



# Underground Injection Control Geologic Sequestration Rule Training Workshop: Injection Well Operation (40 CFR 146.88)

## Purpose: Operating Requirements

- Ensure that Class VI well owners or operators
  - Operate injection wells as permitted
  - Are in compliance with permit conditions
  - Coordinate with the UIC Program Director, as appropriate, regarding specific operational activities

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The Class VI injection well operation requirements provide that Class VI wells are in compliance with permit conditions, and owners/operators coordinate with the UIC Program Director, as appropriate, regarding specific operational activities.

## Class VI Injection Well Operation: UIC Program Director Review

- Proposed injection operating procedures and data
- Proposed stimulation program
  - With the permit application
- Documentation of actual well operation parameters provided in required reports
  - Periodically throughout the operational phase

40 CFR 146.82(a)(7), (9) & (10)

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Proposed injection well operating procedures must be submitted to the UIC Program Director with the permit application. Documentation of actual well operation parameters will be provided in required reports. It is recommended that the UIC Program Director review: 1) the proposed operating procedures as a basis for setting permit conditions (e.g., pressure limits); 2) the proposed stimulation program, if any, as all proposed stimulation programs must be approved by the UIC Program Director as part of the permit application; and, 3) the documented operating information to ensure that injection well operation is proceeding as planned and is not endangering USDWs. Stimulation refers to techniques used to increase the number and size of fractures surrounding the proposed injection zone, in order to enhance the transmissivity/injectivity of the geologic formation.

Specific Class VI well operating information submitted by the owner or operator with the permit application, and that the UIC Program Director must consider in terms of compliance with the Class VI regulations includes information on injection pressure, annulus pressure, continuous recording devices, automatic surface shut-off devices (and down-hole shut-off devices that may be required at the Director's discretion), proposed stimulation program, and possible use of tracers. In general, the UIC Program Director must verify that injection between the outermost casing and the well bore does not occur, and that the annulus between the tubing and the long-string casing is filled with an approved non-corrosive fluid.

## Operating Requirements

- Injection pressure limitations
- Annulus pressure limitations
- Continuous recording devices
- Hydraulic fracturing only during well stimulation
- Mechanical integrity
- Tracers



40 CFR 146.88(a),(c),(d), 146.88(e)(1), and 146.82(a)(9)

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The UIC Program Director will need to review the submitted information pertaining to the following operating requirements:

The owner or operator must inject carbon dioxide at a pressure less than 90 percent of the identified formation fracture pressure, except during stimulation. Fracture pressure calculations will be submitted to the UIC Program Director with the site characterization data. The UIC Program Director will need to review the planned injection pressure information in order to ensure that injection pressure is less than 90 percent of the injection formation fracture pressure. The injection pressure and rate, as well as the volume and temperature of the carbon dioxide stream must be monitored using an installed continuous recording device.

The owner or operator must also operate the Class VI injection well such that the annulus pressure is greater than the injection pressure; this exact annulus pressure will be specified in the permit. This annulus pressure requirement provides extra protection to USDWs, so that the carbon dioxide does not leak into the annulus and migrate upwards to where the pressure is sufficient to allow for a phase change. However, if the Program Director deems this scenario to possibly endanger USDWS, the Director can modify this requirement at his or her discretion. The annulus pressure and fluid volume must be monitored using an installed continuous recording device.

Except during well stimulation, hydraulic fracturing is prohibited for Class VI wells. The UIC Program Director may allow hydraulic fracturing during well stimulation at his or her discretion. Owners or operators seeking to use hydraulic fracturing will indicate this in the proposed stimulation program submitted as part of the permit application. The proposed program must demonstrate that any stimulation activities will not compromise the integrity of the confining zone. The UIC Program Director will need to evaluate the owner's or operator's proposed stimulation plan in the context of all information about the site, and the owner or operator must perform stimulation only as approved. The owner or operator must notify the UIC Program Director before any stimulation activities are undertaken.

Additionally, the owner or operator must maintain mechanical integrity of the injection well at all times, except during periods approved by the Director in which the sealed tubing-casing annulus is disassembled for maintenance or corrective procedures. If the owner or operator decides to perform maintenance, he/she would need to notify the UIC Program Director 30 days in advance of any maintenance activities.

The UIC Program Director **may** require the use of a tracer in situations where it would provide valuable information about the movement of the carbon dioxide plume. The UIC Program Director may specify the type of tracer to be used. EPA advises that the UIC Program Director consider the effects of tracers on human health and the environment when requiring a particular type of tracer. A tracer would tag the carbon dioxide stream and make it easy to record where the stream is in the subsurface.

