TANK INSPECTIONS

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LILLARD & CLARK CONSTRUCTION

ABOUT ME

- DESIGNING TANKS FOR 28 YEARS
- MEMBER OF AWWA D115 “TENDON PRESTRESSED WATER TANKS”
- SERVED ON THE TANK WORKGROUPS FOR THE REWRITE AND UPDATING OF THE CDPHE DESIGN CRITERIA
- FAMILIAR WITH STEEL AND CONCRETE WATER STORAGE TANKS

OVERVIEW

- REVIEW CH. 7 OF THE CDPHE DESIGN CRITERIA
- REVIEW THE STORAGE TANK RULE
- LOOK AT DIFFERENT TANK TYPES AND THEIR PROS AND CONS

CDPHE DESIGN CRITERIA

- 9 CHAPTERS, 191 PAGES
- SOURCE WATER (4 PAGES), TREATMENT (73 PAGES), CHEMICAL APPLICATION (13 PAGES), PUMP STATIONS (5 PAGES), TANKS (13 PAGES), PIPING (8 PAGES), WASTE RESIDUALS (6 PAGES)
- CHAPTER 7, PROTECTED WATER STORAGE

CDPHE DESIGN CRITERIA
CHAPTER 7, PROTECTED WATER STORAGE

- SIZING
- LOCATION
- PROTECTION FROM CONTAMINATION
- SECURITY
- DRAINS

CDPHE DESIGN CRITERIA
TANK DRAINS

- MUST BE SEPARATE
- NOT CONNECTED TO SANITARY SEWER
- OK TO CONNECT TO STORM SEWER WITH VERTICAL SEPARATION
- MUST HAVE FLAPGATE OR DUCKBILL VALVE
- NO SCREENS
- AIR GAP ABOVE DISCHARGE ELEVATION
- MUST BE ABLE TO DRAIN WITHOUT DISRUPTING OPERATION

CDPHE DESIGN CRITERIA
CHAPTER 7, PROTECTED WATER STORAGE

- STORED WATER AGE
- OVERFLOW
- ACCESS
- VENTS
- ROOF TO SIDEWALL – NO CORRUGATED METAL; NO METAL WITH BAD JOINTS
- CONSTRUCTION MATERIALS – NO WOOD OR CONCRETE BLOCK
- SAFETY

CDPHE DESIGN CRITERIA
CHAPTER 7, PROTECTED WATER STORAGE

- SAFETY
- FREEZING (MAINLY STEEL TANKS)
- INTERNAL CATWALK
- SILT STOP – 4” HIGH
- GRADING (NO STANDING WATER WITHIN 50 FEET OF TANK)
- PAINTING/CATHODIC PROTECTION
- DISINFECTION

CDPHE DESIGN CRITERIA OVERFLOWS

- CANNOT BE CONNECTED DIRECTLY TO SANITARY SEWER
- OK WITH VERTICAL SEPARATION ABOVE FINISHED GRADE
- OK TO CONNECT TO STORM SEWERS
- AIR GAP ABOVE DISCHARGE ELEVATION
- MUST BE DESIGNED FOR MAXIMUM INFLOW RATE
- MUST HAVE FUNCTIONING AUTOMATIC DRAINAGE GATE OR CHECK VALVE

FAILED OVERFLOWS

FAILED OVERFLOWS

STORAGE TANK RULE

- EFFECTIVE APRIL 1, 2016
- WATER SUPPLIERS MUST DEVELOP, MAINTAIN AND IMPLEMENT WRITTEN PLAN FOR TANK INSPECTIONS
- PERIODIC AND COMPREHENSIVE INSPECTIONS
- NO SANITARY DEFECTS
- DEVELOP CORRECTIVE ACTION TO FIX ANY SANITARY DEFECTS
- CAN'T USE UNCOVERED TANKS

STORAGE TANK RULE

- CDPHE MUST BE NOTIFIED IF
  - ANIMAL CARCASS FOUND IN TANK
  - CONFIRMED MICROBIAL CONTAMINATION
  - CHEMICAL CONTAMINATION

STORAGE TANK RULE
SANITARY DEFECTS

- SANITARY DEFECT POLICY, DW-010
  - PENETRATIONS THAT AREN'T PROPERLY SEALED
  - EVIDENCE OF CONTAMINATION INSIDE THE TANK
  - SEDIMENT OR SLUDGE DEPTH THAT EXCEEDS 1 INCH
  - FAILED INTERIOR COATING
  - STRUCTURAL DEFICIENCIES IN FLOOR, WALLS OR ROOF (INCLUDES BIOFILM)

STORAGE TANK RULE
INSPECTION PLAN

- TANK INVENTORY
- INSPECTION METHODS
- INSPECTION SCHEDULE
- SANITARY DEFECT CORRECTIVE ACTION SCHEDULES (DETERMINED BY SUPPLIER)
- INSPECTION SUMMARY

STORAGE TANK RULE GUIDANCE

- NOT REQUIRED
- TANKS CLEANED EVERY 3-5 YEARS
- TANK SITES SHOULD BE FENCED
- PREVENT ACCESS TO LADDERS
- HATCHES SHOULD HAVE INTRUSION ALARMS
- NO VEGETATION AROUND THE TANK

STORAGE TANK RULE GUIDANCE (CONT.)

