Read Safety Section before installing or using equipment.

INTRODUCTION

Turbo Refrigerating Company is a supplier of ice generators, chillers, and storage tanks for thermal storage systems. Turbo does not engineer or design buildings, warehouses, mechanical rooms, or any structures that utilize thermal storage equipment but can assist in all phases of selecting the proper equipment to meet the needs of the customer.

Information on safety, installation, operation, maintenance, and trouble shooting is contained in this manual. If you have questions concerning any of these phases, contact Turbo Refrigerating Company or one of its distributors to ensure you fully understand the instructions and guidelines.

You must read all of the information carefully and make sure that all personnel involved in the installation and operation have also read and understood the information and safety instructions. This will help avoid injury to personnel and/or damage to the equipment. Both are valuable assets to your operation. **Take the time to protect them.**

Read the manual contents before you start your installation or operation. This will save time by ensuring all the necessary materials and tools are available when the equipment arrives.

Since 1960, Turbo Refrigerating Company has made the highest quality industrial icemakers available on the market. Turbo's ability to respond to its customer's needs is one of the primary reasons that Turbo has become the major supplier in the Industrial Icemaker market. This ability, along with Turbo's commitment to provide high quality, reliable equipment is incorporated in all of its Thermal Storage Products.

Turbo Refrigerating Company offers this Manual as a guide to owners and operators of Turbo thermal storage systems, to assist in maintaining the equipment in a reliable and efficient manner.

This manual includes information on installation, prestartup and startup instructions, operation, maintenance, and trouble shooting. Please read all information carefully and follow all instructions in order to avoid damage to equipment or injury to personnel. Review the installation instructions prior to the actual rigging operation to insure that the necessary equipment will be available at the jobsite. Also, this can be used to acquaint all personnel with the proper procedures to be followed during installation.

The Turbo nameplate on the electrical control panel has the serial number along with other information. This information should be recorded and used whenever referring to the equipment.

History

Turbo Refrigerating Company has been producing equipment for the ice industry since 1960. Since entering the thermal storage market in 1978, Turbo has been the leader in thermal storage technology.

Single source packaged systems provide simple installation and fast start-up.

If you have an application or a need that is not discussed here, contact the sales department of Turbo Refrigerating Company or a Turbo distributor to discuss your needs:

Turbo Refrigerating Company

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Model Descriptions

All thermal storage units are provided with:

- Aluminum external panels.
- Control panel with programmable controller.
- Programmable time clock for on/off control.

- Water temperature thermostat to control icemaking-to-chiller and chiller-to-icemaking mode.
- Stainless steel evaporator plates.
- Water distribution system to evaporator plates including stainless steel water distribution pan and PVC water distribution header.
- 230/3/60 or 460/3/60 motors with 115/1/60 controls.
- Multiple evaporator sections.
- Open compressors direct-coupled to an open-drip proof motor, a semi-hermetic compressor, a screw compressor, or a multiple open reciprocating compressor.
- Suction accumulator/heat exchangers.
- High ice level cut off switches.

All surfaces in contact with the water or ice are either stainless steel, PVC, or hot-dipped galvanized for maximum corrosion resistance.

HP and IGC Series Models

All Turbo ice harvesting thermal storage units can be operated as either an ice generator or a highly efficient chiller.

HP denotes the low profile models with icemaking capacities from 7 1/2 to 100 tons, and chilling capacities from 11 1/2 to 175 tons. These units are typically less than 60 inches in height and less than 96 inches wide. A smaller HP-series 304 stainless steel evaporator plate is used.

For higher tonnage, the IGC product is utilized. IGCs have a larger evaporator plate requiring enclosures that are typically 7'-7" high and 8'-3" wide. Icemaking capacities range from 55 tons to 300 tons in self-contained unitary packaged units. Chilling capacities range from 90 to 500 tons.

Multiple thermal storage units (HP or IGC) can be mounted on a common thermal storage tank to achieve the tonnage required for each specific application.

Installation and operation of both the HP and IGC models is the same except for some variations in the valving and piping on larger capacity models.

The Turbo model number consists of four parts. For example:

<u>HP</u> <u>300</u> <u>A</u> <u>SC</u> :

HP = HP-series evaporator plate
300 = specifies number of plates and capacity
A = specifies compressor used
SC = method of high side condensing

IGC models use the same method of describing the unit. The various means of condensing are described below and are always the last part of the model description.

SC (Self-Contained)
- Completely self-contained, including refrigerant charge.
- Uses a water-cooled condenser with water regulating valves.
- Optional cooling tower pump and starters for cooling tower pump and fan(s) are available.

SCA (Self-Contained Air-Cooled)
- Completely self-contained, including refrigerant charge.
- Uses an air-cooled condenser.
- Head pressure controls provided with the air-cooled condenser.
- Complete unit and condenser is mounted on a common base frame.

SCE (Self-Contained Evaporative-Cooled Condenser)
- Completely self-contained, including refrigerant charge.
- Uses an evaporative-cooled condenser.
- Optional evaporative condenser is available.
- Head pressure controls provided with the evaporative-cooled condenser.
- Complete unit and condenser is mounted on a common base frame.

SCAR (Self-Contained Air-Cooled Remote)
- Self-contained unit set up for remote air-cooled condenser.

- Air-cooled condenser head pressure controls and starters for the condenser fan(s) can be furnished as options.
- No refrigerant charge.
- Receiver and isolating valves are optional.
- Interconnecting wiring and pumping by others.

SCER (Self-Contained Evaporative Remote)

- Self-contained unit set up for remote evaporative-cooled condenser.
- Evaporative-cooled condenser head pressure controls and starters for the condenser pump and fan(s) can be furnished as options.
- No refrigerant charge.
- Receiver and isolating valves are optional.
- Interconnecting wiring and piping by others.

Associated Turbo Equipment

Turbo Icemaker

Since 1960, Turbo has provided icemaking equipment for the packaged ice industry. Turbo icemakers for this application produce a dry, subcooled, and uniform sized ice suitable for bagging and distribution to convenience and grocery stores. Stainless steel PVC or hot dip galvanizing is used on the icemaker everywhere the ice comes into contact to ensure a sanitary ice. These icemakers are USDA approved and suitable for use in food processing applications.

Turbo Ice Generator (TIG)

Many process applications do not require a dry, subcooled, or uniform sized ice. For these applications, Turbo produces a wet ice generator. All parts of the ice generator in contact with the ice are either stainless steel, PVC, or hot-dip galvanized. Typical applications include:

- fish icing
- top icing of produce in the field or on the process line
- chemical plant reactor cooling
- poultry chilling
- top icing.

These models have preliminary USDA approval.

Turbo Block Press

Turbo offers another feature to make it possible to get your money's worth out of your ice production. Instead of throwing away the snow produced by the breaker bar, screw conveyors or other handling devices, install a Turbo block press. The Turbo block press converts the snow into a ten or fifty-five pound block of ice.

Introduced in 1977, the Turbo block press is a completely automatic hydraulic powered unit capable of producing from 120 to an excess of 400 ten pound blocks per hour. The Turbo block press is available with a block bagger attachment which again means:

- less handling
- a better product
- higher profits for the ice person.

Rugged industrial construction and stainless steel or PVC in all areas of ice contact make the Turbo block press the most reliable on the market.

Turbo Ice Rake

Turbo offers the only proven automatic ice storage and delivery system (from 20 to 300 ton capacities).

There are two basic sizes in the hydraulic version as well as two larger versions known as "automatic ice rakes". The smaller hydraulic models range in capacity from 20 to 75 tons of ice while the larger automatic ice rakes range from 100 to 300 tons of ice storage.

All Turbo ice storage systems are USDA approved. Each system is designed to make the loading and unloading of the ice storage system as safe and simple as possible. Turbo ice rakes are self-leveling and self-unloading.

Typical Applications

- produce (broccoli, carrots, etc.)
  - top icing in the field or in the processing area
  - units can be trailer mounted
- concrete icing
- ingredient icing (as in bakeries)
- fish icing
- poultry icing
- chemical and dye processes

Read Safety Section before installing or using equipment.

- emergency cooling loads
- ice slurries
- catering trucks
- salad bars or display ice
- food processing
- packaged ice for convenience stores.

Customer Service

The Turbo service department provides assistance for all customer needs. Turbo conducts training schools at the factory and various locations throughout the world. For information, contact the service department at Turbo Refrigerating Company.

The model and serial number of your Turbo equipment is located on the nameplate attached to the electrical control panel. Please refer to the model and serial number when making inquiries about the equipment. This will enable our personnel to handle your questions quickly and accurately.

High Values

Turbo highly values its friends and customers in the industry. Please remember to:

T hink safely - act safely.
U nderstand operating procedures and dangers of the equipment.
R emember to think before you act.
B efore you act, understand- the consequences of your actions.
O bserve equipment warnings and labels.

TERMS & CONDITIONS

Turbo Refrigerating Co. (the "Company") agrees to sell the Equipment described herein upon the following terms and conditions of sale which, accordingly, supersede any of Buyer's additional or inconsistent terms and conditions of purchase.

1. TERMS AND PRICES

(a) All orders are to be accompanied by a twenty percent (20%) down payment or an acceptable irrevocable letter of credit confirmed on a U.S. Bank acceptable to Turbo. No orders are to be entered without payment or L/C in hand.

(b) All orders are subject to the approval of the Company's home office. Unless otherwise stated, standard terms of payment are thirty (30) days net from the earlier of date of shipment or readiness of the Equipment for shipment. If partial shipments are made, payment shall become due and payable to the partial shipment.

(c) In addition to the purchase price, Buyer shall pay any excise, sales, privilege, use or any other taxes, Local, State or Federal, which the Company may be required to pay arising from the sale or delivery of the Equipment or the use thereof. Prepaid freight, if applicable, will be added to the purchase price and invoiced separately. Where price includes transportation or other shipping charges, any increases in transportation rates or other shipping charges from date of quotation or purchase order shall be for the account of and paid by Buyer.

(d) Contract prices are subject to adjustment to the Company's prices in effect at time of shipment unless otherwise specified in a separate Price Adjustment Policy attached to the proposal or other contract document of the Company.

(e) If Buyer requests changes in the Equipment or delays progress of the manufacture or shipment of the Equipment, the contract price shall be adjusted to reflect increases in selling price caused thereby.

2. SHIPMENT

Shipment is F.O.B. Company's plant or place of manufacture, unless otherwise specified. Risk of loss shall pass to Buyer upon delivery to transporting carrier.

3. DELIVERY

(a) The Company will endeavor to make shipment of orders as scheduled. However, all shipment dates are approximate only, and the Company reserves the right to readjust shipment schedules.

(b) Under no circumstances will the Company be responsible or incur any liability for costs or damages of any nature (whether general, consequential, as a penalty or liquidated damages or otherwise) arising out of or owing to (i) any delays in delivery or (ii) failure to make delivery at agreed or specified times due to circumstances beyond its reasonable control.

(c) If shipment is delayed or suspended by Buyer, Buyer shall pay (i) Company's invoice for the Equipment as per payment terms, (ii) Company's handling and storage charges then in effect, and (iii) demurrage charges if loaded on rail cars.

4. LIMITED WARRANTY; WARRANTY ADJUSTMENT; EXCLUSIONS; LIMITATION OF LIABILITY

(a) LIMITED WARRANTY
The Company warrants that at the time of shipment the Equipment manufactured by it shall be merchantable, free from defects in material and workmanship and shall possess the characteristics represented in writing by the Company. The Company's warranty is conditioned upon the Equipment being properly installed and maintained and operated within the Equipment's capacity under normal load conditions with competent supervised operators and, if the Equipment uses water, with proper water conditioning. Equipment, accessories and other parts and components not manufactured by the

Company are warranted only to the extent of and by the original manufacturer's warranty to the Company, in no event shall such other manufacturer's warranty create any more extensive warranty obligations of the Company to the Buyer than the Company's warranty covering Equipment manufactured by the Company.

(b) EXCLUSIONS FROM WARRANTY

(i) THE FOREGOING IS IN LIEU OF ALL OTHER WARRANTIES, ORAL OR EXPRESS OR IMPLIED, INCLUDING ANY WARRANTIES THAT EXTEND BEYOND THE DESCRIPTION OF THE EQUIPMENT. THERE ARE NO EXPRESS WARRANTIES OTHER THAN THOSE CONTAINED IN THIS PARAGRAPH 4 AND TO THE EXTENT PERMITTED BY LAW THERE ARE NO IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE. THE PROVISIONS OF THIS PARAGRAPH 4 AS TO DURATION, WARRANTY ADJUSTMENT AND LIMITATION OF LIABILITY SHALL BE THE SAME FOR BOTH IMPLIED WARRANTIES (IF ANY) AND EXPRESS WARRANTIES.

(ii) The Company's warranty is solely as stated in (a) above and does not apply or extend, for example, to expendable items, ordinary wear and tear, altered units; units repaired by persons not expressly approved by the Company, materials not of the Company's manufacture, or damage caused by accident, the elements, abuse, misuse, temporary heat, over-loading, or by erosive or corrosive substances or by the alien presence of oil, grease, scale, deposits or other contaminants in the Equipment.

(c) WARRANTY ADJUSTMENT

Buyer must make claim of any breach of any warranty by written notice to the Company's home office within thirty (30) days of the discovery of any defect. The Company agrees at its option to repair or replace, BUT NOT INSTALL, F.O.B. Company's plant, any part or parts of the Equipment which within twelve (12) months from the date of initial operation but no more than eighteen (18) months from date of shipment shall prove to the Company's satisfaction (including return to the Company's plant, transportation prepaid, for inspection, if required by the Company) to be defective within the above Warranty. Any warranty adjustments made by the Company shall not extend the initial warranty period set forth above. The warranty period for replacements made by the Company shall terminate upon the termination of the initial warranty period set forth above. Expenses incurred by Buyer in replacing or repairing or returning the Equipment or any part or parts will not be reimbursed by the Company.

(d) SPARE AND REPLACEMENT PARTS WARRANTY ADJUSTMENT

The Company sells spare and replacement parts. This subparagraph (d) is the Warranty Adjustment for such parts. Buyer must make claim of any breach of any spare or replacement parts warranty by written notice to the Company's home office within thirty (30) days of the discovery of any alleged defect for all such parts manufactured by the Company. The Company agrees at its option to repair or replace, BUT NOT INSTALL, F.O.B. Company's plant, any part or parts of material it manufactures which, within one (1) year from the date of shipment shall prove to the Company's satisfactory (including return to the Company's plant, transportation prepaid, for inspection, if required by the Company) to be defective within this Parts Warranty. The Warranty and warranty period for spare and replacement parts not manufactured by the Company (purchased by the Company, from third party suppliers) shall be limited to the Warranty and Warranty Adjustment extended to the Company by the original manufacturer of such parts, in no event shall such other manufacturer's warranty create any more extensive warranty obligation of the Company to the Buyer for such parts than the Company's Warranty Adjustment covering parts manufactured by the Company as set forth in this subparagraph (d). Expenses incurred by the Buyer in replacing, repairing, or returning the spare or replacements parts will not be reimbursed by the Company.

(e) LIMITATION OF LIABILITY

The above Warranty Adjustment sets forth Buyer's exclusive remedy and the extent of the Company's liability for breach of implied (if any) and express warranties, representations, instructions or defects from any cause in connection with the sale or use of the Equipment. THE COMPANY SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES OR FOR LOSS, DAMAGE OR EXPENSE, DIRECTLY OR INDIRECTLY ARISING FROM THE USE OF THE EQUIPMENT OR FROM ANY OTHER CAUSE WHETHER BASED ON WARRANTY (EXPRESS OR IMPLIED) OR TORT OR CONTRACT, and regardless of any advices or recommendations that may have been rendered concerning the purchase, installation or use of the Equipment.

5. PATENTS

(a) PATENT INDEMNITY AND CONDITIONS

The Company agrees at its own expense to defend and hold Buyer harmless in the event of any suits instituted against Buyer for an alleged infringement of any claim of any United States Patent covering solely to the structure of the Equipment as originally manufactured by the Company per the Company's specifications, and without modification by the Buyer, provided buyer shall (i) have given the Company immediate notice in writing of any such claim or institution or threat of such suit, and (ii) have permitted the Company to defend or settle the same, and have given all needed information assistance and authority to enable the Company to do so. Buyer shall defend and indemnify the Company against all expenses, costs and loss by reason of any real or alleged infringement by the Company's incorporating a design or modification requested by Buyer.

(b) LIMITATION OF LIABILITY

The Company's total liability hereunder is expressly limited to an amount no greater than the sales price of the Equipment and may be satisfied by the Company's refunding to Buyer, at the Company's option, the sales price of the Equipment in the event the Company elects to defend any such suit and the structure of the said Equipment is held to infringe any such United States Patent and if the Buyer's use thereof is enjoined, the. Company shall, at its expense and at its option (i) obtain for the Buyer the right to continue using the Equipment, or (ii) supply non-infringing Equipment for installation by Buyer, or (iii) modify the Equipment so that it becomes non-infringing, or (iv) refund the then market value of the Equipment.

6. PRIOR USE

If damage to the Equipment or other property or injury to persons is caused by use or operation of the Equipment prior to being placed in initial operation ("Start up") by the Company where start up is included in the purchase price, then Buyer shall indemnify and hold the Company harmless from all liability, costs and expenses for all such damage or injury.

7. EQUIPMENT CHANGES

The Company may, but shall not be obligated to, incorporate in the Equipment any changes in specifications, design, material, construction, arrangement, or components.

8. SECURITY INTEREST; INSURANCE

(a) To secure payment of the purchase price, Buyer agrees that the Company shall retain a security interest in the Equipment until Buyer shall have paid in cash the full purchase price when due, interest at the highest lawful contract rate until so paid and the costs of collection, including reasonable attorney's fees. The Equipment shall at times be considered and remain personal property and Buyer shall perform all acts necessary to assure and perfect retention of the Company's security interest against the rights or interests of third persons. In the event Buyer defaults in payment of any part of the purchase price when due, or fails to comply with any and all provisions of this contract, the Company shall have the remedies available under the Uniform Commercial Code.

(b) So long as the purchase price is unpaid, Buyer at its cost shall obtain insurance against loss or damage from all external causes, naming the Company as an insured, in an amount and form sufficient to protect the Company's interest in the Equipment.

9. CANCELLATION

Buyer cannot cancel orders placed with the Company, except with the Company's express written consent and upon terms and payment to the Company indemnifying the Company against loss, including but not limited to expenses incurred and commitments made by the Company.

10. LOSS, DAMAGE OR DELAY

The Company shall not be liable for loss, damage or delay resulting from causes beyond its reasonable control or caused by strikes or labor difficulties, lockouts, acts or omissions of any governmental authority or the Buyer, insurection or riot, war, fires, floods, Acts of God, breakdown of essential machinery, accidents, priorities or embargoes, car and material shortages, delays in transportations or inability to obtain labor, materials or parts from usual sources. In the event of any delay from such sources, performance will be postponed by such length of time as may be reasonably necessary to compensate for the delay. In the event performance by the Company of this agreement cannot be accomplished by the Company due to any action of governmental agencies, or any laws, rules or regulations of the United States Government, the Company (at its option) may cancel this agreement without liability. In no event shall the Company be liable for any loss or damage of any kind, including consequential or special damages of any nature.

11. WORK BY OTHERS: ACCESSORY AND SAFETY DEVICES

The Company, being only a supplier of the Equipment, shall have no responsibility for labor or work of any nature relating to the installation or operation or use of the Equipment, all of which shall be performed by Buyer or others. It is the responsibility of Buyer to furnish such accessory and safety devices as may be desired by it and/or required by law or OSHA standards respecting Buyer's use of the Equipment. Buyer shall be responsible for ascertaining that the Equipment is installed and operated in accordance with all code requirements and other applicable laws, rules, regulations and ordinances.

12. COMPLETE AGREEMENT

THE COMPLETE AGREEMENT BETWEEN THE COMPANY AND BUYER IS CONTAINED HEREIN AND NO ADDITIONAL OR DIFFERENT TERM OR CONDITION STATED BY BUYER SHALL BE BINDING UNLESS AGREED TO BY THE COMPANY IN WRITING. No course of prior dealings and no usage of the trade shall be relevant to supplement or explain any terms used in this Agreement. This Agreement may be modified only by a writing signed by both the Company and Buyer and shall be governed by the Uniform Commercial Code as enacted the State of Texas. The failure of the Company to insist upon strict performance of any of the terms and conditions stated herein shall not be considered a continuing waiver of any such term or condition or any of the Company's rights.

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

SAFETY

Here are some safety points to keep in mind when creating an efficient yet safe working environment.

Safety Definitions

Statements or labels in this manual or on the product preceded by the following words are of special significance:

Warning
Indicates severe personal injury or death will result if instructions are not followed.

Caution
Indicates a strong possibility of severe personal injury or death if instructions are not followed.

Important
Means hazards or unsafe practices which could cause minor personal injury or product or property damage.

Note
Gives helpful information.

Machinery is Dangerous

Machinery can hurt you if you are not careful. Use caution during assembly and operation of equipment.

ALWAYS:

- Read the entire manual first.
- Use common sense and be careful.
- Have enough manpower.
- Have the proper tools.
- Follow directions and illustrations.
- Check to see that all equipment meets applicable installation codes for your area as well as state and federal requirements.
- Have sufficient safety warnings on all equipment.
- Make sure all safety devices and guards are in place

Note:
The warning labels attached to the control panel, pumps, belt pulley guard, and access panels should be followed. They are shown in Figure 2-1, Figure 2-2, Figure 2-3, Figure 2-4, and Figure 2-5.

If all labels are not attached and visible or labels start to become illegible, contact Turbo Refrigerating Company immediately.

Turbo Refrigerating Company

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

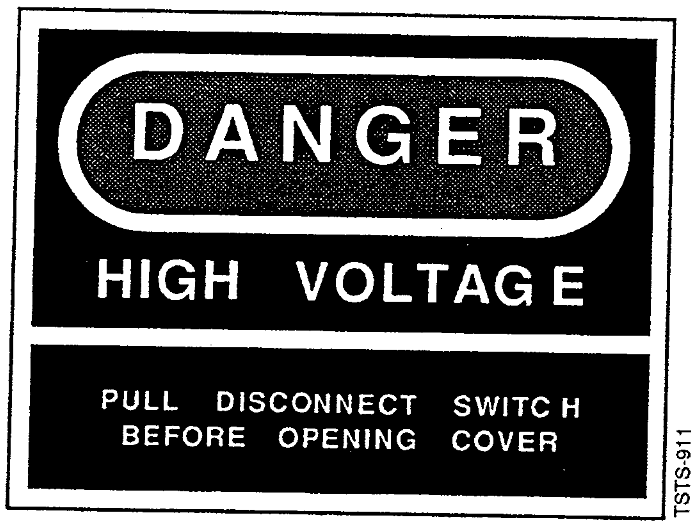


Figure 2-1 Warning Label on the Control Panel

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Involve Your People

Before operating equipment, have the people involved in the operating or maintenance of the equipment meet to discuss the dangers and safety aspects of the thermal storage equipment supplied by Turbo.

- Warn them of the danger of miscommunication.
- Turn electricity off and **lock it out** when working on the thermal storage equipment.
- Have a person trained and qualified in the operation of the equipment on duty to ensure that the electricity stays **locked out** to protect the personnel working on the equipment.

Figure 2-2 Warning Label on the Storage Tank Openings

WARNINGS

- The thermal storage unit is an automatic machine. When in operation, any and all motors may start without warning. Some motors may start even if the master control switch is in the "OFF" position. Never attempt to service the thermal storage equipment unless all electrical power is disconnected and **locked out.** Refer to Figure 2-1.
- The thermal storage system tank during normal operation may contain 32°F chilled water or an ice and water mixture.

ONE ON ALL ACCESS PANELS (ONE PER SIDE)

Figure 2-3 Warning Label on the Access Panels

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

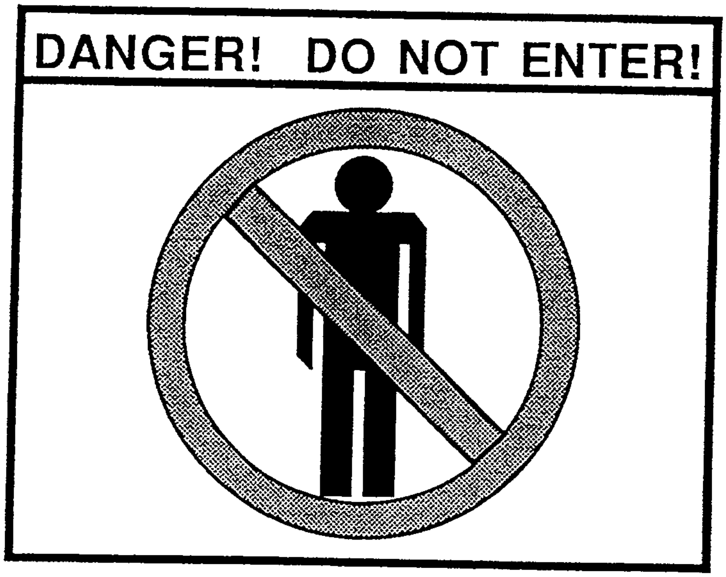


Figure 2-4 Warning Label on the Access to Thermal Storage Units and Tanks

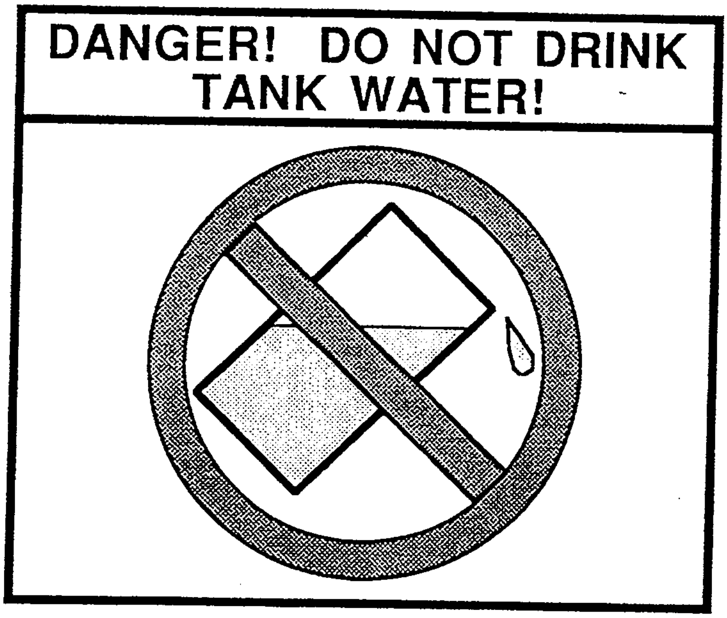


Figure 2-5 Warning Label on the Tank Access Opening

Exposure or immersion from falling into the storage tank could cause loss of consciousness and ability to function safely. Do not get into the tank. Refer to Figure 2-2.

- Storage tanks may be supplied with Turbo thermal storage units (optional). All openings into the tank should be locked and access limited to authorized personnel. If the tank is provided by others, ensure that access to the tank is restricted to authorized personnel. Refer to Figure 2-2.
- Although Turbo does not supply the water used to fill the storage tank, it may contain water treatment chemicals or other contaminants that may be harmful. Never drink or use the water for pottable purposes. Refer to Figure 2-5.
- Never enter the storage tank or engine compartment alone.
- All access doors on the unit should be kept closed at all times. These doors should also be locked and access limited to authorized personnel. Access to the tank can be obtained through these access doors. Refer to Figure 2-3.
- All ladders, catwalks, and platforms for the inside or outside of the tank and/or

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

access to the thermal storage unit must be constructed in compliance with all applicable safety codes. Access to these areas should be restricted to authorized personnel. Refer to Figure 2-4.

- Never work in the storage tank without adequate ventilation or when the thermal storage unit is operating. Falling ice and cold water exists in the unit making entry hazardous.

- Ice may remain on the plates when the thermal storage unit is off and may fall off unexpectedly. Never work directly under the evaporator plates without washing the plates down to remove any ice.

- Pull disconnect and lock **out** all electrical service before removing any guards, access panels, and/or covers.

- Never operate the unit without all guards, access panels, and covers in place and securely fastened.

- If leaks in the refrigerant piping require soldering or welding, be sure refrigerant is bled off and the system is open before attempting to repair. Protect eyes with the proper eye protection.

Evaporator only is not equipped with safety valves. To pressure limits are not exceeded, prior to operating the equipment end user must install a pressure relieving device that will limit a rise in pressure to not more than 110% of the MAP marked on the nameplate.

Adequate lighting should be provided for inspection and servicing of the equipment.

Adequate space should be provided around all equipment to allow safe access for inspection and service.

Always wear eye protection when cleaning the system or adding refrigerant or oil.

Do not expose insulation (polyurethane) to open flame. If ignited, it will give off highly toxic fumes. Leave the area and notify qualified personnel.

Use only recommended water treatment chemicals. Follow instructions and warnings supplied by the manufacturer of the water treatment chemicals.

Never open the control panel without disconnecting and locking out electrical service. All electrical work should be performed by a qualified electrician.

When servicing the thermal storage equipment, Turbo recommends that at least two (2) people be present at all times.

Note:

Per the OSHA Hazard Communication Standard, material safety data sheets for refrigerant and refrigerant oils are on pages 13-20.

- If an outside contractor is required to install or service your thermal storage equipment, require him to furnish you with a certificate of insurance before performing any work on your equipment. Turbo also recommends that the person hiring a contractor to perform work be satisfied with their experience and competence.

Keyed **Control Switch ***

A keyed switch is provided to control the thermal storage unit operations (on and off). To lock out the thermal storage unit controls:

1. Pull disconnect and **lock** out all electrical service.

2. Turn key selector switch (provided) to the "OFF" position.

3. Take key out and keep in your possession.

If you have **questions, call** Turbo **Refrigerating Company at:**

1-817-387-4301.

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Material Safety Data Sheet for Freon

A. General Information

TRADE NAME (COMMON NAME, SYNONYM):
Refrigerant 22, Freon 22, Genetron 22,
Fluorocarbon 22, CFC-22, R-22.

CAS NO.: 75-45-6
DOT NO.: UN 1018

CHEMICAL NAME: Chlorodifluoromethane or monochlorodifluoromethane

FORMULA: $CHClF_2$

MANUFACTURER'S ADDRESS: (MAILING)

Racon Inc.
P.O. Box 198
Wichita, KS 67201

(LOCATION)

Racon Inc.
6040 S. Ridge Road
Wichita, KS 67215

CONTACT:
Vice President of Manufacturing
(316) 524-3245 or
(800) 835-2916

ISSUE DATE: 11/18/85
REVISED DATE:

For Emergency Medical Information: Call Collect (415) 821-5338 (24 hrs.)

B. First Aid Measures

Inhalation --- Vapor contact --- primary route of exposure. If inhaled, remove to fresh air. Keep warm and at rest. If breathing is difficult (labored), give oxygen. If not breathing, give artificial respiration and check for pulse. If no pulse, start CPR (cardiopulmonary resuscitation). **Do Not** give stimulants (adrenaline, epinephrine or hand-held asthma aerosols). Call 911 (if available) and a physician. Keep patient at rest for 24 hours after overexposure. No long-term effects are expected.

Eyes and/or Skin ---
Vapor contact --- flush with fresh water for at least 20 minutes.
Liquid contact --- flush exposed area with lukewarm water or otherwise warm skin slowly. Frostbite is probable. Treat accordingly. Call a physician.

Ingestion --- Liquid --- not probable --- if ingested however, keep patient calm, if conscious, and get to a physician immediately --- frostbite is probable, indicated by necrosis of lips and tongue (contacted tissue), blanching of skin, pain and tenderness. Warm skin slowly.

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

C. Hazards Information

TOXICITY AND HEALTH

EXPOSURE LIMITS: TLV 1000ppm(vol) (8 hr. TWA) STEL 1250ppm(vol)

ACUTE EXPOSURE EFFECTS:

Inhalation --- CFC-22 is relatively non-toxic following acute exposure. Although no long-term comprehensive studies have specifically investigated acute overexposure of humans to CFC-22, experience indicates the cardiovascular and respiratory systems are the primary systems affected. Abuse (intentional inhalation) has caused death. Human exposure to high concentrations (e.g. 20%) may cause confusion, lung (respiratory) irritation, tremors and perhaps coma, but these effects are generally short lived and reversible without late aftereffects when removed to fresh air. LC_{50} values for rats and mice range from 277,000 to 390,000ppm(vol) over varying time periods of 15 minutes to 2 hours. High atmospheric concentrations of CFC-22 produce stimulation and then depression and finally asphyxiation.

Ingestion --- not probable, at atmospheric pressure, liquid CFC-22 boils at -41.4° F (-40.8° C). Freezing and severe frostbite of contacted tissue will result.

Skin --- contact of vapor CFC-22 with skin or eyes should not cause injury. Contact of liquid CFC-22 will result in freezing and frostbite of contacted tissue.

Note: Human Poisoning Potential --- Sniffing of fluorocarbon propellants for their intoxicating effects has produced over 100 deaths. Fluorocarbons exhibit very toxic properties (asphyxiation, cardiac arrhythmia) when sniffed; however, because of variations in response, it is difficult to predict which symptoms will be exhibited following exposure. It is possible that individuals with heart or respiratory disorders may prove especially susceptible.

SUBCHRONIC/CHRONIC EXPOSURE EFFECTS:

Overexposure by inhalation of various animals to 46,000ppm(vol) --- 50,000ppm(vol) of CFC-22 for 8 days to 10 months caused alterations in body weight and physiological endurance, and affected the lungs, central nervous system (CNS), heart, liver, kidneys and spleen. No information was found concerning effects on humans.

CARDIAC STUDIES:

CFC-22 inhaled at concentrations of 50,000ppm and above has been shown in tests on dogs to sensitize the heart to exogenous (outside the body) adrenaline, resulting in serious and sometimes fatal irregular heart beats (cardiac arrhythmias).

CARCINOGENIC POTENTIAL:

A lifetime inhalation study on rats and mice was performed by ICI, Ltd, (UK). The results from this test showed no effects on either rats or mice up to 10,000ppm(vol). At 50,000ppm (vol), CFC-22 was weakly carcinogenic to the oldest male rats (exhibiting a low incidence of fibrosarcoma in the salivary gland). The significance of this finding is questionable. No abnormal incidence was found in mice of either sex or in female rats at 50,000ppm(vol). No other findings of biological significance were made.

TERATOGENIC POTENTIAL:

Teratogenic studies on rats and rabbits showed an increased incidence of absence of eyes in rat fetuses at exposure levels of 50,000ppm. (CFC-22 exposure occurred from the 6th to 15th day of pregnancy). There was no effect on rabbits or their offspring at this level. There was no evidence of other overt fetal abnormalities.

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

FIRE AND EXPLOSION

Nonflammable and nonexplosive. One documented incident has been reported where an explosion occurred during the weld repair of a compressor shell which apparently contained a 50:50 mixture of air and CFC-22. At high temperatures (1170° F, 632° C) under favorable laboratory conditions, CFC-22 is capable of forming weakly combustible mixtures with air. Formation of combustible mixtures, under practical conditions, even at higher temperatures, is extremely unlikely and the fire hazards of CFC-22 are very small.

D. Precautions/Procedures

Do not breathe vapors. Avoid contact with eyes, skin and clothing. Wear protective clothing including goggles and cloth-lined rubber gloves. Not for food, drug or cosmetic use.

Store and use with adequate ventilation. Never use in a closed or confined space. Local exhaust may be necessary to reduce concentrations below TLV (1,000ppm). Store in cool place (<120° F).

When fighting fire near or involving this product, use self-contained breathing apparatus. If CFC-22 contacts open flames or extremely hot metal surfaces, it may decompose to form HF, HCl and traces of carbonyl halides (i.e., phosgene).

In the event of a spill or leak, keep upwind. Ventilate enclosed spaces until gas is dispersed. Do not smoke or operate internal combustion engines in immediate vicinity.

CFC-22 is shipped and stored as a liquefied, compressed gas under pressure.

E. Personal Protective Equipment

Respiratory protection is not needed if concentrations are controlled. If concentrations exceed TLV (1,000ppm), use an approved respirator for organic vapors. In very high concentrations, self-contained breathing equipment should be used.

Protective clothing should minimize exposed skin and include goggles, a full face shield if splashing is possible, and cloth-lined rubber gloves.

F. Physical Data

CFC-22 is a gas at normal conditions of 77° F (25° C) and 1 atm.
Molecular weight 86.5
Boiling Point (1 atm) -41.4° F (-40.8° C)
Vapor pressure @ 77° F (25° C) is 136.7 psig
Vapor density is 2.76 lb/ft^3 @ 77° F
Specific gravity of vapor (air = 1) 3.08 @ 1 atm and 77° F
Specific gravity of liquid (water = 1) 1.20 @ 77° F
% volatile @ 77° F and 1 atm 100% (vol)
Solubility in water (% wt) 3 gm/l
Soluble in acetone, ethanol and chloroform
Appearance --- colorless liquid and vapor
Odor --- very slight ethereal odor to odorless

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

G. Reactivity

CFC-22 is stable and relatively nonreactive. It is incompatible with certain elastomers, alkali or alkaline earth metals, powdered aluminum, zinc, beryllium, etc. The Manufacturing Chemists Association (MCA) reported, 1/4/67, that industry experience shows that alkali and alkaline earth metals (i.e., sodium, potassium and barium) in their free metallic form may react violently with fluorocarbons. The MCA also noted that since materials become more reactive when finely ground, metals such as magnesium and aluminum in the powdered form may also react, especially at high temperatures. CFC-22 may decompose into HF, HCl and carbonyl halides (i.e., phosgene) if contacted with open flame or extremely hot metal surfaces.

H. Environmental

No information found.

Disposal of waste material or residue may be subject to Federal, State or Local regulation. Consult with appropriate regulatory agency before discharging or disposing of waste material. Before transporting waste material, see U.S. publication 49 CFR Section 172.

I. References

American Conference of Governmental Industrial Hygienists (ACGIH), *Documentation of the Threshold Limit Values*, 4th Edition, 87-88 (1980).

Patty's Industrial Hygiene and Toxicology, 3rd Revised Edition, Vol. 2B: Toxicology, 3094 (1981).

Litchfield, M. and Longstaff, E., *The Toxicological Evaluation of Chlorofluorocarbon 22 (CFC-22)*, Fd Chem. Toxic, Vol 22, no. 6, 465-475 (1984).

Sand, J. and Andrijesk, D., *Combustibility of Chlorodifluoromethane*, ASHRAE Journal, 38-40 (May, 1982).

Meeks, R., unpublished review of publicly available literature, U. of Alabama — Birmingham (September, 1985).

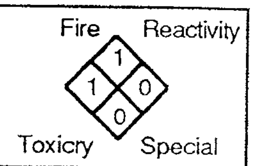
duPont, unpublished review, Haskell Laboratory (March, 1984).

