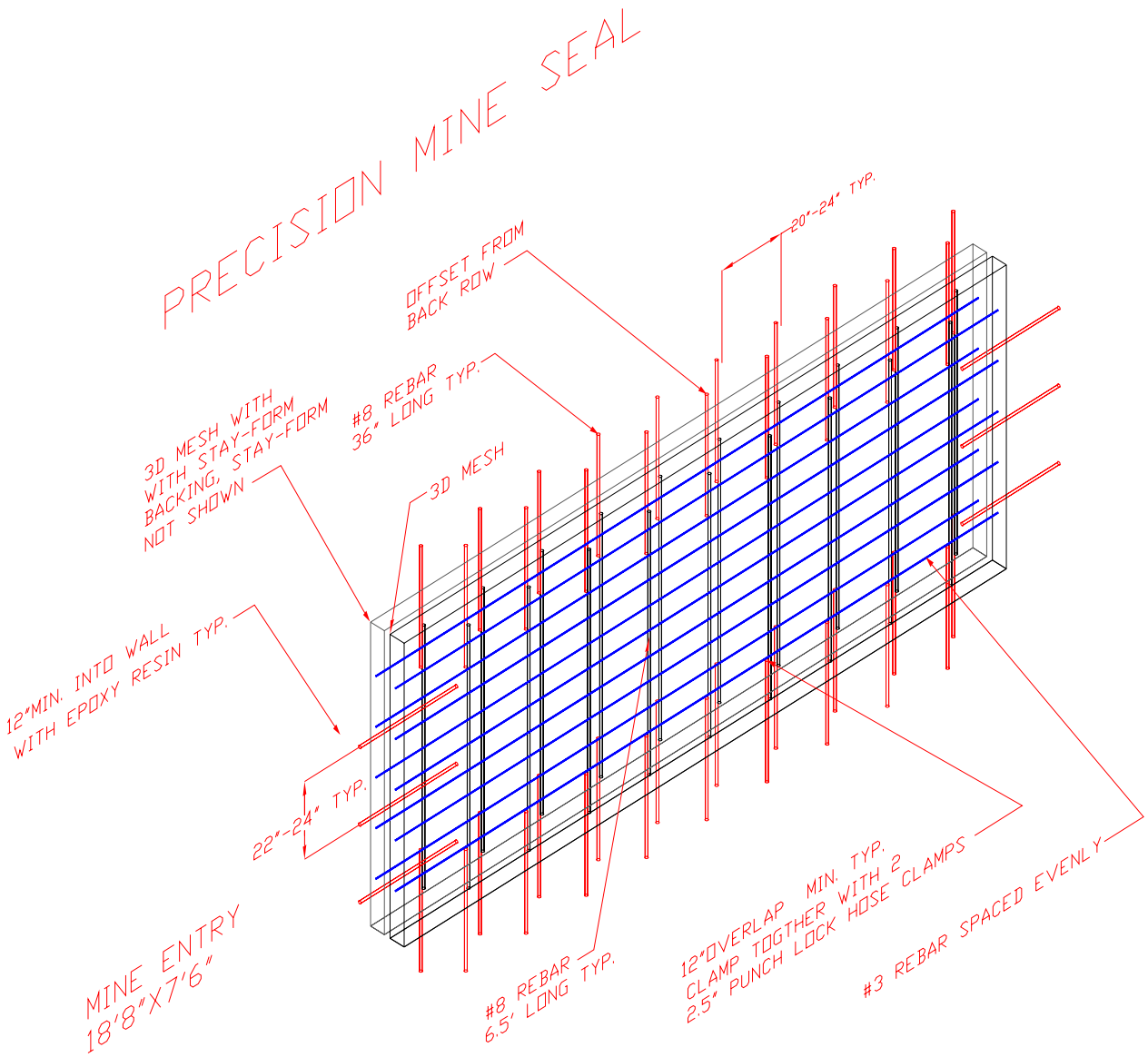
Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function.

Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

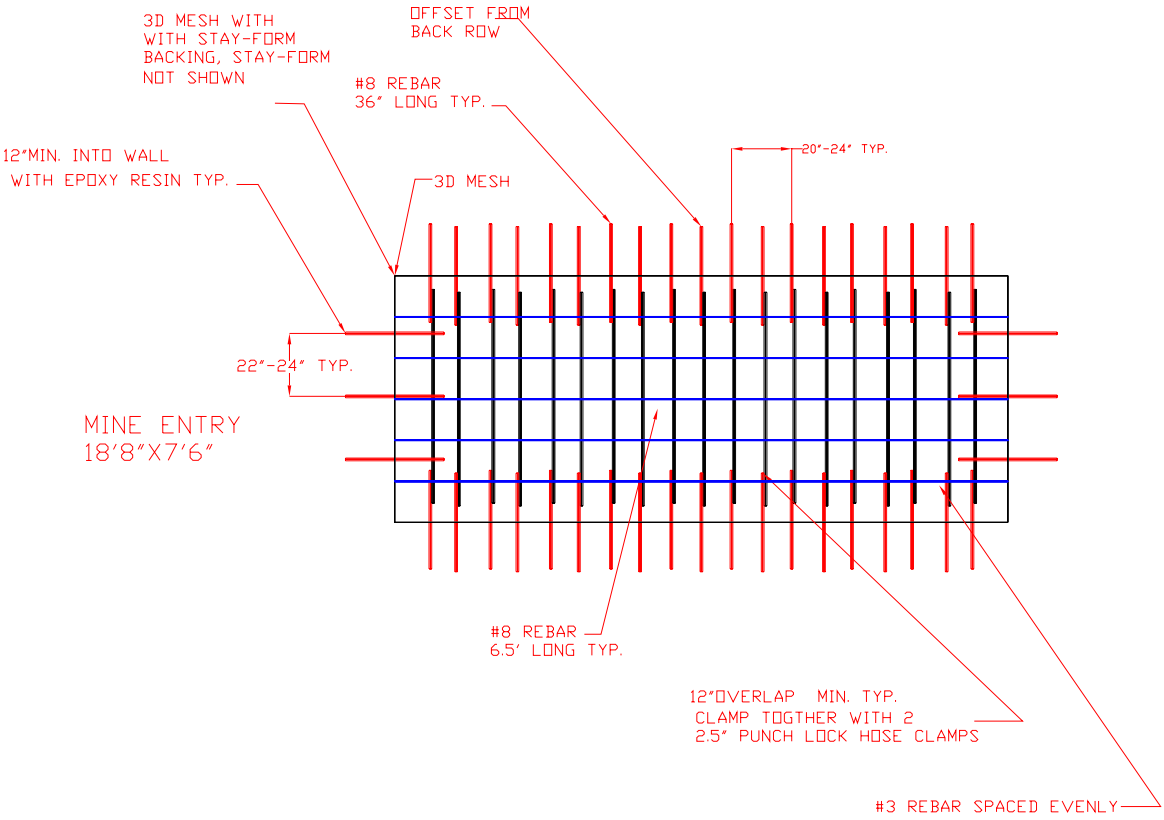
Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Insteel 3-D Seal (Precision) -- Summary of Features	
Thickness in inches	11.5
Reinforcement	Wire mesh panels plus horizontal and vertical steel reinforcement.
Concrete	Pak Mix Pro Line concrete mix, applied by gunite machine.
Hitching	Anchored by steel reinforcement grouted into the roof, rib and floor.
Maximum size	Over 8 ft. high or 20 ft. wide requires case-by-case evaluation.
Sampling	No requirements


PRECISION MINE SEAL
OFFSET FROM BACK ROW
20"-24" TYP.
3D MESH WITH BACKING, STAY-FORM NOT SHOWN
#8 REBAR 36" LONG TYP.
3D MESH
12"MIN. INTO WALL WITH EPOXY RESIN TYP.
22"-24" TYP.
MINE ENTRY 18'8"X7'6"
#8 REBAR 6.5' LONG TYP.
12"OVERLAP MIN. TYP. CLAMP TOGTHER WITH 2 2.5" PUNCH LOCK HOSE CLAMPS
#3 REBAR SPACED EVENLY

PRECISION MINE SEAL



MESHBLOCK

The MESHBLOCK seal is a composite of shotcrete and reinforcing steel constructed with the MESHBLOCK steel-wire forming system. The seal is distributed by R.G. Johnson Company, Inc. of Washington, Pennsylvania (412-222-6810). All materials should be supplied by R.G. Johnson or its approved representatives, and installed by same or task trained mine personnel.

The MESHBLOCK seal, with a thickness of at least 7 inches, has been approved to be installed in openings of up to 9 feet in height and up to 20 feet wide under the 20 psi criterion. For openings exceeding 9 feet in height or 20 feet wide, approval is based on a case-by-case evaluation.

SEAL CONSTRUCTION

The MESHBLOCK form work consists of a lightweight U-shaped frame formed as a folded grid of 4 mm diameter welded wire. A 3 mm wire cloth encloses both vertical faces forming an integral part of the system. The cloth holds the shotcrete in place and allows the nozzle man to examine the shotrete flowing into the form work. The shotcrete used in the Meshblock seal is Quikrete MB 500 castable shotcrete mix.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

The seal is anchored to the surrounding strata by steel bolts installed into the roof, ribs and floor. Bolts and reinforcing bars should be 24 mm diameter. Bolts used should have a threaded end to accommodate spinning into resin anchors.

Resin-grouted steel bolts are anchored 24 inches into the surrounding strata as shown in the attached drawing. The vertical bolts in the floor and roof are on 24 inch centers. Two horizontal bolts are anchored in each rib on no more than 40 inch spacing. Reinforcing bars or bolts should be overlapped 24 inches onto the adjacent roof and floor bolts to complete the steel reinforcement. The reinforcing plane should be centered in the Meshblock form work.

The Quikrete MB 500 (mix of cement and minus 5-mm aggregate) should have a minimum compressive strength of 5800 psi. The recommended water content is 15% by weight of dry concrete and can vary +/- 5% for casting or gunning applications. A set of nine samples representing at least one seal should be tested from each load of dry mix MB500 to confirm compressive strength.

All loose or broken materials should be removed from the roof, ribs, and floor back to competent, solid strata. Unstable ground and mid-seam partings should be scaled back. These seals can be built in dry, damp, or wet conditions, but not in standing water.

Storage, transportation, mixing and pumping of all seal materials should be according to the manufacturer's specifications. Materials should not be used beyond the

manufacturer's specified shelf life. The storage of the material should be in a dry environment. A visual check of the material should be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.
Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers involved in the construction process.

Install Meshblock units in horizontal layers by butting the ends of the units and tying them together with suitable fasteners. Reinforcing steel should be located in the center of the Meshblock units, attached to the roof and floor bolts with a 24 inch overlap and aligned in the same plane. The bottom layer should be leveled and voids between the bottom layer and the floor should be should be minimized and filled in with MB 500 shotcrete. The Meshblock units and reinforcement should be installed as per the manufacturer's requirements.

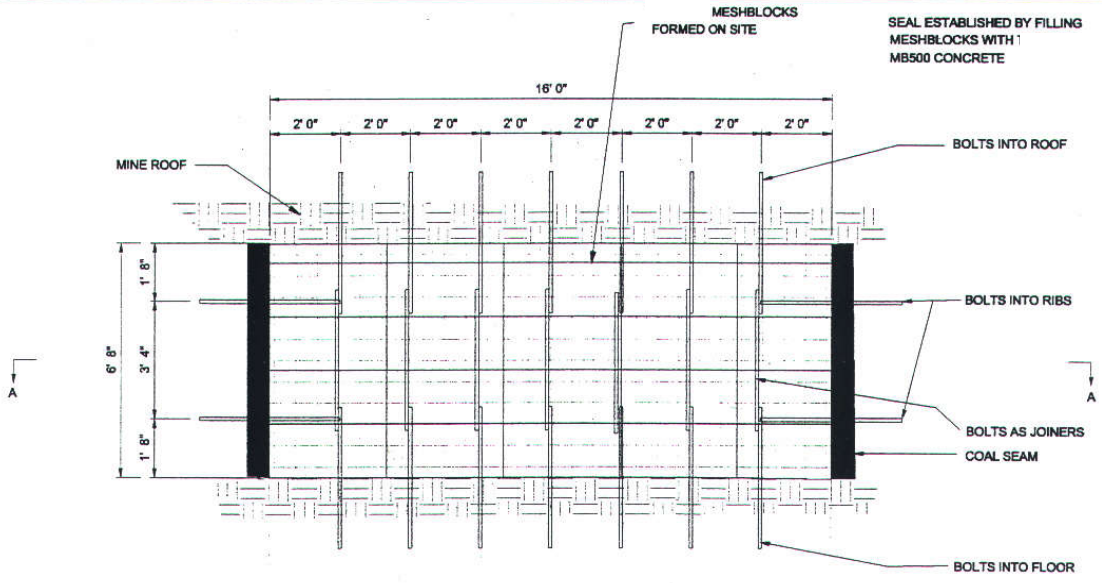
Each layer of Meshblock units should have a nominal 2-inch overlap with the underlying Meshblock layer. The rigidity and alignment of the form work should be checked, and if necessary corrected, before casting.

