

Plugging And Abandoning Injection Wells
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5 GUIDANCE #4
(revised December, 1994)

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MAILING ADDRESS FOR DOCUMENTATION, MONITORING REPORTS, ETC:

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I. INTRODUCTION

These guidelines were developed by the United States Environmental Protection Agency (USEPA) in Region 5 to establish proper plugging and abandonment (P&A) procedures for injection wells. The procedures are provided for use in direct implementation (DI) states, for assisting states with primacy, and for operators. Methods varying from these guidelines may be accepted if first approved by Region 5 or the appropriate state agency. States may develop and enforce independent P&A requirements if they choose to do so ([Attachment 1](#)).

In many cases where USEPA representatives witness the plugging, a Regional Guidance on specific procedures is crucial to ensure consistency. If a USEPA representative is not present, a guidance can assist a State representative in implementing all Region 5 P&A requirements.

This guidance is developed in accordance with the statutory requirement set forth in the Safe Drinking Water Act (SDWA), and the implementing regulations set forth in Title 40 of the Code of Federal Regulations (40 C.F.R.) Sections (§§) 146.10 and 144.52.

II. DEFINITIONS

Well is defined in 40 C.F.R. § 146.3 as a bored, drilled or driven shaft, or a dug hole, whose depth is greater than the largest surface dimension.

Fluid is a material or substance which flows or moves whether in a semisolid, liquid, sludge, gas, or any other form or state.

Injection well is a well into which fluids are being injected.

Disposal/Production wells are a subset of Class II wells. They inject (dispose of) fluids in connection with the production of oil or gas within the same well from which production occurs, but at separate depths.

Underground Source of Drinking Water (USDW) is an aquifer or its portion: (a)(1) which supplies any public water system; or (ii) which contains a sufficient quantity of ground water to supply a public water system; and (A) currently supplies drinking water for human consumption; or (B) contains fewer than 10,000 mg/l total dissolved solids; and (2) which is not an exempted aquifer.

Cast Iron Bridge Plug (CIBP) is a type of mechanical plug inserted into the casing of a well at a specified depth when plugging a well, on top of which cement is placed, for the purpose of isolating the injection zone and preventing migration of fluids.

Deep Class V wells are those Class V wells that inject fluids below the lowermost USDW.

III. CLASSIFICATION OF WELLS

Defined in 40 C.F.R. § 146.5. Class I wells are used to inject industrial or municipal waste, either hazardous or non-hazardous, beneath the lowermost Underground Source of Drinking Water (USDW).

Class II wells inject fluids which are brought to the surface in connection with conventional oil or natural gas production, are used for enhanced recovery of oil or natural gas, or are used for storage of hydrocarbons.

Class III wells inject fluids for the purpose of extracting minerals.

Class IV wells inject hazardous or radioactive wastes into a formation which contains an USDW within one quarter (1/4) mile of the well. Class IV wells are banned.

Class V wells are those injection wells not included in the above categories.

IV. PLUGGING AND ABANDONMENT (P&A) GENERAL REQUIREMENTS

In order to prevent abandoned injection wells from becoming conduits for migration of injected fluids or natural brines vertically into an USDW, proper plugging is necessary. Either open casing or an uncemented annulus may provide such a conduit. In most Class I wells, each casing string is fully cemented to the surface when constructed. Many Class II wells have construction requirements which are not as stringent. Prior to abandoning injection wells, the well shall be plugged with cement in a manner which will not allow the movement of fluids into or between USDWs. To address these concerns, Region 5 has set standards which provide multiple layers of protection for all USDWs. Specific procedures outlined in this guidance may be varied upon approval by USEPA, Region 5.

