

## UVM-CP-24-SD

# CHILLER GENERATOR SYSTEM UNIT 1 AND 2 SYSTEM DESCRIPTION

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#### PREFACE

This System Description has been designed to assist you in meeting the requirements of Module UVM-CP-24 of the Central Heating and Cooling Plant Operator Training and Certification Program. It contains information about the Chiller Generator System Unit 1 and 2. This includes system purpose, flow path, and details about major system components and operation.

You should review chapter objectives. In doing so you will be better prepared to learn the required information. You should also walk down the system and identify the components and controls. Should you have additional questions about the system, ask your Supervisor.

Operators are responsible for learning the information contained in this document. They are also responsible for making proper inspections, recording and logging information, reporting problems of the Chiller Generator System Unit 1 and 2.

A separate document, System Operating Procedure (UVM-CP-24-SOP), covers detailed operation of the Chiller Generator System Unit 1 and 2.

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#### References:

University of Vermont Diagrams

University of Vermont York Chiller Manual

York Model YST MaxE Steam-Turbine Drive Centrifugal Liquid Chiller Operating and Maintenance Manual

York OptiView Control Center MaxE Steam Turbine Drive Centrifugal Liquid Chiller Operation Manual

#### 1.0 Introduction

Chapter Objectives:

Describe the purpose of the Chiller Generator System Unit 1 and 2.

- 1. State, from memory, the purpose of the Chiller Generator System Unit 1 and 2.
- 2. Draw a simplified diagram of the Chiller Generator System Unit 1 and 2.
- 3. Describe the flow path and how the Chiller Generator System Unit 1 and 2 performs their functions.
- State, from memory, the names and purpose of the major Chiller Generator System Unit 1 and 2 components.
- 5. List the normal Chiller Generator System Unit 1 and 2 operating parameters.

#### 1.1 Purpose

The purpose of the Chiller Generator System Units 1 and 2 is to provide chilled water for campus air conditioning and equipment that require cooling.

#### **1.2 Basic System Description**

The Unit 1 and Unit 2 Chillers are York YST Steam Turbine Driven Centrifugal Compressor Chillers manufactured by Johnson Controls. The Chillers operate on Refrigerant R-134a. Each Chiller system includes the Compressor, Evaporator, Condenser, Steam Turbine, Steam Condenser, Lubrication Systems, Power Panel, OptiView Control Center, and all interconnecting unit piping and wiring.

The Chiller Generator System is manufactured by Johnson Controls under their York brand. Other manufacturers supply some components.

#### 1.3 System Flow Path

Water from the Cooling Towers flows through the tubes in the Evaporator where boiling refrigerant evaporates and absorbs heat from the water. The refrigerant rises and passes through Eliminators that remove any water droplets. The dry refrigerant gas flows to the Compressor suction. The Compressor raises the temperature and pressure of the refrigerant through centrifugal force. The higher-pressure refrigerant gas exists the Compressor and enters the

Condenser where the latent heat of the refrigerant is removed and the refrigerant condenses to a liquid by water flowing through the tubes. The liquid refrigerant passes through a subcooling section in the bottom of the Condenser where the liquid refrigerant is cooled to a lower temperature again by water inside tubes. The higher-pressure refrigerant liquid then expands into the Evaporator through a Level Control Valve controlled by the OptiView Control Center based on the signal from a Refrigerant Level Sensor located in the Subcooler.

The water that is chilled in the Evaporator is pumped to the point of use, which includes campus air conditioning and equipment requiring cooling.

The Compressor is direct driven by a variable speed condensing Steam Turbine. High pressure steam from the High Pressure Steam Header is used to power the Steam Turbine. The Steam Condenser condenses exhaust steam from the Steam Turbine to water and the condensate is collected in the Hotwell. When the Level Measurement Transmitter senses Condenser Hotwell is full, surplus condensate is returned to the Boilers.



Drawing 1 – Chiller Generator System (Typical) Block Diagram



**Drawing 2 – Refrigerant Flow Diagram** 



Drawing 3 – Steam and Condensate Flow Diagram

#### 2.0 System Major Components

Chapter Objectives:

- 1. Describe how the Chiller Generator System Unit 1 and 2 Components perform their functions and how they interface with other system components.
- 2. Draw from memory a diagram of the Chiller Generator System Unit 1 and 2 showing major components.
- 3. State from memory the names and purposes of Chiller Generator System Unit 1 and 2 major components.
- 4. Describe the construction of and flow paths through the major components.

The Chiller Generator System Units 1 and 2 each consist of the following major components:

- 1. Compressor
- 2. Steam Turbine
- 3. Evaporator
- 4. Condenser
- 5. Steam Condenser Package
- 6. Power Panel
- 7. OptiView Control Center



**Drawing 3 – Chiller Components** 

#### 2.1 Compressor

The Compressor is the part of the Chiller that pressurizes refrigerant gas before it is sent to the Condenser (also called the Refrigerant Compressor). Dry refrigerant gas flows to the Compressor suction. The Compressor raises the temperature and pressure of the refrigerant through centrifugal force. This higher-pressure refrigerant gas exits the Compressor and enters the Condenser. The Compressor is mounted to a Driveline Base and connected to the Steam Turbine with a flexible disc coupling.



Figure 1 – Compressor

#### Compressor

Manufacturer	York
Туре	Open drive single impeller centrifugal
Drive	Steam Turbine

#### 2.2 Steam Turbine

The Steam Turbine is a high efficiency multistage design operating at a nominal 4500 rpm design maximum speed.

