# TENNEY ENVIRONMENTAL

## TENNEY JUNIOR

## ENVIRONMENTAL TEST CHAMBER

**MODEL NO. TUJR**

SERIAL NO. 27783-09

**CHAMBER TYPE: TEMPERATURE**

**CONTROLLER TYPE: WATLOW 942 CONTROLLER**

**CHAMBER OPTIONS**

☐ Boost Cooling
☐ Boost Heat - Watlow 147
☐ Purge Air System
☐ Chart Recorder
☐ TempGard IV - Watlow 93
☐ Data Communications
☐ LinkTenn Software

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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; drawings, tables, data sheets, test inspection report, parts list, separate vendor user manuals and cut-sheets, expanded instruction and information sections, 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

Tenney Junior test chambers are compact precision environmental test chambers designed to provide a wide ranged temperature environment. The Model Tenney Jr is a benchtop unit, and the Model Tenney T-U Jr is an upright companion. Both models are completely self contained and semi-portable. With its versatility, the Tenney Junior is an excellent choice for applications ranging from R&D work to production testing. Whether it be testing small components or testing in a confined area, you'll appreciate the engineering excellence incorporated into your chamber.

The temperature controlled range is from -75 to +200 degrees Centigrade, ± 0.3 degrees. Temperature conditions are attained by recirculating chamber air through a refrigerated cooling coil and open air nichrome wire heater elements. A cascade refrigeration system is utilized to provide the cooling capacity to reach the extreme low temperature levels. This system incorporates both a high stage compressor and a low stage compressor. Air circulation is generated by a propeller type fan directly driven by an externally mounted motor.

Temperature conditions are controlled by a Watlow 942 microprocessor based time / temperature profile controller, utilizing an RTD for temperature measurement. This controller features dual outputs, auto-tuning control with 24 step program capability, and simple single or fixed set point operation capability. 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 $GN_2$ , 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. We recommend 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.**

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.**

# PARTS AND SERVICE INQUIRIES

**FOR PARTS AND SERVICE INQUIRIES YOU MAY CONTACT TENNEY ENVIRONMENTAL (Division of Lunaire Limited) AT THE FOLLOWING LOCATION:**

**PHONE: 570 - 326 - 1770**

**FAX: 570 - 326 - 3372**

**E - MAIL ADDRESS: service@lunaire.com**

**LUNAIRE LIMITED**
**A UNITED DOMINION COMPANY**
**P.O. BOX 3246**
**WILLIAMSPORT, PA 17701**

## IMPORTANT

**PLEASE HAVE MODEL AND SERIAL NUMBER OF YOUR UNIT AVAILABLE WHEN CONTACTING THE FACTORY.**

### PARTS REPLACEMENT

Your Tenney product has been designed and manufactured to provide years of reliable service. In the event a component should fail, it is recommended that only OEM approved parts be used as replacements. Please contact the Tenney Parts Department for component replacement or repair.

### RECOMMENDED SPARE PARTS

A parts list is provided in the Supplemental Instructions Section. Recommended spare parts are indicated by the letter “S” in the R/S column (Repair/Spare) followed by the quantity required. These items are designated by a “***” symbol. Contact the Tenney Parts Department for delivery information on these items.

# DRAWING LIST

As applicable to the chamber model and serial number, the following drawings are included in the Supplemental Instructions Section of this manual.

| | |
|---|---|
| **Electrical Schematic** | **E - 2189 - 4** |
| **Refrigeration Schematic** | **R - 904 - 4** |

# SUPPLEMENTAL INSTRUCTIONS

As applicable to the chamber model and serial number, the following user manuals and instructions are included in the Supplemental Instructions Section.

