Rules of
Department of Natural Resources
Division 23—Division of Geology and Land Survey
Chapter 4—Monitoring Well Construction Code

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 23—Division of Geology and Land Survey
Chapter 4—Monitoring Well Construction Code

10 CSR 23-4.010 Definitions

PURPOSE: This rule specifically defines words used in Chapter 4 concerning monitoring wells, otherwise the definitions contained in 10 CSR 23-1.010 apply.

(1) Extraction well means any well more than ten feet (10') in depth utilized in the remediation of a site. These include, but are not limited, to the following: wells serving pump and treat systems, wells to capture a contaminant plume or alter the direction or magnitude of groundwater movement, leachate recovery wells that are not a part of the original landfill construction and other associated wells. Passive and active methane wells in landfills are exempted from these rules, but are regulated under the Solid Waste Law.

(2) Monitoring well means a well that is constructed to obtain site-specific water quality, contaminant movement or hydrologic data from proposed or existing waste disposal, waste processing, waste storage, hazardous materials release or other sites which may impact groundwater quality. This includes extraction wells used in the remediation of the site, piezometers for the collection of geologic and hydrologic data, observation wells and field screening technologies such as soil gas monitoring or push-in well screen temporary wells greater than ten feet (10') in depth but excludes wells constructed in the tank pit used as a part of an underground storage tank leak detection system and piezometers used to monitor the geotechnical performance of dams. Monitoring wells less than ten feet (10') in depth are exempt from reporting rules but must be plugged (see 10 CSR 23-4.080(5)).

(3) Nominal diameter means the term used to describe the standard sizes for casing. Depending on the wall thickness, the inside diameter of the casing may be less than or greater than the number indicated. For example, two-inch (2") nominal Schedule 40 polyvinyl chloride (PVC) casing has a standard outside diameter of 2.375 inches, and an inside diameter of 2.067 inches; two-inch (2") nominal Schedule 80 PVC casing has the same outside diameter, but has an inside diameter of only 1.939 inches.

(4) Open-hole completion means a monitoring well cased through all overburden material and upper water producing zones, completed in bedrock, with no well screen or filter pack.

(5) Piezometer means a groundwater monitoring well, screened or opened to a saturated interval, installed for the specific purpose of determining either the elevation of the potentiometric surface or the physical, chemical, biological or radiological properties, or both, of groundwater at some point within the saturated zone.

(6) Potentiometric surface or piezometric surface means an imaginary surface representing the total head of groundwater and is the level to which water will rise in a well.

(7) Protective casing means the casing set from a point below the frost line and extends at least one and one-half feet (1 1/2") above the finished grade. The bottom of the casing must be at least three feet (3') below ground surface. This casing is set to protect the monitoring well from damage.

(8) Riser pipe means the casing extending from the well screen to or above the ground level.

(9) Water table observation well means any monitoring well, in which the screen or open borehole intersects a water table, which is installed for the specific purpose of determining either the elevation of the water table or the physical, chemical, biological or radiological properties, or both, of groundwater at the water table.

(10) Temporary monitoring well means a well or hole used for field screening purposes such as soil gas monitoring, push-in type holes, auger holes, etc. that are greater than ten feet (10') in depth and are plugged within thirty (30) days of completion. These wells may or may not have temporary pipes installed for various purposes.

(11) Concrete means a slurry mixture with a ratio of ninety-four pounds (94 lbs.) of cement, equal volumes of dry sand and gravel and five to six (5—6) gallons of water from a known safe and uncontaminated source. The ratio of sand and gravel to cement may not exceed three parts to one (3:1).

AUTHORITY: sections 256.603, 256.606 and 256.626, RSMo (1994). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed July 13, 1994, effective Jan. 29, 1995. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.603, RSMo (1985), amended 1991; 256.606, RSMo (1991); and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.020 Certification and Registration for Monitoring Wells

PURPOSE: This rule sets required standards for certification report form submittal.

(1) A certification report form, supplied by the division, shall be used to report new monitoring well construction. The certification report form shall be completed and submitted to the division by the permittee within sixty (60) days after the completion of any well. The certification report form shall be accompanied by the certification fee (see 10 CSR 23-2 for applicable fees). The permittee shall furnish the well owner one (1) copy, the division one (1) copy and retain one (1) copy in the permittee's files.

