

**Summary Comparison of Well Construction Requirements
(Internal Energy Program Working Document)**

State/Organization	Conductor Casing	Surface Casing	Intermediate Casing	Production Casing	Notes
Ohio	Cemented to surface if annular space exists. Conductor casing may be driven into place.	Must be set at least 50 ft below the base of the deepest underground water resource or at least 50 ft into competent bedrock, whichever is deeper, or as otherwise approved. Cement required from bottom of casing to land surface or to bottom of cellar.	May be set at the discretion of the "owner", unless certain geological conditions exist. These conditions require cementing based on guidance from the State.	Must be cemented with enough cement to fill the annular space to at least 500 true vertical feet above the seat in an open-hole completion or the uppermost perforation in a cemented vertical completion, or 1,000 ft above the kickoff point of a horizontal well. Note that most operators in Ohio already cement to surface, anyway.	Requires borehole diameter to be at least one inch greater than respective casing for annular space cementing; requires wellbore to be consistent with manufacturer's recommendations for float equipment, centralizers, packers, cement baskets, and all other equipment used in the wellbore. Requires casing be centralized to provide sufficient standoff and to foster effective circulation of cement.
Colorado	N/A	Sufficient surface casing shall be run to reach a depth below all known or reasonably estimated utilizable domestic fresh water levels and to prevent blowouts or uncontrolled flows, and shall be of sufficient size to permit the use of an intermediate string or strings of casings. Surface casing shall be set in or through an impervious formation and shall be cemented by pump and plug or	Cement shall be pumped behind the intermediate casing to at least two hundred (200) feet above the top of the shallowest known production horizon and as required in 317.g. Cement placed behind the surface and intermediate casing shall be allowed to set a minimum of eight (8) hours, or until three hundred (300) psi calculated compressive strength is developed,	Cement shall be pumped behind the production casing (200) feet above the top of the shallowest known producing horizon. All fresh water aquifers which are exposed below the surface casing shall be cemented behind the production casing.	Casing and cementing rules are based on "known" areas and "unknown" areas. Other rules apply to certain locations (i.e. Fox Hills area). Many decisions regarding casing are up to the "Director." States that casing has to protect groundwater and not waste hydrocarbon resources.

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		displacement or other approved method with sufficient cement to fill the annulus to the top of the hole; cemented with a continuous column from the bottom of the casing to the surface	whichever occurs first, prior to commencing drilling operations.		<p>Has a “flaring” provision that flares be done in a safe direction.</p> <p>Has a well logging requirement (p. 300-24): gamma, resistivity, cement bond.</p>
Pennsylvania	If the operator installs conductor pipe in the well, the following provisions apply: (1) The operator may not remove the pipe; (2) Conductor pipe shall be installed in a manner that prevents the subsurface infiltration of surface water or fluids by either driving the pipe into place or cementing the pipe from the seat to the surface; (3) Conductor pipe must be made of steel unless a different material is approved for use by the Department.	Set 50 feet below deepest fresh groundwater or at least 50 feet into consolidated rock, whichever is deeper. May not set more than 200 feet below deepest fresh groundwater zone except to reach consolidated rock. One centralizer 50 feet above the casing seat and continue with an interval no greater than 150 feet. Cement casing by placing cement in the casing and displacing into annular space to the surface.	Prior to cementing the intermediate casing, the borehole, mud and cement shall be conditioned to ensure an adequate cement bond between the casing and the formation. Centralizers shall be used and the casing shall be cemented to the surface by the displacement method.	Prior to cementing the production casing, the borehole, mud and cement shall be conditioned to ensure an adequate cement bond between the casing and the formation. The production string may be set on a packer or cemented in place. If cemented in place, centralizers shall be used and cement shall be placed by the displacement method with sufficient cement to fill the annular space to a point at least 500 feet above true vertical depth or at least 200 feet above the uppermost perforations, whichever is greater.	<p>Minimum of 1 inch annulus required to cement.</p> <p>Subchapter D. Well Drilling, Operation & Plugging. Casing & Cementing 78.83a, b, & c.</p>

