



Central States Industrial Equipment & Service Inc.

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Operation & Maintenance Manual

Pilot Plant

Direct Steam Injection

Vacuum Cool System

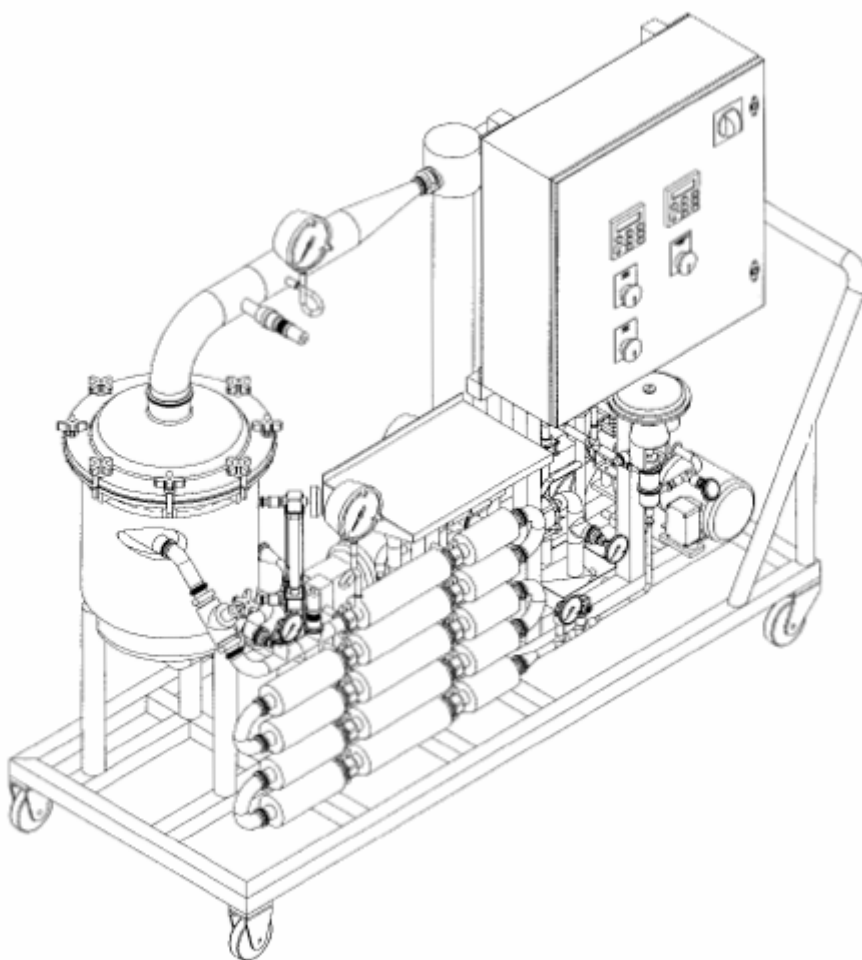


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1.0 INTRODUCTION

1.1 General

The purpose of this manual is to provide instructions for the safe installation, operation and maintenance of your **CENTRAL STATES INDUSTRIAL DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM**.

1.2 Safety

! WARNING

Read and understand the entire manual before unpacking, installing, operating or maintaining the equipment.

Safe installation, operation and maintenance of the **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** requires proper training of all personnel who will operate or service the equipment. Training is provided as part of the startup service, then it is the responsibility of the owner to properly train and supervise personnel for proper operation and maintenance.

Section 2.0, titled "Safety Instructions", should be read and understood before proceeding. This section discusses general safety practices. In addition, specific hazards are indicated by the appropriate hazard label in bold type throughout this manual.

TRAINING IS REQUIRED BEFORE OPERATING THIS SYSTEM !

1.3 Design and Application

Many processes require direct steam injection heating of products and subsequent vacuum cooling, whether for heat treatment or legal pasteurization. **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEMS** are designed uniquely for the duty required by the owner.

This particular pilot plant model was designed with this particular scope:

Trial products will be pumped through a steam injection heater. Heated to 300°F, the product will be held for 45 or 60 seconds under pressure and then introduced into a vacuum chamber where it is cooled and the vapor is condensed and discarded. The product is pumped out of the vacuum chamber.

