CHILLERS

By Lew Hinkle P.E. and Dave Metzger P.E.

Why we do what we do?

Sizing

Selection Type

Efficiency/Financial

HEI ENGINEERING GROUP, INC.

MG energy
MG Energy Group
100 West 6th Street
Mansfield, Ohio 44902

CHILLER TYPES

Air Cooled Scroll

Water Cooled Scroll

Air Cooled Screw

Water Cooled Screw

Chiller Types

Air Cooled Centrifugal (Magnetic Bearing Chiller)

Water Cooled Centrifugal (Magnetic Bearing Chiller)

Water Cooled Centrifugal Chiller (Non-Magnetic Bearing Chiller)

Chiller Relative Costs and Efficiency

Each design decision has first-cost implications. Because of this complexity, products on the market have a wide variety of performance characteristics. The following discussion and comparison chart lay out the broad performance and efficiency issues and provide information that will help in selecting the appropriate equipment for the job.

Chiller Type	Capacity [1] Range (tons)	First Cost [2] Range ($/ton)	COP Range	IPLV Range (COP)
Reciprocating/Scroll	50 - 230 (400)	$200 - $250	4.2 - 5.5	4.6 - 5.8
Screw	70 - 400 (1250)	$225 - $275	4.9 - 5.8	5.4 - 6.1
Centrifugal	200 - 2000 (10,000)	$180 - $300	5.8 - 7.1	6.5 - 7.9
Single-Effect Absorption	100 - 1700	$300 - $450	0.60 - 0.70	0.63 - 0.77
Double-Effect Absorption	100 - 1700	$300 - $550	0.92 - 1.20	1.04 - 1.30
Engine Driven	100 - 3000 (10,000)	$450 - $600	1.5 - 1.9	1.8 - 2.3

[1] Capacities in parentheses are maximum sizes available
[2] First cost includes allowance for contractor mark-ups

Chiller Case Comparison

QUANTECH **EER 9.7** ***IPLV=1.2369KW/Ton***
170 tons **$ 62,000**

Performance at AHRI Conditions					
Evaporator Data		**Condenser Data**		**Performance Data**	
EWT (°F)	54.00	Ambient Temp. (°F)	95.0	EER (Btu/W·h)	9.701
LWT (°F)	44.00	Altitude (ft)	0.000	IPLV.IP (Btu/W·h)	15.47
Flow Rate (USGPM)	404.9			Net Cooling Capacity (ton.R)	169.6
Pressure Drop (ft H2O)	21.9				
Fluid	Water				
Fouling Factor (h.ft².F/Btu)	0.000100				
Fluid Volume (USGAL)	10.04				

SMARDT **EER 23.48** **IPLV = .5111 KW/ton**
170 tons **$ 135,000**

IPLV : 0.5111 kW/tonsR (EER 23.48 (Btu/W*h))

% Load	Capacity	Perf	kW	Fan kW	Fan Speed	Chw Flow	Chw In	Chw Out	Ambient
100	170.0	1.017	172.9	18.79	100%	406.2	54.00	44.00	95.0
75	127.5	0.7276	92.77	10.74	82%	406.2	51.50	44.00	80.0
50	85.00	0.4574	38.88	4.690	62%	406.2	49.00	44.00	65.0
25	42.50	0.3110	13.22	1.630	43%	406.2	46.50	44.00	55.0

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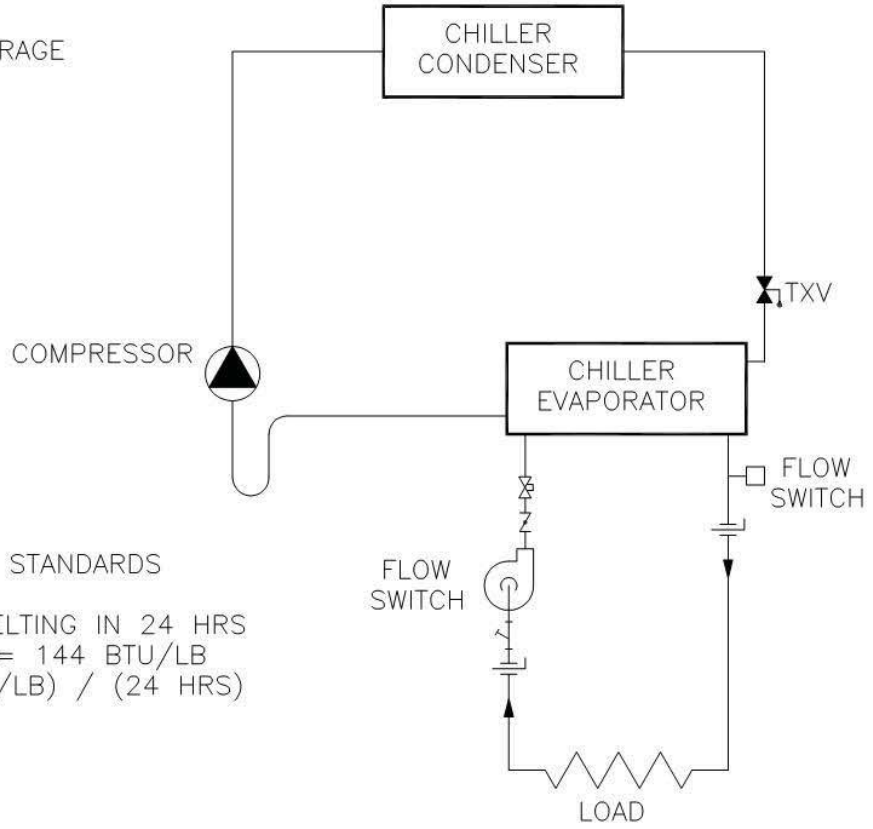
CHILLER TYPES
- ELECTRIC DRIVEN REFRIGERANT COMPRESSION
- ABSORPTION (STEAM / GAS)
- HEAT RECOVERY
- WATERSIDE ECONOMIZER
- ICE MACHINES FOR THERMAL STORAGE

