Design Guidelines for Rural Residential Community Water Systems

2007

Canadian Cataloguing in Publication Data

Main entry under title:
Design guidelines for rural residential community water systems

Previously published 1988.
Includes bibliographical references: p.
ISBN 0-7726-3507-2

1. Water-supply, Rural - Standards - British Columbia. I.Land & Water BC Inc.. Water Management Branch.

TD927.D47 1998 628'.72'0218711 C98-960076-9

For more information and copies of this document, contact:

Ministry of Environment
Water Stewardship Division
Utility Regulation Section
PO Box 9340 Stn Prov Govt
Victoria BC V8W 9M1
Telephone: 250-387-6341
Facsimile: 250-953-5124
Email: WaterUtilityReg@gov.bc.ca

Table of Contents

Foreword

These guidelines cover the design of new waterworks systems or extensions and replacement works to existing systems providing domestic water service for housing in rural areas. They have specific application for water utility systems and may be applicable to most rural residential water systems operated by improvement districts, regional districts or municipalities.

In general, the contents herein are intended to augment pertinent, commonly accepted standards such as those published by Canadian federal and provincial governments, the American Water Works Association and other related agencies in the United States. This document provides minimum values for the design of a rural community water system. The information will be reviewed periodically and amended as necessary in response to appropriate input from consulting engineers and other related technical agencies.

In rural subdivisions currently being developed, the quality of housing is comparable to that found in municipalities. Consequently, it is expected that the water systems will be designed to a standard that is equivalent to municipal water systems. The design of a rural water system also needs to take into account the nature of its operation. Most rural water authorities, including utilities, are remotely located and are operated and maintained by part time staff. Therefore, it is important that the systems be relatively simple to operate and maintain.

The jurisdictions regulating waterworks systems in British Columbia may be summarized in the following manner.

Utility Regulation Section is responsible for licensing and regulating the provincial water resource under the *Water Act*, and regulating water utilities under the *Water Utility Act* and the *Utilities Commission Act*, which is the responsibility of the Utility Regulation Section. Water utilities are regulated by the Comptroller of Water Rights in Victoria and the *Water Act* is generally administered from four major service centres located in Kamloops, Nanaimo, Prince George and Surrey.

Regional Health Authorities are responsible for the health aspects of public water supply under the *Drinking Water Protection Act*. The authorities have an approval and monitoring role with regard to water quality, approve the design of water systems and issue operating permits which authorize the operation of community water systems.

Other government agencies have jurisdiction over various aspects of public water supply including but are not necessarily limited to the following:

- Ministry of Community, Aboriginal and Women's Services – general administration of municipal water supply agencies
- Ministry of Transportation – highway crossings, pipeline routes in public roads, and some subdivision approvals
- Ministry of Community, Aboriginal and Women's Services – Safety Engineering Services
- Regional Districts, Improvement Districts and Municipalities (see CAWS)
- Worksafe BC – construction and operation safety practices

Where there is a fire protection authority in the development area, it should be consulted for the requirements to be met for the proposed development.

The electrical system must be designed and constructed to the approval of the local electrical inspector in accordance with the requirements of the Canadian Electrical Code.

In these guidelines, the use of "shall", or similar imperative, implies a statutory requirement. The use of "should" indicates a strong recommendation.

Role of the Consulting Engineer

The design and construction supervision is carried out by a professional engineer or limited licensee experienced in the waterworks industry. The terms of reference under which the engineer is hired by the developer or utility should specify that the engineer is responsible for both the design and construction supervision of the system or extension.

Design drawings are prepared in sufficient detail to be used to construct the works and as-built drawings contain information that will be useful to the operator in locating system components. The engineer provides certification that the works have been satisfactorily completed in accordance with the design.

The engineer is responsible for determining the requirements of the agencies having jurisdiction over other aspects of the water system. Particularly, with respect to high density developments, this responsibility includes contact with the fire protection authority to determine the required fire fighting provisions.

1. Source of Supply

The design engineer will need to provide information showing that an adequate quantity of water is available to meet the demand.

1.1 Surface Water

A hydrology study by a professional hydrologist may be required to confirm the availability of water.

The reliable yield of the source, after the flow has been regulated by any seasonal balancing storage, should be adequate to supply the design maximum day demand during a moderate drought in the summer. A moderate drought is considered to be a period of low stream flow with an average frequency of once in twenty five years.