## STANDARD INSTRUCTIONS / INFORMATION

**Watlow 942 Controller Manual**

**Test Report**

**Resistance Temperature Conversion Tables**

**Warranty**

## OPTIONAL FEATURE INSTRUCTIONS / INFORMATION

**Watlow 942 Data Communications Manual**

**IEEE 488 Serial Interface Card User Guide**

**Watlow 93 Controller Manual - for TempGard IV option**

**Watlow 147 Limit Controller - with Boost Heat option only**

**Chart Recorder**

**LinkTenn Software**

**Note:** Various other vendor product information sheets are also provided which contain important operation and maintenance instructions. Their inclusion is subject to availability as supplied by the vendor.

# INSTALLATION INSTRUCTIONS

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

**Delivery:** Inspect equipment and shipping crate immediately upon receipt. If any damage is apparent, you should discuss it with the trucking delivery person, and contact the transportation company immediately. Make notes of any damage on the Bill Of Lading. 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.

**Warning!** ALL chambers should be handled and transported in an upright position. They must never be carried on their back, front, or any side.

Inspect the circulation fan inside the chamber. This fan is driven by a motor that is mounted in isolation bushings. Sometimes during shipping, the motor is pushed out of vertical alignment. If this has occurred, the fan blade will strike the casing. Cure the interference by pushing the motor back into alignment on its rubber mounts. However, be sure that the shipping abuse was not so great that the extension shaft on the fan has been bent.

**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. 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.

Leave room for the door hinges. To remove the door, simply open it and lift. You may then fit your chamber with any special door-mounted accessories you like. Standard doors are blank, but special doors having ports, feed-throughs or windows are available from Tenney.

Standard test data is based on the surrounding ambient conditions of 24 degrees Centigrade, a 60 Hz power source, and at sea level. Special performance is predicted on the unit being located in a room where the ambient temperature is between +16 and +38 degrees Centigrade (between +60 and +100 degrees Fahrenheit). The unit may be operated in ambients outside this range but cooling and heating capacity and transient rates will be altered. Performance may also be reduced for 50 Hz units.

**Air Supply Connection:** Your chamber will require a compressed air supply for the Purge Air System option, or for the Dry Air for Dehumidification (humidified chambers only!!) option. The supply should range from 80 PSIG min. to 100 PSIG max. Make sure that the air supply is clean (relatively oil free) and the connection is secure. Reference the corresponding “Optional” section in this manual, or your chamber specifications for more details.

**$GN_2$ Connection:** Your chamber will require a supply of gaseous nitrogen ($GN_2$) for the Purge Air System (using $GN_2$) option. The supply may range up to 100 PSIG maximum. Make sure the connection is secure. Reference the corresponding “Optional” section in this manual, or your chamber specifications for more details.

**Warning!** Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

**$LN_2$ / $CO_2$ Connection:** Your chamber will require a supply of liquid nitrogen ($LN_2$), or liquid carbon dioxide ($CO_2$) for the Boost Cooling option. When $LN_2$ is used, the supply may range up to 40 PSIG maximum. When using $CO_2$, the supply will be rated for either up to 300 PSIG, or up to 1000 PSIG, depending on which option is purchased. Make sure the connection is secure. Reference the corresponding “Optional” section in this manual, or your chamber specifications for more details.

**Warning!** The gases from these systems displace oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

**Power Connection:** Your chamber is equipped with a power cord & plug approximately six feet long, and is rated 115 V, 18 A, 60 Hz, 1PH. 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.

Your power source must be capable of handling the high starting current of the refrigeration system, and voltage drop must be minimal to assure reliable performance. Conductors for the branch circuit must be #12 gauge AWG or heavier. If a circuit breaker is used it should be rated 20 A. If a fuse is used it should be a slow-blow type rated 20 A. A Hubbell type 5361 receptacle is provided which must be installed in this branch circuit for your power connection. Make sure the receptacle is properly grounded in accordance with all codes. Extension cords are not recommended.