The basic requirements for plugging and abandonment of any well are to plug in a manner so as to prevent movement of fluid out of the injection zone and into or between USDWs, and to:

- A. **NOTIFY THE USEPA** - Notification of the USEPA by the owner/operator is required at least 45 days prior to the commencement of plugging operations unless specified otherwise;
- B. **PASS PART (2) OF MECHANICAL INTEGRITY** - The well must have a current demonstration of part (2) of mechanical integrity pursuant to 40 C.F.R. § 146.8(a)(2) (no fluid movement behind pipe) as appropriate for the well classification; and
- C. **SUBMIT PLUGGING AND ABANDONMENT REPORT** - The owner/operator must submit a plugging and abandonment report within 60 days after the well is plugged.

V. CLASS I

A. NON-HAZARDOUS WELL CLOSURE PLANS

1. **Pass Part (2) of Mechanical Integrity** - The well must have a current demonstration of part (2) of mechanical integrity, using an approved log.
2. **All Free Casing Pulled** - All free uncemented casing must be pulled, and the entire hole must be filled with cement.
3. **Squeeze Cement If Casing Remains** - If (2) above is **not possible**, and free casing is left in the hole, cement must be squeezed behind the free casing through perforations, then the **entire hole must be filled with cement**.
4. **Follow P&A Plan** - P&A procedures found in the permit or the most current approved P&A plan must be followed.

B. **HAZARDOUS WELLS CLOSURE PLANS** - 40 C.F.R. § 146.71 requires owners or operators of Class I hazardous waste wells to prepare, maintain and comply with a plan for closure of permitted wells. **The obligation to implement the plan survives both the termination of the UIC permit and the cessation of injection.** Section 146.71(d) enumerates areas of concern to be addressed by the well closure plan and is summarized below in steps (1) - (7):

1. **Pressure Decline** - § 146.71(d)(1) Pressure fall-off should be measured over an agreed time interval;
2. **Mechanical Integrity** - § 146.71(d)(2) The well must have a current demonstration of mechanical integrity. Demonstrations may include a pressure test, approved logs to test casing, cement or interformational fluid flow;
3. **Buffer Fluid** - § 146.71(d)(3) A suitable buffer should be injected into the well prior to closure;
4. **Prevention of Flow Into, Within, and Out of Casing** - § 146.71(d)(4) The well must be plugged in a manner that will not allow the movement of fluids into or between USDWs or from the injection zone:
 - a. **Cement within Casing** - The entire longstring casing of the well should be filled with cement; or if the entire longstring **cannot** be filled with cement, then the well must pass a Standard Annulus Pressure Test (SAPT) and the operator must ensure that there will be no fluid flow into or between USDWs by the placement of cement plugs;
 - b. **Cement outside of Casing** - If necessary, perforate and squeeze cement behind the casing to eliminate fluid flow out of the injection zone and/or into or between USDWs;
5. **Placement of Cement Plugs** - § 146.71(d)(5) Placement of plugs may be by the Balance, Dump Bailer, Two-Plug or alternate method (Attachment 2) approved by the Director;
6. **Tag and Test Plugs** - § 146.71(d)(6) Each plug used shall be appropriately tagged and tested for seal and stability before closure is completed;
7. **Static Equilibrium** - § 146.71(d)(7) Mud weight should be equalized from top to bottom by circulating the mud at least once prior to placing the plugs, or as approved by the Director.
8. **Sampling** - Region 5 requires sampling of a suitable aquifer overlying the injection interval unless:
 - a. A deep monitoring well is in operation on the site;
 - b. Injection of non-hazardous waste occurred subsequent to the injection of hazardous waste, rendering the plume next to the wellbore essentially non-hazardous. In these cases, the sampling requirement will be reviewed on a case-by-case basis;
 - c. Two or more substantial bleed-off zones, separated by confining material, separate the injection zone from the lowermost USDW;

- d. Pressure build-up during injection was not high enough to drive fluid to a potential sampling zone; or
- e. No suitable aquifer exists to sample.

The constituents or characteristics to be analyzed for should be determined on a site-by-site basis. At all sampling sites, pressure (or stable water level) in the sampled zone should also be determined. If there is difficulty finding analytes likely to be good tracers, measurements of tritium (a hydrogen isotope present in virtually all water in contact with the atmosphere since the early 1950's) will be used.