COMPRESSOR TYPES
- CENTRIFUGAL
- SCREW
- SCROLL

CHILLER RATINGS
- NOM. TONNAGE BASED UPON ARI STANDARDS
- (1) TON = 12,000 BTUH
- BASED UPON (1) TON OF ICE MELTING IN 24 HRS
- WATER LATENT HEAT OF FUSION = 144 BTU/LB
- BTUH = (2,000 LB) * (144 BTU/LB) / (24 HRS)
- BTUH = 12,000 BTUH



GENERAL CHILLER REFRIGERATION DIAGRAM

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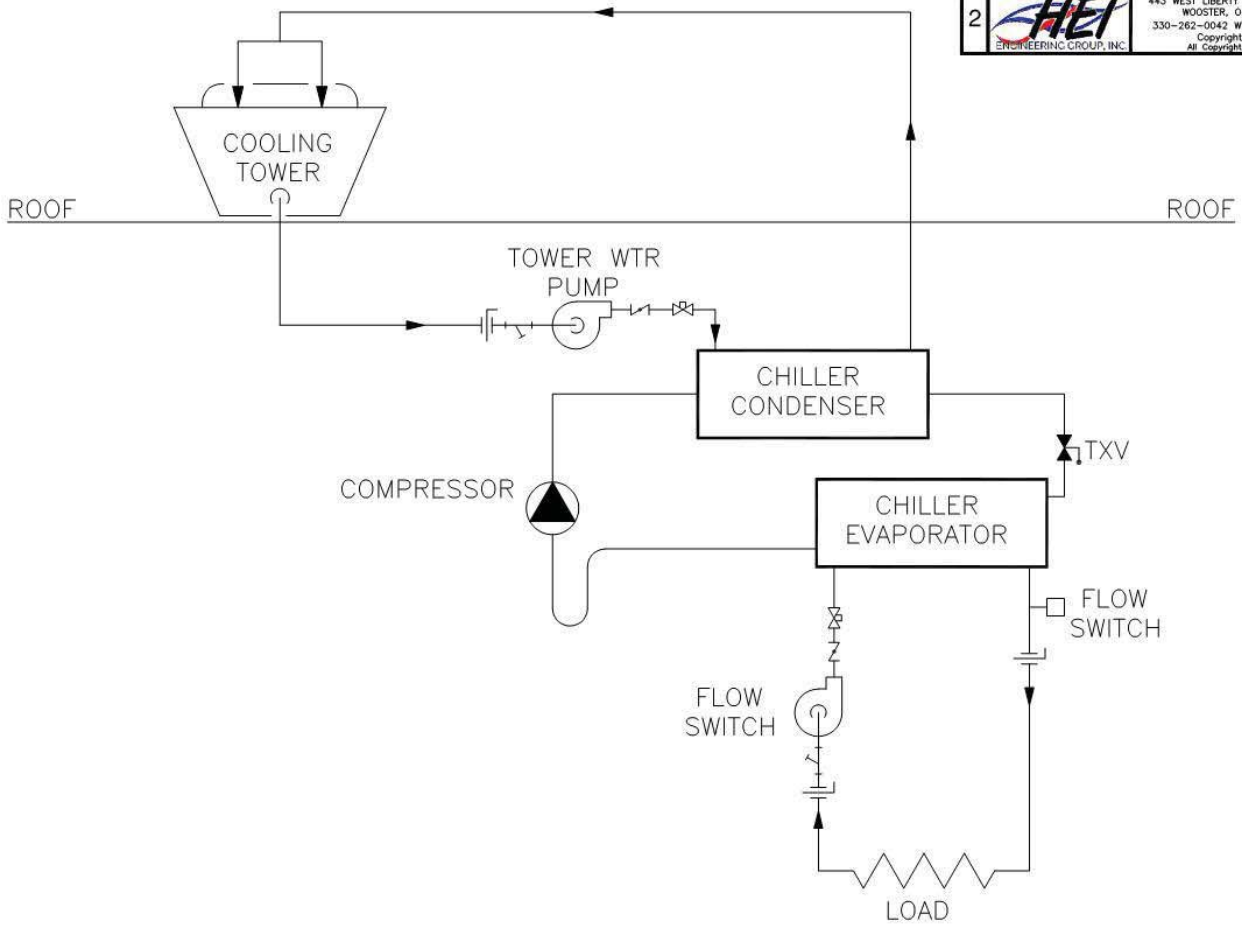