This particular pilot plant model was designed with these parameters:

Design	non sanitary, take apart cleaning, no edible product
Product	Feeding tube formulations and medical nutrition drinks
Flow rate	80 gph (1.3 gpm)
Feed temp	~170°F
Heating to	300°F
Hold time	45 or 60 seconds
Discharge temp	~170°F

The **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** is comprised of the following main components:

- Progressive cavity supply pump with VFD
- Hydro Thermal *Hydro-Heater* steam injector
- Hold Tube
- Back pressure valve
- Vacuum Chamber
- Progressive cavity discharge pump with VFD
- Vapor condenser – shell and tube
- Liquid ring vacuum pump
- Instrumentation
- Laptop computer
- Data Acquisition module

1.4 Receiving and Inspection

CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEMS are assembled and inspected before shipment and are properly prepared for transportation. Upon receipt of this equipment, check all received items against the packing list, drawings, and equipment list. Check for damage or missing parts. **Damage or loss should be reported immediately to the carrier or insurance agent.**

2.0 SAFETY INSTRUCTIONS

2.1 General Statement

CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEMS are designed and manufactured with due consideration and care for generally accepted safety standards. However, like any mechanical device, the proper and safe performance of this equipment depends upon using sound and prudent operating, maintenance and servicing procedures under properly trained supervision.

This system was designed with specific requirements from the owner in consideration of the pilot plant duty and personnel that will operate the system. Note that this system has no control system or safety interlocks that would normally be programmed into a production system. This is a manual system and should only be operated by qualified personnel.

For your protection, and the protection of others, learn and always follow the safety rules outlined in this section. Observe warning signs on machines and act accordingly. Form safe working habits by reading the rules and abiding by them. Keep this booklet handy and review it from time to time to refresh your understanding of the rules.

2.2 Hazard Level Identification

Definitions for identifying the various hazard levels shown on warning labels or to indicate proper safety procedures in the instruction manual are provided in the following labels:

! DANGER

The use of the word “Danger” always signifies an immediate hazard with a high likelihood of severe personal injury or death if instructions, including recommended precautions, are not followed.

! WARNING

The use of the word “Warning” signifies the presence of hazards or unsafe practices that could result in severe personal injury or death if instructions, including recommended precautions are not followed.

! CAUTION

The use of the word “Caution” always signifies possible hazards that could result in minor personal injury or damage to product or property if instructions, including recommended precautions are not followed.

2.3 Operating Zone

An operating zone should be established around the **SYSTEM**. A brightly painted guardrail or warning strip should define the zone. Only the operator or other authorized personnel should be within the operating zone when the unit is operating. No tools or other equipment should be kept within the operating zone. Refer to figure 3.1 for space requirements.

2.4 Pressure and Temperature Ratings

Pressure and temperature ratings for the **SYSTEM** are listed below in Table 3.1. These ratings must not be exceeded at any time during startup or operation of the unit.

2.5 Installation

Utility sources, such as water, steam, electricity, and air should be installed by trained and authorized personnel only. Installations must comply with all applicable codes and standards, including those established by the general industry standards of OSHA.

2.6 Safety Instructions

Before Starting a Unit:

Be certain that all necessary guards and safety devices are installed and operating properly. This includes safety screens and pressure relief devices.

Be sure all personnel are clear of the unit.

Remove (from the operating zone) any materials, tools or other foreign objects that could cause injury to personnel or damage the unit.

Make certain all alarms, indicating lights, pressure gauges and other safety devices or indicators are in working order.

After Shutdown:

Make certain all water, steam, air, and electric utilities are turned off. Make certain all pressure and vacuum is released .

2.7 General Operating Safety**! CAUTION**

Do not operate unit until you have read and understand the operating instructions and become familiar with the unit and its operation.

Never operate a unit while a safety device or guard is removed or disconnected.

Always wear safety glasses, hats, shoes, ear protection or any other required safety equipment.

Never remove “**WARNING**” tags that are displayed on the unit. Torn or worn labels should be replaced.

Do not start the unit until all personnel in the area have been warned and have moved outside the operating zone.

Remove any tools or other foreign objects from the operating zone before starting.

Do not have loose clothing, neckties, jewelry or unrestrained long hair near operating unit.

Do not wear rings, watches, bracelets or other jewelry near an operating unit.

Keep the operating zone free of obstacles that could cause a person to trip or fall towards an operating unit.

Never sit or stand on anything that might cause you to fall against the unit.

“Horseplay” around a unit at any time is dangerous and prohibited.

Know the shut down procedure for the unit in the event of an emergency.

Never operate the unit above specified capacity pressures or temperatures.

Keep alert and observe indicator lights and warnings that are displayed on the unit.

