



# Insight on the technology decisions at King Abdulaziz University Central Utility Plant #2

**Amar Farjo**

**Lead Staff Engineer – Chiller Solutions Complex Projects**



# Key Contacts

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## Designer

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## Consultant

***FLUOR***<sup>®</sup>  
FLUOR ARABIA LIMITED  
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JEDDAH 21482 SAUDI ARABIA  
TEL: (966-2) 640-1445/640-1573/640-1668

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## Contractor

**ARABIAN BEMCO CONTRACTING CO.LTD.**  
INDUSTRIAL and POWER PROJECTS  
DEVELOPERS & CONTRACTORS.



# Main Equipment List

- 5 Three-Stage Titan Chillers – Dual Duty. 3,600 Tons Chilled Water duty and 2,750 Tons Glycol duty. Total =  
**18,000 Tons water/13750 Tons Glycol**
- 14 Two-Stage base CYK Chillers –  
2,185 Tons Chilled Water Each.  
**30,520 Tons**
- 6 Ice Storage Tanks – 21,150 Ton-Hr  
Capacity Each. Total Stored cooling  
capacity is: **126,900 Ton-HR**
- 60 Dry Coolers (120 Fans) 11,978,900  
BTU/HR Each  
**700,000,000 BTU/HR Total**



# District Cooling Design Options

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**Typical District Cooling uses single stage centrifugal chillers with Cooling Towers and water storage system.**

- Requires large amount of water. water quality is an issue.



No water is lost!

- Typically water storage system



- Reduces number of chillers and dry coolers

**Additional Benefits**

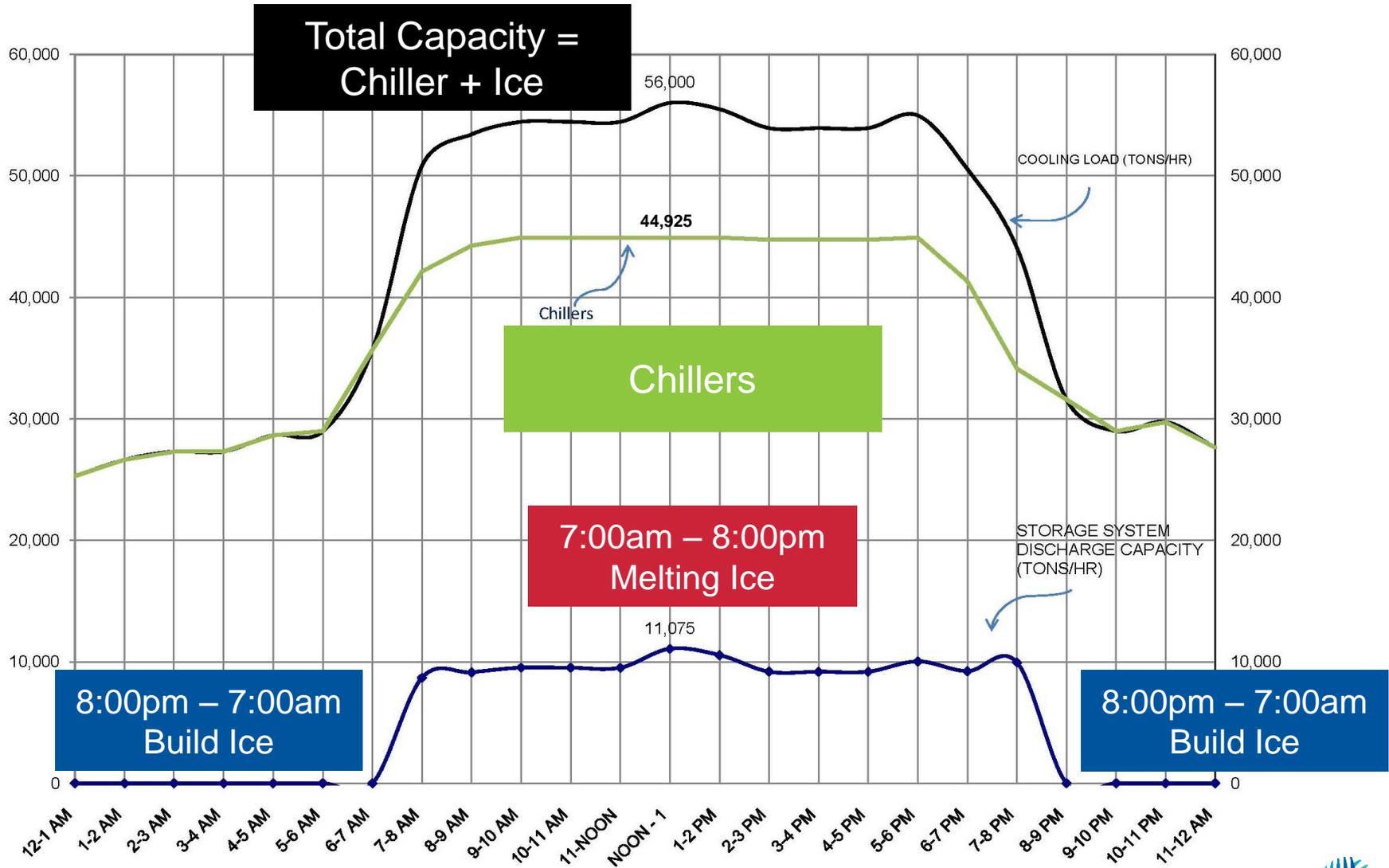
- Reduce peak demand, shift energy usage to non-peak hours.
- Reduce pump, pipes and air equipment sizes