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Material Safety Data Sheet for Suniso 3GS & 4GS

Product: Refrigeration Oil Suniso 3GS and 4GS

N	4 - extreme
F	3 - high
P	2 - moderate
A	1 - slight
	0 - insignificant



Section I.

Manufacturing Division or Subsidiary: Sonneborn Division

Address (Number, Street, City, State, Zip Code): P.O. Box 308 Gretna, Louisiana 70053

Emergency Telephone (Manufacturer): 1-504-366-7281

Chemical Name or Family: Refined Mineral Oil

Formula: A mixture of liquid hydrocarbons refined from petroleum.

Section II. Chemical and Physical Properties

Hazardous Decomposition Products: Upon combustion, CO_2 and CO are generated.

Incompatibility (Keep Away From): Strong oxidizing agents such as chromic acid, hydrogen peroxide and bromine.

List All Toxic and Hazardous Ingredients: None

Form: Viscous liquid

Odor: Petroleum

Appearance: Clear liquid

Color: Amber

Specific Gravity (water = 1): 0.91 @ 15.6° C

Boiling Point: >500° F (>260° C)

Melting Point: NA

Solubility in Water: Insoluble

% Volatile (by weight %): Negligible

Evap. Rate: Negligible

Vapor Pressure (mm Hg at 20° C): <0.0001

Vapor Density (air = 1): >10

pH As Is: NA

Strong Acid ☐
Strong Base ☐
Stable ☒
Unstable ☐

Viscosity Sus at 100° F: <100 ☐ 100 or > ☒

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Section III. Fire and Explosion Data

Special Fire Fighting Procedures: Wear self-contained breathing apparatus. Water spray is an unsuitable extinguishing agent.

Unusual Fire and Explosion Hazards: None

Flash Point (Method Used): ASTM D-92 >300° F (>150° C)

Flammable Limits %: NA

Extinguishing Agents:

- [X] Dry Chemical
- [ ] Waterspray
- [X] Waterfog
- [ ] Other ______
- [X] CO_2
- [X] Foam
- [X] Sand/Earth

Section IV. Health Hazard Data

Permissable Concentrations (air): 5 mg/m^3 mineral oil mist (OSHA).

Effects of Overexpose: Prolonged contact may cause minor skin irritation.

Toxicological Properties: NDA

Emergency First Aid Procedures:

Eyes:	Flush with large amounts of water for at least 15 minutes. If redness or irritation persists, contact a physician.
Skin contact:	Wash with soap and water. Wash clothing before reuse.
Inhalation:	None normally required.
If Swallowed:	Call a physician.

Section V. Special Protection Information

Ventilation Type Required (Local, Mechanical, Special): NA

Respiratory Protection (Specify Type): NA

Protective Gloves: Oil resistant rubber

Eye Protection: Chemical splash goggles

Other Protective Equipment: Rubber apron

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Section VI. Handling of Spills or Leaks

Procedures for Clean-up:

Stop leak, dike up large spills. Use inert absorbent material such as earth, sand, or vermiculite for clean-up.

Waste Disposal:

Dispose of in accordance with Local, State, and Federal government regulations.

Section VII. Special Precautions

Precautions to be Taken in Handling and Storage:

Avoid exposure to heat and flame. Protect against eye and skin contact. Wash thoroughly after handling.

Section VIII. Transportation Data

Unregulated by D.O.T. [X]

Regulated by D.O.T. [ ]

Transportation Emergency Information: CHEM TREC 1-800-424-9300

U.S. D.O.T. Proper Shipping Name: NA

U.S. D.O.T. Hazard Class: NA

I.D. Number: NA

RQ: NA

Label(s) Required: NA

Freight Classification: Petroleum Oil NOIBN

Special Transportation Notes: NA

Section IX. Comments

CAS #64742-52-5

Signature: ______________________

Telephone: ______________________

Revision Date: ______________________

Supersedes: ______________________

Title: ______________________

Date: ______________________

Sent To: ______________________

Turbo believes the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind, express or implied, and we assume no responsibility for any loss, damage, or expense, direct or consequential, arising out of their use.

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

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Safety Lockout Procedure
Effective November 1, 1989

I. Purpose

The purpose of this procedure is to prevent injury and/or death to personnel by requiring that certain precautions be taken before servicing or repairing equipment. It has been developed and implemented so as to comply with 29 CFR 1910.147, of the Occupational Safety and Health Act, as amended.

These precautions include:

1. Shutting off and locking out electrical power.
2. Releasing pressure in pneumatic and hydraulic systems.
3. Effectively isolating those portions of equipment and machinery that are energy intensive and are being serviced or maintained.

II. Scope

This procedure includes those employees whose duties require them to do maintenance work on power-driven equipment. It covers the servicing or maintenance of machines or equipment in which the unexpected energization, start-up or release of stored energy could cause injury.

III. Supervisory Responsibility

It is the responsibility of all supervisors having contact with such operations to:

A. Instruct all affected employees as to the content of this program.

B. Ensure compliance with this procedure.

IV. Safety Locks

Safety locks and keys will be issued to designated employees. Locks and keys must be returned to the plant manager when an employee transfers to another assignment or terminates his employment. Safety and supervisory personnel shall have access to master keys for protective locks, and under certain controlled conditions, be available to assist in the removal of safety locks.

Safety locks are painted yellow for electricians and red for maintenance personnel. These locks are to be used only for locking out machinery, tooling, and equipment described in this procedure.

V. Safety Department Responsibility

It is the responsibility of the Safety Coordinator to inspect the plant on a periodic basis to ensure compliance with this procedure. If it is determined that this procedure is not being complied with, immediate corrective action will be initiated. Wherever possible, such action will be taken in conjunction with the first-line supervisor; however, higher level management personnel will be involved if the violation is of a serious or repetitive nature.

VI. Rules and Regulations

The following rules and regulations have been established and are mandated:

A. Any electrician or maintenance person whose duties require that he or others be exposed to the hazards of electrical shock or moving equipment, must perform those duties in a safe and uncompromising manner. The following steps outline such precautions:

1. The employee must understand the equipment with which he is working and its hazards.

2. When working with electrical equipment where the accidental starting of such equipment or release of stored energy would create a hazard, the employee <u>must turn off all power to the unit or use energy isolating devices and ap</u>

WARNING! Read this section first. Failure to carefully follow these instructions could result in permanent injury or loss of life.

ply his personal lock, and have the supervisor of that area apply his personal lock. At all times when maintenance is being performed on our equipment, that equipment will have 2 locks on it, one by the person performing the maintenance plus the one of the supervisor.

3. In instances where multiple circuits are in a circuit breaker box, an attaching mechanism will be placed on the outside of the box to allow that box to be locked out and prevent the door from being opened.

B. Each employee who performs the duties prescribed above will be provided with an individual safety lock and one key. If more that one employee is assigned to a task, each employee is required to place his own lock and tag so the controls cannot be operated, even though another person may have completed his own task, and remove his own lock.

C. If the equipment controls are so located that only one lock can be accommodated, a special attachment that accommodates several locks must be used. This attachment will be issued to all designated employees.

D. Should an employee be required to work on another piece of equipment and need to leave his lock on the present equipment, another lock must be obtained from the plant manager.

E. Should it be necessary to operate a piece of equipment which is locked out, every effort should be made by supervision to locate the employee whose lock is on the equipment. If that employee cannot be located, the supervisor may obtain a master key for the lock. The supervisor must personally assure himself that it is safe to remove the lock. The lock should than be returned to the proper employee.

This procedure must be used with extreme caution and good judgement. There is danger that the employee involved will return thinking that the machine is still locked out, when it has actually been turned back on.

F. If a machine is locked out and it is necessary to leave the area, recheck the lock upon returning to make sure that the machine is still locked out. While supervision will make every attempt to avoid the removal of locks, there may be situations when it must be done. This recheck is for your protection.

G. It is sometimes necessary to operate equipment for purposes of testing or making adjustments prior to the actual completion of the work. It is recognized that electricians must work on live circuits from time to time, particularly when trouble-shooting, but extreme caution must be used under these circumstances. Never work alone when changing live wiring.

VII. Outside Contractors

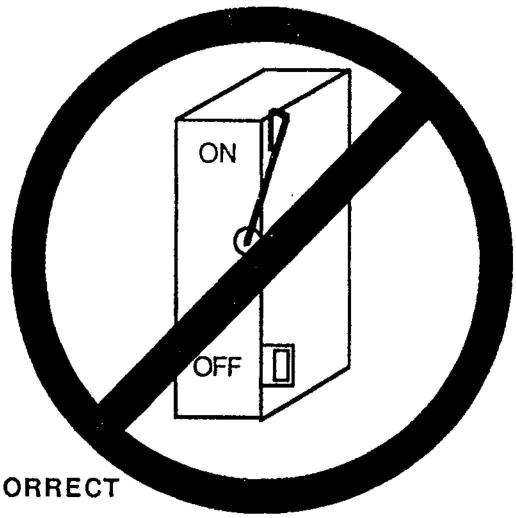
Whenever outside servicing personnel are to be engaged in activities covered by the scope and application of this lockout and tag procedure, such personnel are to be informed of this procedure by the person responsible for their work activity and are to direct them to follow its requirements. Failure to do so shall require that they do not be permitted to continue working in the plant.

VIII. Failure To Follow Procedures

These procedures have been developed to protect employees from serious injury. It is necessary that all employees follow them. Those employees not complying with the provisions in this procedure will be subject to disciplinary action, up to and including discharge.

DISCONNECTING POWER & LOCK OUT

Turbo Refrigerating Company insists that **disconnecting** and **locking out** the power to the motor driving the unit provides the only real protection against injury. Other devices should not be used as a substitute for **locking out** the power prior to removing guards, covers, or other safety devices. Turbo warns that the use of secondary devices may cause employees to develop a false sense of security and fail to **lock out** power before removing guards, covers, or other safety devices. This could result in a serious injury should the secondary device fail or malfunction.



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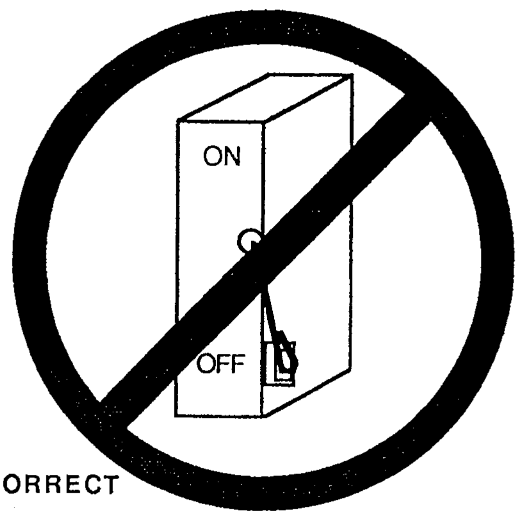

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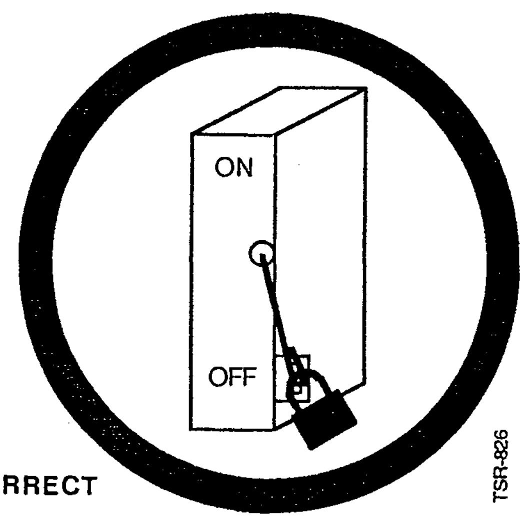

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TSR-826

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

INSTALLATION & PRE-START-UP REQUIREMENTS

To install and prepare the Turbo thermal storage unit for operation, you will need two to four people whose skills include mechanical, welding, and plumbing capabilities as well as a qualified electrician.

This section includes instructions on site preparation, installation, and connection of your thermal storage unit. Your thermal storage unit has been tested and inspected at the factory prior to packing and shipping. The general installation sequence is as follows:

1. Site Preparation
2. Delivery Inspection
3. Hoisting or Moving
   A. Ice Generator
   B. Storage Tank
4. Mounting and Leveling
   A. Storage Tank
   B. Ice Generator
5. Storage Tank and Ice Generator/Chiller Access Openings
6. Refrigerant Piping
7. Electrical Connections
8. Water Connections
9. Aligning Reciprocating Compressors and Motors
10. Testing Refrigeration System for Leaks
11. Evacuating the System
12. Charging the Unit with Refrigerant Oil
13. Refrigerant Charging
14. Air-Cooled Condensers
15. Evaporative-Cooled Condensers
16. Water-Cooled Condensers
17. Pre-Start-Up Checklist
18. Start-Up Checklist

IMPORTANT

Pay special attention to any bold print or boxed in paragraphs. Following this information is essential for a safe, efficient installation and operation.

To Help You Get Started

- Read instructions completely before installation.
- Gather all required tools.
- Establish front and rear, and left and right of the thermal storage unit by facing the motor/compressor and evaporator sections (see Figure 3-1).
  - On the right is the motor/compressor control panel section of the thermal storage unit.
  - On the left is the evaporator section control panels of the thermal storage unit.
  - Access doors are located on the front of the evaporator section.
  - Access panels are provided on the end, back, and top of the evaporator section.
  - Optional panels are available for the engine compartment end, front, back, and top (required for outdoor installations).

Use this method when referring to parts that are left, right, front, or rear.

Helpful Hints

- The refrigerant piping and valves for the evaporator are located behind the access doors on the front of the unit.
- Adequate space must be left around all sides, ends, and the top of the evaporator for service access.
- Do not run piping and/or conduit across the top of the unit (that will limit the ability to remove the roof panels for access to the water distribution system).
- Check the location of all connections before setting the unit in place.
- **Always remember - SAFETY FIRST !!!**

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

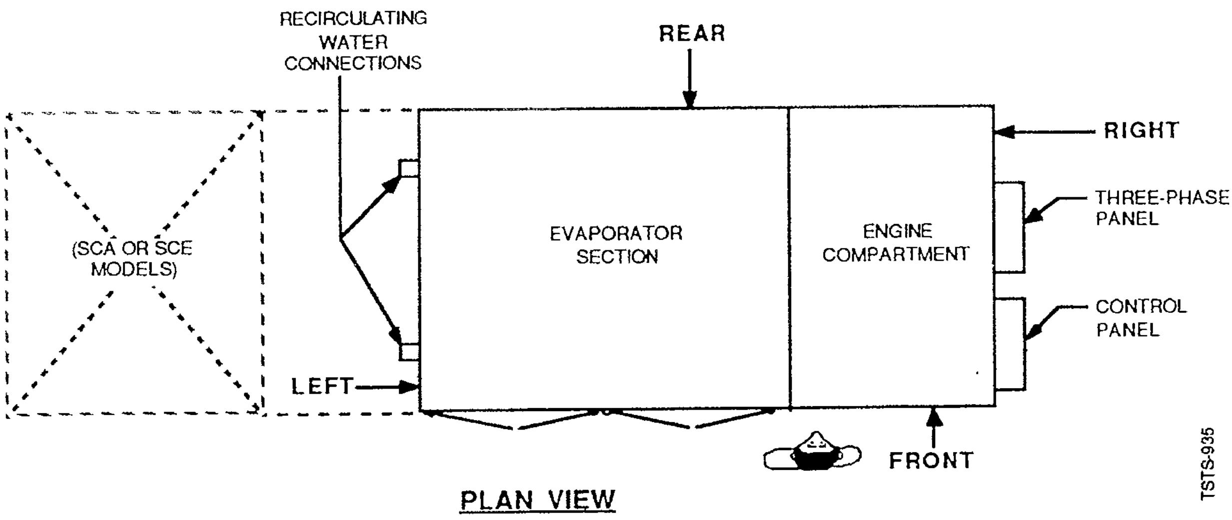

Figure 3-1 Typical Thermal Storage Unit Layout

Notes:

1. On SCA and SCE models, the air-cooled or evaporative-cooled condenser is mounted on the left end of the unit on a common skid with the thermal storage unit.

2. The electrical panels are normally supplied on the right side of the unit.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

TOOLS

To install the thermal storage unit, you will need two to four people whose skills include mechanical, welding, and plumbing capabilities as well as a qualified electrician. The following is a list of tools required for safe erection and assembly of the thermal storage unit:

- Wrenches and sockets (a full set up to 1 1/8")
- Phillips (not cross-point) and standard (slotted) screw drivers
- Level (four feet long)
- Tape measure (fifty feet long)
- Pry bar
- Chain hoists (one ton) or two "come alongs" (1000#)
- Allen wrenches (sizes 1/8" to 1/2")
- Chains (two - 3/8 inch, minimum - ten feet long)
- Arc welder
- Amp probe
- Voltage tester
- Continuity tester
- Framing square
- Forklift or crane
- 8" and 12" adjustable wrench
- Channel-lock pliers
- Needle-nose pliers
- Wire cutter and stripper
- Hand operated refrigerant oil pump
- Portable vacuum pump
- Magnetic mount dial indicator (compressor alignment)
- Refrigerant gauge manifold set with hoses
- Oxy-acetylene brazing set-up with various brazing and cutting tips (primarily for SCAR and SCER models where field installation of refrigerant piping is required)

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

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1. SITE PREPARATION

IMPORTANT

Next to the selection of the proper equipment for the applications and load requirements, the most important pre-delivery task is the job site preparation for the installation of the thermal storage equipment.

Installations utilizing concrete storage tanks fabricated at the job site must ensure that location and construction of the tank is dimensionally and structurally compatible with the thermal storage unit, water recirculation system, and overall system requirements. The use of optional Turbo steel storage tanks also requires that proper concrete pads, working space, and connection access be provided.

The following guidelines should assist in properly preparing for installation of the Turbo supplied equipment. Questions concerning site preparation should be discussed with a qualified Turbo distributor or Turbo application engineer.

Location

The thermal storage equipment may be installed indoors or outdoors. See general requirements for each installation below. Outdoor installations require optional engine compartment panels.

Indoor Installation General Requirements

- Access by a forklift or overhead hoist should be provided to the equipment room for removal of large components such as compressors and motors.
- Install the thermal storage unit in an area where the ambient temperature does not fall below 40°F or rise above 100°F. The evaporator (freezing) compartment of the unit is insulated against excessive heat infiltration. The machinery compartment is designed to provide ventilation for the machinery and motors. Auxiliary heating may be required to maintain the equipment above 40°F during shut-down to prevent damage to components containing water.
- Ventilation of the room is required to remove the heat generated by the motor/compressor assembly, and refrigerant in case of a refrigerant leak.
- If located next to offices or residential areas where noise may be objectionable, consideration should be given to noise abatement in the equipment room.
- Adequate water supply and drainage must be available. Refer to step 8. Water Connections on page 63.
- Control of water inside the room (resulting from water supply line rupture) should be considered.
- Adequate lighting for service work:
  - Around the top of the unit for cleaning the water distribution system.
  - In front of the evaporator access doors for valve adjustment and observation of unit operation.
  - Above and around the engine compartment to check operation and observe compressor crankcase oil levels.
  - Above and around the electrical control panel and three-phase panel.

Note:
The National Electric Code requires a minimum of 36" clearance in front of the electrical enclosures. State or local codes may require additional clearance. The contractor is responsible for ensuring that all equipment is installed in accordance with all local, state, and national codes.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

- Adequate access to the storage tank should be provided for service and inspection. Provide means of locking access doors.
- Access to recirculating pumps and clearance for removal of the pumps (such as vertical turbine pumps) should be provided.
- Proper storage tank suction headers and/or suction screens should be provided to prevent clogging of the pump impeller and water distribution system. Good suction piping ensures proper water distribution and ice burn-off in the tank.
- Adequate space should be allowed on all sides and the top for cleaning and service.

Note:
HP models require a minimum of 36" on the front to allow for the swing of the access doors. IGC models require 48" minimum clearance. Turbo recommends a minimum 36" clearance around all other parts of the equipment for service and maintenance access. The water distribution system located in the top of the evaporator section requires 36" minimum clearance for cleaning.

- Provisions for interfacing thermal storage equipment with equipment or components located outside the equipment room (remote condensers, heat exchangers, etc.) should be provided.
- Provisions for routing safety relief valve vent lines to safe discharge location(s) should be provided.

Outdoor Installation General Requirements

In general, the same requirements exist for outdoor installations as indoor installations. In addition, the following factors and requirements should be considered for outdoor installations:

- Covers should be provided over the electrical control panel and three-phase panel to prevent direct exposure to sunlight. Overheating of the electrical panels could result.
- Provisions should be made for either permanent or temporary covering of the engine compartment and/or evaporator section during all types of weather including rain, sleet, snow, and gusting winds so that service and routine maintenance can be performed without regard to outside conditions.
- Optional engine compartment panels are required for outdoor installations.
- A source of heat may required for receivers to ensure that adequate pressure can be maintained in the vessel during low ambient start-ups.
- A source of heat will be required for all vessels, pumps, or components containing water to prevent freeze-up during shutdown in low ambient (below 40°F) conditions.
- Provisions must be made for access to the equipment with fork lifts, cranes, or other service equipment during all types of weather conditions (i.e. paving up to equipment when surrounding area is muddy, etc.).
- Access to ladders, stairways, and tank tops should be limited during icing or other inclimate conditions, which could result in personal injury due to hazardous and slippery conditions.
- Adequate fencing should be provided around installation to prevent access by unauthorized personnel.
- Adequate warning labels and signs should be provided around the equipment installation (refer to section 2. Safety on page 9) to limit access by authorized personnel only.

Concrete Slab

If the thermal storage tank is to be mounted on a concrete slab, the surface of the slab must be level to within 1/4" or shimming must be provided under the tank to ensure that it is level and properly support-

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

ed. When shimming is required, use caution to prevent long unsupported spans under the structural base frame of the tank or unit. See grouting guidelines on page 43.

IMPORTANT

Failure to follow these guidelines could result in excessive equipment vibration or uneven water distribution over the evaporator plates.

When preparing the slab or tank top, it may be desirable to embed steel plates or anchors in the concrete to secure the tank or unit in place after it is set. Refer to Figures 3-2, 3-11, and 3-12.

Tank and unit details for each model are available from Turbo to allow placement of metal inserts to match the structural base frame. No part of the unit or tank base frame should be cantilevered or unsupported. Refer to Figure 3-3.

Raised Curbing

A raised curbing around the outside of the thermal storage unit tank top and storage tank pad is recommended to contain any condensate, leakage, or cleaning fluid from the unit or tank. To determine maximum curbing height, check the clearance between the bottom of the unit doors and bottom of the structural base frame. A maximum curbing height of 3/4 inch is all that would be needed. This height would clear the doors on all standard units. Refer to Figure 3-2 and step 4A. Mounting and Leveling - Storage Tank on page 41. The lowest point of curbing must be at least a 1/4" above the highest point of the tank top.

Elevated Installation

Some installations require mounting the thermal storage unit on a storage tank mounted above grade. The tank should be mounted on a properly designed concrete pad as described previously. In some cases (particularly SCE and SCA models), the structural base of the thermal storage unit may extend beyond the tank as shown in Figure 3-3. This type of installation should be avoided if possible.

IMPORTANT

On installations of this type, never leave the overhang frame unsupported. A structural steel platform capable of supporting the dynamic as well as static load must be provided.

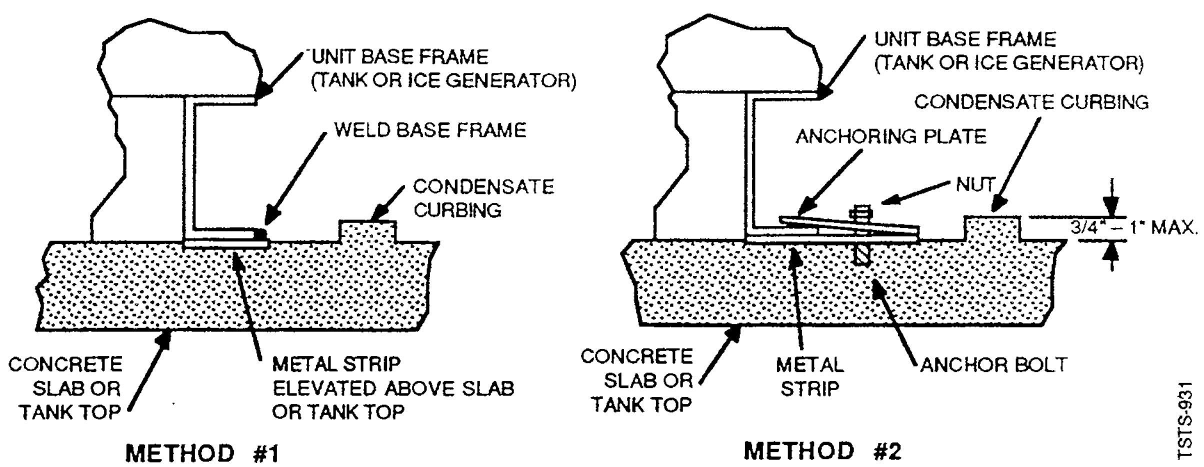

Figure 3-2 Typical Concrete Slab Detail - Tank To Concrete Slab

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

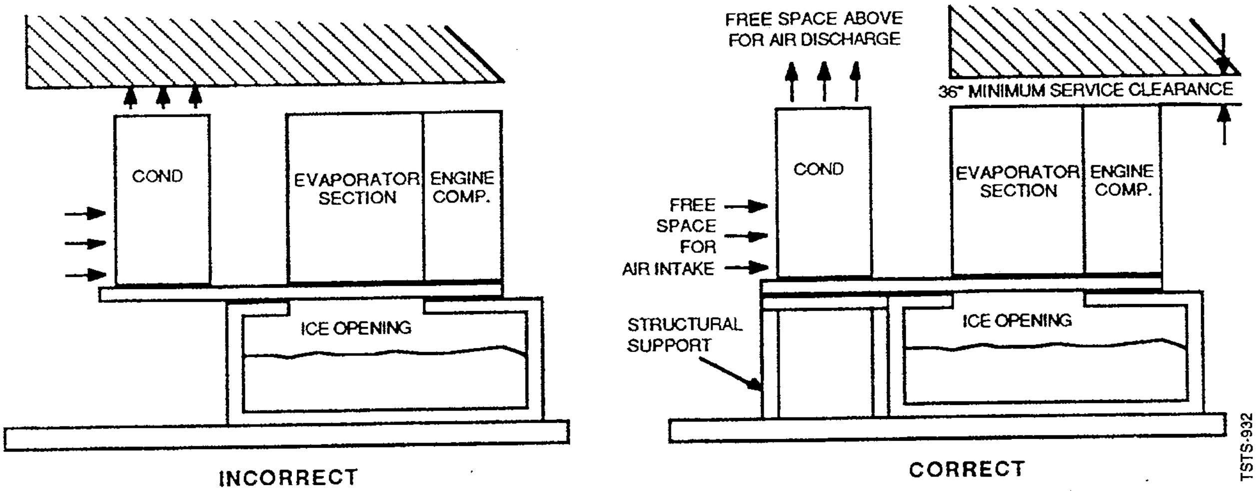

Figure 3-3 Elevated Installation With Overhang Frame

Due to variations in local and state codes, a local firm specializing in structural steel should be consulted to determine the requirements for the steel to be erected. Turbo can be contacted for information required by the local firm to provide the steel platform. The steel supporting the unit must be level or shimmed to obtain a satisfactory level. The guidelines for unsupported sections apply for installations using steel and concrete tanks. Refer to Figure 3-3 and Figure 3-4. A concrete structure may also be used to support the overhang frame or structure.

Access, Service, and Air Space

In laying out the unit installation, adequate space should be allowed around the unit for access and service. Particular attention should be given to the engine compartment end of the thermal storage unit. Removal or service of larger, heavier components (condensers, compressors, etc.) may require access by a forklift or other lifting devices which require additional space.

On air-cooled condensers, evaporative condensers, and cooling towers, adequate space must be allowed for air intake and air discharges to prevent insufficient air supply or recirculation of discharge air.

Vapor flumes created by condensation of moisture in the discharge air streams of evaporative condensers and cooling towers during certain operating conditions should also be considered to avoid aesthetic problems around the building due to visibility of such flumes.

Space must be allowed for electrical disconnects and load centers near the equipment and for conduit runs from the load center to the equipment.

Water Supply

Thermal storage systems require a water charge of 60 to 75% of the storage tank volume. Some systems will require several thousand gallons of water. Inadequate water supply lines may result in excessive time required to fill the tank.

Before the equipment installation begins, an adequate supply of water must be available to clean and charge the storage tank as well as to supply remote equipment such as cooling towers, evaporative condensers, and oil coolers with sufficient water flow and pressure.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Most cooling towers and evaporative condensers require 40 psig water pressure at the make-up water connection for continuous operation.

Water piping from cooling towers to the water-cooled condenser in SC models must be properly sized to deliver the specified flow and pressure. The cooling tower pump must be sized for the proper flow at the total head of the system including pressure drop in the supply line, piping, and condenser, plus the static head resulting from installation of the thermal storage equipment above the cooling tower. Refer to step 16. Water-Cooled Condensers on page 93 for details.

Evaporative condensers also require a continuous source of make-up water during operation.

Drain Connection

Cleaning of the tank prior to charging with water is essential. Water may be used to wash down the walls of the tank and for piping to the water distribution system and external devices such as air handlers. Although the water in the storage tank is not pottable, every effort should be made to keep the tank and all related piping as clean as possible to prevent fouling of the icemaker evaporator plates, heat exchangers, and water distribution system.

To obtain the proper cleaning of the tank, it will be necessary to drain the water from the tank during clean-up and possibly during start-up of the equipment due to debris returning to the tank from the building recirculating water piping. Provisions must be made for draining and refilling the tank in a reasonable time.

A strainer should be provided by others in the return water line to prevent the return of debris to the storage tank.

Water Filtration

Cleanliness of the storage tank, recirculating water system, building water system, and heat exchangers is essential for maximum efficiency and utilization of the equipment without unnecessary maintenance. It is recommended that permanent water filtration be provided in the piping of the water recirculation system. The filtration should be capable of removing all water borne solid particulate matter larger than 25 microns in size.

Installation of the filtration should be made in a location suitable for regular periodic cleaning and/or replacement. Inspection and cleaning is essential during start-up and the first 100 hours of operation.

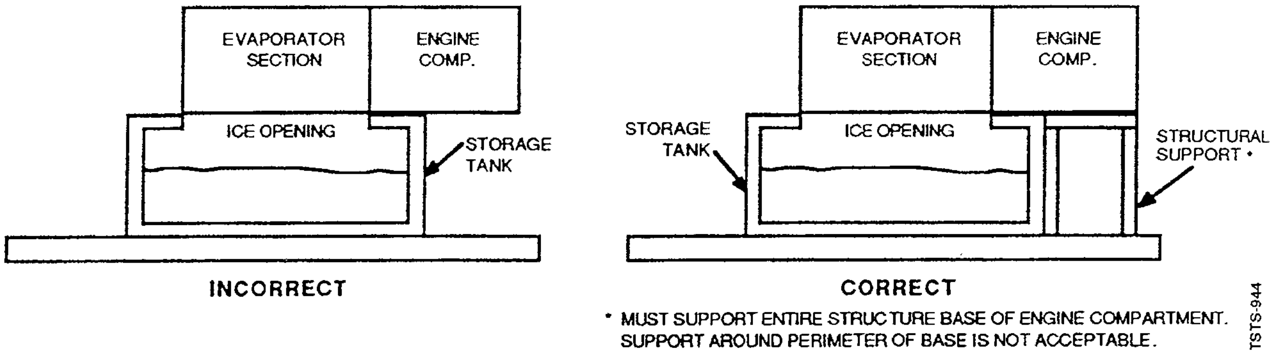

Figure 3-4 SC Unit With Overhung Engine Compartment

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

In typical installations, a sand filter will provide adequate filtration. Provide a filter in the building return water line. A filter in the recirculating water line is also recommended.

If water borne solids with attendant maintenance of the filtration system continues beyond the first 100 hours of service, the system should be checked to determine the source of the contaminants. It may be necessary to contact a water treatment specialist. Operating personnel should also observe the water in the tank for floating debris and changes in the water level.

Publications

The Electric Power Research Institute (EPRI) Water Treatment Manual (Reference Appendix) and the Turbo Operation and Installation Manual should both be reviewed by the installing contractor and operating personnel prior to installation of the water system and water system charge.

Water Treatment

All thermal storage units should be supplied with strainers (by others) in the recirculating water pump line and building chilled water supply line to remove solids and material large enough to plug openings in the distribution system(s).

Consult a local water treatment company to determine if additional water treatment or filtration is required to produce the desired ice quality, reduce maintenance of the water distribution system, and prevent contaminants that may prevent proper operation of the equipment. Extremely hard water will tend to make cloudy, softer ice and leave deposits within the machine necessitating frequent cleaning. Water supplies in various parts of the country are unique in terms of acidity, solid content, and chemistry that may affect the water system.

Consultation with a qualified water treatment company can identify the needs for your system. After start-up, water samples should be taken regularly to evaluate biological, bacteriology, or other contaminants that may result from operation of the system.

Highly chlorinated water should be avoided during operation or cleaning due to the highly corrosive effect on all materials including stainless steel.

Refer to section 6. Maintenance on page 166 for guidelines on cleaning evaporator plates, water distribution pans and headers.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

2. DELIVERY INSPECTION

All self-contained thermal storage units are thoroughly inspected and tested at the factory to assure shipment of a mechanically sound piece of equipment.

Inspect the thermal storage unit thoroughly upon arrival at the installation site to check for any shipment damage.

Report any damage to the transportation company immediately so that an authorized agent can examine the thermal storage equipment, determine the extent of the damage, and take the necessary steps to rectify the claim without costly delays. Notify Turbo of any claims made.

Turbo ice generators are shipped on "air-ride" trailers to ensure that the equipment arrives in the best possible condition. Tanks and accessory equipment are shipped by common carrier.

Delivery Inspection Checklist

Panels

- Inspect all panels for damage.
- Check hardware on panels and door hinges.
- Check all door handles.
- Check roof panels and roof panel sealing strips.
- Make sure all panels and doors are on the equipment or shipped loose with the equipment.

Loose Equipment and Crates

- Open all crates and boxes shipped with the unit.
- Verify all loose parts and crates versus components listed on packing slip.
- Check all components, boxes, or crates for damage.

Evaporator Plates

- Check the mounting of the evaporator plates on the mounting channels for loose or damaged plates.
- Check the water distribution pans and PVC distribution headers on top of the evaporator plates for damage and proper attachment to the plates.

Valves and Piping

- Check for broken or damaged tubes and piping in the evaporator and engine compartment.

Connections to Equipment

- Check all electrical connection stubs for damages.
- Check all water connection stubs for damages.
- Check all refrigerant connection stubs for damages.
- Note location of all connections and verify against data sheets.

Warning Labels

- Check that warning labels are in place (refer to section 2. Safety on page 9) and that an installation manual is available at the job site.
- If labels are not in place or a manual is not available at the job site, contact Turbo Refrigerating Company immediately:

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Lifting Lugs/Pipes

- Check that lifting lugs and pipes are in place and in proper condition for lifting equipment.
- On optional storage tanks, check the location and condition of all lifting lugs and pipes.

WARNING

Do not attempt to hoist equipment if lifting devices are damaged or missing. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Turbo Nameplate

- Locate the Turbo nameplate on the electrical control panel of the thermal storage unit(s) and record all of the information for future reference.
- The Turbo serial number (located on the nameplate) should be referenced in all inquiries to Turbo.
- Remote equipment (condensers, etc.) and optional storage tanks will have the same serial number as the ice generator.

Note:
If the remote equipment or storage tanks are purchased separately, they will have a separate nameplate and serial number.

Equipment

- Check equipment ordered versus the purchase order and Turbo sales acknowledgement form. Report any discrepancies to Turbo Refrigerating Company immediately.

IMPORTANT

Turbo will provide guidelines and advice relative to sizing, configuration, etc. of remote equipment supplied by others with prior written notice of equipment detail. Turbo assumes no liability for proper sizing or installation of equipment, supplied and installed by others. Turbo will not assume responsibility for proper interfacing, capacity, or installation of remote equipment by others.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

3A. HOISTING OR MOVING - ICE GENERATOR

Equipment Rigging Instructions

The thermal storage unit must be lifted by the lifting lugs provided by Turbo. Please note that these lifting lugs are not intended to be used for extended lifting periods. Depending on the orientation of the lifting lugs, the use of a spreader bar and blocks may be required to protect the exterior panels. In some cases, removal of certain exterior panels during the rigging operation may be required.

Figure 3-5 shows the configuration with lifting lugs on the thermal storage equipment ends. This configuration is normally used on smaller thermal storage units. The use of blocks and spreader bars are required to avoid damage to the cabinetry.

Figure 3-6 shows the lifting lug arrangement used on larger thermal storage units. The lifting lugs may be used by running a sling through the 3" pipes which run through the units.

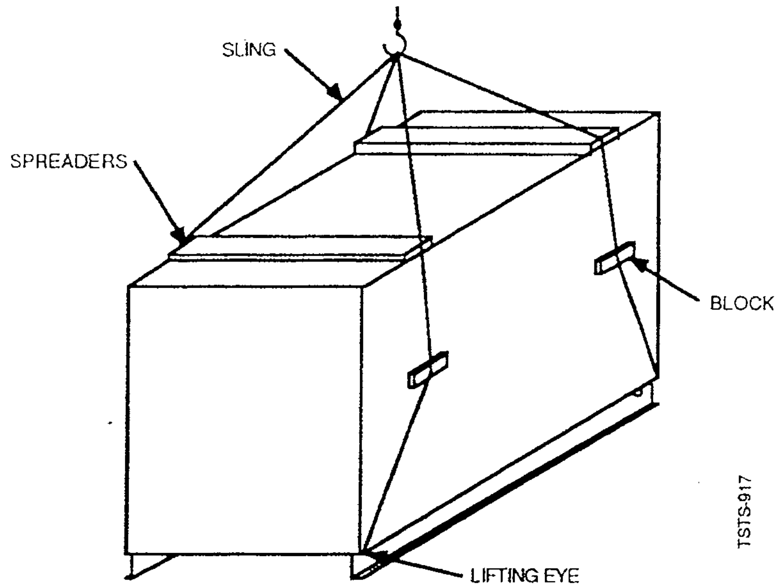

Figure 3-5 Small Thermal Storage Unit Configuration

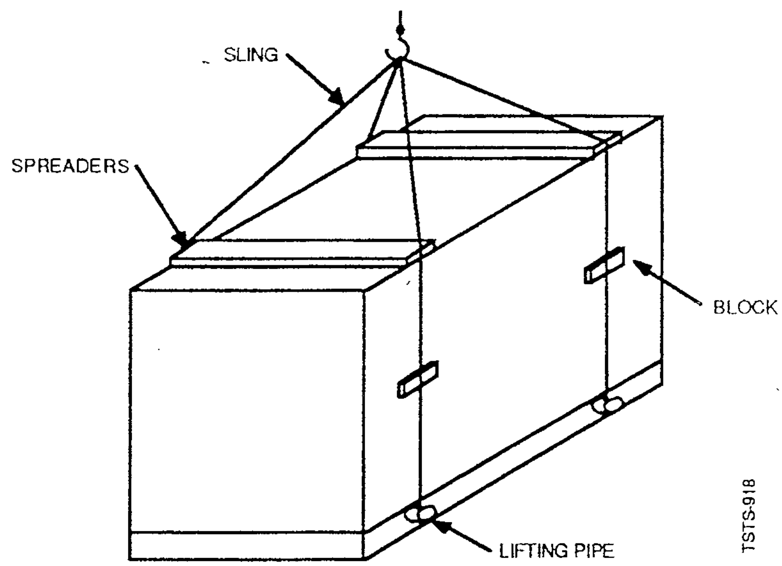

Figure 3-6 Large Thermal Storage Unit Configuration

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Figure 3-7 shows a thermal storage unit and a condenser mounted on a common skid. The lifting method is similar to that of Figure 3-6, with both spreader bars and blocks being required.