## Alarms and Shut-off Systems

- Onshore wells: alarms and automatic surface shut-off systems
  - UIC Program Directors can require automatic down-hole shut-off systems
- Offshore wells: alarms and automatic down-hole shut-off systems (required)



40 CFR 146.88(e)(2)-146.88(e)(3)

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For onshore wells, the owner or operator must use alarms and automatic **surface shut-off** systems. The UIC Program Director *may* require the use of down-hole shut-off systems (e.g., automatic shut-off check valves) or other mechanical devices that provide equivalent protection.

For wells located offshore but within **State territorial waters**, the owner or operator **must** use alarms and automatic down-hole shut-off systems to alert the operator and shut off the well when operating parameters (e.g., annulus pressure, injection pressure) diverge beyond allowed ranges as specified in the Class VI permit.

The down-hole shut-off system is typically comprised of subsurface safety valves controlled at the surface. The system consists of either a ball or flapper type valve which is held open by pressure applied through control tubing from the surface. If the tubing is severed or monitored parameters (e.g., flow or pressure) exceed pre-programmed limits, the valve closes, thereby preventing the flow of fluids out of the well.

## Class VI Well Shutdown

- If a shutdown is triggered or loss of mechanical integrity is discovered, the owner or operator must:
  - Immediately cease injection
  - Determine if releases have occurred into unauthorized zones
  - Notify the UIC Program Director within 24 hours

40 CFR 146.88(f)(1)-146.88(f)(3)

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If the shutdown system triggers a shutdown, or a loss of mechanical integrity is discovered, the owner or operator must immediately cease injection, determine if a release has been made into any unauthorized zones, and notify the UIC Program Director within 24 hours.

## Class VI Well Shutdown (cont'd.)

- Injection may resume when the UIC Program Director confirms that restoration or remediation has been satisfactorily performed
  - UIC Program Director notified when injection expected to resume

40 CFR 146.88(f)(4)-146.88 (f)(5)

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The owner/operator must restore and demonstrate mechanical integrity to the satisfaction of the UIC Program Director prior to resuming injection.

The UIC Program Director must be notified when injection is expected to resume.

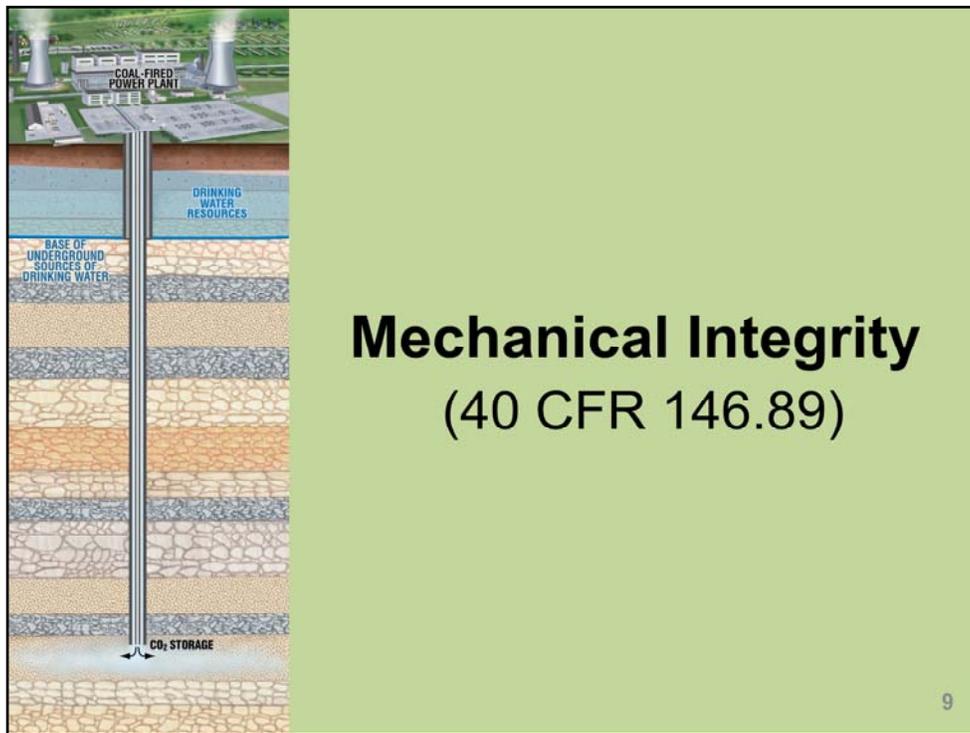
## Some Class VI Program Well Operation Resources

- For more information on injection well operation, refer to:
  - Draft UIC Program Class VI Primacy Application and Implementation Manual
  - Draft UIC Program Class VI Well Construction Guidance
  - EPA's Class VI Web site:  
<http://epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>

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Some Class VI Program injection well operation resources that are currently available are:

- The Draft UIC Program Class VI Primacy Application and Implementation Manual.
- Operating Requirements are also mentioned in the Draft UIC Class VI Well Construction Guidance
- And EPA's Class VI website:  
<http://epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>.



