Note: Manual For Reference Only - Actual Chamber May Vary Depending on Model Year, Options, Controllers, and Individual Configuration

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TENNEY ENVIRONMENTAL

ENVIRONMENTAL TEMPERATURE TEST CHAMBER

MODEL NO. T20C-3

CHAMBER TYPE: TEMPERATURE

CONTROLLER TYPE: WATLOW 942 CONTROLLER

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INTRODUCTION

Congratulations on purchasing a Tenney Environmental test chamber. We truly hope that every aspect of design and quality will measure up to your strictest standards. Your chamber has been designed to operate with the reliability you expect for the demands you impose on your product and research testing.

Your environmental test chamber incorporates many different engineering technologies. Tenney Engineers have designed even the most complex chambers to operate in a way that the customer can competently understand, configure, and maintain. Anytime you have a question, you can phone, fax, or E-mail our dedicated service staff. Their diverse experience and knowledge will get you the answers you need. We have put the Parts And Service Inquiries section in the front of the manual for your convenience.

Like our test chambers, this manual has been designed with the customer in mind. Section General gives a brief overview of the chamber specifications, while the remaining sections detail the different functions and operating conditions and procedures. In the rear of the manual you'll find the Supplemental Instructions Section filled with a variety of information. As applicable to the chamber, this section includes separate vendor user manuals and cut-sheets, expanded instruction and information sections, drawings, tables, data sheets, the test inspection report, and the warranty. It is extremely important that you read the entire manual and all of the information contained therein before operating your equipment.

You must adhere to the warnings and safety procedures listed throughout this manual as well as to those listed in the vendor user manuals and cut-sheets. **Failure to follow the warnings, safety procedures and proper operating procedures listed throughout the manuals could result in damaged equipment, personal injury, or death.**

VERY IMPORTANT WARNING!

YOUR POWER SUPPLY LINE VOLTAGE MAY BE TOO LOW OR TOO HIGH TO PROPERLY AND SAFELY OPERATE YOUR CHAMBER.

BEFORE MAKING THE POWER SUPPLY CONNECTION TO YOUR CHAMBER, YOU MUST FOLLOW THE SPECIFIC DIRECTIONS STATED UNDER "POWER CONNECTION" IN THE INSTALLATION INSTRUCTIONS SECTION.

FAILING TO PERFORM THE DIRECTIONS STATED MAY VOID YOUR WARRANTY!!

GENERAL DESCRIPTION

The Tenney Models T27, T65, Models BTS, BTC, and Models T6S, T6C through T30S, T30C series test chambers are designed to provide a temperature controlled environment. Temperature conditions are attained by recirculating chamber air through a refrigerated cooling coil and open air nichrome wire heater elements. Air circulation is generated by a propeller type fan directly driven by an externally mounted motor. Non-CFC refrigerants are used in the refrigeration systems of all Tenney chambers.

The suffix 'S' in the chamber model number indicates that the chamber is equipped with a single stage refrigeration system, incorporating one compressor. The temperature controlled range for these chambers is -40 to +200 degrees Centigrade, ±0.3 degrees Centigrade. The exception to this standard range are the Models BTS and T6S, which have a low range of -34 degrees Centigrade.

The Models T27 and T65 also incorporate a single stage refrigeration system, but have a smaller temperature operating range than those mentioned above. This range is from -20 to +100 degrees Centigrade, ±0.2/±0.3 degrees.

The suffix 'C' in the chamber model number indicates that the chamber is equipped with a cascade refrigeration system, incorporating two compressors. The temperature controlled range for these chambers is from -73 to +200 degrees Centigrade, ±0.3 degrees Centigrade. The exception to this standard range are the Models BTC and T6C, which have a low range of -70 degrees Centigrade.

Temperature conditions are attained and controlled by a Watlow 942 microprocessor based controller, utilizing an RTD for temperature measurement. This controller provides 24 step programming with dual outputs in the time-proportioned and ON/OFF modes. It also may be used as a non-ramping manual controller. As options, you may have auxiliary event outputs and RS232/RS423, RS422, EIA-485, or IEEE data communications with the Watlow 942.

Your Tenney chamber may include many other unique options such as; TempGard IV feature with the Watlow 93 Controller for redundant product over/under temperature protection, boost cooling using CO_2 or LN_2, boost heating, purge air system using compressed air or GN_2, a two channel chart recorder, and LinkTenn software that permits your computer to control up to 10 chambers.

As you can see, the Tenney Environmental test chamber is a diversified tool designed to encompass a wide range of operating conditions and functions. If you come upon any questions as you continue on through the manual, please feel free to contact our Service Department.

SAFETY WARNINGS

1. PLEASE READ THE ENTIRE TENNEY INSTRUCTION MANUAL AS WELL AS THE VENDOR MANUALS AND CUT-SHEETS PROVIDED, BEFORE OPERATING THIS CHAMBER! FAILURE TO ADHERE TO THE SAFETY WARNINGS, OR TO FOLLOW THE PROPER OPERATING PROCEDURES LISTED THROUGHOUT THE MANUALS AND INFORMATION PROVIDED, COULD CAUSE DAMAGE TO YOUR EQUIPMENT, PERSONAL INJURY, OR DEATH.

2. A MAIN POWER DISCONNECT IS NOT PROVIDED WITH YOUR CHAMBER. IT IS HIGHLY SUGGESTED THAT A DISCONNECT SWITCH ON A SEPARATE BRANCH CIRCUIT BE INSTALLED AS THE POWER SOURCE TO YOUR CHAMBER, IN ACCORDANCE WITH ALL NATIONAL AND LOCAL ELECTRICAL CODES. IF YOUR CHAMBER IS EQUIPPED WITH A POWER CORD AND PLUG, YOU MUST UTILIZE A RECEPTACLE WITH THE APPROPRIATE RATING WHICH IS ON A BRANCH CIRCUIT OF ITS OWN. OPENING THE BRANCH CIRCUIT BREAKER IN THE TEST CHAMBER DOES NOT REMOVE ALL POWER FROM THE CHAMBER.

3. ELECTRICAL ENCLOSURES, GAUGE BOXES, CONDITIONING COMPARTMENT, etc., CONTAIN EXPOSED ELECTRICAL CONNECTIONS. DISCONNECT ALL ELECTRICAL POWER FROM THE FACILITY AT ITS SOURCE BEFORE SERVICING OR CLEANING.

