THERMAL STORAGE FOR LARGE LABORATORY LOADS, A Case Study

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

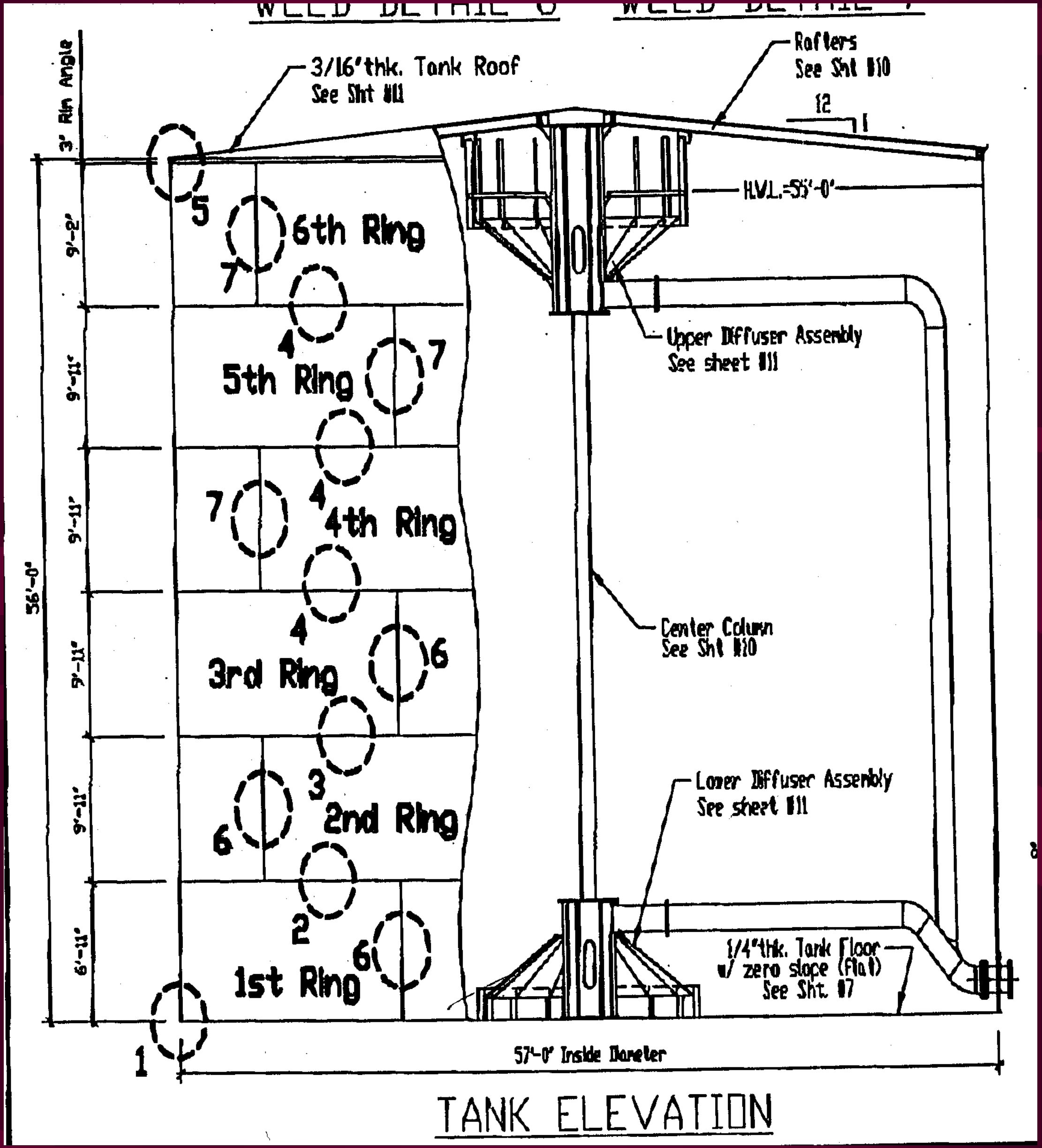
- No Moving Parts
- No New Pumps Required
- Will Last Over Fifty Years
- Low Maintenance
- Fast Payback

THERMAL STORAGE SYSTEM

- **Makes Chilled Water At Night When Electric Rates Are Less For Use During The Day To Cool Ten Connected Buildings**
- **Stores Over One Million Gallons Or Ten Thousand Ton/Hours Of Cooling Water**
- **Allows For The Shutoff Of Chillers During The Day When Electric Rates Are High**
- **Potential Energy Savings Of Over $ 200,000 Per Year**
- **Adds The Potential To Optimize Other Related Systems For Additional Savings**