Owners or operators must perform tests to verify the internal and external integrity of injection wells. Owners or operators must maintain mechanical integrity at all times except during periods of well workover approved by the UIC Program Director. The UIC Program Director may approve alternate mechanical integrity test methods that meet industry standards and have been approved in writing by the EPA Administrator.

## Purpose: Mechanical Integrity

- Internal Mechanical Integrity
  - Absence of leaks in tubing, casing, and packer
  - Tested continuously by monitoring annulus pressure
- External Mechanical Integrity
  - Absence of significant fluid movement into a USDW through vertical channels adjacent to injection well
  - Tested at least once a year

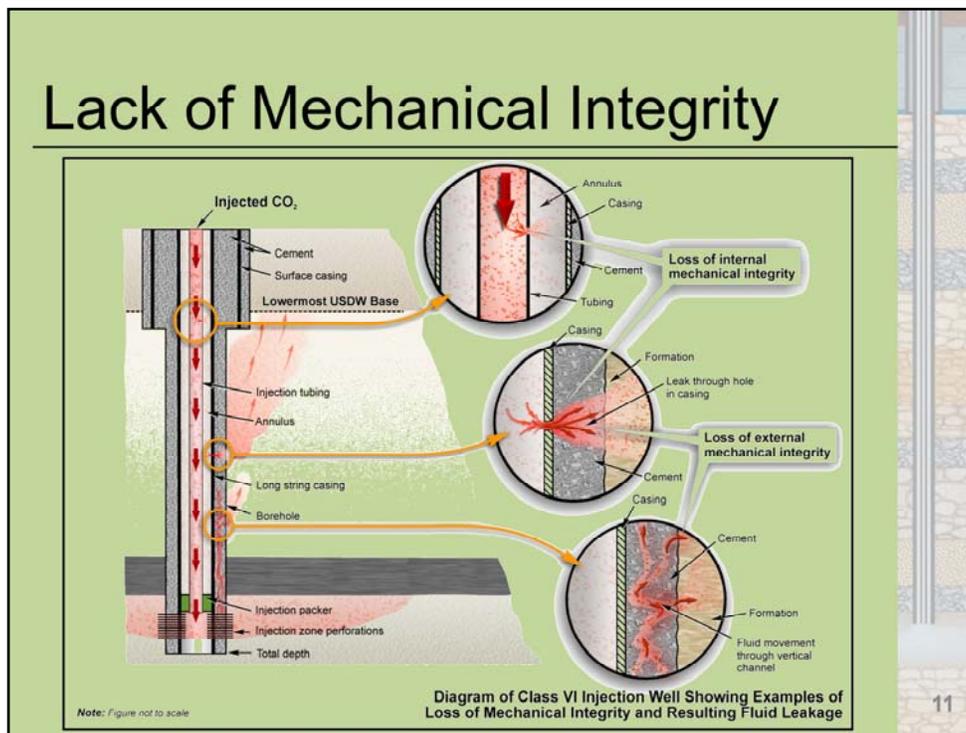
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Internal mechanical integrity refers to the absence of significant leaks in the tubing, casing, or packer. Following an initial annular pressure test, owners or operators must continuously monitor the pressure of the annulus to verify internal mechanical integrity throughout injection operations.

External mechanical integrity refers to the absence of significant fluid movement between formations (or into a USDW) through vertical channels adjacent to the injection well. Owners or operators must conduct an acceptable test for external mechanical integrity at least once a year. In addition, if a casing inspection log is required by the UIC Program Director, the owner or operator must run that casing inspection log at a frequency specified in the T&M plan [146.89(d)] to determine the presence or absence of corrosion in the long-string casing. The casing inspection log is unlikely to be an annual requirement since it requires pulling the tubing and packer, but if it is required annually that would be determined by the Director and approved in the T&M plan.

The results of mechanical integrity tests (MITs) must include a description of the test(s) and the method(s) used. Any additional or alternative tests may be required by the UIC Program Director to demonstrate mechanical integrity.

# Lack of Mechanical Integrity



This image suggests three ways mechanical integrity can be lost at a well. However, the intent of the Class VI regulations is to prevent these types of problems from occurring.

The top two bubbles show examples of how internal mechanical integrity can be lost, though in both cases owners/operators in compliance with the Class VI well construction and operating regulations should prevent these types of integrity losses. The regulations [40 CFR146.88(c)] require that the annulus pressure be maintained at a higher pressure than the injection pressure (injection pressure is the pressure inside the tubing). Unless the Director determines that this requirement will harm well integrity. Therefore a tubing leak as illustrated in the top bubble would usually result in annulus fluid, maintained under higher relative pressure, flowing into the injection tubing. And with continuous monitoring of annulus fluid, this type of fluid loss would be identified through monitoring and the well could be shut-in.

