CHILLED WATER THERMAL ENERGY STORAGE TANK OVERVIEW

Micah J. Somarriba, P.E.
Micah.Somarriba@DNTanks.com

Overview

- Thermal Energy Storage (TES) Concept
- TES Tank Options
- Innovations In Tank Technology
- Example TES Projects

Energy Storage Concept

- Energy is stored during “off-peak” periods, then distributed during “peak” periods.

- Examples of energy storage systems:
  - Batteries in a mobile phone
  - The human body
  - Thermal Energy Storage (**TES**)

Thermal Energy Storage

- Commercialized over 30 years ago
- Thousands of installations throughout the GCC, world, and the U.S.
- Adaptable to almost any chilled water district cooling system

Predominantly Two Types of Commercial TES Systems

Ice Storage

- Energy stored in a solid or ice phase
- Relatively small footprint, ideal for small work areas

Chilled Water

- Energy in the chilled water liquid phase
- Economical in larger applications

BIG “rechargeable batteries”

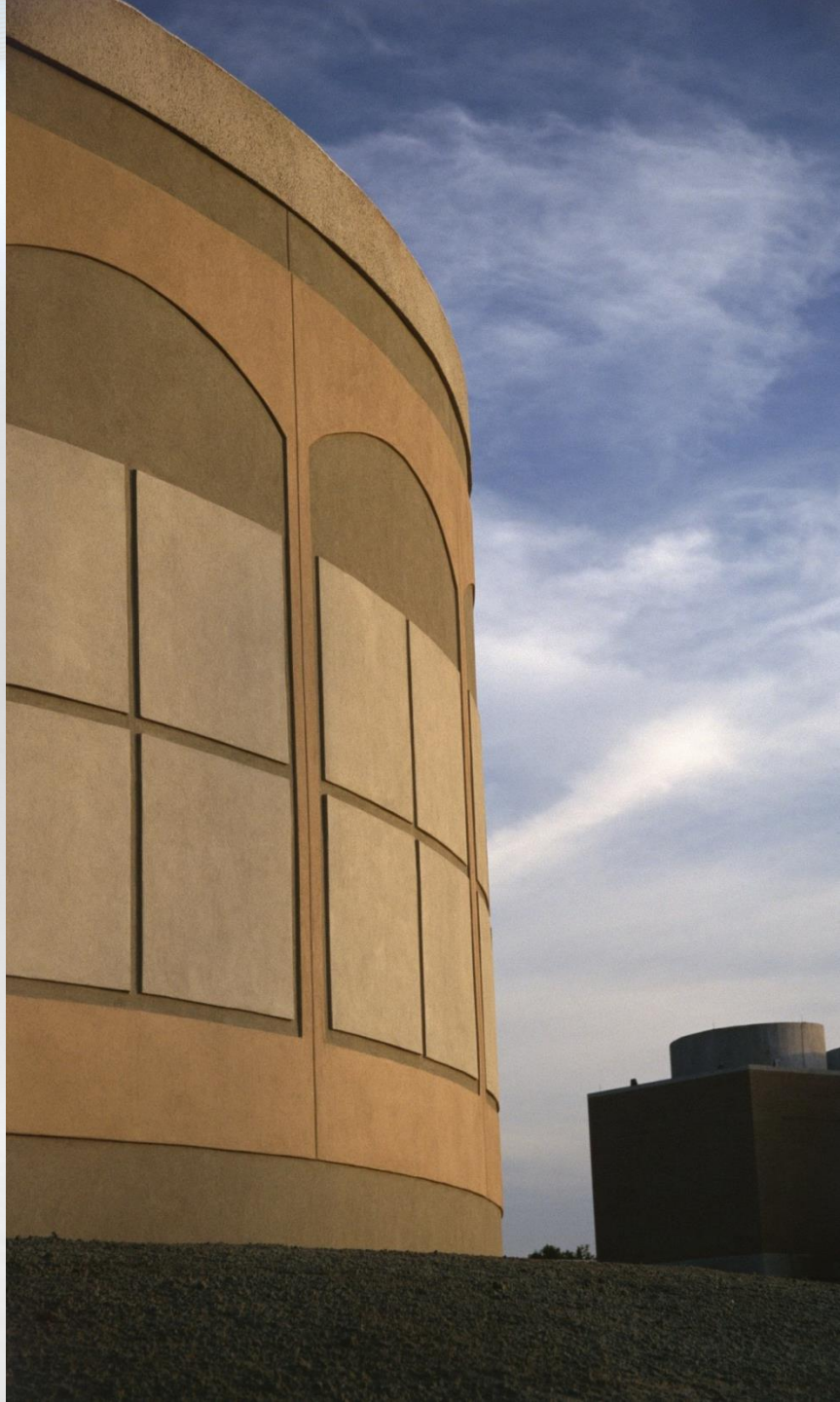
Tank Building Experience

- 3,000+ tanks designed and built world-wide
- Prestressed concrete tanks
- 87 years of tank experience

- 34 years of TES tank experience
- 48 tanks in Middle East
- 40 crews building tanks throughout the world

Our Capabilities

- Circular concrete TES tanks
- Custom built up to 160,000 m3 (35 MIG) & beyond
- Heights up to 30m (98.5 feet)
- Design / Build capabilities



TES Tank Options

- Welded Steel
- Conventionally Reinforced Concrete
- Internal Post Tensioned Concrete
- External Prestressed Concrete

Welded Steel

- **Advantages:**
  - Low initial cost
- **Disadvantages:**
  - Maintenance costs
  - Corrosion
  - Out of service time

Conventionally Reinforced Concrete

- **Advantages:**
  - Concrete likes water
  - Availability of material
  - Widely used in the area
- **Disadvantages:**
  - Concrete in tension
  - Congestion of rebar
  - Liners and coatings
  - Rectangular shape

Internal Post Tensioned Concrete

- **Advantages:**
  - Concrete in compression
- **Disadvantages:**
  - Tendon ducts
  - Base joints
  - Liners
  - Repair is difficult

External Prestressed Concrete

- **Disadvantages:**
  - Potential for higher initial cost
- **Advantages:**
  - Lowest total cost of ownership
  - Complete compression
  - No maintenance
  - Speed of construction