- MAINTAIN EXTERIOR COATINGS
- KEEP OVERFLOW PIPES CLEAR OF VEGETATION, DIRT/ROCKS OR OTHER BLOCKAGES
- PROPER OPERATION TO MINIMIZE STORED WATER AGE
- MAINTAIN INTERIOR LADDERS

STORAGE TANK RULE
DW015 – INSPECTION METHODS AND QUALIFIED PERSONNEL

- INSPECTION METHODS NOT DETERMINED BY CDPHE
- DOCUMENT WITH PHOTOGRAPHS
- DRONES ARE OK BUT DOCUMENTATION MUST BE AVAILABLE FOR REVIEW; MUST BE GOOD QUALITY

STORAGE TANK RULE
DW015 – INSPECTION METHODS AND QUALIFIED PERSONNEL

- WHO CAN INSPECT TANKS
  - DEPENDS ON TYPE OF INSPECTION – PERIODIC OR COMPREHENSIVE
  - NEED TO HAVE INSPECTOR'S QUALIFICATIONS AS PART OF THE WRITTEN PLAN
  - COMMERCIAL DIVERS ARE OK, BUT SHOULD HAVE SOME TRAINING
  - RESPONSIBILITY OF NOTING SANITARY DEFECTS LIES WITH THE SUPPLIER NOT THE INSPECTOR

STORAGE TANK RULE
DW015 – INSPECTION METHODS AND QUALIFIED PERSONNEL

- PERIODIC INSPECTIONS
  - FOCUS ON VENTS, OVERFLOWS, HATCHES AND ANY OTHER TANK PENETRATION
  - HAVE PHOTOGRAPHIC DOCUMENTATION
  - OPEN ACCESS HATCHES TO OBSERVE INTEGRITY OF SEAL
  - PERFORMED BY CERTIFIED OPERATORS

STORAGE TANK RULE
DW015 – INSPECTION METHODS AND QUALIFIED PERSONNEL

- COMPREHENSIVE INSPECTIONS
  - PHOTOGRAPHIC DOCUMENTATION
  - LOOK FOR SANITARY, STRUCTURAL AND COATING SYSTEMS CONDITIONS, SECURITY AND SAFETY
  - FOCUS ON AREAS WHERE SANITARY DEFECTS ARE LIKELY TO OCCUR
  - TANK CLEANING IS NOT A COMPREHENSIVE INSPECTION

STORAGE TANK RULE
DW015 – INSPECTION METHODS AND QUALIFIED PERSONNEL

- INSPECTION METHODS
  - DRY OUT-OF-SERVICE
  - WET IN-SERVICE
  - ROBOTIC
  - FLOATING

STORAGE TANK RULE
COMPREHENSIVE INSPECTION CHECKLIST

Inspection Item:	Yes/No	N/A	Comments/Corrective Action Schedule/Action Taken/Corrective Action Completion Date:
1. Photographs or video taken?	☐ Y ☐ N		If no, why not?
INTERNAL TANK INSPECTION			
2. Contamination in the tank (e.g. floating debris, insects, other animal contamination, roots, etc.)?	☐ Y ☐ N		
3. Water turbid, discolored, stale or foul?	☐ Y ☐ N		
4. Is stored water routinely turned over (stand pipe with valves or mechanical mixer), even in times of low demand	☐ Y ☐ N		

STORAGE TANK RULE
COMPREHENSIVE INSPECTION CHECKLIST

	logged/ written data):		
5.	Cathodic protection functioning appropriately? (is the anode missing, is it in contact with water or is tank corrosion present)	☐ Y ☐ N	☐	Only check 'N/A' if the tank has no cathodic protection system.
6.	**Interior coating: Blistering, peeling, scaling, rusting, any irregularities or other failure?**	☐ Y ☐ N		If conditions exist but do not constitute a sanitary defect, answer 'N' to the left and describe them here; include recommendations to prevent sanitary defects.
7.	**Interior sidewalls: Structural deficiencies, biofilm, sealant loss, any irregularities or other failure?**	☐ Y ☐ N		
8.	**Roof interior: Structural deficiencies, any irregularities or other failure?**	☐ Y ☐ N		

STORAGE TANK RULE
COMPREHENSIVE INSPECTION CHECKLIST

9. Interior hatch: Structural deficiencies, any irregularities or other failure?	☐ Y ☐ N		
10. Is there a stamp in the tank, documentation, or other evidence that the interior coating meets ANSI/NSF Standard 61 or equivalent potable water certification? If there is, include a photograph of the stamp, a copy of the documentation, or other evidence in the written inspection plan.	☐ Y ☐ N	☐	Only check 'N/A' if the tank has no interior coating.
11. Tank floor: Corrosion? Sediment/Sludge? Any structural deficiencies? Any irregularities? Other failure?	☐ Y ☐ N		