Do not operate faulty or damaged equipment. Make certain proper service and maintenance procedures have been preformed.

! DANGER

Make sure that system pressure has been reduced to zero (0 psig) and that the hot surfaces are less than 100°F (38°C) before attempting service or maintenance on the **SYSTEM**.

! DANGER

Follow plant lockout/tagout procedures before attempting service or maintenance the **SYSTEM**.

2.8 Service and Maintenance Safety

Do not service a unit until you are thoroughly qualified and familiar with the tasks to be performed.

Never operate any valves, pumps or controls while persons are performing maintenance on the unit.

Do not bypass a safety device.

Always use the right tool for the job.

2.9 Cleaning Safety**! WARNING**

If disassembling portions of the system, proper lock out procedures must be followed on energy sources until the unit is properly reassembled.

Do not use toxic or flammable solvents to clean a unit.

Always clean up spills around the unit as soon as possible.

Never attempt to clean a unit while it is operating.

Ensure that the system is properly reassembled after cleaning. Check all clamps, flanges, and threaded connections.

3.0 INSTALLATION**3.1 Location****! WARNING**

Proper installation is required for safe operation.

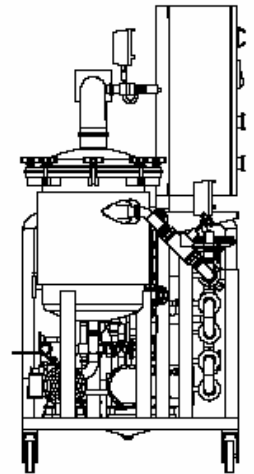
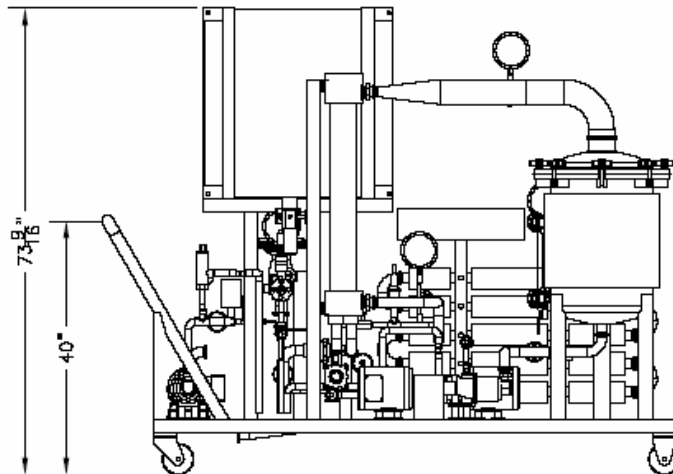
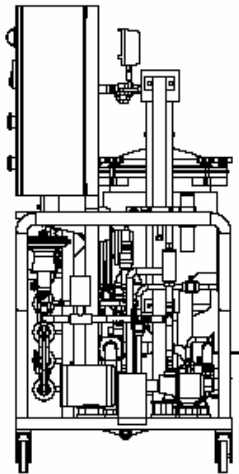
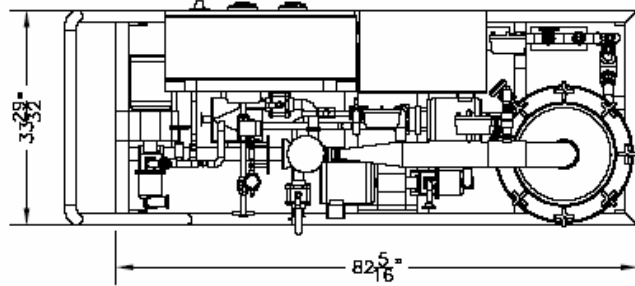
The **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** should be installed in an area with adequate clearance around the unit to operate the equipment and perform maintenance. See section 2.3.

Place the system on a level surface. Locking casters are provided to prevent the system from moving during operation.

The unit should also be located with consideration for the required piping connections. Steam and water piping to and from the unit should be designed to minimize pressure drops and must be adequately supported to minimize the loads on the **DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM**.

Refer to Figure 3.1 for dimensions of the system.

FIGURE 3.1
LAYOUT VIEWS



3.2 Unpacking Equipment

The system is shipped with a shrink wrap protection system. Take great care when cutting this temporary cover off.

Take care to remove all shipping stops and packing from the equipment supplied on the **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** skid prior to operating the unit.