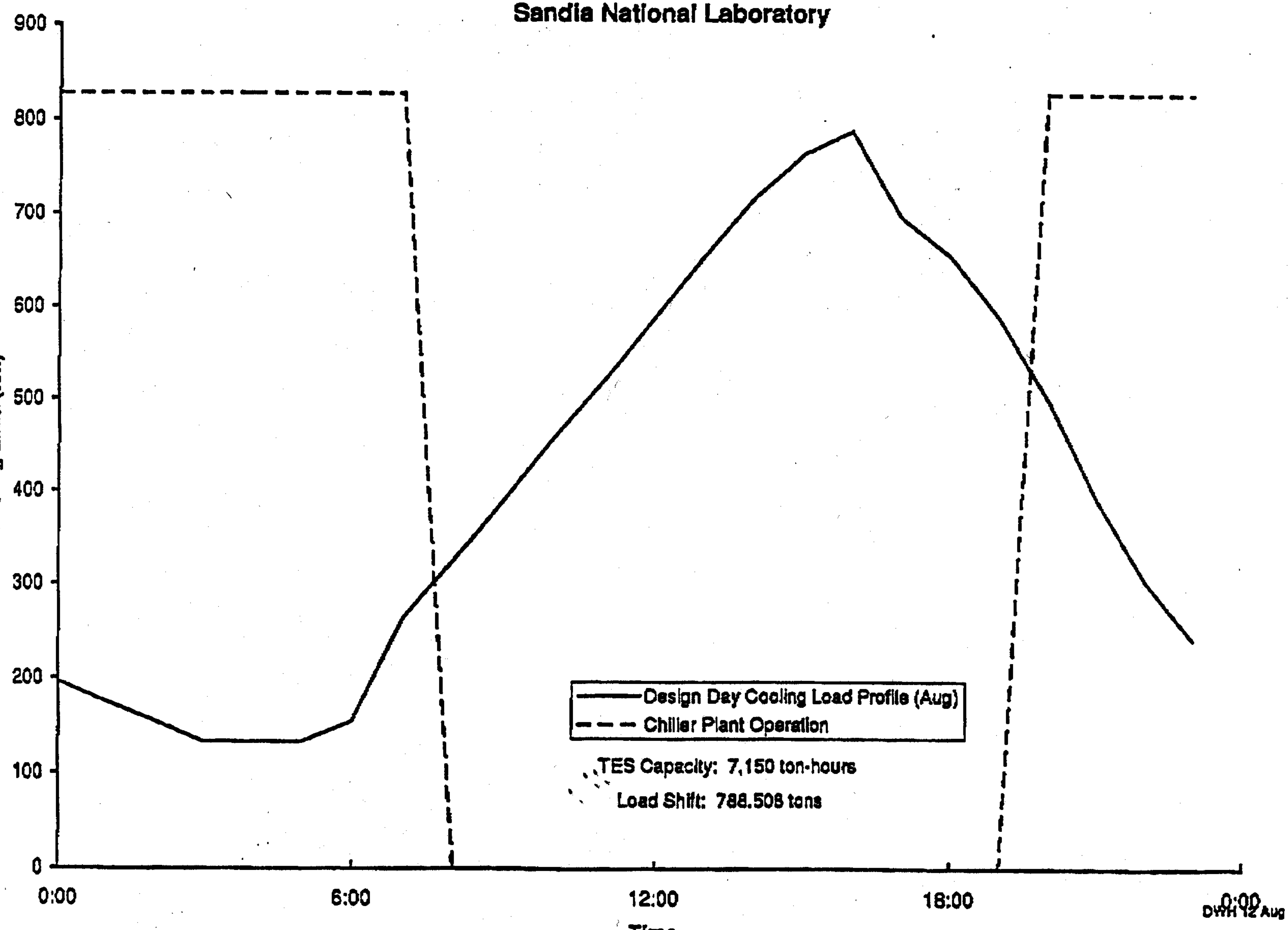
Thermal Storage Theory

- Warm return water and cold supply water in the same tank
- Thermocline forms due to density differences associated with temperature
- Cold water stays at the bottom, Warm at the top, similar to a lake
- Non Turbulent diffuser system
- Closed system, no head loss due to low velocity



Tank Internals

Strata-Therm® Options
Scenario D: Full Shift System - Design Month
Sandia National Laboratory



Background and History

- We were designing a new laboratory, the Processing and Environmental Technology Laboratory or PETL
- PETL would need a source of chilled water for cooling
- We had a nearby Campus chiller plant that served ten other buildings

PETL Nearing Completion

- We were under a normal Electrical rate structure with Peak, Off Peak, and Demand Charges
- Thermal Storage was presented as a possible alternative to new chillers and cooling towers
- The existing chiller plant was in need of a thorough design review (known over pumping problems)

Design Review of Thermal Storage

- Our A&E Firm came back to us with a less than optimistic life cycle cost report
- I worked with CBI and found a totally different result
- A last minute decision was made to use Chilled Water Thermal Storage