(2) The certification process involves the review of the certification report form to be sure that the well meets all construction requirements necessary for the specific area where the well has been drilled. Upon successful completion of review of the certification report form, a certification number will be assigned and sent to the well owner. The issuance of the certification number indicates that the well has met the minimum standards set out in these rules. The minimum construction standards were written to protect Missouri's groundwater and to help ensure that construction of the wells does not constitute a threat to this resource.

(3) The registration process involves the documentation of certain types of activities according to the requirements and reported on forms supplied by the division.

(4) A registration report form, supplied by the division, shall be used to report the plugging of wells and the major repairs and alterations made to monitoring wells and must be submitted to the division by the permittee within sixty (60) days after completion of such operations. Temporary monitoring wells are required to be plugged within thirty (30) days after initial completion. Only a registration report form is required to document plugging of temporary monitoring wells. The registration report form shall be accompanied by the registration fee. The permittee shall furnish the well owner one (1) copy, the division one (1) copy and retain one (1) copy in

the permittee's files. The registration report form shall contain all required information.

AUTHORITY: sections 256.606, 256.614 and 256.626, RSMo (1994). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.606, RSMo (1991) and 256.614 and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.030 Location of Wells

PURPOSE: This rule sets criteria for the locations where monitoring well should be placed.

(1) A monitoring well shall be—

(A) Located so that the well and its surrounding area can be kept in a sanitary condition and provide ready access for maintenance and repairs;

(B) Located, if possible, so proper drainage in the vicinity of the well shall be provided to prevent the accumulation and pooling of surface water within ten feet (10') of the well;

(C) If at all possible, located in areas that do not flood. If no reasonable alternative site exists, special construction criteria will be determined on a case-by-case basis by the division; and

(D) Located where possible farther than fifteen feet (15') from a cavity used for underground utility lines or an overhead electric distribution line or not twenty-five feet (25') from an electric transmission line which is in excess of fifty (50) kilovolt (kV), except for the underground electrical service line in the vicinity of an existing well or known proposed well. If it is necessary to locate wells under electric lines safety precautions should be taken. In areas of traffic, the wellhead must either be protected by pylons to prevent damage, or completed as a surface flush mount as described in 10 CSR 23-4.060(12)(B).

AUTHORITY: sections 256.606 and 256.626, RSMo (Cum. Supp. 1991). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994.*

**Original authority: 256.606, RSMo (1991) and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.040 Drilling Methods for Monitoring Wells

PURPOSE: This rule ensures the method of drilling utilized allows a representative sample to be taken of the zone to be monitored and ensures the appropriate zone is being monitored.

(1) There are many different drilling technologies available for permitted monitoring well drillers to utilize. The method of drilling chosen must not add contaminants to the well which would adversely affect the purpose of the well. Certain types of drilling methods can mask or hide the contaminants which are being monitored for or may not allow for collection of adequate geologic data to properly understand contaminant movement.

AUTHORITY: sections 256.606 and 256.626, RSMo (Cum. Supp. 1991). Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed July 13, 1994, effective Jan. 29, 1995.*

**Original authority: 256.606, RSMo (1991) and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.050 General Protection of Groundwater Quality and Resources

PURPOSE: This rule prevents the use of monitoring wells for any purpose other than the purpose for which they were designed and allows certain modifications to the application of these rules.

(1) Monitoring wells shall not be converted to any other type of well unless approved in advance by the department.

(2) When strict application of these rules presents practical difficulties or unusual hardships, the division, in a specific instance, may modify the application of these rules consistent with the general purpose of these rules and the law. The division may then impose certain conditions as are necessary, in the opinion of the division, to protect the groundwater of the state and health, safety and general well-being of persons using, or potential users, of the groundwater (see 10 CSR 23-1.040 Modification by the Division for procedures concerning variances).

(3) It is the obligation and responsibility of the monitoring well installation contractor to ensure that the well is constructed according to the rules and that the annular space is sealed. This obligation and responsibility with regard to the annular seal ends three (3) years after the date of certification, unless it can be shown that the well seal has been damaged by other persons. The well must be properly plugged or repaired when the well is no longer sealed.

(4) When drilling water is needed, it must be of potable quality.

AUTHORITY: sections 256.606 and 256.626, RSMo (1994). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.606, RSMo (1991) and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.060 Construction Standards for Monitoring Wells

PURPOSE: This rule describes the minimum standards for a properly constructed monitoring well.