1.2 Groundwater

Wells are to be located, constructed, tested and disinfected in general accordance with the "Guidelines for Minimum Standards in Water Well Construction, Province of British Columbia". In addition, wells are to be protected from possible sources of contamination having regard to land use adjacent to the well and over the recharge area of the well. A well protection plan may be required.

The total developed groundwater capacity, or dependable yield of the well(s), should equal or exceed the design maximum day demand. The groundwater source(s) need to sustain this rate of flow continuously for 100 days in the summer, during which the aquifer would not be recharged by precipitation and without utilizing more than 70% of the available drawdown below the lowest seasonal static groundwater table.

1.3 Water Quality

The publication "Guidelines for Canadian Drinking Water Quality" is used as a guideline for evaluation of water delivered to the customer.

In general, these standards require that water supplies for drinking, culinary and other domestic uses be free of pathogenic organisms and their indicators, and free of deleterious chemical substances including radioactive materials. In addition, the water should not have an objectionable colour, odour or taste and should be neither unduly corrosive nor unduly encrusting.

1.4 Impounding Reservoirs

Impounding reservoirs are designed to prevent, insofar as it is practicable, deterioration of raw water quality by minimizing contact with organic materials (grass, peat, trees, etc.) and avoiding shallow water areas and embankment erosion.

1.5 Treatment

Where there are problems with the potability of the source or aesthetic concerns, the provision of treatment may be a condition of source approval.

2. Demand

The projected demand should be sufficient to satisfy the reasonable expectations of all residents to be served. It is usually estimated from reliable records of present consumption in representative community water systems. When reliable records are not available, the design engineer should study the needs of the service area and estimate the average day, maximum day and peak hour demands. These may include but not necessarily be limited to:

a. indoor household use,
b. outdoor residential uses, including lawn and garden watering,
c. replenishment of reserve storage, and
d. allowance for losses due to such things as leakage, flushing of water mains, streets and sewers, and backwashing of filters.

2.1 Indoor Household Use

Basic in-house use is well established at about 230 litres (50 Imp. gal.) per capita per day and varies only slightly with locality.

2.2 Lawn and Garden Watering

By far the largest portion of maximum day use will be for lawn and garden watering. The quantity needed depends on the area to be watered, climate during growing season, soil type and a number of less significant variables.

The quantity of water needed for lawn and garden watering may be obtained by multiplying the area to be watered by the appropriate irrigation rate (within the range given in Table 1) for each of the three climatic zones shown in Figure 1.

Table 1 Peak Irrigation Requirements

Climatic Zone	Irrigation Rate per Day at 70% efficiency		Irrigation Rate per Day at 50% efficiency	
	m^3/ha	Imp. gal./ac.	m^3/ha	Imp. gal./ac.
Temperate (except wet coastal and northern areas)	61-73	5,500-6,500	86-102	7,700-9,100
Intermediate	76-87	6,800-7,800	106-122	9,500-10,900
Arid	91-116	8,100-10,400	126-163	11,200-14,500

The rates are given for two efficiencies of application: 70%, as in a well managed sprinkler system, and 50%. To water with 70% efficiency, home gardeners must exercise considerable restraint, which cannot usually be achieved without metering. Unless all service connections are to be individually metered, only 50% watering efficiency may be expected because lawns and gardens will usually be watered more extravagantly and with less attention to control waste.

The lower rate of a given range in Table 1 applies at higher elevations or adjacent to the next wetter zone. The higher rate applies in the valley floor or adjacent to the next drier zone.

Irrigation rates are not applicable for northern or wet coastal areas, where lawn and garden sprinkling requirements are minimal.

2.3 Requirements for Maximum Day Demand

The design maximum day demand consists of adequate water for lawn and garden watering **plus** a minimum of 1.1 m^3 (250 Imp. gal.) per day per single dwelling unit for all other purposes.

Except where otherwise evident, the lawn and garden area assumed to need watering is:

a. for each single family detached house - 0.04ha (0.1 acre); and
b. for high density development (i.e., mobile home parks and multi family dwellings such as duplexes, apartment buildings or

condominiums) - all available land not occupied by buildings, driveways, etc.

Table 2 gives the design maximum day demand for **single family detached housing**. These are total quantities required for all purposes in most circumstances.

To determine an acceptable design maximum day demand for high density housing, add 1.1 m^3 (250 Imp. gal.) per day for each single family dwelling to the quantity needed for lawn and garden watering of the entire irrigable area.

