NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WATER WELL

(No.)

CODE 642

DEFINITION

A hole drilled, dug, driven, bored, jetted, or otherwise constructed to an aquifer.

PURPOSE

To provide water for livestock, wildlife, irrigation, human, and other uses.

To provide for general water needs of farming/ranching operations.

To facilitate proper use of vegetation on rangeland, pastures, and wildlife areas.

CONDITION WHERE PRACTICE APPLIES

This practice applies on all land uses where the underground supply of water is sufficient in quantity and quality for the intended purpose.

This practice applies only to production wells. Specifically excluded are any types of wells installed solely for monitoring or observation purposes, injection wells, and piezometers. The standard does not apply to pumps installed in wells; aboveground installations such as pumping plants, pipelines, and tanks; and temporary test wells. For decommissioning of wells, refer to Conservation Practice Standard 351, Well Decommissioning

CRITERIA

Laws, rules, and regulations. This practice shall conform to all federal, state, and local laws, rules, and regulations. Laws, rules, and regulations of particular concern include those involving water rights, land use, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.

The well driller must be properly licensed by the Kansas Department of Health and Environment (KDHE) and must drill and install according to stipulations of that agency.

State law must also be complied with where water use appropriation is involved. Owners are responsible for securing permits for such appropriation.

Suitability of site. The availability of ground water for its intended use at the site shall be determined by using reliable local experience and reviewing all available relevant geologic maps and reports; well records maintained by state and federal agencies; and design, construction, and maintenance records of nearby wells. An appropriate level of investigation, including test well drilling, is conducted on-site, as needed, prior to well construction to determine site-specific hydrogeologic conditions.

The site shall be suitable for safe operation of the drilling equipment.

Well head protection. Wells shall be located at safe distances from potential sources of pollution, including unsealed abandoned wells. The allowable distance shall be based on consideration of site-specific hydrogeologic factors and shall comply with requirements of all applicable state or local regulations or construction codes.

Surface runoff and drainage that might reach the wellhead from potential areas of contamination, such as those used by livestock, shall be diverted.

Wells shall be located a safe distance from both overhead and underground utility lines and other safety hazards.

Borehole. Drilled, jetted, bored, and driven wells shall be sufficiently round, straight, and of adequate diameter to permit satisfactory installation of inlet, well casing, filter pack, and annular seal and passage of tremie pipe (including couplings), if used.

Use of casing. Casing shall be installed to seal out undesirable surface or shallow ground water and to support the side of the hole through unstable earth materials. The intake portion of a well through stable geologic materials may not require casing.

Casing diameter. Casing diameter shall be sized to permit satisfactory installation and efficient operation of the pump and large enough to assure that uphole velocity is 5 feet per second or less (to protect against excessive head loss).

Materials. Casings may be of steel, iron, stainless steel, copper alloys, plastic, fiberglass, concrete, or other material of equivalent strength and durability consistent with the intended use of the water and the maximum anticipated differential head between the inside and outside of the casing.

Steel well casings shall meet or exceed requirements specified in American Society for Testing and Materials (ASTM) A 589. Steel pipe manufactured for other purposes may be used if the quality of the pipe meets or exceeds requirements specified in ASTM A 589.

Only steel pipe casings shall be used in driven wells.

To prevent galvanic corrosion, dissimilar metals shall not be joined.

Plastic casings made of acrylonitrile-butadiene-styrene (ABS), polyvinyl chloride (PVC), or styrene-rubber (SR) shall conform to material, dimensional and quality requirements specified in ASTM F 480.

If the water is to be used for human consumption, plastic pipe shall be approved by the National Sanitation Foundation.

Plastic pipe manufactured for water or irrigation pipelines may be used if the quality equals or exceeds requirements specified in ASTM F 480.

Filament-wound fiberglass casings (reinforced thermosetting resin pipe [RTRP]) may be used if material meets requirements specified in ASTM D 2996. Tests for long-term cyclic pressure strength, long-term static pressure strength, and short-term rupture strength as required in ASTM D 2996 are not needed because the pipe is to be used for well casing. Joints shall meet requirements specified in Section 3.8, ASTM F 480.

Fiberglass pressure pipe (also called reinforced plastic mortar pipe [RPMP] or fiberglass pipe with aggregate) shall meet or exceed requirements specified in ASTM D 3517.

Casing strength. Well casing wall thickness shall be sufficient to withstand all anticipated static and dynamic pressures imposed on the casing during installation, well development, and use. Required casing strength shall be determined as shown in NEH Part 631, Chapter 33, “Investigations for Ground Water Resources Development,” in National Engineering Handbook Part 631 (NEH 631), *Geology*.

Except where local experience indicates the need for stronger casings, the maximum differential head for well casings shall be based on the Clinedinst Equation. This equation is contained in Chapter 33 of NEH 631.

