NATGUN

Wire-Wound Concrete TES Tanks

O&M Manual

[PROJECT NAME]

THERMAL ENERGY STORAGE TANK

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Prepared by Natgun Corporation

CONTENTS

Project Specific Information

Design Parameters

Project Name:	[Project Name]
Natgun Job Number:	[Job Number]
Year Tank Built:	[Year Built]
Tank Volume:	[Tank Volume]
Tank Inside Diameter:	[Tank ID]
Backfill Level – High Side:	[Backfill Level - High Side]
Backfill Level – Low Side:	[Backfill Level - Low Side]
Operating Water Depth:	[Operating Water Depth]
Tank Design Side Water Depth:	[Tank Design SWD]
Alarm Water Level – Maximum:	[Alarm Water Level - Max]
Alarm Water Level – Minimum:	[Alarm Water Level - Min]
Usable TES Capacity:	[Usable TES Capacity]
Maximum CHW Flow Rate:	[Max CHW Flow Rate]
Maximum CHW Pressure Drop (at max CHW Flow Rate):	[Max CHW Pressure Drop]
CHW Temperature – Supply:	[CHW Temp - Supply]
CHW Temperature – Return:	[CHW Temp - Return]
CHW Temperature – Delta:	[CHW Temp - Delta]
Distance from Finish Floor to Centerline of Distribution Pipe:	[Distance]
Distribution Pipe Size:	[Pipe Size]
Diffuser Pipe Size:	[Pipe Size]

INTRODUCTION

This manual is prepared to assist the owner's operator in the use of the Thermal Energy Storage (TES) system, specifically the TES tank. Following the recommendations in this manual, the TES tank should perform its intended design use without interruptions. The TES tank includes, internal piping, pipe supports, instrumentation controls and exterior insulation.

SUMMARY - HOW A TES TANK SYSTEM WORKS

Natgun's TES Tank utilitizes natural stratification of the chilled water within the TES tank. Chilled water is a sensible storage medium (remains as a fluid). A naturally stratified TES tank is the main storage vessel used in a straight forward operating strategy utilized in a chilled water cooling system that utilizes simple controls and valving pipe arrangement. This system allows the TES tank to be "charged" (see Figure 1) and "discharged" of chilled water on a daily basis (see Figure 2).

Through careful tank design, stratification in the TES tank is accomplished by separating the cold water (more dense) at the bottom of the tank, from the warm water (less dense) at the top of the tank, in horizontal layers by its density, a natural phenomenon. During the charging or discharging process, a natural barrier is formed separating the chilled water from the warm water by a blended layer referred to as the thermocline (see Figure 3). Inside of the tank there is an upper and lower diffuser system that acts as entry and exit points for the chilled water in the tank.

The lower diffuser is designed to introduce cold water into the tank with the minimum amount of turbulence. The lower diffuser allows the denser water (water is densest at 4ºC or 39.2ºF to flow into the tank creating a density current across the tank bottom, which in turn, results in the horizontal layering of the chilled water. At the same time cold water is introduced into the bottom of the tank, warmer water is removed from the top of the tank through the upper diffuser. Similarly, during the discharge cycle, cold water is removed from the tank using the lower diffuser and warm return water enters the top of the tank through the upper diffuser.

Each TES tank system is individually designed for the specific facility. Natgun uses an octagonal piping type diffuser in its TES tank systems. This diffuser design allows Natgun to provide an extremely efficient system for the required load. The tank is designed and constructed to be watertight, has no moving parts and is made of non-corrosive materials; therefore, its reliability and dependability is excellent. Temperature probes are located in the interior of the tank which transmits data to the control center. At any point in time the chilled water volume is available to provide instantaneous BTU inventory to the operator to assist in load management. Also, a water level sensor continuously feeds data to the energy management system so that the water level can be controlled to remain constant.