Cost Analysis

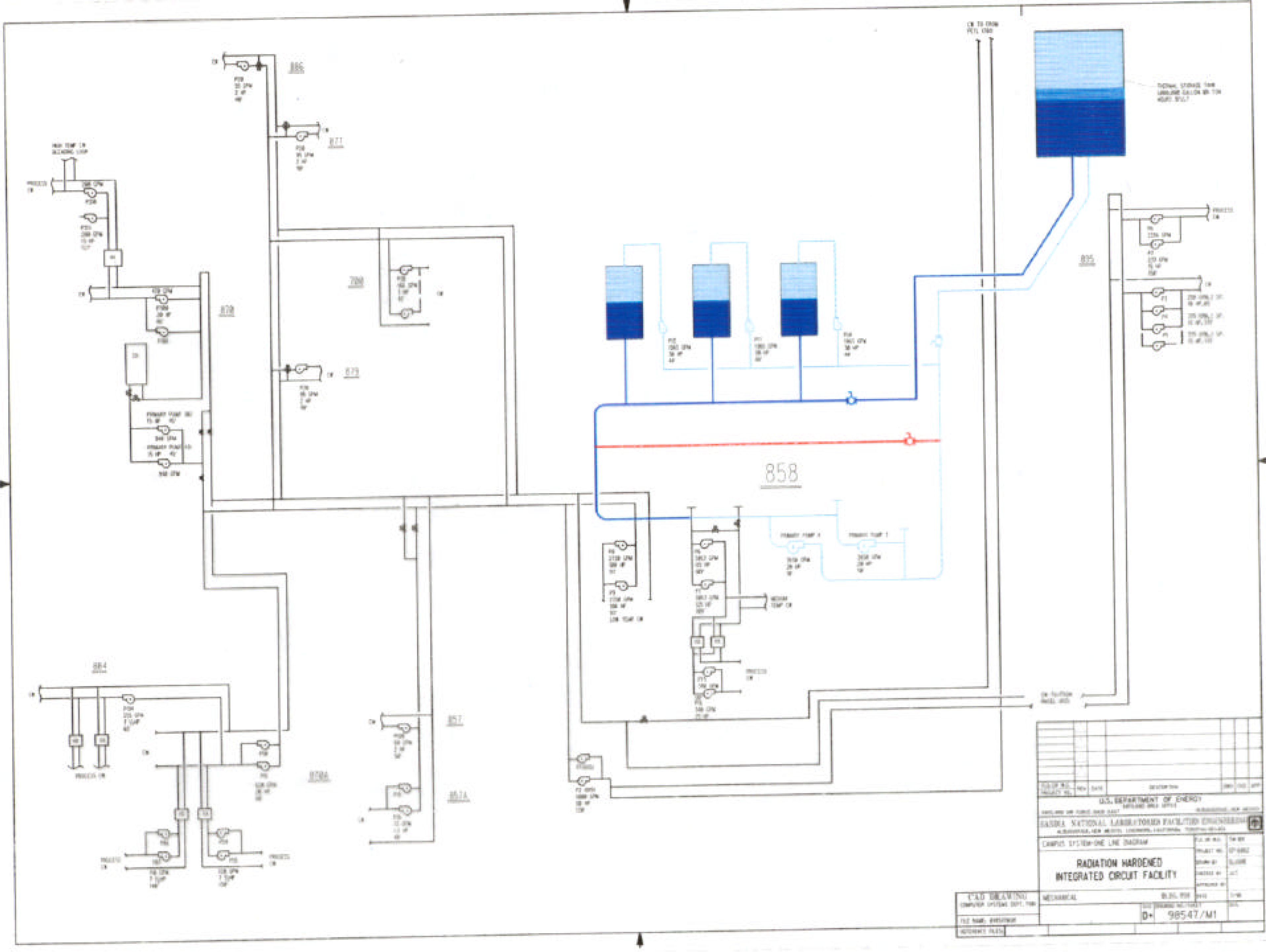
- First cost was available from the PETL project that would have been spent on chillers and cooling towers
- Estimated $200,000 a year in energy costs and reduced maintenance
- Simple payback of less than one year, operational before PETL for a near zero payback period

Our Plan

- Gain a complete understanding of the existing chiller plant operation
- Create a campus wide design intent and operating structure
- Design the Thermal Storage System to supply PETL while correcting design deficiencies of the entire campus system (AE’s design later replaced with Sandia design)

Our Plan

- Perform a complete flow analysis to verify the new design
- Implement the findings
- Keep metrics on the operation and correct the control strategy as required
- Claim victory for our facilities group and live happily ever after



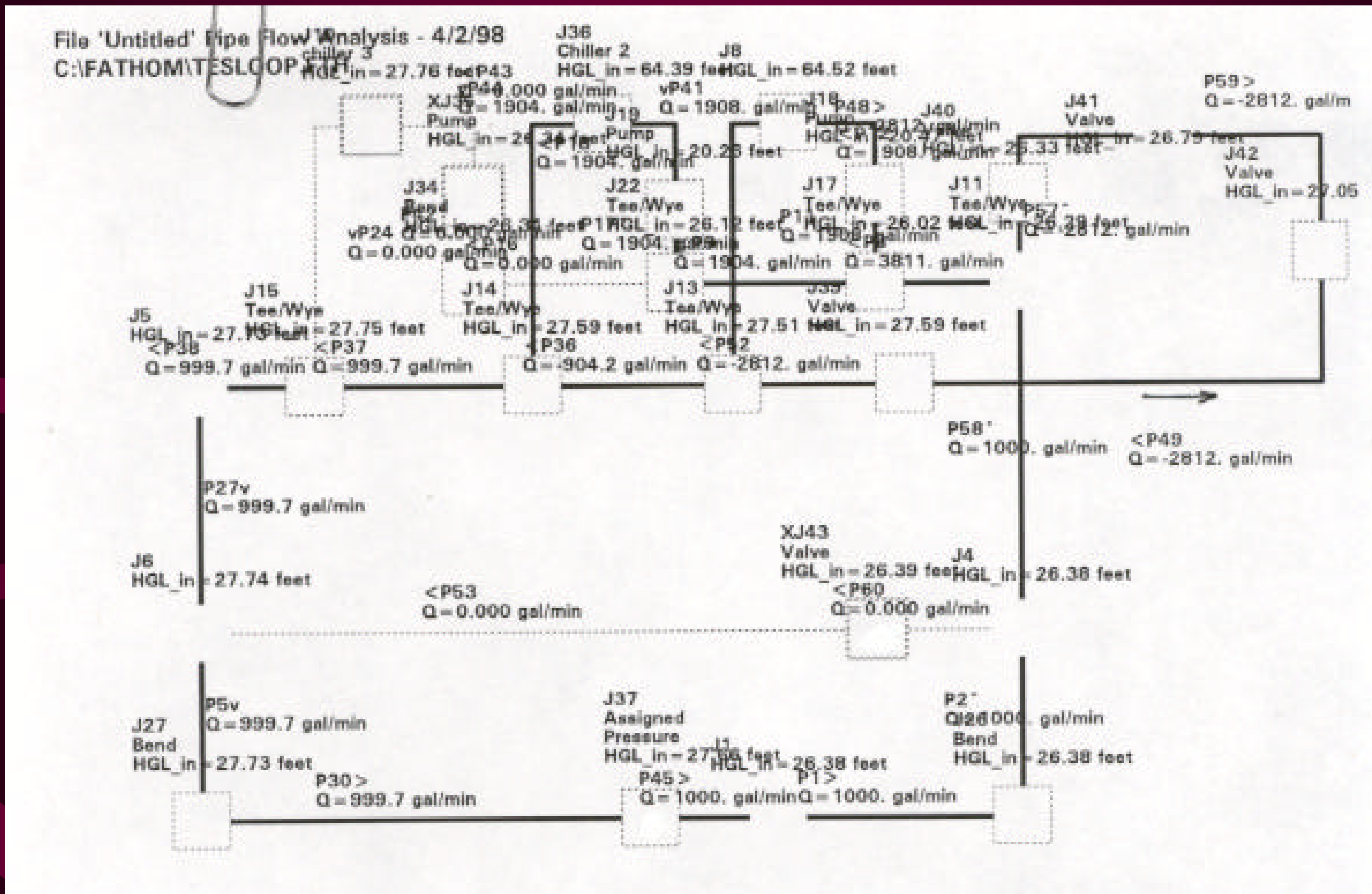
886
871
879
700
873
858
835
884
857
870A
857A
THERMAL STORAGE TANK
PRIMARY PUMP 4
PRIMARY PUMP 1
U.S. DEPARTMENT OF ENERGY
SANDIA NATIONAL LABORATORIES FACILITIES ENGINEERING
CAMPUS SYSTEM-ONE LINE DIAGRAM
RADIATION HARDENED
INTEGRATED CIRCUIT FACILITY
CAD DRAWING
MECHANICAL
D-
98547/M1