Normally two layers of Meshblock units are filled at a time. Typically the rib ends of the structure are built up two to three blocks higher than the horizontal layer to accommodate vertical alignment and the angle of repose of the concrete. Care should be taken to limit casting delays to ½ hour. The top 6" to 12" of the seal requires cutting and fitting the Meshblock units to create a back wall which will be filled in with the shotcrete using the spray nozzle. The perimeter can be sprayed to stabilize and seal the surrounding strata.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

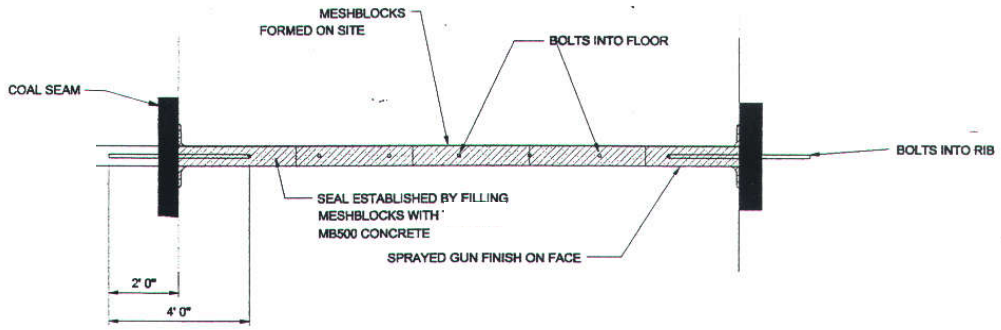
Mesh Block Seal -- Summary of Features	
Thickness in inches	At least 7 inches
Type of Construction	Reinforced concrete
Reinforcement	Steel welded-wire plus wire cloth forming system plus vertical steel reinforcement
Concrete	Quikrete MB 500 castable shotcrete
Compressive strength of concrete	5800 psi
Hitching/Anchorage	Steel reinforcement grouted into the roof, ribs and floor.
Maximum size	Seals for openings exceeding 9 feet high or 20 feet wide are approved on a case-by-case basis.
Sampling requirements	Set of nine samples representing at least one seal from each load of dry mix MB500



ROOF & RIB BOLTS:
4'0" X ⌀7/8"
TYPICAL 2'0" INTO
ROOF, WALLS, & FLOOR

BOLTS FULLY ENCAPSULATED WITH
POLYESTER RESIN
BOLT HOLES - ⌀ 1"3/8"

TYPICAL MESHBLOCK SIDE VIEW



TYPICAL MESHBLOCK PLAN VIEW A-A

SCALE: NOT TO SCALE

MICON 550

The MICON 550 Permanent Ventilation Seal consists of two surface-bonded, dry-stacked concrete block stopping walls with a two component polyurethane foam and aggregate inner core. MICON is located at 25 Allegheny Square in Glassport, Pennsylvania 15045 and can be contacted by telephone at 412-664-7788.

The MICON 550 Seal with a 16-inch thick inner core successfully withstood 20-pound per square inch (psi) explosion testing at NIOSH's Lake Lynn Experimental Mine. A seal constructed in the same manner as the test seal meets the requirements for an alternative seal as per 30 CFR 75.335(a)(2). This summary provides information on how the seal that passed the 20-psi explosion testing was constructed, and on other practices that should be followed during seal construction. In addition, standard engineering construction practices, such as for material tolerances, plumbness, etc., should always be followed.

SEAL CONSTRUCTION

The thickness of the inner core depends on the height and width of the seal. The testing conducted in the Lake Lynn facility was performed in entries that varied in height from 6.5 to 7 feet. Seals have been approved for openings up to 8 feet high and up to 20 feet wide with the core thickness being at least 16 inches. For heights exceeding 8 feet, seals have been approved on the basis of increasing the seal thickness by one inch for each one foot or part of a foot of increase in height. When the height of the mine opening exceeds 12 feet or the width exceeds 20 feet, substantiating information should be provided by the mine operator and seal approval is on a case-by-case basis.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

All loose or broken materials should be removed from the roof, ribs, and floor back to competent, solid strata. No hitching in the roof, ribs, or floor is necessary. Unstable ground and mid-seam partings should be scaled back. Hitching is not required in the construction of the MICON 550 Permanent Ventilation Seal.

The concrete block walls (solid or hollow core) are dry-stacked and coated with an MSHA-approved dry-stacked sealant. The blocks should be dry for adequate bonding of the polyurethane foam. Omega 384 blocks and/or Kennedy panels are not permitted to be used to form a Micon 550 seal. The backside concrete block wall is constructed first. All blocks for the form walls are stacked in place without mortar. After the last block of each row is in place, a wedge is driven between the block and rib to firmly tighten the blocks in place. All notches and holes should be filled with the largest block fragments possible and wedged in place. The backside of the back wall is to be plastered on the outside surface with an MSHA-approved dry-stacked sealant. (Note: MSHA-approved dry-stacked sealants are listed separately from general purpose sealants.)

After completing the back wall, construction of the front wall should begin. The front wall is initially constructed to a height of two to three feet (dependent on seal height). Construction of the front wall is continued by pyramiding the block to the roof so that one or two blocks are in contact with the roof. After the top blocks are in place, a wedge should be driven between the block and roof to hold the wall in place.

With the back wall completed and part of the front wall in place, the inner core construction is started. As the inner core is installed, construction of the front wall continues to completion. The outby side of the front wall is be plastered with an MSHA-approved dry-stacked sealant.

The initial step in the construction of the inner core is to coat the floor, the inside of the block walls, the roof, and the ribs within the core area with high density polymer (70 pounds cubic foot (pcf)) to prevent moisture from affecting the density of the polyurethane core. Installation proceeds as follows:

1. A 4-inch thick layer of #57 limestone is placed (without fines) as the initial lift. Dust and fines can inhibit proper bonding of the foam to the surface, therefore the limestone purchased for use in this seal needs to be washed to remove dust, dried, and then sealed in moisture-protected bags. It should be noted that the limestone may not be received in bulk due to problems with moisture. The limestone must be dry and received in moisture-protected bags.

2. After placing the initial layer of limestone, it is completely coated with polyurethane foam having a density of at least 10 pcf. The polymer will react, expand, and rise along with the limestone. Within five minutes, the core material expands and hardens.

3. Steps 1 and 2 are repeated to the roof to complete the seal.

The MICON 550 seal should not be constructed in any area with perceptible moisture unless measures are taken to eliminate the moisture level on the bonding surfaces. During the curing process, moisture causes the combined polyurethane components to expand to a greater degree than normal. This expansion can reduce the density and therefore strength of the product to unacceptable levels for seal construction.

Concrete walls are to be left in place for the life of the seal. Compromised walls are to be structurally repaired for the seal to remain as an approved seal. The core density is to be at or above 35 pcf after curing (24 hours). Exposed polyurethane must be coated with an MSHA-approved sealant. This is to be done immediately after completion of the seal and at any later time when conditions cause any polyurethane to become exposed to the mine atmosphere.

Storage, transportation, mixing and pumping of all seal materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life.

Temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the

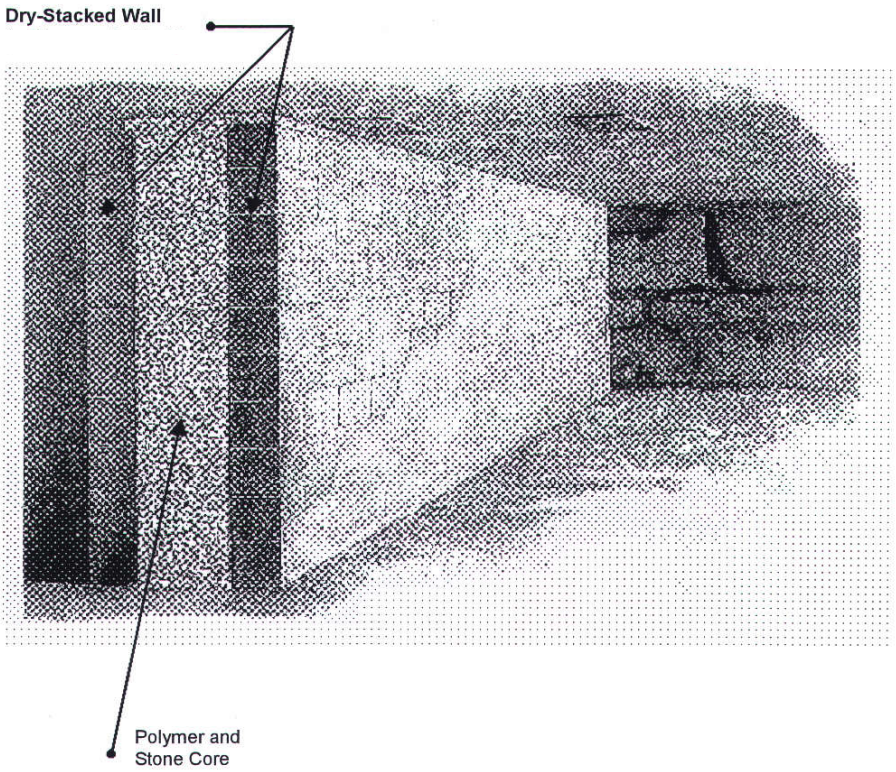
system and its intended function. Training should be given to any workers involved in the construction process.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Micon 550 – Summary of Features	
Thickness in inches	16
Type of construction	Polyurethane foam and aggregate core between two dry-stacked, surface-bonded, concrete block walls
Aggregate for incorporation in polyurethane layers	4 inch thick #57 limestone; must be provided in moisture-protected bags.
Polyurethane for layers	At least 10 pounds-per-cubic-foot foam density
Hitching	None required
Special site preparation	Inner core surfaces coated with high density polymer (70 pounds per cubic foot)
Maximum size	For openings exceeding 8 feet in height, increase the thickness by at least one inch for each foot or portion of a foot of increased height. For openings over 12 feet high or over 20 feet wide, case-by-case evaluation should be performed.
Coating requirement	Keep form walls in place; coat any exposed polyurethane with an approved sealant.
Restriction	The 10 pounds-per-cubic-foot foam cannot be used where perceptible moisture is present because the density and strength of the polyurethane is adversely affected.

FIGURE 1



OMEGA BLOCK SEAL – 24 INCHES/32 INCHES THICK
(Hitched)

Omega 384 block seals, each requiring hitching and one or two pilasters, have successfully withstood 20 pounds per square inch (psi) explosion testing conducted at NIOSH's Lake Lynn Experimental Mine. Seals constructed in the same manner as the test seals meet the requirements for an alternative seal as per 30 CFR 75.335(a)(2). This summary provides specific information on how the seal that passed the 20-psi testing was constructed, and on other practices that should be followed during seal construction. In addition, standard engineering construction practices, such as for material tolerances, plumbness, etc., should always be followed.