Examples of TES Tanks

Los Angeles, CA - USC

Riverside, CA - UC

Orlando, FL - UCF

University Campuses

Lackland AFB, TX

San Antonio, TX - Airport

Raleigh, NC

Government and Municipalities

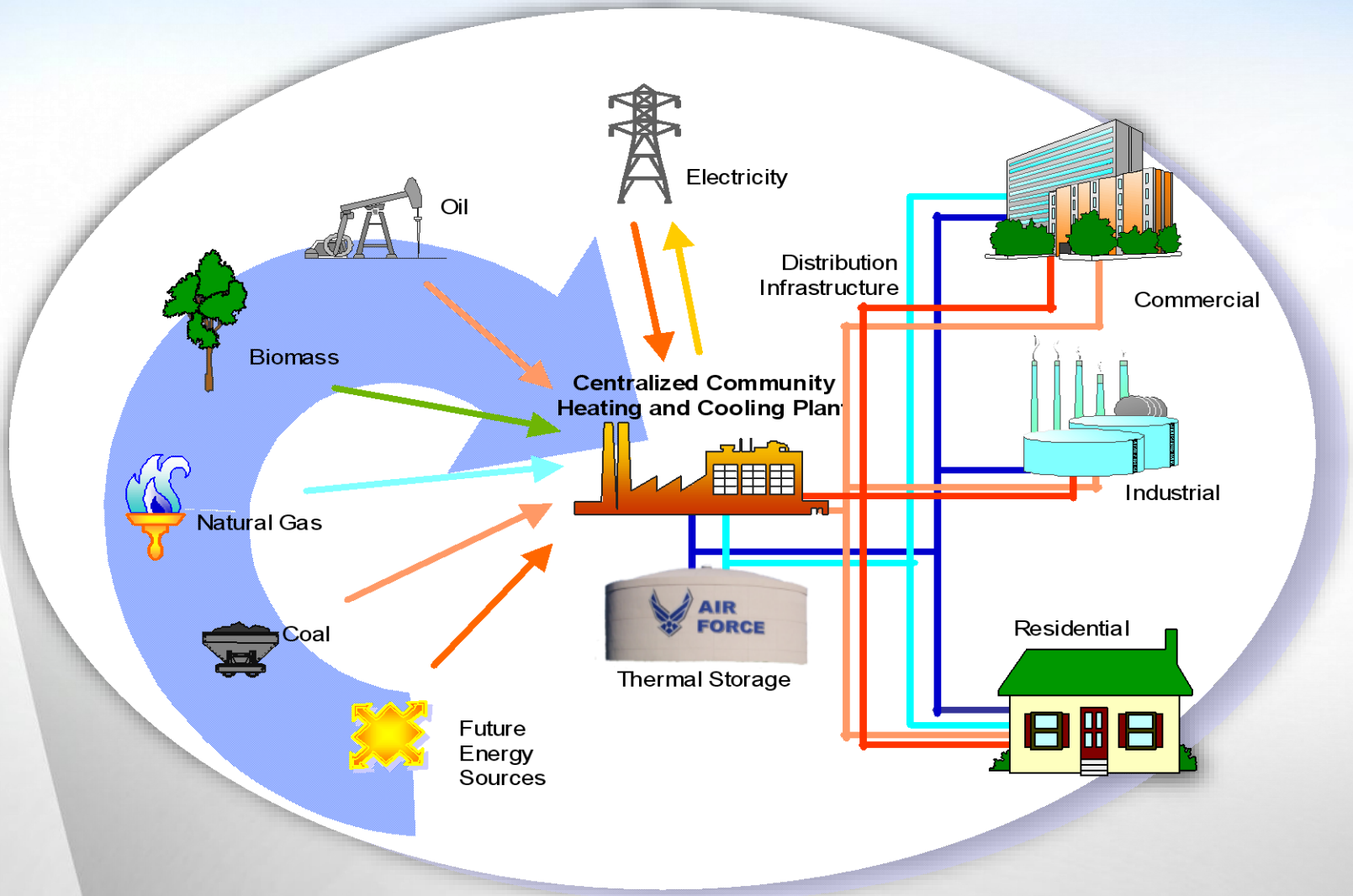
Brooks, CA – CCC Resort

Santa Clara, CA – DFP

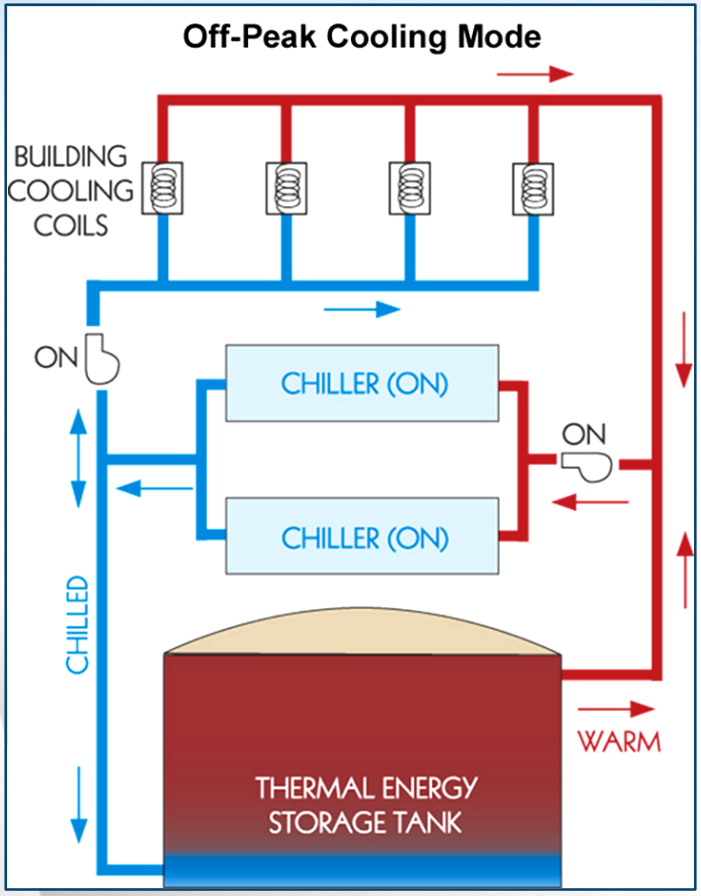
Escondido, CA – SDG&E

Private Industry, Power Plants, and Data Centers

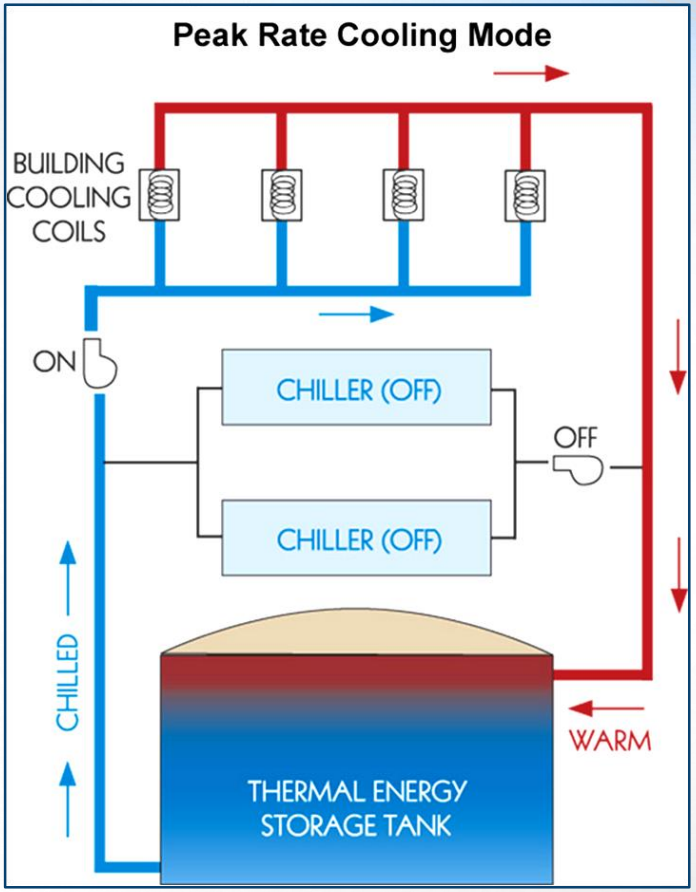
TES with Chilled Water District Cooling Systems