System Layout

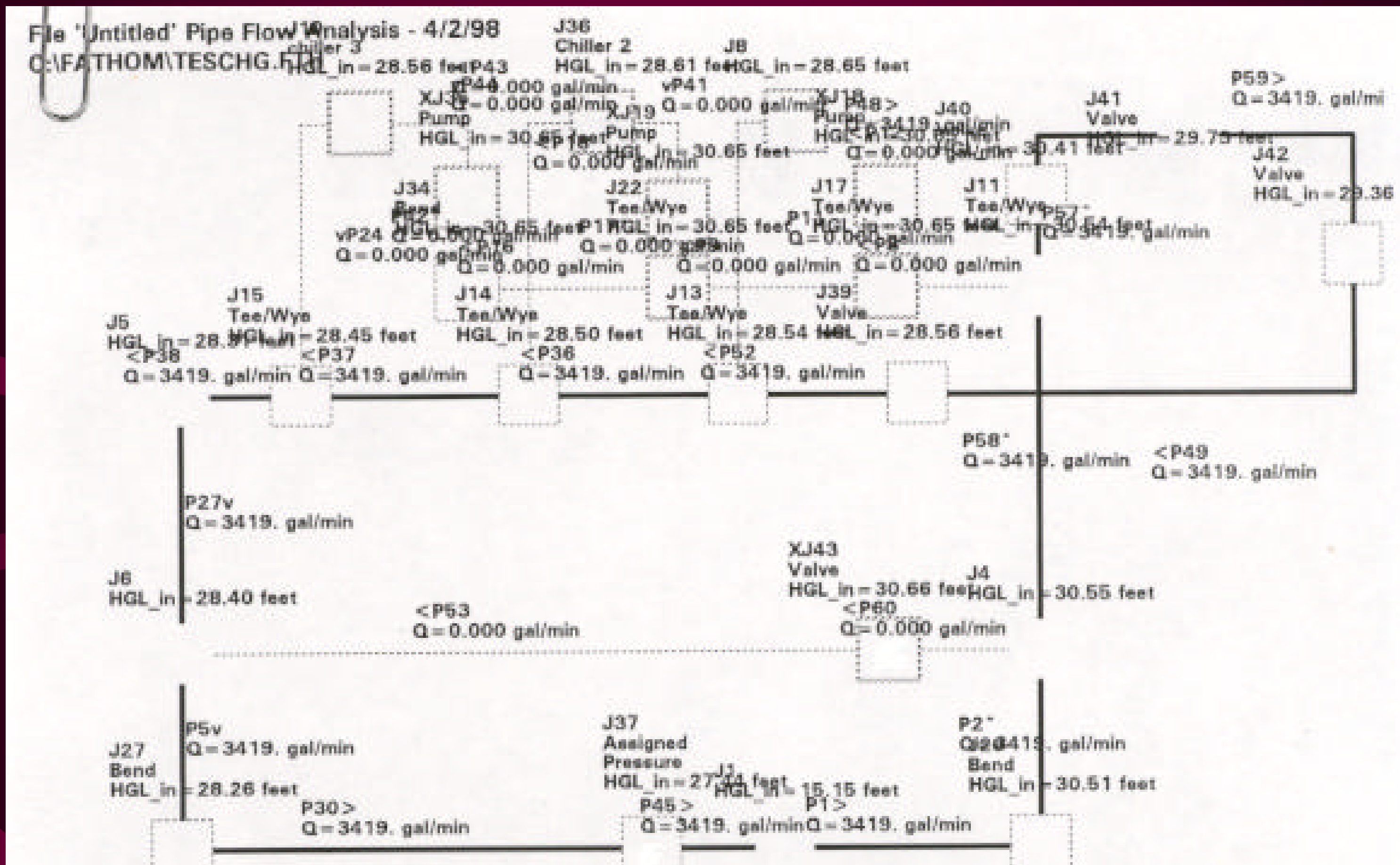
- Three 1300 ton 1000HP centrifugal chillers with 2000 GPM circulation pumps
- Primary loop with 20 HP, 4000GPM circulation pumps
- Decoupled secondary supply loops

System Layout

- We first drew up the system and gathered data, pump curves, etc.
- The system was sketched and reverse engineered with known operating data
- A flow model was done to verify present operation
- The new Storage tank was added to the flow model