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					of surface casing required to be set and cemented to surface. In addition, cement shall be circulated to the surface on all production casings, so as to isolate from the wellbore, all strata encountered in the wellbore above the Fayetteville Shale.
North Carolina (15A NCAC 05D)	N/A	Set at the first impervious layer, not less than 50 ft below freshwater strata; cement annular space to the surface.	N/A	Extend for total well depth; cementing to at least 500 ft above the casing shoe and at least 50 feet above the reservoir, which is nearest to the surface.	"The casing shall be so centralized and the annulus of such size that cement can be injected to fill the entire annular space behind the casing back to the surface."
API	No depth specified; may be driven or drilled and placed; cement annular space to surface.	Set at 100 ft below the deepest underground source of drinking water; cement annular space to surface	Installation; if used, cementing to the surface is optional; cementing may be done to the base of the surface casing, if groundwater sources are protected.	Extend for total well depth; cementing extends from bottom of intermediate or surface casing to the borehole bottom. Cementing to the surface is optional, based on geology.	
DENR (considering...)	Install via drilling and casing placement to 60 ft. below surface; cement annular space to surface.	Set at 100 ft below the deepest groundwater source or at 650 ft., whichever is deeper; cement annular space to surface.	Set at a depth to stabilize borehole instability; or 1000 ft, whichever is deeper; cement annular space to surface.	Extended for production casing length; cement annular space to surface; a slotted or perforated production liner may be connected to the production casing, based on subsurface geological conditions.	Require 1-inch annular space. Require logging: gamma, resistivity, cement bond.

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Other API descriptions (*API Guidance Document HF1, 2009*):

Conductor casing: Serves as the foundation for the well; holds back unconsolidated surface material; isolates shallow groundwater.

Surface casing: Set within the conductor casing; protection of groundwater aquifers.

Intermediate casing: Set within the surface casing; isolate subsurface formations that may cause borehole instability and to provide protection from abnormally pressured subsurface formations.

Production casing: Set within the intermediate casing; provides isolation between the producing zone and all other subsurface formations; used for collection and pumping of hydrocarbon fluids; used for well stimulation.

* Note – remember to include a variance provision for well construction; casing standards (API); cement standards (API); pressuring standards (API or Ohio?); centering (Ohio?).

* Note 2: What about drilling through dikes, sills, or faults?

* Note 3: Drilling Fluids and Additives 15A NCAC 02C .0107 (c). Drilling Fluids and Additives shall not contain organic or toxic substances ~~or include water obtained from surface water bodies or water from a non-potable supply~~ and in addition to water may be comprised only of: (1) the formational material encountered during drilling; or (2) materials manufactured specifically for the purpose of borehole conditioning or ~~water~~ well construction.

* Note 4: Remember provision stating that only fluids that do not geochemically degrade the hydrocarbon resource, source rock, or reservoir may used in the well.

* Note 5: Bonds must be done for (1) well closing, (2) site reclamation, and (3) for the owner of the property. The amount and length of the bonding needs to be determined.

State/Organization	Pressure Testing	Cement	Blowout Preventers	Wellhead	Casing
Ohio	All hydrostatic pressure tests done pursuant to API 5CT; internal yield pressure rating for casing based on calculations from API TR5C-3.	Requires Portland cement to meet "API 10 A" standard or "ASTM C150/150M." Requires that cement reach a compressive strength of 500 lbs/square inch before drilling a plug or initiating a test.	BOP in good working condition of sufficient size and working pressure rating to control normal hydrostatic pressure for the deepest pool to be penetrated must be installed on the casing	All wells must be equipped so that no oil, gas or condensate is allowed to escape with the exception of gas flares. Assemblies used to maintain surface	Steel alloy; manufactured and tested based on standards API CT or ASTM A500/500M; minimum internal yield pressure to withstand ½ times max pressure to which casing may be

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		<p>Requires sulfate reducing cement in areas where H₂S “commonly” occurs.</p>	<p>through which drilling is being performed when drilling within two hundred (200) feet of an inhabited structure or when drilling in urbanized areas. BOP must be capable of closing off the annulus between casing and drill pipe as well as completely closing off the casing when drill pipe is not in the hole. BOP systems must include a device which will permit bleed-off of hydrostatic pressure.</p> <p>When drilling on air or other gaseous material, a rotating air-head in good working condition with stripper rubbers of proper size and sufficient working pressure rating to control normal hydrostatic pressure for the deepest pool penetrated must be installed on the surface casing. The discharge line from the annulus between the casing and drill pipe must be vented not less than</p>	<p>control of the well. All components shall have working pressure rating equal to or greater than the highest anticipated operating pressure to which the components might be exposed during drilling, testing, completing, stimulating, or producing the well.</p> <p>Valve on surface-production casing annulus or surface-intermediate casing annulus shall be accessible and equipped with a pressure gauge to allow continual monitoring of mechanical integrity. Valve shall be equipped with a properly functioning pressure relief valve set at or below the hydrostatic pressure at the surface casing seat.</p>	<p>subjected; re-conditioned casing may be used under certain conditions.</p>