Figure 1: Chilled Water TES Concept

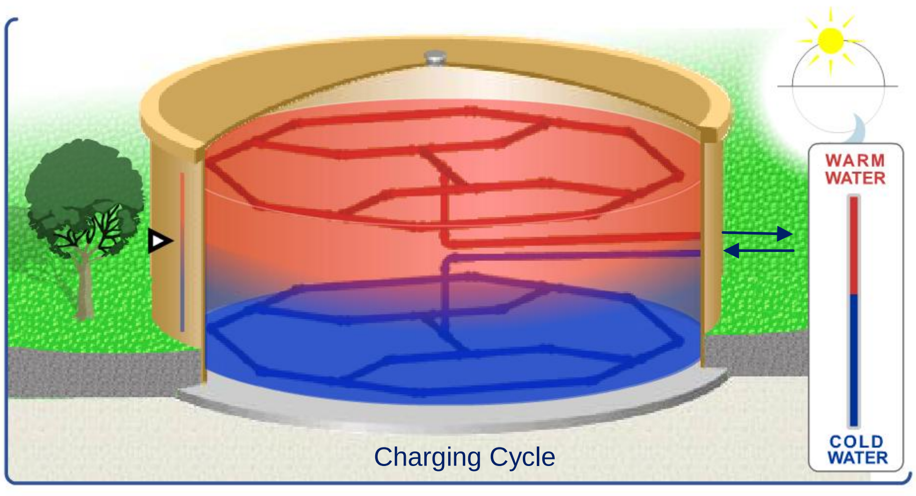


Figure 2: Chilled Water TES Concept

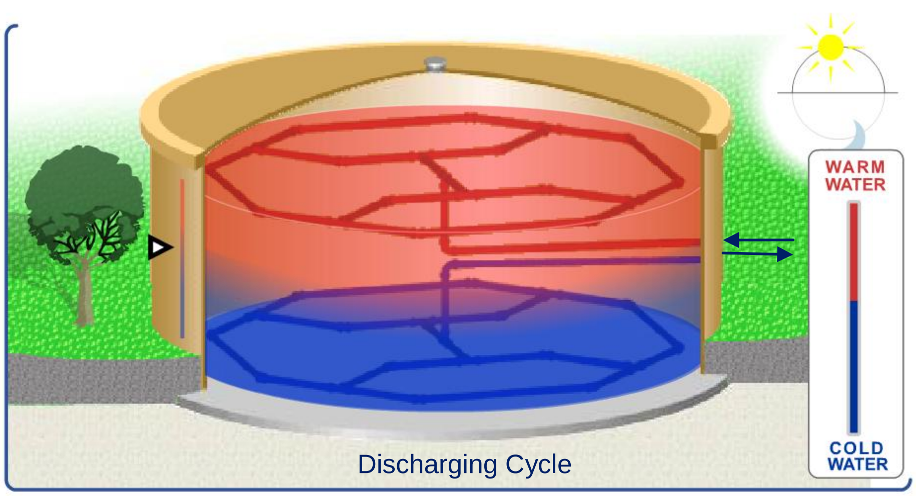
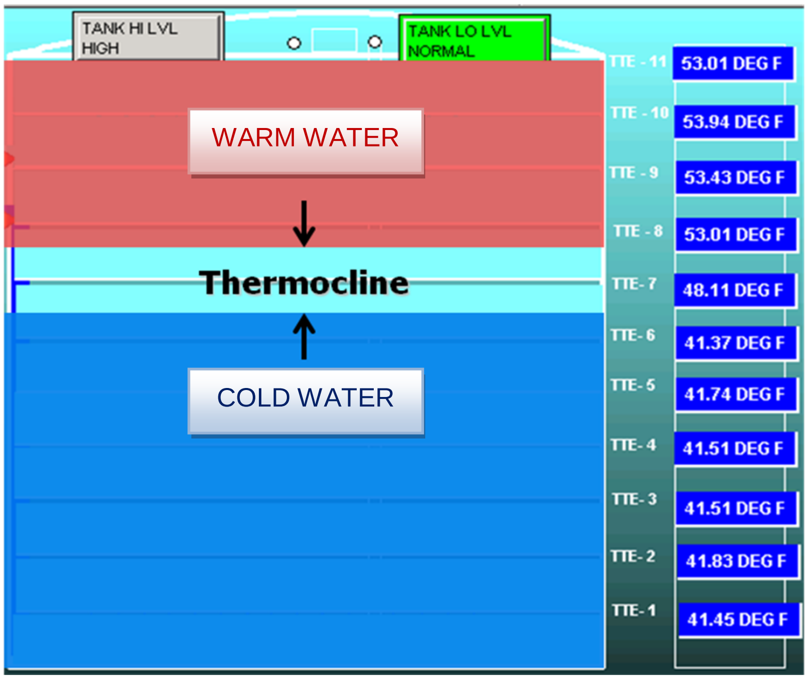