(1) Riser Pipe and Casing Material.

(A) Chemical Compatibility. Special consideration must be given to the selection of riser pipe or casing materials for monitoring wells installed in environments that are chemically reactive. The riser pipe or casing selected must resist chemical corrosion for the life of the proposed monitoring program. Chemical interaction between riser pipe or casing materials and pollutants, contaminants, groundwater, filter pack material and geologic materials could bias groundwater quality determinations. Well construction material must be selected that does not affect these determinations.

(B) Types of Riser Pipe and Casing Materials. The types of riser pipe and casing materials are divided into four (4) categories—

1. Thermoplastic materials, including polyvinyl chloride (PVC) and acrylonitrile-butadiene-styrene (ABS);

2. Metallic materials, including carbon steel, low-carbon steel, galvanized steel and stainless steel (304 and 316);

3. Fluoropolymer materials, including polytetrafluoroethylene (PTFE), tetrafluoroethylene (TFE), fluorinated ethylene propylene (FEP), perfluoroalkoxy (PFA) and polyvinylidene fluoride (PVDF); and

4. Other types of riser pipe and casing may be used if approval is obtained in advance from the division.

(C) All thermoplastic and fluoropolymer riser pipe and casings must meet the requirements set out in 10 CSR 23-3.070(1)(D). This subsection sets standards for well casing markings. Thermoplastic and fluoropolymer riser pipe or casing used in monitoring well construction must meet the following minimum standards:

1. The nominal diameter of the riser pipe or casing must not be less than two inches (2"), except that piezometers and field screening temporary wells may have smaller diameter casings. Monitoring wells utilizing two-inch (2") riser pipe that are greater than one hundred feet (100') in depth must use Schedule 80 pipe.

2. The wall thickness of the riser pipe or casing must not be less than the Schedule 40 for the nominal size riser pipe or casing selected. Thicker walls are recommended in deeper wells or in presence of unstable materials. Wall thickness is also measured in standard dimension ratio (SDR) for thermoplastic riser pipe and casing;

3. Thermoplastic riser pipe and casing must be joined by a mechanical type joint. The joint must be watertight. If O-rings or fluoropolymer tape is used, they must be of inert materials which will not adversely affect the function of the monitoring well; and

4. Riser pipe and casing must be new and free from contaminants that would affect the quality of the groundwater or would adversely affect the monitoring.

(D) All metallic riser pipe and casings must meet the following minimum standards:

1. The nominal diameter of the riser pipe or casing must not be less than two inches (2"), except that piezometers and field screening temporary wells may have smaller diameter casings.

2. The wall thickness for carbon, low-carbon and galvanized steel must not be less than Schedule 40. The wall thickness of stainless 304 and 316 must not be less than Schedule 5. The joint wall thickness must not be less than Schedule 40. Due to the thin wall of Schedule 5 stainless casing, threads are not machined into the casing itself. A threaded section of Schedule 40 stainless is welded onto the thin walled casing so that watertight connections can be made without losing strength;

3. Metallic riser pipe or casings must be joined by a watertight mechanical joint or welded. Welded joints can produce a stronger joint than mechanical joints but if explosive gases are present, they may be ignited by the welding process. The well must be checked for the presence of explosive gases before welding begins. If explosive gases are present, precautions must be taken before construction continues; and

4. Riser pipe and casing must be new and free from contaminants which would affect the quality of the groundwater or would adversely affect the monitoring.

(2) Monitoring Well Borehole Preparation. Boreholes constructed for the installation of monitoring wells, including piezometers must be clean, free of obstructions, and must be at least four inches (4") in diameter larger than the outside diameter of the riser pipe, screen and/or surface casing that is used. For wells with multiple strings of different sized casings, the annulus between the successive casing sizes must be at least two inches (2"). Field testing methods such as soil gas monitoring and push-in well screen sampling holes are exempt from these borehole standards. When constructing a monitoring well that utilizes hollow-stem augers to bedrock, then rock drilling to total depth, the following exceptions may apply:

(A) When using an industry standard size six and one-quarter-inch (6 1/4") internal diameter auger to drill the unconsolidated material portion of the well, the bedrock portion of the well must be drilled with a bit which creates a hole that is at least six inches (6") in diameter, if the well is constructed using a nominal two-inch (2") diameter riser pipe. This will leave an annulus of one and five-sixths inches (1 5/6") within the bedrock portion of the well, which is the minimum allowable annulus for this type of monitoring well; and

(B) When using an industry standard size eight and one-quarter-inch (8 1/4") internal diameter auger to drill the unconsolidated material portion of the well, the bedrock portion of the well must be drilled with a bit which creates a hole that is at least eight inches (8") in diameter, if the well is constructed using a nominal four-inch (4") diameter riser pipe. This will leave an annulus of one and three-quarters inch (1 3/4") within the bedrock portion of the well, which is the minimum allowable annulus for this type of monitoring well.