INDOOR WATER COOLED CHILLER - COOLING TOWER

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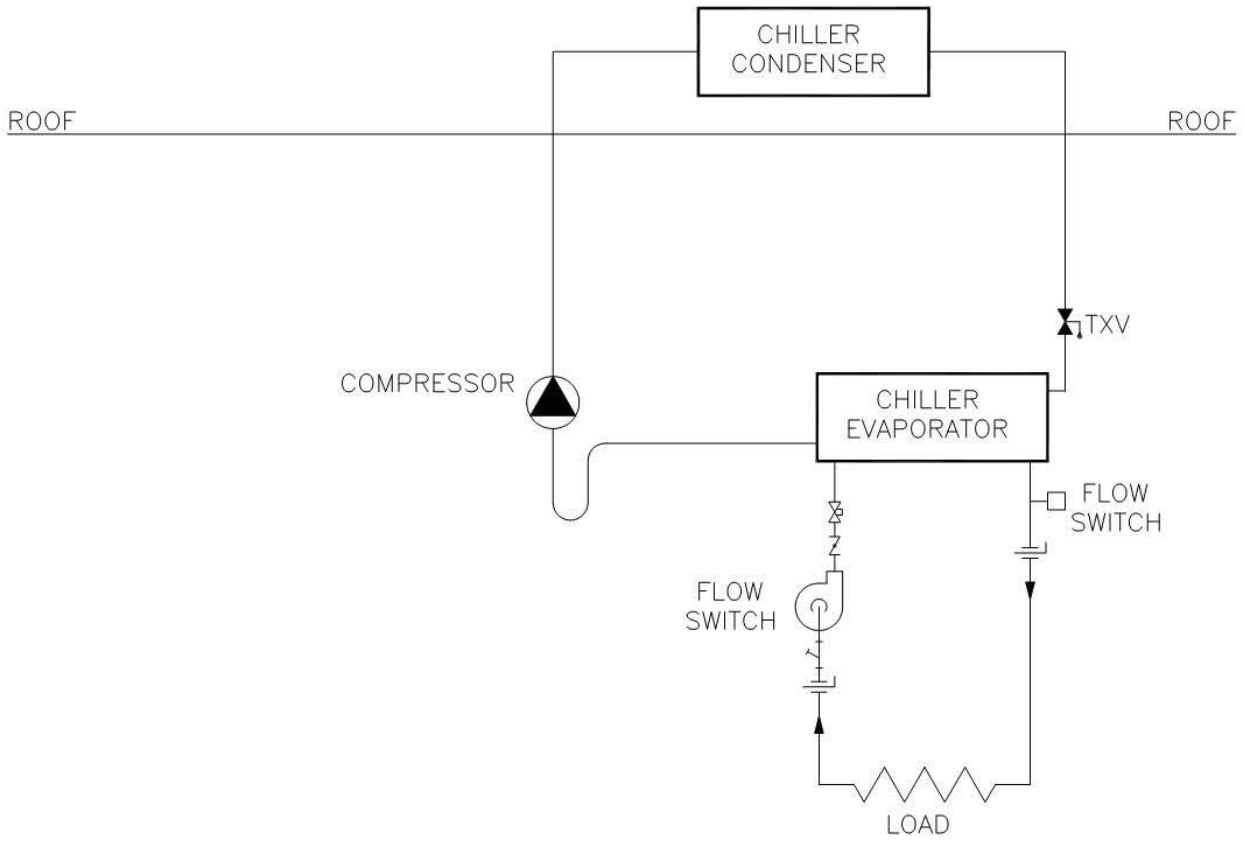