4. DO NOT ATTEMPT ANY SERVICE OR ADJUSTMENT TO ANY ELECTRICAL OR MECHANICAL COMPONENTS DURING OPERATION.

5. KEEP PANELS IN PLACE PROPERLY WHEN THE CHAMBER IS IN OPERATION.

6. THIS IS NOT AN EXPLOSION PROOF CHAMBER --- THE AIR CONDITIONING SECTION CONTAINS LOW MASS, OPEN WIRE HEATING ELEMENTS. DUE TO THIS LOW MASS, THE HEATER ELEMENTS CAN READILY ATTAIN TEMPERATURES SUFFICIENTLY HIGH TO IGNITE GAS VAPORS. DO NOT INSTALL TEST ARTICLES THAT MAY RELEASE EXPLOSIVE OR FLAMMABLE VAPORS IN THE CHAMBER.

7. REFRIGERANTS UNDER HIGH PRESSURE ARE USED. SERVICE OF THE REFRIGERATION SYSTEM MUST ONLY BE CARRIED OUT BY A QUALIFIED REFRIGERATION MECHANIC.

8. HUMAN EXPOSURE TO TEMPERATURE EXTREMES CAN CAUSE INJURY. TAKE APPROPRIATE PRECAUTIONS BEFORE OPENING CHAMBER DOORS AND UPON HANDLING TEST SPECIMENS.

INSTALLATION INSTRUCTIONS

READ THE FOLLOWING COMPLETELY BEFORE ATTEMPTING TO INSTALL OR OPERATE THE EQUIPMENT.

IMPORTANT! - - FOR ALL MODELS EXCEPT BTS, BTC, T6S, T6C

CAUTION: TO SAFELY SECURE THE REFRIGERATION SYSTEM COMPRESSORS AND PIPING DURING SHIPPING, WOODEN BLOCKS HAVE BEEN INSTALLED UNDERNEATH THE COMPRESSORS. THESE BLOCKS MUST BE REMOVED BEFORE OPERATION! SERIOUS DAMAGE MAY RESULT IF NOT REMOVED!

ON COMPRESSORS WITH SPRING MOUNTS ONLY, YOU MUST LOOSEN THE COMPRESSOR HOLD DOWN NUTS JUST ENOUGH TO REMOVE THE BLOCKS. DO NOT LOOSEN NUT BEYOND TOP OF BOLT.

ON COMPRESSORS WITH RUBBER MOUNTS ONLY, JUST SIMPLY SLIDE THE WOODEN BLOCK OUT. DO NOT LOOSEN ANY NUTS.

DELIVERY: Inspect equipment and shipping crate immediately upon receipt. If any damage is apparent, please contact the transportation company immediately. Retain all shipping materials for inspection. Any claims for damage must start at the receiving point. Check packing slip carefully and make sure all materials have been received as indicated on the packing ticket. Unless otherwise noted, YOUR ORDER HAS BEEN SHIPPED COMPLETE.

CAUTION! Benchtop and reach-in chambers should be handled and transported in an upright position. It must not be carried on its back, front, or any side.

Important! Do to the vibration incurred during shipping and handling, it is possible that mechanical connections such as water fittings may become loose. For chambers with a water cooled refrigeration system, check all water fittings to make sure they are tight.

GENERAL INFORMATION: Your equipment has been fully operated, tested, and balanced in our plant prior to shipment. Make sure the chamber is leveled when set up. Many times control panels are removed to facilitate shipment. Replacement usually involves repositioning panels on the equipment mechanically and reconnection of numbered wires to matching numbered terminal blocks. The chamber should be installed in an area where there is good air ventilation, especially if an air-cooled condenser is used. Allow a minimum of 12 inches between any wall and chamber side.

AIR SUPPLY CONNECTION(S): Your chamber may have one or more air supply connections which may include compressed air, purged air, or other. Please check your chamber specifications for complete details. Make sure all air supplies are clean and that all connections are secure.

GN_2 / LN_2 / CO_2 CONNECTION(S): Your chamber may require a supply of GN_2, LN_2, or CO_2. Please check your chamber specifications for complete details. Make sure all connections are secure.

WATER SUPPLY CONNECTION(S): If the chamber utilizes a water-cooled refrigeration condenser, connect the supply to the Water-In connection at the rear of the chamber. Connect the Water-Out connection to an open drain.

POWER CONNECTION: WARNING! -- **BEFORE MAKING THE POWER SUPPLY CONNECTION TO YOUR CHAMBER YOU MUST DO THE FOLLOWING:**

1. **Verify the power supply voltage rating established for your chamber. The voltage rating is found on the serial tag on the side of the chamber. Please note the rated value here: _________**
2. **Measure and record the voltage source you intend to supply your chamber with. Please note the measured value here: _________**
3. **Go to the section entitled "Line Voltage" in this manual. Verify that the power supply voltage source you measured and recorded is within the minimum and maximum allowable operating voltages for your chamber rating. If it is not within this operating range, do not make the power connection! Otherwise, erratic operation and damage may occur to your chamber which may void your warranty. Call the Tenney Service Department with any questions.**

A main power disconnect is not provided with your chamber. It is highly suggested that a disconnect switch on a separate branch circuit be installed as the power source to your chamber, in accordance with all national and local electrical codes. Make sure equipment is properly grounded in accordance with all codes. For units provided with a cord and plug, simply connect to a receptacle which has the appropriate power supply on a branch circuit of its own. Otherwise, connect incoming power supply to the main input connections provided. Most units have a main line block connection which is labeled for the correct service.

Units with three phase motors must be checked to insure proper motor rotation. A red arrow is located on the motor housing to show proper rotation. If it is opposite, simply reverse two of the line feeds to obtain proper operation. Failure to check motor rotation may result in DAMAGE TO THE EQUIPMENT due to opposite airflow or no airflow. If the equipment has more than one motor, they have all been properly phased at the factory.

Before energizing any equipment give it a visual inspection for loose components, electrical connections, fittings, etc. Shut all operating switches to the "off" position before energizing.

Please have trained personnel start and check out the equipment before its first cycle.

LINE VOLTAGE

One of the most common causes of chamber malfunction is low line voltage as the power source to the chamber. Ordinarily in this condition, the compressor motors would operate erratically, eventually overheat and shut down. You must be certain that your equipment is connected to a circuit with an adequate voltage and current source. An oversupply voltage would also cause erratic operation and eventual shutdown or damage to your equipment.

The Tenney Series test chambers are designed to operate with a nominal 230VAC, 60 Hz power supply. Optional equipment is available to allow operation with 208 or 460VAC, 60 Hz supplies or, for foreign use, operation with 200, 220, 380 or 415VAC, 50 Hz power supplies. The allowable minimum and maximum voltages at each of these nominal voltages is tabulated below:

Nominal Voltage	Minimum Voltage	Maximum Voltage
	60 Hz Power Supplies	
208	198	218
230	207	253
460	414	506
	50 Hz Power Supplies	
200	180	220
220	198	242
380	342	418
415	374	456

Operation outside these limits can result in damage to the system's motors.