3.3 Connections and Piping

Retighten all connections. Shipping can occasionally loosen connections and pipe hangers. Ensure that all steam, water, air and product piping is secure and properly connected.

Check electrical wiring connection in the panel and all instrument cabling for proper connection.

Refer to Figure 3.2 for external connections required. A complete set of drawings can also be found in the binder provided.

3.4 Pressure and Temperature Ratings

	Minimum Pressure	Max Pressure	Temperature Range	Flow Expected	Type
Steam Supply	90 psig	125 psig		86 pph	Saturated
Water Supply	50 psig	125 psig	32 - 60 °F	30 gpm	Clean
Air Supply	60 psig	125 psig		<100 cfh	Clean/Dry
Product Supply	0 psig	4 psig (10' head)	~170 °F	80 gph	

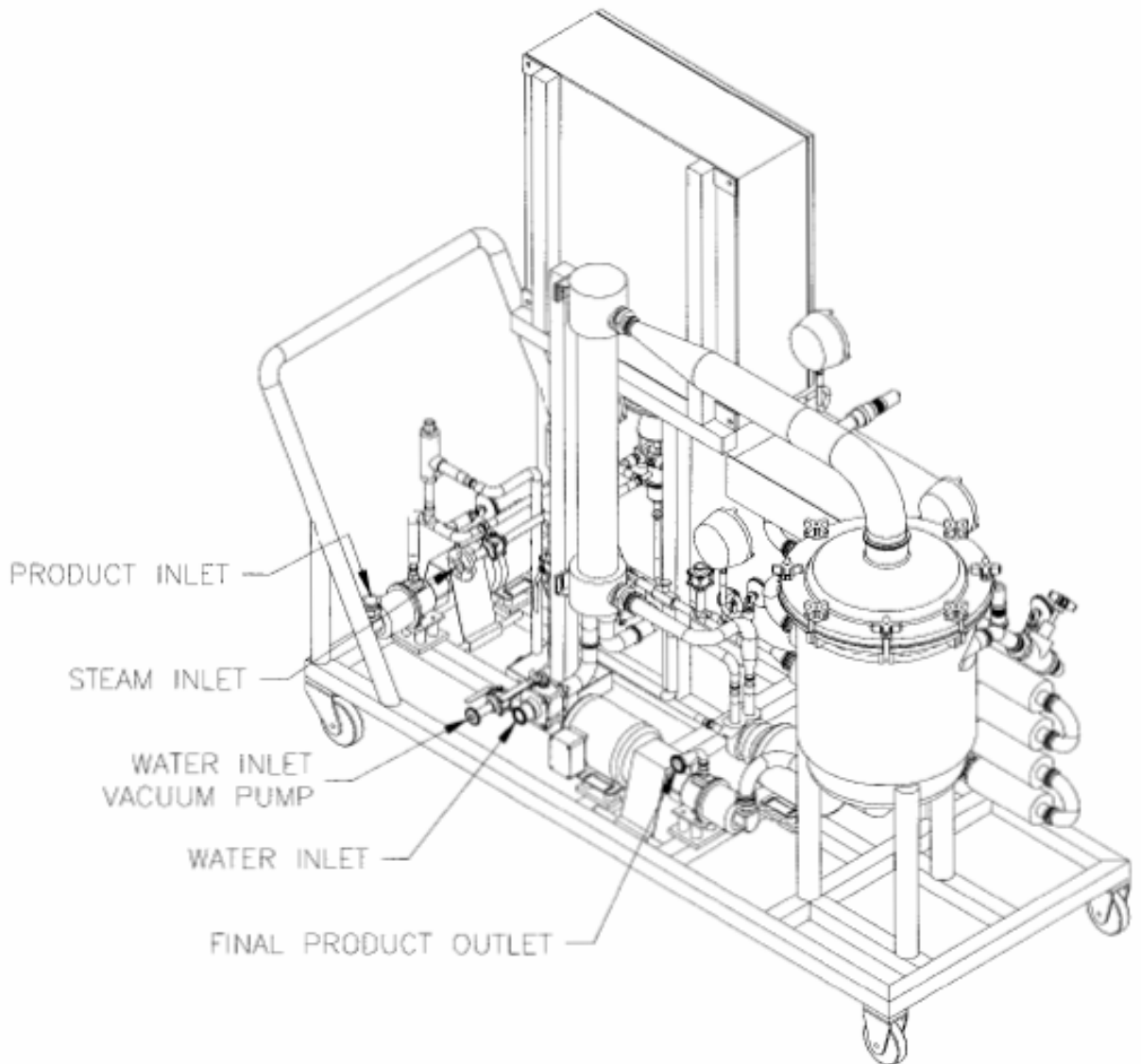
TABLE 3.1

! DANGER

Do not exceed the maximum operating pressure listed in Table 3.1 or damage to the **SYSTEM** may result.