# Central Utility Plants Design Conditions

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- Chilled water loop temperatures:
  - 7:00 am – 8:00 pm = 59°F/36°F (15°C/2.2°C)
  - All other times = 59°F/40°F (15°C/4.5°C)
- Water chillers and Ice Storage:
  - Chillers in plant #1 and #2 deliver 80% of peak load.
  - Ice storage system to provide 20%
- Return chilled water flows through chillers in plants #1 and #2 first, then combine and flow over the ice heat exchangers in the tanks.
- Condenser water loop temperatures:
  - 7:00 am – 8:00 pm = 130°F/140°F (54.4°C/60°C)
  - All other times = 130°F/138°F (54.4°C/59°C)

# Chiller Plant CUP #2 Load Profile



# Plant Energy Analysis – Ice on Coil Design Analysis Peak Day

Water Chiller Electric  
=1075476 kW

+

Glycol Chiller Electric =  
171991 kW

+

Air-Cooled Radiator  
Fans = 97344 kW

+

Condenser Water  
Pumps = 82654 kW

+

Distribution Pumps =  
50114 kW

+

Primary Chiller Pumps=  
17409 kW

+

Glycol Pumps =  
12929 kW

+

Air Pump & Other Small  
Motors = 5248 kW

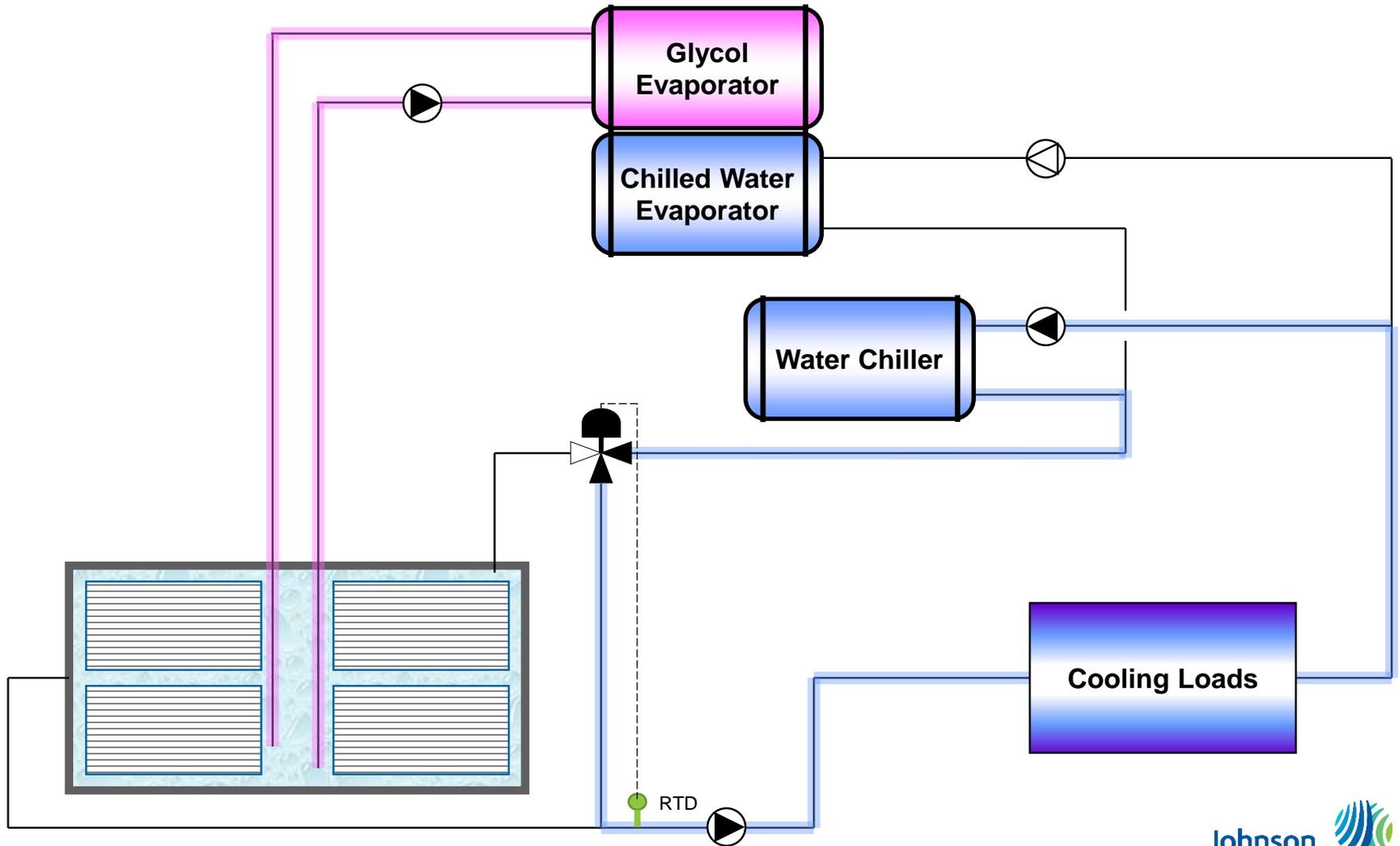
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Fans & Other Non-  
Process Plant Electric  
Loads = 6744 kW