If more than one well at a site is to be closed at the same time, it may be necessary to perforate and sample only one well.

- 9. **RCRA Corrective Action** - If a determination is made that releases of hazardous constituents have occurred as a result of injection operations, these releases may be subject to corrective action under the Resource Conservation and Recovery Act (RCRA), pursuant to 40 C.F.R. § 264 Subpart F.

C. **HAZARDOUS WELLS POST-CLOSURE PLANS** - 40 C.F.R. § 146.72 requires owner/operators of hazardous waste injection wells to maintain an approved plan for post-closure care. The plan can be revised any time before the closure report is submitted. If the operator or the USEPA wants to revise it after the closure report, the USEPA must follow public notice procedures, pursuant to 40 C.F.R. § 124.5. According to UIC regulations, each post-closure plan must include:

- 1. **Cost** - Estimated cost of post-closure care and financial assurance for this cost. Companies should include this amount with their closure costs, pursuant to 40 C.F.R. § 146.73;
- 2. **Hydrological Information** - Information which will help to assess the possibility of future migration from the injection zone includes:
 - a. The pressure in the injection zone (interval) before injection began;
 - b. The anticipated pressure in the injection zone at the time of closure;
 - c. The predicted time the hydrostatic head of the injection zone will fall below that of the lowermost USDW, pursuant to 40 C.F.R. § 146.72(a)(4)(iii).
 - d. The predicted position of waste front at closure.
- 3. **Corrective Action** - The status of any clean-ups or corrective action for AOR wells, pursuant to 40 C.F.R. § 146.64;
- 4. **Monitoring Wells** - If the facility has a monitoring well, the post-closure plan should include a commitment to continue monitoring pressure and water quality for the length of time estimated under (2)(c) above. If the hydrostatic head of the injection interval is naturally higher than that of the lowermost USDW, there should be a minimum of 2 quarters of monitoring after closure, providing the monitoring has had no previous problems. For facilities where the hydrostatic head does not reach the potentiometric surface of the lowermost USDW, no additional monitoring may be necessary.

NOTE: If the hydrostatic head of the injection interval will never fall below that of the USDW because the pre-injection potentiometric surface of the injection zone is above that of the lowermost USDW, monitoring must continue until a loss of 80% of the maximum induced pressure in the injection interval occurs;

5. **Permanent Record** - A record of the use of the site for hazardous-waste injection is necessary for future planning. The necessary information includes:
 - a. A commitment to submit a survey plat to the local zoning authority which indicates the location of the well(s) relative to permanent benchmarks, and to submit a copy to the USEPA;
 - b. A commitment to provide "appropriate notification" to the State, including the following information:
 - i. Total waste volume injected into each well;
 - ii. The period over which injection occurred;
 - iii. The injection interval(s), injection zone(s), and confining zone;
 - iv. A representative waste analysis;
 - v. Notice of prior releases outside the injection interval, including an estimate of quantity of the releases;
 - vi. The predicted location of the waste front at closure;
 - vii. Retain records of injection volumes and composition for three years following closure, and deliver them to the USEPA or obtain written approval from the Regional Administrator to discard the records; and
 - viii. Record on the deed to the property, or on some other instrument which is normally examined during title search, that will provide the information listed under 40 C.F.R. § 146.72(c);

The Post-Closure plan should be submitted at the time of permit review for new and reissued permits. For the remaining permits, a plan should be approved and placed in the Administrative Record until the permit either expires or is modified.

VI. CLASS II

Plugs are required in the well to protect all USDWs. The entire wellbore may be plugged with cement if all casing strings are cemented from their base to the surface. If any casing is not cemented entirely, casing less than 50 feet below the base of the USDWs must be removed. The injection zone, the cut/rip points, and the USDW must be plugged separately. Proper zone isolation will help to ensure that upward fluid migration will not occur.

- A. **NOTIFY THE USEPA** - Notification of the USEPA by the owner/operator at least 45 days prior to the commencement of plugging operations is required unless specified otherwise.