If an engineering analysis is not performed, the information contained in Tables 1 and 2 may be used to determine maximum differential head (maximum depth). This depth may be conservatively interpreted to be total well depth. (See Figure 1.)

If the maximum static water level elevation is known, then differential head (maximum depth) may be interpreted to be the depth below this elevation. In this case, the installation depth to the ground surface is allowed to exceed the maximum depth listed in the tables. The latter interpretation may be used only if the well is to be grouted or gravel-packed and will not be subjected to extreme collapse pressure during development.

Table 1 gives the differential head limitations for polyvinyl chloride (PVC) well casing pipes having different standard dimension ratios (SDRs).

There are a number of ASTM specifications covering plastic pipe products that are acceptable for well casing applications. The modulus of elasticity of these materials may be related to “Cell Classification” or “Designation Code” markings found on the pipe. One or both of these markings may appear on the pipe, depending upon specification requirements.

Table 1 - Maximum differential head for plastic pipe (SDR)

SDR [1/]	Maximum Depth (feet)
13.5	1,020
17	495
21	255
26	130
32.5	65

[1/] Modulus of Elasticity of 400,000 lbs/in^2, PVC - Classification 12454, Codes 1120 and 1220

Table 2 gives the dimensions and maximum differential head for PVC Schedules 40 and 80 pipe. Table 1 and Table 2 values are from NEH Part 631.

Table 2 is for PVC Schedule pipe made of material having a modulus of elasticity of 400,000 lb/in^2. For PVC pipe having a modulus of elasticity of 360,000, multiply the depths by a factor of 0.9. For PVC pipe having a modulus of elasticity of 320,000, use a factor of 0.8. For plastic casing materials having other values of modulus of elasticity, the correction factor may be computed by dividing the material's modulus of elasticity (in lb/in^2) by 400,000. To relate modulus of elasticity to pipe markings, refer to Table 1 or ASTM Specifications D 1784 and D 1785.

Table 3 gives the minimum allowable thickness of metal casings. Table 4 gives the maximum depth of installation for steel casings. Only steel pipe casings shall be used in driven wells.

Casings having a different wall thickness can be used in the same well if the maximum allowable depth for each wall thickness is not exceeded

Table 2 - Dimensions and maximum differential head for Schedules 40 and 80 PVC plastic pipe

		Schedule 40 [1/]			Schedule 80 [1/]		
Nominal Diameter (inches)	Outside Diameter (inches)	Minimum Wall Thickness (inch)	SDR	Maximum Depth (feet)	Minimum Wall Thickness (inch)	SDR	Maximum Depth (feet)
4	4.5	.237	19	350	.337	13.4	1,045
5	5.563	.258	21.6	235	.375	14.8	765
6	6.625	.28	23.7	175	.432	15.3	690
8	8.625	.322	26.8	120	.5	17.3	470
10	10.75	.365	29.4	90	.593	18.1	405
12	12.75	.406	31.4	70	.687	18.6	375

[1/] Modulus of elasticity of 400,000 lbs/in^2, PVC - Classification 12454, Codes 1120 and 1220

Table 3 - Minimum thickness of metal casings for wells

Diameter (inches)	Minimum Wall Thickness	
	Steel Casing (inches)	Lightweight Galvanized Casing (inches)
4	.060	.0322
4.5	.060	.0322
5	.075	.0382
6	.105	.0382
8	.105	.0486
10	.105	.0486

1/ Lightweight galvanized casings should be used only in areas where local experience has proven them to be satisfactory.

2/ For driven or drilled wells

Table 4 - Maximum depth of installation for steel casings

Wall (Uncoated) Thickness	Casing Size (inches)									
	4	5	6	8	10	12	14	16	18	24
	Outside Diameter (inches)									
	4.5	5.563	6.625	8.625	10.75	12.75	14	16	18	24
	(feet) [2]									
10 gage [1]	400	400	400	390	220	135	105	70	50	--
8 gage	500	500	500	500	360	230	180	125	90	--
7 gage [1]	600+	600	600	600	460	290	320	160	110	--
3/16 inch	--	600+	600	600	520	330	260	180	130	60
7/32 inch [1]	--	--	600+	600+	750	500	390	270	200	90
1/4 inch [1]	--	--	--	--	1,030	690	550	390	290	130
9/32 inch	--	--	--	--	--	910	730	520	390	180
5/16 inch [1]	--	--	--	--	--	--	930	680	510	240
11/32 inch	--	--	--	--	--	--	--	860	650	310
3/8 inch [1]	--	--	--	--	--	--	--	--	800	390
7/16 inch	--	--	--	--	--	--	--	--	--	580

1/ Sizes listed by KDHE in Article 30

2/ The depth listed is the most restrictive from tables in KDHE Article 30 and NEH Part 631.