INDOOR AIR COOLED CHILLER - OUTDOOR CONDENSER

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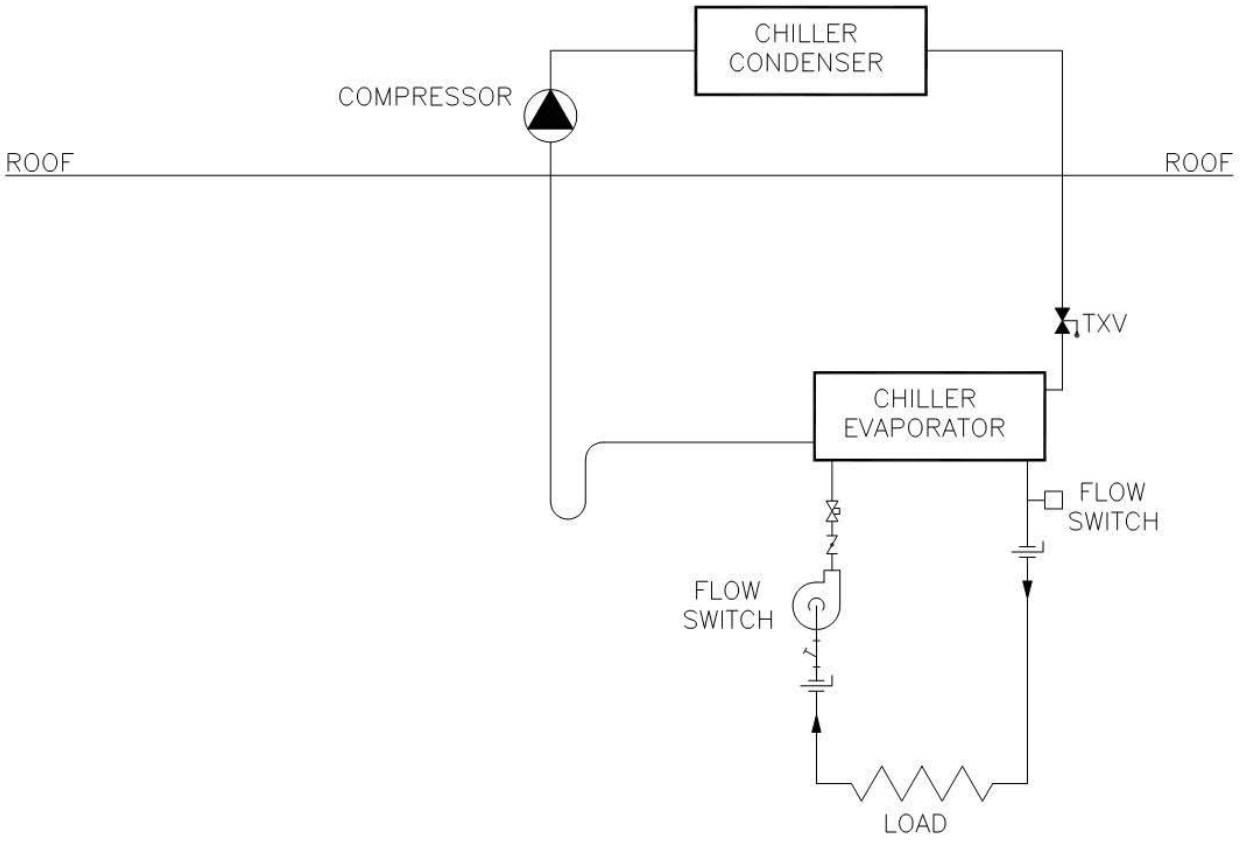

OUTDOOR AIR COOLED CHILLER - INDOOR EVAPORATOR

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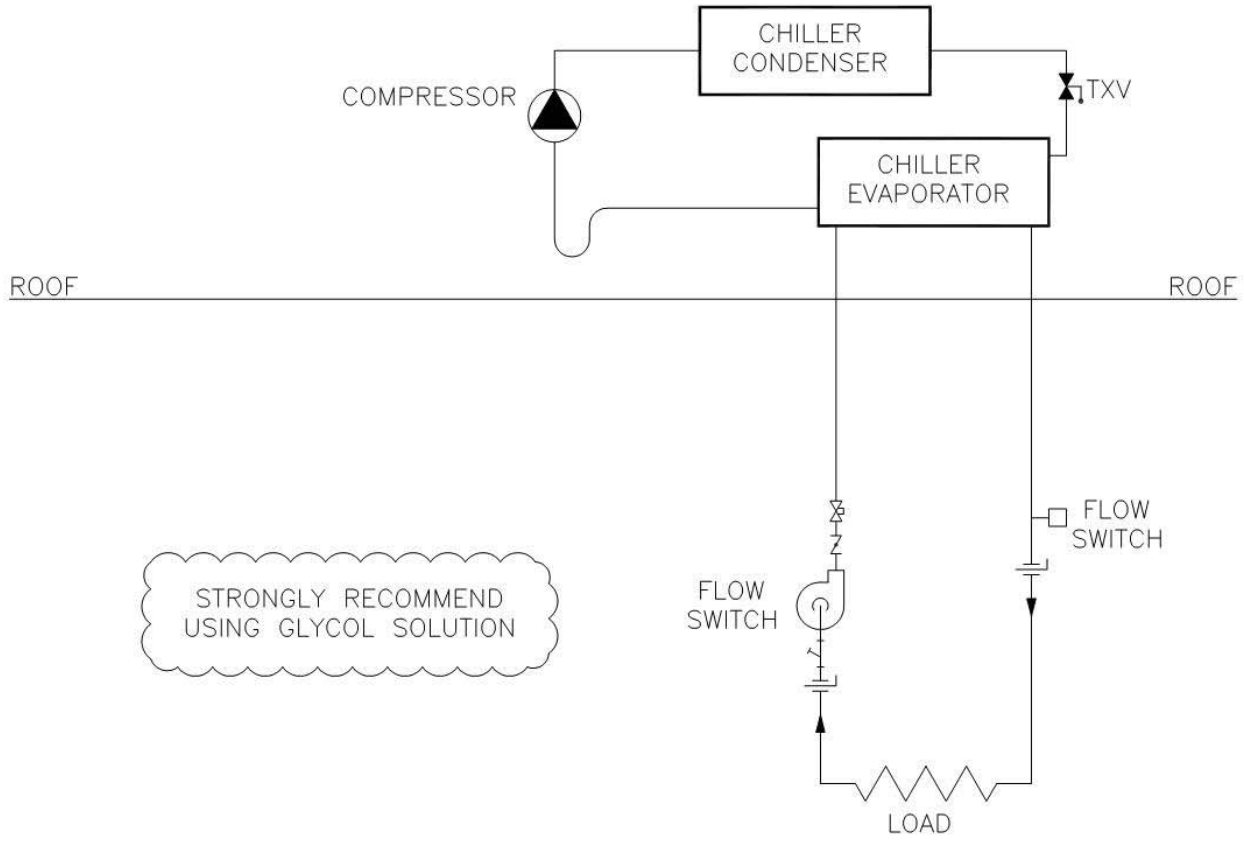