Seal Material

Omega-384 blocks are lightweight, glass-fiber reinforced blocks manufactured by Burrell Mining Products International, Inc. The nominal size of a single block is 8 inches by 16 inches by 24 inches. Omega blocks typically have compressive strength in the range of 70 psi to 110 psi. The average weight of each block is approximately 46 pounds. Omega blocks are noncombustible. The blocks can be cut with a hand saw to fit into spaces between seal and rib or seal and roof where full blocks will not fit. The Omega block seals are only to be constructed using Quikrete BlocBond mortar (product number 1225-51). Burrell Mining Products International (724-339-2511) is located in New Kensington, Pennsylvania. BlocBond is manufactured by Quikrete Company in Atlanta, Georgia.

Conditions for Test Seals

Hitched Omega seals were constructed in thicknesses of 24 or 32 inches with pilasters. Each seal had either one or two interlocked pilasters, as shown in the attached drawings. The smallest pilaster was 48 inches by 48 inches. In the testing, "hitching" was simulated by the installation of steel angles along the floor and ribs. These 6 inch by 6 inch by ½ inch angles were bolted into the ribs and floor on both sides of the seal and pilaster. The blocks were laid with wet mortar with fully mortared horizontal and vertical joints, the vertical joints were staggered, and the pilaster blocks were interlocked with the blocks in the main wall. The test entries varied in height from 6.5 to 7 feet.

BlocBond, a mortar mix manufactured by Quikrete, is the only mortar permitted to be used in the construction of Omega block seals. Quikrete BlocBond mortar (product number 1225-51) is a mixture of Portland cement, fiberglass fiber and additives. All mortar used in the seal construction was mixed with water.

The conditions for the "hitched" Omega block seals that withstood the 20-psi explosion testing are summarized as follows:

- 24 inches thick with one pilaster
  Pilaster is 48 inches square
  Hitched 6 inches into floor and both ribs
  All blocks laid with wet BlocBond mortar
  Two wood planks laid and wedged across top of seal; one flush with each side
  Wood laid and wedged on top on pilaster
  BlocBond completely covering all vertical and horizontal joints
  Gaps between seal and roof and rib filled with BlocBond mortar
  BlocBond completely covering both faces
  Shown in attached Drawing #1

- 32 inches thick with 2 pilasters
  Each pilaster is 48 inches square
  Hitched 6 inches into floor and both ribs
  All blocks laid with wet BlocBond mortar
  Two wood planks laid and wedged across top of seal; one flush with each side
  Wood laid and wedged on top on pilaster
  BlocBond completely covering all vertical and horizontal joints
  Gaps between seal and roof and rib filled with BlocBond mortar
  BlocBond completely covering both faces
  Shown in attached Drawing #2

- 24 inches thick with one pilaster
  Pilaster is 72 inches wide by 56 inches deep
  Hitched 6 inches into floor and both ribs
  All blocks laid with wet BlocBond mortar
  Two wood planks laid and wedged across top of seal; one flush with each side
  Wood laid and wedged on top on pilaster
  BlocBond completely covering all vertical and horizontal joints
  Gaps between seal and roof and rib filled with BlocBond mortar
  BlocBond completely covering both faces
  Shown in attached Drawing #3

Additional Seal Construction Considerations/Requirements

This seal has been approved for openings that are no more than 8 feet high and no more than 20 feet wide. Seals for any larger opening size need to be evaluated on a case-by-case basis. Additional strength-enhancing features for larger openings may include a larger pilaster or increased seal thickness.

There are no dry-stacked seal designs constructed of Omega Blocks. All Omega block seals include all joints mortared with BlocBond and full face coatings of BlocBond on both sides of the seal. Omega blocks used to construct the 24 or 32-inch thick hitched seals have to be wetted and brushed free of loose particles prior to the application of BlocBond to be consistent with the way the test seals were constructed.

It should be noted that the instructions on a bag of BlocBond may indicate that surface bonding mortars are not to be applied to the joints of block walls. However, testing has shown that using BlocBond to fully mortar joints and to fully coat both faces, Omega block seals can withstand 20 psi explosion pressure. This particular bag instruction does not apply for the construction of Omega block seals.

All loose or broken materials should be removed from the roof, ribs, and floor at the seal location back to competent, solid strata. Unstable ground and mid-seam partings should be scaled back. These seals can be built in dry or damp conditions, but not in standing water.

Seals should be constructed on a solid floor. If necessary, the floor should be leveled or made even by removing floor material. Other floor-leveling measures, such as pouring a concrete footer, would need to be evaluated on a case-by-case basis. Blocks which are damaged or defective, or which do not appear normal, e.g. unusual color or easily friable surface, should not be used in seal construction.

BlocBond mortar is to be applied to clean surfaces. It is not to be applied to surfaces that are covered with coal dust or rock dust. The roof, floor and ribs should be cleaned so that a bond can be achieved between the BlocBond mortar and the strata in contact with the seal.

BlocBond is to be applied at a thickness of at least ¼ inch on the top and on all four vertical sides of each Omega block. Each block is to be wetted and loose material brushed off each block before the application of BlocBond (this is how the test seal was constructed). BlocBond mortar is also applied, to a thickness of at least ¼ inch, as a full-face coating on both sides of each seal. It is important that the seal be constructed by mixing the mortar to the proper consistency and applying it to each surface of the blocks so that a sound bond is achieved. Construction should not take place by stacking the blocks and then attempting to place mortar into the joint openings.

A layer of BlocBond is to be applied to the floor for setting the first course of blocks. BlocBond is also used to form a joint between the Omega blocks and the ribs.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Storage, transportation, and mixing of all seal materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life. The storage of the mortar should be in a dry environment. A visual check of the material should be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

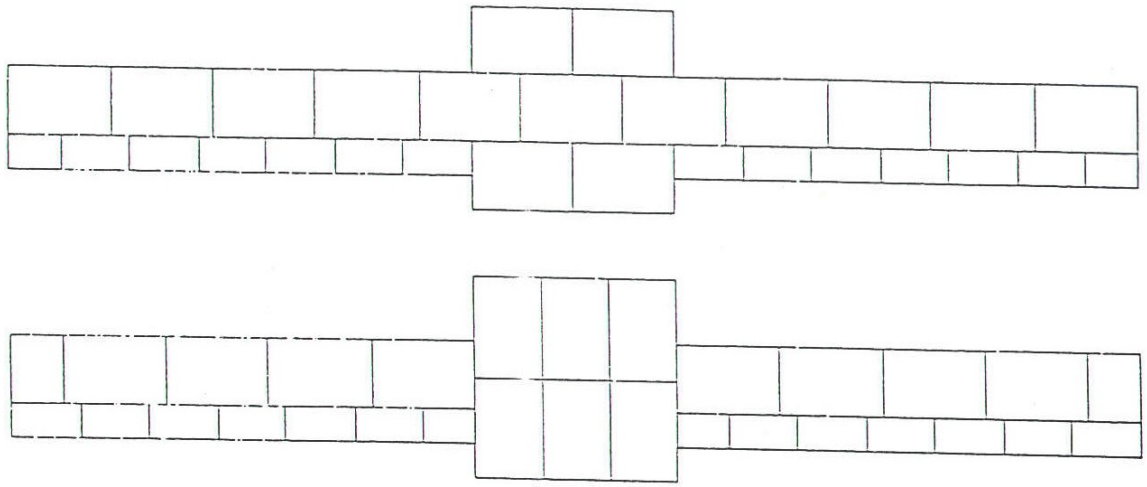
Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the

manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function.
Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

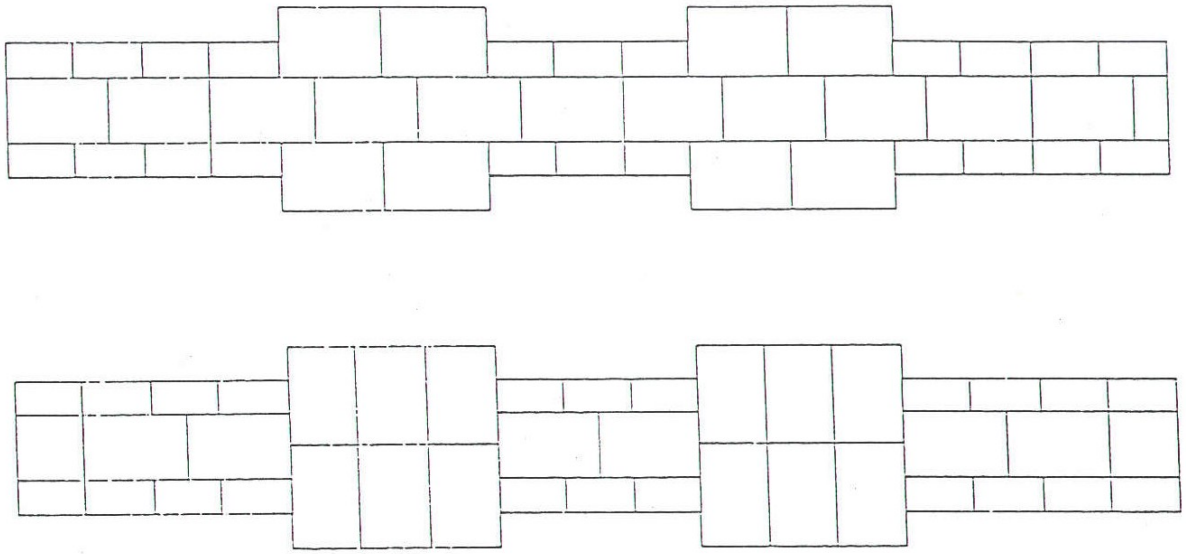
Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Hitched 24 or 32-inch thick Omega Block Seals – Summary of Features		
	24 inch thick seal	32 inch thick seal
Thickness in inches	24	32
Type of construction	Lightweight fiber reinforced block wet mortared on all joints and at contact with ribs and floor - laid with staggered vertical joints.	
Pilasters	One, either 48 inches by 48 inches, or 56 inches by 72 inches, centered or interlocked with wall blocks.	Two, 48 inch by 48 inch, interlocked and positioned as shown on attached drawing.
Hitching	6 inches into floor and rib or 6 inch by 6 inch by ½ inch steel angle bolted into floor and ribs.	
Mortar	Must be Quikrete BlocBond Product No. 1225-51 (blue bag).	
Treatment at roof contact	Wood planks wedged into approx. 2 inch gap with all spaces filled with BlocBond.	
Coating	Both faces coated with BlocBond.	
Maximum Size	Case-by-case evaluation if the height exceeds 8 feet or the width exceeds 20 feet.	



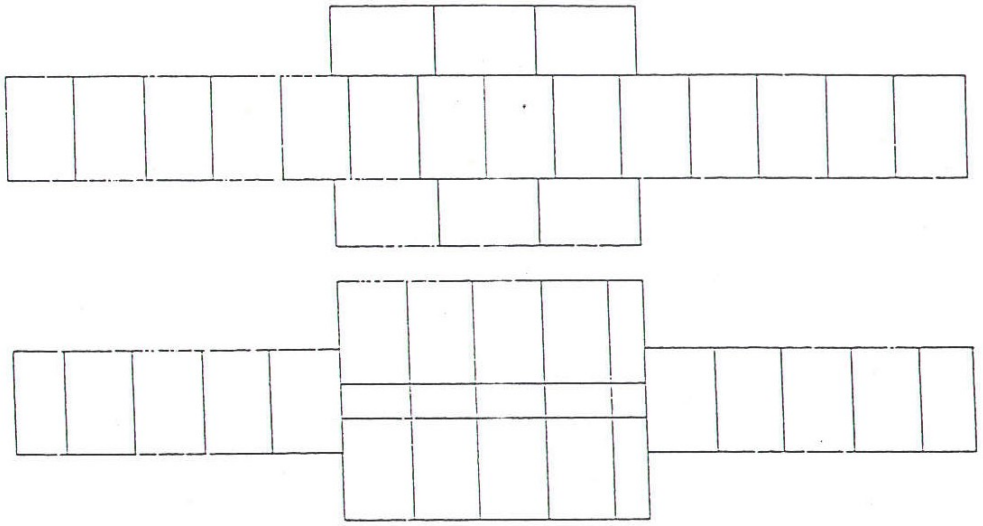
DRAWING No. 1

Omega block seal with thickness of 24 inches and interlocked 48 inch by 48 inch pilaster. Shown are the patterns for alternating layers of blocks.