(3) Piezometer Well Construction. A piezometer must be constructed according to this rule.

(4) Open-Hole Completions. Open-hole completed monitoring wells are allowed only upon written approval in advance from the division. In all cases, the open-hole portion of the well must be in competent, consolidated bedrock and casing must extend from the surface to at least five feet (5') into bedrock. The casing must be grouted full-length.

(5) The joining of two (2) dissimilar metals is not permitted due to the potential for galvanic corrosion.

(6) Decontamination of Well Construction Materials and Equipment.

(A) Hazardous Waste Sites. All materials used in the construction of the monitoring well must be decontaminated on-site by use of steam, high pressure water or be certified by the manufacturer as clean and be wrapped to ensure cleanliness. This includes, but is not limited to, the drilling rig, drilling equipment, drilling fluids, grouting equipment, well screen, riser pipe, filter pack material and other materials that come in contact with the monitoring well environment which could possibly cause contamination. After the well construction material has been cleaned, it must not come in contact with the ground or any other source of contamination. Well construction personnel must take precautions to ensure grease, oil or other contaminants do not come in contact with the well screen and the riser pipe during construction. Personnel must wear appropriate apparel while constructing the well to protect them from contamination and from contaminating the monitoring well. A protective ground covering or other devices should be placed at the wellhead during construction activities to protect all materials from potential ground surface contamination.

(B) Nonhazardous Waste Sites. Precautions must be taken to ensure that monitoring well construction operations are carried out in such a way as not to harm the environment or adversely influence the operation of the monitoring well.

(7) Installation of Well Screen and Riser Assembly. The well screen and riser assembly must be centered in the borehole before the installation of the filter pack. The riser pipe must extend at least one foot (1') above the finished grade in nonflood potential areas and at least two feet (2') above the finished surface grade in flood prone areas and be equipped with a watertight cap. Wells installed in traffic ways may be flush mounted (subsection (12)(B)). The use of centralizers on the riser assembly is required and must be placed just above the well screen and as needed up the hole to maintain the riser assembly in the center of the borehole. The type of centralizer used must not prevent emplacement of filter pack materials or annular seals. The use of centralizers in wells constructed through hollow stem augers or wells less than fifty feet (50') in depth is not required.

(8) Installation of Primary Filter Pack. After the well screen and riser assembly are installed in the well, the filter pack materials can be emplaced. Proper design of monitoring wells drilled in unconsolidated to poorly consolidated geologic material must include an appropriately sized well screen and filter

pack. It is recommended that screen slot size and filter pack size be determined by sieve analysis of formation material to be monitored. The grain size and gradation of the filter pack are selected to stabilize the hydrologic unit adjacent to the screen and permit only the finest soil grains to enter the screen during development. The purpose of the filter pack is to prevent or minimize the entrance of fine material into the well and provide a representative water sample from the monitoring horizon. Sediment-free water reduces the potential for interference in sample analyses and is evidence that proper development of the well has occurred. The use of a fine screen and appropriately sized filter pack is permitted without sieve analysis.

(A) Artificially Constructed Filter Pack Placement. The filter pack material must be placed evenly around the well screen via a tremie pipe. The tremie pipe must be placed near the bottom of the well screen and the filter pack material poured into the tremie pipe while the pipe is slowly removed. A weighted measuring device must be used to ensure that the filter pack is properly installed to the desired depth. All volumes of filter pack material anticipated for construction must be calculated prior to placement. The filter pack material must fill from the bottom of the borehole within two feet to five feet (2'—5') above the well screen. If the borehole is not stable and the well is drilled utilizing the hollow stem auger method, the filter pack material may be poured through the hollow stem auger as it is removed from the borehole. This is allowed only in the unsaturated zone. If the screen is set more than twenty-five feet (25') into the saturated zone or placed into drilling fluid other than clean water or air, the filter pack placement must be via tremie. Prepacked filter pack assemblies may be used.