Table 2 Design Maximum Day Demand for Typical Single Family Detached Housing

	Maximum day demand per dwelling			
Climatic Zone	**All services metered** (watering efficiency 70%)		**No meters** (watering efficiency 50%)	
	m^3	Imp. gal.	m^3	Imp. gal.
Temperate (except wet coastal and northern areas)	4.1	900	5.3	1,150
Intermediate	4.7	1,050	6.1	1,350
Arid	6.4	1,400	8.2	1,800

2.4 Large Lots

The quantities in Table 2 include the watering of average 0.04ha (0.1 acre) gardens. It would be advisable to provide water for larger gardens in subdivisions of arable land into large single family lots, i.e., lots over 0.12ha (0.3 acre).

3. Intakes

Design intake works to optimize water quality, minimize maintenance and adverse environmental impacts, and not obstruct the passage of vessels in navigable waters. To limit the disturbance to the aquatic environment, intakes for waterworks systems that will be expanded in stages should be sized for the ultimate capacity. In order to protect fish in a stream, intake screens shall be designed to meet the requirements of the Department of Fisheries and Oceans.

Site river intakes in a stable reach of the channel, where erosion or deposition will not endanger the works, and in a location where the natural flow regime of the river will not be upset.

Design screens to be self cleaning or to facilitate easy cleaning.

Grade submerged intake pipes in rivers and lakes to prevent accumulation of gasses and anchor or bury them adequately. In addition, make provision to remove sediment by back flushing or other means.

Protect intake works against manipulation by unauthorized persons, the accumulation of ice and pollution (from domestic, industrial or other harmful wastes or runoff). Its also important that intakes are reasonably accessible in all seasons.

4. Disinfection of Water Supply

4.1 Surface Water (including shallow wells)

All new surface water sources and unprotected groundwater (shallow wells) intended for new or existing domestic waterworks systems shall be disinfected as required by the regional health authority.

4.2 Ground Water (deep wells)

Where the regional health authority considers it necessary for sanitary control, a deep-well groundwater source of domestic supply will require disinfection.

4.3 Means of Disinfection

Chlorine is the most commonly used disinfecting agent. Chlorination may be accomplished with sodium or calcium hypochlorites or with liquid (gas) chlorine. Other disinfectants, including ozone and ultra violet, may be considered.

Liquid (gas) chlorine facilities are generally restricted to water systems where qualified operators, trained and equipped to handle any emergency, will be available to operate and maintain the equipment on an ongoing basis.

Requirements for chlorine contact time and free chlorine residuals can be obtained from the local medical health officer. Automatic proportioning equipment is used where the rate of water flow is variable.

Sodium and calcium hypochlorite facilities should include a cool, dark, dry, clean, above ground and vented area for the storage and use of the hypochlorite disinfectant. For hypochlorite facilities include covered make-up and feed solution tanks.

All chlorine handling and storage facilities shall conform to the requirements of the *Workers' Compensation Act*.

5. Pumps

5.1 Number of Units

Wherever water is to be supplied by pumping, excluding wells, install at least two pumping units. With any pump out of service, the remaining pump(s) should be capable of delivering the maximum day demand. In the selection of new pumps, make reasonable allowance for reduction of output due to wear.

In wells where only one pump unit is to be installed, consider having a spare replacement unit readily available.

5.2 Individual Home Booster Pumps

Individual home booster pumps will not normally be acceptable for individual service connections.

5.3 Protection

Design pumping facilities to maintain the sanitary quality of the pumped water. Pumping stations should be above ground, constructed of concrete block and protected from flooding.

6. Electrical

6.1 Design

The electrical system should be designed by a qualified electrical engineer or limited licensee conversant with the design of the water system. See Appendix 1 for detailed electrical design guidelines.

6.2 Auxiliary Power

Where electric supply failure may be expected to be frequent and would result in cessation of minimum essential service, provide an auxiliary source of power, sized so that the system can deliver fire flows plus maximum day demand.

7. Distribution Storage

Finished-water storage facilities should have sufficient capacity to control the operation of pumps, balance the fluctuation in domestic demands, including lawn and garden watering, and provide emergency and fire protection reserves. This storage should be reliably available, preferably by gravity. If site conditions preclude elevated storage, pumping from ground level storage may be considered, in which case auxiliary power should be provided.