OPERATING WITH AN ACTIVE HEAT LOAD

When operating with an active heat load, such as introduced by a powered test unit, this heat must be removed or the chamber temperature will rise. The internal logic of the controller will automatically turn on the refrigeration system to maintain a set temperature. Although a cooling system failure is not likely to occur, it is always a possibility when mechanical systems are used. In the event of a cooling system failure that results in an out of limit over temperature condition, one or more of the system safeties will remove power from the system. However, heating will continue if power remains applied to the active load. To guard against this continued heating, the product should be powered through the spare contact of the master contactor (1CON) which is described in the Alarm And Shutdown Circuit section.

TEMPERATURE CONTROL - WATLOW 942 CONTROLLER

Temperature conditions are attained and controlled by a Watlow 942 microprocessor based controller. Temperature measurements are made utilizing a 100 ohm platinum RTD sensor. This controller features dual outputs, auto-tuning control with 24 step program capability and easy fixed set point operation.

Heating of the chamber is accomplished with the time proportioned (PID) Output 1CI-01 of the controller, which turns on a triac in the heater circuit supplying power to the heater elements. Cooling of the chamber is accomplished with ON/OFF Output 1CI-02 of the controller, which energizes a contactor supplying power to the refrigeration circuitry.

IMPORTANT! Output 1CI-02 is set up for ON/OFF control and the PID value is set to zero. Do not change the PID value for channel two under any circumstance!

Compressor Turn-On Logic

In determining when to turn the refrigeration system on or off, the controller's logic will compare the following signals and setpoints.

1. Actual Chamber Temperature
2. Setpoint Temperature
3. Hysteresis
4. Deadband

Hysteresis (**HYS**) and deadband (**db**) are parameters entered at the factory. Hysteresis is the temperature change necessary to change the output from full ON to full OFF and is detailed in the Setup Menu section in the Watlow 942 Manual. Deadband is the span in which Output 1CI-02 will remain ON below the controller's low setpoint, and is detailed in the Operation Menu section of the Watlow Manual.

HYS and **db** are entered in degrees C. Deadband is always entered as a (-) minus. The logic is as follows:

- Measured temperature rises above setpoint: Refrigeration turn-on equals hysteresis minus deadband.
- Measured temperature falls below setpoint: Turn-on is always above setpoint.
- Turn-off is always below setpoint: Turn-on is always above setpoint.

EXAMPLE SETTINGS FOR HYS AND db

	HYS	**db**	**Turn-On** (Above SP)	**Turn-Off** (Below SP)
Standard	4	-3	1	3
	5	-3	2	3
	5	-1	4	1
No Good	3	0	3	0

Chambers are shipped with HYS = 4, and **db** = - 3, as shown on the top line in the above examples. It is unlikely a change to these settings will be required. Fortunately, these settings are not subject to "cold start" default, and will remain valid after a power interruption. They are held in EEROM, not battery-backed RAM.

The pre-programmed configuration of the Watlow 942 is documented in the Test Report. Please refer to this and the Watlow 942 user's manual for complete operational details. These are found in the Supplemental Instructions Section.

Controller Versions

The Watlow 942 Controller is provided in four versions with the following nomenclature:

1. The basic 24-step ramping control: 942A-3KD0-AE00
2. Basic plus two events: 942A-3KD2-AE00
3. Basic plus communications: 942A-3KD0-BE00
4. Basic plus events and communications: 942A-3KD2-BE00

The nomenclature is printed on the back of the controller and can be seen when the chamber's control panel is opened.

NOTE: The communications arrangement is isolated RS232/RS423, RS422, EIA-485, or IEEE. Each event output is through a mechanical relay having contacts rated 6 Amps, 120 or 240 VAC.

ALARM AND SHUTDOWN CIRCUIT

A comprehensive alarm and shutdown circuit may be provided for multiple protection against product over/under temperature and chamber over temperature. The sensor utilized for temperature measurement and the Heat Limiter Fuse are normally placed at the plenum in the downstream airflow. This is the most responsive area of the chamber.

<u>Chamber Over Temperature Protection:</u> The following device is used.

1. **Heat Limiter (HL)** - - Temperature Actuated Fuse (Standard)

<u>Product Over/Under Temperature Protection:</u> The following optional device may be used. With this option, a 100 ohm platinum RTD is utilized for temperature measurement.

1. **Watlow 93 Controller** - - TempGard IV Feature - High/Low Limits **(Optional)**

WARNING! **When Master Contactor 1CON is deenergized due to ANY alarm condition described below, power is only removed from the conditioning control circuitry. The instrumentation and alarm circuitry will still be energized!**

For any questions concerning the operation of any of the controllers described below, please reference the appropriate user manual located in the Supplemental Instructions Section.

CIRCUIT OPERATIONS:

<u>Normal Conditions:</u>

When chamber temperature is within the selected setpoints the switch (green) ON light is illuminated and the Master Contactor 1CON is energized. The contacts of 1CON provide power to the conditioning control circuitry. (With the optional alarm buzzer / silence switch or TempGard IV feature, the NORMAL light 2LT will illuminate. When either of these optional features are used, the main control switch will not be equipped with any integral lights.)

Note: A spare set of 1CON contacts are provided for the customer's closure. It is recommended that these contacts, wired to terminal blocks #14 & #15, be used to energize an active heat load if utilized.

<u>Opened Heat Limiter:</u>

When a predetermined high temperature limit is reached and the Heat Limiter Fuse (which looks like a regular fuse) opens, Master Contactor 1CON will deenergize along with the conditioning control circuitry. The switch OVERTEMP light will illuminate and the switch ON light will extinguish. (With the optional alarm buzzer / silence switch feature, both the red Chamber OVERTEMP light 3LT and red ALARM light 4LT will immediately illuminate, the alarm buzzer will sound, and the NORMAL light will extinguish.) **When the Heat Limiter Fuse opens, it <u>must</u> be replaced.**

WARNING! When replacing the Heat Limiter Fuse, make sure all power is completely disconnected from the chamber. Open the closest main power disconnect and pull the plug (if provided) from the outlet.

TempGard IV Alarm - - Optional:

When a preset temperature limit is reached within the Watlow 93 TempGard IV, the TGIV alarm contacts open to deenergize Master Contactor 1CON, which removes power from the conditioning control circuitry. The NORMAL light is now extinguished, the red ALARM light 4LT illuminates, and the alarm buzzer sounds. The red Chamber OVERTEMP light 3LT will illuminate when the alarm condition clears **and** the TempGard IV alarm is cleared as detailed in the Watlow 93 manual.

Note: The alarm buzzer with silence switch is an optional feature for all chambers. This alarm circuitry comes standard with the Watlow 93 TempGard IV feature. The TempGard IV configuration is shown in the "Watlow 93 TempGard IV Configuration And Use" section.