DRAWING No. 2

Omega block seal with thickness of 32 inches and two 48 inch by 48 inch pilasters. Shown are the patterns for alternating layers of blocks.



DRAWING No. 3

Omega block seal with thickness of 24 inches and an interlocked 56 inch by 72 inch pilaster. Shown are the patterns for alternating layers of blocks.

OMEGA BLOCK SEAL – 40 INCHES THICK
(Not Hitched)

An Omega 384 block seal with a thickness of 40 inches, constructed using BlocBond mortar, withstood 20-pound per square inch (psi) testing at NIOSH's Lake Lynn Experimental Mine. This summary provides specific information on how the seal that passed the 20-psi testing was constructed, and on other practices that should be followed during seal construction. In addition, standard engineering construction practices, such as for material tolerances, plumbness, etc., should always be followed.

Seal Material

Omega-384 blocks are lightweight, glass-fiber reinforced blocks manufactured by Burrell Mining Products International, Inc. The size of a single block is 8 inches by 16 inches by 24 inches. Omega blocks typically have a compressive strength in the range of 70 psi and 110 psi. The average weight of each block is approximately 46 pounds. Omega blocks are noncombustible. The blocks can be cut with a hand saw to fit into spaces between seal and rib or seal and roof where full blocks will not fit. The Omega block seals are only to be constructed by being laid with wet BlocBond mortar. BlocBond is manufactured by Quikrete and is product number 1225-51.

Conditions for Tested Seal

The thickness of the tested seal was 40 inches plus the thickness of sealants on both sides of the seal. The test seal was not hitched into the floor or ribs and no pilaster was installed. The entry for the test seal was 19 feet wide and 6.8 feet high. Drawings showing the configuration of the test seal are attached.

BlocBond, a mortar mix manufactured by Quikrete, is the only mortar permitted to be used in the construction of Omega block seals. Quikrete BlocBond mortar (product number 1225-51) is a mixture of Portland cement, fiberglass fiber and additives. All mortar used in the seal construction was mixed with water.

Additional seal construction considerations/requirements

This seal has been approved for openings that are no more than 8 feet high and no more than 20 feet wide. Any larger opening sizes should be evaluated on a case-by-case basis. Additional strength-enhancing features for larger openings may include a pilaster, hitching, or increased thickness.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Quikrete's BlocBond is the only mortar permitted to be used in the construction of Omega block seals. Quikrete's BlocBond should not be confused with Quikrete's B-Bond MS Mine Sealant product. These are different products. B-Bond is not permitted to be used in the construction of Omega block seals. BlocBond (Product Number 1225-51) comes in a blue bag and B-Bond (Product Number 1234-40; 1234-50) comes in a green bag. There are no dry-stacked seal designs constructed of Omega Blocks.

It should be noted that the instructions on a bag of BlocBond may indicate that surface bonding mortars are not to be applied to the joints of block walls. However, testing has shown that using BlocBond to fully mortar joints and to fully coat both faces, Omega block seals can withstand 20 psi explosion pressures. This particular bag instruction does not apply for the construction of Omega block seals.

All loose or broken materials should be removed from the roof, ribs, and floor back to competent, solid strata at the seal location. Unstable ground and mid-seam partings should be scaled back. These seals can be built in dry or damp conditions, but not in standing water. Blocks which are damaged or defective, or which do not appear normal, e.g. unusual color or easily friable surface, should not to be used in seal construction.

Seals shall be constructed on a solid floor. If necessary, the floor should be leveled or made even by removing floor material. Other floor-leveling measures, such as pouring a concrete footer, would need to be evaluated on a case-by-case basis.

BlocBond mortar is to be applied to clean surfaces. It is not to be applied to surfaces that are covered with coal dust or rock dust. The roof, floor and ribs should be cleaned so that a bond can be achieved between the BlocBond mortar and the strata in contact with the seal.

BlocBond is to be applied at a thickness of at least ¼ inch on the top and on all four vertical sides of each Omega block. BlocBond mortar is also to be applied, at a thickness of at least ¼ inch, as a full- face coating on both sides of each seal. In constructing the 40-inch thick Omega block seal, the blocks themselves do not need to be wetted prior to applying the BlocBond mortar (to be consistent with the way the test seal was constructed at Lake Lynn).

A properly mixed layer of wet BlocBond is to be applied to the floor for setting the first course of blocks. BlocBond is also used to form a joint between the Omega blocks and the ribs. The courses of Omega blocks are laid, with the vertical joints staggered, until the gap between the blocks and the roof is approximately 2 inches.

Three rows of 1-inch by 8-inch wood planks are placed from rib to rib across the top of the seal. One row of planks is placed along the center of the seal and the other two rows are to be placed with their edges flush with the inby and outby faces of the seal, respectively. Joints in the planking are staggered and the planking is set in a thin layer of BlocBond. The use of plywood is not acceptable for the planking.

Wedges are driven on 6 inch to 1 foot centers. The wedges are driven between the planks and the roof to compress the planks uniformly against the Omega blocks. In no case should wedges be placed between the planks and the Omega blocks. BlocBond is used to fill all the gaps between the mine roof and the top block course, including the areas between the rows of wood planks and the gaps between the wooden wedges. Wedging should be sufficiently tight to firmly fix the top of the wall against the roof. All exposed wood is to be coated with BlocBond.

It is important that the seal be constructed by mixing the mortar to the proper consistency and applying it to each surface of the blocks so that a sound bond is achieved. Construction is not to take place by stacking the blocks and then attempting to place mortar into the joint openings.

During construction of the last seal in a set, an opening should be left for workers to have access to the inby side of the seal. Once the inby side of the seal is completed and coated (except for the opening), then the opening should be closed up by placing the final blocks with coating pre-applied to their inby face and excess joint mortar.

Storage, transportation, and mixing of all seal materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life. Material should be stored in a dry environment. A visual check of the material should be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

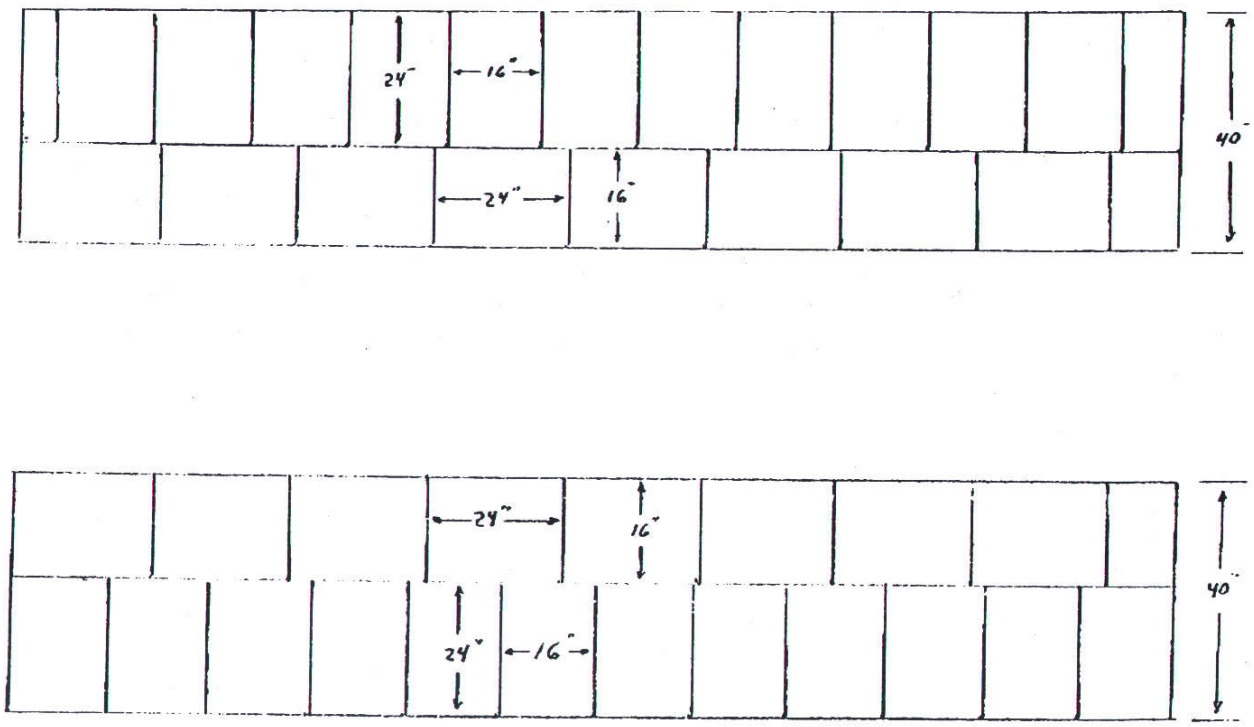
Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function.

Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

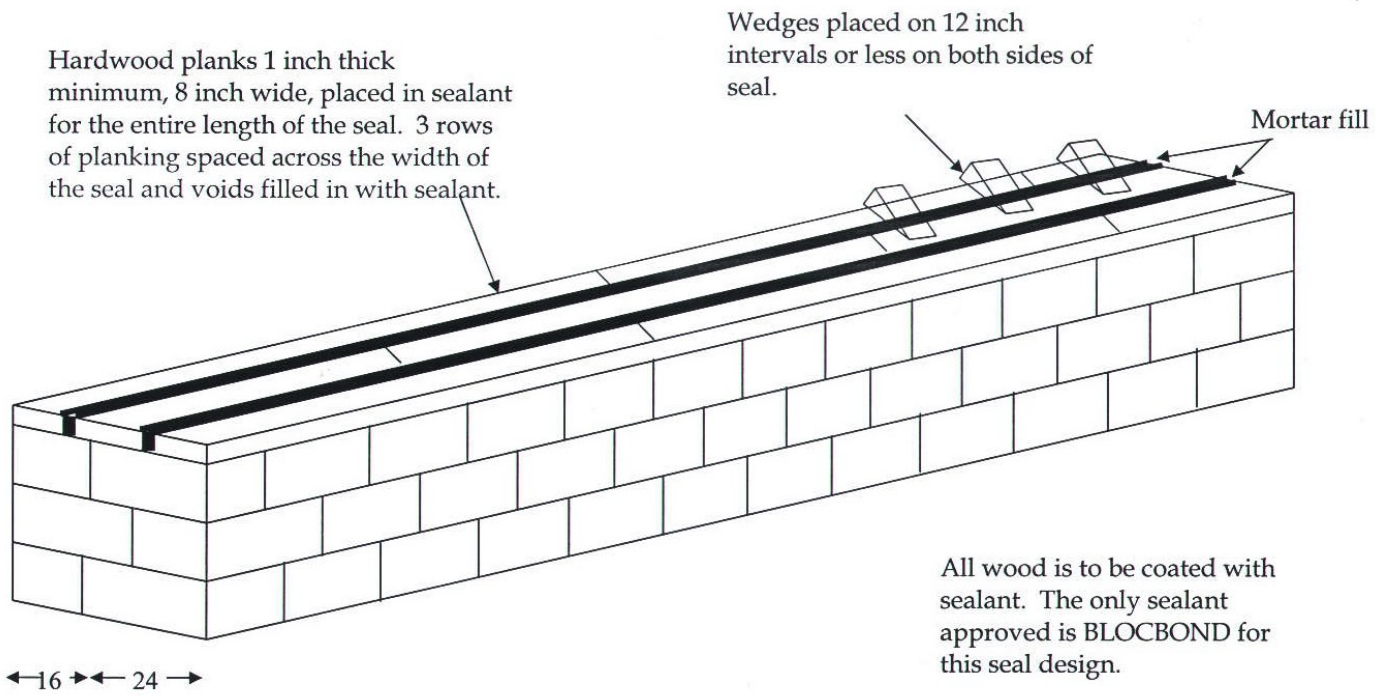
Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

40-inch thick Omega Block seals – Summary of Features	
Thickness	40 inches
Type of construction	Lightweight fiber reinforced block wet mortared on all joints and at contact with ribs and floor. Staggered vertical joints.
Pilasters	None required.
Hitching	None required.
Mortaring	Must be Quikrete BlocBond Product No. 1225-51 (blue bag), all joints, and contacts with floor, ribs and roof to be wet mortared with BlocBond.
Treatment at roof contact	Wood planks wedged into approx. 2 inch gap with all spaces filled with BlocBond.
Coating	Both faces coated with BlocBond to at least ¼ inch thickness.
Maximum size	Case-by-case evaluation if the height exceeds 8 feet or the width exceeds 20 feet.