Chilled Water TES Concept

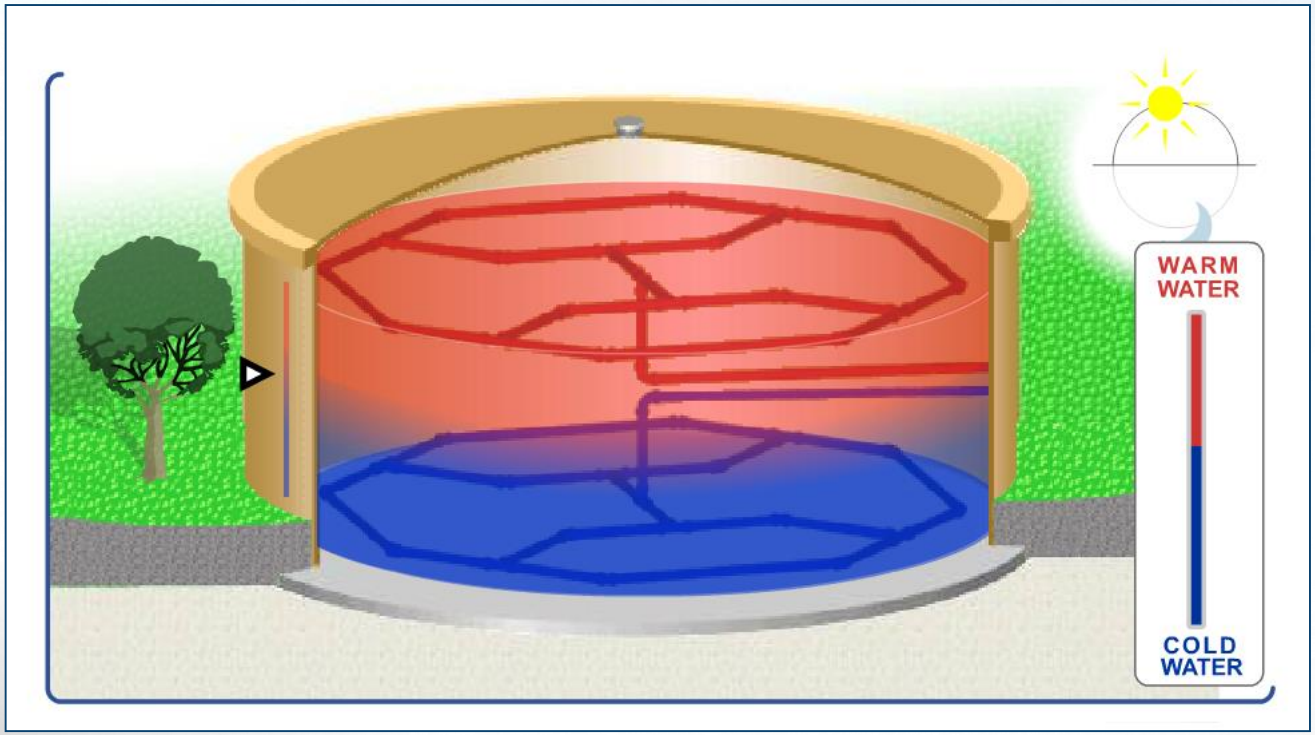


Tank
"Charging"
- Night mode



Tank
"Cooling the Building"
- Day mode

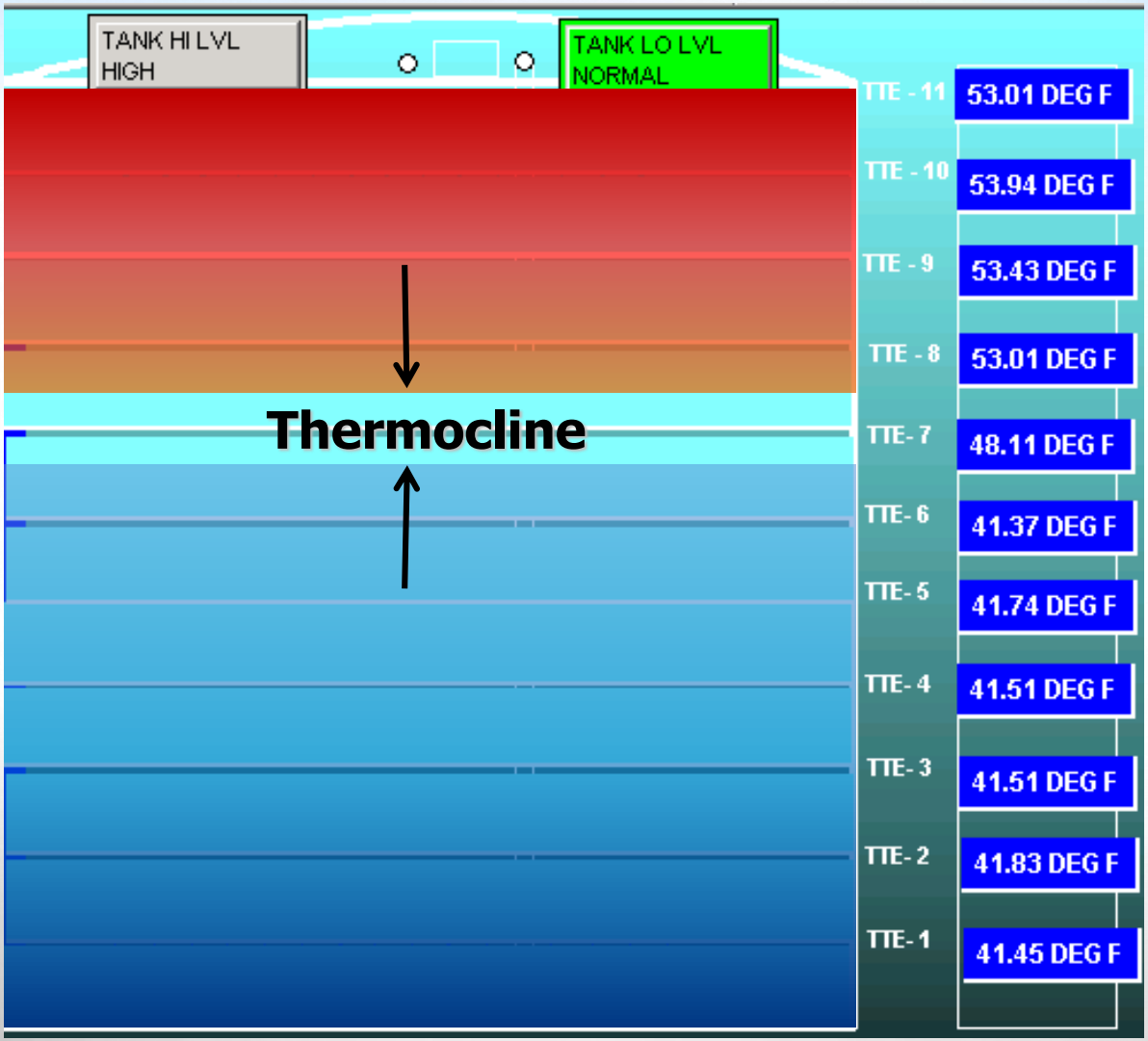
Stratified Chilled Water



Daily Operation of a TES Tank

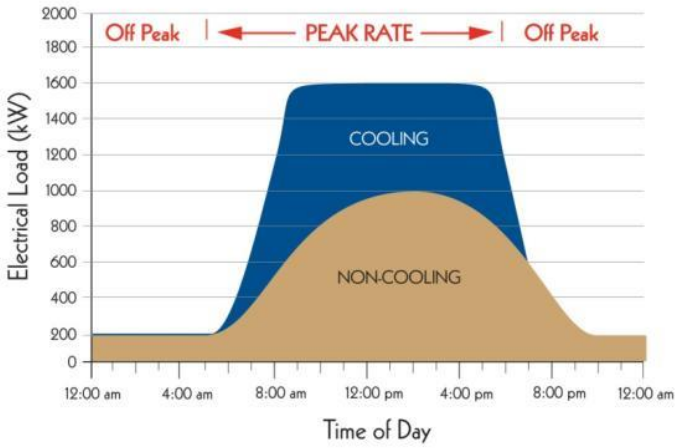
Typical Performance of a Properly Functioning TES Tank