System Reset For Alarm Buzzer / Silence Switch or TempGard IV Option - - Important!

After an out of limit condition has been corrected, the conditioning control circuits must be restarted by momentarily pressing the RESET button 1PB. You must remember to clear the Watlow 93 alarm message.

A 1.5 second timer 1TC, is included in the reset circuit to provide for automatic start when power is applied to the chamber. This avoids the need to press the reset button each time that power is removed and reapplied.

Alarm Buzzer & Silence Switch - - Optional:

With this option the silence switch disables the alarm buzzer while corrective action is taken. When 1SS is activated, the white Silence light 5LT will be illuminated. If the alarm buzzer was disabled and the system was successfully reset with 1PB, the alarm buzzer will now sound to alert the operator to place the silence switch 1SS in it's normal (down) position.

HEATING DESCRIPTION

Heating of the chamber is accomplished with the time proportioned output 1CI-01 of the Watlow 942 Controller, which turns on triac 1TRC to supply power to the heater elements. These elements are open air low mass nichrome wires, which have low thermal lag and provide rapid response to the controller's demands. The heater elements are isolated from the workspace to prevent direct radiation to the product. Please reference the electrical schematic for your particular chamber's heater bank ratings.

SINGLE STAGE REFRIGERATION SYSTEM DESCRIPTION

The basic single stage system consists of a compressor, an oil separator (except for Models BTS, T6S, T27, & T65), either an air cooled or water cooled condenser, an evaporator coil (located in the chamber conditioning section) which is provided with a capillary (tube) type expansion device, and a suction line accumulator to guard against liquid refrigerant return to the compressor.

Refrigerant flow is from the compressor as a hot compressed gas through the oil separator to the condenser. Here the refrigerant cools and condenses to liquid form and flows through the capillary tube to the evaporator cooling coil in the chamber conditioning section. Warm chamber air is circulated through the cooling coil and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The vaporized refrigerant returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

For all units except Model BTS, a thermostat is mounted on the suction return line near the compressor to monitor the temperature of the return gas flow. When a predetermined high temperature is reached, the thermostat will energize an artificial loading solenoid, which will inject refrigerant through a capillary tube into the suction side of the system. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

CASCADE REFRIGERATION SYSTEM DESCRIPTION

The basic cascade system consists of a low stage compressor, a high stage compressor, an evaporator coil, and a cascade condenser.

The low stage system includes an oil separator(for models with compressor motors greater than 1H.P.), a cascade condenser, an expansion tank, and an evaporator coil (located in the chamber conditioning section) which is provided with a capillary (tube) type expansion device. The high stage system includes an air cooled or water cooled condenser, a capillary tube which feeds the cascade condenser, and a suction line accumulator to guard against liquid refrigerant return to the compressor.

The function of the cascade condenser is for the high stage refrigerant to cool and condense the low stage refrigerant. This permits greater system efficiency and allows lower chamber temperatures to be reached than what can be attained with a single stage system. The low stage liquid refrigerant from the cascade condenser is metered through a capillary tube to the evaporator coil. Heat exchange takes place here as the liquid refrigerant converts to a gas and then returns to the low stage compressor.

A thermostat is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When a predetermined high temperature is reached, the thermostat will energize the Artificial Loading solenoid 14SOL, which will inject refrigerant into the suction side of the system. It will first enter the expansion tank where the added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is then sucked out of the expansion tank and metered through a capillary tube to the suction side of the low stage compressor. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

A high pressure cut-in sensor monitors the pressure inside the low stage compressor and will activate the Load Limit Switch 4PS when the low stage discharge pressure reaches 280 PSIG. This will energize the Artificial Loading solenoid 14SOL which will inject refrigerant into the suction side of the system as described above. Switch 4PS prevents the compressor from cycling on and off in response to signals from the high pressure cut-out switch. 4PS will open when pressure falls to 240 PSIG.

For more detailed information on a cascade system, please reference the section entitled "Servicing Cascade Refrigeration Systems".

REFRIGERATION SYSTEM SAFETY DEVICES

The refrigeration system is provided with several safety devices that stop the compressor(s) from running if conditions exceed preset limits. In a cascade system both the low stage and the high stage include these safety devices. With a low limit condition the HI-LO Pressure Cutout Switch 1PS (and 2PS for cascade) will continue to automatically reset until sufficient pressure develops. With a high limit condition you <u>must manually reset</u> 1PS (or 2PS). If the compressor continues to trip off have the system checked by a qualified refrigeration system mechanic. The possible causes of a high or low limit cutout are as follows: **NOTE:** The HI-LO Pressure Cutout Switch does not apply to the Models BTS, BTC, T6S, and T6C.

High Pressure Cutout (1PS, 2PS) -- Opens if a preset compressor discharge pressure is exceeded. Probable cause for high stage cut-out is insufficient cooling water (water cooled systems) or restricted air flow (air cooled systems). Probable cause for low stage cutout is a malfunction of the high stage system. 1PS/2PS are typically set at 300 PSIG.

Low Pressure Cutout (1PS, 2PS) -- Opens if the compressor suction pressure falls below a preset value. Probable causes are a loss of refrigerant (either stage) or restricted air flow across the evaporator (low stage). 1PS/2PS are typically set at 6 inches of vacuum.

Motor Overload -- Opens if the motor windings exceed a preset temperature. Probable causes are insufficient flow across the motor due to a refrigerant loss or a failure of the liquid injection valve provided for suction gas cooling. The motor overload is installed directly in the motor windings and will automatically reset and restart the compressor after the motor has cooled.

WATLOW 93 - TEMPGARD IV CONFIGURATION & USE (Optional)

As an option, your chamber may include the TempGard IV feature with the Watlow 93 Controller. The circuit operation description is explained in the Alarm And Shutdown Circuit section of this manual. This configuration section serves as a brief reference guide. For complete details of the Watlow 93 Controller, please reference the user manual.

When properly configured, the lower display of the control will be blank and the upper display will show the actual temperature as measured by the control's RTD sensor, when conditions are within the alarm settings. If an out of limit condition occurs, the lower display will flash "HI" or "LO" depending on the particular fault.

IMPORTANT: For All Models - When the alarm has cleared you must press the RESET pushbutton 1PB.

To configure the control to perform as described above, power it up and select the setup menu by pressing the UP/Down arrow keys simultaneously. Pressing the "M" key then allows you to scroll through the set up parameters.

Set these parameters in accordance with the table below. The parameter will appear in the lower display; the UP/DOWN keys are used to set the value.