Tank Charge Cycle, Two Chillers On, Partial System Load



Tank Discharge Cycle, Chillers Off, Medium System Load

Final Design Analysis

- Utilized existing pumps, with new VFD drives, increase primary flow by 50%
- Two connection points with valves for tank lines
- Self balancing
- Blending available with bypass valve
- Chiller Plant sensor upgrade with BTU meters

Design Comparison

- A&E Firm design had six new pumps with associated VFD's
- A complicated piping system with at least six connection points
- multiple operating valves and bypass lines
- It doesn't have to be complicated if you take the time to understand your system

Lessons Learned

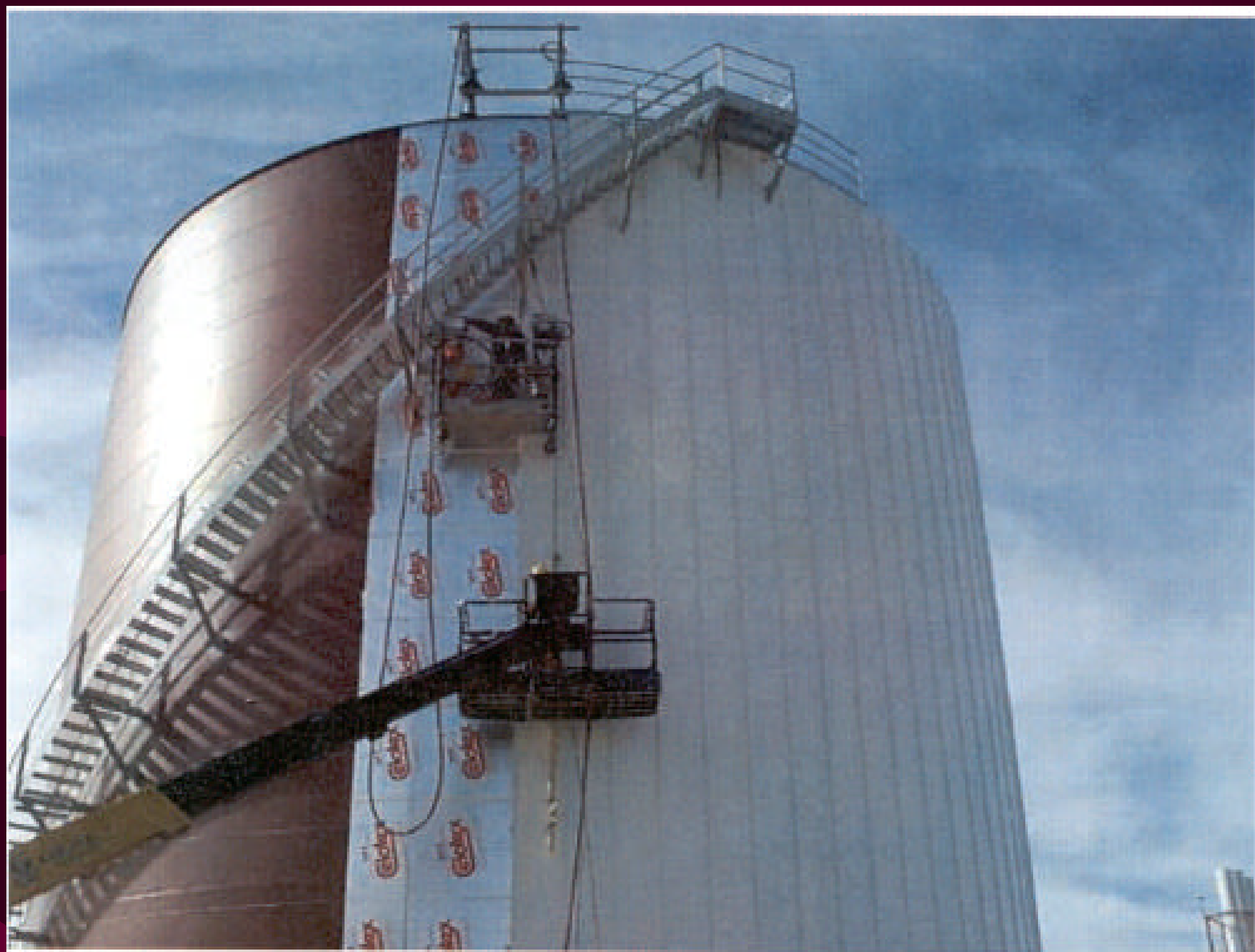
- Keep tank temperature sensors out of the sun
- Watch your chemical program, it can get expensive
- Hire an A&E firm with experience in thermal storage

Tank design

- One million gallon above ground (no UST regulations)
- Steel with epoxy painted interior
- Ring wall foundation with sand fill (no oil)
- Active cathodic protection system (impressed current)