1 Hour into the Test

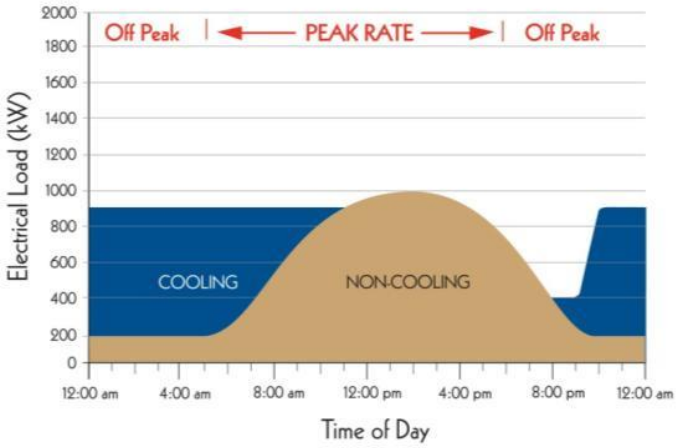


Electric Load Profile

LOAD PROFILE **WITHOUT** TES



LOAD PROFILE WITH TES



With TES:

- permanent electric load shift from peak periods to off-peak periods
- energy consumption reduction by taking advantage of cooler ambient conditions at nighttime when chillers run more efficiently

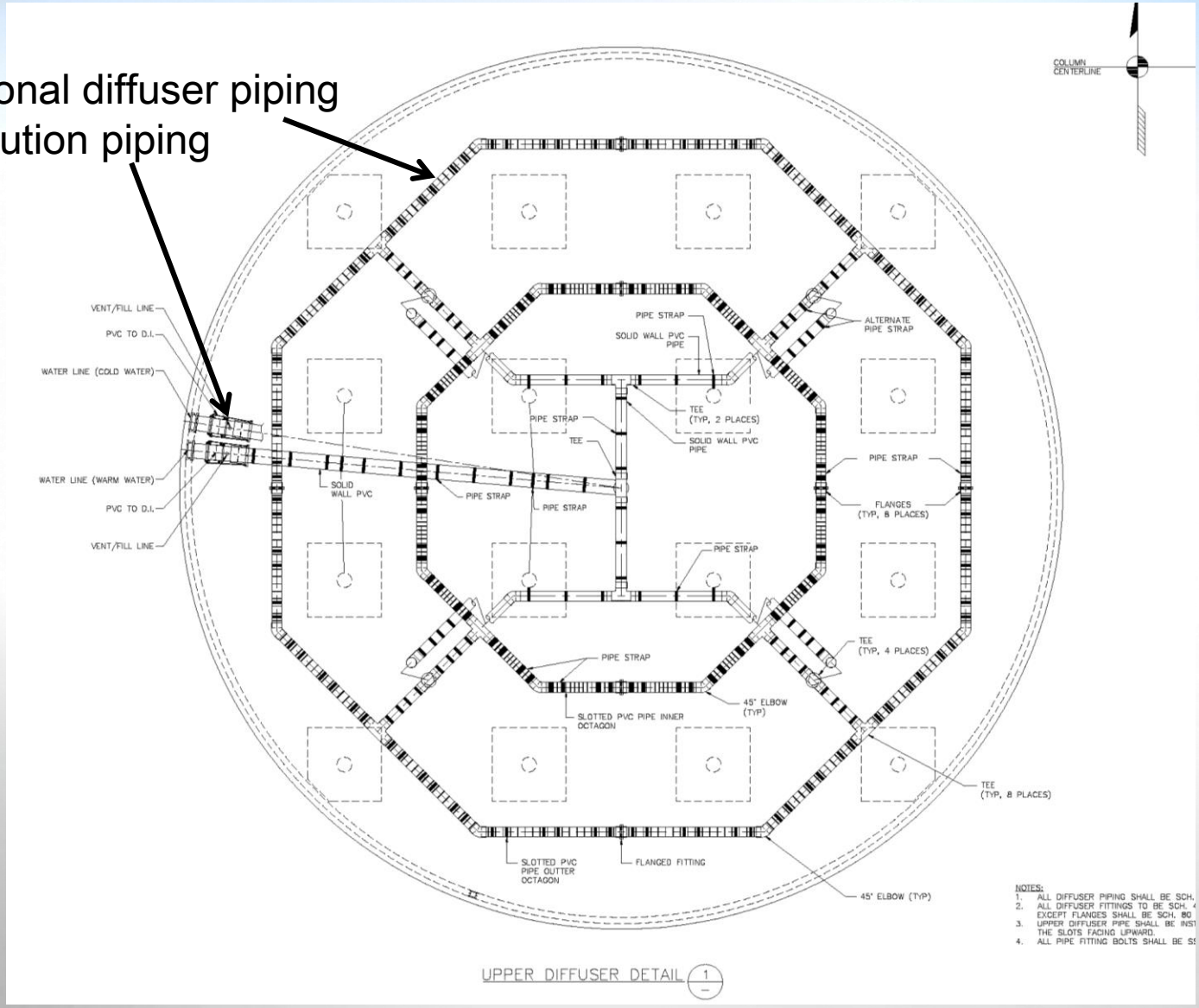
Financial Benefits

All TES systems provide owners with financial benefits – some examples:

- **Energy Cost Savings** – using electrons wisely
- **Cost Avoidance** – when expanding the campus
- **Insurance** – no downtime of critical processes