Omega Block 40-inch thick seal showing alternating block pattern so that vertical joints are staggered. No pilaster.

Wood placement for 40 inch thick seal



PACKSETTER SEALS – CONCRETE BLOCKS

Packsetter Seals are distributed by Strata Products (USA) Inc. of Marietta, Georgia (800-691-6601). Packsetter Seals are constructed in a manner similar to standard solid concrete-block seals, except that Packsetter Bags are used in place of conventional hitching. Packsetter Bags are placed under the bottom corners of the seal, along each rib, and across the top of the seal, incorporating an overlap between bags. Packsetter Bags are then injected with grout under pressure to provide artificial horizontal and vertical loading on the seal upon installation. Tongue-and-groove solid concrete blocks are used for alternating courses.

The materials necessary for construction of a Packsetter Seal are 8 X 8 X 16 inch or 6 X 8 X 16 inch solid concrete tongue-and-groove blocks, a suitable mortar for wet-bed construction, and Packsetter Bags with the necessary grout. No hollow core concrete blocks can be used. The Packsetter grout is a specially formulated Portland-cement based mixture that is blended and packaged for Strata Products, Inc., by Quikrete. The compressive strength of the Packsetter grout was 580 psi after 28 days for the seal tested at the Lake Lynn Experimental Mine.

The tongue-and-groove sides of the solid concrete blocks must interlock on every other course laid. Alternating courses of the seal can be laid with solid concrete blocks without the tongue-and-groove design. This is due to the fact that the blocks are turned on alternating courses to stagger the joints. In this case, the tongue and the groove portions of each block are perpendicular to the seal and cannot lock into one another.

The seals are constructed with fully mortared joints, that is, mortar coats the entire vertical and horizontal block joint interfaces. The mortar used should meet ASTM C270-91a as Type N, S, or M mortar. In addition, Quikrete's BlocBond (product number 1225-51) is considered an acceptable mortar. Although BlocBond is a surface bonding mortar, it is an acceptable mortar for wet-bed construction with solid concrete blocks. BlocBond is the only surface bonding mortar permitted to be used in this type of seal construction. Except for the use of Quikrete's BlocBond, the mortar used cannot be a surface bonding mortar containing fiber reinforcement. B-Bond MS Mine Sealant is one such mortar and is <u>not</u> to be used for the mortared joints in constructing a solid concrete block seal with Packsetter Bags. BlocBond (Product Number 1225-51) comes in a blue bag and should not be confused with B-Bond (Product Numbers 1234-40; 1234-50) which comes in a green bag. These are different products.

Vertical and horizontal joints should be nominally 3/8 -inch thick, however they should not exceed 5/8 -inch nor be less than 1/4 -inch thick. These joint thicknesses are also applicable when Quikrete's BlocBond is used. Concrete blocks should not be wetted before mortar application. Rock dust is not to be mixed into joint mortar.

In no case can Packsetter Seals utilize solid concrete blocks constructed in dry-stacked fashion or concrete blocks smaller than 6 X 8 X 16 inch, with the exception of using solid concrete cap blocks in the top course.

SEAL CONSTRUCTION

Packsetter Seals are a minimum thickness of 16 inches with an interlocked 16 by 32-inch pilaster. For openings greater than 8 feet high or greater than 20 feet wide, case-by-case evaluation is required. Strength enhancements may include increased thickness, increased number and size of pilasters, and/or the inclusion of a footer or pier of concrete.

The initial phases of constructing a Packsetter Seal involves removal of loose material from the roof, ribs, and floor back to competent, solid material. No hitching is necessary. The floor should be leveled or a footer should be constructed to provide a suitable foundation for the placement of the first course of blocks. The first course of tongue and groove block is laid across the floor or footer in wet mortar to within 2 inches of each rib. The vertical joints of these blocks are fully mortared and the blocks are locked together. A Packsetter Bag is laid flat and positioned at least 6 inches under the outside corners of the first course of blocks, as shown in the attached drawing. The concrete block portion of the seal is constructed to within 5 inches but not less than 2 inches of the roof and ribs. Only solid cap blocks should be used at the roof. Because of possible rib and roof undulations, if the distance between seal and strata is up to 8 inches in a localized cavity, a spacer Packsetter Bag can be used.

All vertical and horizontal joints are to be fully mortared. All Packsetter Bags along the ribs and across the roof should overlap adjacent bags by a minimum of 6 inches. The top right and left corner Packsetter bags are to be placed with half the bag down the rib side and half the bag across the roof side of the seal. All Packsetter bags are to overlap the front and back face of the seal by at least 3 inches.

After all seal material and Packsetter bags are in position, grout is pumped into the bags. The recommended sequence for pumping is shown on the attached diagram. It is recommended that the length of grout hose from the pump to the Packsetter Bag be no longer than about 15 feet. Each bag is pressurized with grout to 36 to 44 psi through the use of a compressor driven pump or a hand pump. If a bag ruptures or leaks, it is to be removed and replaced. Each 50-pound bag of Packsetter grout was mixed with 14.5 gallons of water in the seal test performed at Lake Lynn.

After the grout bags are filled, polyurethane foam can be used to fill any small gaps at the roof and ribs or between Packsetter bags. Polyurethane is <u>not</u> to be applied to the roof, ribs, or floor prior to the construction of the Packsetter Seal. The outby side of the seal is to be coated with an MSHA-approved general purpose sealant to minimize leakage through the seal.

This seal is built of rigid materials and can fail in squeezing conditions. This seal can be built in dry, damp, or wet conditions; but not in standing water. Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

Storage, transportation, mixing and pumping of all materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life. Mortar and grout materials should be stored in a dry environment. A visual check of the material shall be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers involved in the construction process.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Packsetter with concrete block wall seal – Summary of Features	
Thickness	16 inches
Type of construction	Solid concrete block wall with pressure grouted Packsetter bags for hitching effect along ribs and roof.
Hitching	Packsetter bags filled with grout under pressure at both ribs and across the top of the seal in lieu of conventional hitching. Bags to be filled in sequence shown in attached sketch.
Wall construction	Fully mortared joints with the blocks in every other course interlocked with tongue and groove. Vertical joints are staggered.
Mortar	Type N, S, M or Quikrete BlocBond product number 1225-51 (blue bag)
Pilaster	Centered; 16 inches by 32 inches; interlocked with wall blocks.
Coating	Small gaps filled with polyurethane foam. Outby side is to be coated with MSHA-approved general purpose sealant.
Maximum size	Case-by-case evaluation for heights exceeding 8 feet or widths exceeding 20 feet.

PACKSETTER BAG PUMPING SEQUENCE FOR
PRELOADED - BLOCK SEAL

SEQUENCE:
PUMP BAGS MARKED "A", THEN "B", THEN "C", THEN "D".

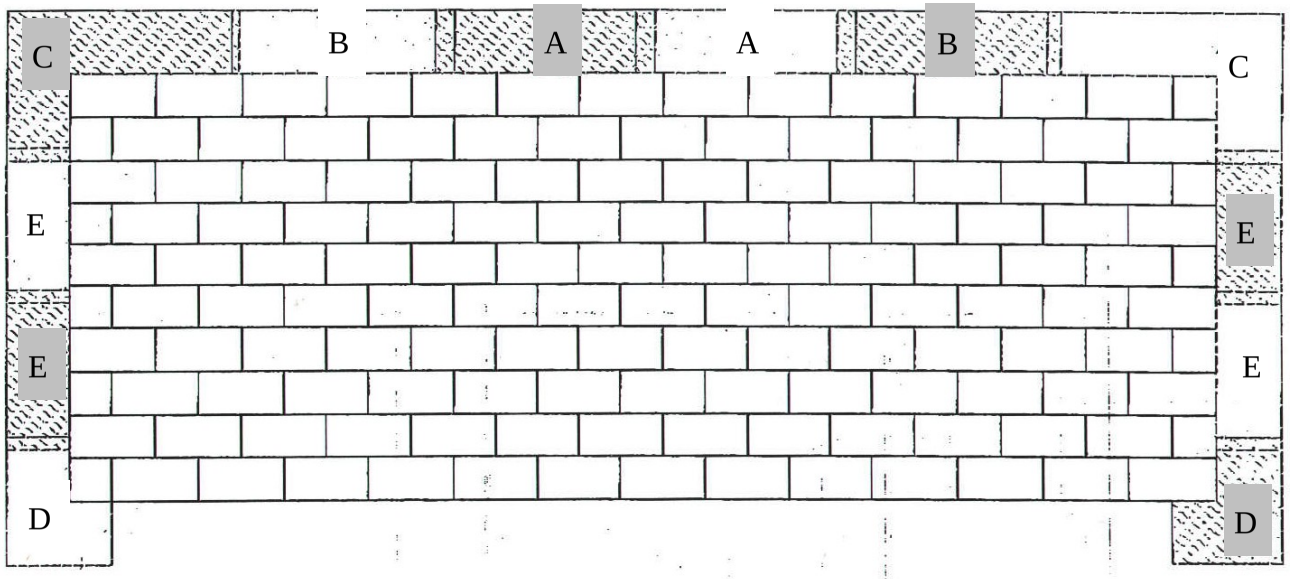


DIAGRAM #1

PACKSETTER SEALS – WOODEN CRIB BLOCKS

Packsetter Seals are distributed by Strata Products (USA) Inc. of Marietta, Georgia (800-691-6601). Packsetter Seals utilizing wooden crib blocks are constructed in a manner similar to wooden crib block seals, except that Packsetter Bags replace the need for hitching. The seals are at least 30 inches thick. Packsetter Bags are placed under the bottom corners of the seal, along each rib, and across the top of the seal, incorporating an overlap between bags. Packsetter Bags are then injected with grout under pressure to provide artificial horizontal and vertical loading on the seal upon installation. The materials necessary for construction of a Packsetter Seal are 30-inch long wooden crib blocks, appropriate glue and applicator, and Packsetter Bags with the necessary grout.

The Packsetter grout is a specially formulated Portland-cement based mixture that is blended and packaged for Strata Products, Inc., by Quikrete. The compressive strength of the Packsetter grout was 580 psi after 28 days for the seal tested at the Lake Lynn Experimental Mine.

SEAL CONSTRUCTION

The wooden crib blocks used for this Packsetter Seal are to be 30 inches long with approximate cross-sectional dimensions of 5 inches by 6 inches. The crib blocks are glued together with FOMO Handi-Stick adhesive and a special applicator. Each crib block requires 3 rows of ½-inch wide bead applied to top and each side of the full length of each crib block. One 32-ounce can of Handi-Stick adhesive typically provides approximately two courses of coverage. The manufacturer recommends that this product not to be used in mine air temperatures below 50 degrees F.

The 30-inch long crib blocks are oriented in the same direction, running lengthwise parallel with the ribs. The vertical joints are staggered in each row. The floor should be leveled or a footer should be constructed to provide a suitable foundation for the placement of the first course of wooden blocks. The first course is laid across the floor or footer in the adhesive.

A Packsetter Seal with crib blocks can be built in openings that are up to 8 feet high or 20 feet wide. Case-by-case evaluations are needed for an opening greater than 8 feet high or greater than 20 feet wide. This seal is built of materials that can withstand some squeezing conditions caused by heavy loading.

All loose or broken materials should be removed from the roof, ribs, and floor back to competent, solid strata. No hitching in the roof, ribs, or floor is necessary. The seal should be constructed on solid strata. Unstable ground and mid-seam partings should be scaled back.

A Packsetter Bag is positioned under the corners of the first course of crib blocks by at least 6 inches. The wooden block portion of the seal should be constructed to within 5

inches, but not closer than 2 inches, of the roof and ribs. Because of possible rib and roof undulations, if the distance between seal and strata is up to 8 inches in a localized cavity, a spacer Packsetter Bag can to be used.

