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SUBJECT: Water – Design – Package Water Treatment Plants

DELETE Working Memo 408

DEFINITION

A package water treatment plant is distinguished from a custom- designed plant in that package plants are factory built, skid mounted, and transported virtually assembled to the operation site. Package plants generally include all treatment equipment, pumps, chemical feeders, and control instrumentation. Package plants are generally characterized by high rate filtration and short unit process detention times. These plants can be purchased as individual unit process modules or as a complete per-assembled unit from a single manufacturer. Multiple units may be installed in parallel to accommodate larger flows where necessary.

GENERAL

Package water treatment plants may be a cost-effective means of treating groundwater under the direct influence of surface water for pathogen removal and turbidity removal. Treatment of surface waters may necessitate the use of simple settling or precoagulation and settling depending on the raw water quality and diurnal or seasonal variations.

The Commissioner will consider approval of package plants on a case by case basis in accordance with 12 VAC 5-590-290 *Procedures for issuance of special permits for new or nonconventional methods, processes, and equipment.*

An application from the owner, a Preliminary Engineering Conference, and Preliminary Engineering Report including pilot testing protocol will generally be required prior to submittal of plans and specifications. Pilot testing will require challenge studies to determine compliance with the Drinking Water Standards in Part II of the *Waterworks Regulations*. Challenge studies should include turbidity, particle, and microorganism challenges. Monitoring should include continuous turbidity monitoring and particle counting and microscopic particulate analysis. The Division may waive the pilot study if similar waters have been successfully pilot tested.

PRELIMINARY EVALUATION

Preliminary Engineering Conference

The applicant's engineer must identify water supply problems and evaluate alternative solutions. Emphasis must be placed on the raw water quality and treatment objectives,

i.e., removal of turbidity, color, disinfection by-product precursors, viruses, bacteria, and protozoa, must be established.

Source restrictions and the operational mode generally necessary for optimal performance may require higher chemical costs than other treatment alternatives. The cost effectiveness of package water treatment plants must include a detailed evaluation of the cost associated with feeding a primary coagulant, flocculent aid polymer, filter aid polymer, and/or a weighting agent.

Due to the reduced detention times, small solids storage volume, etc., package water treatment plants are generally operated as direct filtration plants for optimal performance. This operational mode requires the production of small, filterable, pin floc. Optimal performance requires constant operator attention and may necessitate continuous operation without start-stop operation.

Optimal performance of package water treatment plants should be defined based on current and anticipated drinking water standards. Performance goals for each unit process under all conditions of raw water quality should be established, such as:

a. Settled water turbidity <1.0 NTU
b. Filtered water turbidity <0.1
c. Treatment works particle reduction in the 2 to 25 micron size range >6 log

Preliminary Engineering Report (PER)
A report shall be prepared and submitted to the Commissioner which includes the following specific items, in addition to those listed in 12 VAC 5-590-200 C:

a. Historical summary of meteorological conditions
b. Historical summary of raw water quality covering a period of at least one year with special reference to fluctuations in quality and possible sources of contamination. The following raw water parameters should be evaluated:

(1). Apparent color
(2). Turbidity
(3). Bacterial concentration
(4). Microscopic biological organisms
(5). Temperature
(6). Total solids
(7). General inorganic and organic chemical characteristics
(8). Additional parameters as required by the Commissioner

c. Description of the pilot plant study methods and work to be done.

Pilot Plant Study
The pilot plant study shall be conducted over a sufficient time to treat all expected raw water conditions throughout the year. The pilot plant shall be of a similar type and operated in the same manner as proposed for full-scale operation. The following items shall be addressed as applicable:

a. Chemical mixing conditions including shear gradients and detention periods.
b. Chemical feed rates.

c. Use of various coagulant and filtration aids including polymers and weighting agents
d. Flocculation conditions and contact time necessary for optimum filtration for each coagulant proposed.
e. Filtration rates.
f. Filter gradation, types of media, and depth of media.
g. Filter breakthrough conditions and backwash requirements.
h. Ability to perform filter drop test to determine filtration rate and filter rise test to determine backwash rate.
i. Method to control the coagulation process either by Zeta potential, pilot filters, streaming current monitors, or jar test machines or a combination of these methods.
j. Turbidity and microorganism removal efficiencies under various raw water quality conditions.

Final Engineering Report
A final report including the engineer's design recommendation, identification and justification of all deviations from criteria in the Manual of Practice and detailed cost estimates, including projected monthly user fees if possible, must be submitted prior to the submission of plans and specifications.

APPLICATION

General
Package water treatment plants are acceptable for the treatment of surface water or groundwater under the direct influence of surface water meeting the parameters listed below.

Source restrictions
Where an adequate historical record is not available, raw water quality for application to a package plant without pretreatment shall meet the following requirements:

a. Not exceed a turbidity level of 5 NTU monthly average or 30 NTU peak day over a one-year period;
b. Not exceed 800 total coliforms in 80% of a minimum of 50 samples taken over a minimum of a 52 week period; and
c. Not exceed an apparent color level of 15 CU monthly average over a one-year period.

Waters shall be treated to at least the above quality prior to application to a package plant unit.

Pretreatment
Water containing high turbidity or high coliform organism counts may require pretreatment, usually sedimentation, either with or without the addition of chemicals. When pretreatment is used, the following requirements must be met:

a. Presedimentation basins utilizing a coagulant shall have hoppered bottoms or shall be equipped with continuous sludge removal apparatus;
b. Incoming water shall be dispersed across the full width of the line of travel as quickly as possible to minimize short-circuiting;
c. Provisions for bypassing presedimentation basins shall be included;

d. Twenty four hours detention without a coagulant or three hours detention with a coagulant is the minimum period required - greater detention time may be required depending on raw water quality.
e. Intra-basin baffling is recommended to minimize short-circuiting.