STORAGE TANK RULE
COMPREHENSIVE INSPECTION CHECKLIST

12. Tank penetrations (joints/ gaskets), as seen from the interior, adequately sealed?	☐ Y ☐ N	☐	
13. When viewed from inside the tank, is there visible daylight around the hatches, vents, joints or other fixtures? If yes, document location where light can	☐ Y ☐ N	☐	

STORAGE TANK RULE
COMPREHENSIVE INSPECTION CHECKLIST

14. Is there evidence of damage or corrosion to the internal ladder?	☐ Y ☐ N	☐	
15. Other concerns?	☐ Y ☐ N		(Add pages as needed for other concerns.)
16. Cleaning completed? Please note: The Storage Tank Rule does not require routine tank cleaning during tank inspections.	☐ Y ☐ N	☐	If so, when? If cleaning revealed any findings or sanitary defect corrections, document above.

TANK TYPES

- BOLTED STEEL (AWWA D103)
- WELDED STEEL (AWWS D100)
- CONVENTIONALLY REINFORCED CONCRETE (CIRCULAR OR RECTANGULAR) (ACI 350)
- POST-TENSIONED CONCRETE (CIRCULAR) (AWWA D115)
- WIRE WRAPPED CONCRETE (CIRCULAR) (AWWA D110)

BOLTED STEEL TANKS

- GENERALLY LEAST CAPITAL COST
- CAN'T/SHOULDN'T BE BURIED
- JOINTS ARE SEALED USING GASKETS AND SEALANTS
- NO REQUIREMENT FOR SEPARATE DRAIN
- VENTS ARE NOT REQUIRED TO BE FROST PROOF
- COATINGS (SHOP APPLIED)
  - GALVANIZED
  - GLASS FUSED
  - THERMOSET LIQUID SUSPENSION EPOXY
  - THERMOSET POWDER COATINGS
- LIFESPAN OF ABOUT 30 YEARS

WELDED STEEL TANKS
AWWA D100

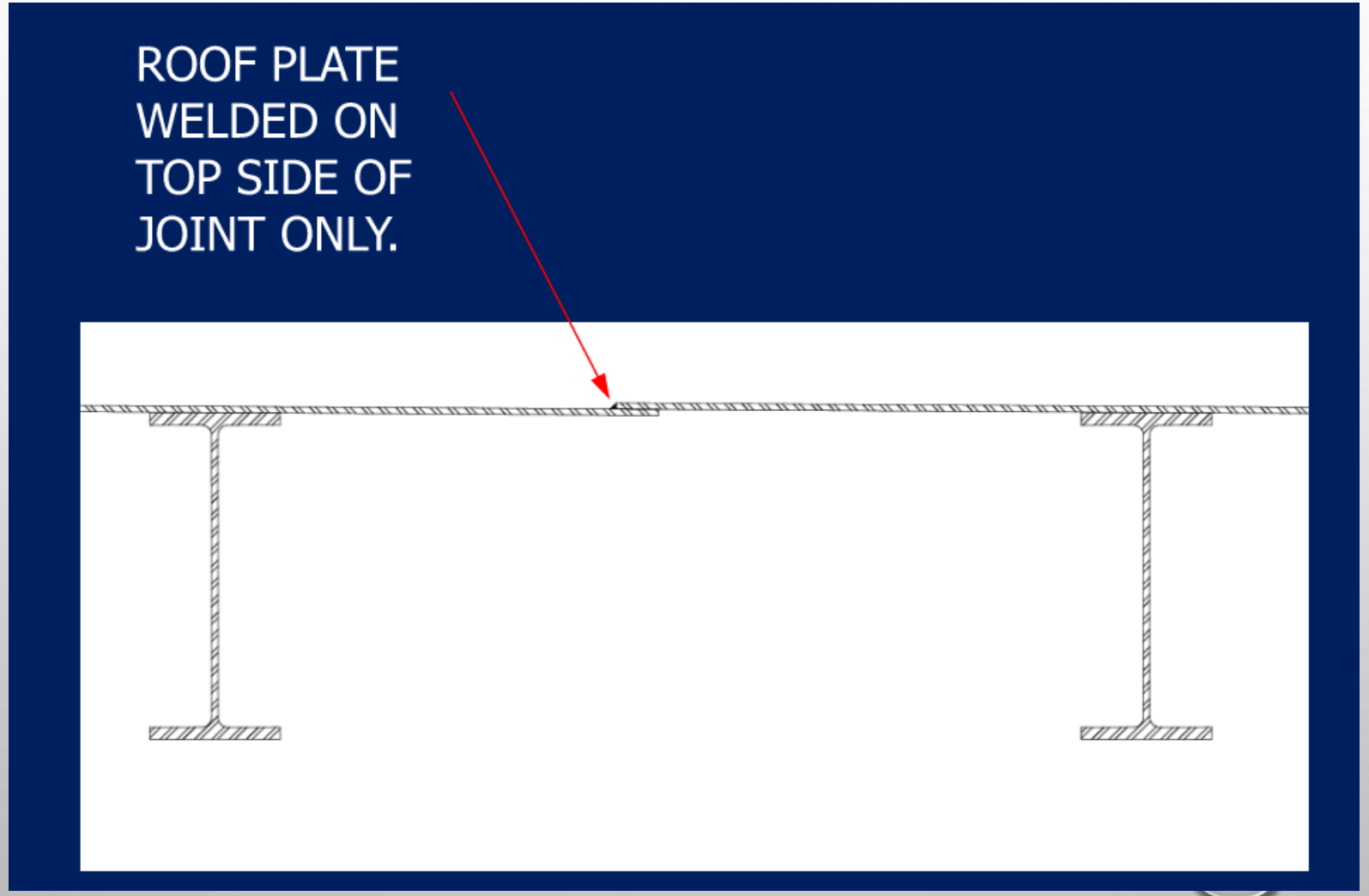
- COSTS ARE WIDE RANGING
- CAN'T (SHOULDN'T) BE BURIED
- JOINTS ARE FULLY WELDED
- INACCESSIBLE AREAS ARE NOT PAINTED
- PRESSURE VACUUM RELIEF VENT IS REQUIRED
- NO REQUIREMENT FOR SEPARATE DRAIN
- COATINGS ARE FIELD APPLIED