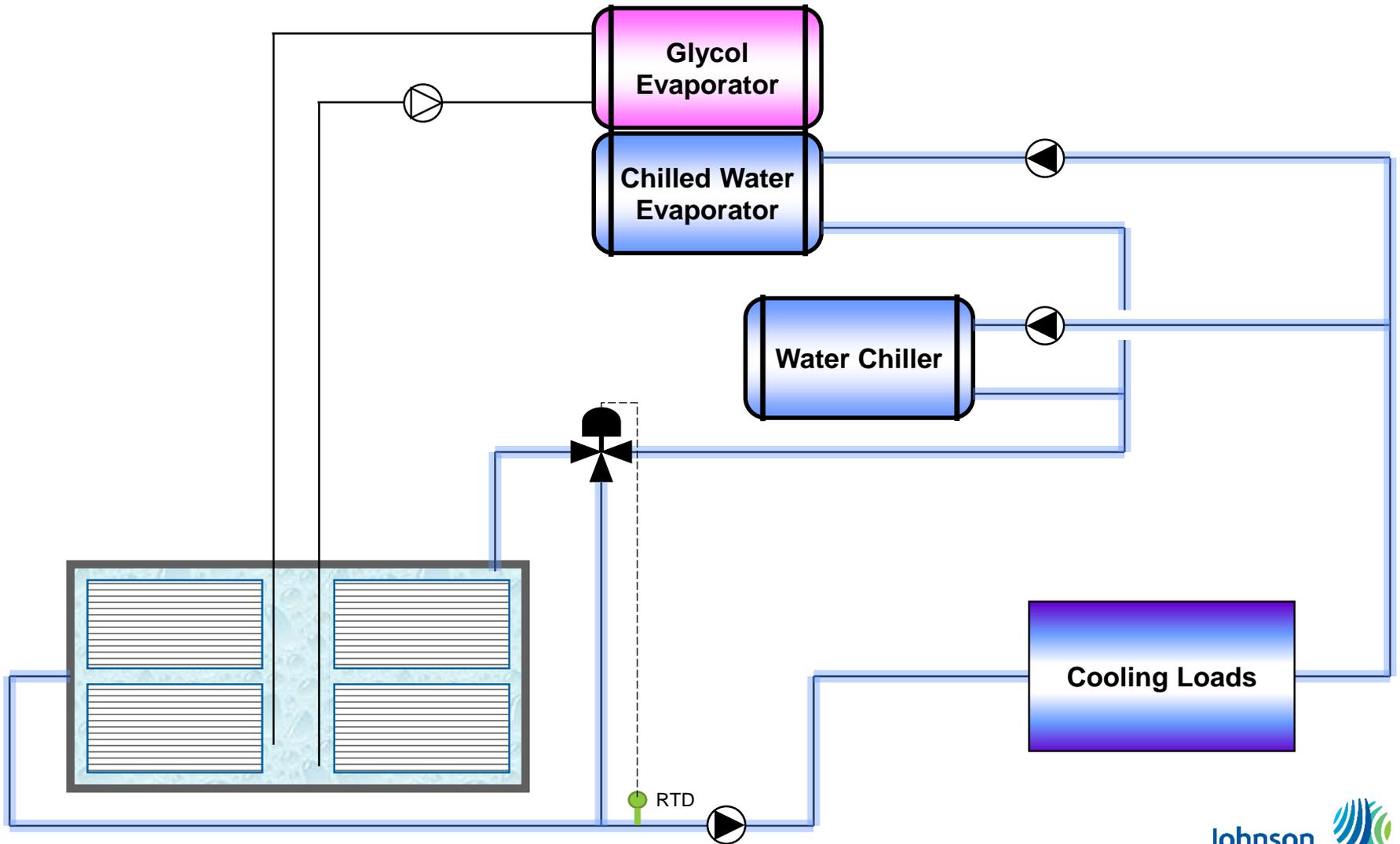
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**Total Daily kW/h = 1,519,918**  
**Daily kW/Ton at peak day = 1.67**  
**Actual measured KW/Ton = 1.36**