Figure 3-8 shows a larger thermal storage unit requiring middle support during lifting. Additional lifting lug(s) will be provided as required for proper rigging.

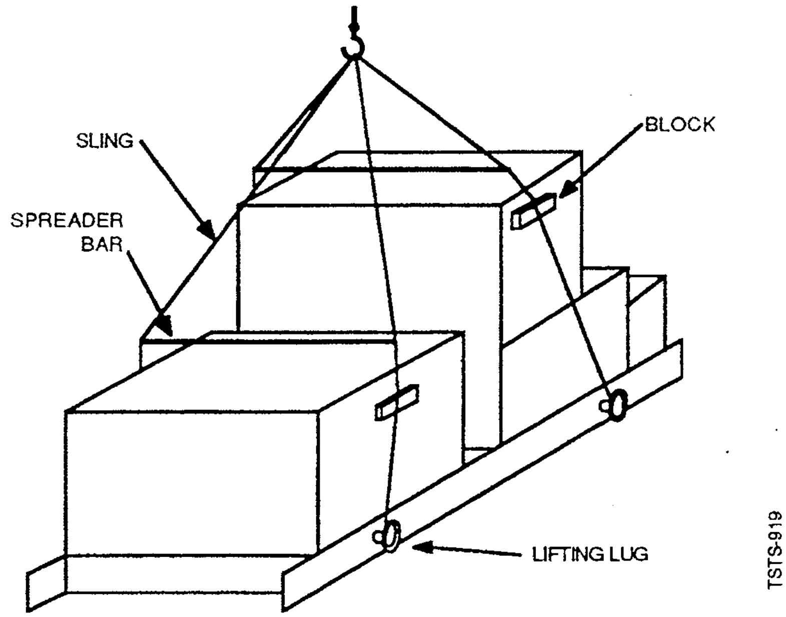

Figure 3-7 Common Skid

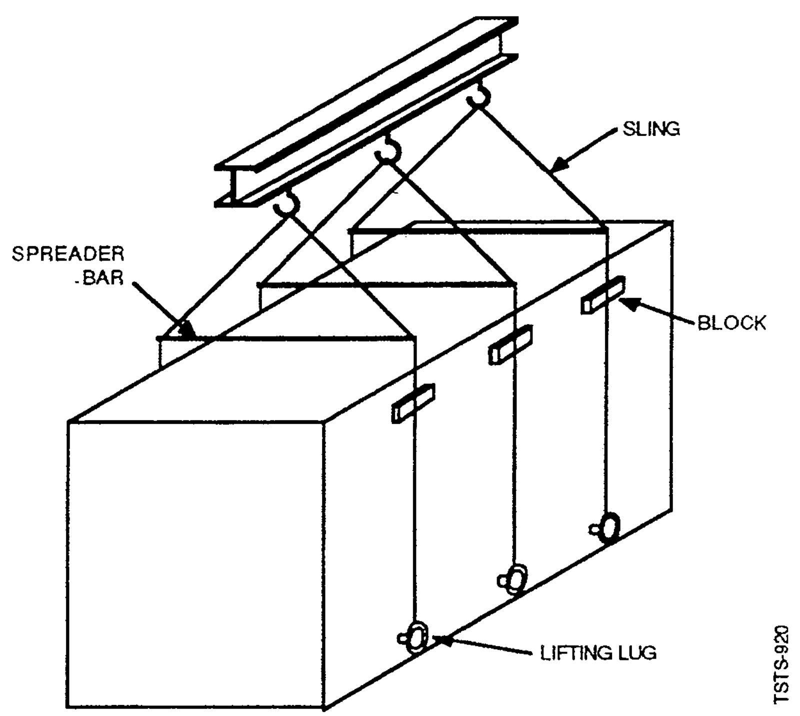

Figure 3-8 Larger Thermal Storage Unit With Middle Support

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Figure 3-9 shows a typical thermal storage unit with an air-cooled condensing unit. This configuration is typical of SCA and SCE models. Multiple spreader bars and blocks are required.

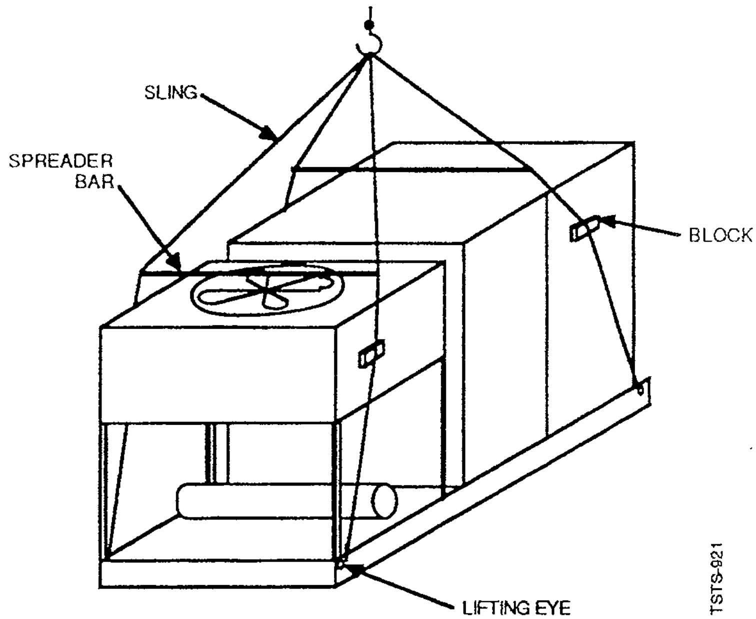

Figure 3-9 Thermal Storage Unit With An Air-Cooled Condensing Unit

Hoisting or Moving

If a thermal storage unit is installed in a location that requires the thermal storage unit to be lifted by means of a crane, Turbo requires that the lifting and/or slinging be done from the bottom of the thermal storage unit and that the unit be kept level during hoisting. Do not hoist from one end. The lifting angle should not exceed 20°.

Note:
Turbo thermal storage tanks may be hoisted from the top with lugs designed for that purpose (see step 3B. Hoisting or Moving - Storage Tank on page 39 for details).

Use a spreader at the top of the unit to prevent the unit panels from crushing. A competent rigging and hoisting contractor can handle the job without danger or damage to the unit.

If a unit or tank has to be moved along a floor, road, driveway, etc., use either pipes as rollers or dollies of sufficient capacity under the unit or tank.

IMPORTANT

Never lift or sling the unit with devices fastened to the top frame structure. Only lift the thermal storage unit from the lifting lugs.

The self-contained thermal storage unit model contains a condensing unit located next to the evaporator section. The evaporator and condensing sections are located on a common base frame provided with either lifting eyes or lifting pipes. Before hoisting, the rigger must ensure that the load is properly balanced to prevent tilting or tipping of the unit. Test the load before lifting off the truck or ground.

WARNING

Hoisting or moving heavy equipment should only be done by competent rigging and hoisting contractors. Never allow personnel under the unit while it is in the air. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

3B. HOISTING OR MOVING - STORAGE TANK

Storage Tank

The Turbo storage tank is an optional item. Turbo storage tanks are furnished only if the Turbo Sales Order specifically includes a storage tank. The following information applies only to storage tanks manufactured by Turbo Refrigerating Company.

Check all connections and openings on the tank including the ice discharge opening on the top of the tank. Check the location and condition of all lifting lugs or lifting pipes before rigging.

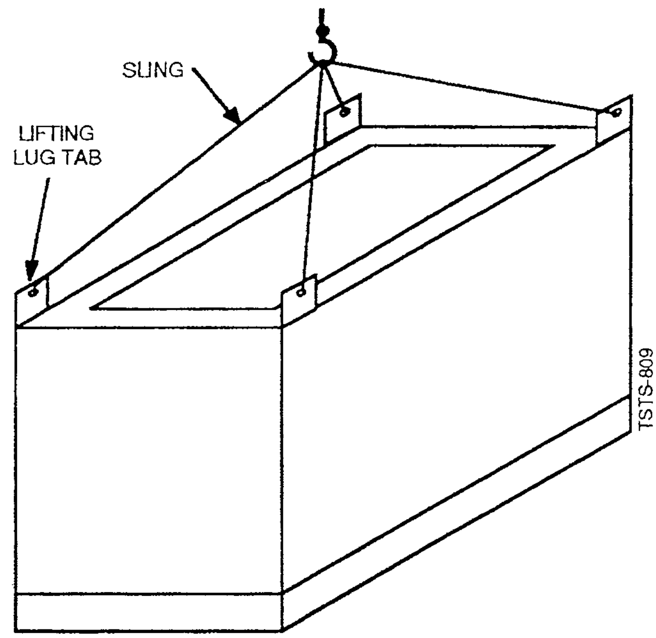

Figure 3-10 Lifting Lug Tab Method

WARNING

Do not attempt to hoist equipment if lifting devices are missing or damaged. Failure to carefully follow these instructions could result in permanent injury or loss of life.

If the tank has to be moved along a floor, road, driveway, etc., use either pipes as rollers or dollies of sufficient capacity under the storage tank.

Note:
The pad that the storage tank rests on must be within 1/4" of level, and supported along the entire length of the tank. This should be checked with an appropriate device prior to rigging and setting the storage tank on the pad. Refer to step 1. Site Preparation on page 27.

Rigging Instructions

The storage tank must be lifted by the factory installed lifting lugs. Note that these lifting lugs are not intended to be used for extended lifting periods. Depending on the orientation of the lifting lugs, the use of a spreader bar may be required to protect the tank exterior or interior.

Figure 3-10 shows lifting lug tabs at the top of the storage tank. The slings may be directly connected to the holes in these tabs.

Longer tanks may also have a set of lifting lugs in the middle of the tank. All lifting lugs may be cut off after installation if so desired.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

4A. MOUNTING AND LEVELING - STORAGE TANK

Set and secure the storage tank on a solid, level concrete pad. Refer to step 1. Site Preparation on page 27 for additional details.

IMPORTANT

It is imperative that the storage tank be level along the top (interface of tank and ice generator/chiller) in both length and width. Failure to level the mounting interface of the tank in both directions will result in excessive shimming of the ice generator/chiller when it is mounted on the tank. Failure to properly level the ice generator/chiller will disturb the water flow pattern over the evaporator plates and may cause incomplete coverage of the freezing surfaces.

Use a level with a minimum length of forty-eight (48) inches to ensure a good installation.

Since shimming is required to level the unit, use caution to prevent long unsupported spans (greater than 30") along the structural base. Mechanical vibration or gas pulsation from the condensing unit could produce unacceptable vibrations resulting in failure of components, broken refrigerant lines, and excessive noise.

Loose dirt, scale, and other debris should be removed from the bottom of the tank interface prior to mounting the tank on the pad.

When the optional Turbo storage tank is supplied, a steel construction is used. However, leveling and grouting the thermal storage unit on the tank would be the same. On Turbo tanks, a flat bar is welded on the tank top to contain condensation.

IMPORTANT

Leveling the thermal storage tank requires shimming. Grouting should be placed under the tank after leveling to fill any voids between the concrete pad and tank to ensure solid support of <u>all</u> structural members. Failure to follow these instructions could result in excessive vibration, refrigerant line breakage, compressor failure, and loss of refrigerant.

Tanks installed above grade should be provided with railing around the tank top, ladders, or stairway access to the equipment that conform to all local, state, and federal requirements.

WARNING

Access to the storage tank and thermal storage unit should be secured and limited to authorized personnel only. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Tanks installed at grade should also be provided with railings if installed outdoors, or in a room with access limited to authorized personnel to prevent access to the ice generator.

On concrete tanks, the ice generator is secured to the storage tank by the grouting installed under the unit after leveling. Steel tanks should be welded to the tank top intermittently around the entire frame after grouting.

WARNING

The inside of the tank is insulated with an insulation foam. Do not attempt to continuous weld or run a heavy weld bead on the tank. Several short intermittent welds should be used. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Securing the Tank

There are several ways to secure the storage tank to the pad on which it will rest. Depending on local practices, the tank may be anchored to the pad in various manners. The anchoring method used should provide a secure installation and conform to all local, state, or federal codes. Figure 3-11 shows a steel insert placed in the pad along the bottom perimeter of the storage tank. In this configuration, the tank bottom frame member is directly welded to the steel insert.

Figure 3-12 shows bolts which hold down a steel plate which secures the tank to the pad. This configuration eliminates the need for holes in the bottom structural member of the tank for securing the tank.

As a result of shimming and grouting to level the tank top, it may be necessary to weld a steel tab to the tank structure as shown in Figure 3-15 on page 47 to anchor the tank to the concrete slab.

Note:
The tank pad must be suitable for supporting the weight of the tank with a full water charge, all catwalks, guard rails, ladders, miscellaneous equipment, and personnel. The tank must be level and properly supported under the entire tank.

If the above anchoring procedure cannot be followed, contact Turbo for alternate meth-

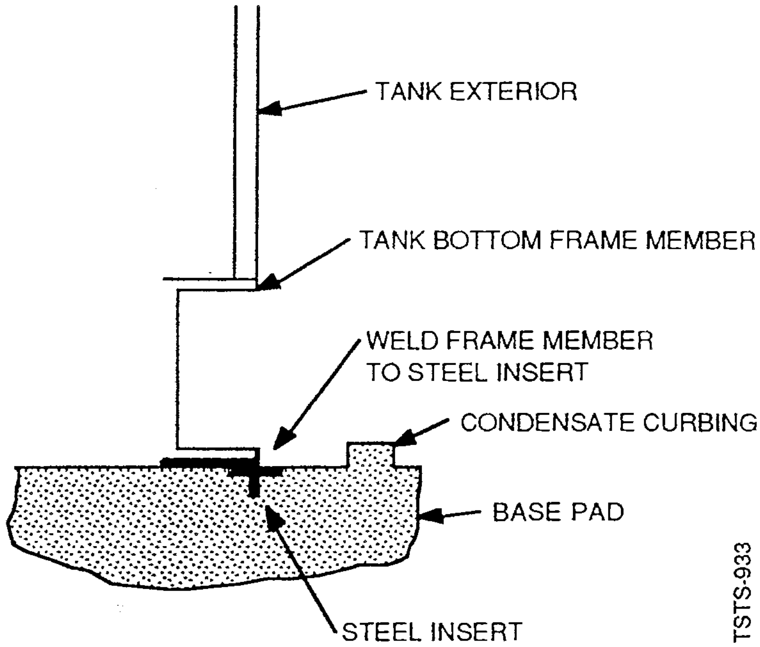

Figure 3-11 Storage Tank to Concrete Slab (Steel Insert)

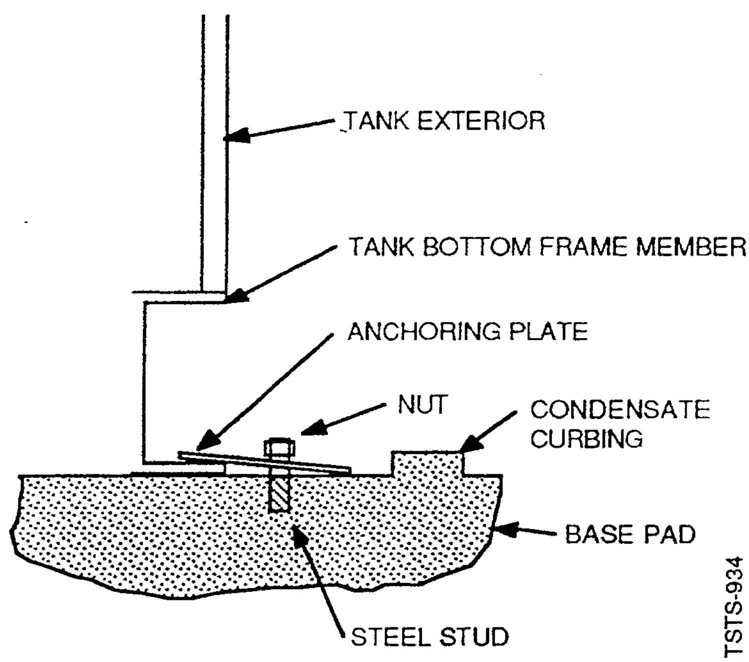

Figure 3-12 Storage Tank to Concrete Slab (Steel Plate)

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

ods. Turbo should be notified in writing of variations from the above guidelines. Comments on these variations will be provided by Turbo. However, Turbo assumes no liability for designs and installations provided by others.

IMPORTANT

Failure to provide written notifications of unauthorized tank installation designs or installation techniques will release Turbo from any obligation or warranty resulting from such installations.

Steel tanks installed below grade also require anchoring even if the tank is to be covered with dirt. Anchoring methods should be the same as above grade installations.

IMPORTANT

Failure to anchor tanks installed below grade could result in shifting or movement of the tank due to changes in soil conditions. Failure to maintain a level system could result in uneven water distribution over the evaporator plates and/or excessive vibration resulting in component failure.

Grouting Guidelines

Guidelines for grouting the space between the bottom of the frame and tank top are described in detail in the "Concrete Tank Guideline" prepared by Portland Cement for Turbo Refrigerating Company (available upon request).

Grouting under the unit in this manner is acceptable on both metal and concrete tank installations. Refer to Figure 3-16 on page 48.

Provide clearance for 3/8" to 1/2" of grout. Wet the top of the tank, pour grout and tamp to fill spaces between frame and tank top. Allow grout to dry slightly and then trowel smooth.

A suggested mixture for the grout is one (1) part Portland cement to two (2) or three (3) parts of sharp sand.

When the grout has hardened for twenty-four (24) to thirty-six (36) hours, tighten any foundation or anchor bolts used to attach the frame to the concrete. Full curing of the grout may require additional time. Consult the installing contractor.

Concrete Tanks

The above instructions apply primarily to steel Turbo tanks. Concrete tanks are typically constructed such that the tank itself is part of the structural concrete pad for mounting the thermal storage unit. The tops of the concrete tanks at the interface of the tank top and ice generator/chiller must meet the same requirements as steel tanks for mounting and leveling.

Installation of a stand alone concrete tank (for smaller systems) on a concrete pad would also utilize the guidelines for mounting and leveling steel tanks.

Concrete tank, design, configuration, and construction is the responsibility of others. Turbo will provide comments, observations, and opinions for specific designs, configurations, and installations based on past experience.

IMPORTANT

Failure to provide written notifications of unauthorized tank installation designs or installation techniques will release Turbo from any obligation or warranty resulting from such installations.

All grouting material and installation of grouting is supplied and installed by others. Use non-shrink grout.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

4B. MOUNTING AND LEVELING - ICE GENERATOR

Set and secure the thermal storage unit on a solid, level tank top structurally sufficient to support the operating weight of the unit and absorb mechanical vibration. Refer to step 1. Site Preparation on page 27 for additional details.

IMPORTANT

It is imperative that the thermal storage unit be level in both length and width. Failure to level the thermal storage unit in both directions will disturb the water flow patterns and may cause incomplete coverage of the freezing surfaces.

Use a level with a minimum length of forty-eight (48) inches to insure a good installation.

Shimming will be required to level the unit. Use caution to prevent long unsupported spans between the unit structural base and concrete slab or support steel. Mechanical vibration or gas pulsation from the condensing unit could produce unacceptable vibrations resulting in failure of components, broken refrigerant lines, and excessive noise.

Loose dirt, scale, and other debris should be removed from the bottom of the ice generator/chiller frame and tank top interface prior to mounting the unit on the tank.

The above information indicates a concrete storage tank is used. When the optional Turbo storage tank is supplied, steel construction is used. However, leveling and grouting the thermal storage unit on the tank would be the same. On Turbo tanks, a flat bar is welded on the tank top to contain condensation.

On concrete and steel tank tops, the surface outside the curbing should be sloped to prevent standing water in these areas. Refer to Figure 3-13.

Figure 3-14 shows a concrete tank top with a raised curb for mounting the thermal storage unit. On this type of installation, the unit must still be leveled and grouted. The engine compartment pad should fully support the entire bottom of the engine compartment. Refer to Figure 3-14, Section B-B.

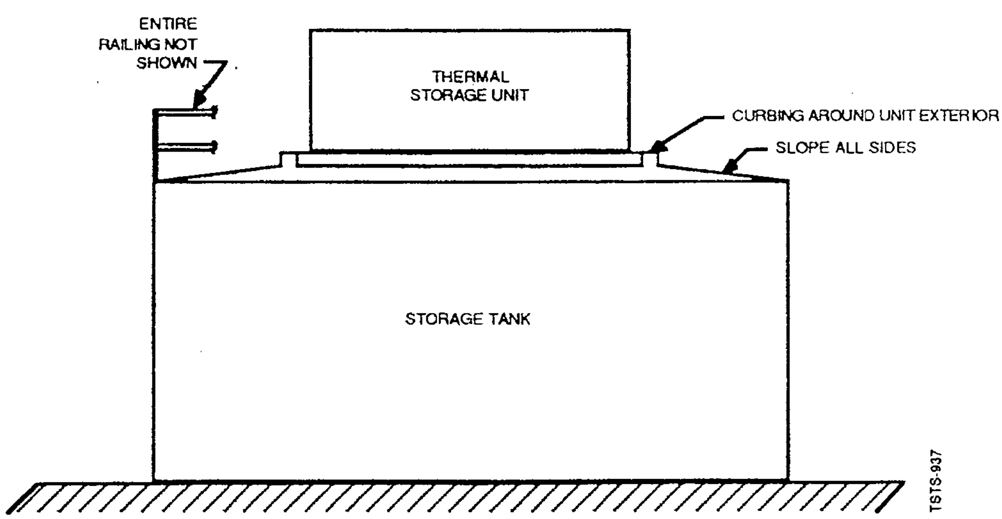

Figure 3-13 Storage Tank Top (Above Grade Installation)

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

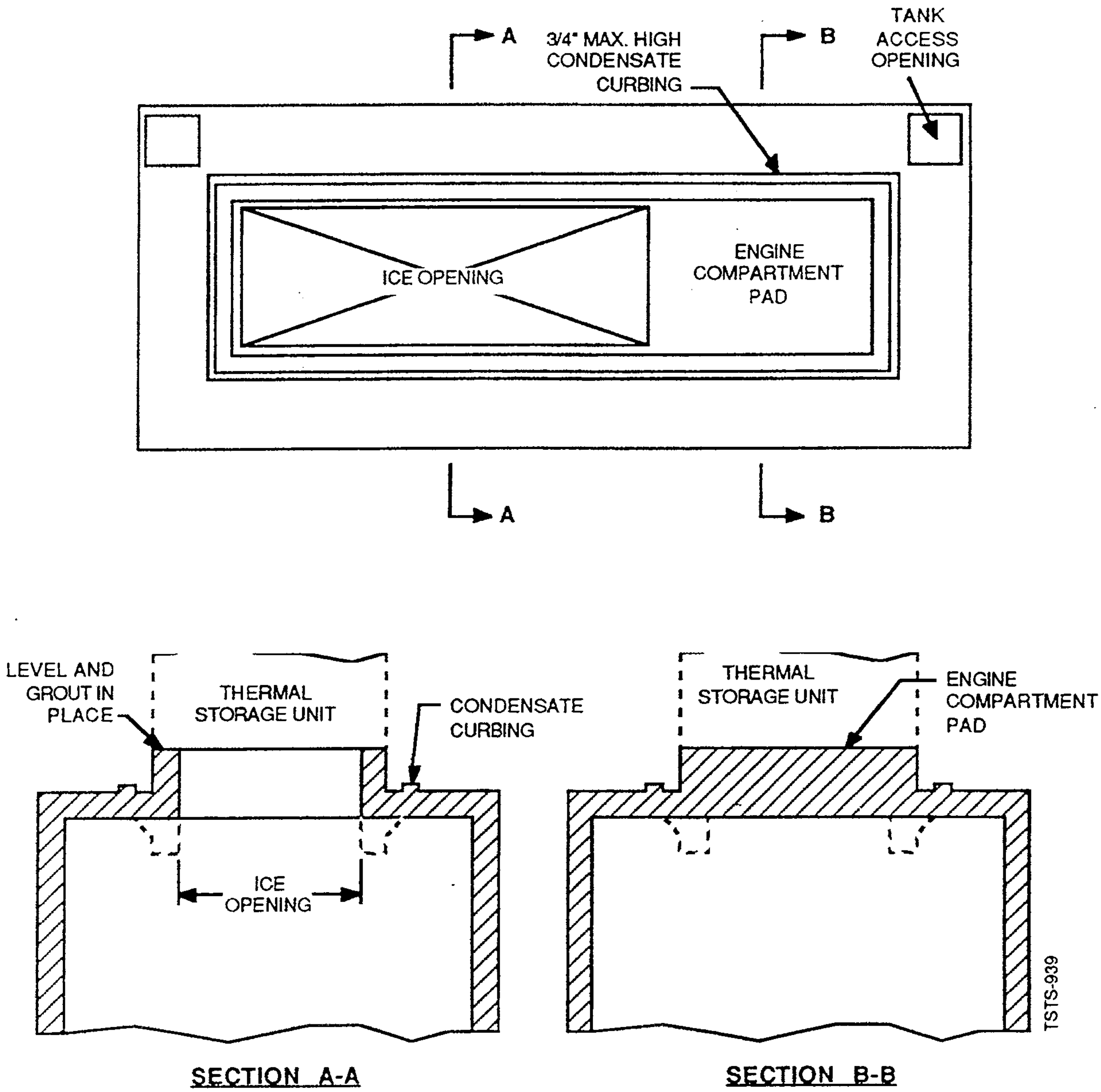

Figure 3-14 Tank Installation with Raised Curbing

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

Leveling the thermal storage unit on the tank top will require shimming under the engine compartment. Grouting should be placed under the engine compartment after leveling to fill any voids between the engine compartment frame and tank top to ensure solid support of all structural members. Failure to follow these instructions could result in excessive vibration, refrigerant line breakage, compressor failure, and loss of refrigerant.

Tanks installed above grade (refer to Figure 3-13) should be provided with railing around the tank top, ladder, or stairway access to the equipment that conform to all local, state, and federal requirements.

WARNING

Access to the storage tank and thermal storage unit should be secured and limited to authorized personnel only. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Tanks installed at grade should also be provided with railings if installed outdoors, or in a room with access limited to authorized personnel to prevent access to the ice generator.

On concrete tanks, the ice generator is secured to the storage tank by the grouting installed under the unit after leveling. Steel tanks should be welded to the tank top intermittently around the entire frame.

WARNING

The inside of the tank is insulated with an insulation foam. Do not attempt to continuous weld or run a heavy weld bead on the tank top. Several short intermittent welds should be used. Failure to carefully follow these instructions could result in permanent injury or loss of life.

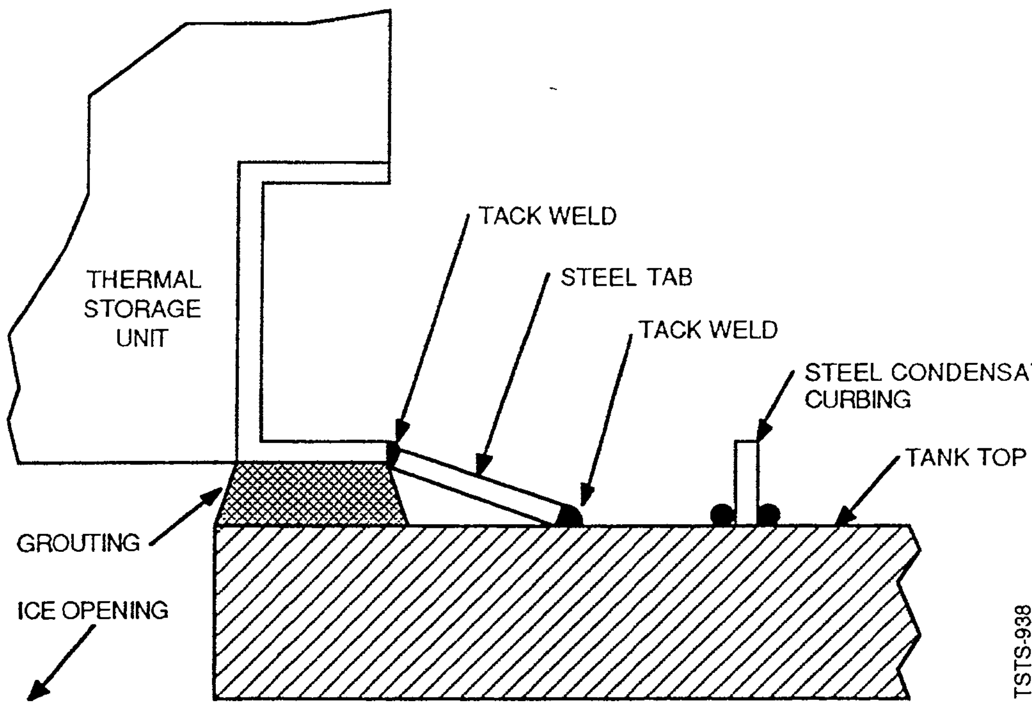

Figure 3-15 Anchoring Unit After Leveling and Grouting

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

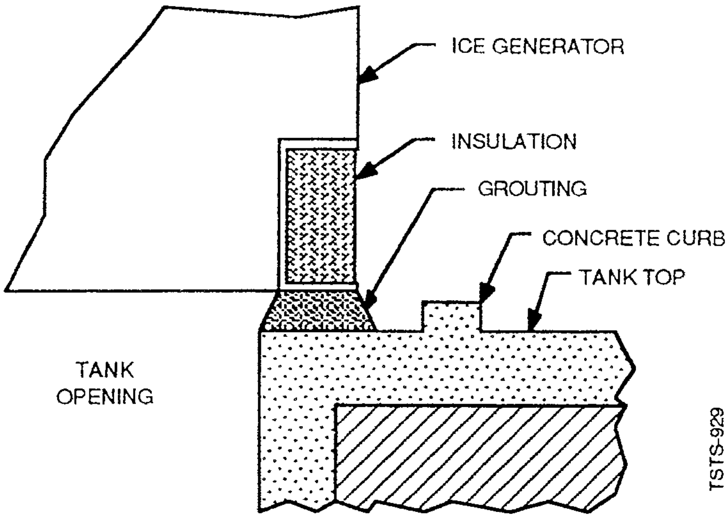

Figure 3-16 Grouting Detail - Ice Generator to Tank Top

Because of the leveling requirements, it may be necessary to weld a tab between the steel frame and steel tank top (refer to Figure 3-15) to provide the proper anchoring.

Grouting Guidelines

Guidelines for grouting the space between the bottom of the frame and tank top are described in detail in the "Concrete Tank Guideline" prepared by Portland Cement for Turbo Refrigerating Company (available upon request).

Grouting under the unit in this manner is acceptable on both metal and concrete tank installations. Refer to Figure 3-16.

Provide clearance for 3/8" to 1/2" of grout. Wet the top of the tank, pour grout and tamp to fill spaces between frame and tank top. Allow grout to dry slightly and then trowel smooth.

A suggested mixture for the grout is one (1) part Portland cement to two (2) or three (3) parts of sharp sand.

When the grout has hardened for twenty-four (24) to thirty-six (36) hours, tighten any foundation or anchor bolts used to attach the frame to the concrete. Full curing of the grout may require additional time. Consult the installing contractor.

All grouting material and installation of grouting is supplied and installed by others. Use non-shrink grout.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

5. STORAGE TANK AND ICE GENERATOR/CHILLER ACCESS OPENINGS

Periodic service and/or cleaning of the storage tank, water pump connections, and water pump suction headers or suction screens will require access to the tank interior. Optional Turbo storage tanks are provided with a minimum of one (1) tank access opening in the tank top. In some cases where space on the tank top is limited, due to the size of the ice generator and the tank selected, it may be necessary to provide an access through the ice generator itself to the storage tank. Turbo should be consulted before designing an installation of this configuration.

A locking hasp is provided on the tank access door to allow locking the door to limit access to the tank interior.

WARNING

The thermal storage system tank during normal operation may contain 32°F chilled water or an ice and water mixture. Exposure or immersion from falling into the storage tank could cause loss of consciousness and ability to function safely. Do not get into the tank. Never enter the storage tank alone. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Access to the tank interior is provided by a ladder located below the access opening.

WARNING

Ensure that proper ventilation and lighting are available inside the tank before entering for service. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Concrete tanks should be provided with the same type openings and access control as described above for steel tanks.

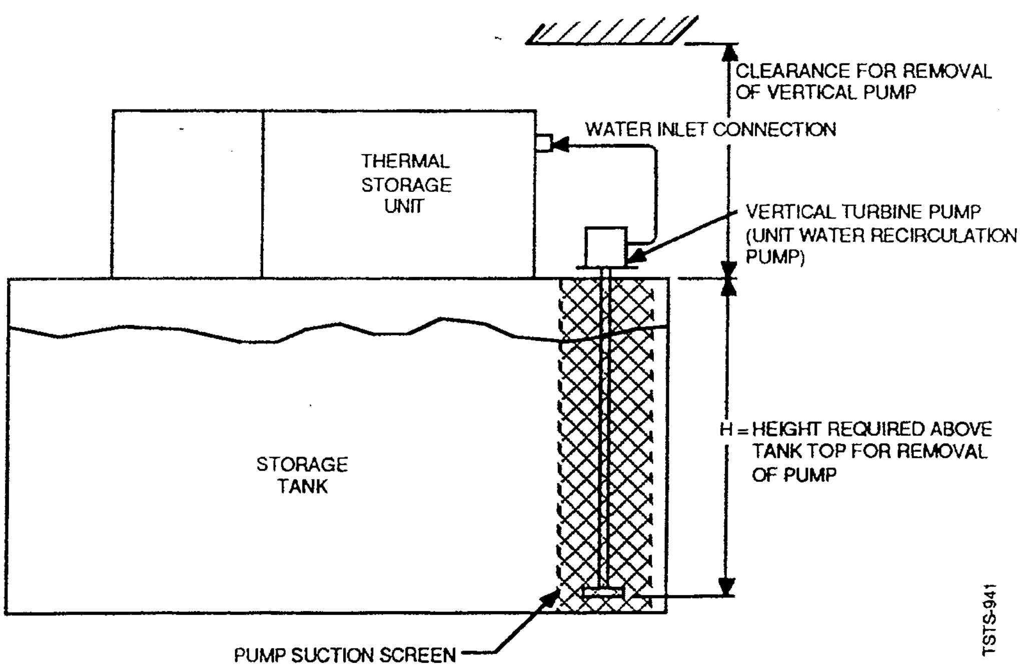

Figure 3-17 Vertical Pump Installation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

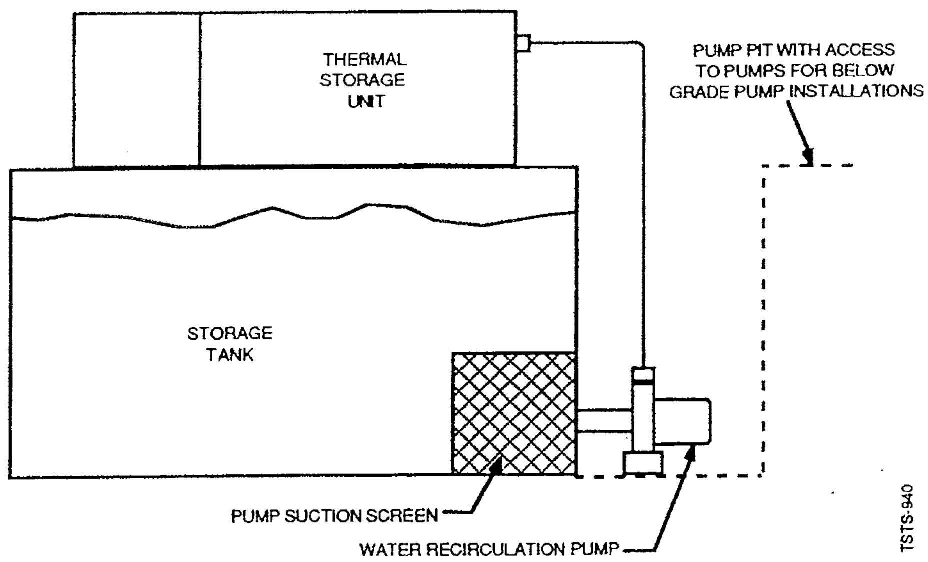

Figure 3-18 Centrifugal Pump Installation

Water Pump Suction Connections

Provisions must be made for the recirculating water pump suction connection. Two types of connections are generally used:

Vertical turbine or pedestal pumps which mount through the top of the tank.
Space is required above the pump to allow removal of the pump. Height required for removal is equal to the shaft length of the pump drive. Refer to Figure 3-17.

External tank connections for use with centrifugal pumps.
Requires access to the bottom of the tank and a pump pit for below grade tank installations. Refer to Figure 3-18.

The pump installations shown are typical for small systems using Turbo ice generator/chillers. For larger systems, a water recirculating pump suction header is recommended to prevent temperature stratification, short-circuiting of return water, and uneven ice burn-off in the tank. Figures 3-19 and 3-20 show typical water suction header arrangements. Consult Turbo for recommendations on specific installations.

Water suction headers consist of PVC piping with perforations. Headers are located in the bottom of the tank away from the ice discharge opening next to the tank walls. The perforated hole pattern and location of the piping are designed to provide uniform ice burn off by drawing water from around the entire ice pile. Consult Turbo for guidelines or suction header design and perforation pattern to ensure proper water distribution. If laterals are required under the ice generator ice opening, schedule 40 steel pipe must be used to prevent damage to the header when the ice pile settles to the bottom of the tank. Suction headers (in optional Turbo storage tanks) are located in the ice voids that exist around the bottom perimeter of the tank, in order to limit exposure to the ice pile that is generated. This minimizes the potential for damage to the suction header.

