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.

PURPOSES

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.

CONDITIONS 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

General Criteria Applicable to All Purposes

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.

State laws and regulations impose certain restrictions on water well construction and development or water well reconstruction. (Reconstruction consists of well deepening or replacing, repairing, or perforating any part of the well casing.) 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.

General. The suitability of the well site and the type of well installed shall be based on detailed geologic investigations (including test well drillings); on ground water assessment studies made by local, state, or federal agencies; or on reliable local experience. The design should include ground water conservation measures, provisions for controlling intrusion of contaminants from adjacent aquifers or surface water, and methods for obtaining a maximum supply of sediment-free water.

Test holes. Unless the well is in an area of proven uniformity of water-bearing materials, a test hole shall be made at the well site and accurately logged to determine location, depth, and grain size of the aquifer.

Well diameter. The diameter of the well shall be adequate to convey the required discharge based upon the yield capacity of the aquifer. The diameter shall also be large enough to permit installation of a pump capable of providing the required discharge and pressure.

Casing and materials. All wells shall be cased, but the lower sections passing through consolidated strata do not require casing. Materials shall meet the requirements detailed under Construction Specifications 642, Well. Casing shall extend a minimum of 12 inches above the finished ground surface. A sanitary well seal shall be installed on the top of the well casing. All pump installations directly over the casing shall include an airtight and watertight seal between the top of the casing and the gear or pump head, pump foundation, or pump stand.

The design of well casing thickness should take into consideration a number of factors--including external fluid pressure, uneven loading due to type and method of backfill placement, forces from expanding clays, impact forces from collapse of the surrounding formation, and forces generated by development and completion practices. Most of these factors cannot be easily evaluated by numerical methods, and judgements must be made on the basis of detailed geologic or construction experience. Only collapse due to external fluid pressure may be readily evaluated.

Except where local experience indicates the need for stronger casings, the maximum depth for well casings shall be based on the Clinedinst Equation. This equation is contained in Appendix X2 of American Society for Testing and Materials (ASTM) F 480.

Engineering analysis may be used to determine the maximum depth of placement for a specific type of casing. Such analysis shall determine the maximum collapse pressure likely to occur during well development and during normal pumping operations. Factors to be considered in determination of maximum pressure during well development include development method, maximum depth of drilling fluid outside of the casing, specific gravity of the drilling fluid, minimum depth and specific gravity of fluid inside the casing, and method used to place gravel or grout backfill around the casing (if applicable). Factors to be considered in the determination of maximum pressure during normal pumping operations include distance to maximum static water level and long-term anticipated drawdown. The greatest value of these 2 pressures shall be compared to the critical collapse pressure given by the Clinedinst Equation for a specific casing material and wall thickness. The ratio of the maximum anticipated pressure to the Clinedinst critical collapse pressure shall not exceed 0.80 (80 percent Resistance to Hydraulic Collapse Pressure [RHCP]).

If an engineering analysis is not performed, the information contained in Tables 1 and 2 may be used to determine maximum depth of placement. This depth may be conservatively interpreted to be total well depth. If the maximum static water level elevation is known, then depth may be interpreted to be depth below this elevation. 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 depth limitations for polyvinyl chloride (PVC) well casing pipes having different standard dimension ratios (SDRs) and moduli of elasticity.

Values in Table 1 were calculated using the Clinedinst Equation with Poisson's ratio, u = 0.33. All depths were rounded to the nearest 5-foot increment. 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 2 gives the dimensions and maximum depth of installation for PVC Schedules 40 and 80 pipe constructed of material having a modulus of elasticity equal to 400,000 lb/in^2. The factors given at the bottom of this table may be used in calculating depth limitations for other PVC classifications.

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 1 - Maximum depth of installation for plastic pipe (SDR)

	PVC Material	
	Modulus of Elasticity (psi)	
	400,000	320,000
	Cell Classification	
	12454-B 12454-C	14333-D
	Designation Code	
	1120 and 1220	2110, 2112, 2116, 2120
SDR	Depth (feet)	
13.5	985	785
17	475	380
21	245	200
26	130	100
32.5	65	50

Table 2 - Dimensions and maximum depth of installation for Schedules 40 and 80 PVC plastic pipe