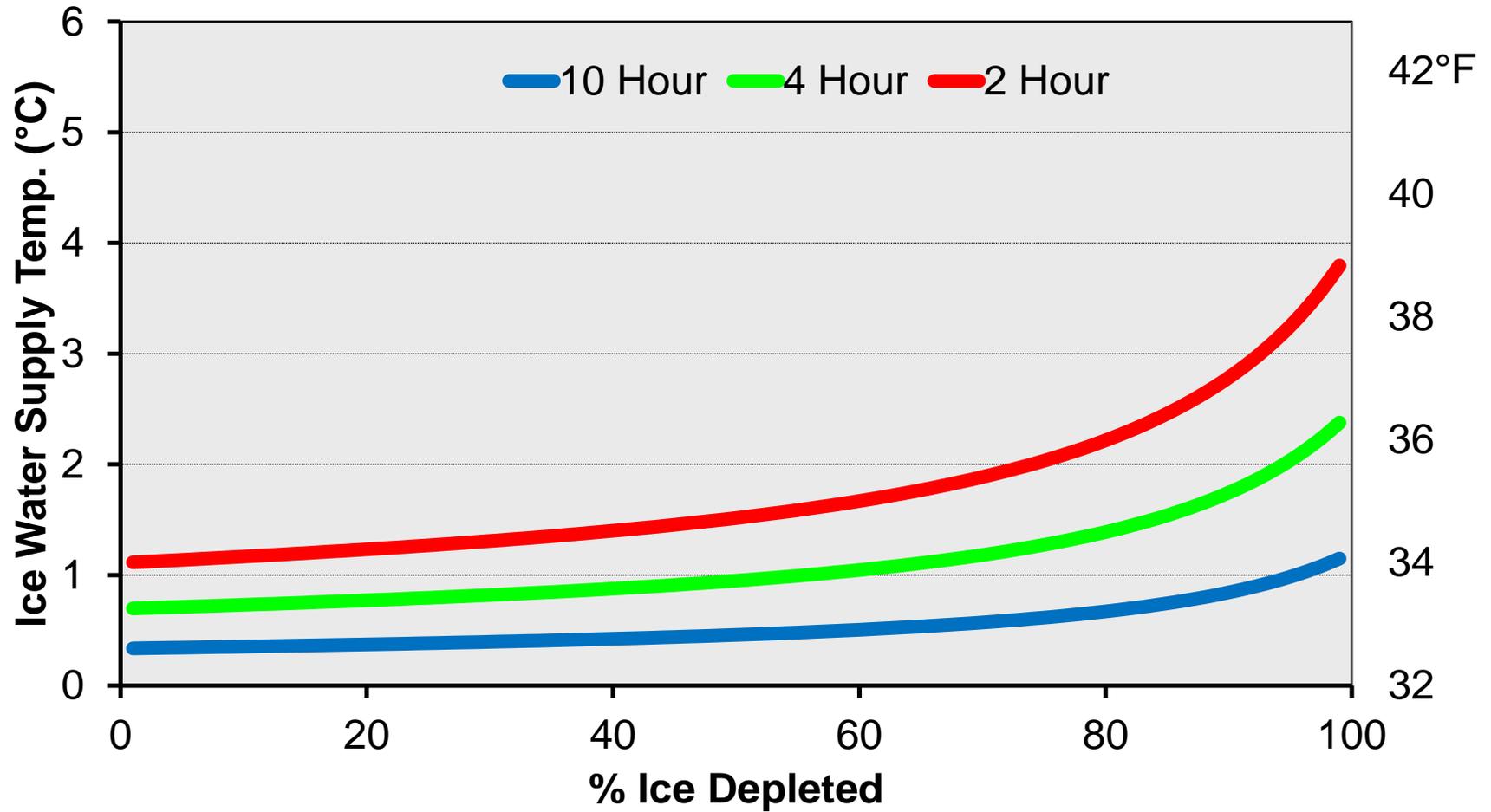
# Ice Build with Water Chilling



# Ice Melt with Water Chilling



# External Melt Supply Temperatures

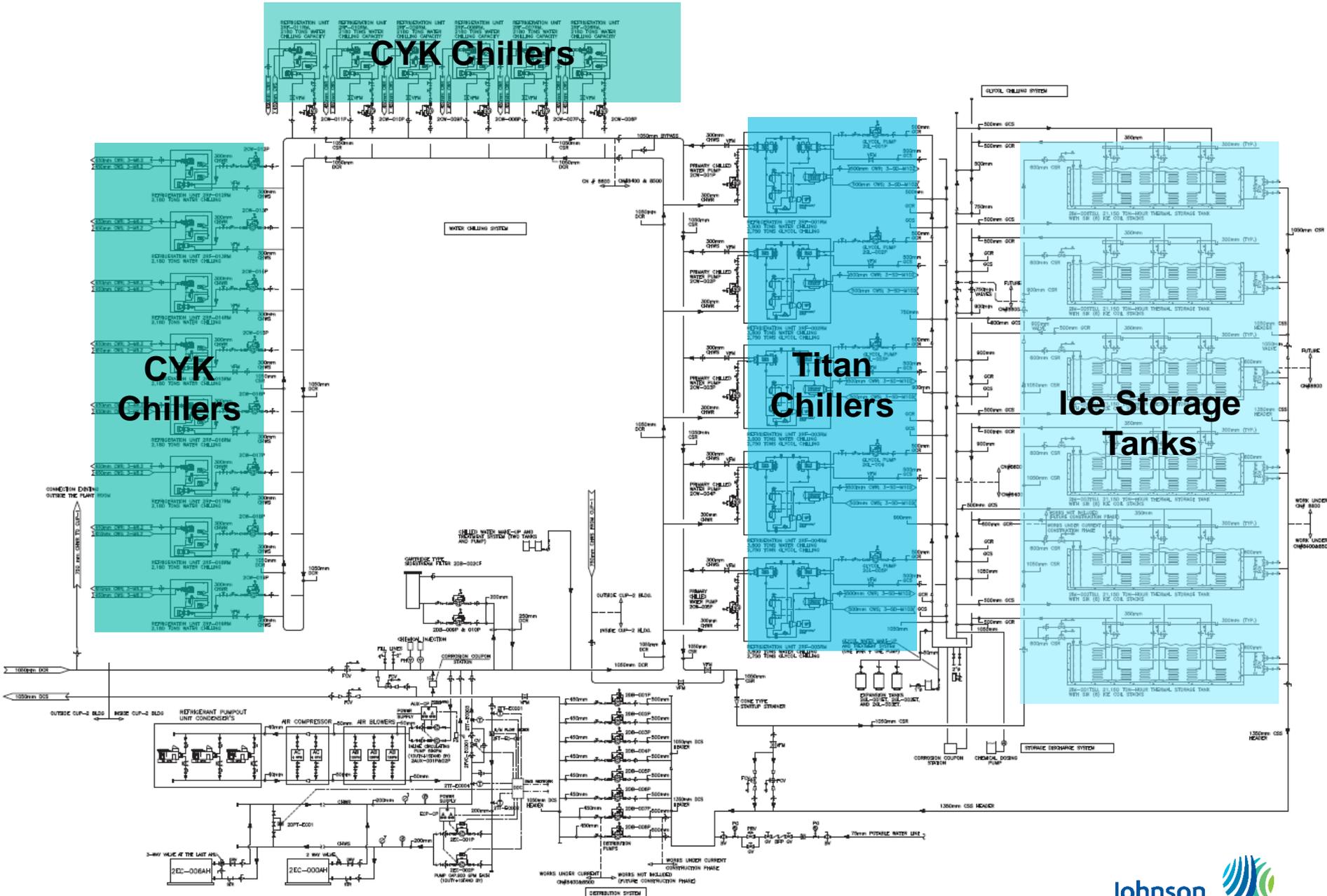