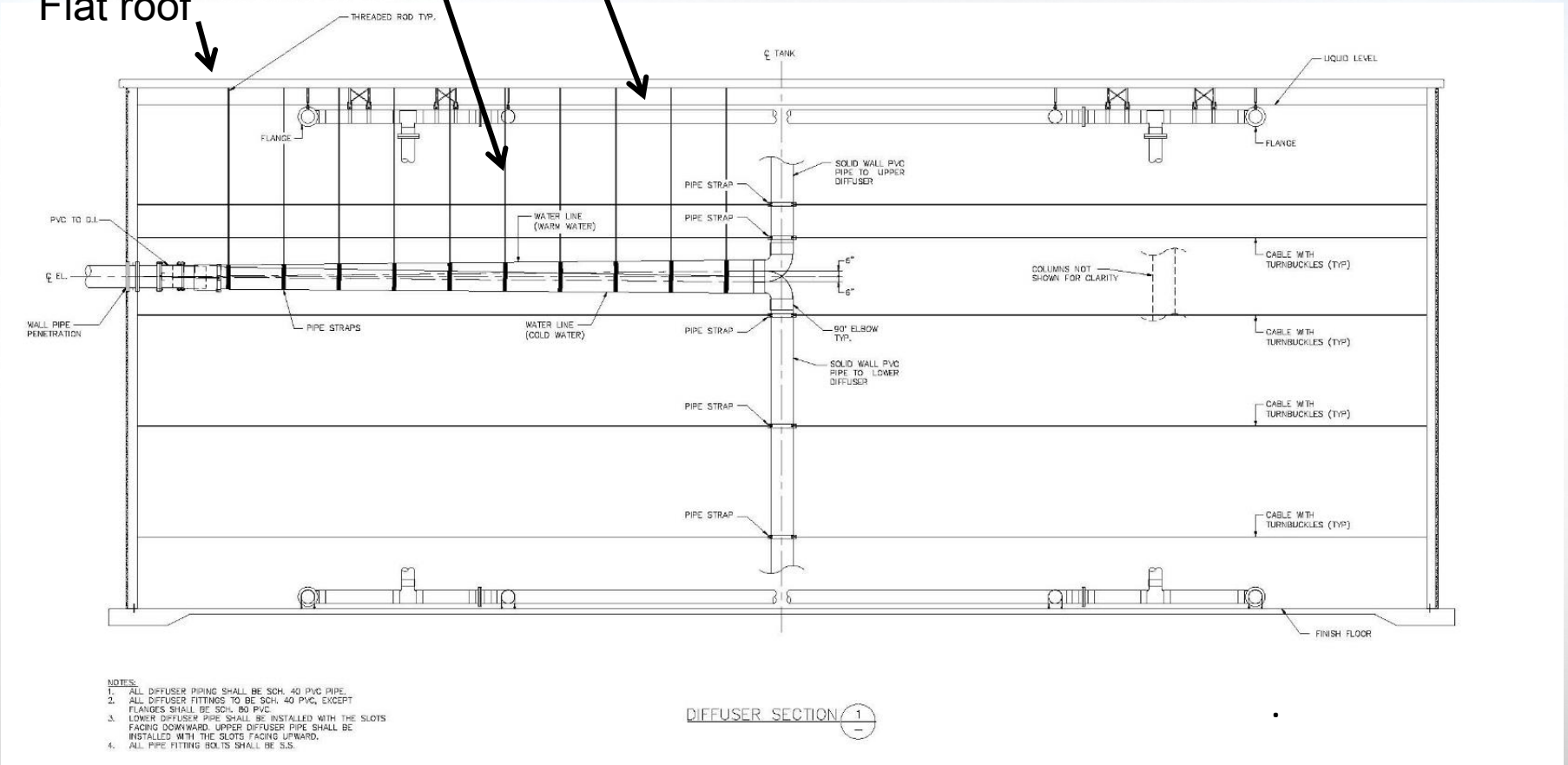
TES Tank Design – Typical Plan

- Octagonal diffuser piping
- Distribution piping

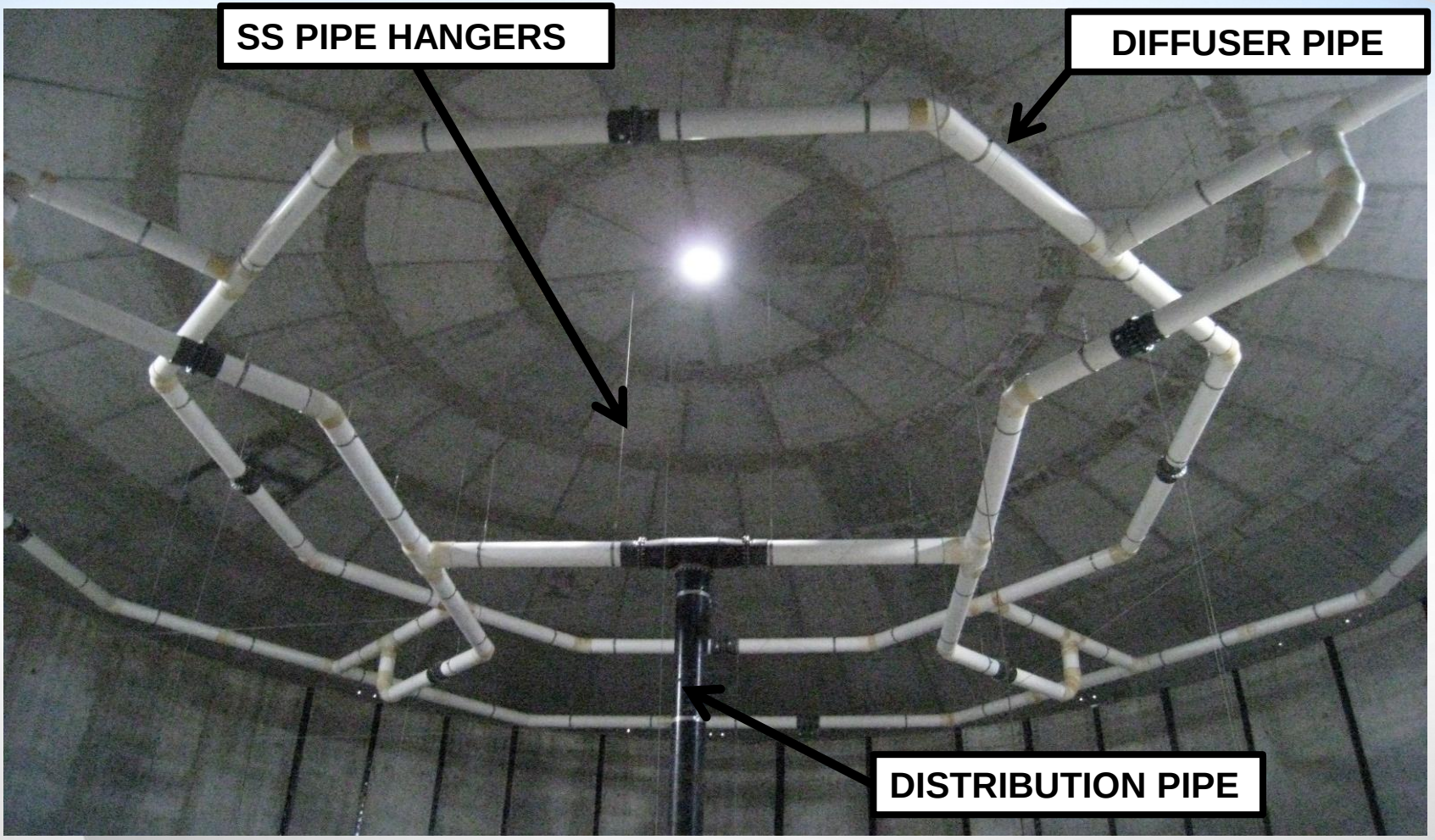


TES Tank Design – Typical Elevation

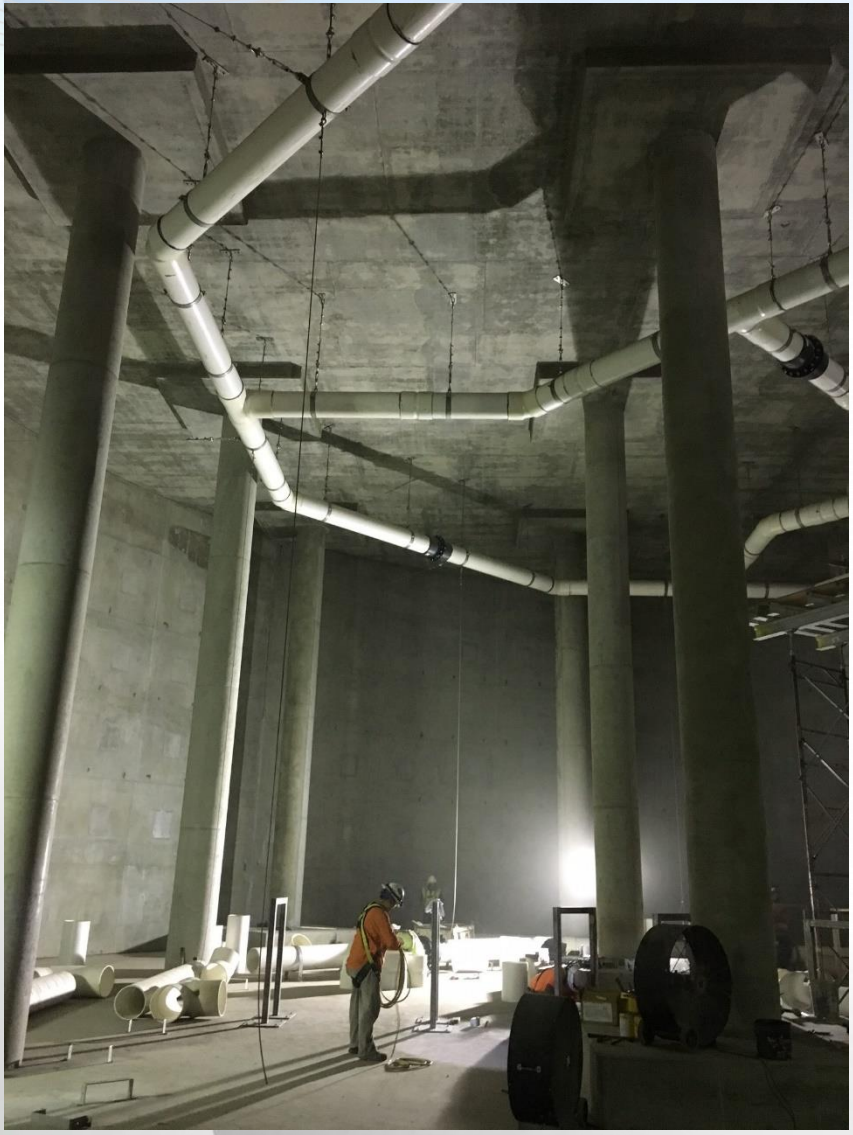
- Diffuser and distribution piping
- SS hangers and supports
- Flat roof