WELDED STEEL TANKS
ROOF DETAILS TO IMPROVE CORROSION RESISTANCE THAT NOBODY DOES

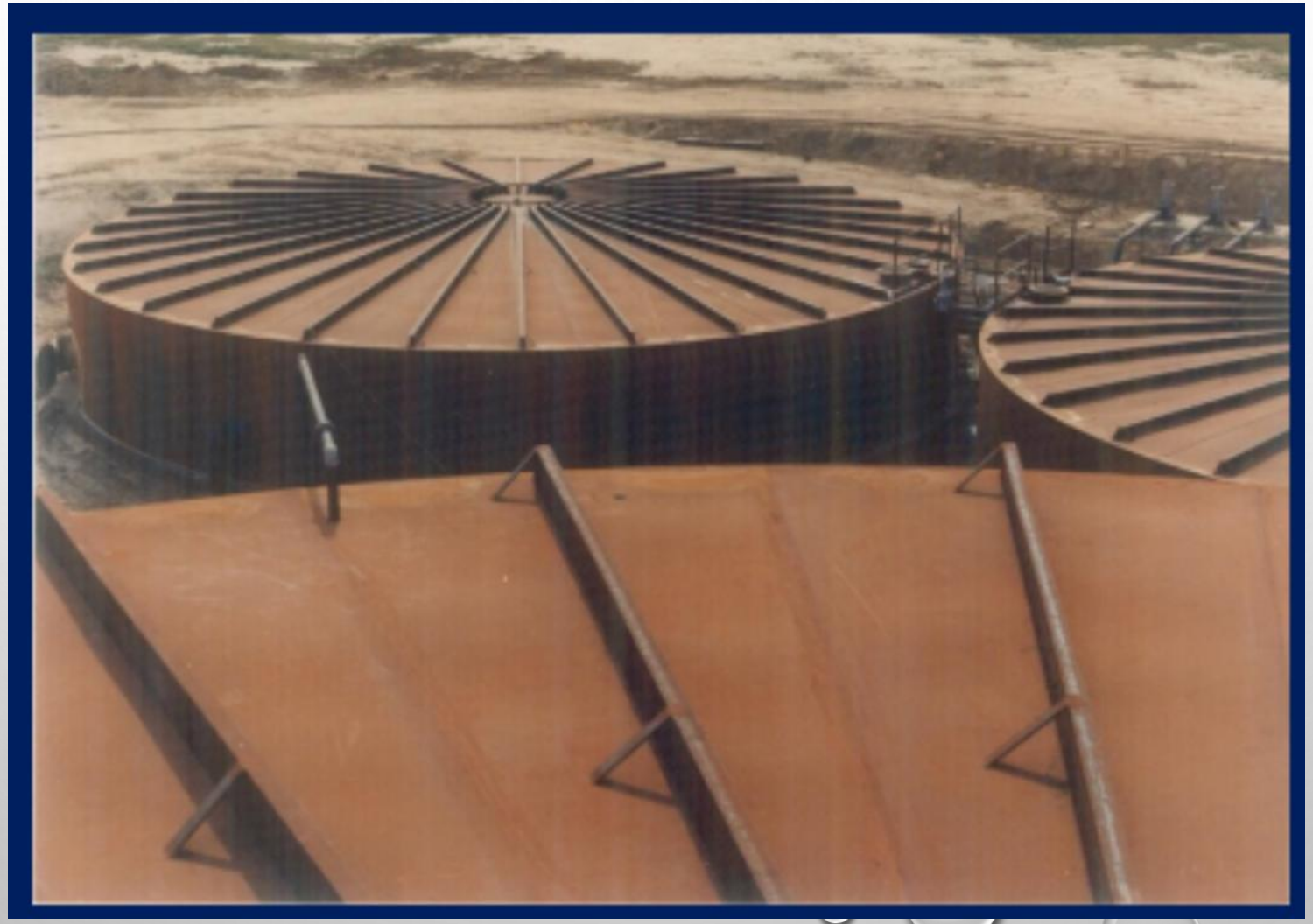
- SEAL WELD ROOF LAP JOINTS
- CAULK ROOF LAP JOINTS IF NOT SEAL WELDED
- SEAL WELD ROOF RAFTERS TO ROOF PLATE
- GET RID OF THE CENTER COLUMN
- USE RADIAL PLATE SEAMS WITH SEAMS BETWEEN RAFTERS