# CYK Chillers

# CYK Chillers

# Titan Chillers

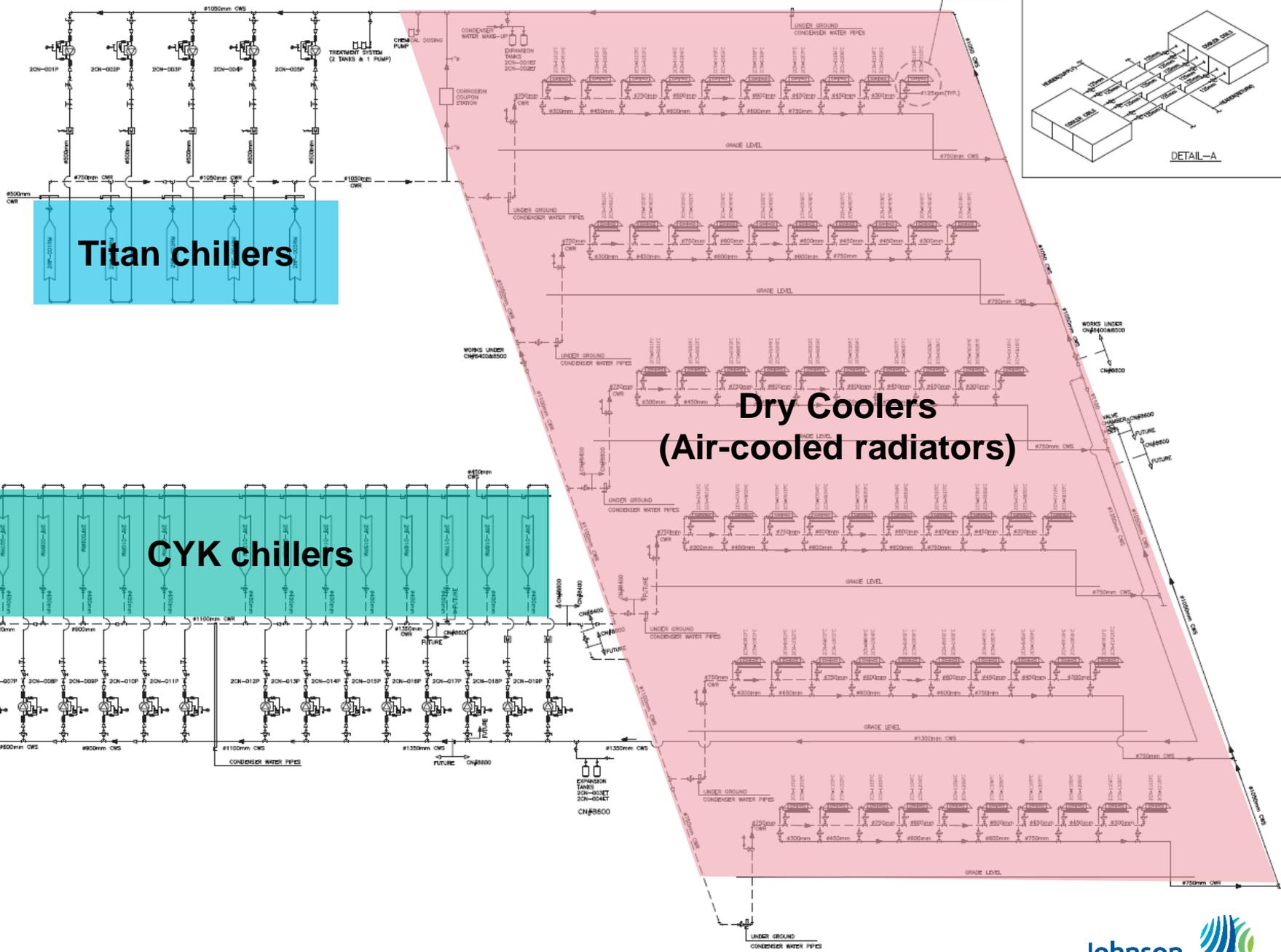
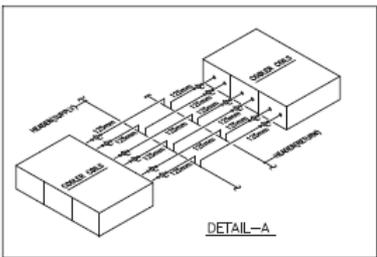
# Ice Storage Tanks







SEE DETAIL-A



Titan chillers

CYK chillers

Dry Coolers  
(Air-cooled radiators)