Lower Difuser Cone

Upper Difuser Cone and Roof Structure

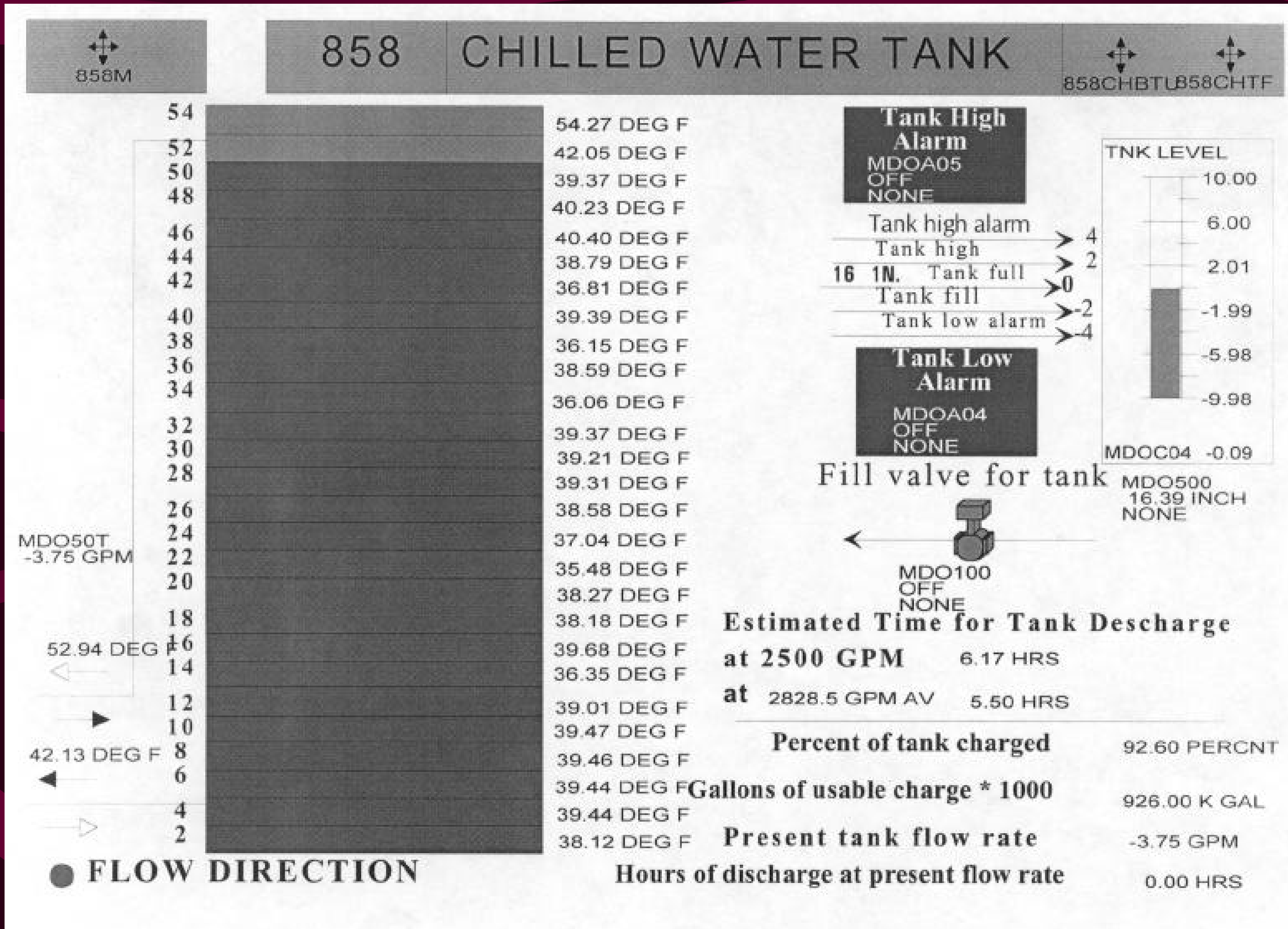


Insulation System and Sheething

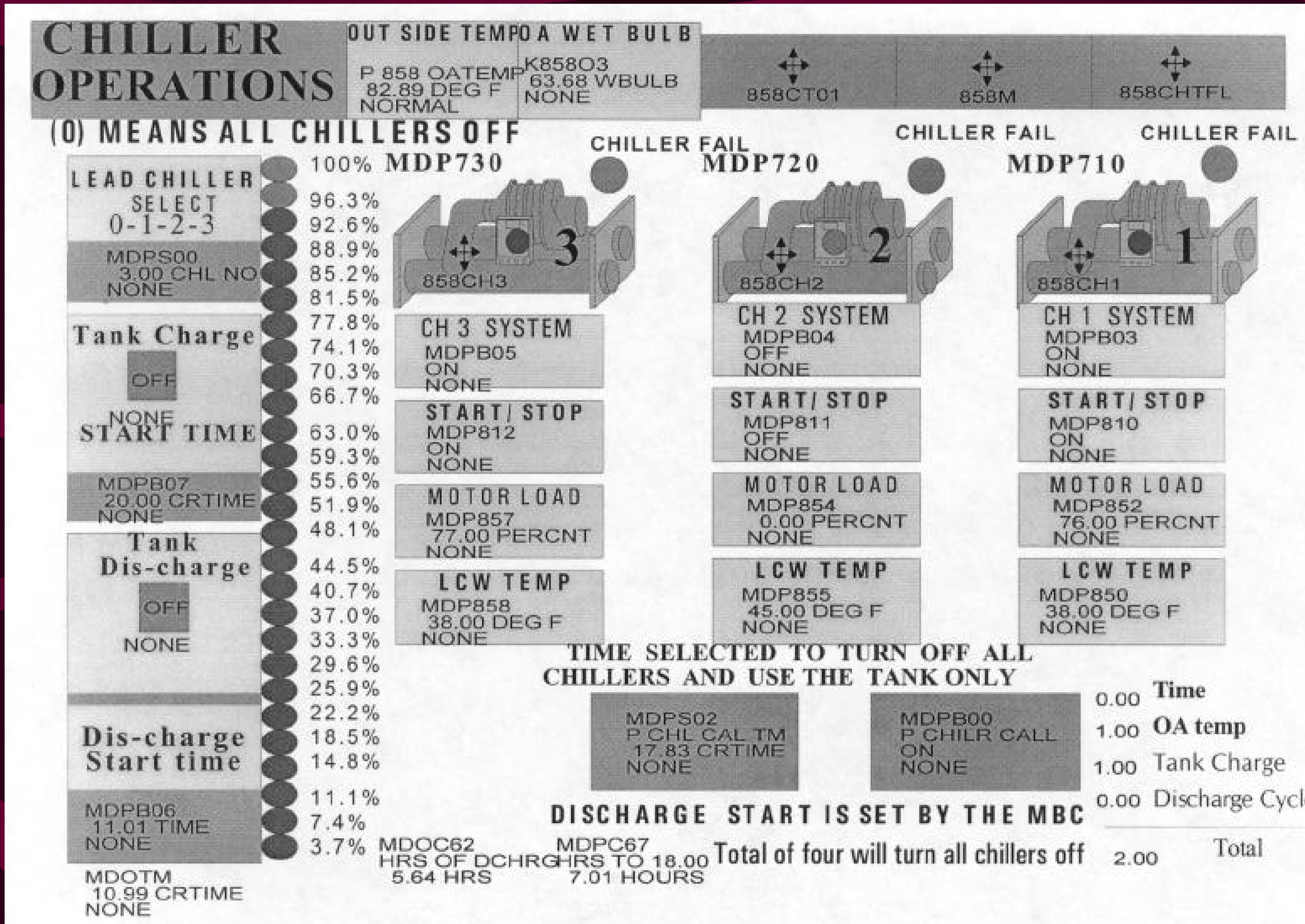
Insulation System

- Two inches of polyiso. With a bonded aluminum skin
- Very low losses due to volume vs.. surface area
- Losses of around one degree per week in 95 degree temperatures