WELDED STEEL TANKS

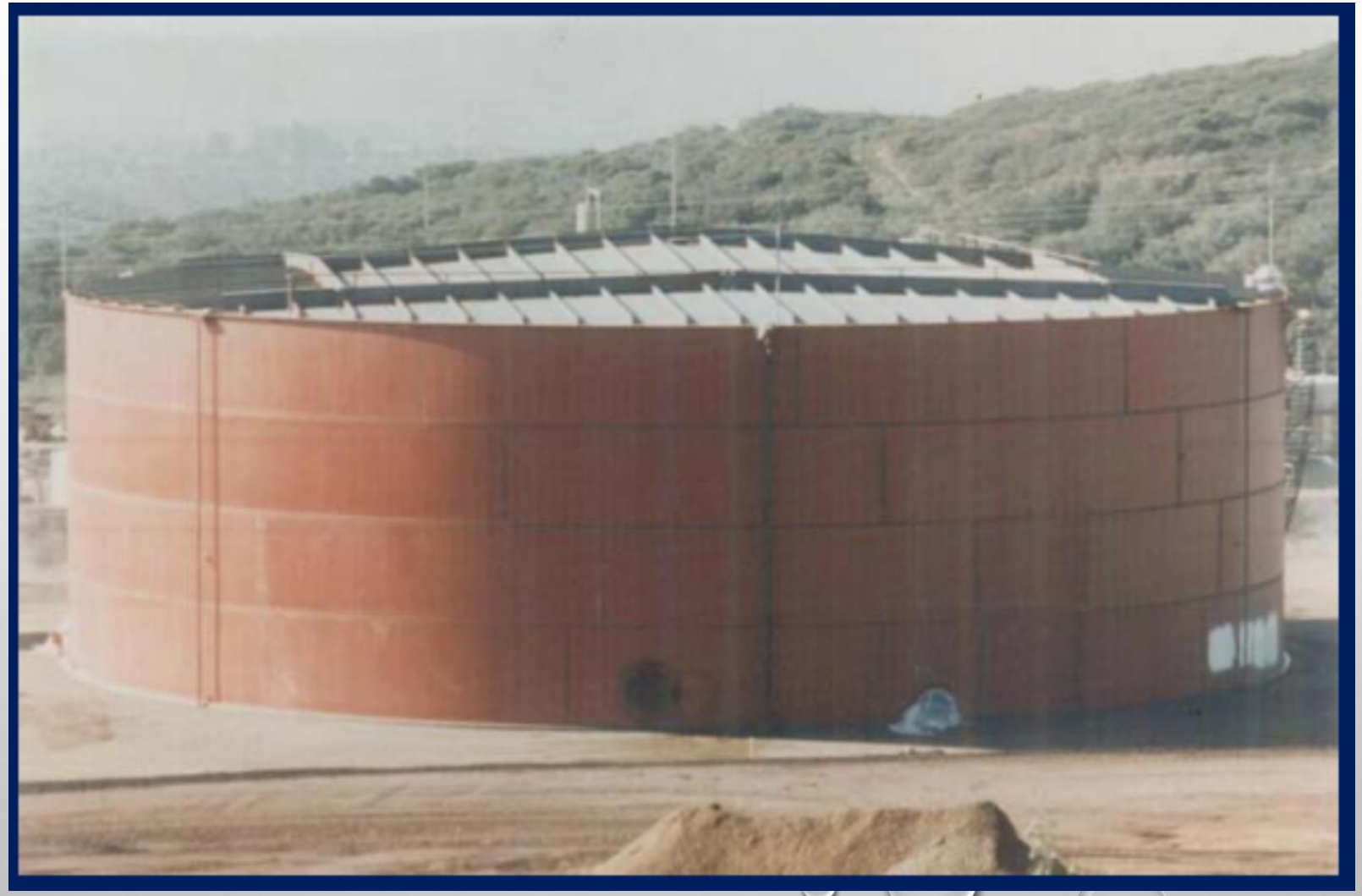
WELDED STEEL TANKS
ROOF DETAILS TO IMPROVE CORROSION RESISTANCE
THAT NOBODY DOES