Figure 3: Example of Stratification within a TES Tank



OPERATION

Start-up

I. <u>Pre-Filling Requirements</u>

A. System Cleaning
(Per ASHRAE HVAC Systems and Equipment – Chapter 50)

Starting with a clean system cannot be stated strongly enough. A clean system at startup minimizes problems throughout the life of the system.

Water containing any contaminants, detergents or disinfectants must be drained to an appropriate site. Check with local authorities before draining the system.

The following are the major steps in preoperational cleaning:

1. Remove all extraneous loose debris, construction material, trash and dirt from tanks, piping, filters, etc. Removal of as much dry material as possible prevents transfer too hard to reach portions of the system.
2. Flush water fill line separately to drain. If a new water line has been installed, be sure that rust and debris from it is not washed into the thermal storage system.
3. Fill system with soft, clean, fresh water. Open all system valves and lines to get thorough, high-velocity recirculation. (Refer to Filling Procedure on pg. 1-4)
4. Add prescribed cleaning chemicals to circulating water. Most cleaners are a blend of alkaline detergents, wetting agents, and dispersants. Be sure cleaning chemical is dissolved and distributed thoroughly so that cleaner does not settle out in one part of the system.
5. Circulate cleaning solution for manufacturer's recommended time, frequently 8 to 24h. Check during recirculation for any plugging of filters, strainers, etc.
6. While water is being recirculated at a high rate, open drain valve at lowest points in system and drain cleaning solution as rapidly as possible. Draining while under recirculation will prevent settling of solids in remote portions of system.
7. Open and inspect system for thoroughness of cleaning. Refill with water and start rinse recirculation. If significant amounts of contaminating materials are still present, repeat cleaning and draining procedures.
8. When cleaning has been thoroughly accomplished, refill system with fresh water for recirculation rinse. Drain rinse water and add fresh makeup until all signs of cleaning chemicals have been removed.
9. System is now clean, unprotected state. Fill with makeup water and proceed with passivating steps to develop protective films on all metallic surfaces. Water should be treated as soon as possible after cleaning the system. The cleaning procedure removes any protective films from equipment surfaces, leaving them susceptible to corrosion. Especially, when there is an extended time period between cleaning and actual system startup, corrosion and biofouling can become significant problems if water treatment is not treated promptly.

B. Water Treatment

Water treatment for cool storage systems is fundamentally no different than water treatment for non-storage systems, except that generally a greater volume of water must be treated.

Chapter 48 of the 2007 ASHRAE Handbook-Applications covers water treatment in detail. Ahlgren (1987) discusses water treatment specifically for cool thermal storage systems, as well as a chapter on sources of further information and reports on water treatment experience of a number of thermal storage systems. Chemical service companies are also a good source of information on water treatment.

Starting with a clean system, whether in a cool storage or a non-storage application, is the surest way to avoid future problems. Among the recommendations to ensure clean, trouble-free water in a cool storage system are:

- A recommended procedure to achieve and maintain a clean system.
- Chemical treatment to avoid corrosion, biofouling, scaling and deposits in a cool thermal storage system.
- Water treatment reference ASHRAE Design Guide for Cool Thermal Storage Page 2-47.