All Packsetter Bags along the ribs and across the roof should overlap adjacent bags by a minimum of 6 inches. The top right and left corner Packsetter bags should be placed with half the bag down the rib side and half the bag across the roof side of the seal. All Packsetter bags should overlap the front and back face of the seal by at least 3 inches.

After all seal material and Packsetter bags are in position, grout is pumped into the bags. Each 50-pound bag of Packsetter grout was mixed with 14.5 gallons of water in the seal test performed at Lake Lynn Experimental Mine. The recommended sequence for pumping is shown on the attached diagram. It is recommended that the length of grout hose from the pump to the Packsetter Bag be no longer than about 15 feet. Each bag is pressurized with grout to 50 psi through the use of a compressor driven pump or a hand pump. If a bag ruptures or leaks, it needs to be removed and replaced.

After the grout bags are filled, polyurethane foam can be used to fill any small gaps at the roof and ribs or between Packsetter bags. Polyurethane is not to be applied to the roof, ribs, or floor prior to the construction of the Packsetter Seal.

Both sides of each seal are coated with an MSHA approved general purpose sealant. In addition, the outby side is covered with brattice and secured with several pieces of 1 X 8 inch rough cut lumber nailed to the seal. The perimeter of the brattice needs to overlap the roof, rib and floor by at least one foot. The brattice overlap is secured by the application of polyurethane. Polyurethane is used to fill any small gaps at the ribs or roof and between Packsetter bags. The MSHA approved general purpose sealant is applied to all exposed polyurethane.

Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

Storage, transportation, mixing and pumping of all materials should be according to the manufacturer's specifications. Materials should not be used beyond the manufacturer's specified shelf life. The storage of the grout material should be in a dry environment. A visual check of the material shall be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers involved in the construction process.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Packsetter with wooden crib blocks seal – Summary of Features	
Thickness	30 inches
Type of construction	Wooden crib block wall with pressure grouted Packsetter bags for hitching along both ribs and roof.
Hitching	Packsetter bags filled with grout under pressure at both ribs and across the top of the seal in lieu of conventional hitching.
Wall construction	Crib blocks, with length running parallel to ribs, are glued together with Handi-Stick adhesive. Vertical joints are staggered.
Adhesive	FOMO Handi-Stick adhesive, three rows of ½ inch wide bead applied to top and each side of each crib block.
Pilaster	None.
Coating	Small gaps filled with polyurethane foam. Both sides of seal coated with MSHA approved general purpose sealant. Outby side also covered with brattice.
Maximum size	Case-by-case evaluation for heights exceeding 8 feet or widths exceeding 20 feet.

PACKSETTER BAG PUMPING SEQUENCE FOR
PRELOADED - BLOCK SEAL

SEQUENCE:
PUMP BAGS MARKED "A", THEN "B", THEN "C", THEN "D".

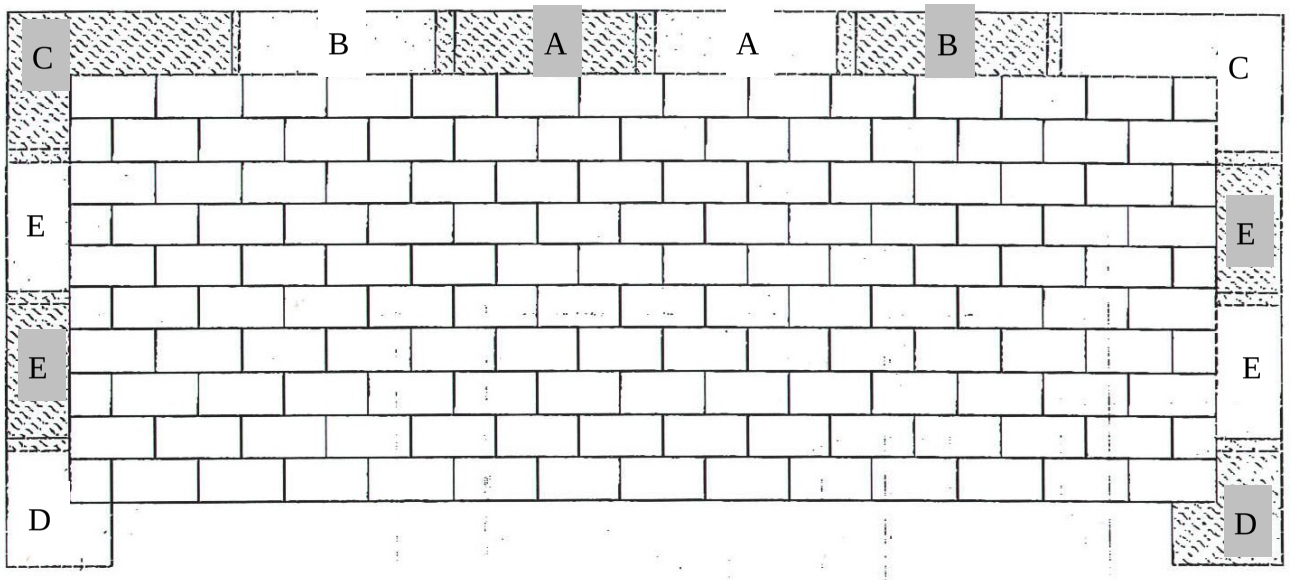


DIAGRAM #1

RIBFILL SEAL

(Pumpable cementitious seal with core thickness of at least 36 inches)

The Ribfill seal is distributed by HeiTech Corporation of Cedar Bluff, Virginia (540-963-4583) and Morgantown, West Virginia (304-284-8004). Ribfill is a water-entrained cementitious material. The seal is constructed by pumping the cementitious material, with a compressive strength of 433 psi, between two support walls or forms which are at least 3 feet apart.

Seal construction has been approved in openings with a height of up to 9 feet and width of up to 20 feet. Larger sizes should be evaluated on a case-by-case basis. Ribfill seals do not need to be hitched into the floor or ribs. Ribfill seals can handle some convergence without failure.

CONSTRUCTION OF RIBFILL SEALS

All loose or broken material should be removed from the ribs, roof and floor in the immediate construction area. Cementitious seals can be built in dry, damp, or wet conditions, but not in standing water. Cementitious seals built in the same manner as the tested seals do not need to be hitched into the floor or ribs. Seals should be constructed using a continuous pour so that a solid plug, with no joints, is obtained.

Storage, transportation, mixing and pumping of all seal materials should be according to the manufacturer's specifications. The shelf life of the material is nine months and should not be used if this time is exceeded. The storage of the material should be in a dry environment. A visual check of the material should be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers operating the pump and any other workers involved in the injection process.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Two support walls need to be constructed. These walls need to have sufficient strength to resist the pressure from the uncured material and can be constructed of concrete blocks or wood framing and brattice cloth. Wood framing can be installed as follows:

(a) Wooden timbers (minimum 4" x 4") should be installed as uprights on three (3) foot centers across the entry;

(b) Wooden boards (1" x 6" or equivalent) should be nailed horizontally across the timbers on not more than two (2) foot centers;

(c) MSHA approved brattice material should be nailed to the inside of the back wall with an overlap of no more than 4 inches onto each rib, the roof and floor. The overlaps should be secured to the ribs, roof and floor.

The front wall should be constructed following the steps outlined above or concrete blocks should be used to form the containment. Injection ports and hatch openings should be placed in the front wall to allow direct placement of the material. Boards should be installed covering the hatch when it is no longer needed. Internal support wires should be installed to keep the seal form from kicking out.

In openings up to 20 feet wide, there should be a minimum of three (3) injection ports incorporated into the top of the formwork to assure uniform distribution of the cement grout. These ports should be installed as to have approximate equal horizontal spacing between them. They should be angled upward and secured into place. The pumped material should be directed through the hatch as long as possible. The remaining material should be pumped through the injection ports until the seal is completed. It is important to make sure the top cavities are filled with material.

In seals where a liner is not used (i.e., concrete block forms), a minimum of two (2) bleeder pipes are to be angled upward to the highest points of the seal along the roof. This is because direct observations of the level of fill are not possible with such a form. The seal can be considered to be topped off when the seal material runs out of these pipes. These pipes are separate from the pipes used for injection of the cementitious material.

The forms are not intended to add structural strength to the seal. The forms may be removed after a curing time of 28 days or may be left in place. If a form is removed, or any deterioration of a form occurs, an MSHA-approved general purpose sealant must be applied to the exposed face of the seal.

The hose for pumping material should be 1.25 inch diameter. A minimum length of 300 feet is needed for a good mix of materials. The temperature of the pumping water affects the curing of the seal and 56 - 69 degrees Fahrenheit is acceptable. The pump should be set up in a fairly level manner with sufficient clearance on sides and top to allow for pouring of the bags of RIBFILL. The maximum pumping distance for this seal is 1200 feet.

The water to solids ratio for this seal should be maintained within the range of 1.9 parts water to 1.0 part solid to 2.3 parts water to 1.0 part solid. The water to solid ratio should be monitored periodically by checking the flow meter to make certain that the gallons of water per minute are constant and that the amount of RIBFILL being mixed per minute is correct. These checks should be made at least every 15 minutes.

Samples need to be collected during seal construction to make certain that the seal material has the required compressive strength. At least nine samples of the cementitious material, representative of the pumped material, should be collected from each seal. Three samples should be taken during the pumping process from the bottom of the seal, three from the center of the seal and three from the top of the seal. The samples should be collected in cylindrical containers three inches in diameter and six

inches long. These samples should be tested for compressive strength 28 days after pouring, by the manufacturer or an independent laboratory, and the test results should be made available. The test results of these samples should have an average minimum compressive strength of 433 psi. None of the tested samples should have a compressive strength of less than 230 psi. Any test revealing insufficient compressive strength or other insufficiency with any seal should be investigated and corrective action taken. Samples should be permitted to cure for 24 hours before transporting. The samples should to be stored underground or in a moisture-controlled environment similar to the mine conditions where the seals are located. The samples should be labeled as to their collection location. ASTM or other applicable sampling and testing procedures should be followed.

Roof sag or floor heave, occurring after seal construction, can result in failure of the form walls. If this occurs, the face of the seal must be coated with an MSHA-approved sealant. Ribfill may experience some deterioration when exposed to mine water and air for prolonged periods. For this reason it is important to maintain the form or to apply an approved general purpose sealant to any exposed portion of the face of the seal.