WATLOW 93 - TEMPGARD IV: SETUP MENU		
PARAMETER	**FUNCTION**	**VALUE**
In	Select type of sensor	**rtd**
C_F	Select temperature units	**C**
r L	Set low range limit	**-100 ***
r H	Set high range limit	**+200 ***
2	Define Output 2	**PrA**
HSA	Select hysteresis	**1**
LAt	Select latch / nonlatch	**nLA**
rtd	Select sensor curve	**JIS**
dSP	Select display	**Pro**

*** Other values may be entered depending on the range of the chamber.**

Scroll through those parameters not listed above; <u>their settings are immaterial</u>. After scrolling through all parameters, the control will revert to the "OPERATE" mode. In this mode, use the "M" key to scroll to the ALO (alarm low) parameter and use the UP/DOWN arrow keys to set the desired low alarm value. Then, use the "M" key to scroll to the AHI (alarm high) parameter and use the UP/DOWN keys to set the desired high limit value.

After setting these values, continue scrolling with the "M" key until the control setpoint appears in the lower display. After a few seconds, this display will go blank.

BOOST HEAT (Optional)

As an option, your chamber may be equipped with the boost heat feature which includes extra heaters to provide rapid increases in temperature. The boost heat will automatically turn on if a preset time delay relay times out, indicating that the desired temperature has not been achieved.

As output 1CI-01 of the controller energizes the main heater bank, 1CI-01 will at the same time energize a time delay relay. When this relay times out it will energize a mercury relay, which provides power to the boost heaters. A mechanical contactor is also provided which has it's contacts wired into the power supply line to the boost heaters. This contactor is provided to deenergize the heaters in the event of an over temperature condition.

BOOST COOLING (Optional)
USING LIQUID NITROGEN or CARBON DIOXIDE

As an option, your chamber may be equipped with a boost cooling system which is activated by an event output from the Watlow 942 Controller. Cooling is achieved by injecting either LN_2 or CO_2, depending on the option purchased, into the chamber through a solenoid valve. To activate the system the event must be turned on as explained in the Watlow 942 Controller manual.

Event No. 1 is generally used for this function. However, a reference table defining the function of each event is affixed to the control panel of each chamber. Please check this table before operating the chamber.

Once enabled through the event, the cooling will turn on if a demand for cooling exists for a preset time period. A timer connected to the time proportioned output of the controller "times out" and energizes the cooling solenoid valve if the output is 100 percent "ON" indicating a need for additional cooling.

When the desired temperature is attained and the controller heat output begins to turn on, the boost cooling function will cease.

LN_2 systems are provided with a manually set flow adjusting valve provided to allow for adjusting the flow to avoid incomplete evaporation at varying LN_2 supply pressures. A setting of 4 turns open generally provides good performance at a supply pressure of 20 to 25 PSIG. This valve may be readjusted as necessary to accommodate the supply pressure at the end use point.

PURGE AIR SYSTEM (Optional)
USING COMPRESSED AIR or NITROGEN

As an option, your chamber may be equipped with a dry air or GN_2 purge system which is activated by an event output from the Watlow 942 Controller. To use the system, the event must be turned on as explained in the Watlow 942 manual. Event No. 2 is generally used for this function. However, a reference table defining the function of each event is affixed to the control panel of each chamber. Please check this table before operating the chamber.

A metering valve and flowmeter is supplied as part of the system to establish the design purge flow. The valve should be adjusted until the indicated flow is about 300 cubic feet per hour.

The GN_2 purge system is primarily utilized to provide an inert atmosphere which minimizes the buildup of moisture and prevents condensation on the product under test. Eliminating the oxygen in the chamber air helps prevent corrosion of the product under test.

A drier is provided for compressed air purge systems. This system requires a supply of relatively oil free compressed air at a minimum pressure of 80 PSIG. This air is dried by a twin tower heatless, self regenerating dryer and is introduced into the chamber through a solenoid valve.

CHART RECORDER (Optional)

As an option, your chamber may be provided with either a circular or strip type chart recorder to record temperature versus time. This recorder is typically a one pen type which also digitally displays the process value. A 100 ohm platinum RTD is used for temperature measurement and is normally placed in the plenum of the chamber.

The recorder configuration is documented in the Test Report, which is located in the Supplemental Instructions Section. For complete details on the operation of the recorder, please reference the recorder's user's manual which is located in the same section.

DATA COMMUNICATIONS (Optional)

As an option, your chamber may include data communications with the main controller's serial port. When employed, either a Data Communications manual or a Computer Interface manual will be included in the Supplemental Instructions Section. As a reference, the available data types are listed and briefly described below. Please contact a Tenney Sales Engineer for more information.

RS232C / RS423A: Both interfaces are compatible and use 3 wires: a single transmit wire; a single receive wire; and a common line. The maximum wire length is 50 feet. Only a single chamber may be connected to your computer. Data signals are measured as plus and minus 12 volts to common with RS232C, and plus and minus 5 volts to common with RS423A.

RS422A: This interface uses 5 wires: a transmit pair; a receive pair; and a common line. Up to ten chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals in each pair are measured as a plus or minus 5 volt differential.

EIA-485: This interface uses only 2 wires. Both wires are used for transmitting and receiving data, and therefore, only one device may talk at a time. Up to 10 chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals are measured as a plus or minus 5 volt differential. An EIA-485 card must be installed for signal conversion.

IEEE-488: This is a parallel multi-drop interface with several control and data lines. Each device connected must be set to a unique address. Data from other test devices may also be collected. Since the controllers we use only have serial communications, an IEEE-488 to serial converter card is installed in the chamber. Maximum cable length is approximately 33 feet for all devices.

LinkTenn SOFTWARE (Optional)

Welcome to another unique optional feature developed by Tenney Environmental. LinkTenn software is designed to operate on a remote computer system and provide complete control of Tenney Environmental test chambers. This is accomplished by communicating through a RS232/RS422 interface with the VersaTenn III or Watlow 942, 945, and 988 Controllers. Up to ten chambers may be controlled from one computer with RS422 interface.

LinkTenn software is provided both in a DOS format and in a Windows format on 3½ inch diskettes. In the DOS format, "LinkTenn II" software is designed to work with the VersaTenn III Controller, and "LinkTenn 942" software is designed to work with the Watlow 942 Controller. In the Windows format, "LinkTenn For Windows" software is designed to work with the VersaTenn III **and** the Watlow 942, 945, and 988 Controllers.

The hardware and software requirements to run LinkTenn software in both formats are listed below.

DOS Format: LinkTenn II & LinkTenn 942

1. Any DOS based computer
2. 256K of RAM memory
3. CGA graphics card
4. DOS 2.0 or higher
5. RS232 computer interface for single chamber control
6. RS422 computer interface for multiple chamber control
7. With IEEE-488 communications, a National Instruments PC2A or compatible card

Windows Format: LinkTenn For Windows

1. Computer with 486 processor or higher
2. Eight Meg of hard drive memory
3. Eight Meg of RAM memory
4. Windows 3.X operating system or higher
5. RS232 computer interface for single chamber control
6. RS422 computer interface for multiple chamber control
7. Currently not available to work with IEEE-488 communications

A sample menu display screen entitled "Program Control" from the LinkTenn For Windows program, is provided in the Supplemental Instructions Section. This screen shows some of the unique features incorporated into the program along with sample setpoints.