Joint strength. Joints for well casings shall have adequate strength to carry the load due to the casing length and still be watertight or shall be mechanically supported during installation to maintain joint integrity. Such mechanically supported casings shall terminate on firm material that can adequately support the casing weight.

Screen. Well screens shall be installed in any aquifer material likely to produce silt or sand. Well screens may be constructed of commercially manufactured screen sections, well points, or field-perforated sections.

The screen shall be constructed with the slot width determined from aquifer samples in Chapter 33 of NEH 631. Perforation by any method is allowable provided proper slot size and entrance velocity limits can be met. Screen open areas can range from 1 percent for field-perforated screens to 25 percent or more for continuous wire-wrapped screens. To assure good well efficiency, open areas should be designed to approximate aquifer porosity. High open area percentages also make well development more effective. The length and open area of the screen shall be sized to limit entrance velocity of water into the well to less than or equal to 0.1 foot per second (Example 33-2 in Chapter 33 of NEH 631).

Depth of the aquifer below ground surface and the thickness of aquifer to be penetrated by the well shall govern the position of the screen in the well.

Maximum drawdown shall not be permitted below the top of the highest screen or pump intake.

Seals (packers). Telescoped screen assemblies shall be provided with one or more sand-tight seals between the top of the telescoped screen assembly and casing.

Filter pack. Installation of a filter pack around the well screen shall be considered under the following conditions: presence of a poorly graded, fine sand aquifer; presence of a highly variable aquifer such as alternating sand and clay layers; presence of a poorly cemented sandstone or similar aquifer; requirement for maximum yield from a low-yielding aquifer; and holes drilled by reverse circulation.

Pre-packed well screens. For heaving or caving sands, silty or fine-grained aquifers, and for horizontal or angled wells, a commercial pre-packed well screen may be substituted for a conventionally installed (by tremie) filter pack.

Installation. Casing shall extend from above the ground surface down through unstable earth materials to an elevation of at least 2 feet into stable material or to the top of the screen.

All wells shall be cased to a sufficient height (minimum of 12 inches) above the ground surface to prevent entry of surface and near-surface water.

Casing for artesian aquifers shall be sealed into overlying, impermeable formations in such a manner as to retain confining pressure.

If a zone is penetrated that is determined or suspected to contain water of quality unsuitable for the intended use, the zone shall be sealed to prevent infiltration of the poor-quality water into the well and the developed portion of the aquifer.

Sanitary protection. When the water from the well is apt to be used for human consumption, the sanitation requirements of KDHE shall be met.

Wells shall be located a safe distance from sources of contamination. In cases where water sources are severely limited, a ground water aquifer that might be contaminated may be considered for a water supply for human consumption only if adequate treatment is provided.

Local regulations, including those issued by ground water management districts, shall be considered when determining the minimum horizontal distances between the well and sources of contamination or other existing wells. Other considerations shall include depth to water, type of construction, vertical zone of influence, geological formations, and porosity of subsoil strata.

Well development. Well development shall be performed to repair damage done to the formation by the drilling process and to alter the physical characteristics of the aquifer surrounding the borehole so that water will flow more freely to the well.

The method of well development used shall be selected based on geologic character of the aquifer, type of drilling rig, and type of screen.

Aquifer development. For massive, unfractured rock that is unresponsive to well development procedures, the use of aquifer stimulation techniques may be considered to improve well efficiency and specific capacity. Techniques may include dry ice, acidizing, explosives, or hydrofracturing, depending on the composition and structure of the formation.

Grouting and sealing. The annulus surrounding the permanent well casing at the upper terminus of the well shall be filled with mortar containing expansive hydraulic cement (ASTM C 845) or bentonite-based grout. The length of the grout seal shall be no less than 10 feet and not less than the minimum specified in state or locally applicable construction codes.

If the water is intended for human consumption, the casing shall be surrounded at the ground surface by a 4-inch thick concrete slab extending at least 2 feet in all directions.

A positive seal (grouted in place) or packer shall be provided between the casing and the less pervious material overlying the aquifer of artesian wells and in all aquifers where co-mingling of waters is undesirable.

Access port. An access port with a minimum diameter of 0.5 inch shall be installed to allow for unobstructed measurement of depth of the water surface or for a pressure gage for measuring shut-in pressure of a flowing well. Access ports and pressure gages or other openings in the cover shall be sealed or capped to prevent entrance of surface water or foreign material into the well. Removable caps are acceptable as access ports.

Disinfection. Wells shall be disinfected immediately following their construction or repair to neutralize any contamination from equipment, material, or surface drainage introduced during construction. The disinfection process shall comply with all local or state requirements.

Water quality testing. Sampling and testing shall comply with all applicable federal, state, and local requirements. These requirements vary according to the water quality parameters associated with the intended use(s) of the water.

DEFINITION OF WELL TERMS

Diagram. See Figure 1 for a diagram of the following terms.