OUTDOOR AIR COOLED CHILLER PACKAGE

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FLUIDS BEING CHILLED

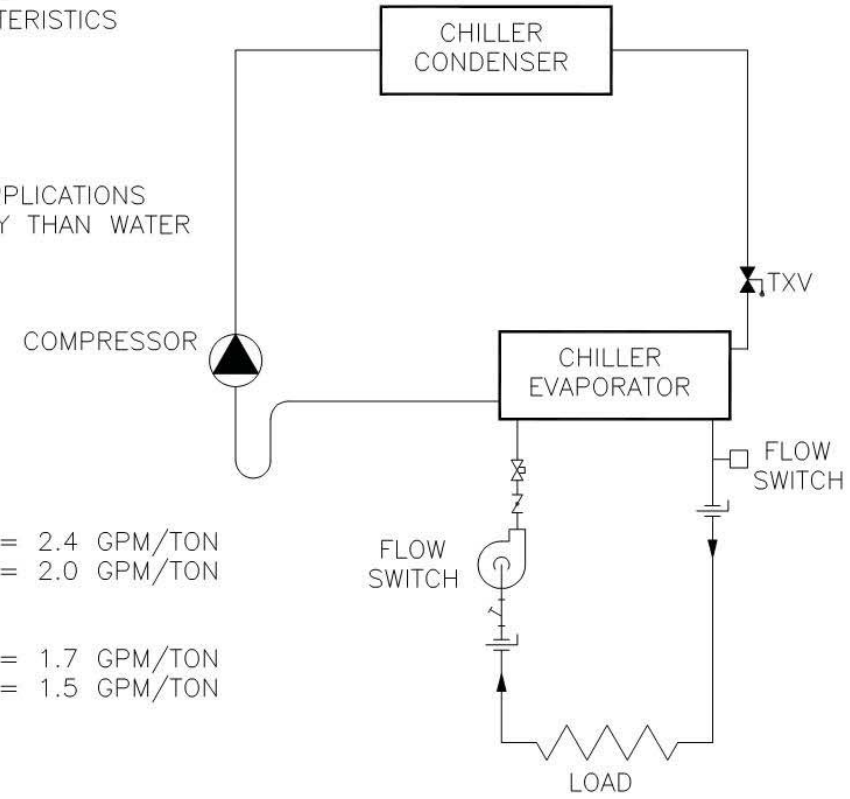
WATER (WITH CHEMICAL TREATMENT)
- CHEMICAL TREATMENT REQUIRED
- BEST HEAT TRANSFER CHARACTERISTICS