(B) Naturally Developed Filter Pack Placement. Allowing the existing geologic material to collapse around the well screen is an acceptable method of filter pack emplacement in only a few geologic conditions. Naturally developed filter packs are only allowable when they can be developed properly. The higher permeability envelope of material is developed in place by the removal of the fine-grained material during proper well development process.

(C) In very shallow monitoring wells, the amount of filter pack material that extends above the well screen may need to be limited to ensure an adequate length of annular seal.

(9) Installation of Secondary Filter Pack. The purpose of a secondary filter pack, which is placed directly on top of the primary filter pack, is to ensure that annular seal slurry grouts do not infiltrate into the primary filter pack. The secondary filter pack must extend from one foot to two feet (1'—2') above the primary filter pack and shall consist of one foot to two feet (1'—2') of clean fine sand. A secondary filter pack is not required if the bentonite seal is composed of nonslurry bentonite.

(10) Installation of the Bentonite Seal. The bentonite seal is emplaced directly over the secondary filter pack or primary filter pack if a secondary filter is not necessary and must be from three feet to five feet (3'—5') thick. The purpose of the bentonite seal is to keep the slurry grout which is emplaced above from mixing with the primary and secondary filter pack materials.

(A) Placement of the Bentonite Seal in the Saturated Zone. When the bentonite seal is to be emplaced in the saturated zone, only chipped or pelletized bentonite that is designed to fall through standing water before it hydrates may be used. To avoid flash swelling and bridging, the fine bentonite material, which may develop during transport must not be introduced into the well bore. One way to accomplish this is to pour bentonite over a screen so that the fine bentonite material which may develop on transport of the product, is filtered out of the bentonite. A weighted measuring device must be utilized to ensure the bentonite chips are evenly placed around the riser pipe. All volumes of bentonite must be calculated prior to construction.

(B) Placement of the Bentonite Seal in the Unsaturated Zone. When the top of the secondary filter pack is in the unsaturated zone, the use of chipped, pelletized or granular bentonite is permitted only if the bentonite is emplaced in one foot (1') layers that are hydrated in place with potable water before the succeeding layers are emplaced. Bentonite slurry may be used and must fill the annular space from the top of the secondary filter pack to the surface seal. The bentonite slurry must be emplaced through a tremie pipe with a side discharge so as to limit disruption of the filter packs.

(11) Installation of the Annular Seal. The monitoring well environment may contain many chemicals or organic compounds that could affect the sealing capabilities of various kinds of grout. The type of grout used must be able to function to one hundred percent (100%) of its designed sealing capabilities until the well is properly plugged. The type of grout used must not influence, contaminate or hinder the use of the monitoring well for its designed purpose. The annular seal must extend from the secondary filter pack or bentonite seal to the base of the protective casing. The following four (4) grout types are permitted in monitoring wells:

(A) Bentonite Slurry-Grout. High solids sodium bentonite slurry, at least twenty to thirty percent (20%—30%) by weight solids, must be tremie grouted from the bottom to the top of the annular space in one (1) continual operation. This grout is recommended for use in most monitoring well situations. Additives may be used to increase or decrease set times for the slurry, with prior approval from the division. Polymer additives may not be used in construction of monitoring wells when investigation may involve hazardous constituents;

(B) Nonslurry Bentonite. Sodium bentonite comes in many shapes and sizes. Nonslurry bentonite includes chips, pellets, granules and powdered varieties. Chipped or pelletized varieties that are designed to fall through standing water may be used when sealing the annulus of a well that is below the saturated zone. Granulated and powdered bentonite must never be poured through standing water because they will flash swell and bridge off before it gets to the bottom of the annular space. Bentonite, chips or pellets may be used to seal portions of the annular space that are in the unsaturated zone. Granulated and powdered varieties are not permitted to be used in the unsaturated zone unless they are used to create a slurry, due to their flash swelling properties which would prevent hydration of the complete column of bentonite. The effective use of bentonite chips or pellets as a sealing agent depends on the efficient hydration of the bentonite following emplacement. Therefore, when using bentonite chips or pellets in the unsaturated zone, it must be hydrated after each three feet (3') interval has been emplaced. To properly hydrate the bentonite, a minimum of three (3) times as much water as bentonite must be used. Quality of water is very important in the hydration process. Bentonite chips or pellets may not adequately hydrate if any of the following chemical parameters exist in the water used for hydration: 1) greater than five hundred (500) parts per million (ppm) total dissolved solids (TDS), 2) high chlorides, 3) large quantities of organic solvents or acids, and 4) separate-phase petroleum hydrocarbons;