Turbo also recommends restraining (but not securely anchoring) the suction header to the tank floor to prevent stress concentrations at the water pump inlet connection due to motion of the ice and water in the storage tank.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

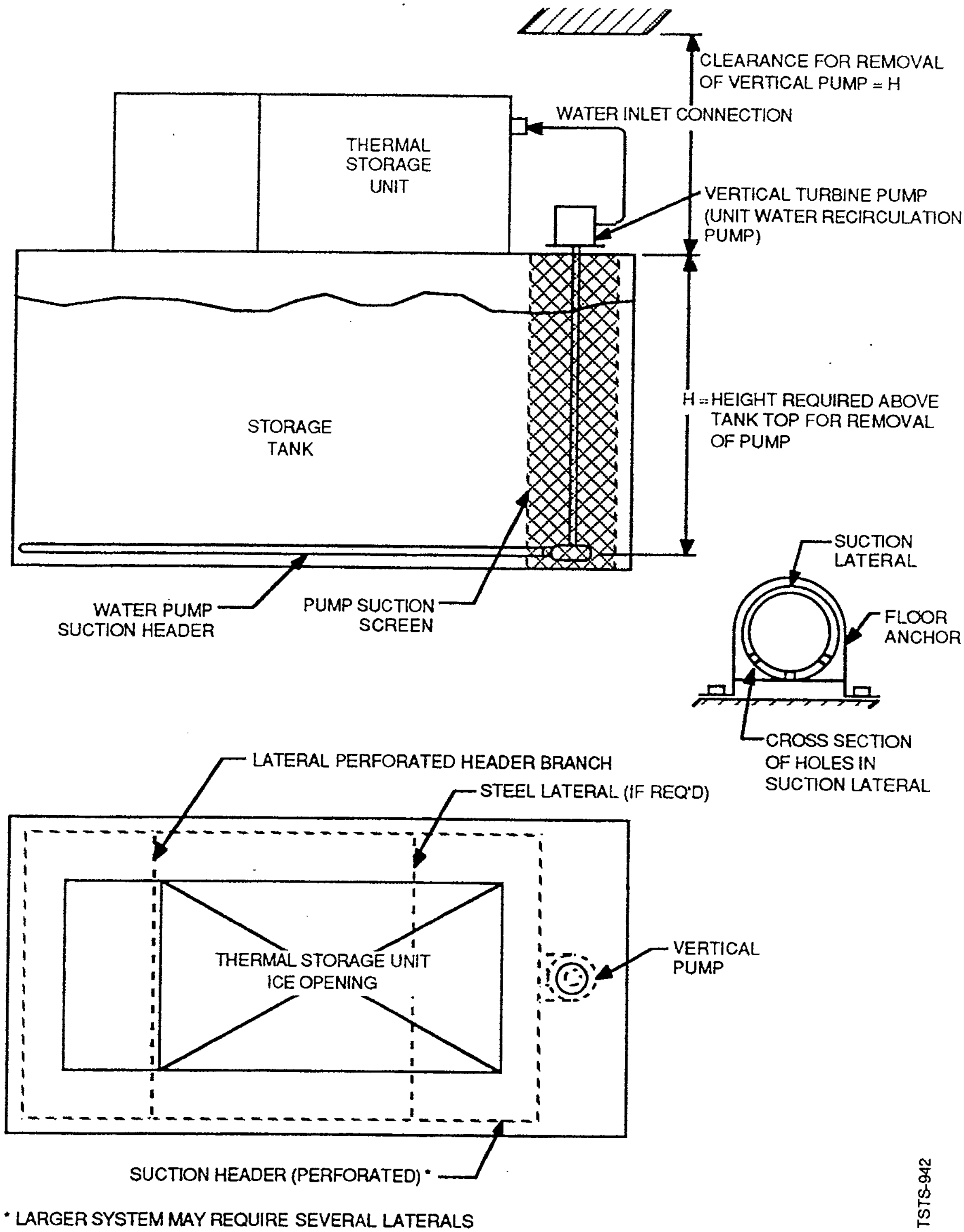

Figure 3-19 Vertical Pump Installation With Water Suction Header

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

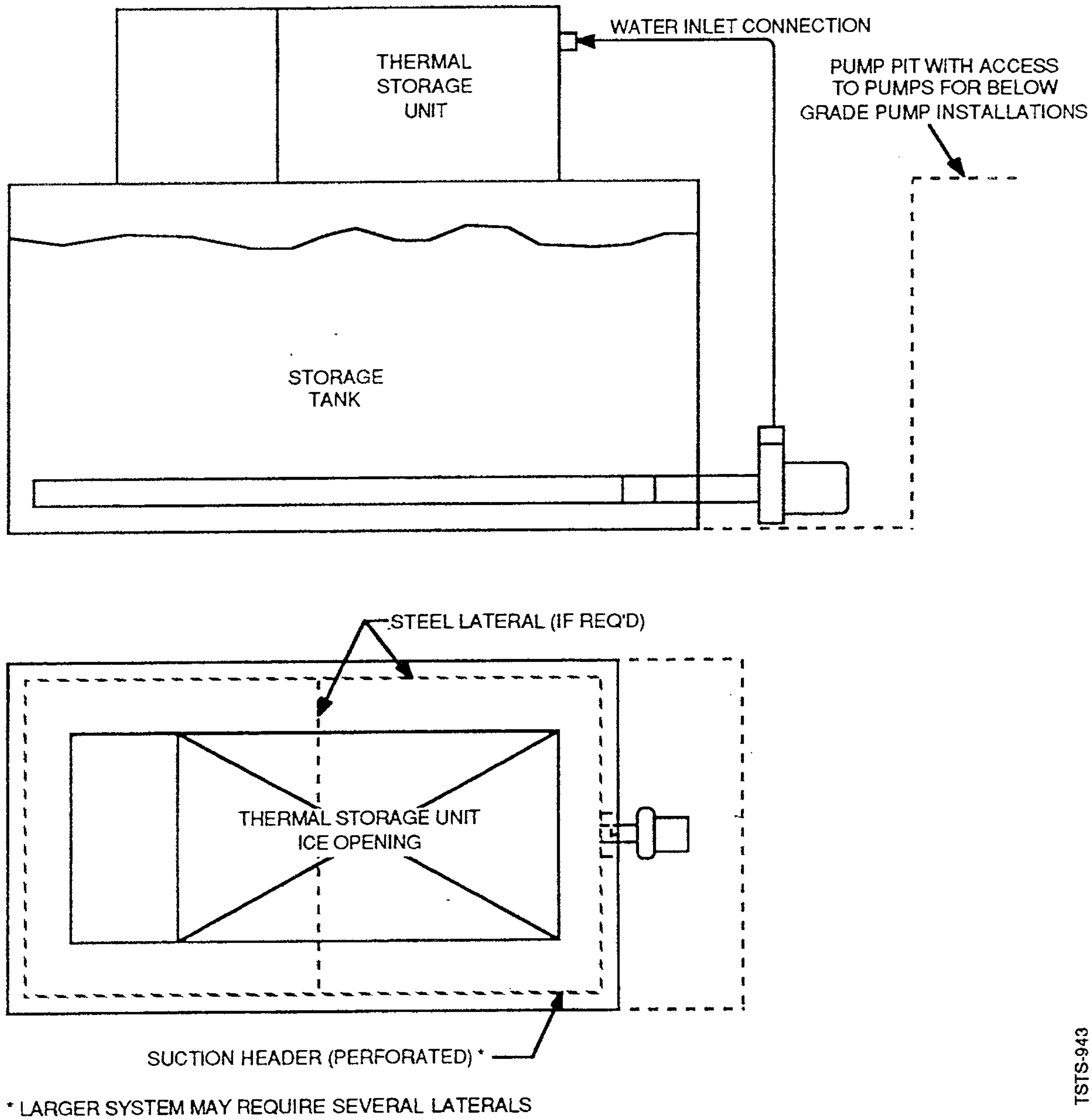

Figure 3-20 Centrifugal Pump Installation With Water Suction Header

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

Turbo will provide guidelines and advice relative to sizing, configuration, location, etc. of headers supplied by others (with prior written notice of suction header detail) . Turbo assumes no liability for proper sizing, configuration, or installation of suction headers supplied by others.

Building Return Water

Water returning to the thermal storage unit is piped to the water distribution system in the thermal storage unit. This ensures uniform distribution of the return water over the ice stored in the storage tank. Refer to Figure 3-21. Return of the water to the primary distribution system is ideal but may not be practical in all installations due to variations in operating parameters. For example, the building chilled water supply pump flow rate may exceed the flow capacity of the water distribution header and pan sized for the optimum evaporator recirculation flow rate. In these cases, it may be necessary to bypass part of the return water flow directly to the tank. If this is necessary, a bypass water distribution header should be installed inside the tank top to distribute the water bypass over the ice pile.

Listed below are a few of the operating sequences that may be encountered in the return water systems:

The recirculating water pump (RWP) and chilled water pump (CWP) operate separately:

1. If the RWP and CWP flow rate are the same, or if the CWP flow rate is less than the RWP flow rate, all of the return water is piped to the existing water distribution system as shown in Figure 3-21.

2. The CWP flow rate is higher than the RWP. In this case, a bypass must be provided to bypass part of the return water flow to the storage tank. Refer to Figure 3-22. A three-way flow control valve is installed in the return water line. When the return wa-

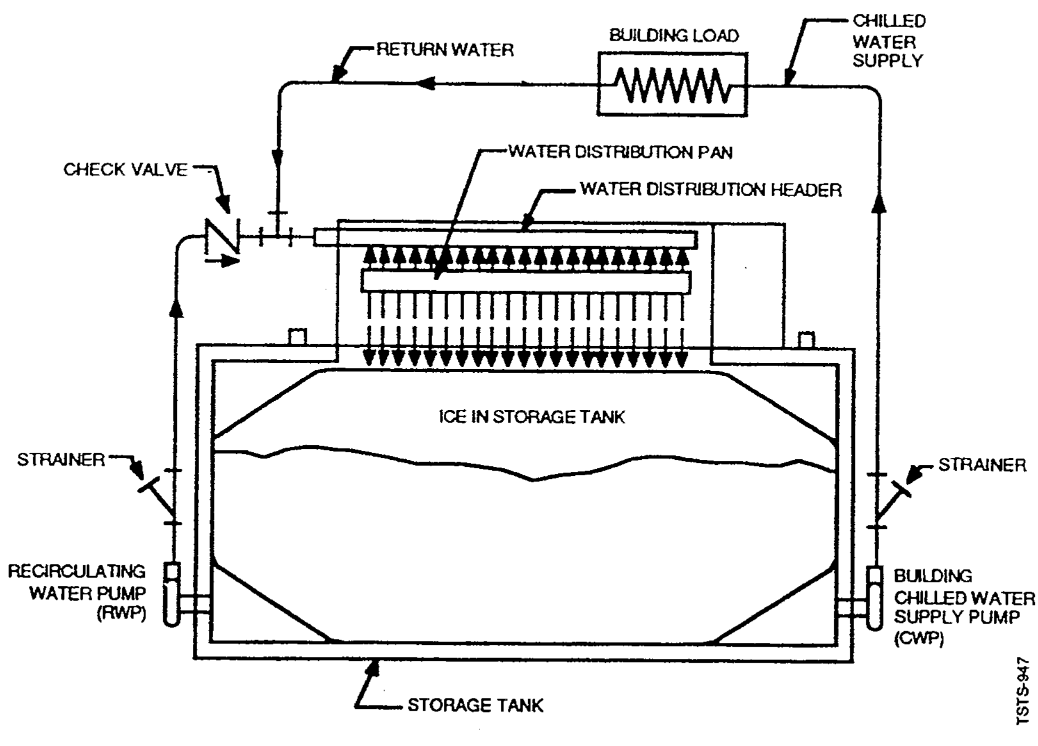

Figure 3-21 Return Water Connections

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

ter flow exceeds the maximum flow rate of the water distribution header and pan, the valve opens to bypass the balance to a bypass line and bypass water distribution header located in the storage tank.

3. If the system permits operation of both the RWP and CWP pump, a bypass arrangement will be required since the combined flow would exceed the capability of the water distribution system. In general, both pumps should not be operated simultaneously. Such an operation may be necessary to obtain lower return water temperatures (i.e. the return water temperature is high and the unit is operated as a chiller) for some installations or processes. In installations where it is not desired to operate both pumps simultaneously, an external electrical interlock (by others) should be installed in the RWP control circuit to prevent operation of the RWP when the CWP is operating. Refer to Figure 3-23.

The above examples represent typical installations and may not include all arrangements or configurations.

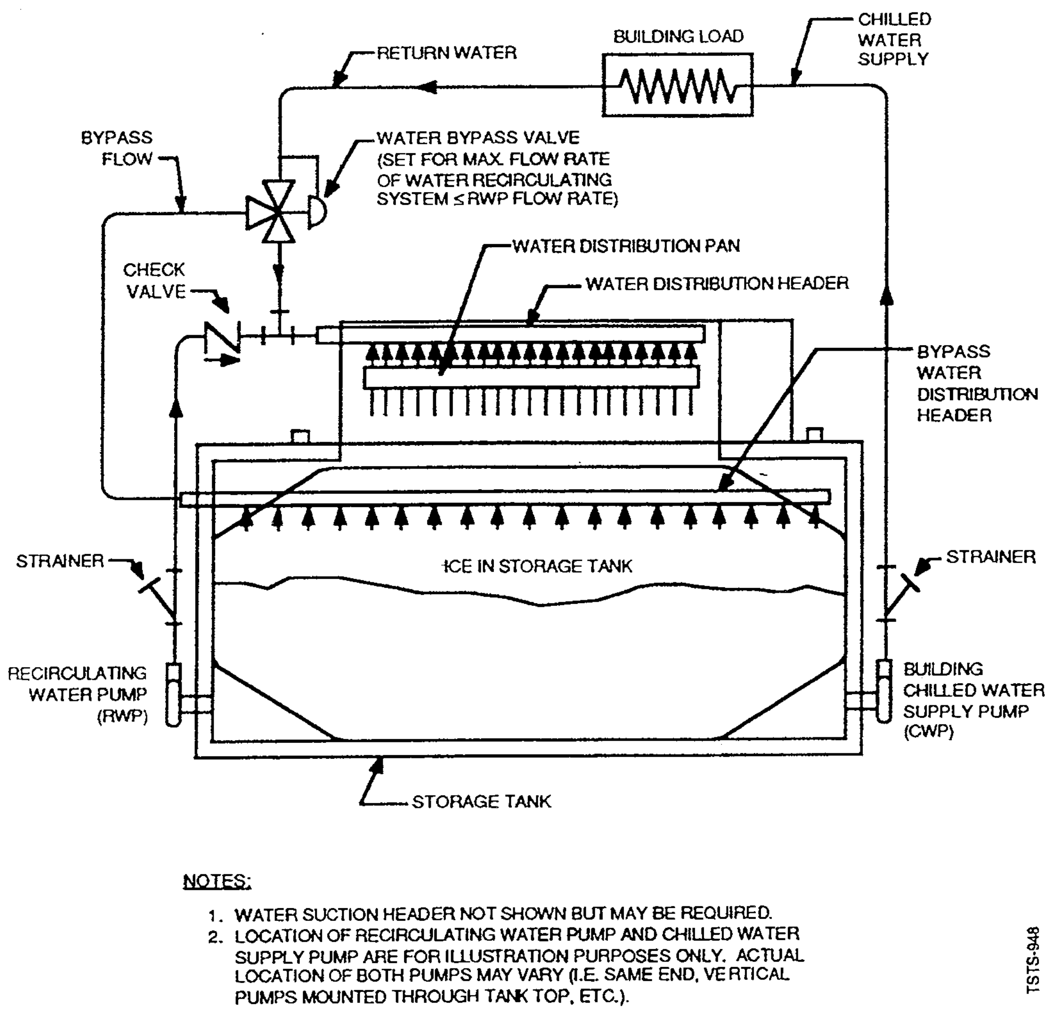

Figure 3-22 Return Water With Bypass

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

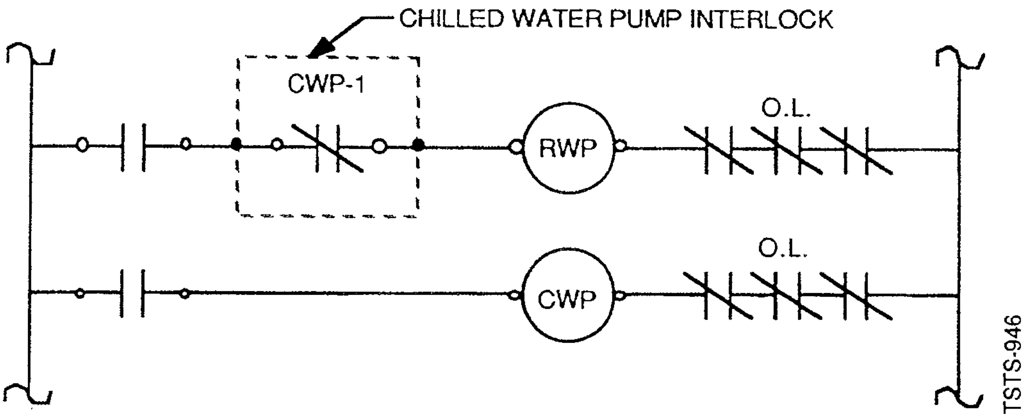

Figure 3-23 Electrical Interlock of RWP and CWP Pumps

IMPORTANT

Turbo will provide guidelines and advice relative to sizing, configuration, and location of return water piping and bypass arrangements supplied by others with prior written notice of piping details. Turbo assumes no liability for the sizing, configuration, or location of return water piping or bypass arrangements. Turbo will not assume responsibility for proper interfacing, operation, or installation of return water piping or bypass arrangements supplied by others.

Other options to consider when providing the return water system, recirculating water pump, and chilled water supply pump include the use of a variable speed pump and control to provide the proper flows for the recirculating and building water system. The use of a variable speed controller may not eliminate the need for a bypass return water system due to higher CWP flow requirements but does eliminate the need for two pumps, two pump connections, and two water strainers.

Two speed pumps may also work where the flow of the RWP and CWP match the flows obtained at low and high speed operation.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

6. REFRIGERANT PIPING

Piping in a refrigerant system has two functions:

1. To carry the refrigerant through the system as a liquid or a gas with a minimum pressure drop.
2. To return any oil entrained in the refrigerant to the compressor. Suction mains should be pitched toward the compressor.

Field piping installation and configuration is critical for proper system operation. Proper refrigeration piping should be installed following commonly accepted piping practices and guidelines.

IMPORTANT

Turbo will provide guidelines and advice relative to sizing, configuration, and location of piping supplied by others with prior written notice of the piping detail. Turbo assumes no liability for proper sizing or installation of piping supplied and installed by others. Turbo will not assume responsibility for proper interfacing, capacity, or installation of piping by others.

Steel Pipe Joints

In making up joints for steel pipe, the following procedures should be followed:

- Clean threads on the pipe and fittings to remove all traces of grease or oil.
- Wipe the threads dry with a lintless wiping cloth.

Refrigerant Installations

For threaded connections on piping for refrigerants, use Teflon thread sealing tape. Wrap the tape around the threaded male portion of the joint about two full turns, thread into the female portion, and tighten. If thread sealing tape is not available, conventional thread filling compound may be used. Use thread filling compound sparingly and on the pipe only. Do not put any thread filling compound on the first two threads, this prevents any of the compound from entering the system.

Pipe Type

Piping for freon refrigerant systems must be type K or L copper (depending on the application). Steel pipe is used in large installations when joints are welded and on ammonia systems.

Freon Refrigerant Installations

For freon refrigerant installations, use copper pipe with solder type fittings where possible. The use of screw type fittings should be held to an absolute minumum to prevent freon refrigerants from leaking through.

Copper Tubing

Type "K" is suitable for working pressures up to 400 psi. Type "L" is suitable for working pressures up to 300 psi. Check local requirements before installation because some local codes forbid the use of type "L". Never use type "M"; it does not have adequate wall thickness to withstand the operating pressures and is used for water service only.

Only wrought copper fittings should be used for freon refrigerant piping. Cast fittings used for water service are porous and not suitable for the refrigerant service. Exception: In larger pipe sizes, wrought fittings are not available. Specially tested cast fittings are available to use with complete safety in refrigerant piping systems.

Soldering

When soldering copper tubing joints, silver solder such as "SilFos", "Phoson #15", "Silbond 15", or any solder

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

that has 15% silver content can be used. Soft solder should never be used because its melting point is too low. Soft solder lacks mechanical strength and tends to break down chemically in the presence of moisture.

Steel Pipe

Carbon steel or stainless steel pipe can be used for refrigerant lines but must be either sand blasted or pickled to ensure complete removal of wax, oil, or other processing films.

Pipe Line Hangers

Hangers and supports for coils and pipe lines should receive careful attention. Hangers must have ample strength and be securely anchored to withstand any vibration from the compressor and adequately support the pipe

Releif Valves

This pressure equipment is not equipped with safety valves. So pressure limits are not exceeded, prior to operating the equipment end user must install a pressure relieving device that will limit a rise in pressure to not more than 110% of the MAP marked on the nameplate." These valves will be installed in the attached piping and meet all local, state and international codes.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

7. ELECTRICAL CONNECTIONS

Before electrical checks (see checklist on this page) are made, all piping and installation of the equipment should be completed to prevent operation without all components being properly installed.

WARNING

All electrical work should be done only by a qualified electrician. Do NOT turn power on at this time. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

Electrical wiring diagrams are located in each control panel and are furnished with each operating manual. These diagrams should be consulted before making the electrical service connections.

Two separate electrical panels are provided with the thermal storage unit. The control panel contains the 115/1/60 electrical components which are used to control the unit. The control panel consists of a programmable controller, a water temperature thermostat, an oil temperature thermostat, a dual circuit seven-day programmable time clock, control relays, terminal blocks, and a two-pole circuit breaker. For special applications, the control panel may be provided for 220 volt and/or 50 Hz power. All interconnecting wiring to remote equipment must be done as per the wiring diagram.

The other electrical panel included is the three-phase panel. This panel will contain the starters/contactors for all motors provided by Turbo. As an option, branch circuit protection can be provided for each starter supplied. If the optional control power transformer is selected, it will be located in this panel. Also, a main circuit breaker can optionally be provided to serve as a main disconnect for the equipment.

IMPORTANT

The electrical contractor should ensure that all interconnecting wiring complies with local, state, and federal codes.

Electrical Controls Check

After the control wiring is complete and with all three-phase power off (main breaker/disconnect off), the electrical control system operation should be simulated to ensure that the proper sequencing is occurring and all protective switches and controls are functioning properly. External controls or switches should be manually tripped to ensure the proper control response. For example: manually stop the rotating paddle wheel on the high ice level switch to simulate high ice level shut off of the unit. Refer to section 4. Operating Instructions on page 103 for the proper operating sequence.

WARNING

Never run the control circuit electrical check with the three-phase power to the motors connected during the control circuit check-out. Improperly connected wiring or controls could result in unsafe operation of the motors. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Electrical Checklist

1. Check the voltage supply versus the voltage indicated on the thermal storage unit nameplate.
2. Check the preset valves, the safety switches (high pressure switch and low pressure switch, cut in and cut out, oil temperature thermostat, etc.), and manual resets on safety devices.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

3. Check all connections for short to ground.

4. Check for electrical continuity on L1 and L2.

5. Check all wiring to interlocks and controls that were field installed versus the wiring diagram supplied with the unit. Check all connections to the input/outputs (I/Os) of the programmable controller.

6. Remove and secure the hot wire (L1 side) from OPTDH to prevent oil pressure failure trip due to lack of oil pressure during simulation checkout. To properly verify operation of the oil pressure failure safety switch, the hot wire to the oil failure switch heater (OPTDH) should be connected. Check time delay required for switch to trip.

7. Check safeties and automatic shut down as well as refrigeration/defrost cycles.

8. Check motor overload heater sizing.

9. Connect three-phase power to each motor individually and verify proper rotation by manually "bumping" the starter on and then off.

10. Check the crankcase oil temperature switch setting. This should be set at 140°F.

Note:
An oil temperature thermostat is not required on units with a semi-hermetic compressor, which utilizes built-in cylinder head discharge temperature safety switches.

11. Turn on the power to the compressor crankcase heater for a minimum of 24 hours prior to operation of the compressor to ensure proper oil temperature and removal of any condensed liquid refrigerant in the compressor crankcase.

IMPORTANT

Failure to turn on the compressor crankcase for 24 hours prior to operation could result in liquid slugging and failure of the compressor.

On remote equipment installed in the field, circuit breakers must be provided. Turbo supplied optional three-phase panels contains all breakers for the unitary mounted equipment. Motors located remotely may require a disconnect at the motor to meet local, state, or federal codes.

Electrical Service Connections

Thermal storage units are furnished completely wired internally, but they may require some interconnecting wiring (e.g. to the recirculating water pump motor starter, to the remote condenser, etc.) as well as the electrical service connections. The electrical service connections required are:

- The three-phase L1, L2, and L3 connections to each of the motor starters/contactors, unless the unit is supplied with the optional main circuit breaker and branch circuit protection. The ampere load requirement for either the individual devices, or the entire unit is listed in the three-phase schematic of the wiring diagram. If starters are supplied for motors which are provided by others, the interconnecting wiring must also be done by others.

- The single-phase (L1 and L2) connections to two-pole breaker in the control panel, unless the optional control panel transformer is selected. In most cases, a 30 amp 115/1/60 power supply is adequate. Some units may require additional amp service; therefore, the wiring diagram must be referred to for the individual installation.

- The equipment grounding as required by the local, state, and federal codes must be done by others.

The thermal storage units are furnished completely prewired internally but require electrical service connections to:

- the L1, L2, and L3 connectors on each of the motor

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

starters (three phase) except on units with optional circuit breaker installed

- the L1 and L2 connections of the control circuit (single phase)
- the top wiring to the circuit breakers on all units so equipped and is field installed by others.

All of these connections are located inside the thermal storage control panel. Install disconnect switches (by others) in the incoming power lines ahead of the control panel on the thermal storage unit.

Checking Rotation

WARNING

Make sure the compressor is clear of all obstacles and warn all personnel to stay clear of the compressor at all times. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Note:
When checking rotation, only the power to the motor being checked should be on.

Control Panel Winterizing

Ambient temperatures can affect many of the electronic controls in the VSM control panel. In general, the devices Turbo uses operate properly in temperatures between 32°F and 140°F. In operating ambients under 40°F, Turbo recommends that a source of heat be available in the control panel to maintain a temperature above 40°F. This will ensure continuous, reliable operation of all components (even in severe applications*). An optional winterizing kit consisting of a heat source and control thermostat can be provided as a factory installation or as a retrofit to existing control panels.

* The control panel winterizing kit is designed for equipment operations in ranges from 0 to 40°F. Consult Turbo for equipment operations in conditions below 0°F.

Installation

All components are factory installed and pre-wired.

Operating Sequence

As the control panel temperature drops below the set point of 40°F, the contacts of CPHT thermostat close to energize the panel heater coil. As the temperature rises above the differential setting of the thermostat, the contact opens to turn off the heater. The thermostat continues to maintain the interior temperature above 40°F. Refer to Figure 3-24.

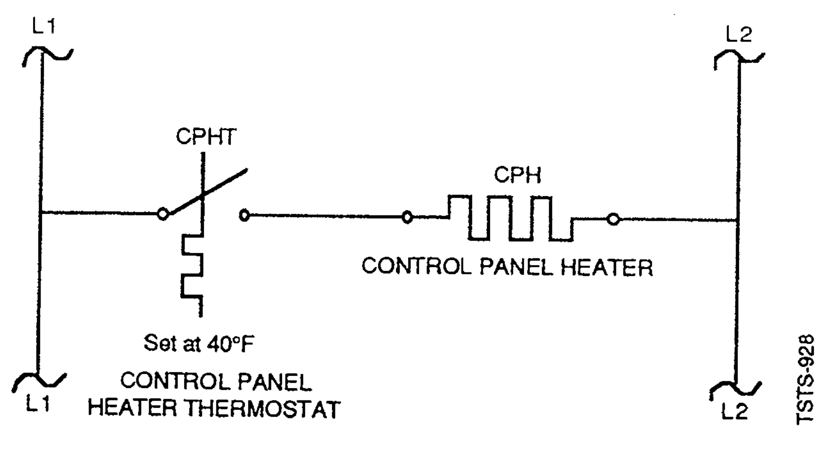

Figure 3-24 Control Panel Winterizing Wiring

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

8. WATER CONNECTIONS

Recirculating Water

Once the thermal storage unit is mounted on the storage tank, a water line must be field installed from the recirculating water pump to recirculating water connection(s) located on the thermal storage unit. A line capable of supplying the water volume specified and allowing a 3 psig pressure at the unit recirculating water connection must be utilized. Pressure drops due to line losses, valves, strainers, and vertical lift must all be considered to ensure 3 psig is available at the inlet connection.

The location of the recirculating water connection is shown on the data sheet for each model. PVC or steel pipe may be used. Suitability of materials used should be checked on systems requiring chemical water treatment.

Normal water temperatures range from 33°F to 60°F. Insulation of the water recirculating piping is recommended (field installed by others). Heat tracing (by others) may also be required for systems operating or exposed to ambient temperatures below 40°F to prevent freezing of the piping.

Make-Up Water

Turbo ice harvesting thermal storage systems utilizing a fixed water charge and automatic make-up water feed is not required. However, periodic additions of water to the system, initial water charging, and cleaning will require a water supply to the tank. Provisions must be made to have a water source near the unit to allow for such water additions.

All water piping, valves, and fittings are supplied by others and are field installed.

Pan Drain Connection

Each thermal storage unit engine compartment has a pan drain installed to remove water, condensation, oil, and other fluid that collects in the pan located on the engine compartment floor. Drain lines should be connected from these connections to a suitable floor drain or disposal point.

All piping, valves, and fittings are supplied by others and are field installed.

Heat tracing of drain line(s) may be required in some installations. Consult Turbo for additional guidelines.

Tank Overflow Drain

Thermal storage tanks are designed to operate with a 60–70% water level in the tank. To prevent overcharging the storage tank with water, an overflow drain(s) is installed at the 75% level on all Turbo supplied tanks.

Water piping from the tank overflow connections to a floor drain or suitable disposal point should be provided. All piping, valves, and connections are supplied by others and are field installed.

IMPORTANT

The tank overflow drain connections should never be plugged. Excessive water charge in the tank could result in an ice level in the unit (due to reduced storage capacity) that prevents proper ice harvest. This could result in damage to the plates and/or refrigerant piping.

On indoor installations, containment of overflow water should be given extra consideration to avoid flooding of basements, mechanical rooms, or occupied space.

Heat tracing of the overflow drain lines may be required for installations operating in low ambients (below 40°F).

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Condenser (SC Models Only)

Thermal storage units with water-cooled condensers will require piping from the water-cooled condenser mounted in the engine compartment to a remote cooling tower. Water regulating valve(s) are supplied by Turbo for field installation. All other piping, valves, and connections are supplied by others and are field installed.

Refer to step 16. Water-Cooled Condensers on page 93 for details of water regulating valves, cooling tower, and cooling tower pump installation.

Cooling Tower Connections

Thermal storage units utilizing a water-cooled condenser will require a cooling tower to remove the heat in the water used to condense the hot discharge gas. All cooling towers require a continuous make-up feed connection to replace water lost through evaporation and for blow down in the airstream of the fan. The supplier of the cooling tower should be consulted for the flow requirements and connection size and location.

A cooling tower can be supplied as optional equipment for field installation.

Water Temperatures

When cooling towers are used and no other positive means of regulating head pressure are provided (such as fan and pump pressure switches), a water regulating valve will be required. Adequate head pressure is important to provide proper refrigerant flow through expansion valves or other refrigerant control devices in order to maintain the suction pressure above the setting of the low pressure cut-out to prevent short cycling and pump-down of the system.

When contemplating the use of city or well water for condensing, a careful check should be made of the seasonal variation in the water temperatures. Water flow lines should be sized large enough for the required flow at the maximum water temperature to be encountered. For applications requiring condenser water above 85°F, consult Turbo. When thermal storage units are installed in an area where the ambient falls below freezing, refer to section 8. Optional Features and Accessories for Winterizing on page 182.

Water Pressure Requirements

No city water connections are required to the thermal storage unit. Water pressure at the recirculating water connection and water-cooled condenser (if so equipped) is provided by a separate water pump.

As stated previously, the recirculating water pressure required is a minimum of 3 psig at the inlet connection to the unit. Pressure drops through the piping, valves, and vertical lift must all be allowed for.

The water pressure at the water-cooled condenser inlet connections is determined by the pressure drop through the condenser and must include the pressure drop through the water regulating valve(s) as well as piping, valves, and vertical lift losses. Pressure drops through the condenser and water regulating valve(s) generally are between 10–15 psig. Specifications on each model should be used to determine the actual pressure drop to determine pump discharge head requirements.

Connections from the condenser are piped to the exterior of the engine compartment cabinet for connecting to external valves and piping by others in the field. The condenser inlet and outlet are each identified.

A local expert on water treatment should be consulted to determine if additional water treatment (chemical, filtration, etc.) is required to obtain the desired ice quality.

IMPORTANT

Normal freeze up precautions should be taken when water lines must be exposed to freezing temperatures.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Water Flow Requirements

Recirculating Water

Refer to the tables in section 10. Appendix A.

Water-Cooled Condenser

Condenser water requirements are based on 85°F water to the condenser, 95°F water off the condenser, and 105°F condensing. The condensers design water flow rate is based on 3 gpm/ton of refrigeration.*

The actual rate of flow is contingent on the water temperature and evaporator load but will not exceed the design flow.

* Tons of refrigeration: Total heat of heat rejection at 20°F SET/105°F SDT for icemaking or 40°F/105°F for chilling divided by 15,000 BTU/ton.

Since the Turbo thermal storage unit can operate as an icemaker or chiller, the actual operating conditions for the specific installation must be considered in determining the saturated evaporator temperature to be used in determining condenser and condenser water flow requirements. Heat of rejection should be calculated at the highest evaporator temperature the system will operate at.

Water Distribution Pans

In order to ensure proper water distribution over the evaporator plates, the water distribution pans must be level as discussed in step 4B. Mounting and Leveling - Ice Generator on page 45. Equally important is the water level maintained in the water distribution pans. All Turbo thermal storage systems have minimum water flow requirements that ensure this level is correct.

Guidelines for determining if the proper flow is obtained is as follows:

- 3 psig pressure is available at the recirculating water connections on the thermal storage unit.
- Water level in the water distribution pan is a minimum 1 inch above the 'V' in the pan at all points. Refer to Figure 3-25. Normal and high levels are also shown.

Note:
A low level results in improper water flow over the plates and erratic water flow conditions, causing the water to flow over valving and piping, resulting in freeze-up of the evaporator. High water levels causing splashing can also result in evaporator freeze-up.

- Standard flow rates for each evaporator plate is:
  - 6.5 gpm/plate for HP models.
  - 8.5 gpm/plate for IGC models.

Note:
Other flow rates can be obtained. Turbo should be consulted for special requirements.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

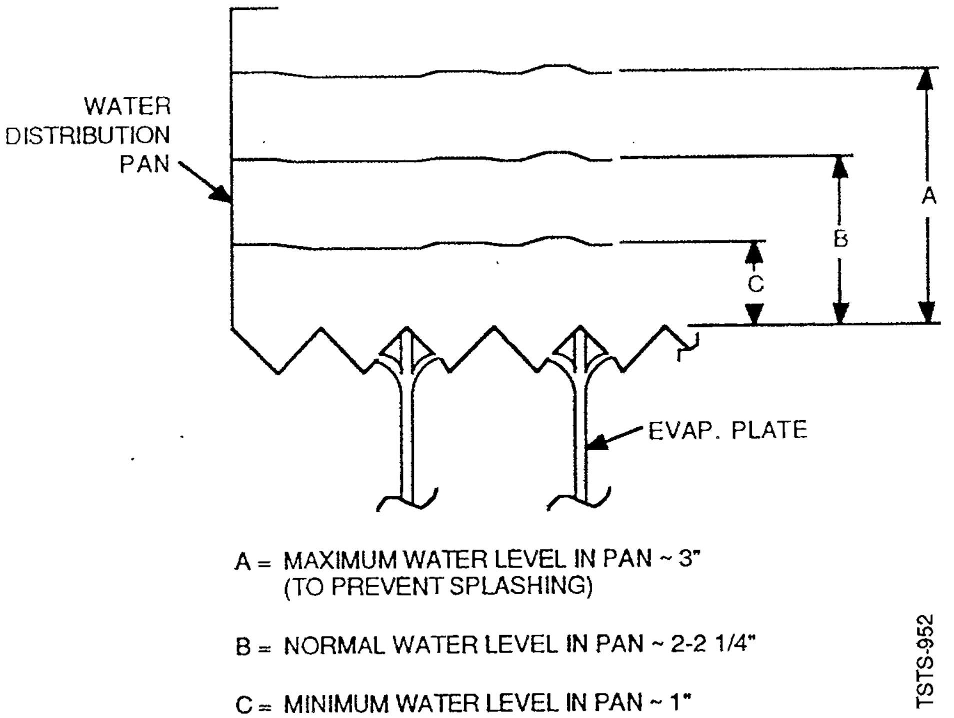

Figure 3-25 Water Distribution Pan Water Level

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

9. ALIGNING RECIPROCATING COMPRESSORS AND MOTORS

Thermal storage units may be furnished with direct coupled motors and compressors. The coupling center section is shipped loose for field installation. The compressor and motor are carefully aligned at the factory before shipping.

Coupling Center

Check for alignment before inserting the coupling center section.

Compressor Motor

Inspect the compressor motor alignment with a dial indicator to check if it may have been disturbed during shipment or installation. See Table 3-1.

Motor & Compressor Flanges

Check the alignment of the motor and compressor flanges with a dial indicator on the motor flange. The procedure for checking alignment and alignment tolerances follow. Both angular and parallel must be checked. For the details on the compressor manufacturer alignment procedure, refer to the Installation, Start-Up and Service Instructions located in the Appendix & Notes Section.

Table 3-1 Compressor Alignment Tolerances

PARALLEL ALIGNMENT	
TOP–BOTTOM	±5 MILS
SIDE–SIDE	±5 MILS
ANGULAR ALIGNMENT	
TOP–BOTTOM	±7 MILS
SIDE–SIDE	±7 MILS

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(REFER TO COMPRESSOR MANUFACTURERS INSTALLATION, START-UP, AND SERVICE INSTRUCTIONS FOR ADDITIONAL DETAILS).

NOTE:
THE COMPRESSOR ALIGNMENT SPECIFIED ABOVE SHOULD BE USED INSTEAD OF THE SPECIFICATIONS RECOMMENDED IN THE MANUFACTURER'S GUIDE.