GLYCOL SOLUTION
- USE FOR FREEZE PROTECTION
- USE FOR LOW TEMP / ICE APPLICATIONS
- REQUIRES MORE PUMP ENERGY THAN WATER

FLOWS & TEMPERATURES

HISTORICALLY
- 10°F TD; 55°F EWT–45°F LWT = 2.4 GPM/TON
- 12°F TD; 55°F EWT–43°F LWT = 2.0 GPM/TON

CURRENT TREND
- 14°F TD; 56°F EWT–42°F LWT = 1.7 GPM/TON
- 16°F TD; 58°F EWT–42°F LWT = 1.5 GPM/TON



GENERAL CHILLER REFRIGERATION DIAGRAM

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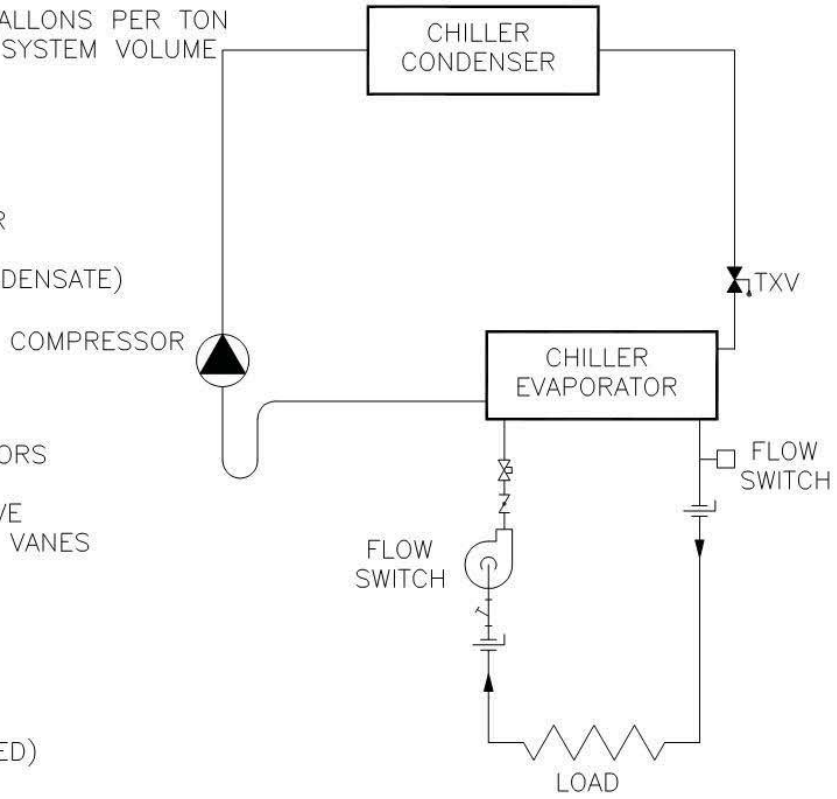
APPLICATION CONSIDERATIONS
- MINIMUM FLOW REQUIRED TO PREVENT FREEZE
- FLOW SWITCH TYP REQUIRED FOR PROOF OF FLOW
- MAXIMUM EWT ±70°F
- MINIMUM SYSTEM VOLUME ± 6 GALLONS PER TON
- USE BUFFER TANK TO INCREASE SYSTEM VOLUME

PUMP ARRANGEMENT
- PUMP TO PUSH INTO CHILLER
- PUMP HEAT REMOVED BY CHILLER
- PUMP HANDLES WARMEST WATER
  (REDUCES PUMP SWEAT / CONDENSATE)

REDUNDANCY & LOAD MATCHING
- CYLINDER UNLOADING
- STAGING OF MULTIPLE COMPRESSORS
- DIGITAL SCROLL COMPRESSORS
- SCREW COMPRESSORS SLIDE VALVE
- CENTRIFUGAL COMPRESSOR INLET VANES
- VARIABLE SPEED COMPRESSORS
- STAGING OF MULTIPLE CHILLERS
- N + 1 CHILLERS
- MODULAR CHILLERS

MULTIPLE CHILLER APPLICATION
- PRIMARY/SECONDARY (DE-COUPLED)
- SYSTEM COUPLED



GENERAL CHILLER REFRIGERATION DIAGRAM

Ohio Code 3318-3-03

- 3318-3-03 Requirements.
- (A) All new construction, renovation, repairs, and replacements of state funded facilities shall
- employ cost-effective, energy-efficient, green building practices to the maximum extent possible.
- **(B) Each state agency shall:**
- **(1) Design and construct state funded facilities achieving the following minimum standards:**
- **(a) New construction shall be designed so that the fossil-fuel, greenhouse gas emitting,**
- **energy consumption of the facility is reduced, as compared to the regional average for**
- **that building type as defined in CBECS, by the percentage specified as follows:**
- (i) Fifty per cent for designs completed on and after February 16, 2010;
- (ii) Sixty-five per cent for designs completed on and after January 1, 2015;
- (iii) Eighty per cent for designs completed on and after January 1, 2020;
- (iv) Ninety per cent for designs completed on and after January 1, 2025; and
- (v) One-hundred per cent for designs completed on and after January 1, 2030.
- (b) Renovation projects shall be designed so that the fossil-fuel, greenhouse gas
- emitting, energy consumption of the facility is reduced, as compared to the regional
- average for that building type as defined in CBECS, by fifty per cent.