# Air-Cooled Radiator – Dry Coolers

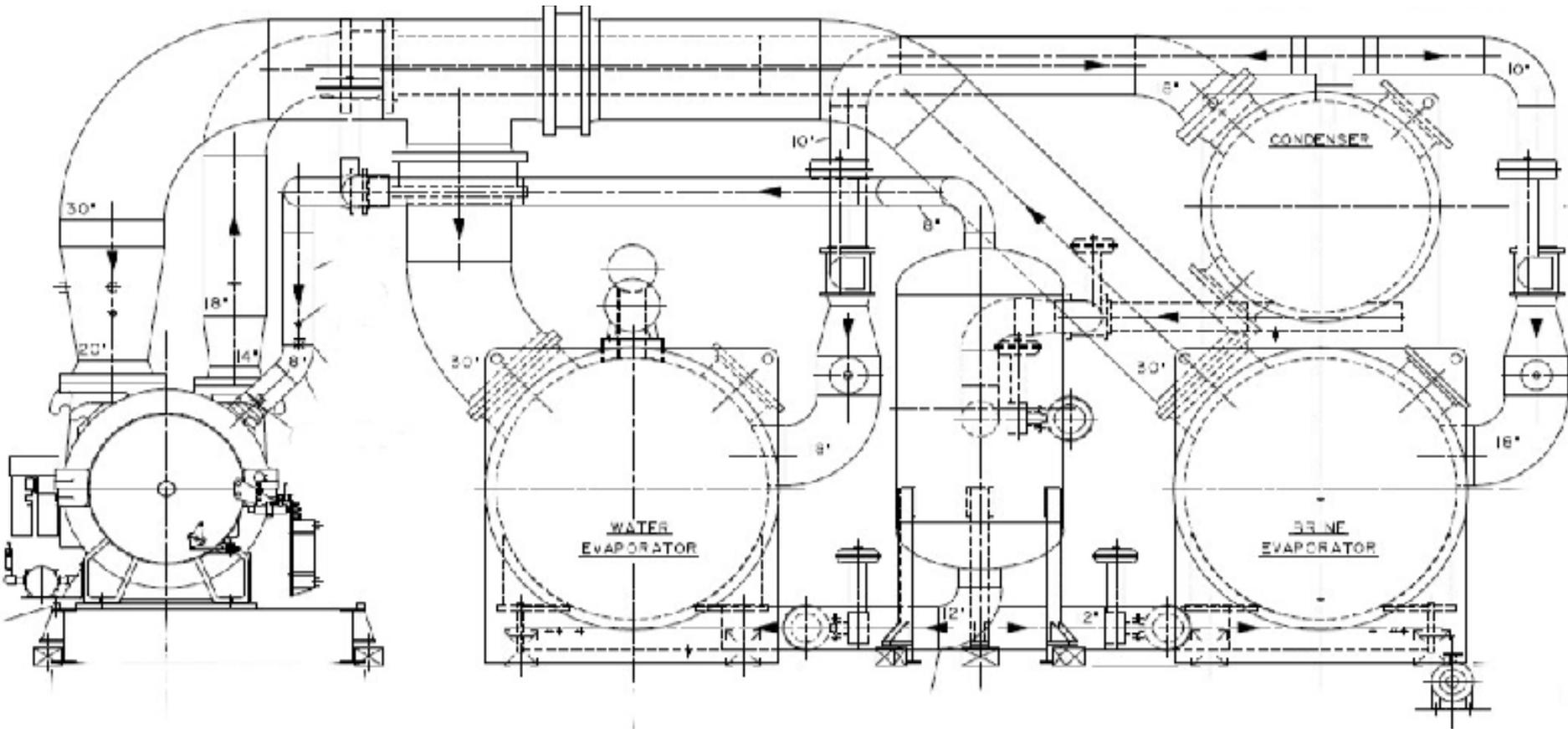
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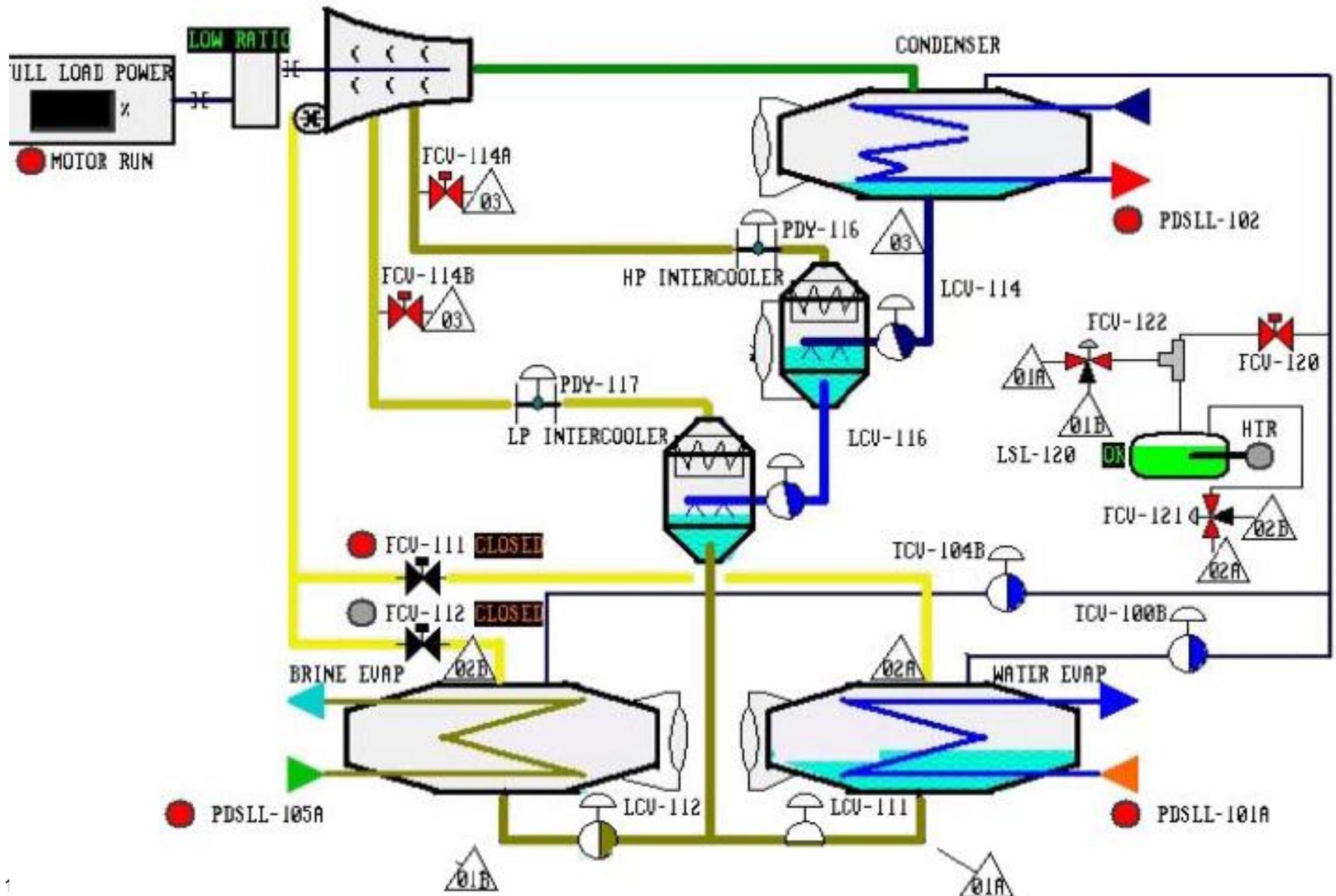
# Titan OM Chillers – 3600 Tons Chilling Duty – 2750 Tons Ice Duty