Motor/Compressor Assembly

The motor/compressor assembly should be doweled to the base after the final alignment and hot check is completed to help maintain alignment and aid in repositioning the motor after servicing.

Compressor Alignment

If, for any reason, the compressor alignment is not within tolerance after reinstallation of the coupling, it must be re-aligned (refer to Table 3-1).

Doweling Procedure

Since doweling is performed after the motor/compressor alignment has been hot checked (i.e. compressor has been run and brought up to operating temperature after initial alignment), the doweling should be done at start-up.

Note:
All self-contained SC, SCA, and SCE models are factory run and doweled. SCAR and SCER utilize remote condensers and are not factory run.

In such cases, doweling is done after the initial start-up of the equipment. The following procedure is used:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

1. With the compressor at operating temperature, verify the compressor alignment.

2. With the compressor still at operating temperature, drill and ream two (2) holes diagonally opposite on both the compressor and motor. Do not ream the holes too deep. Part of the dowel pin should protrude above the compressor or motor foot (see step 4 below). See Figure 3-26.

   Tools Required:
   - drill
   - 9/32" diameter drill
   - #6 taper reamer

3. Insert the #6 x 2 1/2" hardened taper dowel pins in the holes.

4. Using a rubber hammer or mallet, tap the dowel lightly into position. Leave 1/8" – 3/16" of the dowel pin above the motor foot (required to tap and loosen the dowel for removal when required).

5. Coat the dowels with white lead or lubricant to prevent rusting.

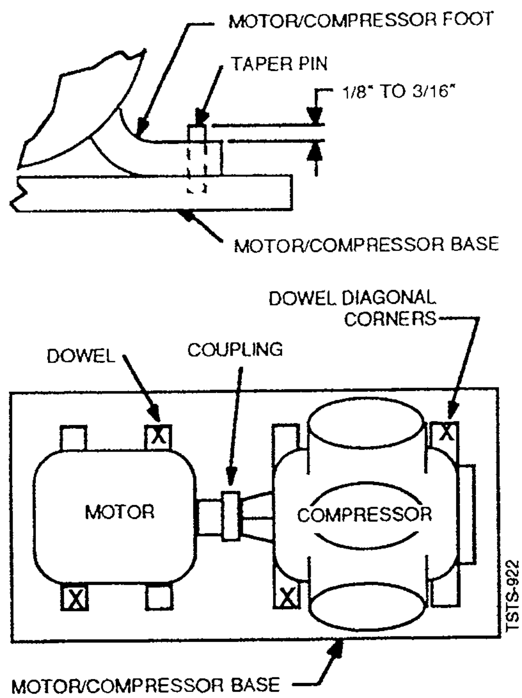

Figure 3-26 Doweling

Reference

Refer to the compressor manufacturer alignment procedure in the Installation, Start-Up and Service Instructions in the Appendix & Notes Section.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

10. TESTING REFRIGERATION SYSTEM FOR LEAKS

Testing for leaks assures a tight system that operates without loss of refrigerant.

In order to test for leaks, the system pressure must be built up. Test pressures for various refrigerants are listed in USAS (formerly ASA) B.9.1 Code Brochure entitled "Safety Code for Mechanical Refrigeration" and USAS B31.5 "Refrigeration Piping Code". These pressures will usually suffice but check local codes as they may differ.

IMPORTANT

Do not use the compressor to build up the pressure - it is not designed to pump air. Serious overheating and damage may result.

Prior To Testing

Before testing, follow these instructions:

1. If test pressures exceed the settings of system relief valves or safety devices, remove the system relief valves or safety devices and plug the connection during the test.
2. Open all valves except those leading to the atmosphere.
3. Open all solenoids by lifting their stems manually.
4. Open all by-pass arrangements.

Oil free dry nitrogen may be used to raise the pressure to the proper level for testing.

WARNING

Never use combustible gas or oxygen or a combustible mixture of gases for system testing. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Testing

When the proper pressure is attained:

1. Test for leaks with a mixture of four parts water and one part liquid soap applied to all flanges, threaded, soldered, or welded joints with a one inch round brush. A small amount of glycerine added to the test solution will strengthen the bubbles and improve the solution.
2. Observe the entire joint. If a leak is present, the escaping gas will cause the test solution to bubble.
3. After all leaks are found and marked, relieve the system pressure and repair leaks.

IMPORTANT

Never attempt to repair soldered or welded joints while the system is under pressure. Soldered joints should be opened and resoldered. Do not simply add more solder to a leaking joint.

4. After all the joints have been repaired and the system is considered "tight", test the unit with refrigerant.
5. Attach a drum of the proper refrigerant to the system and allow the gas to enter until a pressure of 5 psig is reached.
6. Remove the refrigerant drum and bring the pressure to the recommended test level with oil free dry nitrogen.
7. Check the entire system again for leaks, using a halide torch or electronic leak detector. Check all flanged, welded, screwed, soldered and gasket joints, and all parting lines on castings. If any leaks are found, they must be repaired and rechecked before the system can be considered tight.

Note:
See warning on next page.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

WARNING

No repairs should be made to welded or soldered joints while the system is under pressure. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

11. EVACUATING THE SYSTEM

Reasons To Evacuate

Refrigeration systems operate best when only refrigerant is present in the system. Steps must be taken to remove all air, water vapor, and all other non-condensables from the unit before charging it with refrigerant. If air, water vapor, or non-condensables are left in the system, various operating difficulties can be encountered:

1. The moisture will react with the oil in the system forming sludge which can clog passage-ways and lead to lubrication problems.
2. Air and non-condensables will lodge in the condenser, decrease the space for condensing liquid and cause the head pressures to rise.
3. A combination of a moisture and refrigerant, along with free oxygen, can cause the formation of acids and other corrosive compounds which could corrode the internal parts of the system.

Helpful Hints

If properly evacuated as outlined below, the system will be oxygen free, dry, and there will be no non-condensables to cause problems later.

- If at all possible, the piping should not be insulated before the evacuation process is started.
- The evacuation should not be done unless the room temperature is 60° or higher (to allow for proper moisture boil off).
- If free moisture is in the system before evacuation (such as water collected in traps or low places in the piping), this can easily be detected by feeling of these traps and low places. If moisture is present it will condense in the low places and freeze. It can be removed by gently heating the trap the farthest away from the vacuum pump. This causes the water to boil, the ice to melt, and the vapor to collect in the next trap towards the vacuum pump. Repeat this process until all pockets of water have been boiled off and the vacuum pump has had a chance to remove all of the water vapor from the system.

Proper Measuring Instrument

It is not possible to read high vacuums or low absolute pressures with a pressure gauge or mercury monometer. Use the proper gauge manufactured by McLeod, Stokes, and Airserco. These gauges usually read in the range from 20 to 20,000 microns.

High Vacuum Pump

- Use a high vacuum pump capable of attaining a blanked off pressure of 10 microns or less.
- Attach this pump to the system and allow it to operate until the pressure in the system has been reduced somewhere below 500 microns.
- Connect the high vacuum pump into the refrigeration system following the manufacturers instructions.

Note:
For best results, connect the pump to the high side and the low side of the system so that the entire system is thoroughly evacuated.

- Connect the vacuum indicator or gauge into the system in accordance with the manufacturer's instructions.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

First Evacuation

A single evacuation of the system is not satisfactory to remove all of the air, water, and non-condensables present. To do a complete job, the triple evacuation method is recommended:

1. When the pump is first turned on, reduce the system pressure as low as the pump is able to bring it.
2. Allow the pump to operate for five (5) or six (6) hours.
3. Stop the pump and isolate the system.
4. Allow it to stand at this vacuum for another five (5) to six (6) hours.
5. Break the vacuum with oil free dry nitrogen.
6. Raise the system pressure up to zero (0) with oil free dry nitrogen.

Second Evacuation

1. Start the second evacuation, again allowing the pump to operate and reduce the pressure to less than 500 microns.
2. Allow the pump to operate for two (2) or three (3) hours.
3. Stop the pump and allow the system to stand with this vacuum for a minimum of three (3) hours.
4. Break the vacuum with oil free dry nitrogen.
5. Raise the pressure in the system to zero (0).

Third Evacuation

For the third evacuation, the foregoing procedure is again followed:

1. Operate the pump until the system pressure is reduced below the 500 micron figure.
2. Allow the pump to operate an additional six (6) hours.
3. Stop the system and allow to stand for approximately twelve (12) hours at the low pressure.
4. Break the vacuum with the oil free dry nitrogen.
5. Allow the pressure in the system to come up to slightly above zero (0) pounds (drier cartridges and moisture indicators may be installed in the system at this time).
6. Evacuate the system below the 500 micron figure and charge with the refrigerant being used for the system.

Although this procedure is time consuming, it is the only positive way to ensure a properly evacuated system. Short cuts may result in even more time consuming and expensive clean up of improperly evacuated systems.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

12. CHARGING THE UNIT WITH REFRIGERANT OIL

When properly charged, the oil level in the compressor should be visible at the center of the compressor sight glass (located on hand-hole cover on the side of compressor). An oil reservoir is also used on these units. The oil level on the oil/reservoir should be visible at the center of the top sight glass. Other equipment such as the oil filter or oil coolers (when used) also require oil charge. Therefore, the oil level in the compressor and oil reservoir should be rechecked after the compressor has been operated. If additional oil is required, add only the oil specified by the manufacturer. Use only dehydrated, wax-free, refrigerant grade oil of suitable viscosity (refer to Table 3-2).

Periodic Checks & Records

The above oil check should be done at start-up, or after any service work is performed. Periodic checks should also be done on a regular basis. Complete records should be kept of any additions or removal of oil to the system.

Refrigerant Oil

Unless otherwise specified, the following refrigeration oil should be used:

- Sun Oil Suniso 3GS or 4GS (refer to Table 3-2)
- DuPont synthetic oil, 150 SSU only
- Texaco Capella B1.

IMPORTANT

- **Do not mix different types or grades of oil.**
- **Do not over fill with oil, this is especially true on the hermetic type compressors.**
- **Make sure the oil is fresh and not contaminated.**

Table 3-2 Compressor Oil Charge

CARRIER COMPRESSORS – OIL CHARGE (PINTS)*	5H40/46 18	5H60/66 21	5H80/86 41	5H120/126 81
ROYCE COMPRESSORS – OIL CHARGE (PINTS)**	CG040 24	CG060 30	CG080 32	CG120 60

TSTS-904

* 3GS OR EQUIVALENT OIL
** 4GS OR EQUIVALENT OIL

Oil Quality

If the quality of the oil is unknown or is not clear, Turbo recommends that an oil test kit be obtained from a local refrigeration supply house. This will ensure that the oil is acid free and safe to use.

Periodic analysis of oil samples by local testing laboratories can also detect unusual build-up of metals or other contaminants (which result from wear or other debris in the oil) before they become a problem.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

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13. REFRIGERANT CHARGING

Possible Leaks

Self-contained water cooled, evaporative cooled, and air cooled units are furnished complete with necessary operating refrigerant charge and normally require no field charging. A leak in the refrigerant circuit might occur during shipping or handling. If a leak is detected, immediate corrective action should be taken and additional refrigerant gas should be added to the system. Refer to step 10. Testing Refrigeration System For Leaks on page 69.

Models with remote (field installed) condensers are shipped with a holding charge only and will require field charging of the systems. These units are designated as R, SCAR, and SCER. Refer to "Initial Refrigerant Charge" instructions on this page.

Adding Refrigerant

IMPORTANT

Before adding refrigerant or placing the unit in operation, evacuate the entire system to insure a completely dry system. See step 11. Evacuating The System on page 71.

Whenever refrigerant is added to any system that has already been evacuated and charged, extreme care should be taken in admitting the refrigerant to the system.

1. The unit should be placed in operation and the liquid line sight glass observed during the first five minutes of the freezing cycle.
2. With the head pressure between 180 psig and 210 psig (for R-22 system), the refrigerant should be slowly charged into the suction of the compressor as a gas only (never as a liquid). Be sure that all charging lines are clean and properly purged of air. Air is purged from the charging line by allowing some refrigerant to escape while attaching the hose to the charging port.
3. When the liquid line sight glass is free from bubbles during the first five minutes of the freezing cycle, (the period of heaviest refrigerant flow) the unit is fully charged. The unit nameplate lists the unit model, refrigerant type, and refrigerant charge. Always monitor and record how much refrigerant is added. <u>Never</u> exceed the nameplate charge listed.

IMPORTANT

Do not overcharge the refrigerant circuit because this induces high discharge pressures. Be sure the correct type of refrigerant is being added to the systems.

Remote Air-Cooled or Evaporative-Cooled Units

Self-contained units furnished for use with remote air-cooled condensers (SCAR) or remote evaporative-cooled condensers (SCER) are shipped without the operating charge and will require refrigerant gas. Follow the procedure set forth under "Adding Refrigerant" on this page. Each unit is shipped with a holding charge to keep the system dry during shipment or storage.

Remote Type Units

All remote type (R) models are furnished without refrigerant charge. The entire refrigerant system must be evacuated as per step 11. Evacuating The System on page 71 and then charged by following the procedure set forth under "Adding Refrigerant" on this page. Each unit is shipped with a holding charge to keep the system dry during shipment or storage.

Initial Refrigerant Charge

For systems shipped with a holding charge only, it will be necessary to add refrigerant to the system before starting.

To transfer refrigerant from a bottle, cylinder, or drum into a refrigeration system requires

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

the pressure in the refrigerant vessel to be higher than the refrigerant system. In typical charging operations, a commercially available and approved electric heater band is strapped to the refrigerant vessel. The low wattage heat input from the heater band safely raises the pressure in the vessel and drives the refrigerant into the refrigeration system, which is at a lower pressure.

Example:
Charging refrigerant (R-22) gas into the suction side of a system operating at a suction pressure of 43 psig would require enough heat to raise the pressure in the charging vessel above 43 psig; charging an idle system at 150 psig will require a pressure higher than 150 psig.

WARNING

Never use a torch or open flame to input heat into a refrigerant charging vessel. Excessive heat can produce unsafe pressures that can result in rupture or explosion of the vessel. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Small 30 pound bottles offer the safest and easiest handling due to light weight and should be used when practical as outlined below. Thirty pound bottles are also easy to weigh to determine how much refrigerant has been added and if the bottle has been emptied.

The large 125 pound bottles are a little harder to physically handle but are more practical for systems with larger charges.

IMPORTANT

Proper lifting techniques must be used in lifting the cylinder to avoid injury to the back. Use a hand cart with chains to strap the bottle to the cart during transport. Never try to carry the cylinder up a ladder or stairway by hand. Never lift the cylinder alone.

Again, the 125 pound bottles are easy to weigh using standard commercially available scales to determine how much refrigerant has been added and if the cylinder has been emptied.

Large 1,750 pound drums are more practical and economical on larger systems but require special handling with a fork lift, cranes, or other special handling equipment. They are also more difficult to weigh to verify the amount of refrigerant used. Adding a source of low wattage heat is also more difficult.

It is sometimes more practical to lower the pressure of the refrigeration system being charged by either running cool water over the receiver, or surrounding the receiver with ice. Refrigerant liquid transfer pumps are more practical for transferring large refrigerant charge. Because of the size of the charging drum, it may be difficult or impossible to locate the drum next to the system being charged. In this case, it will be necessary to run a charging line from the drum to the system. Copper tubing or charging hoses for this purpose should be used.

Systems with operating charges less than 250 pounds can be safely and easily charged using 30 pound refrigerant bottles. Systems with 250 to 1,500 pounds are more suitable for 125 pound refrigerant containers for safe and easy handling. Systems over 1,500 pounds are generally more suitable for 1,750 pound cylinders with the final charge from 125 pound bottles. The use of 1,750 pound cylinders requires special precautions in handling the drum and may require special charging lines.

Charging procedure:

1. Connect a charging line through a refrigerant gauge set from the charging vessel to the refrigeration system receiver, or combination condenser/receiver.
   - Tighten one end and screw the other end on securely but loose.
   - Open (crack) the valve on the charging vessel slightly, allowing a small flow of refrigerant through the hose.
   - At the loose end, wiggle the charging line to al-

low refrigerant and air to escape.
- While the refrigerant is flowing through the loose end, tighten the fitting.
- At this point, both ends of the charging line should be securely fastened and free of air.

CAUTION

Always wear eye protection and protective rubber gloves when attaching the charging line.

WARNING

Never attach the charging line to the discharge (high pressure) side of the compressor. Excessive pressure building in the vessel could result causing the vessel to rupture or explode. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

Never charge liquid refrigerant directly into the compressor unit or suction line. Damage to the compressor could result. Always charge with refrigerant gas into the low side of the system.

2. Open the valve on the refrigerant vessel to fill the charging line.

3. Connect the heater band to the charging vessel and connect to a proper voltage outlet.

4. Open the inlet (charging) valve on the refrigerant system.
   - Refrigerant should flow from the refrigerant charging vessel to the system.

5. If possible, set the refrigerant vessel on a scale.
   - Record the initial weight and the weight of the bottle or cylinder to determine when the bottle is empty.
   - Record each bottle, drum, or cylinder added and maintain a total of the refrigerant added after each bottle, cylinder or drum is added.

6. Repeat the above process until the refrigerant charge specified on the nameplate is in the system.

WARNING

Do not exceed the recommended refrigerant charge. Overcharging can result in excessive pressure causing rupture or failure of the system. Failure to carefully follow these instructions could result in permanent injury or loss of life.

7. Close the valve on the charging vessel and disconnect the heater band.

8. Close the valve on the refrigerant gauge manifold set.

9. Loosen the hose fitting on the receiver end to allow the schrader fitting to seat and hold the charge. Screw a cap on the charging fitting to prevent leakage through the schrader fitting.

WARNING

Refrigerant will flow from the schrader fitting until the stem seats. Always wear eye protection and protective rubber gloves when connecting or disconnecting a hose to the schrader fitting. Failure to carefully follow these instructions could result in permanent injury or loss of life.

10. Loosen the fitting on the center manifold connection to release the refrigerant trapped between the gauge set and shut off valve.

11. Remove and secure all empty refrigerant vessels including replacing the protective cap.

Note:
A charging hose is shown connected to the discharge (high pressure) side of the system in Figures 3-27 and 3-28. This is recommended so that the discharge pressure may be observed during the charging procedure to avoid

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

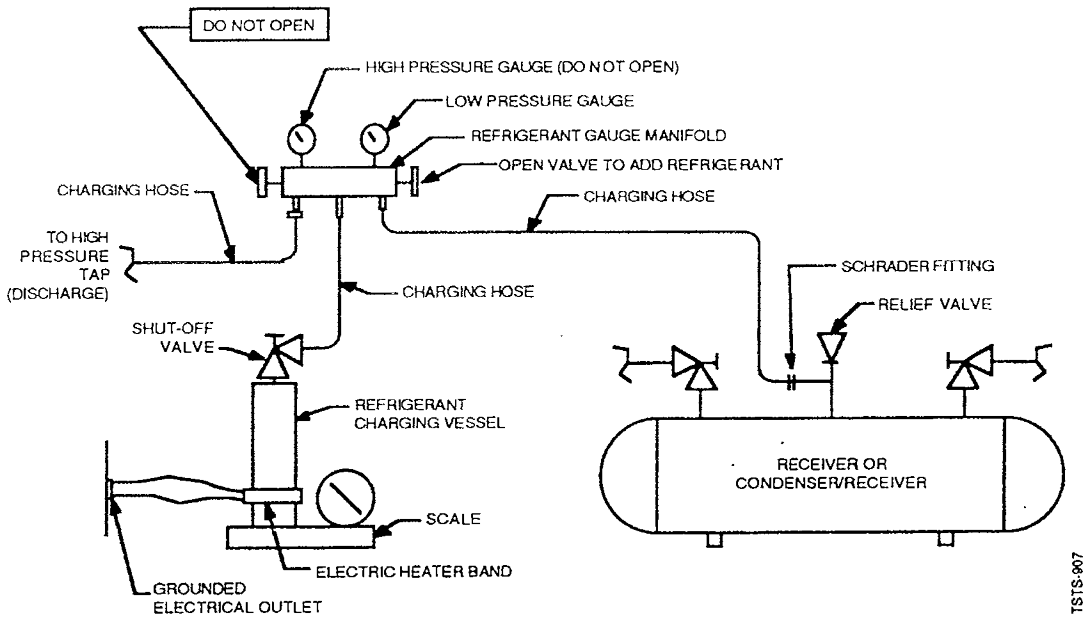


Figure 3-27 Typical Connections for Initial Refrigerant Charge

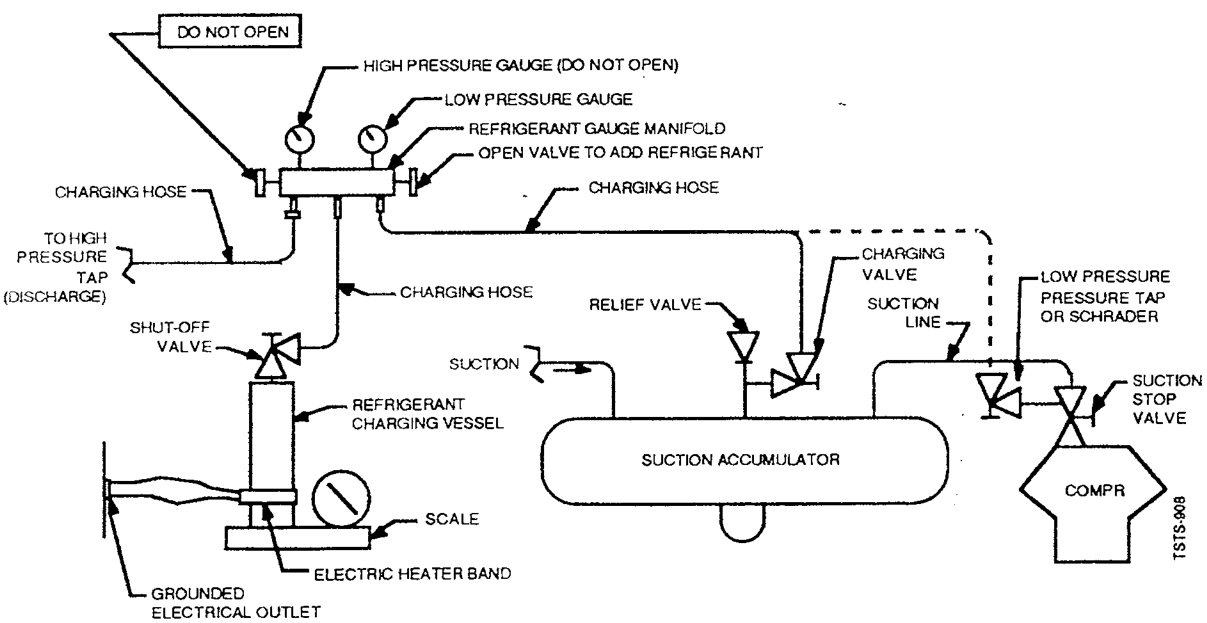


Figure 3-28 Adding Refrigerant to Existing Charged System

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

accidental overcharging or overpressure due to the isolation valve being in the wrong position or location.

WARNING

Do not open the manifold gauge set valve connected to the high side during the charging operation. High pressure could enter the charging vessel resulting in rupture or failure causing serious injury. Failure to carefully follow these instructions could result in permanent injury or loss of life.

On large systems where a liquid transfer pump or charging system is used, the manufacturer's instructions should be followed in connecting the pump and hoses. However, all other guidelines as outlined above should be followed.

Relief Devices

Relief valves are installed on pressure vessels (condensers, receivers, etc.) to prevent excessive pressure build-up in the system. These safety relief valves should be vented to a safe discharge point. Field piping (by others) will be required to vent the valve outside for indoor installations or to a location away from personnel exposure for indoor or outdoor installations. Refer to Figures 3-29, 3-30, and 3-31.

WARNING

All relief valves must be piped to a safe discharge location. Failure to carefully follow these instructions could result in permanent injury or loss of life.

All relief valves are tagged with the above or a similar warning.

Do not attempt to add refrigerant to the system before piping all relief valve connections.

ANSI/ASHRAE 15-1978 code permits a maximum back pressure through the relief valve discharge piping of 25% of the inlet pressure while the device is discharging at rated

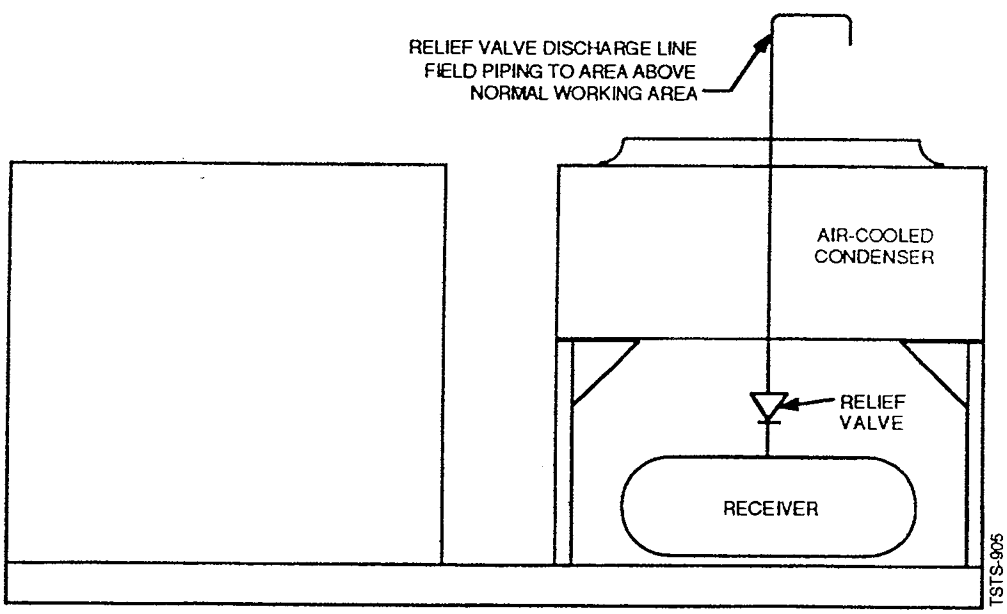


Figure 3-29 Typical Air-Cooled Condenser Relief Valve Field Piping

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

capacity. Based on the set pressure and capacity of the relief device, the maximum length of discharge piping can be calculated using the formula:

$$L = \frac{9P^2d^5}{16C^2}$$

$$C = f DL_1$$

where:

L = length of relief valve discharge piping, in feet

P = 0.25 [(relief valve pressure setting) x 1.1 + 14.7]

d = internal diameter of discharge piping (or tubing), in inches

C = minimum required discharge capacity, in pounds of air per minute

f = 1.6 for R-22

f = 0.5 for ammonia

D = outside diameter of vessel in feet

L_1 = length of vessel in feet

Turn to the next page for example problem.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Example:

HP200BSCE uses a 12 3/4" diameter x 48" receiver.

Design relief pressure is 300 psig.

Refrigerant is R-22.

Therefore, $C = f\ DL = (1.6)\left(\frac{12\ 3/4}{12}\right)\left(\frac{48}{12}\right) = 6.8$ pounds of air per minute.

A 1/2" x 3/4" (inlet x outlet) pressure relief valve rated at 41.6 pounds of air per minute is used.

Maximum discharge piping length:

$$L = \frac{9P^2d^5}{16C^2} = \frac{(9)\ (7{,}430)\ (0.38)}{(16)\ (46.24)} = 34.3 \text{ feet}$$

where:

$P =$ 0.25 [(300) (1.1) + 14.7] = 86.2

$P^2 =$ 7,430

$d =$ 0.824" (3/4" sch40 pipe)

$d^5 =$ 0.38

$C =$ 6.8 pounds of air per minute

$C^2 =$ 46.24

Therefore, a 3/4" sch40 pipe is completely adequate for normal installations with relief valve discharge piping less than 34 feet long. If longer piping is required, a larger size piping would be required.

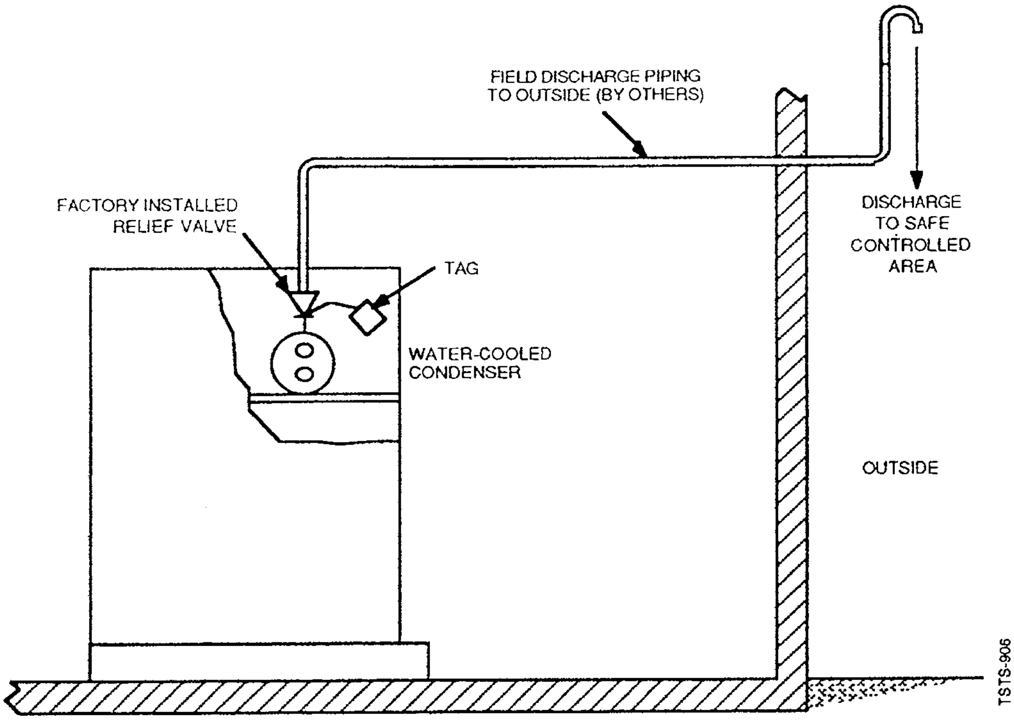
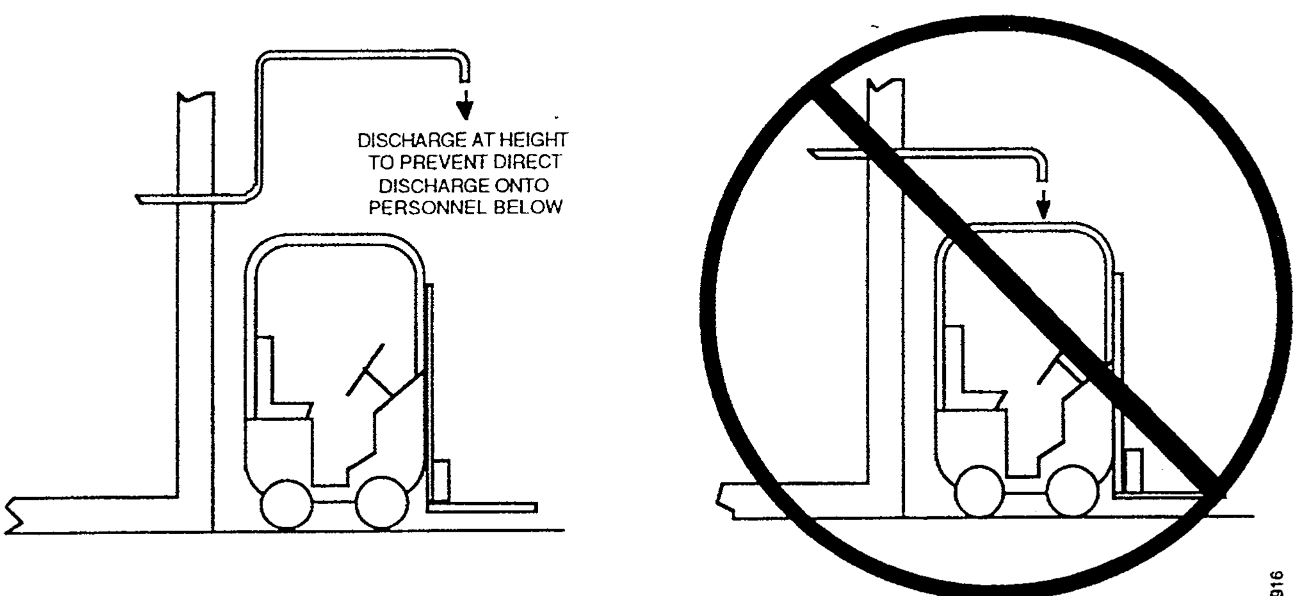


Figure 3-30 Typical Indoor Installation Relief Valve Piping



CORRECT

INCORRECT

Figure 3-31 Correct and Incorrect Relief Valve Discharge Piping

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

14. AIR-COOLED CONDENSERS

Design Conditions

All SCA condenser selections are based on the following conditions (for R-22):

- 100°F ambient (dry bulb)
- 20°F approach (condensing temperature - air entering temperature)
- 120°F condensing temperature, SDT (260 psig)
- 20°F saturated evaporator temperature, SET for ice-making/40°F SET for chilling
- THR total heat of rejection (evaporator load in BTUH at highest operating °F SET and 120°F SDT) + (heat of compressor in BTUH)
- During operation on non-design days, the system can and should be operated at a lower saturated condensing temperature. For proper thermal valve operation, a minimum pressure of 150 psig should be maintained.

Example:

HP model with 5H60 compressor.

- Compressor capacity at 20°F SET and 120°F SDT = 35.6 tons = 427,200 BTUH
- Compressor BHP at 20°F SET and 120°F SDT = 55.2
- THR = (427,200) + (55.2) (2,545) = 567,684 BTUH
- Condenser selection would be based on 567,684 BTUH with 20°F TD.

Mounting

Air-cooled condensers supplied with the thermal storage unit SCA models are based on 100°F air on, 110°F air off, and 120°F condensing (260 psig). The air-cooled condenser is mounted on a common base frame with the evaporator at an elevation that allows free draining of the liquid from the condenser into the receiver and unrestricted airflow through the coil. When an air-cooled condenser is field installed, mount the condenser so that the condensed liquid refrigerant will flow into the receiver without restriction or traps. Pitch the liquid line down from the condenser to the receiver. Mount the air-cooled condenser high enough so trash will not be sucked into the coils by the airflow over the coils. These condensers can be furnished for horizontal or vertical air flow (as required). Horizontal mounting is standard.

Equipment

Self-contained air-cooled (SCA) models are furnished with a properly sized condenser to reject the total heat of rejection (THR) of the evaporator and the heat of compression. A receiver, isolation valves, safety relief valve, check valve, and winter control valves (for operation in low ambient) are also supplied. The piping and wiring are factory installed.

For remote air-cooled (SCAR) models, all of the above is available as an option for field installation and piping to the evaporator. Motor starter(s) for the condenser fan(s) can also be furnished.

Operation

The need for a modulating device for use in conjunction with constant air flow air cooled condensers is generally recognized. Falling ambient temperatures produce correspondingly lower operating pressures and eventually cause system problems at the expansion valve due to low pressure. The Turbo winter control, which consists of four valves ("L", "G", "LC", "LD"), is a completely automatic system that eliminates these conditions.

Operation of the Turbo condenser winter control is as follows (refer to Figure 3-32):

- When low ambient air conditions are encountered which allow condensing pressure to drop, the principle of operation is to hold back enough of the condensed liquid in the air cooled condenser coil so that some of the surface is rendered inactive as condensing surface. This reduction of active condensing surface results in a rise

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

of condensing pressure permitting normal system operation. This method of control is typically called "flood-back" control.

- The system must be capable of holding enough refrigerant so that liquid can be stacked in the condenser and still have enough charge in the receiver for proper operation.
- The receiver must have sufficient capacity to hold all of the liquid refrigerant in the system which must be returned to the receiver when high ambient conditions are encountered.

Note:
If the receiver is too small, liquid refrigerant will be held back in the condenser during the high ambient conditions and excessively high discharge pressures will be encountered.

IMPORTANT

Sufficient refrigerant must be in the system to permit the winter control to operate satisfactorily and maintain a liquid seal on the receiver.

Valve Functions

Valve "L" (Upstream Regulator)

Valve "L" (located in the discharge line from the compressor to the condenser) is the modulating type. The spring tension is set so that a minimum pressure in the condenser is required before valve "L" will begin to open. Any increase in pressure opens valve "L" more, permitting more condensate to pass into the condenser. If the spring tension is increased (by clockwise adjustment), a higher pressure will be required to open the valve. If the spring tension is decreased (by counter-clockwise adjustment), a lower condenser pressure required. Valve "L" is set at the factory (on SCA models) to open at 180 psig for R-22 which should permit satisfactory operation. If a field adjustment is required and the condenser pressure does not vary with the adjustment, this indicates a shortage of refrigerant in the system.