**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.**

**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 TJR and TUJR test chambers are designed to operate with a nominal 115 V, 60 Hz, 1PH power supply. Optional equipment is available to allow operation with 208 or 230, 60 Hz supplies, or for outside The United States, operation with 200, 220 V, 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** | |
| 115 | 104 | 127 |
| 208 | 198 | 218 |
| 230 | 207 | 253 |
| | **50 Hz Power Supplies** | |
| 200 | 180 | 220 |
| 220 | 198 | 242 |

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

## OPERATING WITH AN ACTIVE HEAT LOAD - USED WITH TEMPGARD IV OPTION

**Note:** This feature is only available with the TempGard IV option.

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 contacts of the Master Contactor (CON) from the TempGard IV circuitry. This is described in the Alarm And Shutdown Circuit section.

# TEMPERATURE CONTROL - WATLOW 942 CONTROLLER

Temperature conditions are controlled by a Watlow 942 Controller, which is microprocessor based and features a single input, dual outputs, and two optional event outputs. Time / temperature profile operations include 24-step program capability with time / temperature profile-rate or time-based programming. The controller can also be used for single or fixed set point operation. Temperature measurements are made utilizing a 100 ohm platinum RTD sensor, which is placed in the discharge air of the conditioning plenum.

When heating is required, the time-proportioned output 1CI-01 will close and trigger triac 1TRC to conduct, which provides power to the electric heater elements. Cooling of the chamber is accomplished with the ON/OFF output 1CI-02, which triggers triac 2TRC to conduct and energize the refrigeration system. 1CI-02 must first be enabled by 2CR contacts. 2CR is energized by the Main Power Switch. 2TRC will immediately energize the high stage compressor. The low stage compressor will start after a slight delay from the Low Pressure Cut-In Switch PS2.

**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.

**Continued On Next Page!**

**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.

## HEATING DESCRIPTION

Heating of the chamber is accomplished with the time proportioned output 1CI-01 of the Watlow 942 Controller. 1CI-01 turns on triac 1TRC which conducts to supply power to the electric 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. The heater bank is rated 500 W, 115 V, 60 Hz.

## CASCADE REFRIGERATION SYSTEM DESCRIPTION

A cascade refrigeration system is utilized to provide the cooling capacity to reach the extreme low temperature levels. This system incorporates a high stage compressor and a low stage compressor, integrated with a cascade condenser, where the high stage refrigerant cools and condenses the low stage refrigerant.

Refrigerant flow in the high stage is from the compressor in the form of a hot compressed gas to an air-cooled condenser which cools and condenses the refrigerant. It is then metered through a capillary tube type expansion device to the cascade condenser where it evaporates upon cooling the low stage refrigerant. Refrigerant returns to the suction side of the compressor through a suction line accumulator which guards against any liquid refrigerant return.

Refrigerant flow in the low stage is from the compressor in the form of a hot compressed gas through a desuperheater (which is part of the high stage condenser) where most of the heat of compression is removed by heat exchange with circulating air. The cool gas then flows to the cascade condenser where it is condensed into a liquid by heat exchange with evaporating high stage refrigerant. The liquid flows through a drier assembly and is metered through a capillary tube type expansion device to the evaporator 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. The cycle is repeated.

**NOTE:** Please reference the section entitled “Servicing Cascade Refrigeration Systems” for a more detailed description.

**SAFETY DEVICES:**

The low stage compressor will start after a slight delay from the Low Pressure Cut-In Switch PS2, which monitors the suction pressure in the high stage compressor. This switch will close when the suction pressure reaches 20 PSIG. This delay prevents both compressors from hitting the power line at the same instant.

An Artificial Loading solenoid valve SV will be energized by the High Pressure Cut-in Switch PS1, when low stage compressor head pressures reaches 280 PSI. This action dumps refrigerant into the expansion tank for storage until the pressure drops to 240 PSI.

A motor overload protective device is installed in the windings of each compressor which will open 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 will automatically reset and restart the compressor after the motor has cooled.