In the second bubble, annulus fluid (not carbon dioxide) exits the casing, which is another example of the loss of internal mechanical integrity. In cases where the formation opposite of the casing leak was of a higher pressure than the annulus pressure, formation fluid could instead enter the annulus. Note, though, that simultaneous leaks in the tubing and casing would be unlikely if an owner/operator was in compliance with the requirements for continuous monitoring of injection pressure, annulus pressure and annular fluid volume.

The bottom bubble shows external mechanical integrity loss in the wellbore cement; here a channel has developed in the cement over time and allows carbon dioxide to migrate behind the casing. External mechanical integrity must be demonstrated prior to authorizing injection. Any loss of external mechanical integrity that occurs during operations should be identified during the annual external mechanical testing and early warning might be given earlier because of the continuous monitoring that is required.

# Mechanical Integrity: UIC Program Director Reviews

## Internal Mechanical Integrity:

- Test results verifying absence of significant leakage
- Initial annular pressure test
  - Prior to well operation
- Continuous annulus pressure monitoring
  - Periodically throughout operational phase



40 CFR 146.89(a) & 146.89(b)

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Data and information that must be reviewed by the UIC Program Director for a demonstration of internal mechanical integrity include:

- The owner or operator is required to conduct an initial annular pressure test prior to injection. The standard annulus pressure test is the most common means used to demonstrate internal mechanical integrity. The owner or operator must submit results of the pressure test, and the UIC Program Director may ensure that the well has demonstrated internal mechanical integrity and that the test was conducted correctly before authorizing injection.
- During injection, the owner or operator is required to continuously monitor the pressure on the annulus to verify mechanical integrity. The purpose of continuous pressure monitoring is to demonstrate that no pressure changes are occurring. The owner or operator must submit results of continuous pressure monitoring and any fluid addition or losses to the annulus. When a loss of internal mechanical integrity is suspected, the UIC Program Director may require an annulus pressure test to confirm mechanical integrity. If the well demonstrates mechanical integrity, the UIC Program Director may allow continued operation. If the well does not demonstrate mechanical integrity, regulations at 146.88(f) state that the owner or operator must investigate, immediately cease injection, take all steps to determine if carbon dioxide was released, notify the UIC Program Director within 24 hours, restore and demonstrate mechanical integrity to the Director's satisfaction, and notify the Director when injection can be expected to resume.

## Mechanical Integrity: UIC Program Director Reviews

- Annual External Mechanical Integrity
  - Measures flow outside of casing
    - Oxygen activation log
    - Radioactive tracer survey
    - Temperature log
    - Noise log
- Review done periodically throughout operational phase, Director may also require casing inspection logs

40 CFR 146.89(c) & (d)

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Data and information that must be reviewed by the UIC Program Director for a demonstration of external mechanical integrity include:

- The owner or operator must perform an external MIT at least once a year and report results to the UIC Program Director. External MITs measure the flow outside of the well casing and include tests such as oxygen activation logs, radioactive tracer surveys, temperature logs, and noise logs. The UIC Program Director may independently evaluate the results of the external MIT to verify integrity. The Director may require additional information regarding tests, or that additional tests be run, if, among other things, loss of mechanical integrity is suspected.
- If required by the Director, the owner or operator must run a casing inspection log according to the timeframe specified in the Testing and Monitoring Plan. The purpose of the casing inspection log is to determine the presence or absence of corrosion in the long-string casing. The owner or operator will need to submit results of the casing inspection logs and an interpretation of the logs to determine the presence of corrosion. The UIC Program Director may independently assess the presence of corrosion, and the potential for corrosion, or a casing defect, to cause loss of mechanical integrity, through interpretation of the casing inspection logs and external MITs. The Director may require that additional logs be run if corrosion is suspected based on the submitted data.

## Some Class VI Program Mechanical Integrity Resources

- For more information on mechanical integrity, refer to:
  - Draft UIC Program Class VI Primacy Application and Implementation Manual
  - Draft UIC Class VI Well Construction Guidance *and* Draft UIC Class VI Testing and Monitoring Guidance
  - EPA's Class VI Web site:  
<http://water.epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>

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Some Class VI Program mechanical integrity resources that are currently available are:

- The Draft UIC Program Class VI Primacy Application and Implementation Manual.
- Draft Class VI Well Construction and Draft UIC Class VI Testing and Monitoring Guidance.
- And EPA's Class VI website:  
<http://water.epa.gov/type/groundwater/uic/class6/gclass6wells.cfm>.