(C) Cement Slurry. Neat cement slurry is a mixture of one (1) ninety-four pound (94 lb.) bag of Portland Type I cement and six (6) gallons of clean water and is the most commonly used cement product for sealing annular spaces. Five (5) general types of cement are

produced: Type I, for general use; Type II, for moderate sulfate resistance or moderate heat of hydration; Type III, for hi-early strength; Type IV, for low heat of hydration; and Type V, for high sulfate resistance. Following are some problems associated with cement slurry grout usage:

1. During the curing process of cement slurry, the chemical reactions that take place produce heat as a by-product. This heat of hydration can, in some cases, cause failures when riser pipe or casing is made of PVC or ABS materials. When neat cement slurry is used to fill annular spaces that are one and one-half inches to four inches (1 1/2"—4"), temperature increases from sixteen degrees Fahrenheit to forty-five degrees Fahrenheit (16°F—45°F) can be achieved. If there is a small washout of the annular space, that increases it to twelve inches (12") and this space is filled with neat cement slurry, temperature increases up to one hundred and seventy degrees Fahrenheit (170°F) can be achieved. These extreme temperatures can cause riser pipe or casing failures (see 10 CSR 23-3.070(3)(G) for table showing percent of strength loss for PVC casing with elevating temperatures);

2. Type II cement used to produce a hi-early strength and additives that are used to speed up set times of cement slurries cause higher than normal heat of hydration temperatures. These can only be used in association with metallic casings or riser pipes with prior approval by the division;

3. Another problem that occurs during the curing process of neat cement slurry is that it shrinks from twelve percent to seventeen percent (12%—17%). This shrinkage is not acceptable for monitoring well applications;

4. Cement slurry may only be used if additives are incorporated to minimize shrinkage.

A. Bentonite is the most commonly used additive to prevent shrinkage of cement slurries. The powdered bentonite must be thoroughly mixed with the water before it is added to the cement. Powdered bentonite from two percent to six percent (2%—6%) by weight must be added. The added bentonite improves the workability of the slurry, reduces shrinkage and reduces the heat of hydration. This additive does reduce the strength of the seal but is adequate for annular sealing. For each percent of bentonite by weight added to a ninety-four pound (94 lb.) bag of Type I cement an additional six-tenths (.6) gallon of water must be added. The following table set out the amount of bentonite and water needed to be a ninety-four pound (94 lb.) bag of Type I cement to get from one to six percent (1%—6%) cement-bentonite mixture.

CEMENT/BENTONITE SLURRY CALCULATIONS

Product	% bentonite added/ sk cement	total water requirement (gallons)
Type I Portland 1 sack=94 lbs.	0	5.2 to 6
	1% bentonite=.94 lbs. bentonite/sk of cement	5.8 to 6.6
	2% bentonite=1.9 lbs. bentonite/sk of cement	6.4 to 7.2
	3% bentonite=2.8 lbs. bentonite/sk of cement	7 to 7.8
	4% bentonite=3.8 lbs. bentonite/sk of cement	7.6 to 8.4
	5% bentonite=4.7 lbs. bentonite/sk of cement	8.2 to 9
	6% bentonite=5.7 lbs. bentonite/sk of cement	8.8 to 9.6

B. Other shrinkage reducing additives must be approved in advance by the division;

5. The water used to mix cement slurry must be clean water, free of oil or other organic material and the total dissolved mineral content must be less than two thousand (2000) ppm. If too much water is used, the grout will be weakened and excessive shrinkage will occur upon curing; and

6. Cement slurry must be emplaced in the annulus via a tremie pipe placed to the bottom of the annular space. The tremie pipe must have a side discharge which directs the grout away from the bentonite seal, reducing the potential for infiltration. Care must be taken so as not to dislodge the bentonite seal that is above the primary filter pack. The grouting of the annular space must be completed in one (1) continual operation, lifting the tremie pipe as the space fills. If determined necessary by the division, a staged grouting procedure will be approved;

(D) Other types of grout may be used when necessary and for good cause if prior approval by the division is granted; and

(E) When zones of high grout loss are anticipated or experienced, contact the division for alternative methods to seal the annulus.