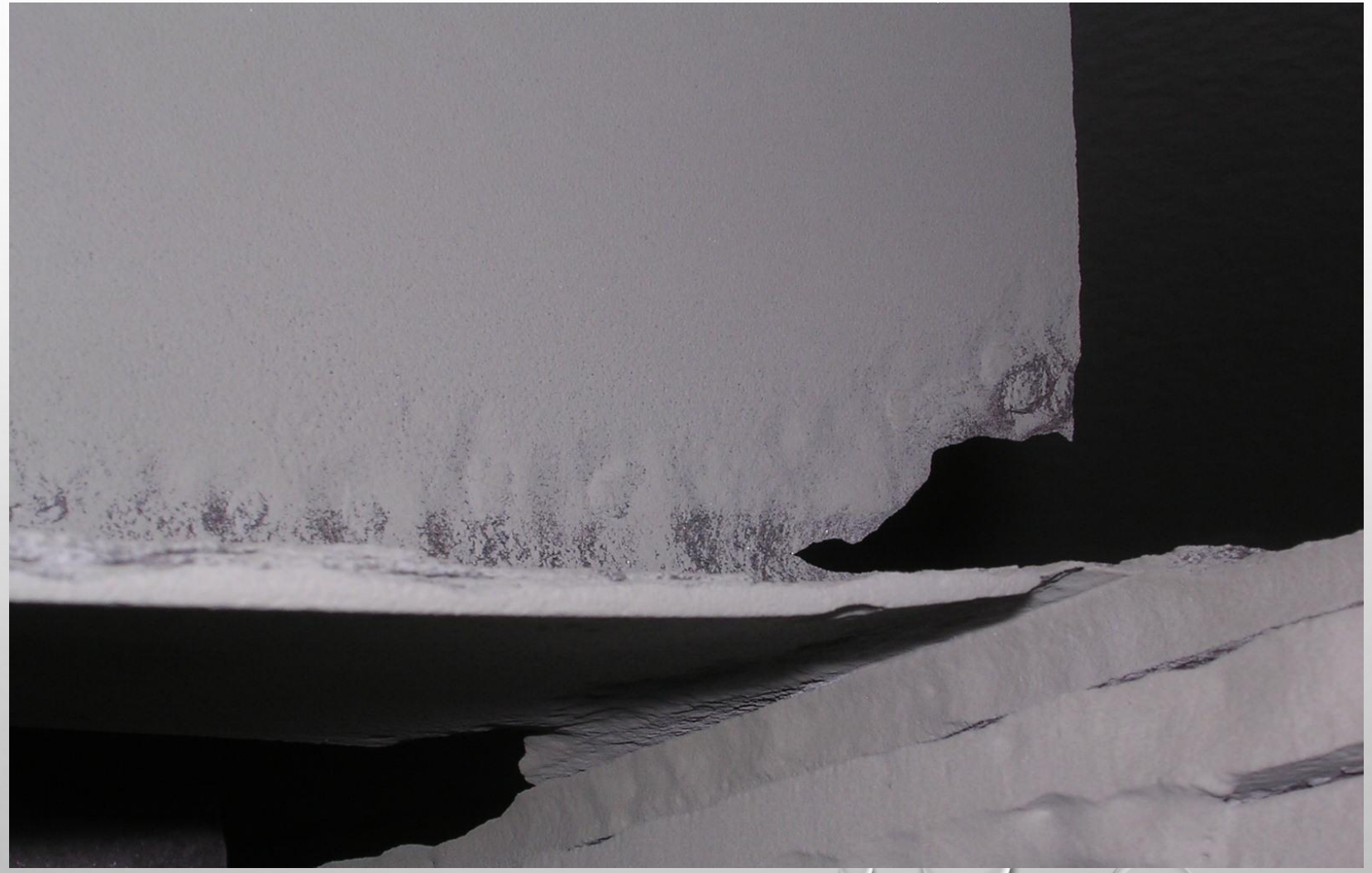
WELDED STEEL TANKS



WELDED STEEL TANKS



WELDED STEEL TANKS



WELDED STEEL TANKS

WELDED STEEL TANKS

CONCRETE TANKS CONVENTIONALLY REINFORCED

- NO AWWA STANDARD
- WILL CRACK MORE THAN POST-TENSIONED OR WIRE WRAPPED
- CONCRETE COVER TO REINFORCING STEEL IS CRITICAL