7.1 Storage Capacity

Provide storage for balancing, emergency use and fire protection. Unless otherwise determined by engineering studies, storage to control pumps, balance fluctuations in domestic demand and stabilize pressures should not be less than 25% of maximum day demand. Emergency storage also should not be less than 25% of maximum day demand.

Fire storage should be a minimum of 114 m^3 (25,000 Imp. gal.). This will provide a fire flow of about 1.9 m^3 (400 Imp. gal.) per minute for one hour (in accordance with Fire Underwriters Survey “Water Supply for Public Fire Protection – A Guide to Recommended Practice”, 1991).

Based on the maximum day demands given in Table 2, and the foregoing requirements for emergency and fire protection storage, the minimum volume of storage should be as shown in Figure 2.

7.2 Pressure Tanks

Hydropneumatic tanks are acceptable as a means of providing pump control but not for providing balancing, emergency and fire protection storage, no matter how small the system.

7.3 Reservoir Design

Preferably storage reservoirs are buried, reinforced concrete structures constructed with two cells for ease of maintenance. In situations where the site is inaccessible or low pressures would result, other types of reservoirs may be considered.

Good reservoir design includes: water level controls which are protected from freezing; access hatches in the roof that are elevated to prevent drainage water from entering the reservoir; vents designed to exclude birds, vermin and dust; and separate inlet and outlet pipes, positioned to allow the circulation of water within the reservoir.

Overflows and drains should be capable of safely discharging the greatest possible inflow, should not have a direct connection to a sewer or storm drain, and should be located so that any discharge is visible.

8. Distribution Pipe

Size all water distribution pipes, including service connections, according to flow demands and pressure requirements.

8.1 Pressure

Design the system to maintain a minimum residual pressure of 140 kPa (20 p.s.i.) at ground level at all points in the water authority’s distribution system under all conditions of flow, including maximum day demand plus a minimum fire flow of 1.9 m^3 (400 Imp. gal.) per minute.

At locations where buildings are to be equipped with automatic sprinkler systems for fire protection, a higher pressure may be required in the distribution mains during the fire flow than would otherwise be required where the fire protection is to be provided by water pumped from hydrants.

The working pressure at peak hourly flow (excluding fire flow) in the water authority's distribution system should ideally be about 400 kPa (60 p.s.i.) but within a range between a minimum of 275 kPa (40 p.s.i.) and a maximum of 700 kPa (100 p.s.i.) at the living floor elevation. To reduce the number of pressure zones required and where only a few sites would receive pressures exceeding 700 kPa (100 p.s.i.), individual pressure reducing valves may be allowed in dwellings.

A steady working pressure is desirable. Fluctuations should not exceed 20% of working pressure at peak hourly flow at the water authority's shut-off on a customer's service connection.

8.2 Minimum Size of Distribution Mains

The minimum diameter of distribution mains is 150 mm (6 in.) except within 100 m (300 ft.) of a cul-de-sac or other dead end termination such as a body of water, ravine, railway embankment or similar obstruction. A dead end termination would preclude the possibility of future extension, in which case 100 mm (4 in.) may be acceptable.

8.3 Minimum Size of Service Pipes

In determining the acceptable pressure loss in the service pipe between the distribution main and the customer's property line (hence the minimum pipe size), consider the probable location of dwelling(s) on the customer's lot, the working pressure in the main, and whether or not a water meter is to be installed. The minimum size of service pipe should be 19 mm (3/4 in.).

9. Waterworks for Fire Protection

9.1 Hydrants

Provide tees with minimum 150 mm (6 in.) outlets for fire hydrants in the distribution system at suitable locations for fire fighting and not more than 300 m (1,000 ft.) apart measured along public access routes. Where a fire authority exists or is proposed in the vicinity, install hydrants; otherwise install standpipes off the hydrant tees.

An isolation valve should be installed on each hydrant lead and both valve and lead should be minimum 150 mm (6 in.) diameter.

Where practical, locate hydrants and standpipes for the dual purpose of fire fighting and system flushing. Hydrants need to be exercised periodically and serviced after use.

Fire hydrants should be dry barrel type and have at least two 60 mm (2 ½ in.) nozzles with British Columbia standard fire hose thread.

9.2 Standpipes

Install a key operated isolation valve on each standpipe lead and both valve and lead should be minimum 50 mm (2 in.) diameter.