- B. **PASS PART (2) OF MECHANICAL INTEGRITY** - There must be a current demonstration of no fluid movement behind pipe, pursuant to 40 C.F.R. § 146.8(a)(2).
1. **Cementing Records** - Cementing records or other evidence (such as cement bond logs) must show that there is an adequate quantity of cement to prevent upward fluid movement within the borehole outside of the casing; or
 2. **Approved Tests or Logs** - USEPA approved tests (such as Oxygen Activation, Temperature or Noise Logs) are current and demonstrate to the USEPA's satisfaction that there is no significant fluid movement into a USDW through vertical channels adjacent to the injection well bore.
- C. **REMOVAL OF DEBRIS** - Removal of any downhole material and/or debris located above the injection zone is required. Region 5 requires that wells be opened and/or any obstruction be removed prior to commencing plugging. Tubing, packer, and any debris which remains in the well above the injection zone must be removed because it interferes with the proper plugging of a well. Normal well entry may be impossible when injection wells have collapsed casing, collapsed bore holes, broken or stuck tubing, or debris obstructing the wellbore. Some wells have been abandoned for several years with tubing and packer left in the well, and in some cases, these wells contain tubing that has deteriorated to the point that normal retrieval is impossible. This equipment may be left in the well if alternate plugging methods which provide protection to USDWs are approved, if the cement is placed as close as possible to the injection zone and is within an interval of cemented casing in the confining zone. Approval by Region 5 will depend on well construction, geology, and area operations.
- D. **REMOVAL OF UNCEMENTED CASING** - In most cases, all uncemented ("free") casing must be removed from the well. **Where this is impossible because of deterioration of, or damage to casing, or collapsing of the hole, the following procedures should be followed:**
1. **Perforate Uncemented Casing** - Perforate uncemented casing as low as possible, but at least 50 feet below the base of the lowermost USDW;
 2. **Establish Circulation** - Establish circulation through the perforations with a preflush (fresh water is preferred). Circulate the annulus with at least one hole volume of preflush until the flush circulates clean; and
 3. **Squeeze Cement** - Squeeze cement through the perforations into the well bore-casing annulus and circulate to surface using at least 120 percent of the required volume, or greater if necessary to achieve circulation of cement. The following cementing methods are acceptable:
 - a. The tubing squeeze method;
 - b. The tubing/packer squeeze method;
 - c. The bull plug method;
 - d. An alternative method approved by Region 5, which will reliably provide a comparable level of protection to USDWs. Alternatives will be

considered only after the operator demonstrates that conventional attempts have been unsuccessful.

E. **PLUGGING AND CEMENTING** - The well is to be plugged with cement in a manner that prevents movement of fluids from the injection zone to the base of the lowermost USDW and into or between USDWs. The injection zone must be properly isolated so that no upward fluid migration will occur. Region 5 recommends that the injection zone be filled with cement. In all Class II wells, the top of each plug must be verified.

1. **Isolation of Injection Zone** - If an injection interval is not filled with cement, fluid flow from open perforations or open hole into the well may cause contamination of cement during plugging and abandonment. To eliminate the possibility of contamination in cases where injection zones produce significant amounts of fluid, Region 5 requires a mechanical plug to be set in order to control fluid movement and give the cement a good base for placement.

A combination of a Cast Iron Bridge Plug (CIBP) and cement plug will provide greater protection of USDWs. CIBPs may not properly pressurize or may experience problems such as deterioration over time, weak casing, burrs of metal, a malfunctioning equalizing pressure port, or incorrect gauging. If the CIBP moves due to pressure from the formation, fluid movement upward from the injection zone could result. Operators must meet the following requirements:

- a. Set a CIBP, cement retainer, or an alternative type plug or method, approved by Region 5, within cemented casing and within the confining zone to prevent fluid flow out of the injection zone and provide a sound base for the bottom cement plug;
- b. Set cement plugs on top of the mechanical plug;
 - i. If a cement retainer is used a **minimum of 250 feet of cement** must be set on top of it;
 - ii. If a CIBP is used a **minimum of 50 feet of cement** must be set on top of it.