When LinkTenn software is provided in either format, a corresponding LinkTenn User's Manual will be provided in the Supplemental Instructions Section.

CHAMBER OPERATION

To operate the chamber, turn on the power source to the chamber and close all chamber circuit breakers. The display of the Watlow 942 should now be illuminated. Enter the desired temperature program or manual setpoints as explained in the Watlow 942 user's manual. Close the Power On switch 1SS. The green ON light should be illuminated.

If your chamber includes the optional Watlow 93 Controller with TempGard IV feature, set this controller's high/low temperature limits at this time. Refer to the "Alarm And Shutdown Circuit" description and the "TempGard IV Configuration And Use Instructions" for further details.

For those chambers which include any other options, please refer to the appropriate "optional" manual sections for a detailed operation description.

IMPORTANT NOTE! For **complete** programming and/or operating instructions on any of the controllers, electrical / mechanical components, or optional equipment, you must refer to their operating manuals included with your Tenney Environmental manual.

PREVENTIVE MAINTENANCE GUIDE

Frequency of preventive maintenance operations depends upon how the facility is used and upon other circumstances. Because of this, a hard and fast schedule of maintenance operations is difficult to present. Indeed, an inflexible schedule might be suitable for one user, but completely inadequate for another. Therefore, the preventive measures given here are offered as a guide, allowing you to arrange your own program.

We suggest that you maintain a preventive maintenance log. In this log you will record operating notes, pressures, temperatures, and electric readings. The log is valuable because it will help maintenance and service people by documenting long term trends and by showing parameter levels when the chamber is operating properly.

Since the refrigeration system is sealed and the instruments are solid state, little maintenance is required on the temperature chamber. However, the following preventive maintenance steps are suggested.

ALL INTERLOCKS AND SAFETY FEATURES SHOULD BE TESTED PERIODICALLY FOR PROPER OPERATION.

1. Periodically inspect the refrigeration system condenser coil for dust or dirt accumulation that would impede the flow of air. A dirty condenser will drive up head pressure. If necessary, clean with a brush or vacuum cleaner. Frequency of cleaning depends upon the air quality at the chamber. (Air Cooled)

2. Make sure the condenser water supply is adequate and is flowing unimpeded to its drain. Inadequate flow will drive up head pressure. (Water cooled)

3. Inspect the door gasket, making sure the door seals tightly. Replace gasket if significant wear is evident.

4. If the door does not seal well, adjust the door latch. If adjustment of the latch does not make the door close tightly, replace the gasket.

5. Only after disconnecting all power to the chamber, inspect and clean the condenser fan and the conditioner fan. Make sure they spin freely and that the conditioner fan is tight on its shaft.

6. Only after disconnecting all power to the chamber, inspect inside the machinery compartment; look for loose electrical connections, frayed wires, and loose components.

7. Only after disconnecting all power to the chamber, inspect the electric heater inside the conditioner; look for sagging elements, broken insulators or other defects. Inspect the heat limiter (if supplied), making sure that its contacts are bright and clean.

8. If your chamber has the optional TempGard IV, do the following:

   a) **High Setpoint:** Dial a temperature well below actual workspace temperature. The instrument must transfer to alarm state, disabling protected circuits.

   b) **Low Setpoint:** Dial a temperature well above actual workspace temperature. The instrument must transfer to alarm state, disabling protected circuits.

   c) Test the alarm buzzer, making sure it is operable.

   d) If customer's contact closure is used to energize an externally powered heat source, make sure that the contact closure removes power when TempGard IV is in the alarm state.

IMPORTANT NOTE: For **complete** preventative maintenance instructions or equipment maintenance instructions on any of the instruments, electrical or mechanical components, or electrical / mechanical machinery and motors, you must refer to their operating manuals included with your Tenney Environmental manual. The smaller manuals and vendor cut-sheets are located in the Supplemental Instructions Section. Any large manuals that could not fit into this 3-ring blue binder are sent alongside of it.

NOTES:

- The refrigeration system is permanently sealed and a periodic oil change is NOT required.
- If a loss of cooling performance is noted, immediately check the condenser for restricted air or water flow.
- All motors are permanently lubricated; therefore, greasing or oiling is not required.

IN CASE OF TROUBLE

Tenney chambers have conductors carrying dangerous voltages with heavy current carrying capacity. Be careful when trouble-shooting.

Circuit breaker 1CB opens the circuit to some of the controls. However, many power circuits remain hot and are dangerous unless a main disconnect switch is opened or the chamber is disconnected. Do not take chances. Before working on a machine, open the main disconnect switch and label it with a red tag saying "DANGER -DO NOT CLOSE THIS SWITCH", Otherwise, unplug or disconnect the chamber.

Our refrigeration systems are sealed and require little service. if you suspect a malfunction, write or call Tenney's Service Department. Unless you are an expert in the refrigeration art, do not tamper. Insufficient cooling, increasing vibration, compressor overheating and constant compressor over loading are signs of trouble.

But note: This Tenney facility is designed to operate with the compressor locked on continuously whenever the cooling mode is selected. Do not be alarmed about the compressor running for long periods.

Before writing or phoning Tenney, inspect the system superficially: Be sure the condenser is getting plenty of water or air. Make certain the cooling coils are defrosted and that power supply voltage is nominal when all systems are operating. Adequate voltage is important.

Should you have to contact Tenney about your refrigeration system, please jot down all the numbers on the compressor identification plate. Also, give us the serial number of the chamber. This will help us give you fast service on spare parts.

Before trouble-shooting the control system, get a copy of the electrical schematic. It is included with these instructions. Open or short circuits, inoperative relays, blown fuses or open fail safe devices are most common malfunctions. When trouble-shooting, carefully trace one system at a time. Be systematic. Use a trouble light, buzzer or voltmeter. Do not carelessly tinker on a circuit or system out of adjustment only to find the trouble somewhere else: Then you will have double trouble to repair and the job will be twice as difficult. Use the X1 scale on an ohmmeter when checking circuit continuity. Do not use X1O, X1OO or higher or you may get false readings.

TROUBLESHOOTING GUIDE

This section does not propose to be a complete and comprehensive troubleshooting guide for the serviceman. However, it attempts to help you locate the causes of possible troubles so that you can make simple repairs or adjustments yourself. The information here should also help you in localizing trouble so that you can better describe the malfunction when contacting the Tenney Service Department. Refer to the appropriate electrical and refrigeration drawings when using these troubleshooting suggestions.