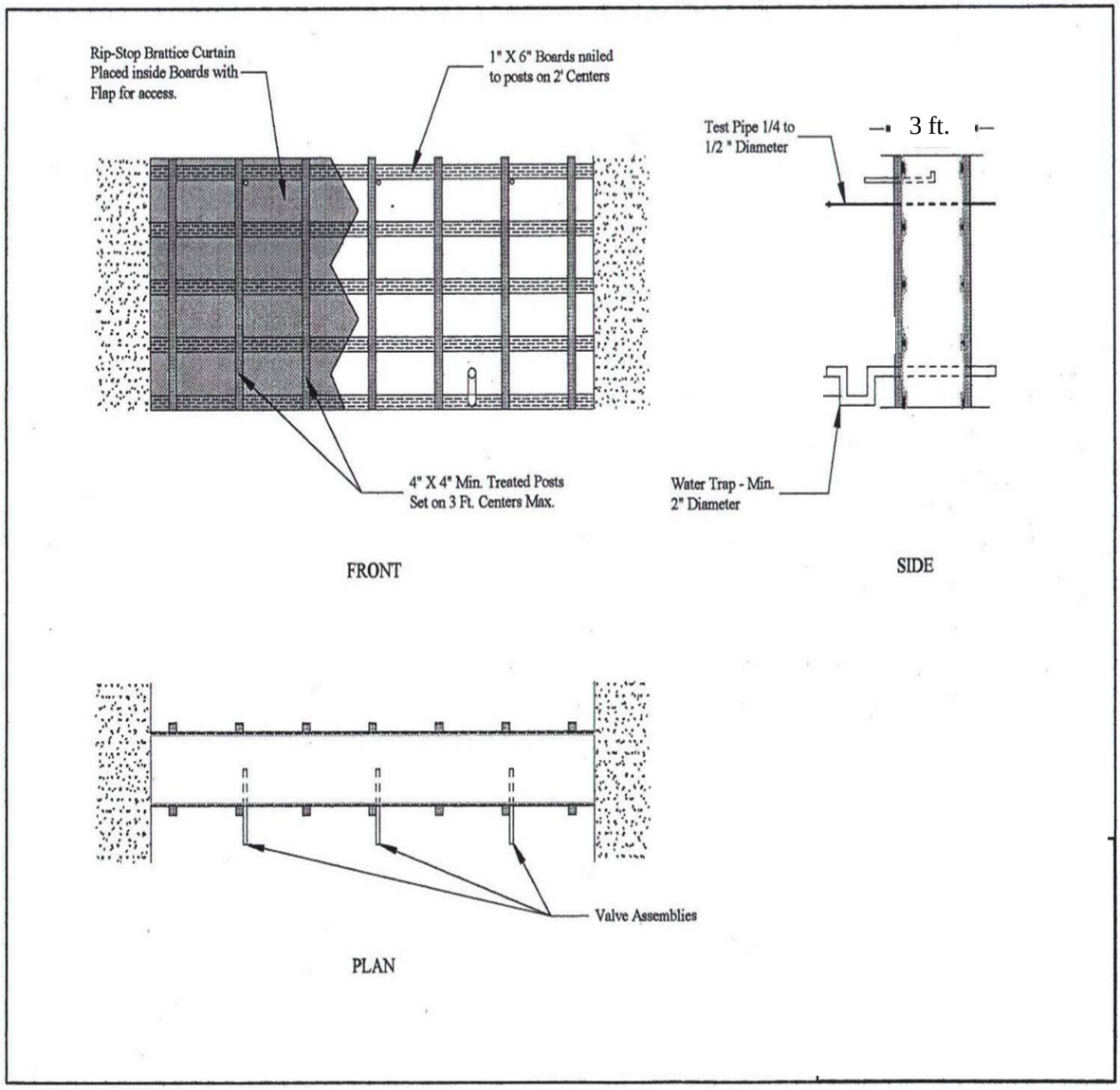
Convergence of an amount that compromises the function of any portion of the seal will require that the seal be replaced. Mine operators should provide information to MSHA to substantiate how much convergence a seal can withstand.

Where the ribs, roof, or floor are smooth at the seal location, measures should be taken by the mine operator to increase the shear bond between the seal and the surrounding strata. This may include such measures as notching the seal into the smooth surface, or bolting an angle to create an artificial hitch effect.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Ribfill Seal – Summary of Features	
Thickness	At least 36 inches
Type of construction	Cementitious material pumped between two support forms.
Hitching	Not required
Compressive strength	Average of at least 433 psi No samples below 230 psi
Material sampling	At least 9 samples for each seal to confirm compressive strength; 3 from bottom portion, 3 from center portion, and 3 from top portion.
Coating/forms	If a form is removed, or any deterioration of a form occurs, an MSHA approved general purpose sealant needs to be applied to the exposed seal material.
Pilaster	None.
Maximum size	Case-by-case evaluation if height exceeds 9 feet or width exceeds 20 feet.


Rip-Stop Brattice Curtain
Placed inside Boards with
Flap for access.
1" X 6" Boards nailed
to posts on 2' Centers
4" X 4" Min. Treated Posts
Set on 3 Ft. Centers Max.
FRONT
Test Pipe 1/4 to
1/2 " Diameter
3 ft.
Water Trap - Min.
2" Diameter
SIDE
Valve Assemblies
PLAN

ROCKFAST SEAL

(Pumpable cementitious seals with core thicknesses of at least 24 or 30 inches)

The Rockfast seals are distributed by HeiTech Corporation of Cedar Bluff, Virginia (540-963-4583) and Morgantown, West Virginia (304-284-8004). The Rockfast M-FGL material used for these seals is a modified, Portland cement-based, fiber-reinforced pumpable grout which exhibits rapid gelation and high early strength. It is a water-entrained cementitious material.

Rockfast M-FGL can be used to construct seals of two separate minimum thicknesses. These seals can be either 24 inches thick or 30 inches thick. The 24-inch thick seal requires material with a compressive strength of at least 677 psi, while the 30-inch thick seal requires material with a compressive strength of at least 480 psi. Rockfast seals do not need to be hitched into the floor or ribs.

Rockfast seal have been approved in openings with a height of up to 9 feet and width of up to 20 feet. Larger sizes should be evaluated on a case-by-case basis. Rockfast seals do not need to be hitched into the floor or ribs. Rockfast seals can handle some convergence without failure.

CONSTRUCTION OF ROCKFAST SEALS

All loose or broken material should be removed from the ribs, roof and floor in the immediate construction area. Cementitious seals can be built in dry, damp, or wet conditions, but not in standing water. Cementitious seals built in the same manner as the tested seals do not need to be hitched into the floor or ribs. Seals should be constructed using a continuous pour so that a solid plug, with no joints, is obtained.

Storage, transportation, mixing and pumping of all seal materials should be according to the manufacturer's specifications. The shelf life of the material is nine months and should not be used if this time is exceeded. The storage of the material should be in a dry environment. A visual check of the material shall be made before use. The bagged material should be relatively soft, indicating limited exposure to moisture.

Water quality and the temperature of the mine atmosphere during construction should be within manufacturer requirements. Safety precautions provided by the manufacturer should be followed. Personnel involved in erecting the seals should be familiarized with the system and its intended function. Training should be given to any workers operating the pump and any other workers involved in the injection process.

Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Two support walls need to be constructed. These walls need to have sufficient strength to resist the pressure from the uncured material and can be constructed of concrete blocks or wood framing and brattice cloth. Wood framing can be installed as follows:

(a) Wooden timbers (minimum 4" x 4") should be installed as uprights on three (3) foot centers across the entry;

(b) Wooden boards (1" x 6" or equivalent) should be nailed horizontally across the timbers on not more than two (2) foot centers;

(c) MSHA approved brattice material should be nailed to the inside of the back wall with an overlap of approximately 4 inches onto each rib, the roof and floor. The overlaps should be secured to the ribs, roof and floor.

The front wall should be constructed following the steps outlined above or concrete blocks should be used to form the containment. Injection ports and hatch openings should be placed in the front wall to allow direct placement of the material. Boards should be installed covering the hatch when it is no longer needed. Internal support wires may be installed to keep the seal form from kicking out.

In openings up to 20 feet wide, there should be a minimum of three (3) injection ports incorporated into the top of the formwork to assure uniform distribution of the cement grout. These ports should be installed as to have approximate equal horizontal spacing between them. They should be angled upward and secured into place. The pumped material should be directed through the hatch as long as possible. The remaining material should be pumped through the injection ports until the seal is completed. It is important to make sure the top cavities are filled with material.

In seals where a liner is not used (i.e., concrete block forms), a minimum of two (2) bleeder pipes should be angled upward to the highest points of the seal along the roof. This is because direct observations of the level of fill are not possible with such a form. The seal can be considered to be topped off when the seal material runs out of these pipes. These pipes are separate from the pipes used for injection of the cementitious material.

The forms are not intended to add structural strength to the seal. The forms may be removed after a curing time of 28 days or may be left in place. If a form is removed, or any deterioration of a form occurs, an MSHA-approved general purpose sealant must be applied to the exposed face of the seal.

The hose for pumping material should be 1.25 inch diameter. A minimum length of 300 feet is needed for a good mix of materials. The pump should be set up in a fairly level manner with sufficient clearance on sides and top to allow for pouring of the bags of Rockfast material. The maximum pumping distance for this seal is 1000 feet.

The water to solids ratio for this seal should be maintained within the range of 1.0 part water to 1.0 part solid up to 1.4 parts water to 1.0 part solid. The water to solid ratio should be monitored periodically by checking the flow meter to make certain that the gallons of water per minute are constant and the amount of Rockfast being mixed per minute is correct. These checks should be made at least every 15 minutes.

Samples need to be collected during seal construction to make certain that the seal material has the required compressive strength. At least nine samples of the cementitious material, representative of the pumped material, should be collected from

each seal. Three samples should be taken during the pumping process from the bottom of the seal, three from the center of the seal and three from the top of the seal. The samples should be collected in cylindrical containers three inches in diameter and six inches long. These samples should be tested for compressive strength 28 days after pouring, by the manufacturer or an independent laboratory, and the test results should be made available. The test results of these samples should have an average compressive strength of 677 psi in the 24-inch thick seal and 480 psi in the 30-inch thick seal. None of the tested samples should have a compressive strength of less than 280 psi in the 24 inch thick seal and 110 psi in the 30 inch thick seal. Any test revealing insufficient compressive strength or other insufficiency with any seal should be investigated and corrective action taken. Samples should be permitted to cure for 24 hours before transporting. The samples should be stored underground or in a moisture-controlled environment similar to the mine conditions where the seals are located. The samples should be labeled as to their collection location. ASTM or other applicable sampling and testing procedures should be followed.

Roof sag or floor heave, occurring after seal construction, can result in failure of the form walls. If this occurs, the face of the seal must be coated with an MSHA-approved sealant. Rockfast may experience some deterioration when exposed to mine water and air for prolonged periods. For this reason it is important to maintain the form or to apply an approved general purpose sealant to any exposed portion of the face of the seal.

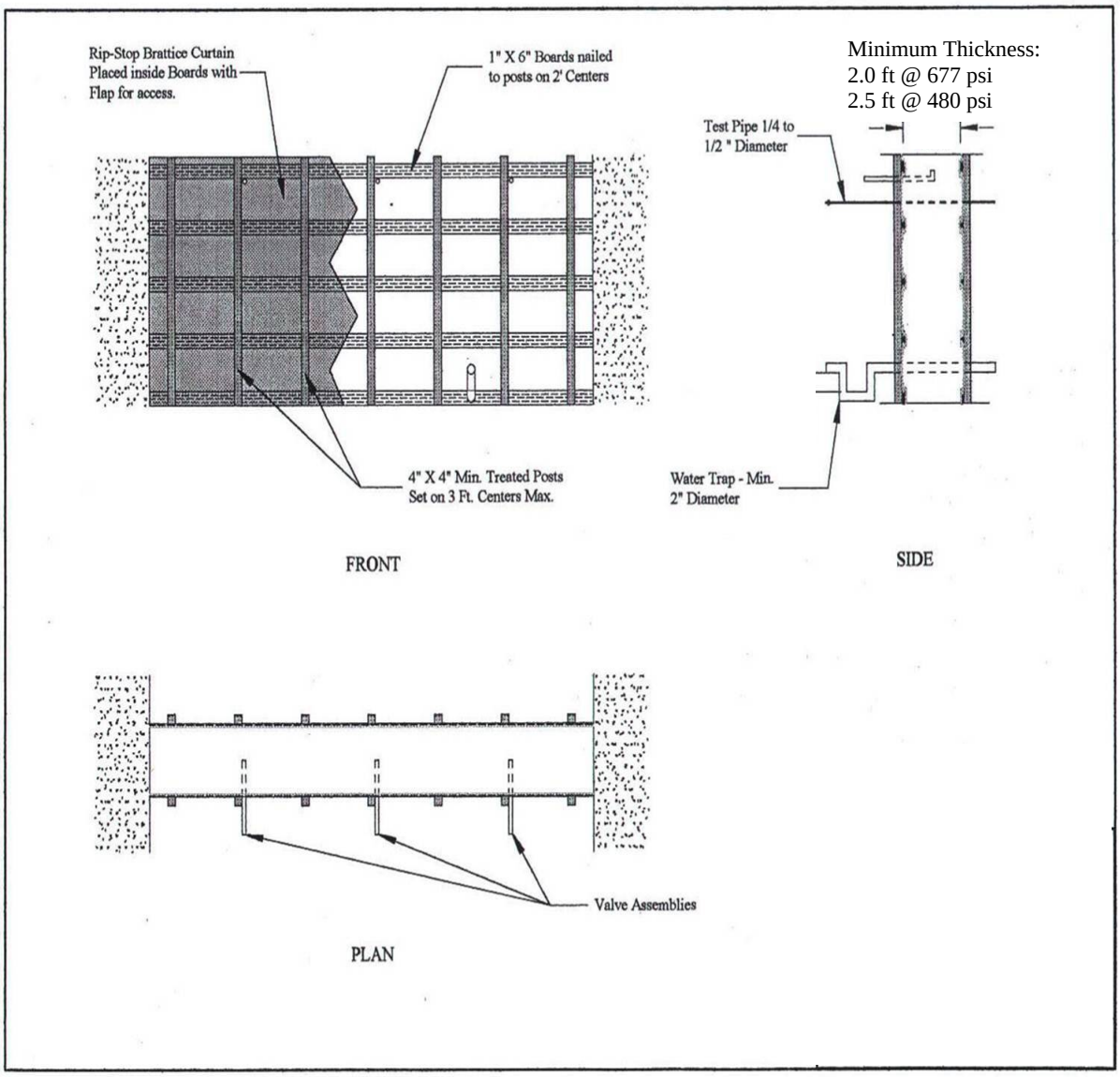
Convergence of an amount that compromises the function of any portion of the seal will require that the seal be replaced. Mine operators should provide information to MSHA to substantiate how much convergence a seal can withstand.