The operator must verify the location of all plugs to assure that plugs have not "fallen".

2. **Protection at Cut/Rip Points** - A **minimum of 100 feet** of cement is required across any point where casing is cut or ripped. This cement plug must extend from at least **50 feet below the rip point to 50 feet above** the rip point. Casing should be cut or ripped as close to the top of the cement sheath outside the casing as possible. After casing is cut, the free casing must be removed from the well. See Attachment 2 to determine which method will be used to place the plug.
3. **Protection of USDWs** - The well is to be plugged with cement in a manner that prevents movement of fluid into or between USDWs. A cement plug must be placed from at least **50 feet below the base of the lowermost USDW to the surface** to properly isolate USDWs. (Exceptions, as described below, are only allowable if the base of the lowermost USDW is more than 500 feet below the surface.)

In Michigan, (if approved by Region 5) a top and bottom plug may be used to isolate USDWs. If surface casing is cemented to surface and is set below the lowermost USDW, then the bottom USDW plug must extend from a point at least 50 feet below the surface casing shoe to at least 50 feet above the base of the lowermost USDW. If surface casing is cemented to surface and is not set below the lowermost USDW, then the bottom USDW plug must extend from a point at least 50 feet below the lowermost USDW to at least 50 feet above the surface casing shoe. The top plug must extend from a depth of at least 50 feet below the surface to the surface.

4. **Surface Restoration** - Casing should be cut off and the surface restored to its original condition in accordance with State requirements ([Attachment 1](#)).
5. **P&A Reporting Requirements** - P&A reporting requirements pursuant to 40 C.F.R. § § 144.28(k) and 144.51(o) to be followed include:
 - a. A statement that the well was plugged in accordance with the plan previously submitted to the Director; or
 - b. Where actual plugging differed from the plan previously submitted, a signed, updated version of the plan, on the form supplied by the Director, specifying the different procedures used must be submitted.
 - c. After plugging, cementing tickets and a State plugging record must be submitted to Region 5 within 60 days after the report is complete (Attachment 1). USEPA may request confirmation of plugging prior to completion of the report in cases where State requirements may include surface inspection or remediation. This report should be sent to:

USEPA - Region 5
Underground Injection Control, DI Section
(WU-16J)
77 W. Jackson
Chicago, Illinois 60604-3590

- F. **VARIATION FROM GUIDANCE** - Specific procedures outlined in this guidance may be varied for unusual types of well construction, geologic conditions, or situations encountered during plugging and abandonment. The owner/operator must receive approval from Region 5 prior to plugging a well if varying from the procedures outlined in this guidance.

VII. CLASS III

CLOSURE PLANS - All free casing must be pulled and the well cemented to surface due to pressure changes downhole in the solution mining galleries, and their potential to cause fluid movement. The borehole or the casing must be cemented to surface. The solution cavern itself need not be filled with cement. Except for this requirement, the details of closure for Class III wells are the same requirements for Class II, including: the notification of the USEPA, demonstration of Part (2) of MI, removal of downhole material and/or uncemented casing, plugging and abandonment reporting, and surface restoration.

NOTE: The ODNR has developed special P&A requirements for Class III wells in certain areas and under special conditions.

VIII. CLASS V DEEP WELL (5X16) CLOSURE PLANS

Class 5X16 wells are deep Class V wells which resemble Class I nonhazardous wells more than shallow Class V wells. Spent brine is injected into the same formation from which it was withdrawn after extraction of halogens or their salts. The closure plans for these wells are the same as for Class I nonhazardous wells. Region 5 has prepared other guidance for plugging shallow Class V wells, and it may be obtained by request.

IX. ATTACHMENTS

ATTACHMENT 1

STATE OIL AND GAS REGULATORY REQUIREMENTS

- A. **GENERAL REQUIREMENTS** - State requirements also have to be considered by the operator in addition to Federal requirements specified in 40 C.F.R. § § 146.10 and 144.52. Any differences may be resolved by cooperation with the State and Federal agencies.