Over pressure protection must be provided if it is possible the system may develop a higher pressure than the maximum allowable working pressure of the **SYSTEM**.

FIGURE 3.2
Service Connections



3.5 Electrical

A qualified electrician will follow NEC procedures and connect 208V 3Ph into the panel. The panel penetration will be made so as to ***maintain the UL listing and the NEMA 4X rating***. Check the panel drawings and control panel labels for the correct voltage, full load amperage, and wiring.

Insure the panels are appropriately grounded and that protection devices are rated for the interrupting current at the installed facility.

Confirm motor rotation before operating the equipment. **DO NOT RUN PUMPS DRY FOR MORE THAN 1 SECOND.**

3.6 Steam – Air - Water

Steam will be connected to the system by a qualified person. Install a proper drop leg trap to eliminate condensate in the supply line.

! WARNING

Exercise caution when operating equipment that uses steam, injury can result from high temperatures. Not all hot surfaces are insulated. Wear proper protective equipment.

A clean, dry source of oil free instrument air supply must be run to the system for operation of the pneumatic actuator on the *Hydro-Heater*. See Table 3.1 for air requirements. Set the regulator to ZERO (0) psig for startup. Keep the supply valve closed.

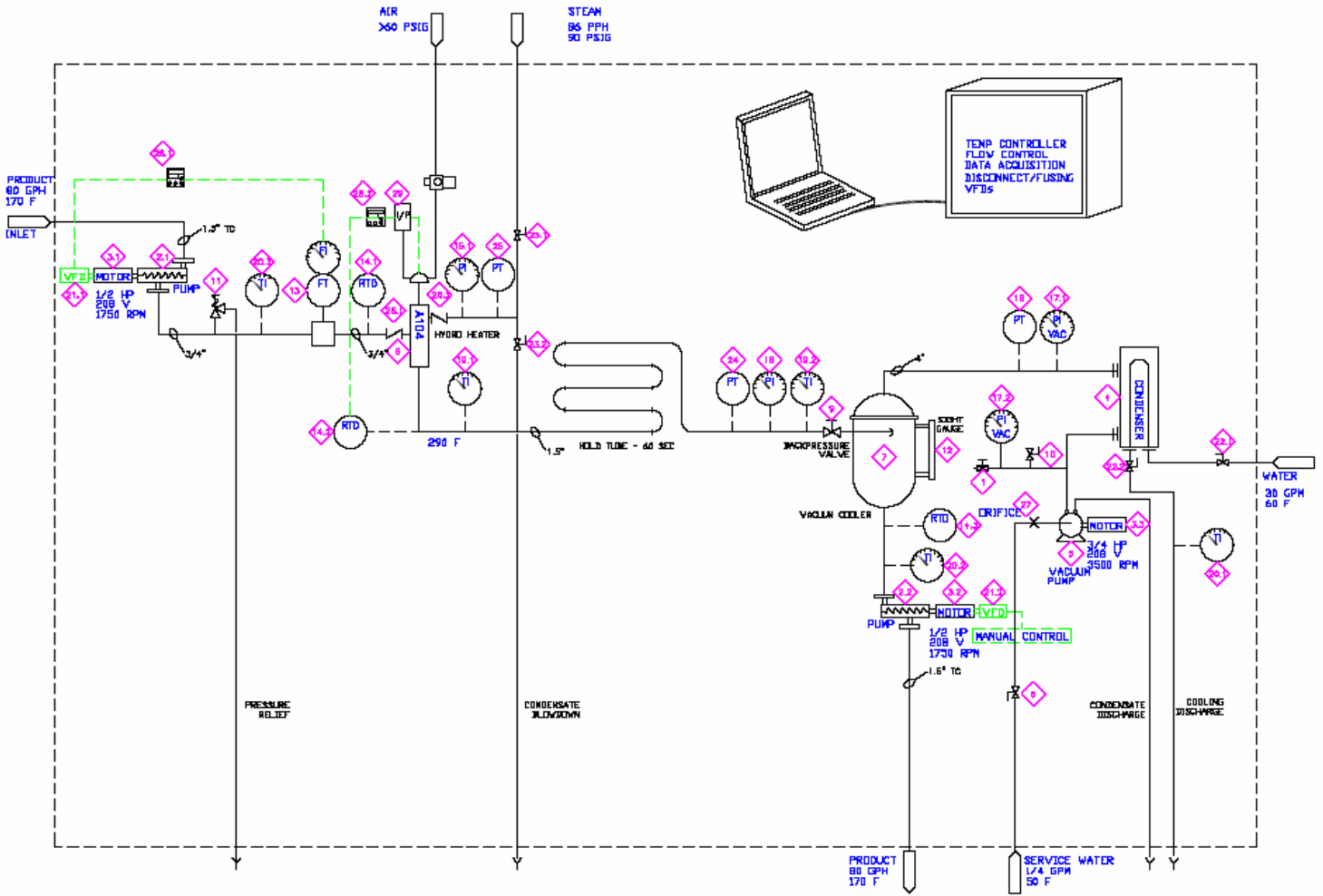
Connect city or chill water to the condenser. Observe the requirements of Table 3.1.