DESIGN OPERATING CONDITIONS		Water Chilling	Brine Chilling
Chiller:	Design Load	3600 Tons	2750 Tons
	Efficiency (w/o liquid injection)	1.26 kW/Ton	1.50 kW/ton
	Efficiency (with liquid injection)	1.28 kW/Ton	1.54 kW/ton
Evaporator:	Water Ent. & Lvg. Temperatures	59.0 °F to 40.0 °F	32.0 °F to 24.7 °F
	Water Flow	4547 gpm	9795 gpm
	Water Diff. Press. (nozzle – nozzle)	27.8 ft. water	44.6 ft. water
	Tubeside Fouling Factor	0.00010 ft <sup>2</sup> -h-°F/Btu	0.00010 ft <sup>2</sup> -h-°F/Btu
	Refrigerant Temperature	38.8 °F	20.7 °F
	Refrigerant Pressure	48.6 psia	33.6 psia
Condenser:	Water Ent. & Lvg. Temperatures	130.0 °F to 140.5 °F	130.0 °F to 138.4 °F
	Water Flow	10,800 gpm	10,800 gpm
	Water Diff. Press. (nozzle – nozzle)	27.8 ft. water	27.8 ft. water
	Tubeside Fouling Factor	0.00025 ft <sup>2</sup> -h-°F/Btu	0.00025 ft <sup>2</sup> -h-°F/Btu
	Refrigerant Temperature	142.4 °F	139.9 °F
	Refrigerant Pressure	251.7 psia	243.6 psia
	Subcooler leaving refrigerant temp	132.9 °F	132.2 °F
Compressor:	Suction & Discharge Temperatures	38.4 °F to 167.1 °F	20.5 °F to 167.8 °F
	Full Load Rotational Speed	4379 rpm	4682 rpm
	Shaft Power (w/o liquid injection)	5661 HP	5153 HP
Gear:	Input Power (w/o liquid injection)	5841 HP	5333 HP
Motor:	Input Elect. Power (w/o liquid injection)	4532 kW	4138 kW
	Electrical Requirements	13,800 V / 3 Ph / 60 Hz	13,800 V / 3 Ph / 60 Hz

# Titan OM Chiller Design



# Titan OM Chiller Schematic



# Installation Photo – Titan OM Chiller



# CYK Two Stage Chiller – Two Externally Compounded Compressors

ISSUE DATE: 04/14  
PROJECT - 14-4021  
SALES ENGINEER - AMAR FARJO/ARIF H  
CUSTOMER - KAAU CUPUII

PROGRAM: LTC  
REV: v1.135.yau  
DATE: 06/24/14  
PAGE: 1 OF 1

MODEL CYKSSSSK4U2-DJDJG  
(MOTOR LS SPECIFIED BY USER)  
RATED CAPACITY (TONS) 2185  
REFRIGERANT (LB 134A) 7408  
OPTISOUND CONTROL-LS YES  
INPUT POWER-LS (KW) 1516  
INPUT POWER-HS (KW) 1281  
TOTAL INPUT POWER (KW) 2797  
TOTAL FULL LOAD (KW/TON) 1.280  
VOLTAGE/HZ-LS 13800/60  
VOLTAGE/HZ-HS 13800/60  
ECONOMIZER YES (48IN)

(MOTOR HS SPECIFIED BY USER)  
SPECIFIED CAPACITY (TONS) 2185  
OPTISOUND CONTROL-HS YES  
GEAR CODE-LS PY (SPEC)  
GEAR CODE-HS EB (SPEC)  
FLA-LS 73  
FLA-HS 73  
LRA-LS 471  
LRA-HS 471

LS-STARTER TYPE (0)  
HS-STARTER TYPE (0)

	EVAPORATOR WATER	CONDENSER WATER
FLUID TUBE	273*	262*
PASSES	3*	2*
FOUL FACTOR	0.00010*	0.00025*
FLUID ENT TEMP (F)	59.00	130.00*
FLUID LEV TEMP (F)	40.00*	140.00
FLUID FLOW (GPM)	2751.0*	7174.0*
FLUID PRDROP (FT)	31.4	36.9
REFRIGERANT INTERMEDIATE TEMP (F)	94.00	

(\*) DESIGNATES SPECIFIED INPUT  
(LS) DESIGNATES LOW STAGE COMPRESSOR  
(HS) DESIGNATES HIGH STAGE COMPRESSOR

PART LOAD PERFORMANCE:  
(ELFT & EVAP FLOW + CEFT & COND FLOW are Constant)  
OPERATING MACH = 1.353

% LOAD	CAP (TONS)	% POWER	INPUT (KW)	ELFT (F)	CEFT (F)	CLFT (F)	PERF (KW/TON)	VGD (COP) EFF	HeatRejec (TONS)	
100.0	2185.0	100.0	2797	59.00	40.00	130.00	140.00	1.280	2.75	2948.2
90.0	1966.5	88.3	2468	57.10	40.00	130.00	138.96	1.255	2.80	2640.3
80.0	1748.0	77.3	2180	55.20	40.00	130.00	137.95	1.247	2.82	2342.9
70.0	1529.5	67.5	1909	53.29	40.00	130.00	136.95	1.249	2.92	2045.6
60.0	1311.0	58.8	1665	51.39	40.00	130.00	135.98	1.270	2.77	1763.0
50.0s	1092.5	50.9	1480	49.49	40.00	130.00	135.06	1.355	2.60	s 1492.8
40.0s	874.0	43.5	1263	47.59	40.00	130.00	134.12	1.445	2.43	s 1213.3
30.0s	655.5	34.5	1013	45.69	40.00	130.00	133.13	1.545	2.28	s 924.1
20.0s	437.0	26.5	767	43.79	40.00	130.00	132.16	1.755	2.00	s 636.3
19.1s	417.2	25.9	745	43.62	40.00	130.00	132.07	1.786	1.97	s 610.1