TROUBLESHOOTING GUIDE

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Chamber Control Is Dead	Circuit Breaker 1CB open	Close 1CB
	Contactor 1CON failing to close	Press Reset 1PB, Check Heat Limiter
2. Red OVERTEMP Light On & Chamber Dead, Doesn't Reset	Heat Limiter Fuse has opened	Replace
3. Conditioner Fan Dead	Any cause from Problem #1	Do as stated
	Motor shaft frozen	Verify - rotate by hand carefully!
	Defective motor	Verify - feel for heat & measure current
	Open conductor at term. #32 or 37	Secure termination
4. Insufficient Heat	Chamber door is ajar	Close securely
	One heater element is burned out	Verify - measure current
	Controller Failure	Carefully check programming
5. No Heat	Heater elements burned out/open	Replace
	Controller output 1CI-01 failing to close	Verify - Call Tenney Service
	Triac 1TRC failed open	Replace
	Open connection between: triac & heater, or term. #22 & heater	Secure connection
	Open temperature sensor	Replace
6. Excessive Heat	Short circuited temperature sensor	Replace
	Triac 1TRC failed in conducting state (usual failure mode)	Replace
	Controller output 1CI-01 failing to open	Verify - Contact Tenney Service

TROUBLESHOOTING GUIDE - Continued

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
7. Refrigeration System Dead	Controller output 1CI-02 failing to close	Verify - Contact Tenney Service
	Contactor 2CON failing to close	Replace
	Compressor motor overload protector has tripped	Wait 5 minutes, if overload does not close - replace it
	Pressure Switch 1PS not closing	Verify - Contact Tenney Service
8. Compressor hums but will not start	Low Line Voltage	Get proper electrical service
	Starting Capacitor is defective	Replace
	Compressor relay defective	Replace
	Internal compressor problem	measure winding resistance, test for grounds, contact Tenney
9. Repeated shorting or blowing of start capacitors	Excessive start time, voltage too low	Correct low line voltage problem
10. Compressor starts, hums, runs slowly, staying on start winding	Low Line Voltage	Get proper electrical service
	Compressor relay is stuck	Replace
	Shorted winding	Test resistances, test for grounds, Notify Tenney
11. High Stage Compressor Will Not Run (Cascade System)	Any cause in Problem #1 or #7	Do as stated
12. Low Stage Compressor Will Not Run (Cascade System)	Any cause in Problem #1 or #7	Do as stated
	Pressure switch 2PS not closing	Contact Tenney Service
	Pressure switch 3PS not closing	Verify that high stage is running
13. Low Stage Runs, But Little Or No Cooling	Low stage is low on refrigerant	Have system leak tested
	Artificial loading valve 14SOL stuck open full time	Replace
	Main cooling coil badly frosted	Raise temperature to defrost
14. Compressor runs but cools inefficiently	Restricted ventilation, dirty condenser fins	Move unit away from wall, clean condenser fins

TROUBLESHOOTING GUIDE - Continued

PROBLEM	POSSIBLE CAUSE	CORRECTIVE ACTION
15. Refrigeration works long or continuously	Excessive heat load	Reduce load if possible
	Ice on evaporator coil	Defrost
	Low refrigerant Charge	Have charge checked by refrig. mechanic - charges are on ID label
16. Compressor repeatedly trips out overload protector	Pressure switch failure	Have refrigeration mechanic check switches. Contact Tenney Service
17. Noisy Compressors	Compressor loose on mounts	Tighten hold down nuts
18. Noisy compressors, even with secure hold-downs	Broken springs within compressor housing	Replace compressor - Call Tenney for assistance

NOTE: At site ambient temperature, if the chamber does not pull down substantially in temperature within 15 minutes, something is wrong. Turn the chamber off. Let it normalize and defrost. Then, try it again. If it still does not pull down to low temperature, shut it off and get technical help. A refrigeration system which does not cool properly should not be run for prolonged periods. It may have a leak and be low on refrigerant. Since the compressor depends upon cool returning refrigerant for cooling, it can be overheated when operated in an undercharged system.

Remember that the compressors have internal overloads with automatic reset; these are in addition to circuit breakers. Therefore, when a compressor cuts out, it must be given time to cool so that its internal protector has time to reset.

SERVICING CASCADE REFRIGERATION SYSTEMS

INTRODUCTION

This information is written to help the refrigeration serviceman trouble-shoot and repair low temperature cascade systems. It is assumed that the reader is familiar with standard refrigeration practice and is interested in the special techniques applicable to cascade systems.

Important: Please remember that the following description may differ in some respects to the refrigeration system equipped with your particular chamber.

HISTORY

Prior to the development of low boiling point refrigerants such as R13 (-114 deg. F) and R503 (-127 deg. F), reaching ultra low temperatures with mechanical refrigeration was difficult. R22 was used down to -80 deg. F, but its system had serious drawbacks. Large and cumbersome, the machinery was subject to the many troubles that afflict a compound system operating at suctions as low as 23 inches of vacuum. The modern cascade system can reach as low as -120 deg. F with suction pressures of 0 PSIG or higher. Compact, serviceable, and reliable, today's cascade system is found on thousands of environmental test chambers.

HOW IT WORKS

Two types of popular cascade systems are expansion valve and capillary tube. The system described in this manual is the capillary tube type.

Refrigerants with low boiling points have correspondingly high condensing pressures at normal ambients. They cannot be liquefied by conventional air or water-cooled condensing units. Therefore, low temperature refrigerants are condensed by a separate refrigeration system called "the high stage". The sole job of the high stage in most cascade systems is to condense low stage refrigerant.

HIGH STAGE

The high stage is a conventional single-stage system having a compressor, air or water cooled condenser, expansion valve, and evaporator. The evaporator is the cascade condenser, serving the low stage. Modern systems use R404a in the high stage, making -50 deg. F refrigerant temperature possible at 0 PSIG suction pressure.

LOW STAGE

The low stage is charged with refrigerant in vapor phase only, to a specified gauge pressure. When the low-stage is idle with all components stabilized at 70 deg. F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line through an oil separator, and then to the cascade condenser where it is liquefied by heat exchange with high stage refrigerant. It then flows to the capillary tube which feeds the evaporator coil.

CASCADE CONDENSER

The cascade condenser is the high stage system's evaporator and low stage system's condenser. It can be either tube-in-tube with the low-stage refrigerant in the outside tube or tube-in-shell with the low-stage refrigerant in the shell.

EVAPORATOR COIL

The evaporator coil is part of the low stage system in which the liquid refrigerant boils or evaporates, absorbing heat as it changes into a vapor. The refrigerant flow to the evaporator is metered by a capillary tube.