NOTE: Chemical additives (excluding chlorine) should be evaluated for their compatibility with concrete. Some additives have a deleterious effect on various materials in the tank; i.e., concrete, pipes, pipe supports, etc (consult the chemical admixture supplier). Chemical additives may change the characteristics of the water, thereby interfering with the efficiency of the TES design. Maintain a pH balance between 6.5 and 7.5 of the fluids in the tank. Other sources of protective chemical additive information can be found in the American Concrete Institute Guide (ACI 515.1R-79), and the Portland Concrete Association Circular (IS001).

II. Tank Filling Procedure

The TES tank must be filled either through the chilled water piping that is connected to the upper diffuser or the "optional" dedicated fill valve. Note: The tank must not be filled through any other ports or nozzles.

Description

There are numerous pipes within the TES tank, differentiated between the distribution (solid) piping and the diffuser (slotted) piping. The distribution piping is either supply or return and the diffuser piping is the slotted octagonal shaped piping at the bottom of the tank and at the top of the tank. The diffuser piping has radial slots allowing the water into the bottom of the tank and the top of the tank. The slots in the bottom diffuser pipe face down and the slots in the top of the diffuser pipe face up.

Step 1 – Fill the tank directly through the upper diffuser distribution piping or the "optional" dedicated fill valve. Filling through the upper diffuser will prevent the piping from becoming buoyant. If the diffuser becomes buoyant causing flotation, the distribution/diffuser piping can be damaged along with the associated hangers & supports.

NOTE: Always open and close valves slowly, thereby preventing excess water hammer and/or blow-outs, to the tank's interior piping.

Step 2 – Continue filling the tank until the water is 6-inches minimum (can vary – design dependent) above the top of the upper diffuser pipe. Water must always be 6-inches (can vary – design dependent) above the top of the upper diffuser pipe array, thus, preventing the introduction of air into the system (during charging cycles). If the water level is not 6-inches (can vary – design dependent) above the upper diffuser pipe array once the tank is filled, extensive damage to the upper diffuser may occur. If water is flowing out of the overflow piping during the initial fill, discontinue the filling of the tank. In the event that the tank does overflow, water may be observed coming out of the overflow for up to 48 hours.

NOTE: Make certain all air has been bleed off the system (Tank piping, exterior piping, pumps, etc.) prior to circulating the water.

III. Initial Charging of the TES Tank

The initial lowering of the water temperature should be performed in increments thereby reducing the possibility of excessive shrinking of the reinforced concrete floor. The water temperature should be lowered in intervals not to exceed 12°F differential temperature within a two-hour duration. The suggested procedure to initially charge the tank is as follows. e.g., assuming the existing tank water temperature 75°F;

- lower the CW water temperature to 63°F, for a minimum two (2) hours duration;
- then lower the CW water temperature to 51°F, for a minimum two (2) hours duration;
- then again, lower the CW water temperature to design water temperature (but never less than 39ºF, water begins to expand, reducing the density) until the TES tank is fully charged. The TES tank is now available for normal usage operations in accordance with the design criteria (Δt= *Per the contract documents* (°F) at a maximum water flow *Per the contract documents*(gpm)).

IV. Tank Draining Procedure

Step 1 – Prior to draining the tank, check the exterior groundwater elevation. The tank foundation has not been designed for uplift pressures. If the groundwater is at or above the tank finish floor and the tank is not at full capacity, extensive damage to and failure of the tank may occur.

Step 2A – The TES tank must be drained through the lower diffuser piping (CW line) until there is minimal water left on the tank floor less than 2 ft.

Step 2B – Drain the tank from the “optional” permanent floor drain.

Step 3 – Finally, drain the upper diffuser. Draining the tank in this sequence will prevent the piping from becoming buoyant. If the diffuser becomes buoyant causing flotation, the distribution/diffuser piping can be damaged along with the associated hangers & supports.