## CHAMBER OVERTEMPERATURE PROTECTION

A heat limiter fuse is provided to protect the chamber against overtemperature conditions. It is mounted to the heater element bracket in the conditioning plenum at the top of the workspace. The heater limiter will permanently open and remove power from the heater elements when a temperature of approximately 221°C is reached. **Once it opens it must be replaced.**

**WARNING! Before replacing the heat limiter, you must disconnect your power supply cord and plug from the power supply receptacle. If your chamber is hard wired, you must open the closest main power disconnect switch. Read the description below before attempting to replace the heat limiter.**

**Heat Limiter Description:**

This 1¼” long device has a white ceramic body with two copper forked terminals on either end. It is wired in series with the heating elements, having one terminal attached to a heater element mounting stud, and the other connected to the neutral line with an 8-32 bolt and nut. This end hangs in free air to the left of the heater bracket. A copper metal strip on the back side of the heat limiter connects the two forked terminals and carries the heater current. When a temperature of approximately 221°C is reached, the copper strip will separate from the heat limiter body at the soldered connection on the one end. As a result, power is removed from the heater elements.

**Removing the Heat Limiter:**

1. Remove the conditioner (plenum) cover at the top of the workspace by removing the four mounting screws.

2. Remove the heater bracket from the plenum ceiling by removing the two mounting screws located at either end. Once the screws are removed, the bracket can be left to hang.

3. Remove the heat limiter by loosening the No. 8-32 nut that secures the one end to the heater element mounting stud, and the No. 8-32 bolt/nut assembly which secures the opposite end to the neutral wire.

4. As you install the new heat limiter, **take great care in your replacement procedure!** Make sure all connections are secure.

**Note:** The heat limiter is not used when the Boost Heat option is employed. This option uses a Watlow 147 Limit Controller for overtemperature protection. Please reference that section for details.

## ALARM AND SHUTDOWN CIRCUIT (Optional)

A comprehensive alarm and shutdown circuit may be provided for protection against product over/under temperature. This optional feature utilizes a Watlow 93 Controller configured as a TempGard IV temperature protector. The Watlow 93 is a microprocessor based controller which incorporates programmable high and low temperature limits. A one hundred ohm platinum RTD is used for temperature measurement which is placed at the plenum in the downstream airflow, which is the most responsive area of the chamber.

An electrical schematic of the TempGard IV circuitry will be included in the Supplemental Instructions Section when this option is utilized.

### Circuit Operation:

When chamber temperature is within the selected setpoints, the white NORMAL light 2LT is illuminated and the Master Contactor CON is energized. The contacts of CON provide power to the conditioning control circuitry. **Note:** A spare set of CON contacts are provided for the customer's closure. It is recommended that these contacts be used to energize an active heat load if utilized.

When a preset temperature limit is reached within the Watlow 93 TempGard IV, the alarm contact TG opens and deenergizes CON, 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. When the TempGard IV alarm condition clears, the red Chamber OVERTEMP light 3LT will illuminate.

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

A silence switch 3SS is provided to disable the alarm buzzer while corrective action is taken. When 3SS is activated, the white Silence light 5LT will be illuminated. **To reset the alarm circuitry and the conditioning control circuitry you must open and then close the POWER RESET switch 2SS.** If the alarm buzzer was disabled and the system was successfully reset with 2SS, the alarm buzzer will now sound to alert the operator to place the silence switch 3SS in it's normal (down) position.

A 1.5 second timer TC is included in the reset circuit to provide for automatic start when power is applied to the system. This avoids the need for a manual reset each time that power is removed and reapplied.

**The configuration for the TempGard IV option is detailed in the section entitled; Watlow 93 - TempGard IV Configuration & Use. Please reference the Watlow 93 user manual for complete details of the controller, which is found in the Supplemental Instructions Section.**

## 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 Model TJR / TUJR** - When the alarm has cleared you must cycle the POWER ON/RESET switch 2SS.

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; their settings are immaterial. 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 Watlow 942 Controller energizes the main heater bank, 1CI-01 will at the same time energize time delay relay TC. When this relay times out it will energize mercury relay MR, which provides power to the boost heaters.