CAPILLARY TUBE

A capillary tube is a length of tubing of small diameter with the internal diameter held to extremely close tolerances. It is used as a fixed orifice to meter the proper feed of liquid refrigerant.

THERMOSTAT

A thermostat TS is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When a predetermined high temperature is reached, the thermostat will energize the Artificial Loading solenoid 14SOL. The setting is normally 70 degrees Fahrenheit.

LOAD LIMIT SWITCH

A high pressure cut-in sensor monitors the pressure inside the low stage compressor and will activate the Load Limit Switch 4PS when the low stage discharge pressure reaches 280 PSIG. This will energize the Artificial Loading solenoid 14SOL. 4PS will be deactivated when the pressure falls to 240 PSIG.

ARTIFICIAL LOADING

In response to the Thermostat switch TS or the Load Limit switch 4PS, the Artificial Loading solenoid will inject liquid refrigerant into the suction side of the low stage. It will first enter the expansion tank where the added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is then sucked out of the expansion tank and metered through a capillary tube to the suction side of the low stage compressor. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

EXPANSION TANK

An expansion tank is provided to add volume to the low stage. Added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is sucked out of the expansion tank during system operation. It is metered through a capillary tube, regulating the rate of gas entry into the system.

FROSTED LINES ARE TYPICAL

A low-stage characteristic is frosted liquid and suction lines. In a normal cascade system, the liquid line is always below +32 deg. F. The suction line, returning from a -100 deg. F evaporator, assuming 15 degree superheat, will also be far below freezing.

LEAK TESTING

Loss of refrigerant is the most common cause of refrigeration failure. Because of temperature extremes experienced by its metal parts, the cascade system is particularly susceptible to leaks.

Check the entire system with an electronic leak detector. If the system is empty or at low pressure, boost pressure to 200 PSIG with inert gas (not oxygen) diluted with a percentage of high stage refrigerant. Test again.

A leak check while the system is at low temperature, -80 deg. F or colder, is a necessity. Expansion valve flanges, superheat adjustment caps, and other mechanical joints should be tightened and checked for leaks while at low temperature.

You may use a Halide torch to locate large leaks, but make your final test with the more sensitive electronic leak detector. This is especially important on the low stage. The low stage is gas charged with a relatively small quantity of refrigerant. Because of this, small leaks can quickly incapacitate the system.

TESTING BY STATIC CHARGE

One advantage of a gas charged system is that its tightness can be checked by periodic observation of static or standby pressure. You must read the pressure with all parts of the system at ambient temperature. This is important. The unit must be shut down at least 24 hours before a static pressure reading is taken. To eliminate the possibility of cooling the cascade condenser with the high-stage, pump-down cycle, all power to the unit must be off during the shut down period.

When reading static pressure, consider ambient temperature. Most static charge data are for a 10 deg. F decrease in temperature. Due to a large system's considerable thermal mass, several days may be required for all components to completely stabilize at a particular ambient.

EVACUATION

Granted, refrigerants R23 and R404a are expensive, but there are times when charges must be recovered. A contaminated system must be cleaned and evacuated regardless of refrigerant expense.

If there is a possibility that moisture, non-condensibles, or the wrong refrigerant contaminated a system, recover the charge and evacuate.

Select a two-stage pump capable of pumping the system down below 200 microns, and connect an appropriate gauge to ready system pressure. The ordinary compound refrigeration gauge is inadequate, however a thermocouple gauge is ideal. Evacuating a leaky system is an exercise in futility; therefore, make sure the system is absolutely tight before beginning evacuation.

REFRIGERANT FLOW

This description pertains to a small cascade system and can be followed with your Refrigeration Drawing R-10XX-4, or R-11XX-4. There may be variations as noted elsewhere in this manual. The high stage charge is noted on the serial tag. The low stage carries a static pressure, noted on the serial tag, at room temperature. 10 cc of pentane is added to the low stage charge to help prevent waxing of the lubricant at extremely low temperatures.

Flow of refrigerant in the high stage is from compressor C1 in the form of a hot gas, to the chamber door mullion heater(optional), and then to the air-cooled or water-cooled condenser. As a liquid, the high stage refrigerant flows from the condenser to capillary tube dryer assembly D, which meters refrigerant to the cascade condenser. After evaporating in the condenser assembly, which is a heat-exchanger, the high stage refrigerant returns to the compressor C1 through the suction line and accumulator SLA. The function of pressure switch 3PS is to energize the low stage compressor after the high stage has started. The purpose of the arrangement is to prevent both compressors from hitting the power line at the same instant.

Refrigerant flow in the low stage is from the compressor through the oil separator to the cascade condenser where gaseous very high pressure refrigerant or low stage refrigerant is cooled and liquefied. Capillary tube assembly D meters very high pressure refrigerant or low stage refrigerant into the evaporator which cools the chamber. From the evaporator, refrigerant returns to the compressor through the suction line.

Excess refrigerant is stored in the expansion tank and is fed back to the system on demand through a capillary tube.

Solenoid valve 14SOL serves two purposes: On a cooling "off" cycle, it functions as an artificial loading valve, partially by-passing the evaporator and reducing cooling capacity. Refrigeration is modulated through this valve, not by cycling of the compressors. Valve 14SOL also functions as a dump valve. Responding to signals from pressures with 4PS, it is energized and opens when head pressure exceeds a predetermined pressure setpoint, typically 280 PSIG. 14SOL will deenergize when head pressure falls back to 240 PSIG.

SUPPLEMENTAL INSTRUCTIONS SECTION

CHARGING A LOW STAGE

1. Do not charge liquid into the low stage.
2. Do not charge the system when it is below room temperature.
3. Do not use charging hoses on very high pressure refrigerants or low stage refrigerants. Cylinder pressure exceeds 500 PSIG.
4. Never charge the unit when it is running.

As you will note from the above, low stage charging procedure differs from the conventional method. Correct charging pressure will be noted on the equipment nameplate or in the instructions. Remember, it is important that you charge by pressure, not by volume of refrigerant.

Use 1/4 inch copper tube between refrigerant cylinder and system. Open the cylinder valve very slowly. Charge into the suction side while closely watching the discharge gauge. When correct pressure is reached, shut off the refrigerant cylinder valve, allowing the system to equalize from 10 to 15 minutes. If the pressure drops, crack open the cylinder valve, and slowly raise the pressure. Always take enough time: systems with expansion tanks connected by a capillary tube or restrictor valve may need several minutes for gas pressure to equalize.

Keep the refrigerant cylinder upright when charging. Above all, be careful. Do not over-pressurize. Disconnect the cylinder immediately when charging is complete. A leaky cylinder valve could continue to bleed high pressure refrigerant into the system, possibly causing it to rupture. Do not take chances. The saturation pressures of low temperature refrigerants are extremely high.