Standpipes should be minimum 50 mm (2 in.) diameter galvanized steel or ductile iron, self draining, dry barrel type. The outlet should have a British Columbia standard 60 mm (2 ½ in.) fire hose thread with cap securely fastened to the standpipe while permitting free rotation.

10. Water Meters

10.1 Metering of Supply

Provide an acceptable means of metering and recording the supply of water taken from the source.

10.2 Customers' Services

For new systems, provide water meters on individual customer's service connections.

11. Materials

All waterworks materials, including steel tanks (where approved), pipe, fittings, valves, hydrants, etc., should conform to the latest standards of the American Water Works Association (A.W.W.A.) or, in the absence of applicable A.W.W.A. standards, to such other standards as may be approved.

All electrical equipment and materials shall be approved by the Canadian Standards Association or specially approved by the local electrical inspector.

Hydropneumatic tanks shall be constructed to comply with *B.C. Power Engineers and Pressure Vessels Safety Act*.

Painting, repainting and coating of all steel tanks, including elevated steel tanks, should conform to applicable A.W.W.A. standards.

All pressure pipe, including polyvinyl chloride (PVC) pipe, should conform to the applicable A.W.W.A. standard.

All waterworks materials should be approved by the local public health engineer and should be suitable for use in potable water systems. Manufacturer's or supplier's certification may be required.

12. Installation

Specifications should incorporate the provisions of A.W.W.A. standards or manufacturers' recommended installation and testing procedures.

All water works should be adequately protected from freezing. Install buried pipe below the maximum depth of frost penetration except where special precautions such as insulating the pipe have been approved.

Lay water pipes at least 3 m (10 ft.) horizontally from any sewer or storm drain unless otherwise approved by the local public health engineer.

Where this horizontal separation is not possible, e.g., where water and sewer pipes must cross or share the same trench, the water pipe should be at least 0.5 m (18 in.) above the sewer or storm drain and should be located on the opposite side of the common trench. If this vertical separation is not possible, the sewer or storm drain should have the same pressure rating as the water pipe.

12.1 Disinfection of Works

All new or newly repaired waterworks system components shall be disinfected according to A.W.W.A. standards or other equivalent method, as directed by the local public health officer, before being put into use.

To prevent environmental hazard, disinfected water should not be discharged directly or indirectly into streams, rivers or lakes without prior treatment to remove or reduce detectable residual chlorine to limits approved by the local environmental protection officer.

13. System Layout

13.1 Simplicity of Layout and Operation

A simple layout is desirable. Loop distribution pipes where practical and minimize the number of dead-ends. Where dead-ends are unavoidable, provide standpipes or hydrants for flushing purposes.

13.2 Water Service Planning

Wherever practical, water systems should be planned to facilitate emergency exchange of water between, and possible eventual integration with, neighbouring community water systems.

13.3 Distribution Valving

Install valves in the distribution system in accessible locations such that conveniently sized segments of the system can be isolated for ease of maintenance and repair. This may require valves on all branches of tees and crosses.

13.4 Air and Vacuum Valves

Consider installing properly sized air release and vacuum relief valves at high points in water mains. These valves vent the pipe on filling, release accumulated air under normal operating conditions, and introduce air into the pipe on draining. The functions may be combined in a single air valve.

13.5 Location within Public Rights of Way

Wherever practical and where permits can be obtained, lay all supply and distribution pipe, including the water authority’s portion of service pipe to customers, within road allowances and other public rights of way, existing or planned.

Works owned and operated by the water authority normally terminate at, and include, a curb stop and drain valve and valve box located adjacent to the customer's property line, with the exception that the water authority may own a water meter installed on the customer's property.

Where it is necessary to supply a property via a service pipe across an adjacent property (due to unusual lot layouts or other site specific conditions), an easement in favour of the property to be served shall be obtained. The owner of the property served shall be responsible for the service line within the easement. Only one customer should be connected to that service pipe.

13.6 Easements, Statutory Rights of Way and Restrictive Covenants

A water authority's works that will be located on privately owned land should be within an easement or statutory right of way registered in favour of the water authority in perpetuity. The minimum practical width of an easement for a buried pipeline is 6 m (20 ft.).

Restrictive covenants on use of land may be required to protect a water authority's source of supply or works, or may be required to restrict building elevations to ensure minimum pressure requirements are met.