Connect city or chill water to the service liquid connection on the vacuum pump. This water forms the liquid ring which allows the pump to produce a vacuum. It also lubricates and cools the mechanical seal.

! Notice

An orifice is installed on the inlet of the vacuum pump at the ¾" Tri-Clamp fitting. This orifice is drilled to 3/32" and is designed to provide the required 0.20 gpm of service liquid at 30 psig supply pressure. The orifice limits flow to the pump so excessive water is not used.

FIGURE 4.1
PROCESS & INSTRUMENTATION DIAGRAM
 (full size copy in DRAWING section of manual)



4.0 STARTUP AND OPERATION

4.1 General

It is suggested to conserve product and start the system using water and run several times to gain familiarity with its operation.

Equipment numbers below in brackets [xx.x] refer to the Process and Instrumentation Diagram (P&ID) Figure 4.1. See also the equipment list included in the binder for further information.

Prior to startup, make sure the **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** is installed correctly. Follow the guidelines outlined in Section 3.

! DANGER

Do not exceed the maximum operating pressures or temperatures listed in Table 3.1 or damage to the **SYSTEM** may result.

! WARNING

Proper installation is required for safe operation.

! CAUTION

All pipelines to and from the unit must be inspected and flushed to prevent debris from entering the system.

4.2 Description of Control

! WARNING

This is a manually controlled system and requires proper startup and shut down procedures. These must be fully understood before attempting operation of the system.

This particular model of **PILOT PLANT DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** is designed with manual controls. There are, however, two loop controllers included for temperature and flow control after startup.

Temperature Controller [28.2]

This is a simple to operate PID loop controller with easily changeable parameters as well as auto-tune features. After start up, this controller will control the *Hydro-Heater* [8] to maintain a set point temperature. The operator should read and understand the Watlow operations manual provided.

At the discharge of the Hydro Thermal *Hydro-Heater*, RTD [14.2] senses the temperature of the heated product and sends a signal to the *Temperature Controller*. Based on a desired set point entered by the operator and PID response parameters, a 4-20 mA output signal is sent to a current-to-pressure transducer (I/P). The I/P [29] converts the signal to a 3-15 psig air signal which is sent to the positioner on the *Hydro-Heater* actuator. This gives precise positioning of the *Hydro-Heater* stem in the nozzle.

! WARNING

Always start the system with the **temperature set point** at or below room temperature.

When the SYSTEM POWER is turned ON, the Temperature Controller is activated and will introduce steam into the system piping if the set point is higher than the temperature sensed at RTD [14.2].

! WARNING

There are no interlocks to prevent steam from entering the piping when there is no flow. The operator must ensure that flow has been established through the *Hydro-Heater* before increasing the temperature set point.

Flow Controller [28.1]

The magnetic flow meter on the discharge of the supply pump sends a 4-20 mA signal proportionate to the flow into the *Flow Controller*. Based on a desired set point and PID response parameters, another 4-20 mA signal is sent to the variable frequency drive (VFD) for the supply pump. The speed of the supply pump is then automatically adjusted to maintain the desired flow rate. The VFD start button must be pressed to start the pump.

There are two other control devices that may require frequent adjustment during operation of the system.

Back Pressure Valve [9]

Since products will be heated above the atmospheric boiling point of the liquid, the *Back Pressure Valve* will provide pressure in the holding tube section to raise the boiling point, preventing the liquid from flashing to vapor. This valve is equipped with a stop limit on the stem to prevent full closure, protecting the supply pump from a dead head condition.