**With this option the Heat Limiter fuse is not used.** In its place, a Watlow 147 Limit Controller 1TS is used to monitor and protect the chamber against an overtemperature condition. This controller is an open board type with an adjustable dial and a calibrated scale for selecting the high limit temperature setpoint. It is normally installed inside the main control panel. A red LED on the Watlow 147 will illuminate in an alarm condition. A Type T thermocouple is used for temperature measurement. **Note:** The high limit is preset at the factory and should **never** be changed.

When the temperature is below the preset limit, 1TS contacts will be closed to energize contactor CON. Separate contacts of CON are wired in series with both the existing heater elements and the boost heat elements. When the Watlow 147 detects an overtemperature condition 1TS will open to deenergize CON and all heaters.

The boost heat option is available in a 500 W and a 1000 W version. A corresponding electrical schematic would be included with each type.

## BOOST COOLING (Optional)
## USING LIQUID NITROGEN or CARBON DIOXIDE

As an option, your chamber may be equipped with a boost cooling system utilizing either liquid nitrogen ($LN_2$) or liquid carbon dioxide ($CO_2$). When $LN_2$ is used, the supply may range up to 40 PSIG maximum. When using $CO_2$, the supply will be rated for either up to 300 PSIG, or up to 1000 PSIG, depending on which option is purchased.

**Warning!** The gases from these systems displace oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

The boost cooling system 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. 1, output 1CI-03 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.

**Operation:**

Cooling is achieved by injecting either $LN_2$ or $CO_2$ into the chamber through a solenoid valve. Once enabled through the event, boost cooling will turn on if a demand for cooling exists for a preset time period, and as long as the heat control doesn't turn on. Normally closed contacts of control relay CR enables the boost cooling circuitry whenever heat output 1CI-01 is OFF. Output 1CI-03 of the controller is used to energize timer TC. This timer will time out after ten seconds. As long as 1CI-03 is still energized, indicating that more cooling is necessary, TC will energize the $LN_2$ / $CO_2$ injection solenoid valve SOL. 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, which permits the adjustment of nitrogen flow to avoid incomplete evaporation at varying $LN_2$ supply pressures. **Incomplete evaporation of nitrogen may damage the door gasket.** 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.

$CO_2$ systems are provided with a manually set flow adjusting valve, which permits the adjustment of carbon dioxide flow to avoid incomplete evaporation at varying $CO_2$ supply pressures. **Incomplete evaporation of carbon dioxide may damage the door gasket.** This setting will vary, depending on the optional supply pressure used. The 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 purge air system utilizing either compressed air, or gaseous nitrogen ($GN_2$). When compressed air is used, the supply must range from 80 PSIG min. to 100 PSIG max. It should be relatively oil free. When $GN_2$ is used, the supply may range up to 100 PSIG max.

**Warning!** Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

The purge air system 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, output 1CI-04 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.

**Compressed Air w/Dryer Purge:**

This system incorporates a heatless desiccant dryer for the generation of a controlled flow of dry air into the chamber. When activated, output 1CI-04 will directly energize the dryer and the Purge Air solenoid valve ASOL.

The dryer is a twin tower heatless desiccant type that is self regenerating. Each desiccant tower (chamber) contains a compression packed molecular sieve. As the compressed air passes through the sieve, moisture is picked up by the desiccant. The dried air is released through an outlet port and injected into the test chamber's conditioning airflow through solenoid valve ASOL. A small portion of the dried air is passed through a sized orifice to the other tower to purge the desiccant of moisture collected during the previous cycle. There are four distinct phases of the heatless dryer where the compressed air is alternately cycled and dried in each of the two desiccant towers. This is all controlled by integral timers and solenoid valves within the dryer.

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.

**$GN_2$ Purge:**

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.

When activated, output 1CI-04 will energize and open the GNSOL solenoid valve to permit the injection of $GN_2$. 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.