Static water table. The surface level of the ground water at the top of the saturated zone in a water-bearing formation is known as the water table.

Cone of depression. As water approaches a well that is being pumped, the water table decreases. As distance from the well increases, the slope becomes flatter until it merges with the water table level beyond the influence of the well. The water surface in the influence of a pumped well is an inverted cone with its apex in the well and its base in the static water table. This is known as the cone of depression.

Area of influence and circle of influence. The area affected by the discharge from a well is known as the area of influence. The boundary of the area of influence is known as the circle of influence. The radius of the circle is the radius of influence (R).

Profile of cone of depression (drawdown curve). If a cross section is made through a pumped well as shown in Figure 1, the water table appears in profile and is known as the profile of cone of depression.

Thickness of aquifer (H). This is the saturated thickness before pumping.

Pumping level (h). Depth of water in the well while pumping is known as the pumping level.

Drawdown (H-h). Drawdown is defined as the distance from the position of the static water table before pumping to the level of the water in the well during pumping.

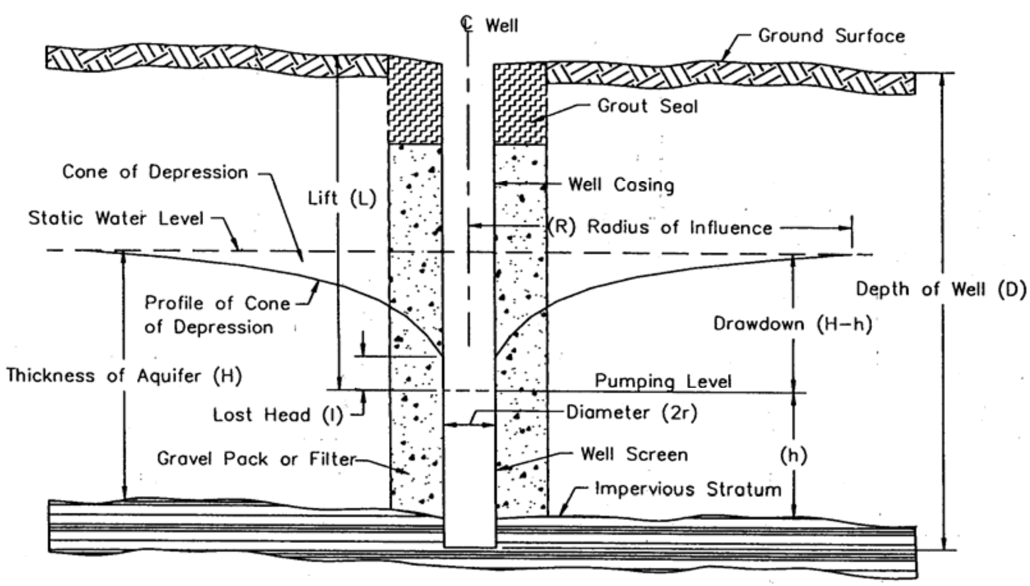

Figure 1 - Well terminology

Lift (L). The term lift or head (as applied to a pumped well) is defined as the vertical distance from the water level in the well during pumping to the ground surface or some other specified point as the center of the discharge pipe.

Lost head (l). Lost head is defined as the difference in the elevation between the water level inside the well (during pumping) and outside at the point where the drawdown curve intersects the casing.

Gravel pack or filter. This is a gravel envelope surrounding the casing and designed to prevent surrounding sand from entering the well.

Well casing. This is a rigid pipe installed in the well to prevent the walls of the well from sloughing into the well.

Well screen. A perforated or slotted section of pipe used to separate the water from the surrounding aquifer is a well screen.

Grout seal. This is a permanent impervious material injected between the casing and the walls of the borehole to form a seal. This seal prevents potentially contaminated surface and/or ground water from entering the well or (where necessary) aquifer mixing.

CONSIDERATIONS

The potential for adverse interference with existing nearby production wells shall be evaluated in planning.

The potential for ground water overdraft and the long-term safe yield of the aquifer shall be considered in planning.

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If practicable, wells shall be located in higher ground and up gradient from sources of surface contamination or flooding. In determining gradient, both pumped and unpumped conditions shall be considered.

Potential effects of installation and operation of the well on cultural, historical, archeological, or scientific resources at or near the site shall be considered in planning.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared for specific field sites in accordance with this standard and shall describe the requirements for applying the practice to achieve its intended uses.

OPERATION AND MAINTENANCE

A plan for maintenance of a well shall be prepared. The well construction records shall be kept on file with the maintenance plan by the owner/operator. As a minimum, the plan shall include a statement of identified problems, corrective action taken, date, and specific capacity (yield per unit drawdown) of well before and after corrective action was taken.

REFERENCES

National Engineering Handbook, Part 631, Chapter 33, “Investigations for Ground Water Resources Development.”