CONCRETE TANKS CONVENTIONALLY REINFORCED

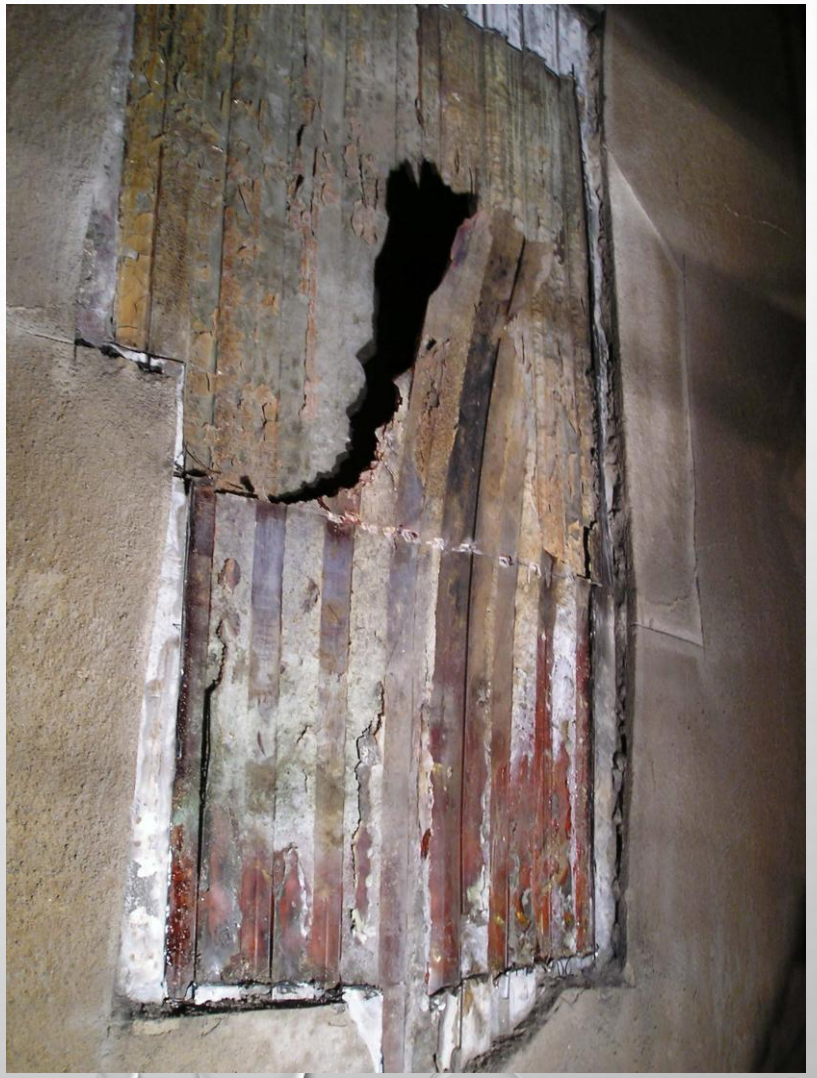
CONCRETE TANKS CONVENTIONALLY REINFORCED

CONCRETE TANKS
PRESTRESSED CONCRETE WATER TANKS

- AWWA D110
- CIRCULAR ONLY
- CONVENTIONALLY REINFORCED CONCRETE FLOOR
- FOUR DIFFERENT TYPES OF CORE WALLS
  - TYPE I – CAST-IN-PLACE CONCRETE WITH VERTICAL PRESTRESSED REINFORCEMENT
  - TYPE II – SHOTCRETE WITH A STEEL DIAPHRAGM
  - TYPE III – PRECAST CONCRETE WITH A STEEL DIAPHRAGM
  - TYPE IV – CAST-IN-PLACE CONCRETE WITH A STEEL DIAPHRAGM
- LOTS OF JOINTS TYPICALLY
- DIFFICULT TO REPAIR WALL LEAKS

PRESTRESSED CONCRETE WATER TANKS

CONCRETE TANKS
PRESTRESSED CONCRETE WATER TANKS



CONCRETE TANKS
PRESTRESSED CONCRETE WATER TANKS

- ROOF SLAB - CONCRETE ROOF STRUCTURES WITH ROOF JOINTS ARE NOT ALLOWED, EXCEPT DOMED, PRE-STRESSED ROOFS AND SIDEWALLS, THAT HAVE A WATERTIGHT EXTERIOR COATING WITH NO EXPOSED METAL CONNECTIONS OR CABLES (FROM CDPHE DESIGN CRITERIA)
- TYPICALLY HAVE A DOMED ROOF

CONCRETE TANKS
PRESTRESSED CONCRETE WATER TANKS

CONCRETE TANKS
PRESTRESSED CONCRETE WATER TANKS

CONCRETE TANKS
POST-TENSIONED CONCRETE WATER TANKS

- AWWA D115
- CAN BE RECTANGULAR WITH RADIUSED CORNERS OR CIRCULAR (TYPICALLY CIRCULAR)
- POST-TENSIONED FLOOR, WALLS AND ROOF
- TYPICALLY LESS JOINTS