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			<p>sixty (60) feet from the well into a pit of sufficient size to contain drill cuttings, foam, produced water, oil and/or casing-head gas.</p> <p>Casing integrity may be verified in conjunction with BOP testing without a test plug using either the test pressure described in paragraph (D)(3)(b), or the pressure required to test the BOP, whichever is greater.</p>		
Colorado	The installed production casing shall be adequately pressure tested for the conditions anticipated to be encountered during completion and production operations.	<p>All surface and intermediate casing cement shall be of adequate quality to achieve a minimum compressive strength of three hundred (300) psi after twenty-four (24) hours and eight hundred (800) psi after seventy-two (72) hours measured at ninety-five degrees Fahrenheit and at eight hundred (800) psi.</p> <p>Production casing cement: placed behind production casing; shall be of adequate quality</p>	<p>The operator shall take all necessary precautions for keeping a well under control while being drilled or deepened. BOPE, if any, shall be indicated on the Application for Permit to Drill, Deepen, Re-enter, or Recomplete and Operate (Form 2), as well as any known subsurface conditions (e.g. under or over-pressured formations).</p> <p>The working pressure of any BOPE shall exceed the anticipated surface pressure to which it</p>	<p>All pipe fittings, valves and unions placed on or connected with blowout prevention equipment, well casing, casinghead, drill pipe, or tubing shall have a working pressure rating suitable for the maximum anticipated surface pressure and shall be in good working condition as per generally accepted industry standards.</p> <p>All wells located within one hundred fifty (150) feet of a residence(s), normally occupied</p>	Pressure testing of the casing string and each component of the blowout prevention equipment, if blowout prevention equipment is required, shall be conducted prior to drilling out any string of casing except conductor pipe. The minimum test pressure shall be five hundred (500) psi, and shall hold for fifteen (15) minutes without pressure loss in order for the casing string to be considered serviceable.

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		<p>to achieve a minimum compressive strength of at least three hundred (300) psi after twenty-four (24) hours and eight hundred (800) psi after seventy-two (72) hours measured at ninety-five degrees Fahrenheit (95 °F) and at eight hundred (800) psi.</p>	<p>may be subjected, assuming a partially evacuated hole with a pressure gradient of 0.22 psi/ft. [For BOPE requirements in high density areas see Rule 603.b.(4)B. For statewide BOPE specification, inspection, operation and testing requirements see Rule 603.f.]</p> <p>Blowout prevention equipment for drilling operations for high density area shall consist of (at a minimum): Rig with Kelly - double ram with blind ram and pipe ram; annular preventer or a rotating head. Rig without Kelly - double ram with blind ram and pipe ram.</p> <p>Mineral Management certification or Director approved training for blowout prevention shall be required for at least one (1) person at the wellsite during drilling operations.</p>	<p>building units, or well defined normally occupied outside area(s), shall be equipped with an automatic control valve that will shut the well in when a sudden change of pressure, either a rise or drop, occurs. Automatic control valves shall be designed so they fail safe.</p> <p>Pressure control valves required in (a) shall be activated by a secondary gas source supply, and shall be inspected at least every three (3) months to assure they are in good working order and the secondary gas supply has volume and pressure sufficient to activate the control valve.</p>	

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			<p>BOPE testing for high density area drilling operations. Upon initial rig-up and at least once every (30) days during drilling operations thereafter, pressure testing of the casing string and each component of the blowout prevention equipment including flange connections shall be performed to seventy percent (70%) of working pressure or seventy percent (70%) of the internal yield of casing, whichever is less. Pressure testing shall be conducted and the documented results shall be retained by the operator for inspection by the Director for a period of one (1) year. Activation of the pipe rams for function testing shall be conducted on a daily basis when practicable.</p>		
Pennsylvania	Casing which is attached to a blow-out preventer with a pressure rating of greater than 3,000 psi shall be pressure tested after	When cementing surface casing or coal protective casing, the operator shall use cement that meets or	BOP shall be used in the following circumstances: (1) Drilling a well that is intended to produce	The operator shall prevent gas, oil, brine, completion and servicing fluids, and any other fluids or materials	New pipe must have an internal pressure rating that is at least 20% greater than the anticipated maximum