During start-up, when the

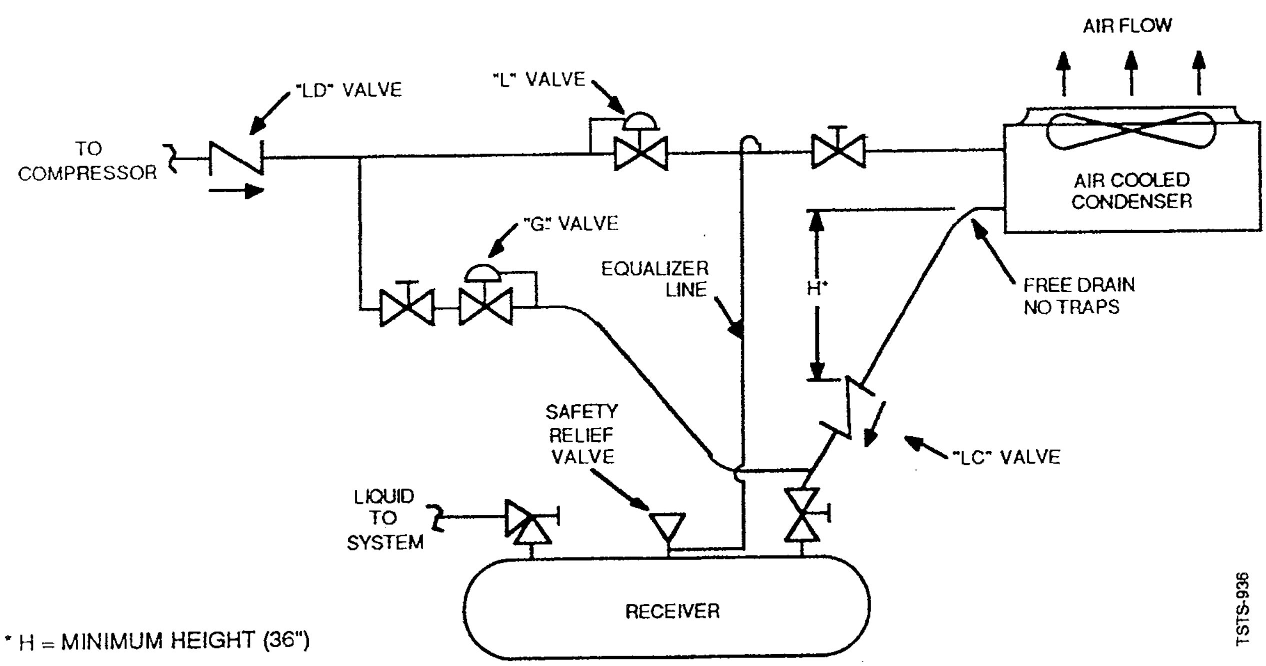


Figure 3-32 Typical Air-Cooled Control & Winter Control Valve Piping (Flood-Back Method)

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

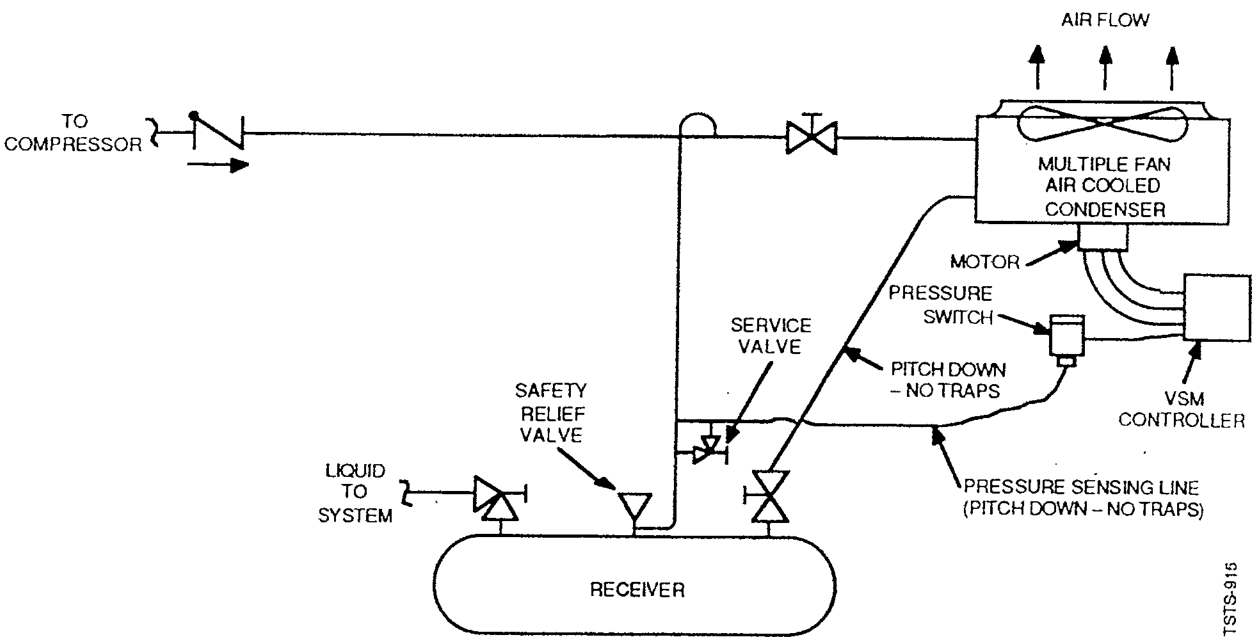


Figure 3-33 Typical Piping for Fan Cycling or Variable Speed Fan Motor (VSM) Controls

condensate in the condenser has been exposed to a low ambient air temperature, it is cooled down below the temperature corresponding to the existing condensing pressure. The pressure in the receiver needs to be raised to a point that corresponds to the pressure required for proper operation of the thermal expansion valve. This is accomplished by permitting hot discharge gas to bypass the condenser and enter the receiver through valve "G" to maintain pressure until the condenser warms up.

Valve "G" (Downstream Regulator)

Valve "G" is a modulating valve that acts in reverse so that the spring tension opens the valve to admit hot gas. Valve "G" remains open until the pressure (temperature) in the receiver rises to the set point and drives the valve closed. Valve "G" is preset at the factory to close at 160 psig for R-22. If a field adjustment is required, a clockwise adjustment increases the spring tension. A higher rise in pressure is obtained before the valve closes, shutting off the hot gas flow into the receiver. A counter-clockwise adjustment would permit the valve to close at a lower pressure.

Valves "L" and "G"

When adjusting valves "L" and "G", a certain differential in pressures (approximately 20 psig) must be maintained to ensure enough of a difference between discharge pressure and receiver pressure so that hot gas will enter the receiver when required.

When the system is not in operation, no refrigerant gas will enter the condenser. Eventually the pressure in the condenser will drop to a point that corresponds to the ambient air temperature. During this period, there may be a large difference between the pressure in the warm receiver and the cold condenser. The service for which valves "L" and "G" are designed does not require them to be gas tight. During this shut down period, it is possible for refrigerant gas to escape from the higher pressure in the warm receiver through the condenser drain line back into condenser (because of low ambient at a low pressure). A check valve

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

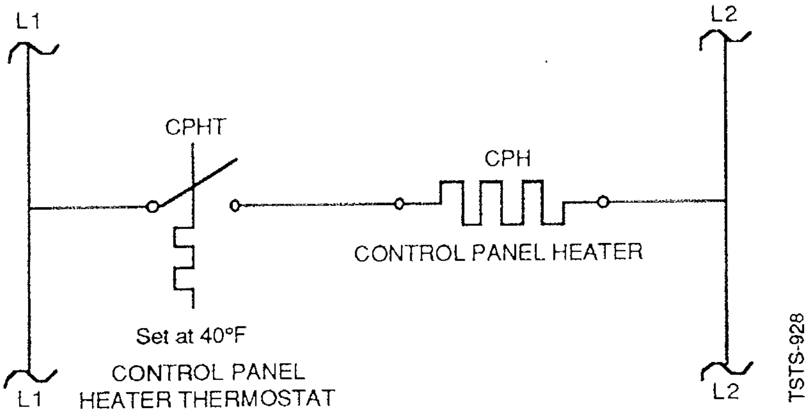


Figure 3-34 Control Panel Winterizing Wiring

"LC" is placed in the drain to prevent migration of the liquid back to the condenser. This lowers the pressure in the receiver making it impossible for the thermal expansion valve to open when the unit calls for refrigeration again.

Valve "LC"

To prevent the escape of gas, a check valve ("LC") is located in the drain line which feeds the receiver. This valve is gas tight and must be maintained as such.

Valve "LD" is also a check valve which must be installed in the discharge line as close to the compressor as possible. Valve "LD" insures that no gas in the condenser will migrate to the compressor head. Refer to Figure 3-32 for valve arrangement. Flow in the condenser drain line is sized for 2 FPM.

Alternate Head Pressure Controls

Fan Cycling

On some models, a pressure switch(es) is used to cycle the fan(s) on and off in response to an increase or decrease in discharge pressure. This method reduces the refrigerant charge by eliminating the need to flood the condenser coil. It is generally limited to applications using condensers with several fan motors, allowing several capacity reduction steps. Under certain conditions, rapid cycling of the fan(s) may result when used on models with only one or two fans.

Variable Speed Motor (VSM) Controller

A variable frequency solid-state controller is used to vary the output RPM of the condenser fan motor(s). A pressure differential switch is used to signal the controller to increase or decrease the motor speed from 0 to 100% to maintain the pressure set point.

The VSM controller eliminates the need for flooding the condenser coil thus reducing the refrigerant charge and receiver size.

VSM controllers can also be used with single or multiple fan motors and maintain a steady pressure control (i.e. eliminates sudden reductions or increases in airflow associated with cycling the fan on and off).

See Figure 3-33 for typical piping with fan cycling or VSM controls. For the type of head pressure control used on a unit, refer to the manual cover sheet.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Control Panel Winterizing

Ambient temperatures can affect many of the electronic controls in the VSM control panel. In general, the devices Turbo uses operate properly in temperatures between 32°F and 140°F. In operating ambients under 40°F, Turbo recommends that a source of heat be available in the control panel to maintain a temperature above 40°F. This will ensure continuous, reliable operation of all components (even in severe applications*). A winterizing kit consisting of a heat source and control thermostat can be provided as a factory installation or as a retrofit to existing control panels.

* The control panel winterizing kit is designed for equipment operations in ranges from 0 to 40°F. Consult Turbo for equipment operations in conditions below 0°F.

Installation

All components are factory installed and pre-wired.

Operating Sequence

As the control panel temperature drops below the set point of 40°F, the contacts of CPHT thermostat close to energize the panel heater coil. As the temperature rises above the differential setting of the thermostat, the contact opens to turn off the heater. The thermostat continues to maintain the interior temperature above 40°F. Refer to Figure 3-34.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

15. EVAPORATIVE-COOLED CONDENSERS

Mounting

Evaporative condensers supplied with SCE models are based on 78°F design wet bulb and 95°F condensing (181.8 psig) for R-22. The condenser is mounted on a common base frame with the evaporator section. A receiver is mounted on the same frame (below the condenser outlet) a distance that ensures free flow of the liquid from the condenser to the receiver without traps. Pitch the drain line down from the condenser to the receiver. Control of the evaporative condenser fan(s) and water pump is wired into the unit control panel.

Equipment Furnished

Self-contained evaporative-cooled (SCE) models are furnished with a properly sized condenser to reject the total heat of rejection (THR) of the evaporator and the heat of compression. A receiver, isolation valves, safety relief valve, and head pressure controls are supplied. The piping and wiring are factory installed.

For remote evaporative-cooled (SCER) models, all of the above is available as an option for field installation and piping to the evaporator. Motor starters for the pump and fan motors can also be provided.

Head Pressure Control

Two types of head pressure control are used on thermal storage units:

1. Variable speed fan motor control (VSM).
2. Flood-back control.

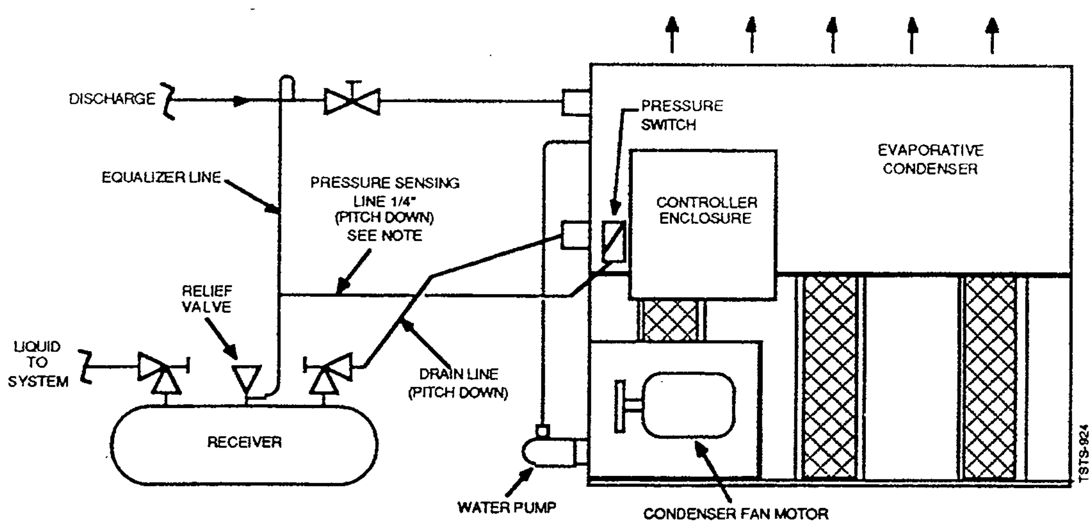
Refer to Figure 3-35.

VSM Controls

A solid state variable frequency constant torque drive monitors the pressure at the inlet to the condenser. This signal is directed to the frequency control to adjust the fan motor RPM either up or down to maintain the pressure at the set point.

A differential pressure switch with two (2) SPST switches is used to sense the discharge pressure.

1. As the pressure reaches the upper set point, the switch contact closes, sending a signal to the controller to increase the fan RPM.
2. As the pressure falls back below the set point, the controller holds the RPM constant.



NOTE: THE SENSING LINE FOR THE VSM PRESSURE SWITCH SHOULD ALSO BE PITCHED DOWN TO PREVENT TRAPPING OF LIQUID OR OIL IN THE LINE.

Figure 3-35 Typical VSM Controller Installation

3. If the discharge pressure falls below the set point of the lower switch, the contact of this switch closes to signal the controller to reduce the fan RPM, allowing the pressure to either raise or hold steady.

The above sequence continues maintaining the discharge pressure between the two set points or in the switch deadband.

On SCE models, the pressure switch settings (although they are factory set) should be checked and adjusted as required during start-up.

Adjustment

The discharge pressure can be increased or decreased by changing the setting of the two pressure switches.

Using a screwdriver, turn both adjustment screws clockwise to raise the pressure and counterclockwise to decrease the pressure.

By adjusting both adjustment screws the same, the differential between the switches is maintained. The differential should be adjusted only if the pressure variation exceeds 12–16 psig. Refer to Figure 3-36.

Flood-Back Controls

Refer to step 14. Air-Cooled Condensers on page 83.

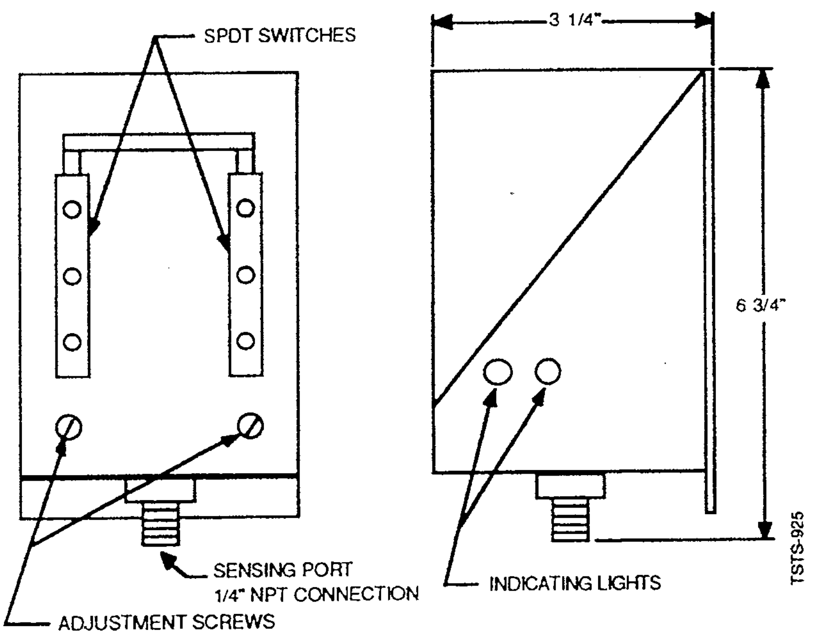


Figure 3-36 Differential Pressure Switch

VSM Controls vs Flood-Back Controls

Flood-back controls are used on smaller systems where:

- the system refrigerant charge is relatively small.
- adequate elevation between the condenser outlet and receiver is available to prevent the liquid refrigerant from stacking in the condenser during operations when flood-back is not required.

Flood-back controls require higher refrigerant charges and larger receivers.

VSM controls are more practical on larger systems to reduce the refrigerant charges.

Notes:

1. Cycling the condenser water pump is not recommended due to scale build-up on the condenser coils (caused by the residue of solids left on the tubes by evaporation of the water).
2. In some low ambient conditions, it may be practical to drain the condenser water sump and operate the evaporative condenser as an air cooled condenser (this does not contradict note #1 because the coil is not alternately wetted and then dried).
3. Sump heaters or indoor sumps should be considered in installations when the system is operated frequently in low ambient conditions.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Differential Pressure Switch Specifications (VSM Controller Input)

Pressure Range
0 to 300 psig

Proof Pressure
350 psig

Switch Output
2 SPDT switches

Electrical Rating
15 amps
125/250/480 VAC resistive

Approvals
UL
CSA

Temperature Operating Limits
–40°F to 160°F

Accuracy
±1% of adjustable range

Enclosure
NEMA 4 cast aluminum

Weight
Approximately 3 pounds

Variable Speed Motor Controller Specifications

Power, Input - Voltage
208, 220, 230, 240 VAC
(LV switch position)

380, 415, 440, 460 VAC
(HV switch position)

Power, Input - Phase
3-phase

Power, Input - Frequency
50 or 60 hertz

Power, Output - Voltage
208, 220, 230, 240 VAC
(LV switch position)

380, 415, 440, 460 VAC
(HV switch position)

Power, Output - Phase
3-phase

Power, Output - Frequency
30, 50, 60, 75, 90, 100, 120, 180 hertz can be selected. Standard switch setting is 60 hertz.

Power, Output - (VSM) Amp Capacity
Model V00800A00 – 8 amps
Model V01200A00 – 12 amps
Model V01500A00 – 15 amps
Model V02200A00 – 22 amps
Model V03200A00 – 32 amps
Model V04200A00 – 42 amps
Model V04600A00 – 46 amps
Model V06000A00 – 60 amps

Power, Output - Temperature Operating Limits
32°F to 104°F

Power, Output - Temperature Storage Limits
–4°F to 140°F

Control Panel Winterizing

Ambient temperatures can affect many of the electronic controls in the VSM control panel. In general, the devices Turbo uses operate properly in temperatures between 32°F and 140°F. In operating ambients under 40°F, Turbo recommends that a source of heat be available in the control panel to maintain a temperature above 40°F. This will ensure continuous, reliable operation of all components (even in severe applications*). A winterizing kit consisting of a heat source and control thermostat can be provided as a factory installation or as a retrofit to existing control panels.

* The control panel winterizing kit is designed for equipment operations in ranges from 0 to 40°F. Consult Turbo for equipment operations in conditions below 0°F.

Installation

All components are factory installed and pre-wired.

Operating Sequence

As the control panel temperature drops below the set point of 40°F, the contacts of CPHT thermostat close to energize the panel heater coil. As the temperature rises above the differential setting of the thermostat, the contact opens to turn off the heater. The thermostat continues to maintain the interior temperature above 40°F. Refer to Figure 3-37.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

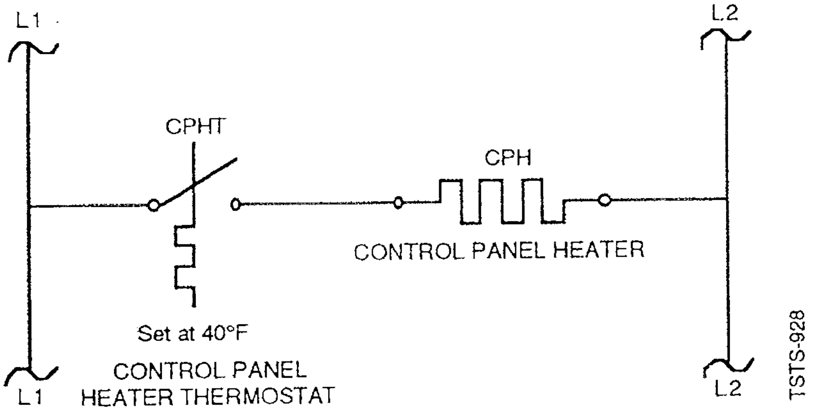


Figure 3-37 Control Panel Winterizing Wiring

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

16. WATER-COOLED CONDENSERS

Mounting

Water-cooled condensers are supplied with SC models. The condenser is located on a structural support above the motor/compressor assembly in the engine compartment. A compressor discharge line is piped to the condenser inlet and a drain line connection is piped to the receiver below.

Design Conditions

The selection of a water-cooled condenser is dependent on the evaporator load, refrigerant used, the source and temperature of the cooling water, the amount of water circulated, and the desired operating pressure.

All SC condenser selections are based on the following conditions (for R-22):

- 85°F water entering
- 95°F water leaving
- 105°F saturated condensing temperature, SDT (210 psig)
- 20°F saturated evaporator for icemaking
- 40°F for chilling

THR (total heat of rejection) = (evaporator load at 20°F SET and 105°F SDT in BTUH) + (heat of compression in BTUH)

Example:
Thermal storage unit with 5H60 compressor

Compressor capacity @ 20°F SET and 105°F SDT = 40.2 tons = 482,400 BTUH

Compressor BHP @ 20°F / 105°F = 51.3

THR = (482,400) + (51.3) (2,545) = 612,958 BTUH

Tower gpm = (THR ÷ 15,000 BTUH / tower ton) (3.0 gpm / tower ton) = (612,958 / 15,000) (3.0) = 122.6 = 125 gpm

THR calculations for highest SET condition.
SET = saturated evaporator temperature.
SDT = saturated discharge temperature.

Equipment

Self-contained water-cooled (SC) models are furnished with a properly sized condenser to reject the THR (total heat of rejection) of the evaporator and the heat of the compressor. A safety relief valve and isolation valves for the inlet and outlet are also provided. Piping and wiring of the components are factory installed.

Water regulating valves for head pressure control, optional cooling towers, and cooling tower pumps can also be supplied.

Water Treatment

For maximum operating efficiency and equipment life of the condenser and cooling tower, Turbo recommends that a local water treatment supplier be consulted to analyze the water system to be used.

Fouling caused by scaling results in high heat pressure, higher operating cost, and lower capacity.

Operation

Superheated discharge gas enters the shell side of the water cooled condenser. Water is circulated through the tubes to remove the heat from the gas. The amount of surface area in the condenser, the flow rate (gpm) of the water, and the temperature of the water entering the condenser are all sized to remove the heat of compression and the heat absorbed by the refrigerant in the evaporator and converts the gas back to the liquid phase at the condenser pressure. Shell-and-tube (horizontal) condensers are used for this purpose.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

A typical water cooled system operates as follows:

For a system with:

- Water-cooled condenser
- Pressure-actuated water regulating valve
- Cooling tower with fan cycling thermostat
- Cooling tower pump
- Low discharge pressure switch

1. A switch sensing the discharge pressure closes at 150 psig to start the cooling tower fan and pump (starters, pump, and cooling tower are all optional equipment).

2. The water pump runs all the time (i.e. do not cycle water pump on and off).

3. As the water temperature in the cooling tower sump reaches the set point (usually 80–85°F) of the thermostat, the contacts close to energize the cooling tower fan motor magnetic starter. The fan runs until the temperature of the water drops below the differential of the thermostat and the contacts open to turn the fan off.

4. The water flow through the condenser is controlled by a pressure actuated water regulating valve that modulates open or closed in response to the discharge pressure. Water regulating valve kits are available from Turbo. As the discharge pressure increases, the water regulating valve opens to increase the water flow through the condenser. Conversely, as the discharge pressure drops, the valve modulates closed to reduce the water flow.

Note:
As the water temperature available from the cooling tower increases, the flow rate through the condenser must also increase to maintain the desired pressure setting. Therefore, for the controls to work properly, the settings of both the water regulating valve and cooling tower sump temperature thermostat must both be properly adjusted.

5. The setting of the water regulating valve and the resulting discharge pressure can be changed by turning the adjusting stem located on the top of the valve clockwise to raise the pressure and counterclockwise to reduce the discharge pressure. By turning the valve in, the spring in the bonnet is compressed, requiring a greater discharge pressure to move off its seat, thus allowing the water flow to decrease. As the stem is turned out, the compression of the spring is decreased and the force required to open the valve is also decreased. Thus, water flow through the valve increases and the discharge pressure is lowered.

Refer to Figures 3-38 and 3-39 for typical water-cooled condenser piping and wiring.

General Information

A safety relief is provided on each condenser. Refer to step 13. Refrigerant Charging on page 75 for guidelines on relief valve venting.

Water-Cooled Condensers

Water condensers supplied on thermal storage units are the conventional condenser receiver combination type. They feature shell and tube type construction, cleanable with removable heads. The water in and out connections are sized to permit maximum water flow at peak requirements. All models are furnished with the connections piped to the outside of the unit for ease of installation.

Water Requirements

Condenser water requirements are based on 85°F water to the condenser, 95°F water off the condenser, and 105°F condensing. The condensers design water flow rate is based on 3 gpm/ton of refrigeration*. The actual rate of flow is wholly contingent on the water temperature and evaporator load but will not exceed the design flow.

* Tons of refrigeration = total heat of rejection @ 20°F SET/105°F SDT divided by 15,000 BTU/ton.

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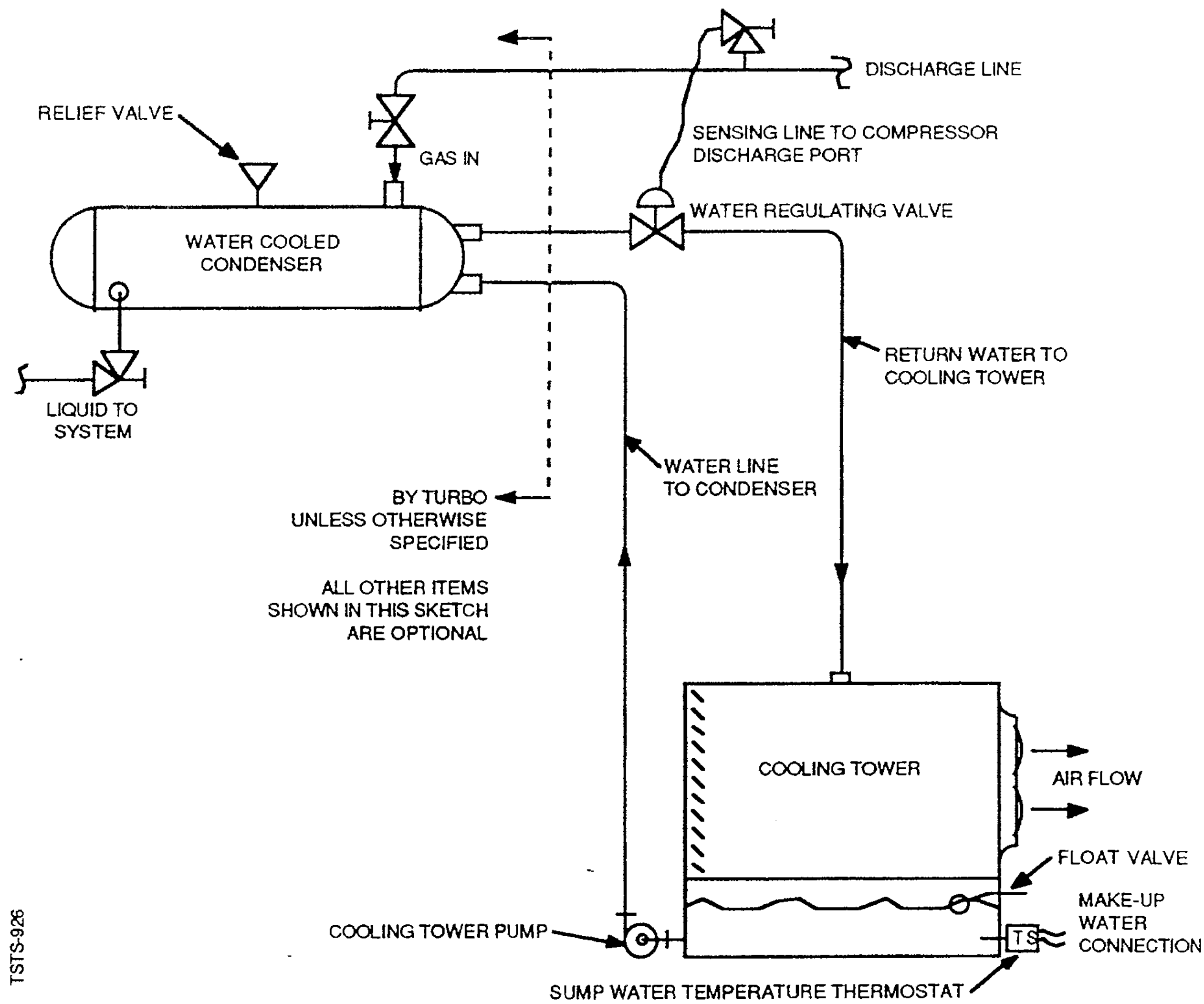

Figure 3-38 Typical Water-Cooled Condenser Piping

Water Regulating Valve (SC Models Only)

A water regulating valve is furnished in the thermal storage unit and must be field installed external of the thermal storage unit in the outlet water line of the condenser piping to the cooling tower. A 1/4" SAE flare type valve is provided on the water-cooled condenser for the water regulator high pressure gas connection that provides the signal that modulates the water flow through the condenser.

Note:
Refer to section 10. Appendix C on using 3-way water regulating valves.

Systems With Multiple Condensers

On systems utilizing a single cooling tower and cooling tower pump for multiple water-cooled condenser, the piping shown in Figure 3-38 may have to be modified if all of the units (condensers) are not operated. For a system with

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

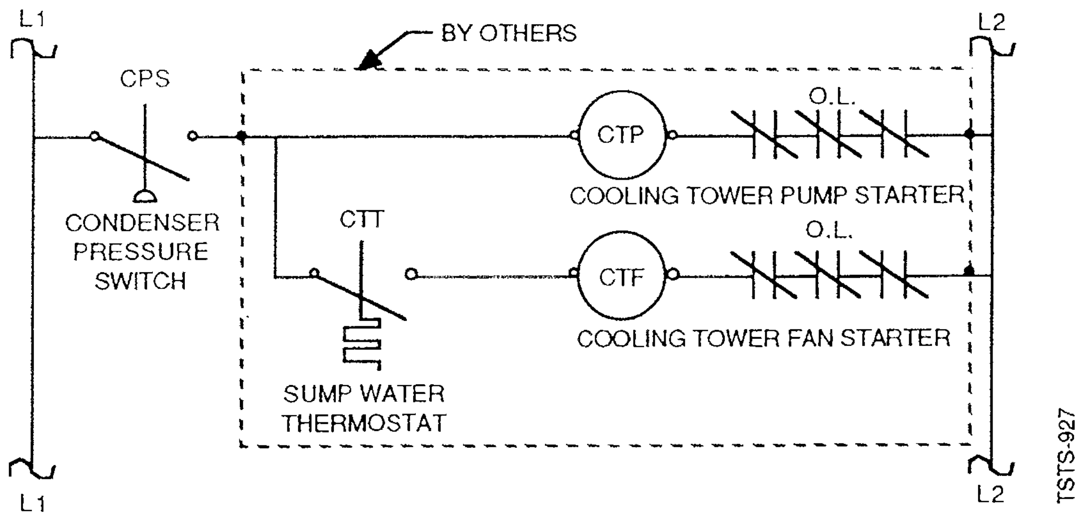

Figure 3-39 Typical Wiring for Water-Cooled System

three thermal storage units piped to a single cooling tower and cooling tower pump suitable for handling all three systems, it may require a condenser water bypass if only one system is operated. Excessive pressure drops across water regulating valves or changes in the pump operating curve may prevent proper operation. Figure 3-40 shows a typical multiple condenser installation. As the idle system(s) cools, the water regulating valve will close in response to the decrease in pressure (sensed by the water regulating valve sensing line). As the valve closes, the pressure in the condenser water line increases. A pressure modulating bypass relief is installed in the discharge of the cooling tower pump and piped either to the suction of the pump or directly into the cooling tower sump to maintain a constant head on the pump.

Figure 3-40 shows a cooling tower located above the condenser. On installations with the cooling tower located below the multiple condensers, a check valve should be installed in the pump discharge to prevent drainage of the water during the off cycle (resulting in excessively high discharge pressure at start-up due to lack of water flow).

As an alternative to a bypass relief, separate cooling tower pumps may be used with a single cooling tower. This is generally limited to systems with 2 to 3 condensers since the cost of the additional pumps and piping is not attractive for larger systems.

Optional heat tracing of the condenser water line and a cooling tower sump heater may be required for operations in low ambient conditions (below 40°F) to prevent freeze-up during shut down.

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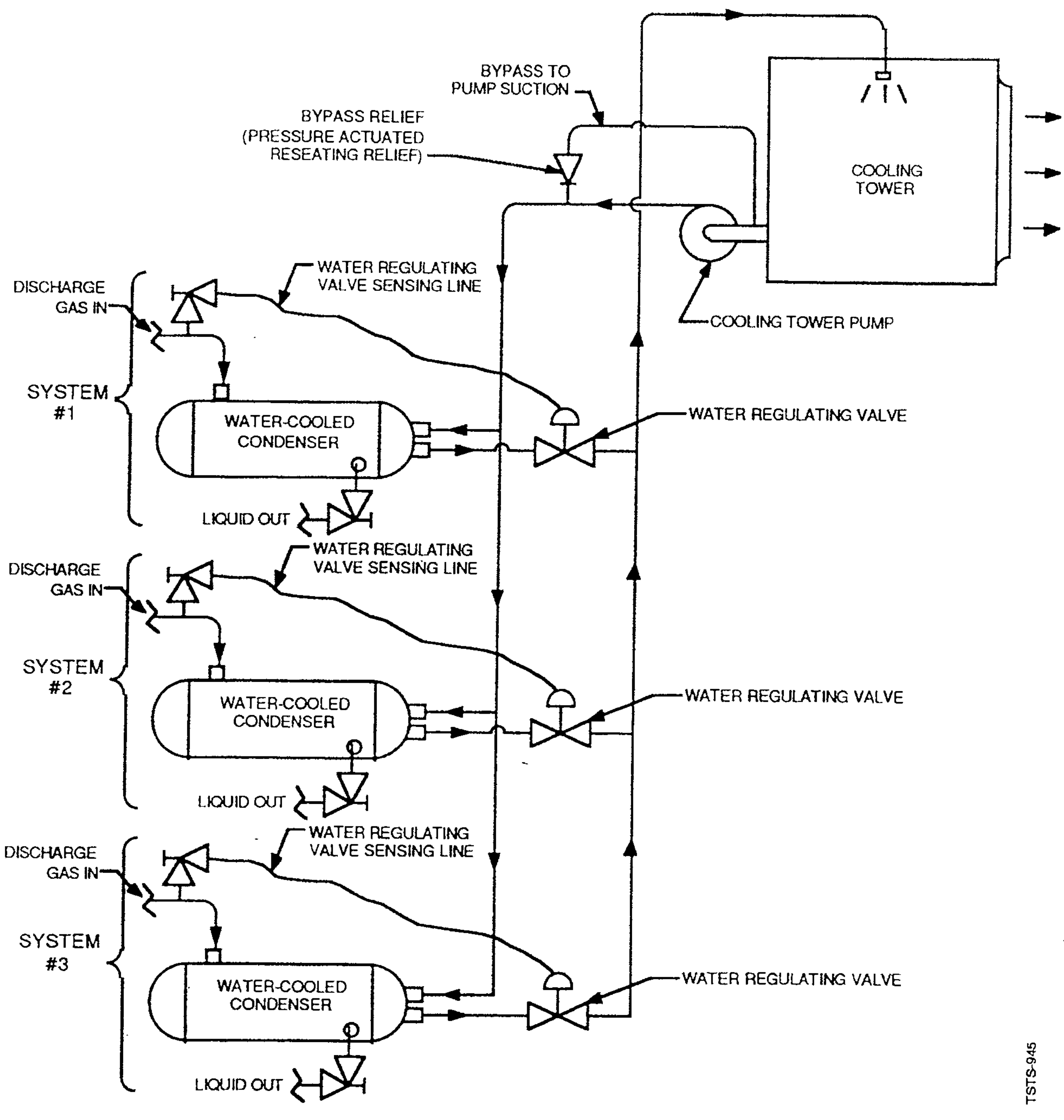

Figure 3-40 Multiple Condenser Installation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

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17. PRE-START-UP CHECKLIST

Before starting the Turbo unit, the pre-start-up checklist must be completed. The items should be checked off and initialed by the person who does the pre-start-up.

1. A visual inspection of the unit should be made.
2. The electrical checklist on page 59 should be completed.
3. The rotation of all motors should be checked.
4. The compressor(s) should be aligned and the couplings(s) installed. See the compressor manufacturer's owner's manual for alignment procedures.
5. The drier cores should be installed unless they were installed in the factory. Drier cores are factory installed only for units which require no field refrigerant piping.
6. The water lines should be connected and any debris should be flushed out of the lines.

Note:
It is strongly recommended that a strainer be placed at the evaporator water inlet connection. The mesh on this strainer should be smaller than the 7/64" diameter holes in the water distribution pan. The strainer's pressure drop must be accounted for when calculating the head loss on the water pump. This strainer is supplied and field installed by others.

7. Clean the storage tank and fill the storage tank 60 to 70 percent full of water.
8. Remove tags from valves and open. Solenoid valves should be put in the automatic position.

WARNING

When conducting the pre-start-up checklist procedures above, follow all precautions and safety practices as detailed in each previously outlined installation step. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

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18. START-UP CHECKLIST

The following items must be checked off prior to starting unit.

Customer____________________ Date__________ Model__________ Serial # __________

CHECK ITEM	INSTALLED BY	CHECKED BY	DATE	COMMENTS
Compressor/Motor Alignment				
Refrigerant Lines				
Pressure Test ________ psig				
Evacuated ________ in water				
Charged ________ lb.				
Drier Cores				
Oil Level				
Pressure Control Set				
Control Settings (psig)	COMP #1	COMP #2	OMP #3	
CPTD Cut Out				
Low Pressure Cut Out				
Low Pressure Cut In				
High Pressure Cut Out				
(SC and SCER 250 psig, SCA 275 psig)				
Condenser Fan Cut Out				
Condenser Fan Cut In				
Suction Pressure Cut Out				
Suction Pressure Cut In				
Water Connections				
Water Flow (gpm)				
Electrical Power				
Control Power				
Motor Rotation				
Tags Removed				
Safety and Operation Instructions Performed				

MOTOR PERFORMANCE DATA

MOTOR	VOLTAGE	PHASES	AVERAGE OF 3 PHASES #1	#2	#3	#4	#5	#6
Compressor Motor								
Water Pump								
Condenser Fan Motor								
Condenser Pump Motor								

COMPONENT DATA

	#1	#2	#3	#4	#5	#6
Component						
TEV Setting - Turns Open						
Evaporator Pressure at Suction During Defrost						
Super Heat @ Evaporator Plate Suction Tube Line						

TSTS-801

________________ ____________ ________________

ACCEPTED BY DATE COMPANY

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

OPERATING INSTRUCTIONS

Introduction

This section describes the Turbo Thermal Storage system operation and control components. Operating hints are provided for safe, efficient, and reliable operation of the ice generator/chiller. Before proceeding with reading this section, the safety and installation sections should be read and understood. These sections contain guidelines that must be followed to ensure start-up and operation of the system without costly delays due to improper installation or interfacing with other system components.

Typical operation of both HP and IGC models are described. Turbo can also provide a variety of options for these systems. The appendix of this manual should be referred to for the operation of these options. Only standard features are discussed in this section.