PACKAGE PLANT DESIGN STANDARDS

General
Applicable items in Part III of the Manual of Practice for Waterworks Design shall be complied with. Deviations from criteria in the Manual of Practice may be granted by the Division on a case by case basis.

Proprietary designs of package plants may use tube or plate settlers to enhance settling in small units. Plants may use solids contact units to substitute for flocculation and settling units. Upflow adsorption flocculation and settling may also be used in manufactured package plants. These proprietary designs shall be evaluated on a case by case basis.

Mixing
The design of flash mixing units or static inline mixers shall be in accordance with 12 VAC 5-590-870C. Static inline mixers shall be located 10 pipe diameters before discharge of chemically treated water to the flocculators.

Chemical addition for pH or alkalinity adjustment should occur at a separate mixer a sufficient distance upstream from the coagulant addition mixer to assure chemical treatment stabilization prior to coagulant addition.

Flocculation
The design of flocculation units shall be in accordance with 12 VAC 5-590-890C2 or as identified and justified in the approved PER. Particular attention should be paid to the prevention of short-circuiting and the provision of plug flow.

Sedimentation
The design of sedimentation units shall be in accordance with 12 VAC 5-590-890C3 or as identified and justified in the approved PER.

Overflows and Drains
Sufficient overflows and drains shall be provided to maintain a maximum water level within the plant, including the depth of water over the filters, and to facilitate complete draining of the package plant.

Filtration Rate of Flow Control
A constant or declining filtration rate is necessary to prevent filter breakthrough due to filtration rate changes at startup or shutdown, when one filter is taken out of service for backwashing or during the filtration cycle.

Filter flow rate control by influent or effluent pumping or by float operated valves to maintain a constant water level on top of a filter is prohibited. A positive means to control the filtration rate shall be provided.

Effluent rate of flow controllers of the constant rate direct acting or declining rate types shall be required on each filter. All control devices used must incorporate an auxiliary

shutoff valve in the filter effluent line. Direct acting effluent rate of flow control devices shall start operation from the closed position.

The preferred control system for constant rate flow control would include:

a. Venturi, flow tube, or magnetic type meter as the primary metering element.
b. Flow sensor output to an indicator with a simplex logic controller (single valve/function controller) preferably a standardized, non-proprietary unit.
c. Electric motor driven, slow speed valve actuator mounted to resilient seated butterfly valve. The butterfly valve should be sizes specifically for flow control at the filtration rate. The actuator motor should include a small UPS type battery backup to close the valve on power failure.

In the non-mechanical variable declining-rate system, the filters are connected by a common inlet channel or pipe and thus have the same available head with the maximum available head set by the upstream unit overflow elevation. Backwashing is initiated when a filter overflows due to its declined filtration rate. The maximum clean bed filtration rate shall be mechanically restricted to 4-gpm/sq. ft.

Available Head for Filtration
Available head for filtration is the driving force or energy necessary to force water through the filter media. This hydraulic head is measured from the water surface overflow elevation to the filter underdrain effluent header outlet. To limit available head, the effluent pipe must terminate above the clearwell overflow elevation.

Pumping from the filter effluent header is prohibited. An air gap must be maintained between the filter underdrain and any effluent pumping to protect against creating a negative pressure in the filter.

Common Wall Construction
Common wall construction between filtered water and the sedimentation basin or clarification unit is prohibited. Vertical, double division walls, where separated sufficiently to permit inspection and fitted with a weep hole to drain the area between the vertical walls, shall be provided.

Surface Wash
Surface wash facilities with appropriate backflow prevention shall be provided in accordance with 12 VAC 5-590-880A8.

A high-pressure potable water hose bib shall be available for washdown, etc., during backwash.

Filter to Waste
Provisions for filter to waste (rewash) shall be provided. The rewash rate shall not exceed the permitted design filtration rate. The rate shall be adjustable by volume and time. The continuous turbidity monitor and sample tap shall be located upstream of the filter to waste line.

OPERATIONAL CONSIDERATIONS

Automatic Operation
Automatic unit process operation (coagulation control and filter backwash) is strongly discouraged. Manual override of all automatic features shall be provided. Automatic startup is prohibited. Motorized valve actuators with manual override actuators are required. Automated troubleshooting capabilities shall be built into the automatic control system if provided.

O&M Manual
An O&M Manual is required for package plant operation. This manual must provide a detailed description of the treatment units and control of each unit for optimal performance. A preventative maintenance schedule, manual override procedures, and a troubleshooting guide for typical problems must be included.

Classification
Treatment works classification and operator requirements shall be in accordance with 12 VAC 5-590-460.

Access
For units installed at ground level, stairways and walkways shall be provided to allow access for operation and maintenance and observation of the treatment process units. The control console and other operational controls should be located such that the process being controlled can be observed while at the same time being adjusted. Filters must be adequately accessible to perform filter bed expansion testing and to facilitate evaluation of the entire filter bed for media condition and placement. Evaluation of fluidization during backwashing and evaluation of compaction during filtration are, among other operational control and monitoring practices, essential for proper operation.

Installation of units partially below grade with appropriate access and safeguards is the preferred alternative. Cathodic protection shall be considered for any metallic components located partially below grade.

Training
The manufacturer shall provide start-up and follow-up training and troubleshooting as determined by the owner and engineer.