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	<p>cementing. A passing pressure test must be holding the anticipated maximum pressure to which the casing will be exposed for 30 minutes with not more than a 10% decrease. Certification of the pressure test shall be confirmed by entry and signature of the person performing the test on the driller's log.</p>	<p>exceeds the ASTM International C 150, Type I, II or III Standard or API Specification 10.</p> <p>After the casing cement is placed behind surface casing, the operator shall permit the cement to set to a minimum designed compressive strength of 350 pounds per square inch (psi) at the casing seat. The cement placed at the bottom 300 feet of the surface casing must constitute a zone of critical cement and achieve a 72-hour compressive strength of 1,200 psi and the free water separation may be no more than 6 milliliters per 250 milliliters of cement. If the surface casing is less than 300 feet, the entire cemented string constitutes a zone of critical cement.</p> <p>(c) After any casing cement is placed and cementing operations are complete, the casing may not be disturbed for a</p>	<p>natural gas from an unconventional formation. (2) Drilling out solid core hydraulic fracturing plugs to complete a well. (3) Well head pressures or natural open flows are anticipated at the well site that may result in a loss of well control. (4) When the operator is drilling in an area where there is no prior knowledge of the pressures or natural open flows to be encountered. (5) On wells regulated by the Oil and Gas Conservation Law (58 P. S. § § 401—419). (6) Drilling within 200 feet of a building.</p> <p>Controls shall be accessible to allow actuation. Additional controls with pressure rating of greater than 3,000 psi, not associated with rig hydraulic system, shall be located 50 feet away from rig to actuate if well control is lost.</p>	<p>from below the casing seat from entering fresh groundwater, and shall otherwise prevent pollution or diminution of fresh groundwater.</p> <p>Except for gas storage wells, the well must be equipped with a check valve to prevent backflow from the pipelines into the well.</p>	<p>pressure to which the casing will be exposed.</p> <p>Used casing may be approved for use as surface, intermediate or production casing pressure tested after cementing and before continuation of drilling. A passing pressure test is holding the anticipated maximum pressure to which it will be exposed for 30 minutes with not more than a 10% decrease in pressure.</p> <p>New or used plain end casing, except when being used as conductor pipe, that is welded together for use must meet the following requirements:</p> <p>(1) The casing must pass a pressure test by holding the anticipated maximum pressure to which the casing will be exposed for 30 minutes with not more than a 10% decrease in pressure. The operator</p>

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		<p>minimum of 8 hours.</p>	<p>All equipment should have working pressures capable to handle anticipated pressures and be flame resistant.</p> <p>Complete test of ram type BOP before placing into service. Annular type BOP shall be tested according to manufacturer's instructions prior to use.</p> <p>Test the pipe rams for closure daily during drilling and blind rams for closure on each round trip. Testing in accordance with API RP53.</p> <p>An individual with current certification from a well control course accredited by the International Association of Drilling Contractors shall be on site if a BOP is in use.</p>		<p>shall notify the Department at least 24 hours before conducting the test. The test results shall be entered on the drilling log.</p> <p>(2) The casing shall be welded using at least three passes with the joint cleaned between each pass.</p> <p>(3) The casing shall be welded by a person trained and certified in the applicable American Petroleum Institute, American Society of Mechanical Engineers, American Welding Society or equivalent standard for welding casing and pipe or an equivalent training and certification program as approved by the Department.</p> <p>When casing through a workable coal seam, the operator shall install coal protective casing that has a minimum wall thickness of 0.23</p>

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					inch.
Arkansas	<p>The casing-tubing annulus above the packer shall be tested under the supervision of a Commission representative at a minimum pressure differential between the tubing and the annulus of fifty (50) psig for a period of thirty (30) minutes. The casing-tubing annulus starting test pressure shall not be less than three hundred (300) psig and may vary no more than ten (10) percent of the starting test pressure during the test (this is for UIC wells).</p>	<p>"Cement" means a class A or H neat cement with a minimum weight of 14.5 pounds per gallon, unless the cement contains additives which improve the ability of the cement to provide necessary protection and which maintains a minimum compressive strength of 500 PSI after 72 hours.</p> <p>Rule B-15: Surface casing cement shall be allowed to set a minimum of twelve (12) hours.</p> <p>Production casing cement shall be allowed to set a minimum of 24 hours.</p>	<p>Rule B-16: All proper and necessary precautions shall be taken for keeping the well under control during drilling operations, including but not limited to the use of blow-out preventers and high pressure fittings attached to properly anchored and cemented casing strings or maintain mud-laden fluid of sufficient weight to provide proper well control. Blow-out preventers shall be tested at regular intervals to insure proper operation.</p>	<p>Rule B-14: Wellhead equipment shall be installed and maintained in first-class condition so that static bottom hole pressures may be obtained at any time by duly authorized agents of the Commission. Valves shall be installed so that pressures can be readily obtained on both casing and tubing.</p> <p>Rule B-18: Christmas tree fittings or wellhead connections shall have a working pressure or a test pressure in keeping with the expected depth of the well.</p> <p>The wellhead shall be maintained in a leak-free condition, and must have a working pressure in excess of the maximum discharge pressure of the pump. The</p>	<p>Rule B-19: The well will have steel alloy casing designed to withstand the anticipated maximum pressures to which the casing will be subjected in the well.</p> <p>All dry gas wells are not required to produce through tubing, provided surface casing has been set in the well in accordance with applicable rules.</p>