Vacuum Control Valve [1]

The *Vacuum Control Valve* bleeds room air into the vacuum pump inlet, thus reducing the amount of vacuum produced in the vacuum flash chamber (tank). With this valve closed, the vacuum pump produces its maximum vacuum.

4.3 Equipment Protection

! CAUTION

Supply and Discharge pumps. Do not run dry and do not shut off discharge port or damage to the pumps may result.

! CAUTION

Vacuum pump – Do not operate without service liquid flow turned on and at least to minimum pressure or damage to the pump may result.

! CAUTION

Vacuum pump – starting the vacuum pump with excessive liquid in the casing can lead to motor overload and possible damage. Break connection and allow the pump to drain if the pump has become flooded.

! CAUTION

Components of this system may be disassembled for cleaning. Proper reassembly is critical for proper operation and safety !

4.4 Startup Pre-Checks

1. Review the P&ID drawing. Ensure that all components are properly in place.
2. Ensure that the installation has been completed properly as outlined above before operating this equipment.
3. Check that the removable spray device has been removed and that the 4" vacuum/vapor pipe is installed from the vacuum chamber top port to the shell and tube condenser.
4. Check that all clamp and bolted connections are properly assembled.
5. Check that all instruments are properly installed and wired to the data acquisition equipment.
6. Ensure that product connections are made on the supply and discharge.
 - a. Make sure the supply pump suction remains flooded
 - b. Make sure the discharge is not connected such that the flow/pressure capacity of the pump is exceeded.
7. A thorough understanding of the Watlow Controller operation is required for proper operation of this system. Study the owner's manual provided and understand how to cycle through menus and make parameter changes. Note that setpoint changes do not take affect until the change button is released.
8. A thorough understanding of the Omega Engineering *iNet World* data acquisition (DAQ) software is required to properly save process data. Study the owner's manual provided.

! WARNING

Read and comply with the above sections of this document before proceeding to start the system

4.5 Startup and Operation

Refer to the Process and Instrumentation Diagram, Figure 4.1, and follow the steps listed below to startup the ***DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM***.

1. Energize the control panel by turning the electrical disconnect ON. Displays on the VFDs will now be visible but the VFD outputs are off until started manually (below).
2. Ensure that the manual steam valve [23.1] is OFF.
3. Turn system power switch ON. The flow controller and temperature controller displays are now visible.
4. Adjust the set point on the Temperature Controller [28.2] so that the set point is lower than the room temperature. See the Watlow Operations Manual for this procedure.

5. Set the laptop on the shelf provided. Connect the power and data acquisition network cord provided.
6. Turn on the computer.
 - a. Start the *iNet World* software.
 - b. Select the NETWORK tab and look for reasonable readings on the channels connected.
 - c. Press the RESTORE button to reload the configured channels for the **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM**.
 - d. See drawing G5039D for details on channels and the associated inputs and wiring.
 - e. Push SAVE and specify a location for data to be saved. This will start data acquisition and graphing on the screen.
7. Adjust the Flow Controller [28.1] to the desired flow rate in gpm. 1.3 gpm is the design flow rate.
8. Press the green START button on the Supply Pump VFD.
 - a. The pump will start turning.
 - b. The flow indication in the upper window of the Flow Controller will start to rise to match the set point.
 - c. The Flow Controller set point, ramping and PID parameters dictate the response rate.
9. Adjust the backpressure valve as needed.
 - a. Note that ~ 53 psig is required to prevent water from flashing at 300°F. The product may require more or less. Plan to use a back pressure at 10-20% higher.
10. Watch the sight gauge [12] on the vacuum chamber for a level indication.
11. Open Cooling valves [22.1] and [22.2] to start the flow of cooling water through the condenser. Monitor the temperature on gauge [20.1] and adjust the flow accordingly throughout the operation. Full open flow will likely not be required and water can be conserved.
12. Open the vacuum pump Service Water Valve [6]. An orifice is installed on the inlet of the vacuum pump at the 3/4" Tri-Clamp fitting. This limits flow to the required service liquid flow at 30 psig. City water is expected and higher pressures are acceptable.
13. Press the green START button to start the Vacuum Pump [5]. Adjust the Vacuum Control Valve [1] to attain the desired vacuum on the vacuum chamber.
 - a. After hot product reaches the vacuum chamber, adjust the vacuum as needed for the desired outlet temperature.