13.7 Working Space

Locate structures and buried facilities within parcels of land and easements in such a way that there will be ample space for access, maintenance and replacement of works.

Locate storage structures and pump houses within parcels of land and easements in such a way that additional storage or pumping capacity may be added at the site, especially if future expansion of the water authority's service area is anticipated.

14. As-Built Drawings and System Certification

As-built drawings of the water system are required to be submitted. These drawings show the location of all works, including buried works, by dimensions to legal survey lines accurate to the nearest 0.3 m (1 ft.). Plan drawings overlay a composite legal base. Key elevations and pressure zones are shown on distribution system drawings.

All drawings are signed and sealed by a professional engineer or limited licensee registered to practice in the province of British Columbia. The same professional engineer should submit a letter certifying that the water system was constructed substantially in accordance with the as-built drawings and that the system was tested and disinfected in accordance with A.W.W.A. manuals of practice.

References

A.W.W.A. Standards	American Water Works Association 6666 W Quincy Avenue Denver CO USA 80235
Guidelines for Canadian Drinking Water Quality	Canada Communications Group - Publishing Ottawa ON K1A 0S9
B C. Power Engineers and Pressure Vessels Safety Act	Ministry of Community, Aboriginal and Women’s Services Boiler & Pressure Vessels Safety Branch Safety Engineering Services Division Ste 300 – 750 Pacific Blvd. South Vancouver BC V6B 5E7
Electrical Safety Act	Ministry of Community, Aboriginal and Women’s Services Electrical Safety Branch Safety Engineering Services Division Ste 300 – 750 Pacific Blvd. South Vancouver BC V6B 5E7
Guidelines for Minimum Standards in Well Construction	Groundwater Section Water, Air and Climate Change Branch Ministry of Water, Land and Air Protection PO Box 9340 Stn Prov Govt Victoria BC V8W 9M1
Navigable Waters Protection Act, Canada	Canadian Coast Guard Navigable Waters Protection Division Ste 350 - 555 West Hastings St. Vancouver BC V6B 5G3
Workers Compensation Act	Worksafe BC 951 Westminster Highway Richmond BC V7C 1C6

Appendix 1

1. Electrical Design Guidelines

1.1 General

Successful operation of a pumped water supply system depends on a secure supply of energy and proper control and protection of the equipment. Electrical equipment and supply and control systems should be properly designed, constructed and maintained in order to ensure satisfactory operation and safety to personnel.

The BC Safety Authority publishes and enforces regulations governing construction of electrical systems. The regulations are contained in the current edition of the Canadian Electrical Code Part I, as adopted and amended for use in British Columbia.

An electrical installation should be designed by an electrical engineer or limited licensee knowledgeable in power and control circuitry, electrical protection, safety requirements and the requirements of the water system, or by an electrical control company having similar knowledge. Suitable schematic and layout drawings, signed and sealed by a professional engineer, are prepared prior to commencing the installation or purchasing equipment.. If the drawings are prepared by an electrical control company, they should be reviewed and approved by an electrical engineer or limited licensee. The drawings must be submitted to the local electrical inspector, who can often make useful suggestions based on knowledge of local conditions. The electric supply utility should also be contacted for confirmation of electrical supply information. The telephone company should be contacted if its system forms part of the control or alarm functions.

All new electrical installations shall be inspected and approved by the local electrical inspector. Connection to the electric utility will be authorized only after the installation is inspected and accepted. The engineer should prepare as-built drawings and certify that the installation has been satisfactorily completed. If the as-built drawings are prepared by an electrical control company, they should be reviewed by an electrical engineer or limited licensee who should provide a signed and sealed letter stating that the installation was completed in accordance with the drawings and was tested and operates satisfactorily as designed.

The frequency and length of power outages and the storage capacity and drawdown rate of reservoirs are factors determining the need for standby electric generators (diesel or gas engine driven). A standby system shall meet both the Electrical Code and the electric utility's safety standards.

Single-phase services are generally adequate for small electrical systems. However, economics and electric utility regulations usually dictate the use of three-phase systems where motors larger than about 6 kw (8 hp) are required.

1.2 Power and Control Systems

Each electrical system requires:

- a kilowatt-hour meter owned by the electric utility;
- a service switch (fused or circuit breaker type) that allows the whole of the electrical system to be disconnected from the supply;
- a lightning arrestor on the main service;
- power distribution and control equipment for the pumps;
- adequate lighting for safe access and maintenance; and
- adequate heat and ventilation.