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				<p>wellhead shall be configured to include a one half inch female fitting, with shut-off valve, to allow monitoring of the annulus between the production casing and the injection tubing and a one half inch female fitting, with shut-off valve, installed on the tubing to measure the injection pressure.</p>	
<p>North Carolina (05D)</p>	<p>Pressure Test. If a pressure test is used, the pressure should be raised to a pressure calculated by multiplying the length of casing in feet by 0.2 not to exceed 1,500 psi and after 30 minutes if the pressure has dropped 10 percent or more, the casing has failed to meet the requirements.</p>	<p>The cement shall set a minimum of 24 hours before the plug is drilled. The flow string shall be tested by either of the two methods below: (1) Pressure Test. If a pressure test is used, the pressure should be raised to a pressure calculated by multiplying the length of casing in feet by 0.2 not to exceed 1,500 psi and after 30 minutes if the pressure has dropped 10 percent or more, the casing has</p>	<p>In all proven areas, the use of blowout preventers shall be in accordance with practice established in drilling the pool under development. In unproven areas, all drilling wells should be equipped with a master gate or equivalent, an adequate blowout preventer and a properly sized flow line valve. "Adequate" shall be taken to mean that consideration has been given to the depth of the test and pressures</p>	<p>Christmas tree fittings or well head connections, flow lines and treating facilities, shall have a working pressure in keeping with anticipated working pressures generated by the well as determined from drillstem tests or other pressure testing procedures acceptable to the director.</p>	<p>No information</p>

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		<p>failed to meet the requirements.</p> <p>(2) Bailer Test. If the bailer test is used, the fluid level shall be lowered to a point midway between the casing base and the top of cement column behind such casing, and if after 12 hours the fluid level rises or subsides two percent or more of the length of the water column, the casing has failed to meet the requirements.</p>	<p>likely to be encountered at those depths. The entire control equipment shall be in good working condition at all times and shall have been tested to working pressures at least 50 percent above the hydrostatic pressures anticipated in the well.</p>		
API	<p>In addition, each casing string, except the conductor casing, should be pressure tested prior to "drill out." The test pressure will vary depending on the casing string, depth, and other factors.</p> <p>After the surface, intermediate, and production casing cement has achieved the appropriate compressive strength and prior to drilling out, the surface and intermediate casing and perforating the production casing, all</p>	<p>API Specification 10A/ISO 10426-1, <i>Specification for Cements and Materials for Well Cementing</i></p> <p>API Recommended Practice 10B-2/ISO 10426-2, <i>Recommended Practice for Testing Well Cements</i></p> <p>API Technical Report 10TR1, <i>Cement Sheath Evaluation</i></p> <p>A general recommendation applicable to all casing strings is that after the cement is set</p>			<p>API Specification 5B, <i>Specification for Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads</i></p> <p>API Specification 5CT/ISO 11960, <i>Specification for Casing and Tubing</i></p> <p>API Recommended Practice 10D-2/ISO 10427-2, <i>Recommended Practice for Centralizer Placement and Stop Collar Testing</i></p> <p>API Technical Report</p>

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	<p>strings should be pressure tested (commonly known as a casing pressure test). This test should be conducted at a pressure that will determine if the casing integrity is adequate to meet the well design and construction objectives.</p> <p>In addition, immediately after drilling out of the surface and intermediate casing plus a short interval of new formation below the surface and intermediate casing shoe, a formation pressure integrity test (also known as a “shoe test” or “leak-off test”) should be performed. If the test results of the formation pressure integrity test are inadequate, remedial measures should be undertaken as appropriate.</p>	<p>and prior to commencing further drilling or completion operations, the cement surrounding the casing shoe should have a compressive strength of at least 500 psi and should achieve 1200 psi in 48 hours at bottomhole conditions. However, for production casing the cement should be tested to ensure that it is adequate to withstand the anticipated hydraulic fracturing pressure.</p>			<p>10TR4, <i>Technical Report on Considerations Regarding Selection of Centralizers for Primary Cementing Operations</i></p>
DENR (considering...)					