## 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 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 make sure the plug is secured in the receptacle. The display of the Watlow 942 Controller should now be illuminated. Enter the desired temperature program or manual setpoints into the controller, as explained in the Watlow 942 user's manual. Close the Main Power Switch 1SS. This will start the conditioner and condenser fans, and energize control relay 2CR. This relay enables the cooling output of the Watlow 942. The switch light should illuminate whenever the switch is closed.

If your chamber includes the optional Watlow 93 Controller with TempGard IV feature, close the Power switch 2SS and set the controller's high/low temperature limits at this time. Refer to the TempGard IV Configuration And Use Instructions, or the user's manual 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.** Inspect the door gasket, making sure the door seals tightly. Replace gasket if significant wear is evident.

**3.** 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.

**4.** 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.

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

**6.** 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.

**7.** 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 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. 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 chamber 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. Conditioner Fan Dead** | Motor shaft frozen | Verify - rotate by hand carefully! |
| | Defective motor | Verify - feel for heat & measure current |
| | | |
| **2. Insufficient Heat** | Chamber door is ajar | Close securely |
| | One heater element is burned out | Verify - measure current |
| | Controller Failure | Carefully check programming |
| **3. No Heat** | Heat Limiter opened | Replace |
| | Heater elements burned out/open | Replace |
| | Output 1CI-01 failing to close | Verify - Call Tenney Service |
| | Triac 1TRC failed open | Replace |
| | Open temperature sensor | Replace |
| **4. Excessive Heat** | Triac 1TRC failed in conducting state (usual failure mode) | Replace |
| | Output 1CI-01 failing to open | Verify - Contact Tenney Service |
| | Short circuited temperature sensor | Replace |
| **5. Refrigeration System Dead** | Output 1CI-02 failing to close | Verify - Contact Tenney Service |
| | Triac 2TRC failing to conduct | Replace |
| | Compressor motor overload protector has tripped | Wait 5 minutes, if overload does not close - replace it |
| **6. Compressor hums but will not start** | Low Line Voltage | Get proper electrical service |
| | Starting Capacitor is defective | Replace |
| | Compressor relay defective | Replace |
| | | |

## TROUBLESHOOTING GUIDE - Continued

| PROBLEM | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|
| **6. Compressor hums but will not start** - continued | Internal compressor problem | measure winding resistance, test for grounds, contact Tenney |
| **7. Repeated shorting or blowing of start capacitors** | Excessive start time, voltage too low | Correct low line voltage problem |
| **8. 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 |
| **9. Low Stage Compressor Will Not Run** | Pressure switch PS2 not closing | Contact Tenney Service |
| **10. Low Stage Runs, But Little Or No Cooling** | Low stage is low on refrigerant | Have system leak tested |
| | Artificial loading valve SV stuck open full time | Replace |
| | Main cooling coil badly frosted | Raise temperature to defrost |
| **11. Compressor runs but cools inefficiently** | Restricted ventilation, dirty condenser fins | Move unit away from wall, clean condenser fins |
| **12. 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 |
| **13. Compressor repeatedly trips out overload protector** | Pressure switch failure | Have refrigeration mechanic check switches. Contact Tenney Service |
| **14. Noisy Compressors** | Compressor loose on mounts | Tighten hold down nuts |
| **15. 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. **SUVA 95** refrigerant is now used in the low stage system of all Tenney Junior Test Chambers.

## 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 to the de-superheater (on 1HP units only). The de-superheater, air or water-cooled, removes some heat from the refrigerant gas, lightening the heat load on the cascade condenser. Leaving the de-superheater, the gas passes through an oil separator, then flows to the cascade condenser where it is liquefied by heat exchange with high stage refrigerant and flows to the expansion valve.

## 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.

## DE-SUPERHEATER (only on 1HP units)

Consists of coils as part of the high stage air cooled condenser with low stage discharge gas running through them. Its purpose is to remove some heat from the low stage discharge gas and thereby lighten the load on the high-stage system.

## 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.

## 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.

# SUPPLEMENTAL INSTRUCTIONS SECTION