Controls

Before describing the various sequences of the ice generator, it is important to review and understand the purpose of the controls located in the control panel, three-phase panel, and gauge and safety console.

Control Panel

Referring to section 3. Installation & Pre-Start-Up Requirements, Figure 3-1 shows that the control panel is typically located on the right end of the ice generator/chiller. This panel contains the programmable controller, time clock, water temperature thermostat, control relays, and terminal blocks. Single phase (120/1/60 is standard) power is provided to this control panel by others. Interfacing between the thermal storage units and building management systems and external controls is provided in this panel via terminal strip connections. All factory wiring and field wiring is made to a factory installed terminal strip.

Following is a description of the various components:

Master Control Switch (MCS)
The Turbo ice generator/chiller is controlled by the MCS. The MCS is a key-operated, three-position switch controlling the OFF/RESET, MANUAL, and AUTOMATIC modes of the Turbo-unit. It is located in the control panel door.

Automatic
The AUTOMATIC position allows the ON/OFF operation of the Turbo-unit to be controlled by either a remote contact (if supplied by others), or by the contact of the Programmable Time Clock (PTC-1). The contact of the PTC-1 comes factory wired, using one circuit of the dual circuit PTC-1 to control the ON/OFF operation of the Turbo-unit. Refer to the Appendix & Notes section for instructions on how to set the PTC-1.

OFF/RESET
The OFF/RESET position of the MCS has two functions.

1. If the Turbo-unit is running when the switch is put into the OFF/RESET position, it will put the unit into pump down (i.e. the refrigerant charge will be stored into the high pressure liquid receiver), and then shut the unit off. This is done by closing the Liquid Solenoid(s) (LS-"X"), and returning any section which is in defrost to the refrigeration mode. With the Liquid Solenoid(s) closed, the refrigerant boils out of the evaporator plates and will be stored in the high pressure liquid receiver. When the compressor suction pressure drops below the setting of the Low Pressure cut out switch (LP), the unit will shut off. If, for any reason, the compressor suction pressure does not reach the cut out setting of the LP within three (3) minutes, an internal timer in the Programmable Controller (PLC) will automatically turn the Turbo-unit off after three (3) minutes.
2. The OFF/RESET position is also used as a RESET switch if the Turbo-unit cycles off on a safety failure.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

When this occurs, the red Safety Failure pilot light on the control panel will come on, and the unit will not restart until the MCS is turned to the OFF/RESET position, and then turned back to either the MANUAL or AUTOMATIC position. Turning the switch to the OFF/RESET position resets the counters, and I/Os in the PLC. The status of each I/O (light on or off) should be recorded before resetting it and for determining the cause of the failure.

Note:
After the unit has been reset after cycling off, the unit should be inspected by a qualified refrigeration serviceman to determine why the unit failed, and to correct the problem.

Manual
The MANUAL position is used only to operate the Turbo unit without the use of a remote contact or the contact of the PTC-1. It does not override any of the built-in safety and protection features of the Turbo-unit.

IMPORTANT

The unit will continue to run regardless of the status of the time clock or remote ON/OFF input.

Safety Pilot Light
Pilot lights are located on the control panel door to indicate the status of the ice generator/chiller safety circuits. In normal operating mode, the light should be "off". If the safety failure is "on", the unit will be "off" due to a safety failure. Safety failure conditions include low suction pressure, high discharge pressure, low oil pressure, high oil temperature, oil pot heater failure, recirculating water pump failure, and compressure overload protection.

IMPORTANT

The MCS must be turned to the OFF/RESET position before the unit can be restarted. Before resetting the status of the PLC, I/O lights should be recorded. After the unit is reset, operation should be monitored to determine the cause of the failure and corrective action taken immediately. Failure to do so may result in compressor or equipment failure.

High Ice Pilot Light
A green pilot light is located on the control panel door to indicate the status of the ice storage in the storage tank below.

A motorized paddle wheel switch is located below the ice making plates. If the tank is not full, the paddle wheel continues to rotate and the unit continues to operate. Once the ice level reaches the paddle wheel, stopping its rotation, the storage tank is full. The high ice level switch turns the high ice level pilot light "on" and inputs a signal to the programmable controller to terminate operation of the unit through a normal shut-down sequence.

If the ice level drops due to the melting or loading from the building, the paddle wheel will again rotate. The ice generator/chiller will restart, provided that the time clock or other external inputs are still calling for operation of the unit. If this signal is absent, the unit will remain off.

Circuit Breaker-
Control Circuit
A two-pole single phase control circuit breaker is also located on the control panel door. This breaker provides branch circuit protection for the controls located in the control panel. Short circuit and overload protection is provided on both legs of the single phase power supplied.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

CAUTION

The two-pole control circuit disconnects power only to the single-phase control circuit. A separate disconnect or breaker (supplied by others) must be supplied to remove the three-phase power. In case of emergency, the main three-phase circuit breaker should be pulled first to remove power from all motors. The single phase breaker is not to be an emergency stop. Failure to follow these instructions could result in personal injury or equipment damage.

Programmable Controller (PLC)

A GE Series One Programmable Controller is provided with each ice generator to control the operating sequence of the ice generator itself. Remote contacts or time clocks may be used to signal start-up and termination of the ice generator but all control sequencing and logic is provided by the PLC and Turbo supplied software.

The PLC consists of the power supply/frame, a CPU, and input/output modules. Refer to the GE PLC maual in the appendix for additional details and specifications. In addition to the power "on" and battery light on the CPU, each input and output module has a status light for each I/O. If the status light is "on", the input or output is "on". During trouble-shooting or after safety failures, the status (ON/OFF) of each light should be recorded. This will help determine the cause of the failure (refer to section 5, Trouble-shooting for additional information). Turning the MCS to the OFF/RESET position will change the status of some of these lights. Note the status of each light before using the OFF/RESET switch.

All standard modules using the GE PLC require 120/1/60 power to the controller.

Note:

A power failure or interruption of power to the controller will reset many of the counters and sequencers in the PLC and will restart the icemaking or chilling sequence. However, some internal coils are not affected by interruption of power. To properly reset the controls after a safety failure, the OFF/RESET switch must be used.

The GE PLC is mounted on the backplate inside the control panel. All connections required to the PLC are factory wired to a terminal strip mounted on the control panel backplate. No connections should be made directly to the PLC without factory approval.

An optional hand held programmer/monitor is available for the PLC. The hand held programmer is required to change control presets.

Water Temperature Thermostat (WTT)

All Turbo ice generators can operate as icemakers or chillers. A signal to the PLC is required to indicate which mode of operation the ice generator/chiller is in. This signal is based on the temperature of the water supplied to the Turbo unit. A thermostat with a remote sensing bulb is provided to determine the return water temperature and provide the proper signal to the PLC.

For HP models, the thermostat is typically set at 37°F and for IGC models, 40°F. (The higher setting for the IGC model results from the deeper icemaking plates used on these models and the tendency to form ice at the bottom of the plate before the water temperature reaches 38°F). The final setting of the WTT thermostat is made in the field by observing the formation of ice on the plates. Additional 36°F and 38°F resistors are provided with HP models; 39°F and 41°F for the IGC models are also available.

All WTT thermostats are field adjustable and have an ON/OFF/AUTOMATIC switch. This switch must be in the AUTOMATIC position (refer to the Appendix & Notes for the operating instructions for the WTT thermostats). The thermostat is located on the control panel backplate and is factory wired to a terminal strip. No connections should be made directly to the thermostat without factory approval.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

The setpoint of the thermostat is changed by replacing the resistor connected to terminals 3 and 4 on the thermostat terminal strip. A chart of resistors is provided in the Appendix & Notes.

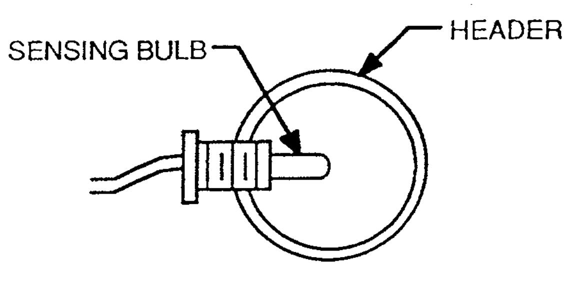
The setpoint differential (DIFF) of the WTT must be set at the minimum setting, or full counterclockwise. This will give the WTT a 1°F deadband. A chart of resistors is provided in the Appendix & Notes.

Input to the thermostat is provided by a sensor located on a water distribution header (refer to Figure 4-1). The bulb is located directly in the return water flow.

An optional monitor is available for the thermostat to provide a readout of the temperature being sensed.

Note:
The same monitor can be used for the WTT and OTT thermostats.

Oil Temperature Thermostat (OTT)
All Turbo ice generator/chillers are supplied with an oil still to ensure proper return of the refrigerant oil to the compressor. The oil management system is described in detail later in this section. In general, each oil recovery system is provided with an oil pot, oil pot heater, and oil temperature thermostat. The OTT controls the operation of the oil heater to ensure that a refrigerant free oil is returned to the compressor. Control of the solenoid between the suction accumulator/ heat exchanger and oil pot is also maintained by the OTT through the PLC logic (i.e. the oil temperature must be at the OTT setpoint before the solenoid will open). In the event of the oil heater failure, the controls will not allow refrigerant rich liquid to be metered to the oil pot and ulti-



DETAIL A

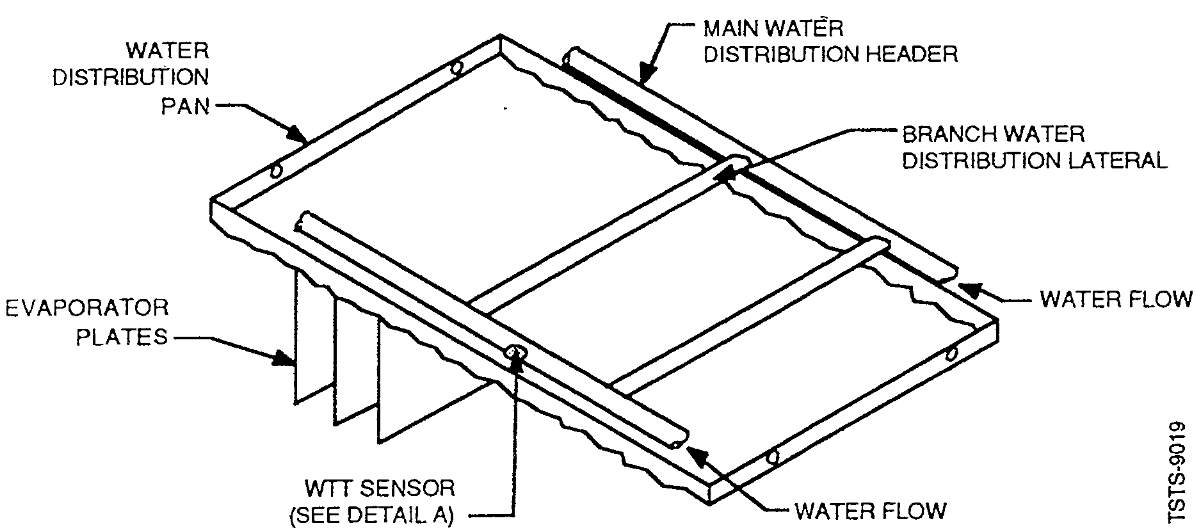


Figure 4-1 Water Temperature Thermostat Sensing Bulb Installation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

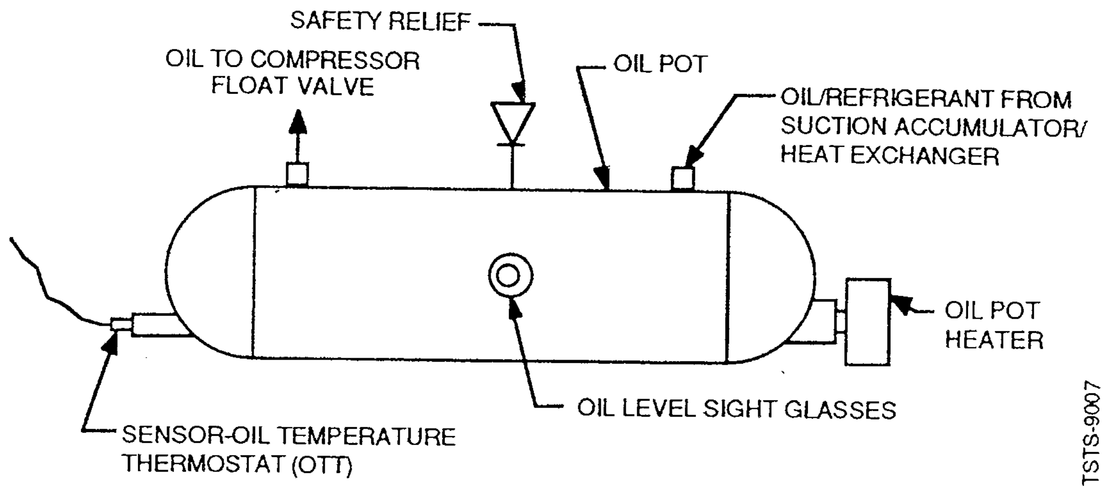


Figure 4-2 Oil Temperature Thermostat Location

mately to the compressor.

Controls are set to terminate operation of the unit if the OTT setpoint is not obtained within the time setting of the controls. This prevents continuous operation of the equipment without the oil heater, or proper oil return to the compressor.

The OTT is located on the control panel backplate and is factory wired to the terminal strip on the backplate. No connections should be made directly to the thermostat without factory approval.

Adjustment of the OTT thermostat is obtained by rotating the adjustable knob located on the front of the thermostat. The sensor for the thermostat is located in a bulb well mounted in the bottom of the oil pot. (refer to Figure 4-2).

Single-phase (120/1/60) power is required to operate the OTT (factory wired).

An optional monitor is available for the thermostat to provide a readout of the temperature being sensed.

Note:
The same monitor can be used for the WTT and OTT thermostat.

<u>Programmable Time Clock (PTC)</u>
When the MCS is in the AUTOMATIC position, the start-up of the ice generator/chiller is controlled by either the PTC provided by Turbo, or a remote time clock or external contact.

The PTC control is a seven day programmable clock containing four (4) SPDT switches. Details and specifications of the PTC are provided in the Appendix & Notes section of this manual. In general, the user defined operating periods for the ice generator/chiller are programmed into the PTC. Different daily requirements can be programmed to meet each customer's particular requirements. An ON/OFF signal from the PTC into the GE PLC initiates a normal start-up sequence. A digital readout and easy monitoring provide an easy review of the program settings.

All PTCs are located on the control panel backplate and are factory wired to a terminal strip located on the backplate.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

No connections should be made directly to the programmable time clock without factory approval. Turbo assumes no liability for connections made to the PTC or damage to the PTC as a result of such connections.

Single-phase 120/1/60 power is required for the PTC.

Sample programming is described later in this section.

CAUTION

It is the responsibility of the contractor or a qualified electrician to ensure that any interconnecting wiring complies with applicable local, state, and federal codes. Failure to do so could result in damage to electrical controls and other equipment as well as severe personal injury.

Three-Phase Panel

Referring to section 3. Installation & Pre-Start-Up Requirements, Figure 3-1 shows that the three-phase panel is located on the right end of the ice generator/chiller next to the control panel. This panel contains all starters for motors supplied with the ice generator/chiller. Turbo ice generator/chillers are supplied with 230/3/60 or 460/3/60 power as standard. Other voltages and frequencies are available as extra cost options. This enclosure is not supplied with a knockout for the three-phase power connection.

Both the penetration into the enclosure and the electrical connector are field installed and furnished by others. Interconnecting wiring from the control panel to the three-phase power is factory installed. All starters are wired from the starter overload relay module to the motor terminal connector. Top wiring for each starter as well as branch circuit protection or sub-fusing is supplied by others and field installed. Optional branch and main circuit protection and/or sub-fusing of all motors is available from Turbo.

Note:
Motor starters are supplied only for motors specified in the Turbo proposal or specifications sheet. Installation, wiring, and control of remote motor or motor starters is the responsibility of others. Turbo assumes no liability for the interfacing of these controls with the Turbo control panel.

Turbo can provide starters in the control panel for remote equipment which may require bottom wiring to the motor (field wiring by others).

<u>Optional Three-Phase Panel Circuit Protection</u>
Turbo can provide branch circuit protection (in the form of sub-circuit breakers or sub-circuit fuses) and main circuit breaker protection for all motors specified in the Turbo proposal or specification sheet.

If supplied with branch circuit protection, each magnetic motor starter is top wired and three-phase wiring is required only to the circuit breaker or fuses.

If the main circuit breaker is also supplied, all wiring from the main breaker to the branch circuit breakers or sub-fusing is factory installed and a single three-phase connector is required to the main circuit breaker.

Note:
All magnetic starters supplied by Turbo are supplied with bimetallic current overload trip relay modules for three-phase protection of each motor. Loss of phase, phase reversal, and low voltage protection are not supplied. A phase/voltage monitor is available as an option to provide for loss of phase, phase reversal, and low voltage protection.

<u>Optional Single-Point Electrical Connection</u>
On Turbo ice generators/chillers supplied with the optional branch and main circuit protection, single-point electrical connection is available. Standard models require the supply of separate 230/3/60 or 460/3/60 power, and 120/1/60 control circuit power. Single-point electrical connections provide a three-lug terminal block for connection of the three-phase power.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

In addition, a control circuit transformer located in the three-phase panel is connected from two phases of the main power. The step-down transformer converts the 230/1/60 or 460/1/60 primary to a 115 volt, 60 hertz secondary supply. Wiring is factory installed from the transformer secondary to the single-phase power terminal connections located in the control panel. Therefore, only the three-phase connection to the ice generator/chiller is required.

CAUTION

All electrical connections to the three-phase or control panel must be made according to the wiring diagram supplied for the ice generator/chiller. A copy of the wiring diagram is shipped with the unit as well as supplied with the operating manual. Failure to do so could result in personal injury or equipment failure or damage.

Only a qualified electrician should make connections to the electrical panel provided.

IMPORTANT

Failure to provide written notification of unauthorized electrical connections to Turbo control or three-phase panels will release Turbo from any obligation or warranty resulting from such connections.

Turbo can provide guidelines and advice relative to electrical connections, control of remote imput or output devices, and components sizing (supplied by others - with written notice of required details). Turbo assumes no liability for proper connections of electrical components supplied by others.

Safety and Gauge Console

Before making the initial start-up of the ice generator/chiller, the safety switches and controls should be reviewed and verified.

High Discharge Pressure/Low Suction Pressure (HP/LP)

Two pressure automatic reset switches are provided to sense the discharge pressure and suction pressure. This switch is located at the base of the compressor on a frame containing the suction pressure, discharge pressure, and oil pressure gauges as well as the oil failure switch.

Typical settings of the switches are:

LP cut-out:	25 PSIG
LP cut-in:	30 PSIG
HP cut-out:	275 PSIG
HP cut-in:	250 PSIG

Refer to the Appendix & Notes for additional information on dual pressure switches. Figure 4-3 shows the typical safety and gauge console arrangements for each compressor supplied.

Oil Pressure Failure Switch (OFS)

An oil pressure failure switch is provided to ensure proper oil pressure for compressor lubrication. Oil failure switches consist of three basic elements. The pressure switch (OPS), the oil pressure time delay heater (OPTDH), and the oil pressure time delay contacts (OPTD).

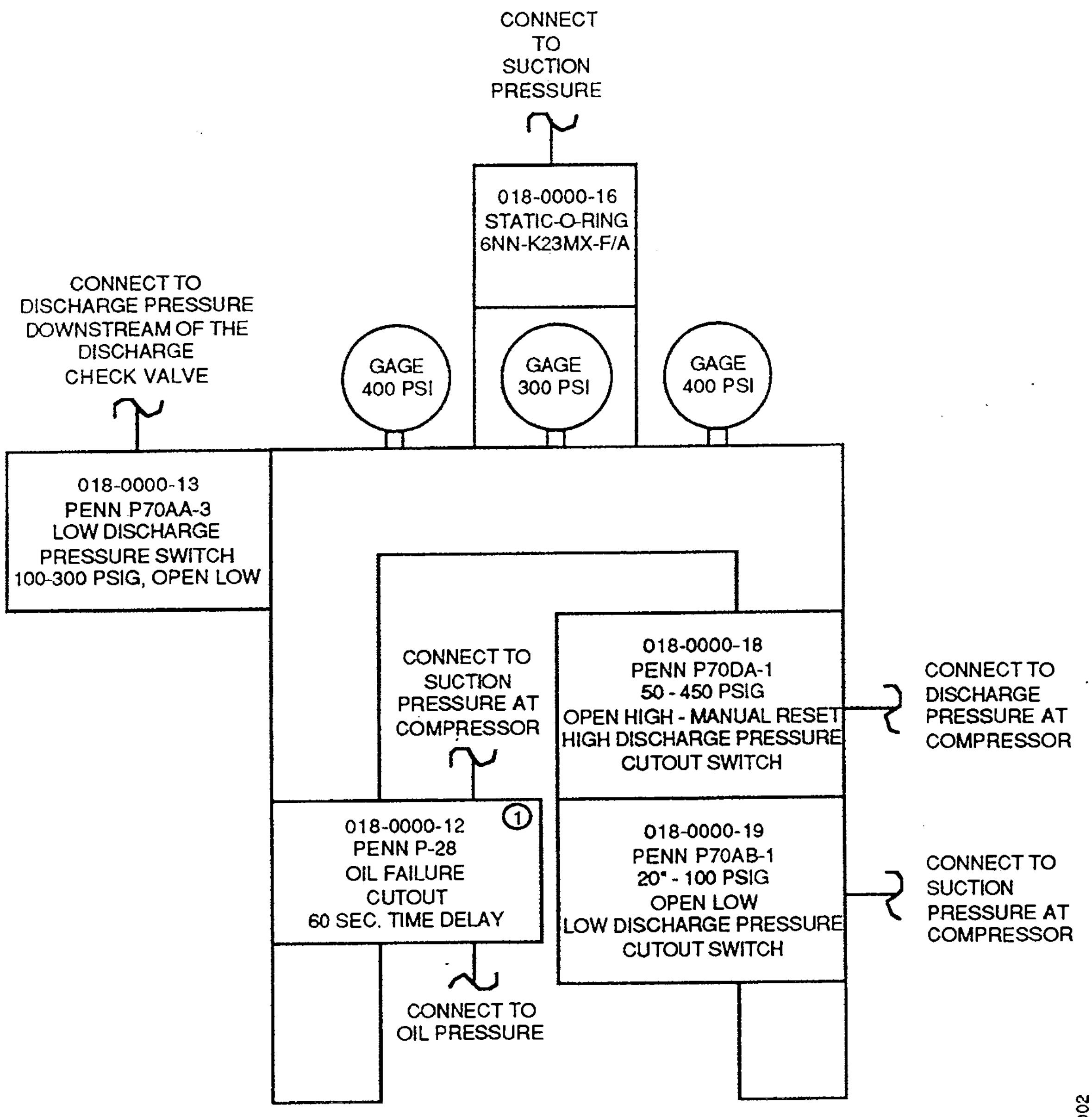
The OPTDH is a resistance heater supplied with electrical current through the OPS switch when the oil pressure is below the setpoint and the switch remains closed. Upon a rise in oil pressure, the pressure switch opens, disconnecting power to the heater.

If the pressure does not rise, the heater warms a bimetallic element in the OPTD circuit. When the temperature reaches the setpoint of the switch after a time determined by the heater resistance, the OPTD contacts open to terminate operation of the ice generator/chiller.

The OPS senses the differential between the pressure at the compressor oil pump discharge and suction pressure. If the oil pressure is below the minimum differential for a 60 second period, the heater (OPTDH) in the switch heats a bimetallic trip element causing it to trip.

Note:
Units with Royce compressors have a 30 second delay to OPTDH.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.



(1) FOR CARRIER & COPELAND COMPRESSOR INSTALLATIONS
P/N _______________ FOR ROYCE COMPRESSOR (30 SECOND TIME DELAY)

218-1094-02 ASSEMBLY INCLUDES:

- (3) GAGES
- 018-0000-12
- 018-0000-18
- 018-0000-19

ADD 018-0000-13 AND 018-0000-16 AS REQUIRED.

GAGE PANEL ASSEMBLY
218-1094-02
(CARRIER/COPELAND)

Figure 4-3 Safety and Gauge Console Arrangement

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Oil failure switches require a manual reset before operation can be resumed (i.e. the unit will not automatically restart until the reset button is depressed.)

Typical settings for the oil failure switch are: 15 psig. Normal net oil pressure for the various standard compressors used by Turbo on ice generator/chillers are:

Carrier open:
45 psig (5H series)

Royce open:
35 psig (CG series)

Copeland Semi-Hermetic:
25 psig.

Actual net oil pressure is determined by subtracting the reading of the suction gauge from the oil pressure gauge.

Example: Carrier 5H compressor, oil pressure gauge reading is 85 psig, suction pressure gauge is 40 psig. Net oil pressure is:

	oil pressure	85 psig
–	suction pressure	40 psig
	net oil pressure	45 psig

Oil Temperature Switch (OTS)
The OTS switch is used only on ice generator/chillers that utilize open reciprocating compressors. Semi-hermetic compressors utilize a different type of safety that is described later in this section. Operation of the OTS thermostat is the same as the OTT thermostat except the oil temperature in the compressor crankcase is sensed by the OTS thermostat. If the oil temperature in the compressor exceeds the OTS setpoint (typically 145°F-165°F), the OTS thermostat contacts open to terminate operation of the compressor. OTS switches are manual reset.

IMPORTANT

Check the compressor and compressor oil cooler (if so equipped) for oil level before resetting the OTS switch. After reset, the operation of the compressor should be closely monitored to determine the cause of the trip. Failure to do so could result in improper lubrication of the compressor resulting in failure or damage.

Motor Protection Module (MP)
The MP and its normally closed set of contacts (MP-1) are used to protect the windings of semi-hermetic compressor motors. These motors will have some type of temperature sensor embedded in the windings of the motor, or in some cases, the temperature sensor will monitor the compressor discharge temperature. When the temperature exceeds the limit set by the motor protection module, the contacts will open up to stop the compressor motor. These contacts are usually automatically reset; however, by the time they will allow the compressor to restart, the other controls within the PLC will usually have locked the unit out.

Overloads (OL)
The motors which drive open reciprocating compressors will have motor overloads which sense the amperage that the motor is using, and will trip if the amperage exceeds the capacity of the motor. The overloads used by Turbo have adjustable trip ranges. The trip setpoint must correspond to the Full Load Amp rating of the motor. This value can be found on the equipment nameplate located on the three-phase electrical panel. These overloads are ambient compensated overloads, and they must be set such that they must be manually reset after tripping.

IMPORTANT

If frequent tripping occurs, the reason for the high amp draw must be determined and corrected. Simply raising the trip setpoint is not an appropriate solution, and may result in a motor failure.

Freeze-Stat SOR Switch (LSP)
A low suction pressure switch is also provided to sense the suction pressure and initiate a refrigeration/defrost sequence to prevent freeze-up of the ice generator/chiller. The low pressure element of the low

pressure cutout switch (LP) is used to terminate the unit operation after a normal pump-down sequence and in the event of a loss of refrigerant. A separate LSP is used to monitor a low suction condition caused by harvest failure, poor water distribution, WTT failure, or ice formation on the plates.

LSP settings are typically set to initiate an extended defrost sequence if the normal suction pressure drops more than 2–3 psig. Final setting of the switch is done in the field to match the actual operating characteristics of the ice generator/chiller and prevent nuisance tripping.

Further explanations of the LSP are given later in this section under "Extended Defrost Sequence". The LSP switch is mounted next to the gauge and safety console at the compressor base.

Low Discharge Pressure Switch (LDP)

Turbo direct-expansion ice generator/chillers require a minimum discharge pressure to ensure a proper harvest is obtained during the defrost sequence. During the refrigeration cycle, the discharge pressure can drop below the minimum pressure.

Note:
All direct-expansion systems utilize a thermal expansion valve to feed refrigerant to the evaporator plates. The sizing of all thermal expansion valves is based on the pressure available at the valve inlet, pressure drop in the distributor orifice and distributor tubes, and refrigerant liquid temperatures. If the system is to be operated at low discharge pressure (below 165 psig), Turbo should be consulted so that the thermal expansion valves may be properly sized.

The LDP switch senses the pressure in the hot gas line feeding the hot gas defrost solenoid (HG) valves to each section. A typical setting of the LDP switch is 165 PSIG. Below the setpoint of the switch, the defrost sequence is automatically extended through the PLC logic to compensate for the lower defrost pressure. LDP switches are mounted on the hot gas supply line located in the engine compartment.

Further explanation of the LDP switch is given in this section under "Extended Defrost Sequence" on page 120.

Evaporator Refrigerate Control Valve

Thermal Expansion Valve (TXV)

Metering of refrigerant to the evaporator plates is controlled through a device consisting of the thermal expansion valve, an external equalizer line, and a power head with a remote sensing bulb. The remote sensing bulb is mounted on the suction line to sense the temperature of the refrigerant gas leaving the evaporator. Turbo evaporators require the use of an external equalizer line to compensate for the pressure drop through the evaporator plates thus allowing for a true reading of the saturated evaporator pressure at the evaporator outlet.

A gas charged sensing bulb transmits a pressure to the power head of the TXV in response to increases or decreases in suction temperature. As the suction temperature decreases, the corresponding refrigerant pressure also decreases, producing a lower pressure at the power head. This pressure is opposed by the evaporator pressure, and the superheat spring in the TXV.

As the temperature/pressure decreases at the outlet of the evaporator, the pressure exerted by the evaporator (plus spring pressure) is now less than the decreasing outlet pressure and the TXV closes to reduce refrigerant flow to the evaporator.

If the temperature/pressure increases at the evaporator outlet, the superheat of the suction gas is higher, indicating that the refrigerant feed is low. In this case, as the temperature/pressure increases, the pressure in the sensing bulb increases thus exerting a greater force on the power head. This increase in pressure drives the diaphragm down applying force to the push rods causing the TXV to open and feed additional refrigerant to the evaporator.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Therefore, as the suction gas superheat (temperature) increases, the TXV opens to supply more refrigerant and as the superheat drops, the TXV throttles the refrigerant flow to prevent the evaporator from flooding.

Superheat is defined as the difference in the actual temperature leaving the evaporator and the saturated temperature of the suction gas at the measured evaporator pressure. For example, a typical Turbo ice generator/chiller operates at a 43 psig evaporator pressure which corresponds to a saturated temperature of 20°F. If the temperature of the suction line from the evaporator at the location of the TXV sensing bulb is measured at 25°F, the superheat would be 5°F.

Typical Turbo ice generator/chillers should operate between 5-8°F for both HP and IGC models. Too high a superheat setting will result in reduced evaporator capacity and possible overheating of the compressor or suction cooled compressor. A low setting may result in an overfeed of refrigerant which could result in compressor damage.

IMPORTANT

TXV superheat adjustments should be made by a qualified refrigeration technician or engineer. Improper adjustment of superheat can result in overfeed of the evaporator causing liquid slugging of the compressor. Liquid slugging will cause damage and/or failure to the compressor.

The TXV sensing bulb must be firmly strapped to the suction line in the 4 or 8 o'clock position to ensure proper sensing of the evaporator suction gas. Emory paper should be used to clean the area the bulb is to be mounted in to ensure proper contact with the surface. Refer to Figure 4-4 for TXV installation.

Figure 4-4 shows the installation of the external equalizer line and sensing bulb. The TXV also requires the use of a refrigerant distributor and distributor tubes to properly distribute the liquid feed of the TXV to each plate.

Refrigerant Distributor

A refrigerant distributor is installed on the outlet of the TXV valve. The distributor consists of an orifice nozzle and multiple outlet for connection to each evaporator plate. For each evaporator, an orifice nozzle is selected to match the load and operating parameters of the system. A distributor has two purposes:

1. To reduce the pressure of the liquid refrigerant, thereby reducing the refrigerant temperature.

2. To provide uniform refrigerant feed to all the distributor outlet openings.

Refrigerant Distributor Tubes

Refrigerant is fed into the outlet of the refrigerant distributor and into an individual tube for each evaporator plate. The OD and length of the distributor tube is selected for each evaporator section to provide a uniform balanced flow to each plate. In addition, the pressure drop through the distributor tube is used to drop the liquid refrigerant pressure to the final evaporator pressure and corresponding evaporator temperature.

The TXV, distributor, and distributor tubes operate together to produce the valve capacity and refrigerant distribution required. A typical selection is shown below.

In the example, a ten (10) plate section with three (3) distributor tubes per plate is used. Therefore, thirty (30) circuits or distributor tubes will be required. At the design operating conditions of 20°F saturated evaporator and 95°F saturated condensing, the evaporator load is 37.5 tons refrigeration, and the refrigerant used is R-22.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

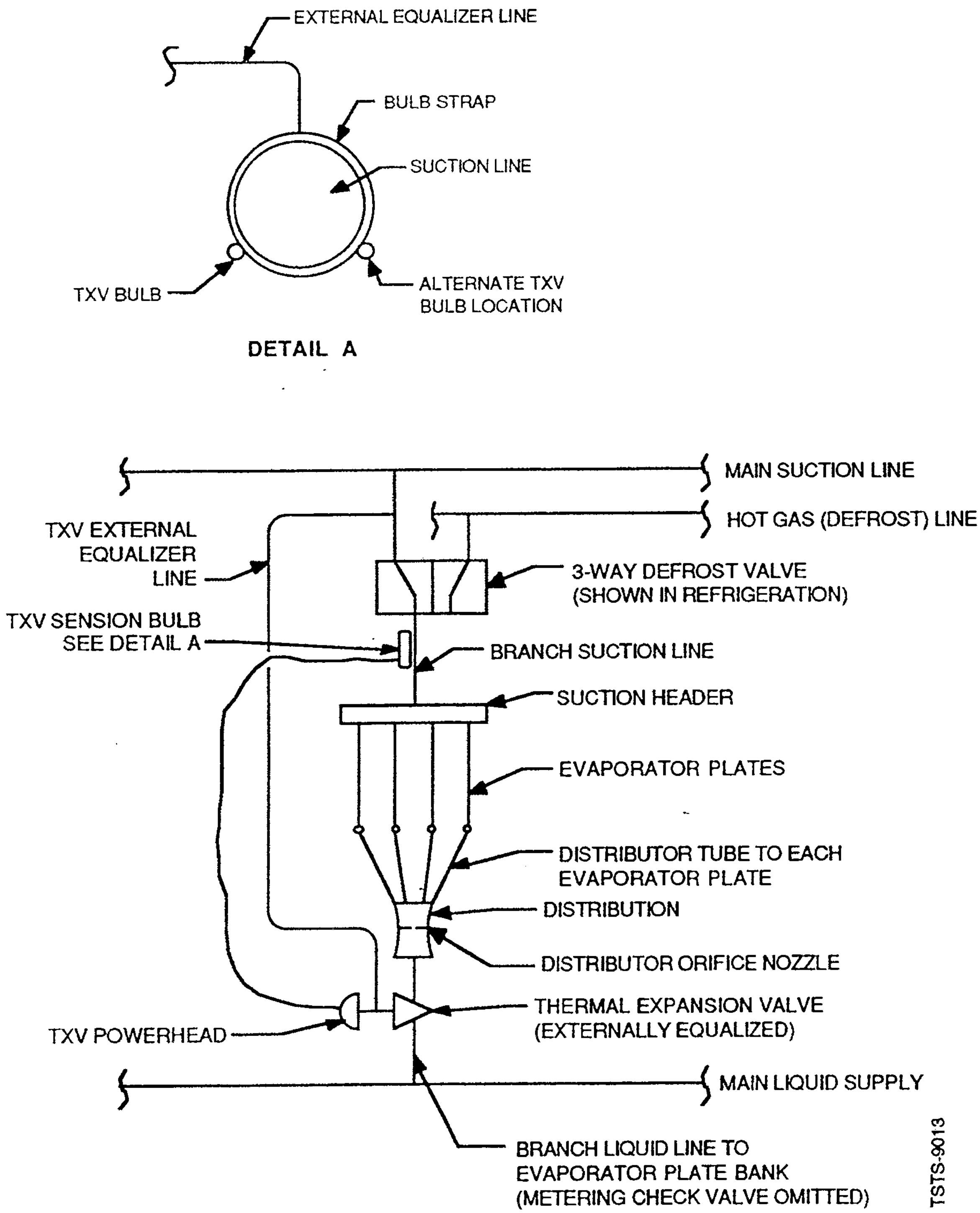


Figure 4-4 Thermal Expansion Valve Installation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

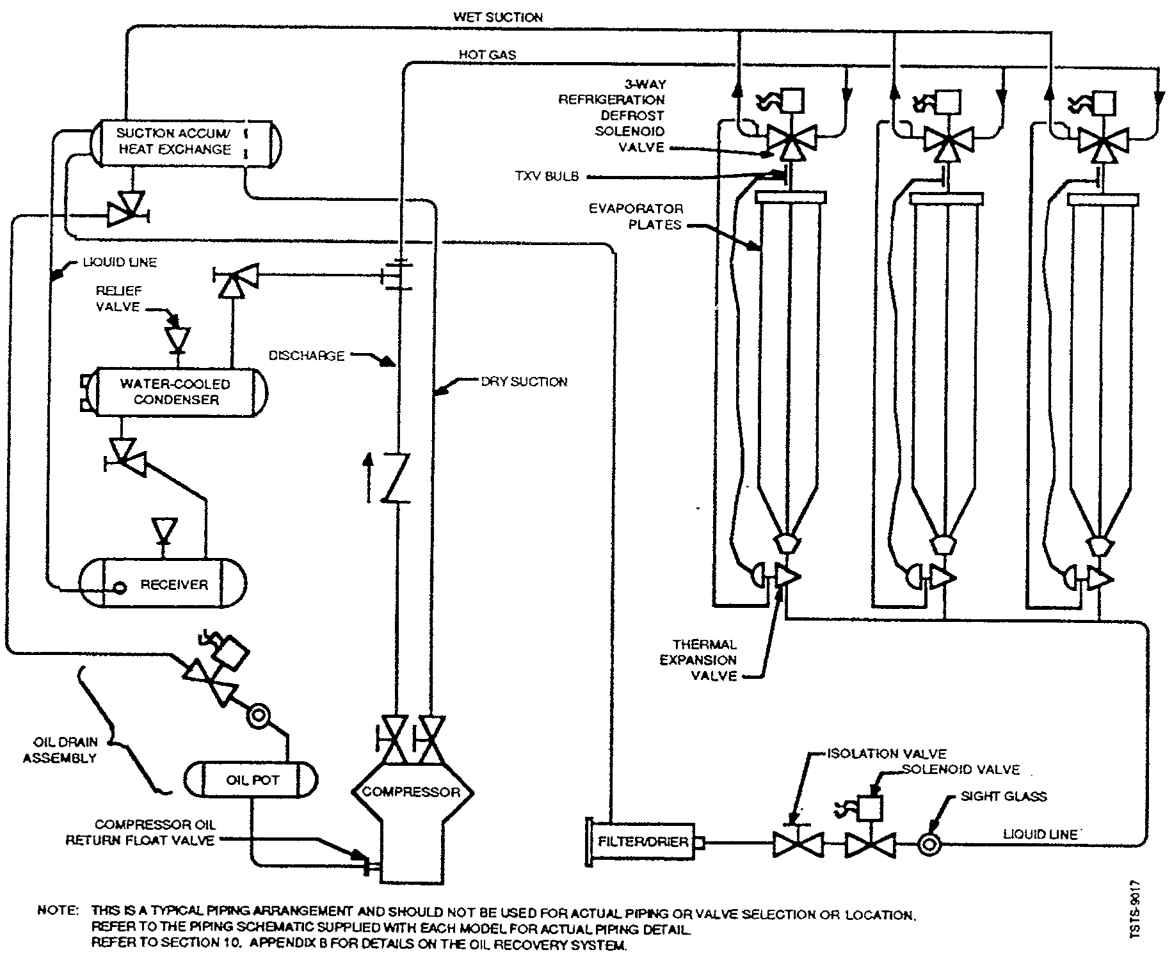


Figure 4-5 Simplified Piping Layout for Standard Single Compressor/Single Circuit HP or IGC Model

Note:
For the rated capacity of the thermal expansion valve to be obtained, the inlet to the TXV (or TEV) must have a solid liquid flow. Flash gas or bubbles in the liquid line will reduce the TXV capacity and cause erratic operation.