Where the ribs, roof, or floor are smooth at the seal location, measures should be taken by the mine operator to increase the shear bond between the seal and the surrounding strata. This may include such measures as notching the seal into the smooth surface, or bolting an angle to create an artificial hitch effect.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Rockfast Seal – Summary of Features		
	24–inch thick seal	30-inch thick seal
Thickness	At least 24 inches	At least 30 inches
Type of construction	Cementitious material pumped between two support forms.	
Hitching	Not required	
Compressive strength	Average at least 677 psi No samples less than 280 psi	Average of at least 480 psi No samples less than 110 psi
Material sampling	At least 9 samples for each seal to confirm compressive strength; 3 from bottom portion, 3 from center portion, and 3 from top portion.	
Coating/forms	If a form is removed, or any deterioration of a form occurs, an MSHA approved general purpose sealant must be applied to the exposed seal material.	
Pilaster	None.	
Maximum size	Case-by-case evaluation if the height exceeds 9 feet or the width exceeds 20 feet.	


Rip-Stop Brattice Curtain
Placed inside Boards with
Flap for access.
1" X 6" Boards nailed
to posts on 2' Centers
4" X 4" Min. Treated Posts
Set on 3 Ft. Centers Max.
FRONT
Minimum Thickness:
2.0 ft @ 677 psi
2.5 ft @ 480 psi
Test Pipe 1/4 to
1/2 " Diameter
Water Trap - Min.
2" Diameter
SIDE
Valve Assemblies
PLAN

WOODEN CRIB-BLOCK SEAL

Wood-block seals are used in mines that experience high convergence forces. These high convergence forces exceed the compressive strength of the standard-type, concrete block seals, rendering concrete seals ineffective.

A wooden crib-block seal with a thickness of 36 inches successfully passed 20-psi testing in testing at NIOSH's Lake Lynn Experimental Mine. A seal constructed in the same manner as the test seal meets the requirements for an alternative seal as per 30CFR 75.335(a)(2).

The wooden crib-block seal is limited to openings that are no more than 8 feet high and no more than 20 feet wide. Any larger opening size should be evaluated on a case-by-case basis. Additional strength-enhancing features for larger openings may include hitching or increased thickness.

This seal can be built in dry, damp, or wet conditions; but standing water is to be avoided during construction. The seal can tolerate some convergence. As with all seals, the wood crib block seal should be set back at least ten feet from the nearest corner of a pillar.

Seals constructed of crib blocks with rock dust between courses and no nailing or plywood faces were found to be of insufficient strength to withstand the effects of a 20-psi explosion during tests at the Lake Lynn facility. A seal constructed with the crib-blocks secured with 20-penny screw-type nails, with 5/8-inch plywood sheeting secured to both sides of the seal, and with an MSHA-approved general purpose sealant was applied to both faces, withstood 20-psi testing.

SEAL CONSTRUCTION

All loose or broken material should be removed from the ribs, roof and floor, back to competent, solid strata, at the seal location. All cracks shall be grouted in the site preparation area. The seal thickness is to be at least 3 feet plus the thickness of plywood and sealant applications. The nominal size of the wood crib blocks is 6x6x36 inch.

The seal is to be hitched into the ribs and mine floor at least 6 inches. Gaps between the seal and the edges of the hitch are to be filled with mortar up to the original floor level. Alternatively, hitching can be provided by bolting 6 by 6 by 2-inch steel angle to the ribs and floor. Angles are installed with grouted 1-inch diameter case-hardened steel bolts.

Crib-blocks are installed horizontally with their length parallel to the ribs. Each crib-block is toe-nailed to the crib-block in the lower course using three 20-penny common nails spaced on 9-inch centers. Voids around the perimeter are to be wedged tight.

Additionally, 5/8-inch thick CDX exterior plywood sheeting is to be installed on both sides of the seal. This plywood is secured to the ends of the crib-blocks using 16-penny common nails on 6 inch centers. The plywood facing should extend into the hitch or behind the angle. An approved sealant is to be applied around the perimeter and at the joints in the plywood sheeting on both faces. A drawing showing the components of a crib-block seal is attached.

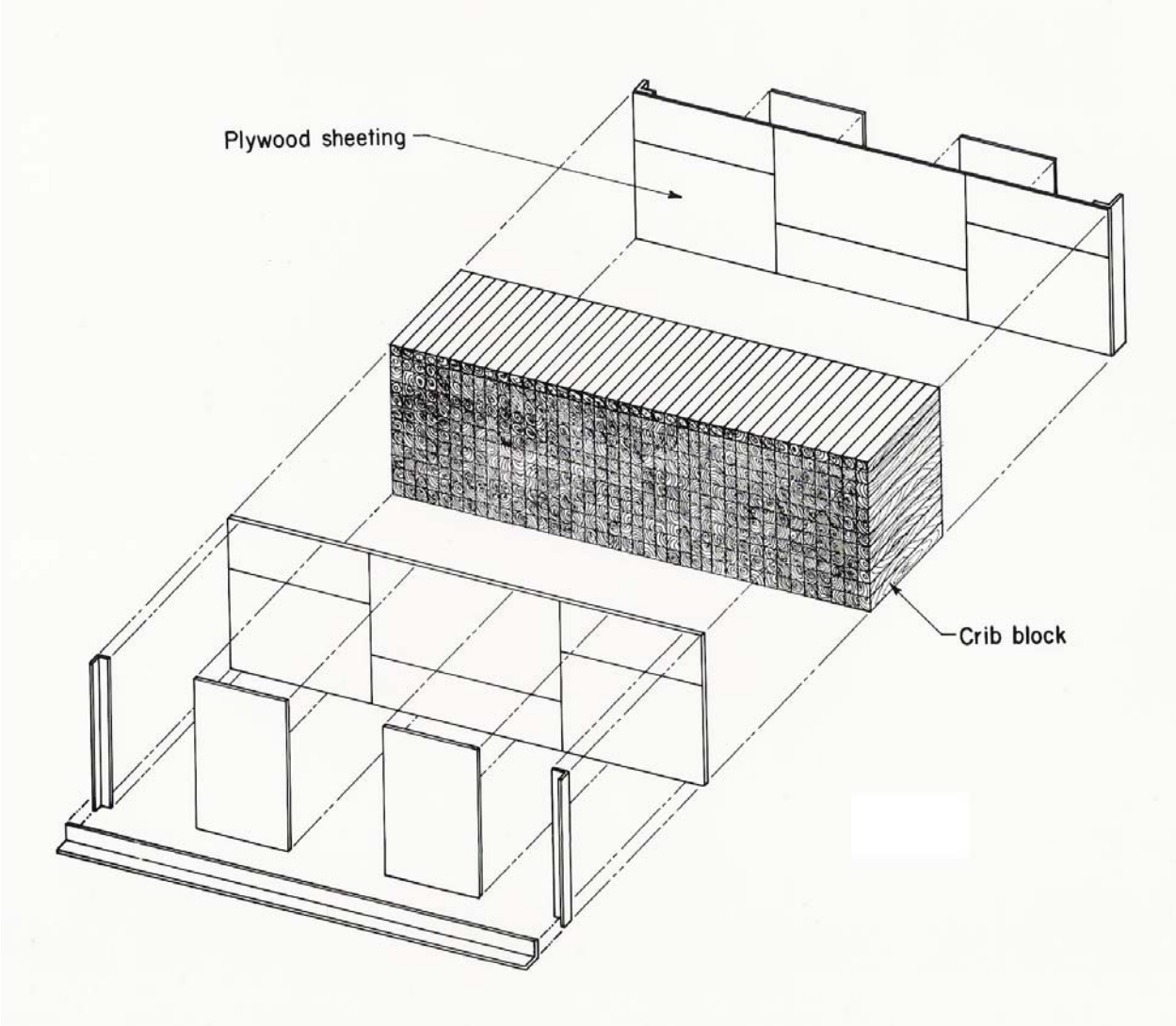
Seal construction should be supervised, including quality control and procedures, by a responsible person(s) who is knowledgeable of construction techniques and the specific seal construction requirements.

Seals should be set back at least 10-feet from the nearest corner of pillar to restrict air leakage around seal. Construction of seals at less than 10-feet from a pillar corner should be evaluated on a case-by-case basis.

Prior to seal construction, objects passing through the seal location, such as roof mesh, straps, rails, pipes and wires, should be safely removed.

Part 48 training should be provided to assure that all miners, including contractors, who construct or maintain the seals, are appropriately trained to perform such duties safely.

Wooden Crib-Block Seal – Summary of Features	
Thickness in inches	36
Type of Construction	Nailed together wooden crib blocks with plywood facing on both sides.
Crib block size (nominal)	6 in. by 6 in. by 36 inches
Hitching requirement	6 inches into solid floor and solid rib; or 6 in. by 6 in. by 1/2 inch steel angle bolted to ribs and floor.
Coating	An approved sealant is to be applied around the perimeter and at the joints in the plywood sheeting on both faces.
Maximum size	Case-by-case evaluation if the opening height exceeds 8 feet or the width exceeds 20 feet.


Plywood sheeting
Crib block

Appendix - List of Reference Material

Addition information on seal testing and construction can be found in the following publications:

1. Methods of Evaluating Explosion Resistant Ventilation Structures, M. Sapko, E. Weiss and S Harteis, 8th International Mine Ventilation Congress, July 6-8, 2005, Brisbane, Australia.

2. Designs for Rapid Insitu Sealing; M. Sapko, E. Weiss, J. Trackemas, and C. Stephan; 2003 SME Annual Meeting, February 24-26, Cincinnati, Ohio.

3. Evaluation of Explosion-Resistant Seals, Stoppings, and Overcast for Ventilation Control in Underground Coal Mining; E. Weiss, K. Cashdollar; RI 9659, NIOSH, 2002.

4. Strength Characteristics and Air Leakage Determinations of Alternative Mine Seal Designs; E. Weiss, N. Greninger, C. Stephan, and J. Lipscomb; RI 9477, U.S. Bureau of Mines, 1993.

5. Evaluation of Polymer Construction Material and Water Trap Designs for Underground Coal Mine Seals; E. Weiss, W. Slivensky, M. Schultz, C. Stephan, and K. Jackson, RI 9634, 1996.

6. Evaluation of Reinforced Cementitious Seals; E. Weiss, K. Cashdollar, I. Mutton, D. Kohli, and W. Slivensky; RI 9647, 1999.

7. Evaluation of Solid Block and Cementitious Foam Seals; N. Greninger, E. Weiss, S. Luzik, and C. Stephan; RI 9382, 1991.

8. Explosion-Proof Bulkheads – Present Practices; D. Mitchell, U.S. Bureau of Mines, RI 7581, 1971.

9. Omega 384 Block as a Seal Construction Material; C. Stephan, Industrial Safety Division, MSHA, Report No. 10-318-90, November 14, 1990.

10. Mortar for Use in the Construction of Concrete-Block Stoppings and Seals in Underground Mines by S. Sawyer, Industrial Safety Division, MSHA, Report No. 02-174-92, June 22, 1992.

11. Construction of Seals in Underground Coal Mines; C. Stephan, Industrial Safety Division, MSHA, Report No. 06-213-90, August 1, 1990.