(12) Well Protection. Surface protection on monitoring wells is needed to deter unauthorized entry, prevent surface water from entering the annular space and to protect the well from accidental damage caused by collision from vehicles or heavy equipment. The two (2) types of protective casing designs are above ground completions and flush mount completions.

(A) Above Ground Completions. Above ground completions must meet the following standards:

1. The protective casing must extend from at least one and one-half feet (1 1/2') above the finished grade of the ground surface to a point at least two feet (2') below the finished grade, except as stated in subsection (12)(B) of this rule for flush mount completions. The riser pipe must be at least two inches (2") below the top of the protective casing. The casing must be placed in an enlarged hole that is at least eight inches (8") in diameter larger than the protective casing size. Care must be taken so that the shape of this hole, when filled with concrete or cement-slurry does not encourage frost heaving. The protective casing must be centered in this hole and concrete poured around the casing to secure it. Cement or bentonite slurry is not to be used. All water must be removed from the enlarged hole before concrete may be added. The surface of the grout must slope away from the protective casing so that pooling of surface water does not occur;

2. A small diameter hole must be drilled into the protective casing near the ground level to drain any water that fills the protective casing annulus. Installation of a small amount of gravel for filling the annular space above the drain hole or installing a screen on the drain hole should be sufficient to prevent insects from entering this area;

3. A locking well cap and a suitable lock must be attached to the top of the protective casing. The riser pipe must extend at least two feet (2') above the finished surface grade in flood prone areas and be equipped with a watertight cap;

4. All monitoring wells that have a protective casing extending from the ground must have a marker to show location. This marker must be plainly visible so that it can be easily located and its presence will help to prevent accidental damage. In some situations, it may be required that additional protective devices be installed, such as metal concrete filled posts (bolsters) or fencing. This is to prevent damage or unauthorized entrance; and

5. All monitoring wells must be labeled so as to distinguish one (1) well from another on the monitoring site.

(B) Flush Mount Well Completions. Monitoring wells may only be completed utilizing a flush mount when they must be located in traffic areas. Flush mount completions must meet the following standards. In a flush-to-ground completion, the flush mount assembly is installed around the riser pipe that has been cut off below grade. The flush mount assembly must be at least eight inches (8") in length

and have a lockable watertight cap. The assembly must be set into a hole that is at least eight inches (8") in diameter larger than the diameter of the flush mount assembly and set in concrete. This completion must withstand all stresses due to traffic and to freeze thaw processes. If the monitoring well is being placed through asphalt or concrete, a hole that is a least four inches (4") in diameter larger than the diameter of the flush mount assembly must be drilled. The flush mount must then be set in concrete. Cement or bentonite slurry is not permitted. In areas where significant amounts of runoff occurs, additional safeguards to manage drainage may be necessary to discourage entry of surface runoff.

(13) Wells must be adequate in size, design and development for the intended use.

(14) Extraction wells must be constructed to standards determined on a case-by-case basis by the division.

AUTHORITY: sections 256.606 and 256.626, RSMo (1994). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed July 13, 1994, effective Jan. 29, 1995. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.606, RSMo (1991) and 256.626, RSMo (1985), amended 1991.*

10 CSR 23-4.070 Monitoring Well Development

PURPOSE: This rule describes the minimum standards that must be met in developing a monitoring well.

(1) Monitoring well development serves the function of cleaning up the well, setting the filter pack and allowing for the collection of a representative sample from the horizon being monitored. The purpose of development is to remove any fine grained material from the well screen and filter pack that may interfere with analyses and return the monitoring zone to its original hydraulic state, which was disturbed by the drilling of the well. Development will also redistribute the sand grains within the filter pack to allow for coarser sand material to congregate near the slotted screen and finer sand grains may be removed by development.