RATINGS < 65 DEG. F CEFT ARE OUTSIDE THE SCOPE OF AHRI STD. 550/590-2011 (IP), ALL OTHER LOAD POINTS ARE RATED IN ACCORDANCE WITH THE STANDARD.

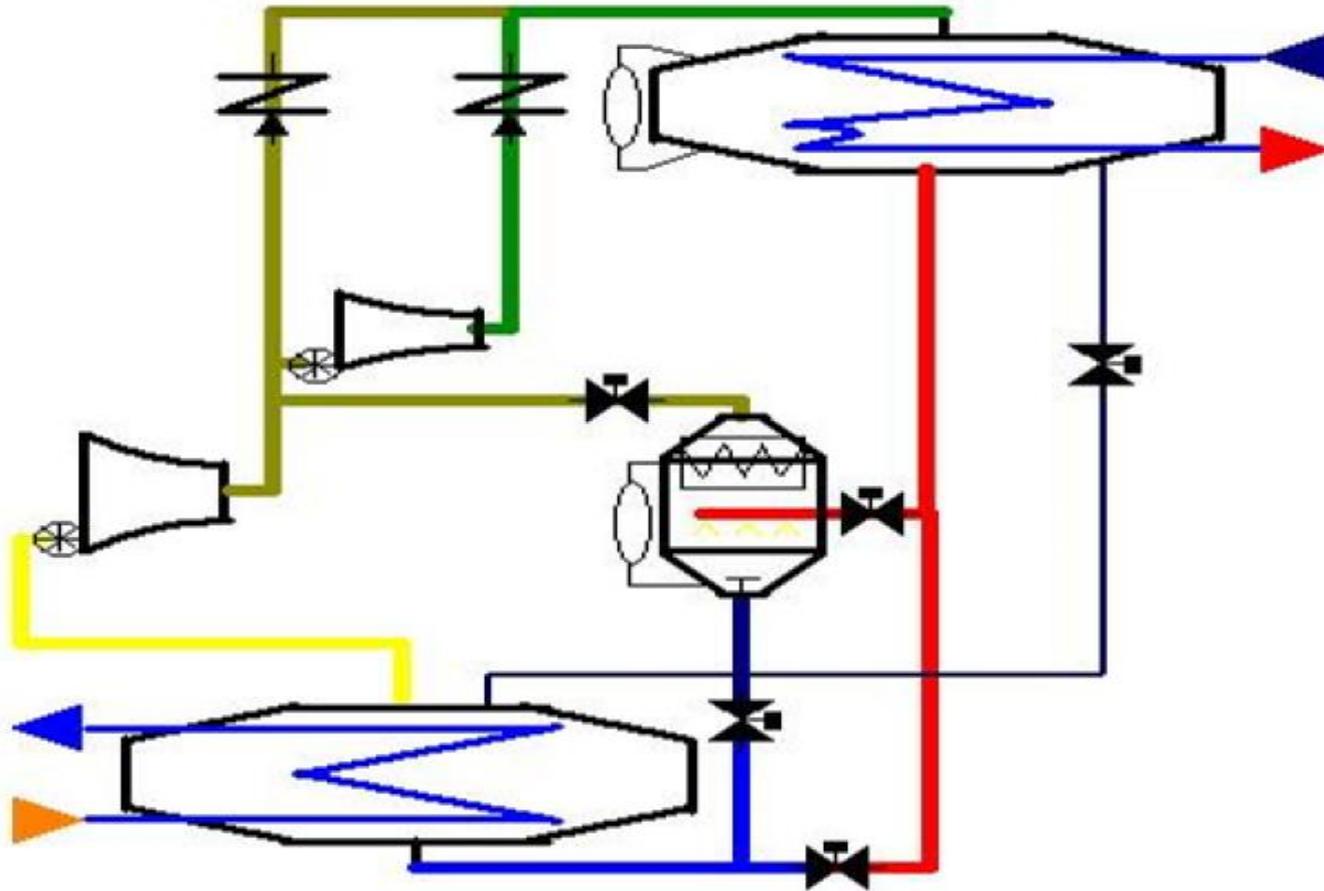
AUXILIARY COMPONENTS INCLUDED IN TOTAL KW - CHILLER CONTROLS.

MATERIALS AND CONSTRUCTION PER MECHANICAL SPECIFICATIONS - FORM 160.82-EG1.

MODEL CYKSSSSK4U2-DJDJG  
(MOTOR LS SPECIFIED BY USER)  
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REFRIGERANT (LB 134A) 7408  
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TOTAL FULL LOAD (KW/TON) 1.280  
VOLTAGE/HZ-LS 13800/60  
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ECONOMIZER YES (48IN)

	EVAPORATOR WATER	CONDENSER WATER
FLUID TUBE	273*	262*
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FOUL FACTOR	0.00010*	0.00025*
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REFRIGERANT INTERMEDIATE TEMP (F)	94.00	

# CYK Chiller Schematic



# Installation Photo – CYK Chiller

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# Thank you

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