Information about the requirements and authority for the State of Michigan can be found on the Michigan Department of Environmental Quality (MDEQ), [web page](http://www.epa.gov/epahome/exitepa.htm) <http://www.epa.gov/epahome/exitepa.htm>. The MDEQ P&A Requirements are found in Circular 15 in Part 9, page 54.

- B. **SURFACE RESTORATION** - State requirements should be met where applicable regarding the return of the land surface to its original condition. All casing should be cut off below plow depth, but exact depth may vary depending on the specific location. However, 3-5 feet is usually acceptable to State programs. These specifications are also suggested by USEPA.
- C. **PRIMACY STATES** - In Region 5, the states of [Illinois](#) and [Ohio](#) maintain programs to ensure environmentally protective operation of all well classes and [Indiana](#) maintains a Class II program. In states having primacy for one or more well classes, wells must be plugged in accordance with state policies rather than Regional guidance. Therefore, the procedures in those states may vary from those recommended here.

ATTACHMENT 2

COMMON METHODS OF CEMENT PLUG INSTALLATION

Several methods of plug installation may be accepted under the Region 5 UIC program, pursuant to 40 C.F.R. § 146.10 for Class I-III wells. Of these, the most common is the Balance Method; however, the Cement Retainer Method, the Two-Plug Method, and the Dump Bailer Method may also be used.

- A. **BALANCE METHOD** - This technique involves setting a cement plug at some predetermined point. A cement slurry is pumped down the drill pipe or tubing and back up to a calculated height that will balance the cement inside and outside the pipe. Then

the pipe is slowly pulled out of the cement. When the pipe is a sufficient distance above the top of the cement to prevent contamination of the cement, the pipe is cleaned by reverse circulation.

It is desirable to leave as large an annulus area as possible outside the cementing string without causing an excessive cement drop or surge of the cement plug, thereby decreasing the chance of mud contamination. This is done by using a small diameter pipe or tubing string. The mud system must be in static equilibrium; any fluid movement may cause a poor plug. For a balanced plug job, calculations must be made to determine cement volumes and heights of fluid. Region 5 requires 120% of the calculated slurry volume to be used for any plug adjacent to open formation.

- B. **CEMENT RETAINER METHOD** - This technique involves the installation of a cement retainer (packer) plug within a cased hole. The cement can be displaced through the cement retainer so that the formation below the retainer can be squeezed with cement. After cementing these formations, the cement retainer can be closed at the bottom and the cement pipe can be disconnected from the top of the retainer. Cement can then be placed on top of the retainer by slowly withdrawing the cement pipe above it. Region 5 requires a minimum of 250 feet of cement on top of the cement retainer.
- C. **TWO-PLUG METHOD** - This method is used in open holes employing a plug catcher into which two separate plugs are injected. It is designed to allow a bottom cementing plug to pass through the plug catcher and out of the tubing or drill pipe. Cement continues to flow out of the string at the plugging depth, filling the annulus. The top plug is introduced into the cementing string, and when caught by the plug catcher, causes a sharp rise in the cement pressure at the surface, proving that it has closed off the plug catcher. This top plug is latched into a position which prevents cement from backing up into the cementing string; however, reverse circulation can be achieved if required.
- This method allows the cement string to be pulled up after cement placement, in order to place the top of the cement at the desired depth by reverse-circulating through the plug catcher. Excess cement is thereby reversed up and out of the tubing. The cementing string is then pulled, leaving the cement plug.
- D. **DUMP BAILER METHOD** - This method is available for setting plugs in shallow wells. A wireline truck lowers a bailer into the well. Generally, a bridge plug or cement basket is first placed in the hole at a specified depth. The bailer opens upon contact with the mechanical plug and releases the cement slurry at this position, as it is raised.

http://www.epa.gov/region5/water/uic/r5guid/r5_04.htm