CONCRETE TANKS
POST-TENSIONED CONCRETE WATER TANKS

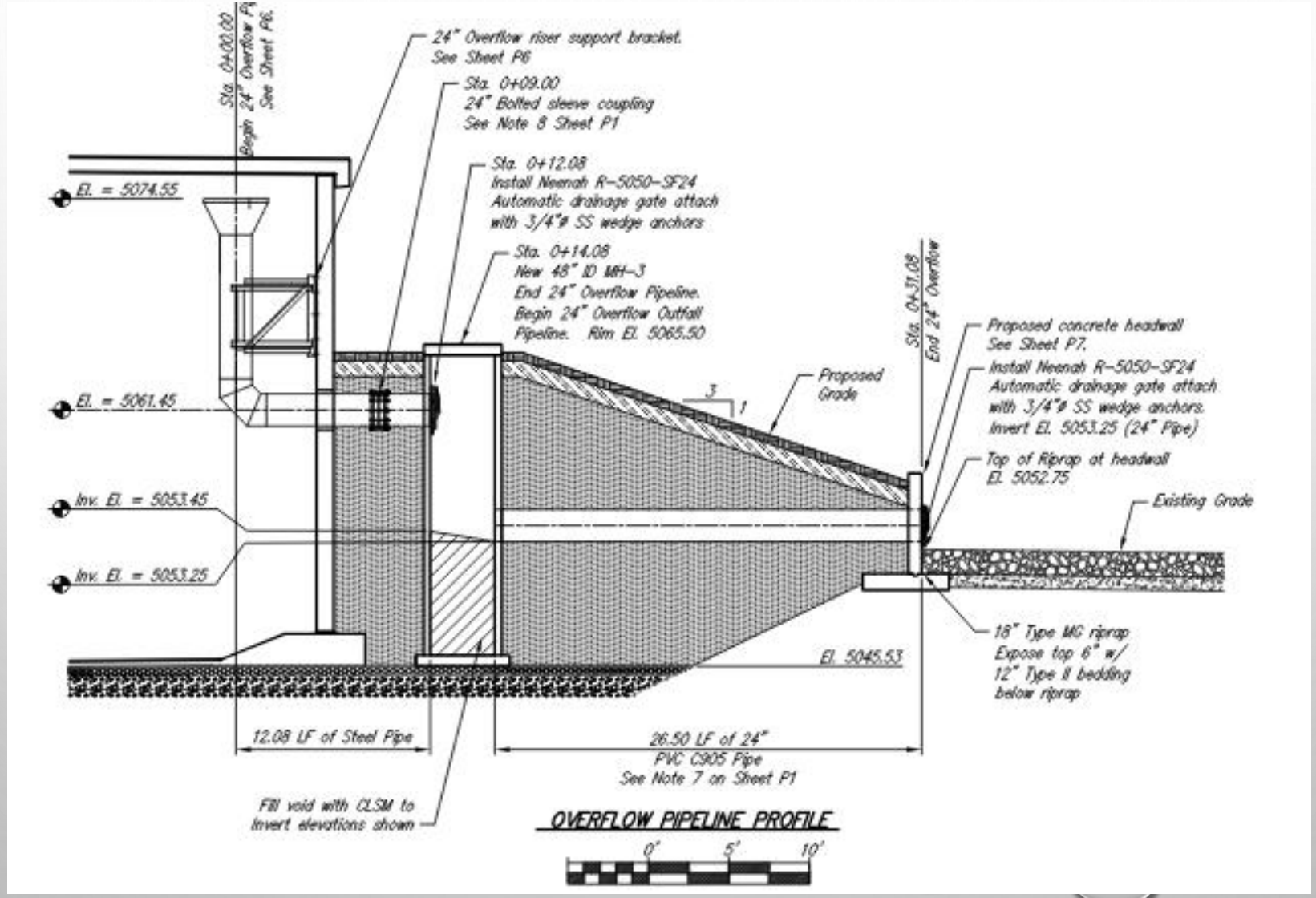
- WALL TENDON TYPE
  - UNBONDED VS BONDED TENDONS

CONCRETE TANKS
POST-TENSIONED CONCRETE WATER TANKS

CONCRETE TANKS
POST-TENSIONED CONCRETE WATER TANKS

CONCRETE TANKS
POST-TENSIONED CONCRETE WATER TANKS

CONCRETE TANKS
OVERFLOW THROUGH WALLS



CONCRETE TANKS ALLOWABLE LEAKAGE

TANK TYPE	ALLOWABLE LEAKAGE (% OF TANK VOLUME PER DAY)	ALLOWABLE LOSS FOR A 5.0-MG TANK IN GALLONS PER DAY	LOSS PER YEAR IN GALLONS
CONVENTIONALLY REINFORCED	0.05	2,500	912,500
WIRE WRAPPED (D110)	0.05	2,500	912,500
INTERNAL TENDON (D115)	.0125	625	228,125

SUMMARY
AREAS OF CONCERN BY TANK TYPE

- BOLTED STEEL TANKS
  - LEAKING JOINTS
  - CONDITION OF COATINGS/CORROSION
  - REPAIRS ARE DIFFICULT IF NOT IMPOSSIBLE

SUMMARY
AREAS OF CONCERN BY TANK TYPE

- WELDED STEEL TANKS
  - CONDITION OF COATINGS/CORROSION
  - CONDITION OF THE UNDERSIDE OF THE FLOOR PLATE
  - CATHODIC PROTECTION SYSTEMS

SUMMARY
AREAS OF CONCERN BY TANK TYPE

- CONCRETE TANKS
  - CORRODED REINFORCING STEEL
  - CONCRETE QUALITY
  - WALL PENETRATIONS FOR BURIED TANKS

SUMMARY
AREAS OF CONCERN FOR ALL TANKS

- SEDIMENT ON THE FLOOR
- LEAKS
- PIPE PENETRATIONS
- VENTS
- DRAIN/OVERFLOW DISCHARGE POINTS
- HATCHES
- LADDERS/STAIRS