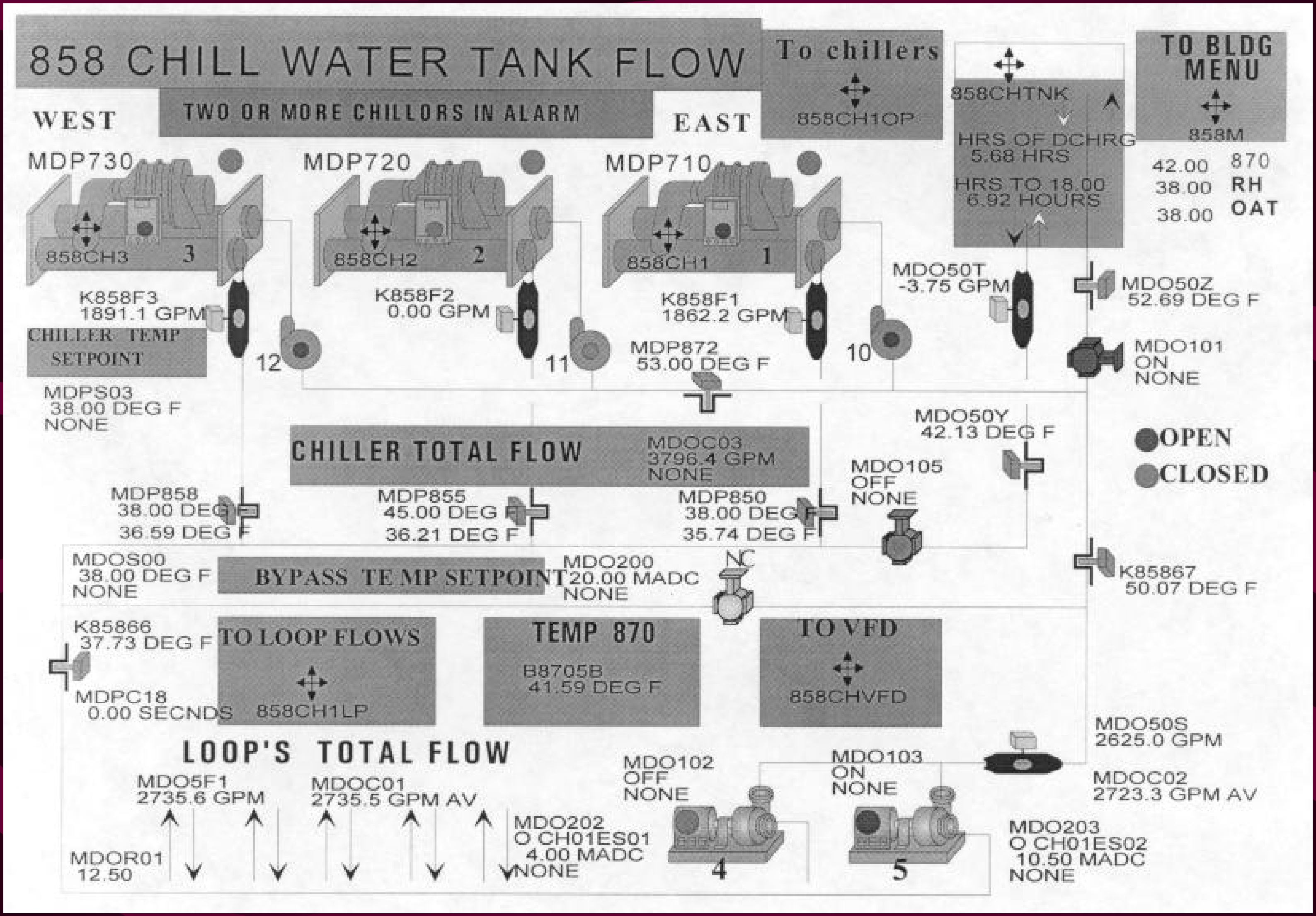
Completed Tank



858M
858 CHILLED WATER TANK
858CHBTU
858CHTF
54
52
50
48
46
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
54.27 DEG F
42.05 DEG F
39.37 DEG F
40.23 DEG F
40.40 DEG F
38.79 DEG F
36.81 DEG F
39.39 DEG F
36.15 DEG F
38.59 DEG F
36.06 DEG F
39.37 DEG F
39.21 DEG F
39.31 DEG F
38.58 DEG F
37.04 DEG F
35.48 DEG F
38.27 DEG F
38.18 DEG F
39.68 DEG F
36.35 DEG F
39.01 DEG F
39.47 DEG F
39.46 DEG F
39.44 DEG F
39.44 DEG F
38.12 DEG F
MDO50T
-3.75 GPM
52.94 DEG F
42.13 DEG F
FLOW DIRECTION
Tank High Alarm
MDOA05
OFF
NONE
Tank high alarm
Tank high
16 1N.
Tank full
Tank fill
Tank low alarm
4
2
0
-2
-4
Tank Low Alarm
MDOA04
OFF
NONE
TNK LEVEL
10.00
6.00
2.01
-1.99
-5.98
-9.98
MDOC04 -0.09
Fill valve for tank
MDO500
16.39 INCH
NONE
MDO100
OFF
NONE
Estimated Time for Tank Descharge
at 2500 GPM 6.17 HRS
at 2828.5 GPM AV 5.50 HRS
Percent of tank charged 92.60 PERCNT
Gallons of usable charge * 1000 926.00 K GAL
Present tank flow rate -3.75 GPM
Hours of discharge at present flow rate 0.00 HRS



CHILLER OPERATIONS
OUT SIDE TEMP
P 858 OATEMP
82.89 DEG F
NORMAL
O A WET BULB
K85803
63.68 WBULB
NONE
858CT01
858M
858CHTFL
(0) MEANS ALL CHILLERS OFF
CHILLER FAIL
CHILLER FAIL
CHILLER FAIL
LEAD CHILLER
SELECT
0-1-2-3
MDPS00
3.00 CHL NO
NONE
Tank Charge
OFF
NONE
START TIME
MDPB07
20.00 CRTIME
NONE
Tank
Dis-charge
OFF
NONE
Dis-charge
Start time
MDPB06
11.01 TIME
NONE
MDOTM
10.99 CRTIME
NONE
100%
96.3%
92.6%
88.9%
85.2%
81.5%
77.8%
74.1%
70.3%
66.7%
63.0%
59.3%
55.6%
51.9%
48.1%
44.5%
40.7%
37.0%
33.3%
29.6%
25.9%
22.2%
18.5%
14.8%
11.1%
7.4%
3.7%
MDP730
3
858CH3
CH 3 SYSTEM
MDPB05
ON
NONE
START/ STOP
MDP812
ON
NONE