(2) Methods Used to Develop Wells. The method used must not introduce any contaminants into the well. Wells must be developed until water representative of the formation is discharged. The volume of fluid should be a multiplier (three (3) times minimum) of the amount of fluid lost to the formation during drilling or added to the well during development. Mechanical surging in combination with pumping or bailing is a recommended method for well development. Water must be moved both in and out of the filter pack to rearrange the sand grains. If a well is completed in a silt or clay rich material or if the screen straddles the water table, the well discharge may never totally clear up. The purpose of the well development is to remove formation damage caused by the drilling process and produce water that is representative of the formation. The well should be capable of producing clear water samples using appropriate sample methods.

(3) The use and installation of sampling, development, maintenance, or testing devices and equipment in monitoring wells, including extraction wells, is not regulated except that pumping system installation in extraction wells used for remediation or clean-up must be performed by a nonrestricted pump installation contractor.

AUTHORITY: sections 256.606, 256.626 and 256.637, RSMo (1994). Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed July 13, 1994, effective Jan. 29, 1995. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.606, RSMo (1991) and 256.626 and 256.637, RSMo (1985), amended 1991.*

10 CSR 23-4.080 Plugging of Monitoring Wells

PURPOSE: This rule sets standards for the plugging of monitoring wells.

(1) A monitoring well that is abandoned as defined in 10 CSR 23-1.010 must be plugged immediately. If a monitoring well has been determined to present a threat to groundwater, the division may order that the well be permanently plugged. When plugging a monitoring well, the following minimum requirements shall be met:

(A) All pumps, sampling equipment, debris or other substances must be removed that would interfere with the proper plugging of the well;

(B) All protective casing, riser pipe and well screen must be removed from the borehole, if possible, unless approved by the division. Because the primary purpose of well plugging is to eliminate vertical fluid migration along the borehole, the preferred method of plugging involves casing and riser pipe removal. If, when removing the casing the borehole begins to collapse, grout must be simultaneously emplaced while the casing is removed to ensure a proper seal. In certain situations, the casing or riser pipe must be drilled out if it cannot be removed before the well is plugged. These situations will be determined on a case-by-case basis by the division. When casing is not required to be removed or if after attempting to remove the casing, it is not possible to remove it, then a hole must be dug around the casing three feet (3') deep and the casing and riser pipe cut off at that depth;

(C) The well must be filled from bottom to top with grout. 10 CSR 23-4.060(11) sets standards for grout types that may be used when plugging monitoring wells; and

(D) If bentonite grout is used, after the grout is fully cured, check for settlement and top off if necessary. Fill with soil and compact the upper two feet (2') of hole or pave. The purpose of the compacted soil is to ensure that dehydration of the bentonite grout does not occur over time. If cement-slurry grout is used, fill the upper two feet (2') with soil or pave. Slight mounding over the well is recommended to prevent water from standing in the immediate area of the well.

(2) The plugging or complete excavation of all monitoring wells must be reported on a registration report form supplied by the division. These forms must be submitted, along with the fee, within sixty (60) days of the plugging (see 10 CSR 23-2 for applicable fees). If the review of the registration report form shows that the well has been plugged according to the rules, a registration number will be issued and sent to the well owner. The registration number indicates that the well was plugged according to the standards set out in the rules. When field screening type of temporary wells are drilled, usually multiple installations per monitoring site are used. All temporary wells per monitoring site may be reported on one (1) registration report form if they are all plugged the same way and only one (1) registration fee is required per site.

(3) Monitoring wells must be plugged by a permitted monitoring well installation contractor.

(4) Material used to plug monitoring wells must be compatible with any contaminants in the well so that the plugging action of the grout is not destroyed by any chemical reactions that may take place in the borehole environment.

(5) Monitoring wells less than ten feet (10') in depth must be plugged by returning uncontaminated native material or grout into the hole it was taken from. No reporting is required for these wells.

(6) Temporary monitoring wells greater than ten feet (10') in depth must be plugged by removing any temporary pipe and filling the well from total depth to ten feet (10') from the surface with approved grout, with the remainder of the well filled with compacted uncontaminated native material or grout.

AUTHORITY: sections 256.606, 256.615 and 256.623, RSMo (1994). Emergency rule filed Nov. 16, 1993, effective Dec. 11, 1993, expired April 9, 1994. Original rule filed Aug. 17, 1993, effective March 10, 1994. Amended: Filed July 13, 1994, effective Jan. 29, 1995. Amended: Filed Nov. 1, 1995, effective June 30, 1996.*

**Original authority: 256.606 and 256.615, RSMo (1991) and 256.623, RSMo (1985), amended 1991.*