		Schedule 40			Schedule 80		
Nominal Diameter (in.)	Outside Diameter (in.)	Minimum Wall Thickness (in.)	SDR	Maximum Depth (ft.)	Minimum Wall Thickness (in.)	SDR	Maximum Depth (ft.)
4	4.5	.237	19	340	.337	13.4	1,010
5	5.563	.258	21.6	230	.375	14.8	740
6	6.625	.28	23.7	170	.432	15.3	660
8	8.625	.322	26.8	120	.5	17.3	450
10	10.75	.365	29.4	90	.593	18.1	390
12	12.75	.406	31.4	70	.687	18.6	360

Table 3 - Minimum thickness of metal casings for wells

Diameter	Minimum Wall Thickness	
	Steel Casing	Lightweight Galvanized Casing
(inches)	(inches)	(inches)
1 [2]	.133	--
1.5 [2]	.145	--
2 [2]	.154	--
2.5 [2]	.203	--
3 [2]	.216	--
3.5 [2]	.226	--
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)									
10 ga.	400	400	400	400	310	180	100	90	60	--
8 ga.	500	500	500	500	455	305	210	150	105	--
7 ga. [1]	600+	600	600	600	600	430	320	210	150	--
3/16 in.	--	600+	600	600	840	500	370	250	170	70
7/32 in. [1]	--	--	600+	600+	1340	800	600	400	280	110
1/4 in. [1]	--	--	--	--	--	1190	890	600	420	170
9/32 in.	--	--	--	--	--	--	1280	850	590	250
5/16 in. [1]	--	--	--	--	--	--	--	1170	820	340
11/32 in.	--	--	--	--	--	--	--	--	1100	460
3/8 in. [1]	--	--	--	--	--	--	--	--	--	600
7/16 in.	--	--	--	--	--	--	--	--	--	960

[1] Sizes listed by KDHE in Article 30

Screens. All wells constructed to recover water from unconsolidated aquifers shall be equipped with manufactured screen sections, well points, or field perforated sections meeting the criteria stated below. The screen openings for aquifer material of near uniform size shall be smaller than the average diameter of the aquifer material. The screen or slotted casing section must be protected with a device immediately above the intake section (if necessary) to prevent well stabilizer materials from entering the intake section area.

For aquifer materials of non-uniform gradation, the screen shall be sized so that 25 to 40 percent of the aquifer material is larger than the screen opening. For wells in which a gravel pack envelope is used, the screen shall have openings that will exclude at least 85 percent of the gravel pack material. The length and open area of the screen shall be adequate to maintain the entrance velocity of water into the well at an acceptable level, preferably less than 1/10 ft/s.

The position of the screen in the well shall be governed by the depth of the aquifer below the ground surface and the thickness of the aquifer to be penetrated by the well. If practical, the top elevation of the screen shall be below the lowest water level expected during pumping and be located opposite the most permeable area in the waterbearing strata.

Filter pack. Sand or gravel filter packs shall be used in wells constructed in fine material of relatively uniform grain size to prevent the aquifer materials from passing through the well screen or the perforated casing. The pack shall be 3 inches to 12 inches thick and shall consist of sand or gravel material having a D30 grain size 4 to 9 times the D30 grain size of the aquifer material. Refer to Chapter 12 in National Engineering Handbook Part 650, Engineering Field Handbook, for more detailed design criteria. Provisions shall be made for centering the casing in the filter pack.

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. The recommended minimum horizontal distance between the well and sources of potential contamination is shown as follows:

Source of Contamination	Minimum Distance (ft.)
Waste disposal pond or lagoon	300
Cesspool	150
Silo pit, seepage pit	150
Livestock and poultry yards	100
Privy, manure pile	100
Septic tank and disposal field	100
Gravity sewer or drain (not pressure-tight)	50
Gravity sewer or drain (pressure-tight), property line	25

Wells shall be located so as to minimize the risk of contamination from flooding. Proper drainage shall be provided to prevent ponding and concentrated flow of surface water within 50 feet of the well. Drainage that might reach the well from areas used by livestock shall be diverted. Wells must be readily accessible for maintenance and repair and be located a safe distance from overhead utility lines or other safety hazards. Each well shall be provided with a watertight cover or seal to prevent the entry of contaminated water or other objectionable materials. The annular space around the casing shall be at least 3 inches and shall be filled with cement grout, bentonite clay, or other suitable materials to a depth that will seal off surface waters. A positive seal shall be provided between the casing and the impervious material overlying the aquifers of artesian wells.

Any water used for drilling will be disinfected before use. This includes both well or surface water.

Gravel for gravel-packed wells shall be disinfected by immersing the gravel in a chlorine solution containing not less than 200 mg/l of available chlorine before it is placed in the annular space of the well.