MOTOR LOAD
MDP857
77.00 PERCNT
NONE
LCW TEMP
MDP858
38.00 DEG F
NONE
MDP720
2
858CH2
CH 2 SYSTEM
MDPB04
OFF
NONE
START/ STOP
MDP811
OFF
NONE
MOTOR LOAD
MDP854
0.00 PERCNT
NONE
LCW TEMP
MDP855
45.00 DEG F
NONE
MDP710
1
858CH1
CH 1 SYSTEM
MDPB03
ON
NONE
START/ STOP
MDP810
ON
NONE
MOTOR LOAD
MDP852
76.00 PERCNT
NONE
LCW TEMP
MDP850
38.00 DEG F
NONE
TIME SELECTED TO TURN OFF ALL
CHILLERS AND USE THE TANK ONLY
MDPS02
P CHL CAL TM
17.83 CRTIME
NONE
MDPB00
P CHILR CALL
ON
NONE
0.00 Time
1.00 OA temp
1.00 Tank Charge
0.00 Discharge Cycle
2.00 Total
DISCHARGE START IS SET BY THE MBC
MDOC62
HRS OF DCHRG
5.64 HRS
MDPC67
HRS TO 18.00
7.01 HOURS
Total of four will turn all chillers off


858 CHILL WATER TANK FLOW
TWO OR MORE CHILLORS IN ALARM
WEST
EAST
To chillers
858CH1OP
858CHTNK
HRS OF DCHRG
5.68 HRS
HRS TO 18.00
6.92 HOURS
TO BLDG MENU
858M
42.00 870
38.00 RH
38.00 OAT
MDP730
858CH3 3
MDP720
858CH2 2
MDP710
858CH1 1
K858F3
1891.1 GPM
K858F2
0.00 GPM
K858F1
1862.2 GPM
MDO50T
-3.75 GPM
MDO50Z
52.69 DEG F
CHILLER TEMP SETPOINT
12
11
10
MDP872
53.00 DEG F
MDO101
ON
NONE
MDPS03
38.00 DEG F
NONE
MDO50Y
42.13 DEG F
OPEN
CLOSED
CHILLER TOTAL FLOW
MDOC03
3796.4 GPM
NONE
MDO105
OFF
NONE
MDP858
38.00 DEG F
36.59 DEG F
MDP855
45.00 DEG F
36.21 DEG F
MDP850
38.00 DEG F
35.74 DEG F
MDOS00
38.00 DEG F
NONE
BYPASS TEMP SETPOINT
MDO200
20.00 MADC
NONE
NC
K85867
50.07 DEG F
K85866
37.73 DEG F
TO LOOP FLOWS
858CH1LP
TEMP 870
B8705B
41.59 DEG F
TO VFD
858CHVFD
MDPC18
0.00 SECNDS
MDO50S
2625.0 GPM
LOOP'S TOTAL FLOW
MDO102
OFF
NONE
MDO103
ON
NONE
MDOC02
2723.3 GPM AV
MDO5F1
2735.6 GPM
MDOC01
2735.5 GPM AV
MDO202
O CH01ES01
4.00 MADC
NONE
MDO203
O CH01ES02
10.50 MADC
NONE
MDOR01
12.50
4
5