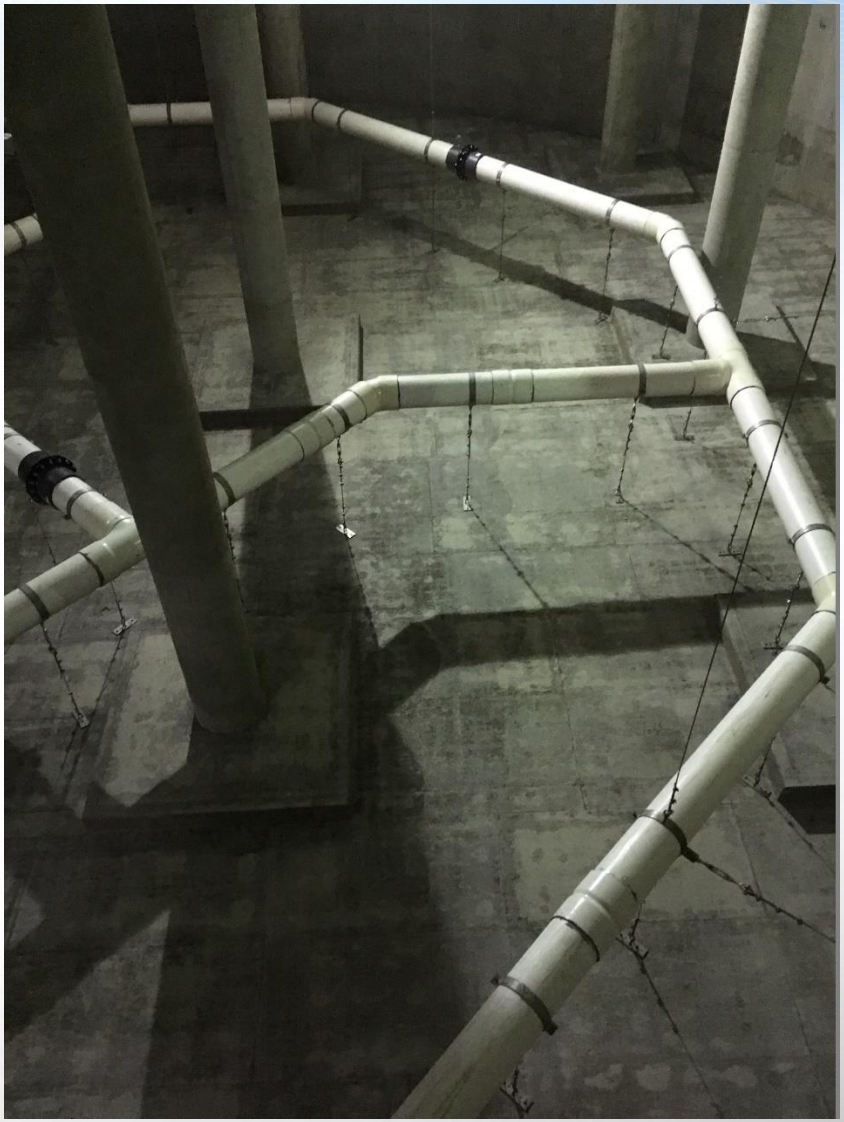


Upper Diffuser Piping



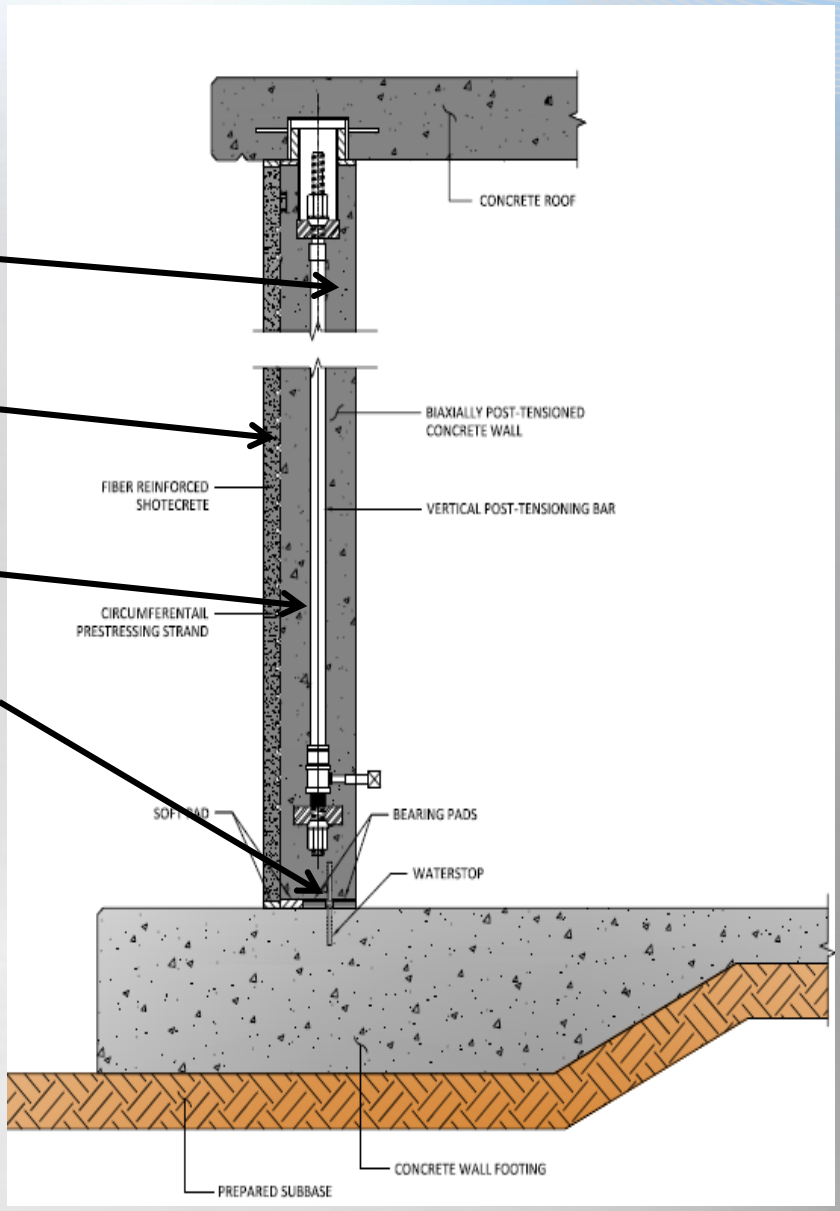
Diffuser Piping





AWWA D110 Type 1 PRESTRESSED CONCRETE TANKS

- Inner Concrete Core
- Horizontal Prestressing
- Vertical Post-Tensioning
- Flexible Floor-Wall Connection