! WARNING

The Vacuum Dump Valve [10] can be used to quickly break the vacuum in the system. Caution should be used as this could cause excessively hot product to reach the Discharge Pump.

14. Press the green START button on the Discharge Pump VFD. Using the up/down arrows, adjust the output frequency (HZ) to match the Supply Pump VFD.
 - a. Continue to monitor the sight level gauge on the vacuum chamber throughout the operation. Adjust the Discharge Pump VFD setting as needed to maintain a level in the vacuum chamber.

! WARNING

Start steam heating only after a level is established in the vacuum chamber and there is flow through the *Hydro-Heater*.

While the *Hydro-Heater* will close with a low signal or no signal, it is not designed for full shut off. The manual steam valve must be used for full steam shut off.

! WARNING

Exercise caution when operating equipment that uses steam, injury can result from high temperatures.

15. Open the air supply valve. Adjust the air regulator to 60 PSIG.
16. Open the Condensate Bleed Valve [23.2] to drain condensate from the *Hydro-Heater* inlet pipe. Close the valve.
17. Using proper protective gear, slowly open the Steam Supply Valve [23.1].
 - a. Note that the Temperature Controller is still set to a low point, thus the *Hydro-Heater* is still closed.
18. Adjust the Temperature Controller [28.2] set point up to the desired set point. The *Hydro-Heater* will respond and the outlet temperature will start to rise to meet the set point.
19. Monitor back pressure and adjust as needed.

! CAUTION

If leaks occur during startup or operation, shut the system down and repair the leaks.

4.6 Shutdown

Use the following steps to shutdown the ***DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM***.

1. Change the temperature set point on the Temperature Controller [28.2] to a set point below room temperature.
2. Close the manual steam shut off valve [23.1]
3. Close the air supply valve .
4. Press the red STOP button on the Supply Pump VFD.
5. Press the red STOP button on the Vacuum Pump VFD.
6. Close the vacuum pump Service Water Valve [6]
7. Close the cooling water supply valve [20.1]
8. When no level is observed on the vacuum chamber sight level gauge, press the red STOP button on the Discharge Pump VFD. Do not run the pump dry.

5.0 MAINTENANCE

5.1 Inspection

Good inspection and maintenance practices should ensure that the **DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** you have purchased will be operational for years. Inspect the **SYSTEM** before and after each use for visible signs of wear.

5.2 Cleaning

Review the Cleaning Safety section 2.9

After operation flush the entire system with water. A mild caustic solution may also be desired. Finish with a fresh water rinse.

Remove the 4" vapor/vacuum pipe from the top of the vacuum chamber. Insert the rotating spray device dip tube and secure. Connect proper flow and pressure of water. See the spray device instruction sheets. Use the Discharge Pump to pump out the solution. **DO NOT RUN THE DISCHARGE PUMP DRY.** Note that the Discharge pump capacity may not keep up with the required flow for the spray device. Cycle CIP supply flow on/off as needed.

Reassemble the system completely.

5.3 Maintenance

Review the Service and Maintenance section 2.8

! DANGER

Never perform maintenance on a **DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** until the surface temperature has cooled to below 100°F (38°C).

Never perform maintenance on a **DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** until the system pressure has been reduced to zero gauge pressure.

Use plant lockout/tagout procedures before performing maintenance.

Always disconnect electrical power before performing maintenance.

Always disconnect instrument air supply before performing maintenance.

Review the safety procedures outlined in Section 2 before performing maintenance.

5.4 Storage

A **CSI DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** can be placed in storage for a short period of time. The unit must be fully drained of all residual water prior to storage. The unit must be stored in a cool, dry environment and covered loosely by a tarp or plastic to allow air circulation and protection from water, debris and sunlight.

! CAUTION

A **DIRECT STEAM INJECTION - VACUUM COOLING SYSTEM** that has been in storage for more than six months should be inspected by a **CSI** representative prior to putting the unit back into operation.

6.0 CONTACT INFORMATION

6.1 Project Information

Start Up – November 8, 2004
Built for - Novartis R&D, St. Louis Park, MN

Novartis Contacts

Steve Ndely – Process Engineer
Jeff Meister – R&D Supervisor

CSI Contacts

Steve Cook – Process Engineer
Eric Gore – Fabrication Designer
Chris Villa – Fabrication Designer

6.2 Support

For technical support call Central States Industrial Process Engineering 800-654-5635.

For replacement parts call Central States Industrial Customer Service at 800-654-5635.