V. Water Level Control

The TES tank is a vented atmospheric type containment vessel, i.e., the TES tank is not under pressure and some of the water will evaporate into the atmosphere; therefore, requiring makeup water added to the system. It is imperative that the chilled water system be equipped with a level sensing control system. This water level control system shall be calibrated and maintained to ensure proper operation of the TES system. Also, it is very important to maintain the water level above the top of the upper diffuser to prevent air from entering the diffuser causing buoyancy in the piping (risking damage to the internal system).

The water level in the tank should be maintained at a minimum of 6” (can vary – design dependent) above the upper diffuser piping. The water level control system should send an alarm to the operator if the water level has dropped below the minimum of 6” above the upper diffuser. The overflow elevation is located 2” above the operating liquid level.

VI. Confined Space

The TES tank is a confined space structure requiring certain safety procedures to be maintained prior, during and after entering the tank (a confined space plan may be required to be provided by the owner in accordance with OSHA requirements).

VII. Safety

All appurtenances shall be in accordance OSHA requirements.

VIII. Maintenance

- Regular scheduled maintenance of the TES tank is not required
- Tank cleaning—interior & exterior as required.
- Tank Inspection—Refer to Section IX

IX. TES Tank Inspection Checklist

The following is a suggested checklist for inspecting a TES tank.

Annually

1. Instrumentation (By Others) - All instrumentation (such as level sensors & temperature sensors) that is added to the TES tank should be tested and calibrated regularly per the manufacturers recommendations.

2. Roof Vent - Inspect vent to insure the screen is intact and no obstructions are limiting airflow through the vent.

3. Roof Hatch and Handrails (if required) - Inspect the roof hatch and safety rail for damage, ease of operation and security, i.e., pad locks.

4. Overflow Pipe - Inspect overflow to insure that there are no obstructions at the inlet or outlet of the overflow, which would restrict flow.

5. Interior Ladders - Check anchorage to wall, soundness of rungs and handrails.

6. Exterior Walls - Inspect for damaged areas in the insulation.

7. Exterior Roof – Check roof for debris.

8. Interior Piping and Supports – Check diffuser pipe hanger rods and supports. Inspect all exposed piping in the tank interior. Inspect and clear obstructions, which could restrict flow.

9. Check pH of water.

Every Five (5) Years or More

1. Leakage Test - Isolate the tank for a period of 24 hours and measure the water level at the beginning and end of the period to check for leakage. Check valves for tightness. Leakage test can be conducted in conformance with AWWA D-110.

OTHER IMPORTANT OPERATIONAL INFORMATION

Draining, refilling or recharging the tank
If the tank ever needs to be drained, refilled or re-charged, please adhere to the procedures in this O&M Manual. Always fill through the upper diffuser piping, or the optional dedicated fill nozzle.

Chilled water flow rate is too high
If the CHW flow rate is higher than the design maximum flow rate then it could cause excess water hammer or excessive pressure drop, and turbulence within the tank. Turbulence within the tank will decrease the total useable thermal energy storage capacity. (Note – low flow will not have an adverse affect.)

Thermocline is not well defined
If the thermocline (boundary layer separating the warm water at the top and cold water at the bottom) is not well defined during the charging or discharging cycles, then check the diffuser piping, and check the system operation.

Water is flowing out of the overflow pipe
If water is flowing out of the overflow piping, the water level has risen too high in the tank, which may be due to too much make-up water in the CHW system, or a hydraulic imbalance. In the event that the tank does overflow, water may be observed coming out of the overflow for up to 48 hours.

Condensation
There is the possibility to observe minor seepage due to condensation at overflow, manway and/or vent. This minor condensation is natural and should not be of a concern.

Water Level Alarm
If the control system is in alarm due to low water level, visually inspect the water level immediately. Do not allow the water level to drop down to the top of the upper diffuser piping.

Cavitations of Pumps
If pumps start to cavitate, make certain all air has been bleed off the system. Check the water level in the tank to make certain that the upper diffuser has the required amount of water over the piping.

Tank – Planned Out of Service
If the tank is going to be drained and out of service for an extended period of time, please contact Natgun.

Drawings from Shop Drawing Package 1.00D, 1.10D and 2.00D shall be inserted at end of package.