Wall Construction
- AWWA D110 Type 1

Wall Shutters

Wall Detail


Cast-in-Place
APR 19 2006

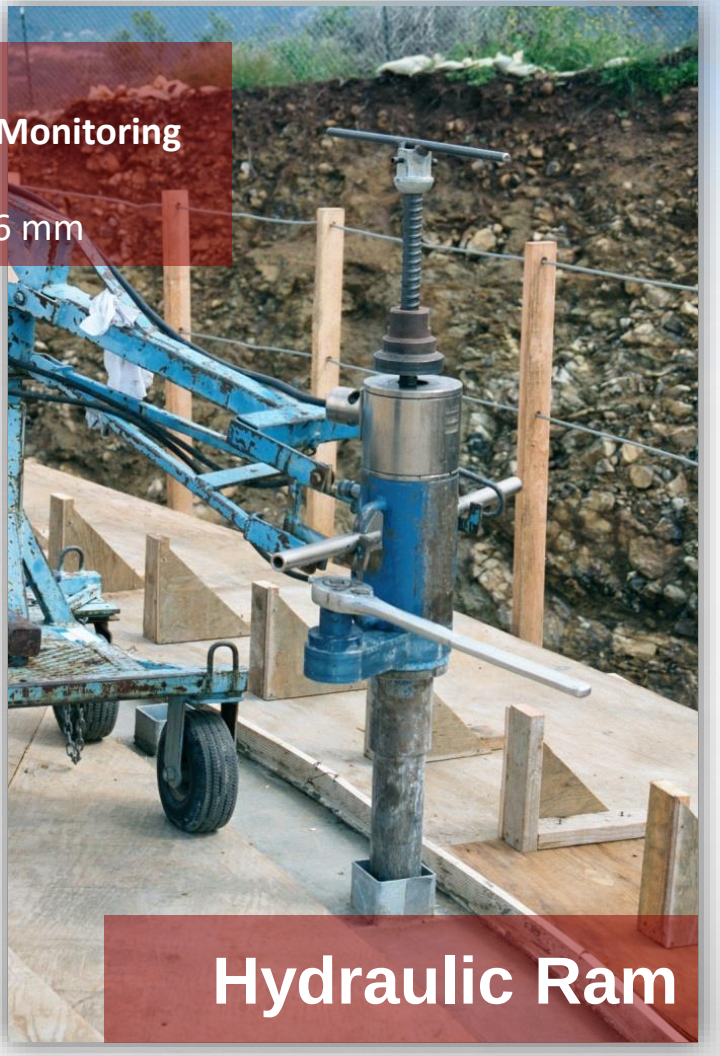
Pour Windows

Vertical Post Tensioning - AWWA D110 Type 1

Continuous Electronic Monitoring

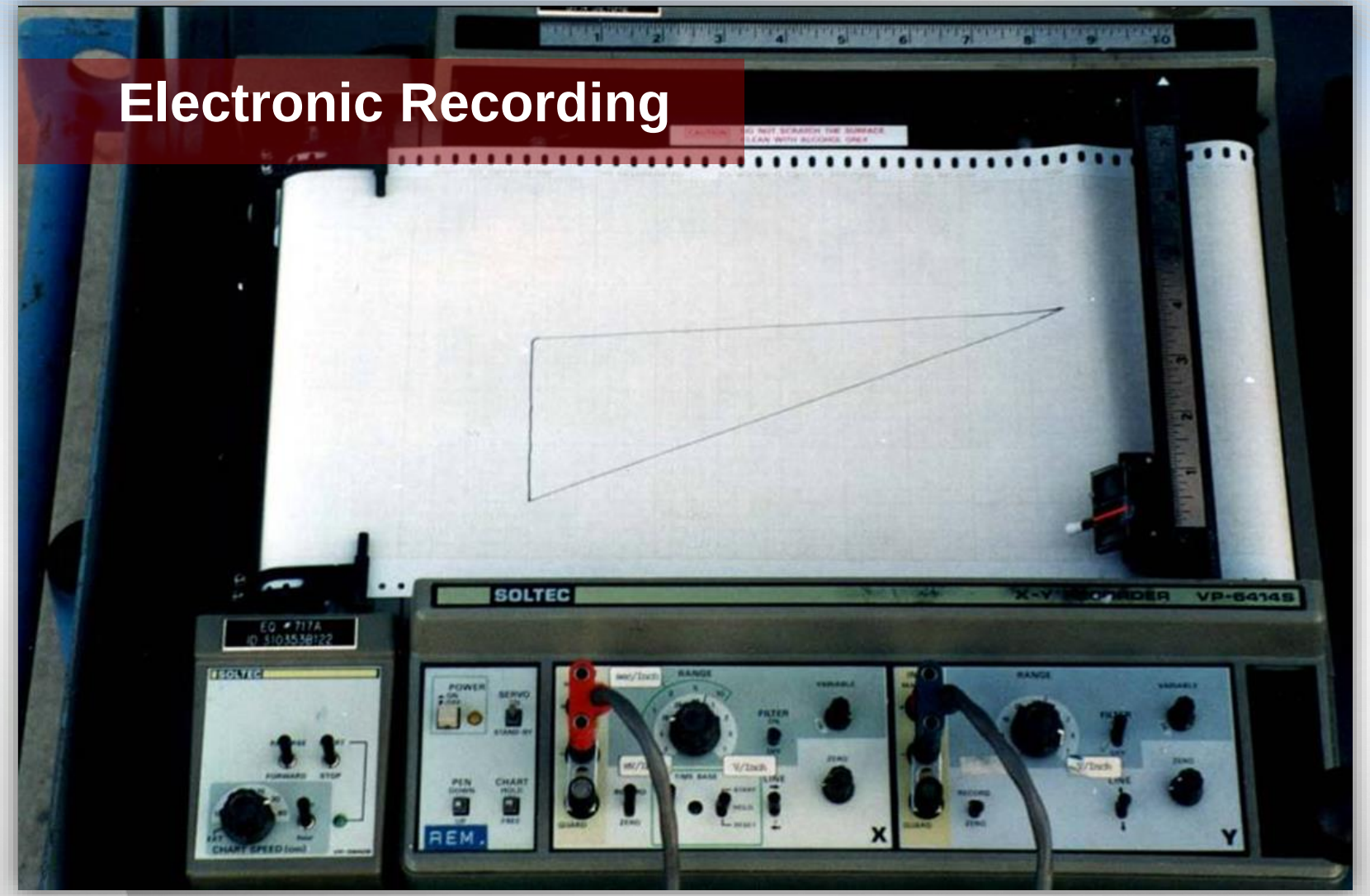
78 tons force – 36 mm

Electronic Recorder



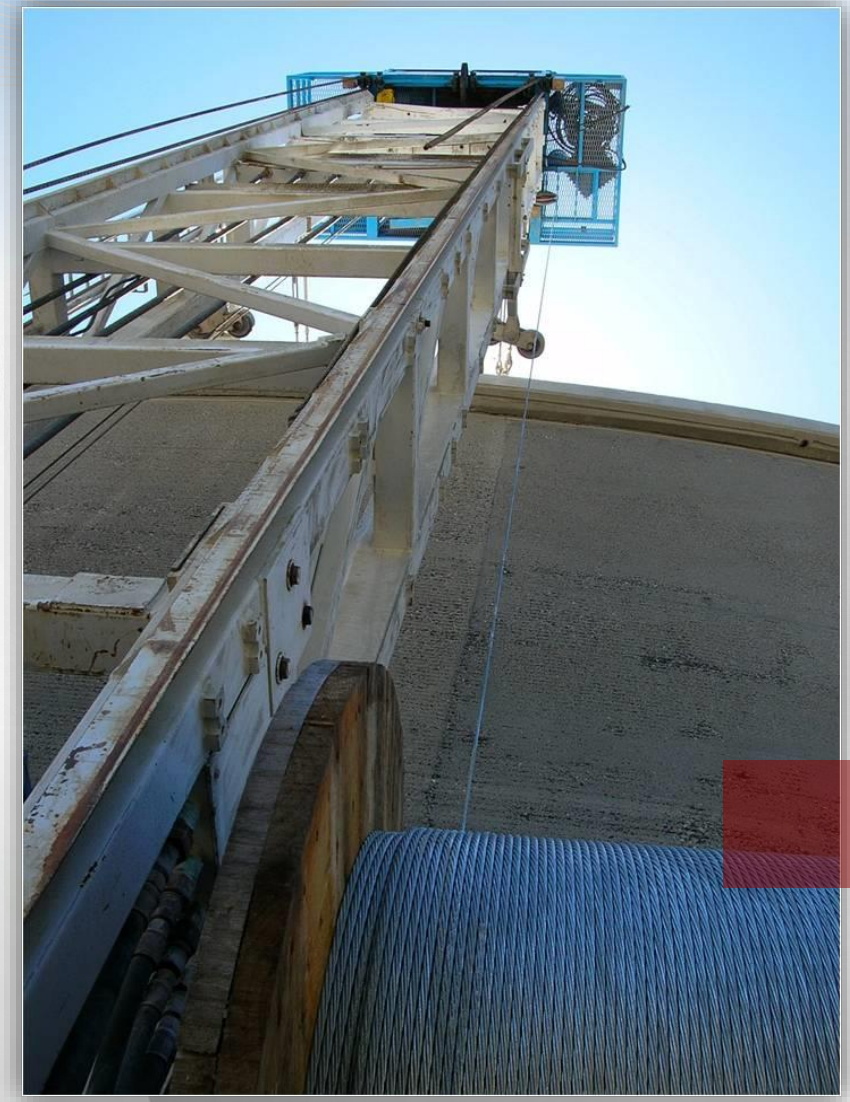
Hydraulic Ram

Electronic Recording



Circumferential Prestressing - AWWA D110 Type 1

Machine Wrapped Strand



Machine Wrapped Prestressing

Water Blasting VIDEO

Strandwrapping

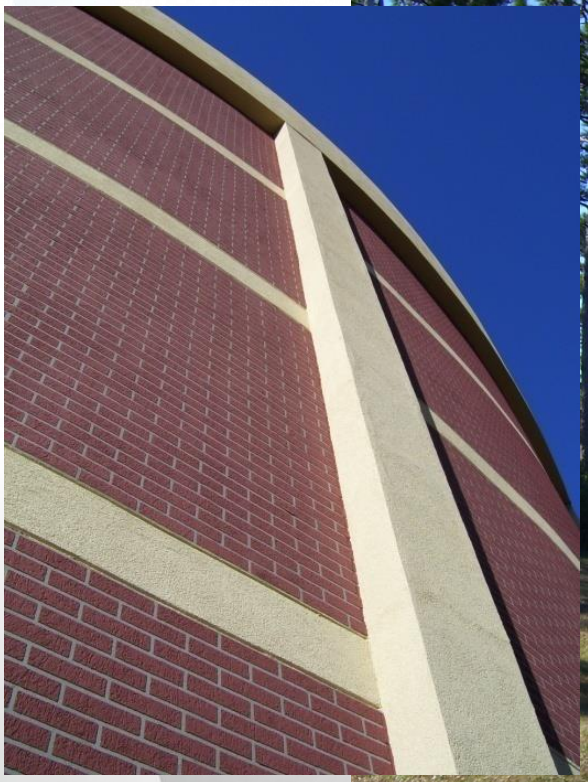
Automated Shotcrete

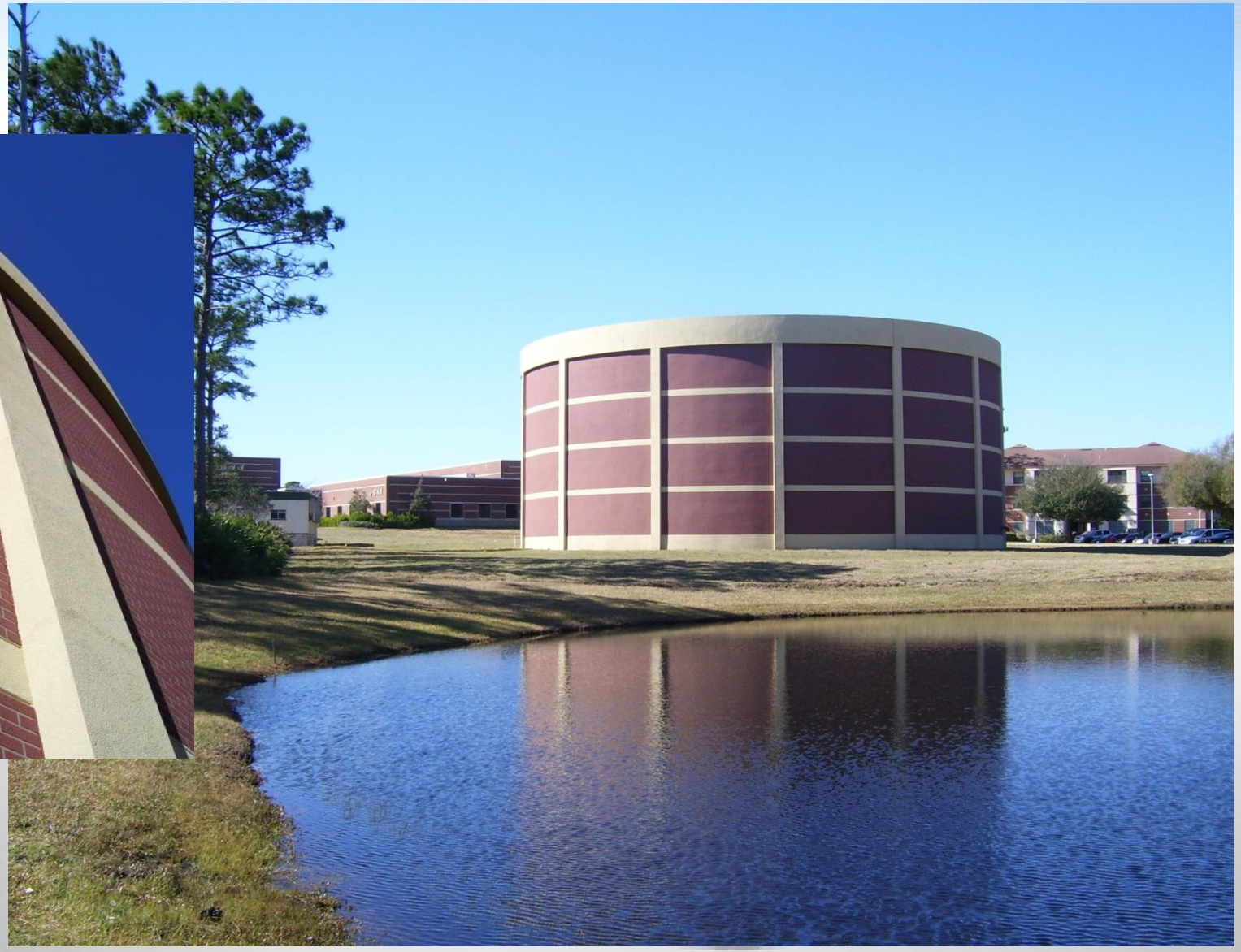
Automated Shotcreting VIDEO

Plastic Wrapping

Exterior Insulation & Finishing System (EIFS)

Blend in with the Campus





Industrial

Owner's Logo

Multi-Color

Partially Buried with Flat Roof / Multi-Use

2 Nos. X 19,000 m3 (4.2 MIG) Tanks

Fully Buried with Flat Roof / Green Space

4,500 m3 (1.0 MIG) Tank

Advantages: AWWA D110 Type 1

- Superior track record of performance
- Concrete in biaxial compression
- No maintenance – no cracks, no leaks
  - No internal coatings
  - No corrosion
  - No measureable leakage
- Quicker construction time
- Singular responsibility: design, diffuser & tank building

Micah J. Somarriba, P.E.
Micah.Somarriba@DNTanks.com
Mobile: +974.6690.6245