The Steam Turbine is packaged on a Driveline Base. The Driveline Base has a mating flange on the shaft end of the package that bolts directly to the Compressor D-flange face providing a rigid interface between the Steam Turbine and the Compressor.

The Steam Turbine casing is horizontally split to allow longitudinal thermal expansion without affecting alignment or efficiency of the Steam Turbine.

Protection against overspeed is built into the automatic speed control for the Chiller System. The Steam Turbine operating speed is controlled by a Governor Valve that is integrated with the Chiller controls. The Governor Valve controls flow throughout the entire operating range of the Steam Turbine. If the speed sensed by the automatic controls exceeds the maximum speed of 4500 rpm it will automatically begin closing the Governor Valve. If the speed should continue to increase the controls will continue to send a signal to close the Governor Valve.

If the automatic speed controls should fail to slow the Turbine by closing the Governor Valve in an overspeed condition, the software overspeed logic will de-energize the Turbine Trip Solenoid at a programmable setpoint that is usually set 50 rpm below the mechanical trip activation speed.

A mechanical spring loaded overspeed device will trip at 110 percent of maximum design speed. This mechanical overspeed trip mechanism will immediately close the Overspeed Trip Butterfly Valve.



Figure 2 – Steam Turbine

#### Steam Turbine Data

Manufacturer	York
Nominal design maximum operating speed	4500 rpm
Design	Horizontal split-case, multistage
Model	KG

#### **Steam Turbine Data**

There is an overspeed trip that can be used by the Operator in an emergency. The EMERGENCY STOP knob at the base of the Steam Turbine activates this manual trip. The manual trip is connected to the same linkage as the mechanical trip.



Figure 3 – Steam Turbine Emergency Stop

#### 2.3 Evaporator

The Evaporator is a shell and tube, flooded type heat exchanger. A Distributor Trough provides uniform distribution of refrigerant over the entire shell length. Stainless steel mesh eliminators or suction baffles are located above the tube bundle to prevent liquid refrigerant carryover into the Compressor. A Liquid Level Sight Glass is located on the side of the shell to aid in determining proper refrigeration charge. The Evaporator shell contains dual Refrigerant Relief Valves.



Figure 4 – Evaporator

#### 2.4 Condenser

The Condenser is a shell and tube type heat exchanger, with a discharge gas baffle to prevent direct high velocity impingement on the tubes. A separate Subcooler is located in the Condenser to enhance performance. Dual Refrigerant Relief Valves are located on the Condenser shell.

The removable compact Water Boxes are fabricated of steel. Integral steel water baffles provide the required pass arrangements. Stub-out water nozzle connections with Victraulic grooves are welded into the Water Boxes.



Figure 5 – Condenser

#### Condenser Data

Manufacturer	ITT Standard
Туре	Shell and tube
Water box design working pressure	150 psig
Water box tested pressure	225 psig

#### 2.5 Steam Condenser Package

The Steam Condenser Package consists of a Steam Condenser, Single Hotwell (condensate) Pump, single Vacuum Pump, Hotwell Condensate Level Control System, and an Atmospheric Relief Valve.

The Steam Condenser is provided to condense steam exhausted from the Steam Turbine. Cooling water supply for the Steam Condenser is piped from the outlet of the Condenser. The Steam Condenser is a shell and tube heat exchanger. Steam condenses on the outside of the tubes. Condensing water flows inside the tubes. Subcooling sections in both ends of the Condenser cool non-condensibles (mainly air) sufficiently below the condensing temperature to reduce the capacity of the Vacuum Pump. Cooling water end plates are provided on each end of the Steam Condenser so that tubes may be accessed without having to disturb the water piping connections. An Atmospheric Relief Valve protects the steam side of the system.

The Hotwell Pump is a 5 hp, 3600 rpm motor driven direct connected pump with a maximum suction pressure of 5 psig. The Hotwell Pump is automatically controlled during operation to remove condensate as it builds up in the Steam Condenser.

The Vacuum Pump is a 7.5 hp, 1800 rpm motor driven direct connected single stage liquid ring type pump designed for continuous operation. As liquid moves outwards, air is drawn into the pump, compressed and expelled through the discharge port into a Discharge Separator that separates the water from the air. Approximately 3.5 gpm of makeup water is required to maintain the Liquid Seal Ring while the Vacuum Pump is in operation.

The Level Control System automatically controls the condensate level in the Hotwell during operation. The Level Measurement Transmitter senses the condensate level in the Hotwell and sends a signal to the OptiView Control Center, which in turn sends a control signal to position the Condensate Recirculation Valve and the Condensate Overboard Valve. The Level Control System includes a visual magnetic Level Gauge. High Level Trip and Low Level Alarm Switches are wired to the OptiView Control Center to provide the safety functions required.



Figure 6 – Steam Condenser Package

#### 2.7 Power Panel

The Power Panel contains all motor contactors and circuit protectors, the Compressor Oil Pump Variable Speed Drive, and the Control Power Transformer. The Power Panel enclosure is installed adjacent to the OptiView Control Center. The Main Power Disconnect Switch is mounted on the door of the Power Panel.



Figure 7 – Power Panel and OptiView Control Center

#### 2.8 OptiView Control Center

The OptiView Control Center provides control of the entire Chiller, including Steam Turbine and Steam Condenser monitoring. The Control Panel includes a color Liquid Crystal Display (LCD) surrounded by "soft" keys, which are defined based on the Screen displayed at that time, mounted in the middle of a keypad interface and installed in a locked enclosure. The Screen details all operations and parameters, using graphical representation of the Chiller and its major components.



Figure 8 – OptiView Control Center