Constructed or reconstructed wells shall be disinfected by adding sufficient hypochlorite solution to them to produce a concentration of not less than 100 mg/l of available chlorine when mixed with the water in the well.

The pump, casing, screen, and pump column shall be washed down with a 200 mg/l available chlorine solution.

All persons constructing, reconstructing, or treating a water well and removing the pump or pump column, replacing a pump, or otherwise performing an activity which has potential for contaminating or polluting the ground water supply shall be responsible for adequate disinfecting of the well, well system, and appurtenances thereto.

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.

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. 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.

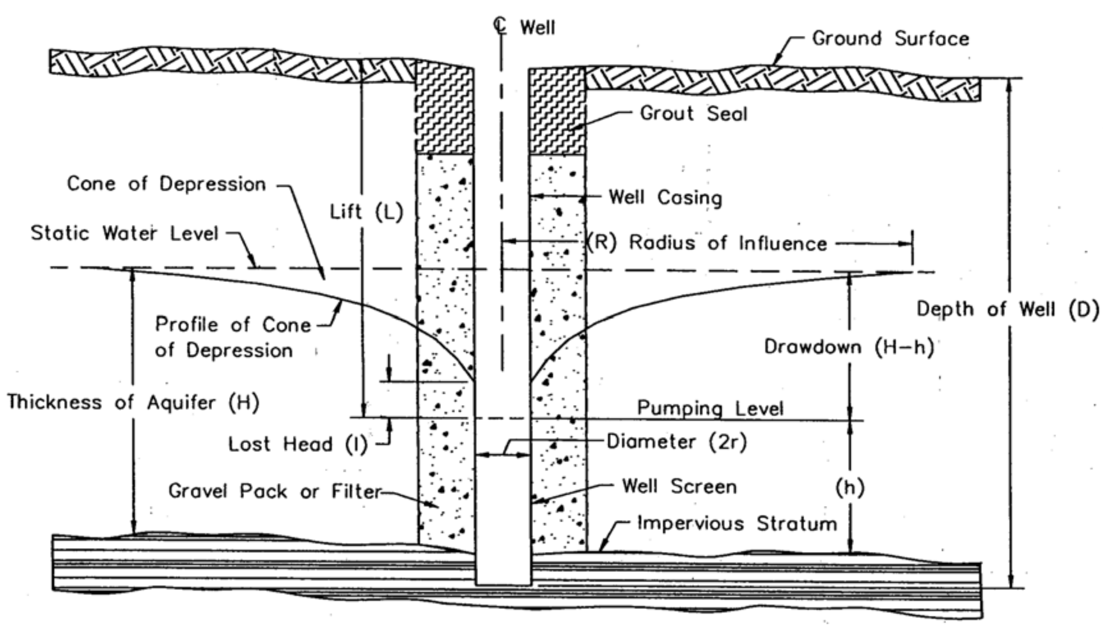

Figure 1 - Well terminology

CONSIDERATIONS

Wells should be located on sites that facilitate distribution of water and are accessible to the aquifer with typical water-well construction equipment. Where applicable, wells should be planned in conjunction with distribution and storage facilities such as pipelines and tanks.

The effects of well development and operation on adjacent water uses should be considered. In many instances, development may be subject to regulation by the Kansas Division of Water Resources or ground water management districts. Extensive development may interfere with the operation of adjacent wells or alter water table elevations.

Consider the effects of water removal from the aquifer versus water available for recharge. From an economic aspect, considerations include the value of the water, installation and operation costs, probable life of the well, and costs of plugging an abandoned well.

The long-term effects of ground water use should be considered. Use of large volumes of poor quality ground water for irrigation purposes may result in toxic levels of salts or trace elements in the soil along with internal drainage problems. Irrigation tailwater derived from such ground water may impact adjacent streams and impoundments. Consumption of poor quality ground water by livestock may result in adverse health effects. Such problems may be anticipated by water quality testing prior to final development.

Methods and procedures for the construction, development, and operation and maintenance of wells should be considered that will minimize adverse effects to surface or ground water quality. Some considerations include protection of confined aquifers, well head design, and protection from contamination by distribution systems (e.g. chemigation and other mixing operations).

PLANS AND SPECIFICATIONS

Plans and specifications for the well shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

Construction and material specifications shall be developed which conform to KDHE Article 30, Water Well Construction and Abandonment.

For access to Article 30, Kansas Statutes Annotated, and Kansas Administrative Regulations, refer to the KDHE website at http://www.kdhe.state.ks.us.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed and reviewed with the landowner or individual responsible for operation and maintenance. 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.