Ohio Code 3318-3-03

- 3318-3-04 Procedures and guidelines for new and renovated facilities.
- (A) During the facility's preliminary schematic design stage, a state agency shall require the
- designer to:
- **(1) Develop practical alternative design concepts, considering passive and/or active**
- **building components, for the purpose of minimizing future energy consumption.**
- **(2) Estimate the annual energy consumption and associated energy costs of each**
- **alternative, analyze their impact on facility life-cycle costs and incorporate into the final**
- **facility design alternatives which are cost effective.**
- **(3) Re-evaluate life-cycle cost as additional alternatives to be considered during the**
- **continuing design development to assure their cost effective implementation.**
- **(B) The energy consumption calculations shall be performed in accordance with**
- **established engineering practices and currently accepted methodology including**
- **computerized simulation techniques approved by the Ohio facilities construction**
- **commission.**
- Effective: 1/10/2016
- Five Year Review (FYR) Dates: 10/26/2015 and 01/10/2021
- Promulgated Under: 119.03 Statutory Authority: 123.21, 123.22(D) Rule Amplifies: 123.22 Prior Effective Dates: 12/30/1980, 02/16/2010, 4/2/2012
-

CHILLER LIFE CYCLE ANALYSIS

Courthouse & Park Building Chiller Replacement Projects

Courthouse & Park Building Chiller Projects Bid Sheet

Courthouse Chiller Bids	Bid Package #1 Smardt Chiller	Bid Package #1 Vykon/Jace Controls Add/Deduct	Bid Package #2 Dunham Bush Add/Deduct	Bid Package #2 York/Johnson Add/Deduct	Bid Package #2 Alternate Add/Deduct
	315,230.00	11,850.00	-84,030.00	-71,730.00	11,850.00
Standard Plumbing & Heating	334,910.00	10,185.00	-70,000.00	-55,000.00	17,000.00
Universal	360,000.00	5,500.00	-105,000.00	-95,000.00	5,500.00
H & A Mechanical					

ParkBuilding Chiller Bids	Base Bid Dunham Bush	Unit Price York/Johnson Add/Deduct	Alternate Jace System Extension Add/Deduct
	172,100.00	6,000.00	7,705.00
Standard Plumbing & Heating	165,138.00	8,400.00	21,000.00
Universal	190,000.00	5,000.00	6,700.00
H & A Mechanical			

Courthouse & Park Building Chiller Project Options

Courthouse Chiller Options	Option #1 Smardt Chiller Package Only	Option #2 Smardt Chiller with Vykon/Jace Controls	Option#3 Dunham Bush Chiller Package Only	Option #4 Dunham Bush Chiller with Jace Controls	Option #5 York/Johnson Chiller Package Only	Option #6 York/Johnson Chiller with Jace Controls
	315,230.00	327,080.00	231,200.00	243,050.00	243,500.00	255,350.00
Standard Plumbing & Heating	334,910.00	345,095.00	264,910.00	281,910.00	279,910.00	296,910.00
Universal	360,000.00	365,500.00	255,000.00	260,500.00	265,000.00	270,500.00
H & A Mechanical						

ParkBuilding Chiller Options	Option #1 Dunham Bush Chiller Package Only	Option #2 Dunham Bush Chiller with Jace Extension	Option#3 York/Johnson Chiller Package Only	Option #4 York/Johnson Chiller with Jace Extension
Standard Plumbing & Heating	172,100.00	179,805.00	178,100.00	185,805.00
Universal	165,138.00	186,138.00	173,538.00	194,538.00
H & A Mechanical	190,000.00	196,700.00	195,000.00	201,700.00