Both manual and automatic control of the pumps is usually provided. Manual control is provided for testing purposes and also to permit pump operation upon failure of the automatic controls. The degree of automation required is a "value judgement" considering safety, economics, convenience and reliability.

Each pump should have the following control:

- an adjustable motor circuit interrupter for short circuit protection;
- a magnetic contactor which incorporates an adjustable, manually re-settable, overload protection relay to monitor the motor current and shut down the pump if the current exceeds the motor manufacturer's recommended values;
- a HAND-OFF-AUTOMATIC control selector switch;
- an elapsed time meter to total the hours of operation of the pump;
- a green indicator light which turns on when the pump is running;
- a control power-on light to allow the operator to determine if power is available to operate the controls;
- a red alarm indicator light which turns on to indicate pump trouble, and;
- single phase protection for three phase systems.
- An ammeter and phase switch is optional.

Single phasing, which can cause motor burnout, often results when one of the electric utility’s distribution lines are broken and the other phases remain energized. A motor might continue to run when this occurs, although it cannot be started. Higher-than-normal current and overheating of the motor can result. Overload protectors are generally designed to provide single phase protection. The designer should confirm that the protector selected is adequate, or should provide a separate voltage-sensing type of relay to detect loss of one or more phases and shut down the motors.

A "lead-lag" pump-sequence manual selector switch or an automatic control alternator should be installed to even out the wear of pumps of similar size in a multiple-pump installation, instead of leaving a particular pump in the leading (first started) control position.

Multiple pump systems should have controls designed for time-delayed automatic restarting of the pumps which ensures staggered starting of the pumps after a power outage. This will avoid low voltage which could result in motor overheating, or magnetic controllers and relays dropping out, i.e., failing to maintain their contacts closed.

A well pump should be provided with a protection device that will shut it off in the event that the well water level drops below a level that will adversely affect the pump operation. A number of methods are available to perform this protective function. A red alarm light requiring manual resetting should be provided to draw attention to the problem if it occurs. All other pumps should be provided with protective devices that will shut them off if there is a loss of water supply to the pump.

For booster pumping systems that do not include balancing storage, pumps should be controlled in a manner that does not adversely affect pump operation and that does not consume excessive electrical energy.

Reservoir level control systems should use either loop-powered pressure transmitters or loop-powered ultrasonic transmitters. These devices can provide a remote level indication at the pump station and can provide operating levels for several pumps as well as high and low reservoir alarms. This can all be provided over a single pair of wires. Any changes to operating levels can be made at the pump house. The high level alarm should override individual pump controls to shut off all pumps.

1.3 Alarm Systems

An alarm system provides warnings of trouble. Its signals can be transmitted by leased telephone lines, private lines or radio to an agency headquarters or a private home. Alternatively, it can be designed to operate a light or audible device in a prominent location to attract attention. A separate electrical contact provided for each of the following alarm conditions can be used to initiate a general alarm signal.

- motor overload
- power failure
- low pressure
- low reservoir level
- high reservoir level
- security (break-in)
- pump control failure
- standby generator trouble

The system design should make it possible to differentiate the individual causes of alarms.

1.4 Construction

Electrical equipment should be housed above ground with good ventilation. Floor drains should be provided with P-traps or screens to prevent entry of vermin.

Power, control and alarm wiring installed on poles is usually the least expensive form of construction but might be susceptible to damage from falling branches or trees, or vehicle accidents. Underground wiring can be directly buried or pulled through buried electrical ducts. Warning tape buried about ½ metre (1½ feet) above the underground wiring will caution anyone excavating in the area.

If mounted outdoors, electrical equipment should be suitably enclosed and protected from moisture, extreme temperatures and vandalism. One metre (3 feet) minimum working space should be provided in front of the equipment for maintenance. There should be ample room for removal of pumps and motors. Overhead wires should have proper clearance over vehicle access and be away from hatches.

1.5 Operation and Maintenance

Where practical, the electrical system designer should attend start-up to check all the protection and explain the operation of the system.

A copy of electrical drawings, manufacturers' handbooks, and step-by-step explanation of the control logic should be kept in a convenient, safe and dry place, normally in the pumphouse.

Any well-designed and constructed system can fail because of inadequate maintenance. All electrical equipment should be inspected and all functions checked annually. Records should be kept of the motor currents and voltages and the maintenance work done.