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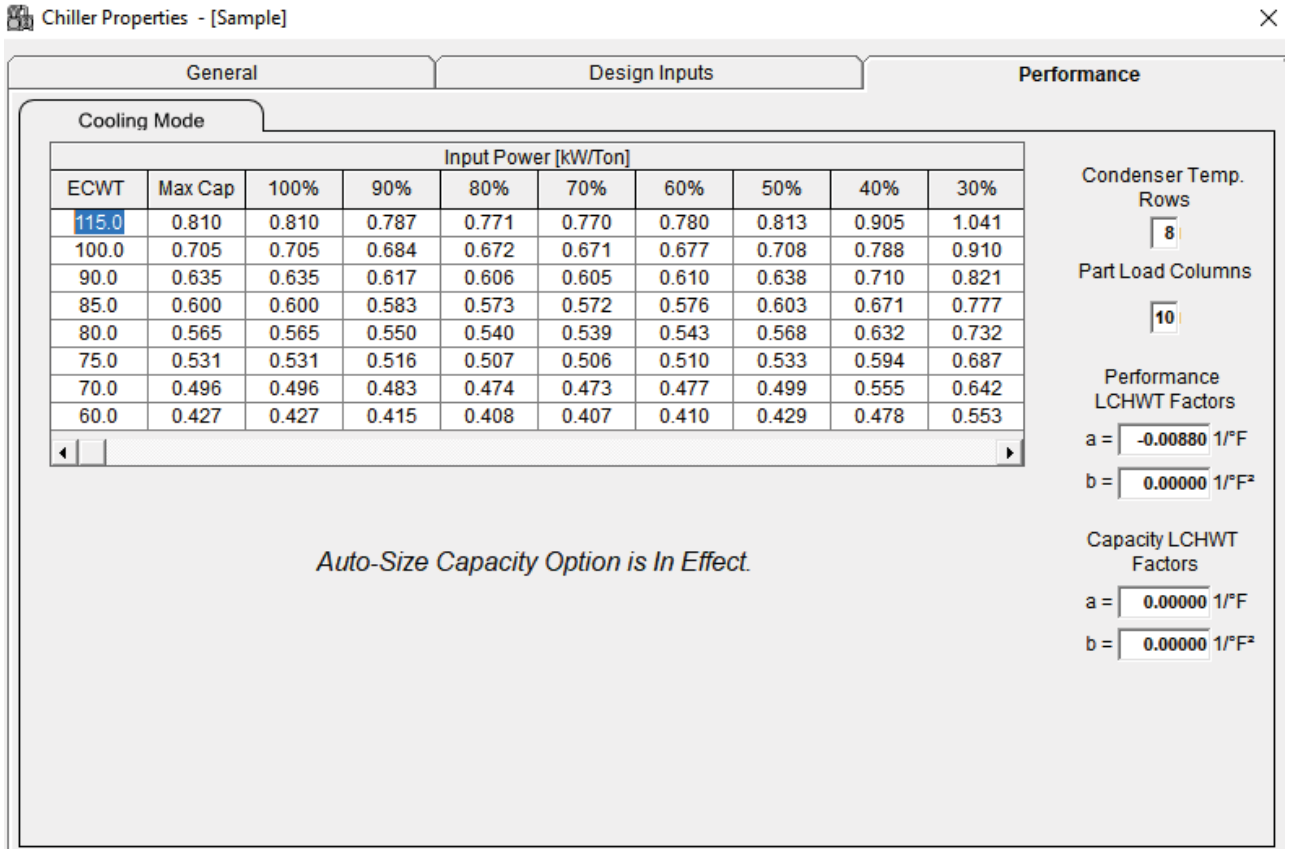
Richland Co. Courthouse Chiller & Condenser

Richland Co. Courthouse Chiller & Condenser –180 Nominal Tons

Chiller Performance and Modeling with Carrier HAP Software



Financial Analysis with Carrier Engineering Economic Software

Lifecycle Summary

Project: Richland County Courthouse Revised 3.75%
Prepared By: MG Energy Group

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Simple Payback Analysis

Type of Analysis	Public Sector Lifecycle Analysis	
Type of Design Alternatives	Mutually Exclusive	
Length of Analysis	20	yrs
Discount Rate	3.75	%

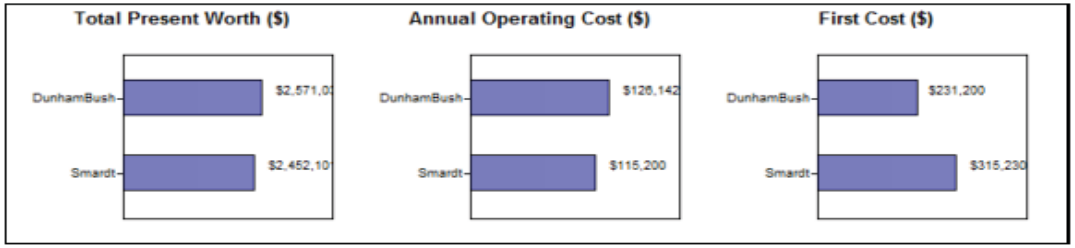

Table 1. Executive Summary

Economic Criteria	Best Design Case for Each Criteria	Value ($)
Incremental SIR Analysis	Court House Richland County Smardt Chiller	-
Lowest Total Present Worth	Court House Richland County Smardt Chiller	$2,452,101
Lowest Annual Operating Cost	Court House Richland County Smardt Chiller	$115,200
Lowest First Cost	Court House Richland County Dunham Bush	$231,200

Table 2. Design Cases Ranked by First Cost

Design Case Name	Design Case Short Name	Total Present Worth ($)	Annual Operating Cost ($/yr)	First Cost ($)
Court House Richland County Dunham Bush	DunhamBush	$2,571,036	$126,142	$231,200
Court House Richland County Smardt Chiller	Smardt	$2,452,101	$115,200	$315,230

Table 3. Incremental Analysis Data

Challenger	Base Case	Additional First Cost ($)	NPW Savings ($)	SIR	Payback Period (yrs)
Smardt [Winner]	DunhamBush	$84,030	$118,936	2.415	7.9

Wake Up, Time to Go Home
But first ask a question or two