Refrigerant entering the evaporator plate from the TXV, distributor, and distributor tube is a liquid at the temperature corresponding to the saturated evaporator pressure. As the liquid flows through the plates, it absorbs the heat from the falling water film on the outside of the plate. The liquid evaporates to gas and continues to absorb the heat from the media being cooled. Thus, the gas is heated to a temperature above the saturated temperature. This is known as superheat.

Suction Solenoid (SS)

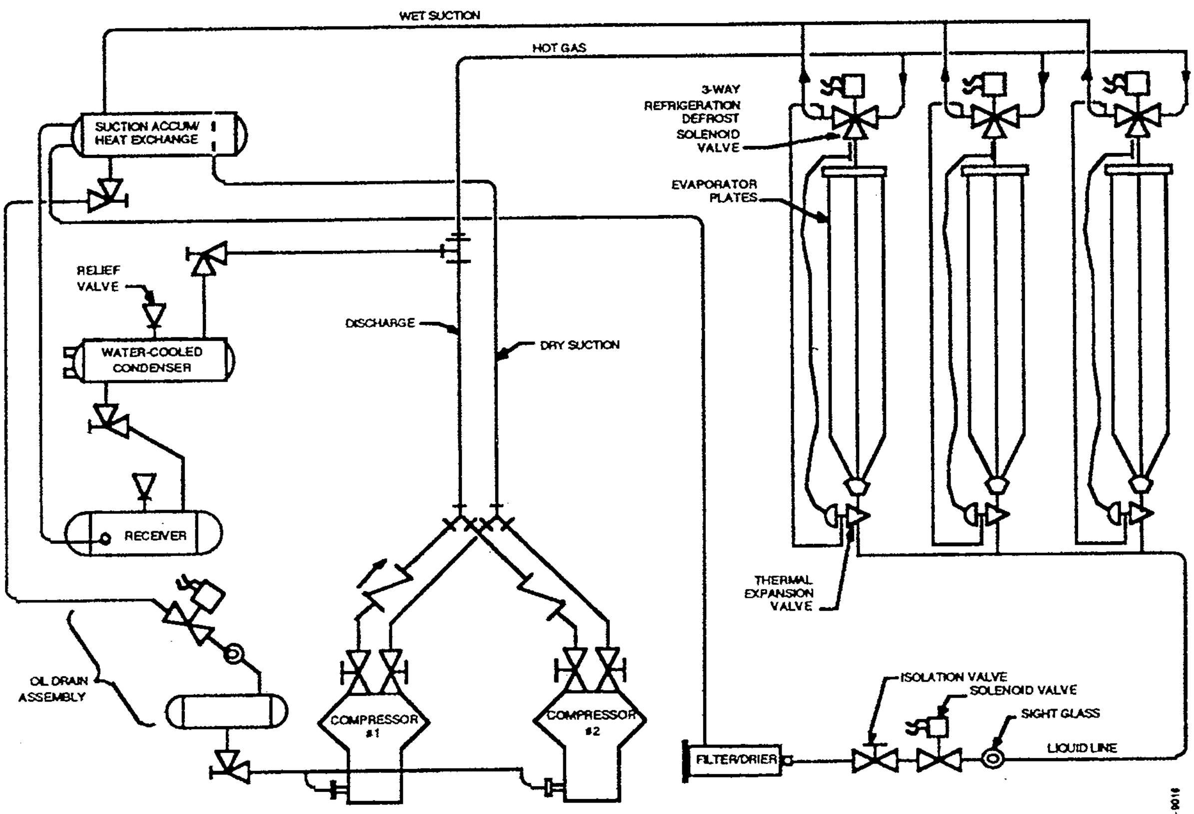
During the icemaking or chilling mode, the suction of the evaporator is connected to the main suction line for return of the refrigerant to the compressor. In order to harvest the ice produced on a plate during refrigeration, the pressure in the evaporator plates must be raised to a pressure corresponding to 40°F. To accomplish this, a solenoid valve or gas powered check valve is installed in the branch suction line of each evaporator section to isolate the evaporator plates during the harvest cycle.

On smaller HP models, a single three-way solenoid valve is used instead of two (2) two-way solenoid valves for the larger HP and IGC models. Refer to your piping schematic for your valve set-up.

For the smaller models, the three-way valve is open to suction when the coil is deenergized. Refer to Figures 4-5 and 4-6. When the coil is energized during the harvest sequence, the valve spool shifts to isolate the branch suction line, at the same time, the hot gas supply to the evaporator section in harvest opens. At the end of harvest, the coil de-energizes and the spool shifts back to the refrigeration position.

Two-way valve suction solenoids are used with a hot gas solenoid (HGS) to isolate the suction line on larger evaporator sections. In most cases, a gas powered check valve is used due to the large port sizes required for suction service. The gas powered check valve is mounted in the branch suction line. A small two-way pilot solenoid valve is piped from the hot gas supply line to the solenoid and then to a port on the top of the gas powered check valves. Refer to Figure 4-7.

During the refrigeration cycle, the gas powered check valve is wide open allowing normal operation. Upon initiation of the harvest cycle, the pilot solenoid (SS) valve is energized to supply high pressure gas to the top of the gas powered check valve. This causes the valve to close tight, thus isolating the branch suction line.



NOTE: THIS IS A TYPICAL PIPING ARRANGEMENT AND SHOULD NOT BE USED FOR ACTUAL PIPING OR VALVE SELECTION OR LOCATION. REFER TO THE PIPING SCHEMATIC SUPPLIED WITH EACH MODEL FOR ACTUAL PIPING DETAIL.
REFER TO SECTION 10. APPENDIX B FOR DETAILS ON THE OIL RECOVERY SYSTEM.

Figure 4-6 Simplified Piping Layout for Standard Multiple Compressor/Single Circuit HP or IGC Model

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

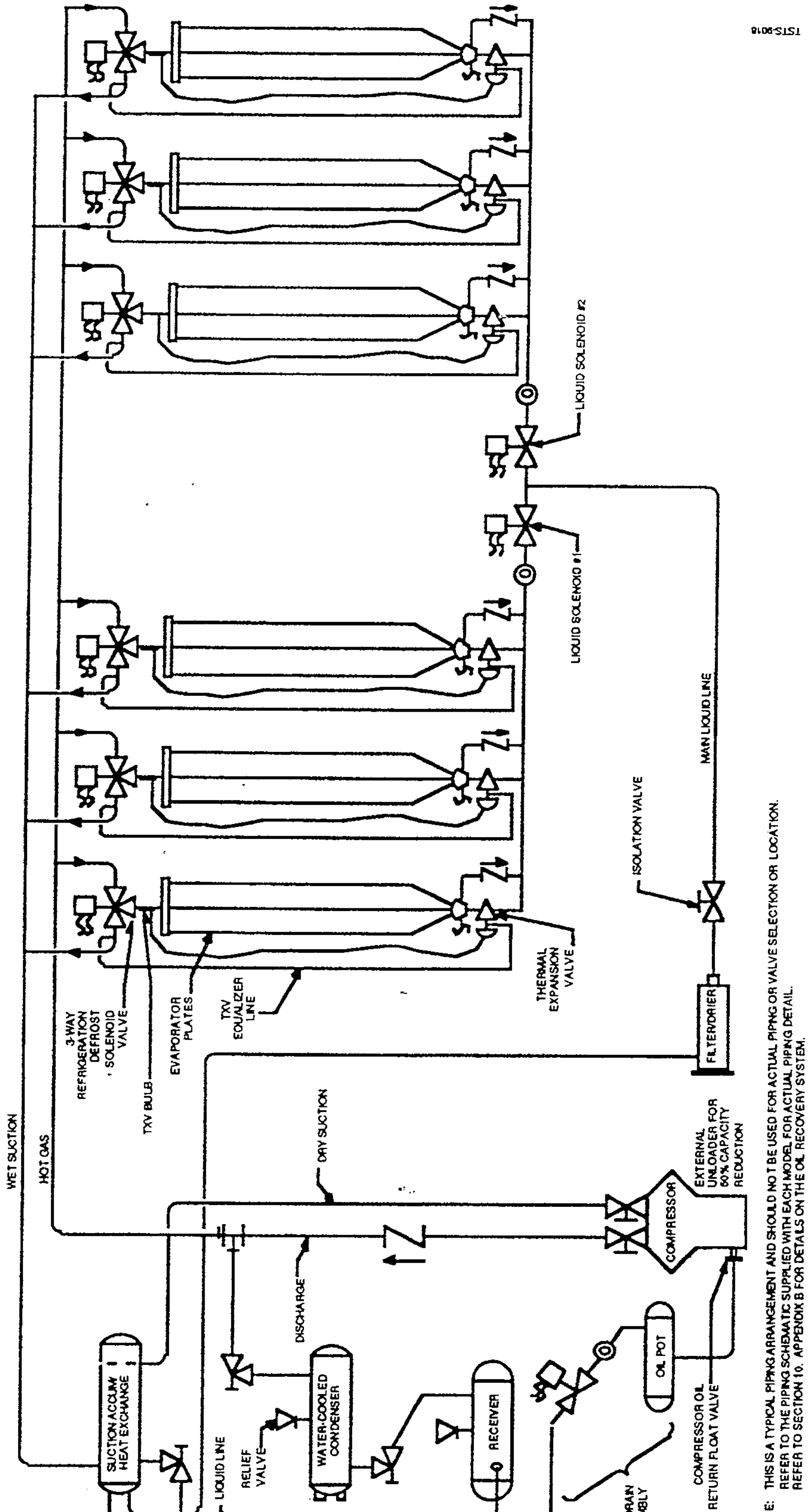


Figure 4-7 Simplified Piping Layout for Single Compressor/Dual Circuit System

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

At the end of defrost, the pilot solenoid is deenergized and the spring attached to the check valve opens the valve, returning it to suction service.

Hot Gas Solenoid Valve (HGS)

During the icemaking or chilling mode, the hot gas supply to the evaporator is isolated from the evaporator. When the harvest sequence is initiated, the HGS opens to supply hot gas to the evaporator plates. Refer to Figures 4-5, 4-6, and 4-7.

For the smaller models, the three-way valve is open to suction when the coil is deenergized. Refer to Figures 4-5 and 4-6. When the coil is energized during the harvest sequence, the valve spool shifts to isolate the branch suction line, at the same time, the hot gas supply to the evaporator section in harvest opens. At the end of harvest, the coil deenergizes and the spool shifts back to the refrigeration position.

Liquid Solenoid Valve (LS)

A two-way solenoid valve is mounted in the main or branch liquid lines of dual circuit models. Turbo ice generator/chillers utilize a pump-down cycle which requires a means of shutting off the liquid supply to the evaporators.

Through the logic of the PLC, the liquid solenoid valve is deenergized (closed) during pump-down and remains closed during shut-down to prevent liquid migration. During the start-up sequence, the liquid solenoid is opened (energized) to allow liquid refrigerant to the evaporator plates through the thermal expansion valves.

The liquid solenoid is mounted in the liquid line between the filter/drier assembly and the TXVs.

Initial Start-Up Procedure

1. Connect all power to the unit a minimum of 24 hours prior to startup. This allows the oil in the compressor crankcase to reach minimum operating temperature (approximately 80°F) and ensures that all refrigerant is evaporated from the compressor crankcase. This prevents liquid sludging and damage to the compressor.

IMPORTANT

Failure to turn the power on 24 hours prior to start-up could result in equipment failure or damage.

2. Check compressor crankcase heaters to ensure that they are energized and operating properly.

3. Open the king valve on the high pressure receiver.

Note:
Turbo recommends leaving the king valve (liquid outlet valve) on the receiver closed until the system is ready to start. This minimizes the risk of losing the refrigerant charge due to damage or line breakage during installation as well as refrigerant migration in the system during shut-down. The receiver is designed to hold the complete system refrigerant charge during "pump-down".

4. Turn the MCS to the MANUAL or AUTOMATIC position.

5. After the unit starts, check the compressor suction, discharge, and oil pressure gauges. Verify all pressures are within operating limits of the equipment.

6. Check the water temperature in the storage tank and water distribution pans.

Note:
During warm weather when the water temperature in the tank may be high (greater than 50°F), it is suggested that the water be added to the tank on the day of the start-up if feasible. Add only enough water to provide the minimum net suction head to the recirculating water pump (RWP). This allows the unit to pull down to normal operating pressure without excessive refrigerant load due to "hot" water in the system. Water is then slowly added until the proper water level (70% level) is reached allowing the refrigeration sys-

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

tem to handle only the incremental load of the water being added.

7. Complete the "Sequence of Operations" that follows.

After Start-Up Maintenance

1. Remove the compressor suction filter sock after the recommended run time. (Refer to the compressor manufacturer's owner's manual for this information.) The tag on the compressor will indicate whether the socks have been removed at the factory or not. (Only the Carrier 5H compressor comes factory equipped with a sock.)

2. Check the oil level and clean the oil return line strainer after the first eight (8) and twenty-four (24) hours of operation. This strainer is located at the outlet of the bottom of the accumulator.

3. Check the refrigerant level in the receiver.

4. Check the water flow rate and head in pan. Check for any accumulation of debris in the pan and clean if necessary.

Oil Recovery Systems

Refer to section 10. Appendix B for details on the various oil recovery systems used on Turbo thermal storage equipment.

Sequence of Operations

Introduction

As discussed previously, the Turbo ice generator/chiller may operate as an icemaker or a water chiller. Therefore, in addition to typical start-up and operation termination sequences, the icemaking mode, chilling mode, icemaking-to-chilling, and chilling-to-icemaking sequences must all be considered and understood. In addition, the storage tank condition in each of these modes must be taken into account. The following tank conditions may exist in the tank during start-up:

1. Water with no ice - temperature above setpoint of WTT thermostat.

2. Water with no ice - temperature below setpoint of WTT thermostat.

3. Ice level in tank below high ice level switch (HLS).

4. Ice level in tank in contact with HLS switch.

In case number 1, the ice generator/chiller will start immediately if all other safeties and controls are within their normal operating limits. In case number 2, the ice generator/chiller will go through a "Wash Down Cycle" prior to starting the compressor and beginning normal operation.

Wash Down Cycle

When the water temperature on the plates is below the setpoint of the WTT, the ice generator/chiller will produce ice. Since the ice generator/chiller does not go through a final defrost sequence to clear all ice from the plates during termination of operation, the status of the evaporator plates is unknown during the start-up.

Depending on the length of time the unit has been off and the outside ambient conditions, the ice may have completely melted off all plates, or could be partially melted and hanging from the plate. In this condition, water flowing over the plates may be deflected or diverted from its normal path by the hanging ice causing the water to flow over distributor tubes, inactive parts of the evaporator plate, etc.

To prevent this water overflow from freezing, the compressor is left off and the recirculating water pump (RWP) is turned on to wash away all remaining ice. After the wash down cycle, the compressor is turned on and the water which is now flowing properly over the plates is frozen and harvested in a normal sequence.

Typical wash down cycles are fifteen (15) minutes and are provided as standard in the PLC logic. Wash down sequence is initiated regardless of whether the start-up sequence signal is supplied by

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the Turbo PTC or a remote time clock or input.

Pump Down Cycle

The term "pump-down" cycle as used in this manual refers to isolating the system refrigerant charge into the high pressure liquid receiver.

When the ice generator/chiller receives the signal to terminate operation, the PLC logic closes the refrigerant liquid solenoid (LS) to cut off the supply of liquid to the evaporator plates.

The compressor continues to operate and the refrigerant in the evaporator plates, suction accumulator/heat exchanger, and the refrigerant piping is pumped from the refrigerant low side through the condensing unit and into the receiver. Turbo ice generator/chillers are supplied with check valves in the compressor discharge line(s) to prevent migration of the liquid back to the compressor. Since the liquid solenoid is closed, the system refrigerant charge is transferred to the receivers. As the liquid is removed from the evaporator, the suction pressure of the system begins to drop. When system begins to drop. When the suction pressure reaches the setpoint of the low pressure cut-out switch (LP), the compressor stops.

Pump-down cycles are provided on all thermal storage ice generator/chillers for several purposes:

- Safely stores the system refrigerant charge in a high pressure vessel designed for that purpose. All receivers are provided with safety relief valves to prevent excessive pressure (greater than 300 psig) from developing in the vessel.
- Prevents trapping of liquid refrigerant in low side components. Hydraulic pressure produced by the warming of this liquid could easily exceed the pressure rating of low side components.
- Allows service of the ice generator/chiller without excessive loss of refrigerant when the unit is "opened for service".
- Prevents liquid migration and accumulation in areas which could result in damage to the compressor during start-up.

Note:
Winterizing of the receivers for operation in ambients below 20°F (for R-22 systems) is not provided but is recommended to ensure adequate system pressure during equipment start-up. The LP cut-out switch requires 25 psig to reset and allow the ice generator/chiller to start.

Extended Defrost Sequence

Most units contain a feature called extended defrost. Extended defrost denotes a sequence in which the defrost time is extended and the refrigeration time is decreased. The purpose of the extended defrost sequence is to remove residual ice build-up in areas not within the active refrigerant area of the plate. Such build-ups normally occur after extended run time or as the suction pressure drops. A drop in discharge pressure can also initiate the extended defrost sequence due to a lack of hot gas at the lower discharge pressure.

The methods used to initiate the extended defrost sequence are:

- Periodic extended defrost through the programmable controller (PLC).
- Low suction pressure input to the PLC through the low suction pressure (LSP) switch.
- Low discharge pressure input to the PLC through the low discharge pressure (LDP) switch.

<u>Periodic Extended Defrost</u>
A counter in the PLC logic counts the number of cycles (refrigeration/defrost sequences). After a preset number of counts, it automatically shortens the refrigeration time and extends the defrost time for one complete cycle (all sections). Then it returns to the standard refrigeration and defrost times. The sequence is repeated until the unit operation is terminated and the counter is automatically reset to zero.

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The ladder logic supplied with the manual should be referred to in determining the setting of the extended defrost counter, extended defrost, and short refrigeration time. If more frequent extended defrost sequences are required to prevent ice build-up, the extended defrost counter preset is reduced. Conversely, if less frequent extended defrost sequences are needed, the counter preset is increased.

Example:
A unit operating with a refrigeration time of 204 seconds and a defrost time of 60 seconds with five (5) harvests per cycle.

204 seconds refrigeration
60 seconds defrost
264 seconds

If we wish to go through an extended defrost sequence every 10 hours:

$$\frac{264 \text{ seconds}}{60 \text{ secs/min.}} = 4.4 \text{ minutes}$$

$$\frac{600 \text{ minutes}}{4.4 \text{ min./harvest}} = 136.4 \text{ harvest}$$

Therefore, the periodic extended defrost counter preset would be 136.

Low Suction Pressure Extended Defrost
A low suction pressure (LSP) switch senses the system suction pressure. If the suction pressure drops due to an ice build-up on the plates or a change in operating conditions, the LSP switches input a signal to the PLC to initiate a defrost sequence. The sequence itself is the same as described for the "periodic extended defrost". The PLC will go through one complete cycle (all sections) in the extended defrost mode. After the first sequence, the PLC (after a short time delay, 30–60 seconds, to allow the suction pressure to stabilize) will again check the status of the LSP switch. If the suction pressure is still low, the extended defrost sequence will again be initiated. After the third LSP sequence, the operation of the unit will be terminated if the suction pressure does not return to its normal level (i.e. the LSP switch does not reset due to a raise in suction).

If the unit goes off on a low suction pressure (lockout), the master control switch (MCS) must be turned to the off/reset position to reset the controls. The source of the ice build-up or cause of the low suction should be determined and corrected.

Example:
An HP600 BSC has a normal balance of 43 psig suction during proper operation. The LSP switch is typically set 2 psig below the normal suction pressure. In this case, the LSP switch would be set at 41 psig.

If the suction pressure drops to 41 psig or lower, the defrost sequence will be initiated.

Oil Return System
Refer to section 10. Appendix B.

Low Discharge Pressure Extended Defrost
Various components and refrigerant flow are based on the discharge pressure. Although it is acceptable to operate the unit at a low discharge pressure (below 150 psig) during refrigeration, additional defrost time is required to offset the decreased hot gas flow rate. An LDP switch senses the discharge pressure and if the pressure drops below 150 psig, the extended defrost sequence is initiated. Again, the extended defrost and refrigeration sequence is the same as described under "extended defrost sequence". Unlike the LSP extended defrost sequence, there is no limit to the number of cycles that the extended defrost sequence can use in the LDP mode. Note that the lower discharge pressure may cause a lower suction pressure and cause trips on the LSP switch, unless the unit is set up for and can harvest properly at the lower discharge and suction pressure. Additional time may be required for the standard defrost time if low discharge pressure operation is normal.

Typical Operating Sequence

Described below is a typical operating sequence in which the storage tank contains no ice and the water temperature is above the setpoint of the WTT thermostat as shown in Figure 4-8 (A) (i.e. no ice will be formed). In this mode the ice generator/chiller will operate as a chiller. The water

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temperature drops until the WTT thermostat trips to initialize the icemaking mode. Since ice is now being formed on the evaporator plates, the plates must be periodically harvested to remove the ice which drops into the storage tank (Figure 4-8 (B)). When the tank is full of ice, the operation of the ice generator/chiller is terminated by the high ice level switch (HLS) as shown in Figure 4-8 (C).

Note:
Even when the tank is full of ice, there is water left in the tank. This water level is required to ensure the recirculating water pump (RWP) has sufficient net suction head to ensure adequate water flow to the evaporator plates.

Sequence of Operation

With the MCS in either the MANUAL position or the AUTOMATIC position and the remote contact and/or the PTC-1 satisfied, the Turbo-unit will now check its safeties and other inputs.

The HLS is a motorized paddle wheel. The rotation of the paddle wheel can be stopped momentarily without affecting the operation of the Turbo-unit. If, however, the rotation is stopped for fifteen (15) seconds, this will signal the Turbo unit that the storage tank is filled with ice. It will then put the Turbo unit into normal pump-down mode, and the Turbo unit will not restart for at least fifteen (15) minutes to allow some of the

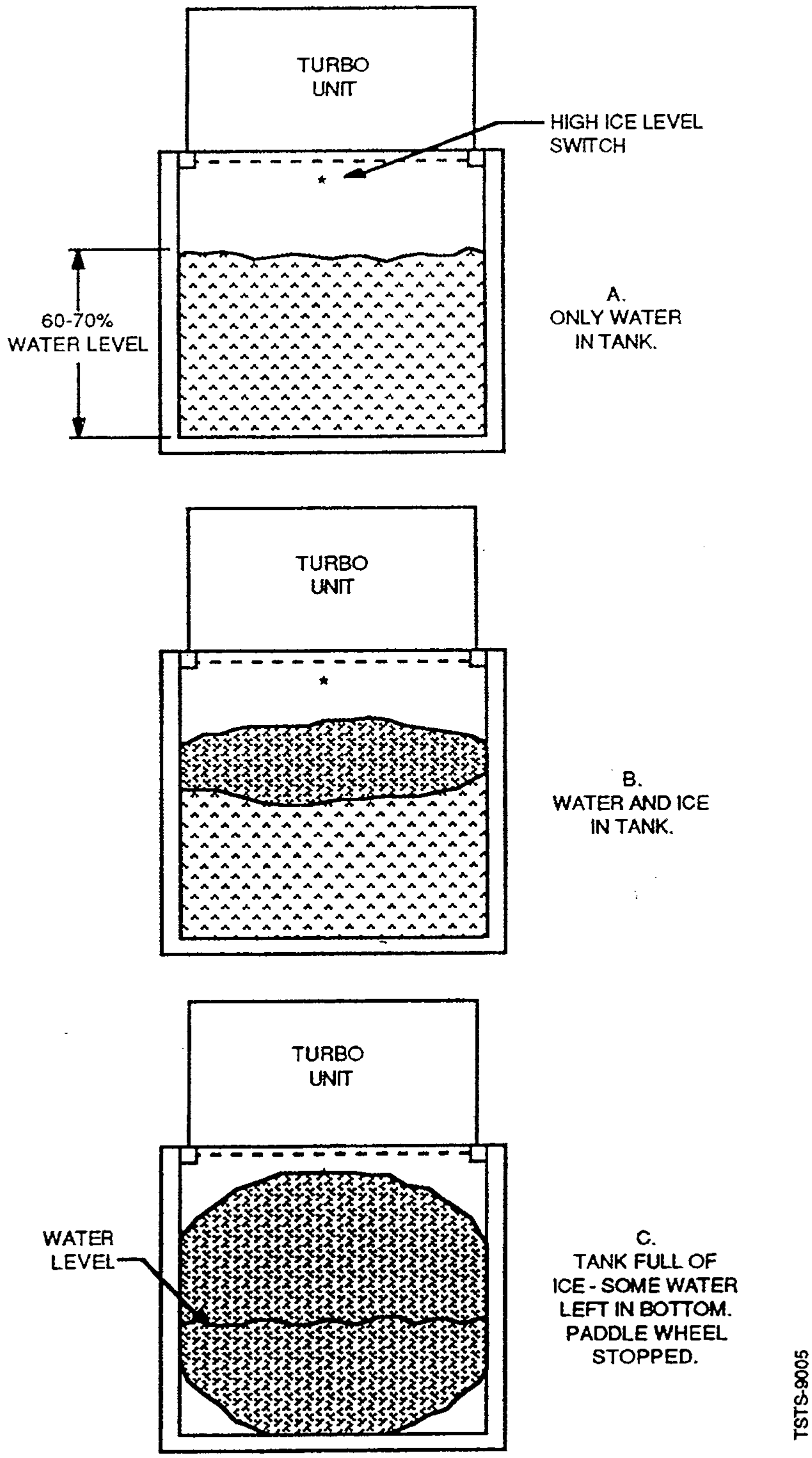

Figure 4-8 Sequence of Operation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

ice to melt off and to prevent short cycling of the compressor.

In the normal operating mode, the WTT will sense the temperature of the water coming onto the plates, and determine whether the unit will operate as a chiller (refrigeration only), or as an icemaker (refrigeration and defrost cycles). When the temperature of the water onto the plates drops below the preset value (between 36°F and 39°F for HP models, and 39°F to 41°F for IGC models), the thermostat contacts will close. This initializes the timer within the PLC which sequences the Turbo unit through its refrigeration/defrost cycle. This refrigeration/defrost cycle is strictly a time cycle.

The PLC will monitor the status of the safety switches. If either the Oil Pressure Time Delay Switch (OPTD) or the Oil Temperature Switch (OTS) are tripped, they must be manually reset. This is done to prevent operating the compressor without oil. The LP cut out switch is automatically resetting, and the HP cut out switches is manually resetting. The Turbo unit will automatically restart once the "cut-in" setting of the safety switch is reached. Any motor overloads used must also be manually reset.

<u>Chilling Mode</u>
When the temperature of the water coming onto the plates is above the setpoint of the WTT, the switch will be open. In this mode, the liquid solenoid(s) will remain open, allowing the evaporator plates to be fed with refrigerant. The refrigerant will be boiled off in the plates as the water flowing over the outside of the plates is chilled. The refrigerant then goes through the suction accumulator/heat exchanger, and the dry suction is taken back to the compressor. Refer to Figure 4-9.

Each evaporator section is supplied liquid refrigerant through a TXV which controls the amount of liquid fed to each evaporator section. Setting of the TXV is done when the ice generator/chiller is in the icemaking mode and is described later in this section. Distribution of the liquid refrigerant to each individual plate is provided by the distributor and distribution tubes.

Since ice is not being formed on the plates, the ice generator/chiller continues to operate in this mode. If the evaporator capacity is greater than the load imposed on the system or the water is being recirculated only to the ice generator/chiller, the water temperature in the tank will begin to drop until the setpoint of the WTT thermostat is reached.

Some installations do not require the ice generator/chiller to operate as a chiller (i.e. the entire building load is handled by melting the ice stored in the tank) and the ice generator/chiller runs only at night or during off-peak utility rate hours to replenish the ice supply. Even in this type set-up, the ice generator/chiller will operate as a chiller until the WTT setpoint is reached. This is done to reduce the heat input and associated efficiency losses by eliminating the harvest sequence when the water temperature is too high to allow production of ice.

During the chilling mode, none of the refrigerant valves change position and the metering check valves remain closed. However, all safety switches are active to provide protection of the compressor. The LSP described previously acts as a backup to the WTT during this mode of operation. In the event the WTT fails to switch the ice generator/chiller out of the chilling mode, the LSP will sense a drop in suction pressure due to formation of ice on the evaporating plates.

<u>Icemaking Mode</u>
When the water temperature onto the plates is below the setpoint of the thermostat (between 36°F and 39°F for HP models and 39°F to 41°F for IGC models), the PLC initiates the refrigeration/defrost cycle.

The refrigeration cycle is identical to the chilling mode operation with the exception that ice is being formed on the evaporator plates. At the predetermined interval, the PLC will initiate the defrost cycle. When this occurs, the LS which feeds the section going into defrost will close. Then, the Hot Gas Defrost Solenoid

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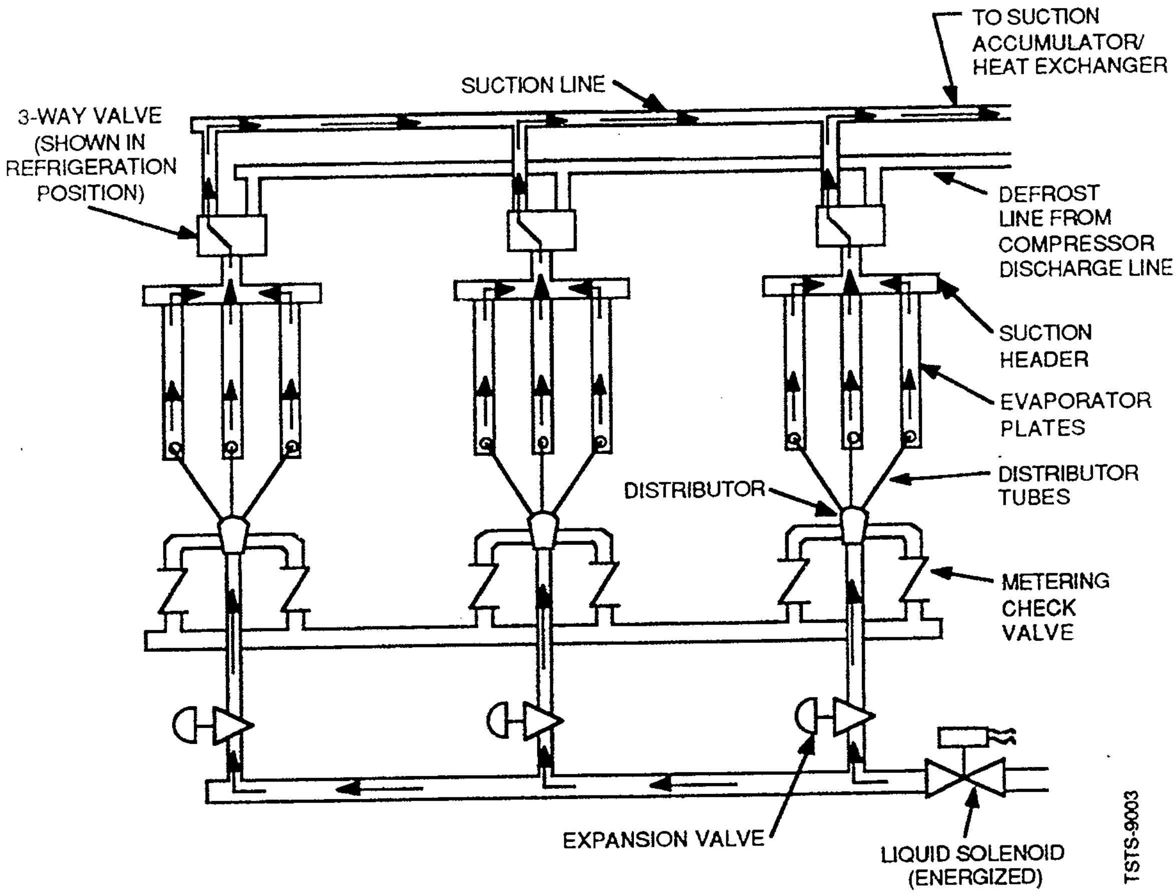


Figure 4-9 Refrigeration Cycle

Valve (HG-"X") will energize, allowing refrigerant gas to enter the evaporator section in defrost.

The other sections controlled by the same LS are fed refrigerant from the section in defrost. The condensed liquid coming out of the section in defrost is metered through the special Turbo metering check valves to feed the sections which are still in refrigeration. When the defrost cycle is finished, the HGS will deenergize, and the section returns back to the refrigeration mode. Refer to Figure 4-10.

As long as the ice generator/chiller is supplied with a "run" signal through either PTC or remote signal, and the WTT is below the setpoint, the ice generator/chiller will continue to go through the refrigeration and defrost of each evaporator plate section in a sequence controlled by the PLC.

In order to ensure proper refrigerant feed to each evaporator section, the TXV for each section must be adjusted for the proper superheat during the icemaking mode. All Turbo ice generator/chillers utilize externally equalized TXV's to compensate for the pressure drop in the evaporator plates.

A detailed description of the TXV operation, installation, and adjustment is described in the section on oil management systems and valve adjustments. Typical superheat settings for the TXV is 5-8°F for both HP and IGC models. Too high a setting for superheat will result in reduced evaporator capacity and possible overheating of the compressor or suction cooled compressor. A low setting may result in an overfeed of refrigerant which could result in compressor damage.

IMPORTANT

Thermal expansion valve superheat adjustments should be made by a qualified refrigeration technician or engineer. Improper adjustment can result in overfeed of the evaporator causing liquid slugging of the compressor. Liquid slugging will cause damage and/or failure of the compressor.

Refer to Figure 4-11.

Chilling-To-Icemaking Transition

As described in the "Chilling Mode" operation, the temperature of the water in the storage tank will drop anytime the capacity of the ice generator/ chiller exceeds the load. When the water temperature reaches the WTT setpoint, the contact will open. Absence of the WTT contact inputs a signal to the PLC to initiate the icemaking sequence (i.e. start periodic harvest of each eva-

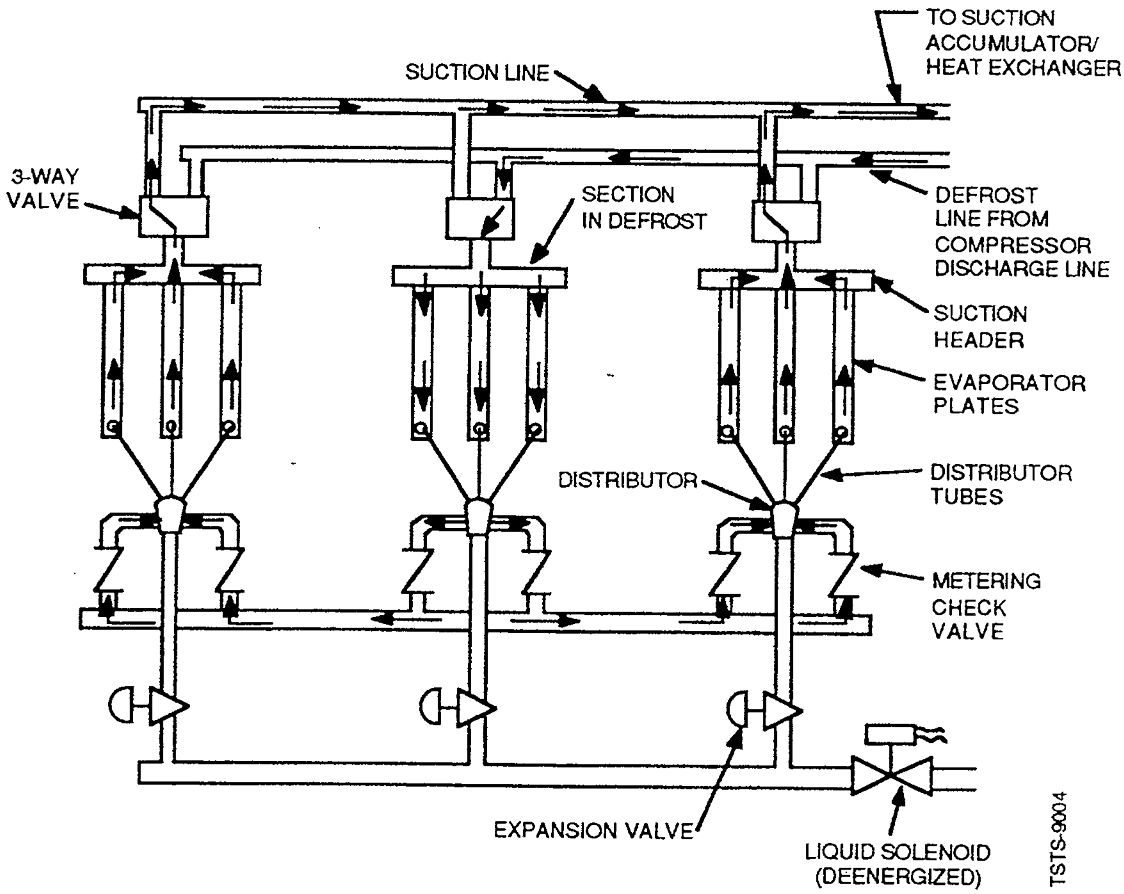


Figure 4-10 Defrost Cycle

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

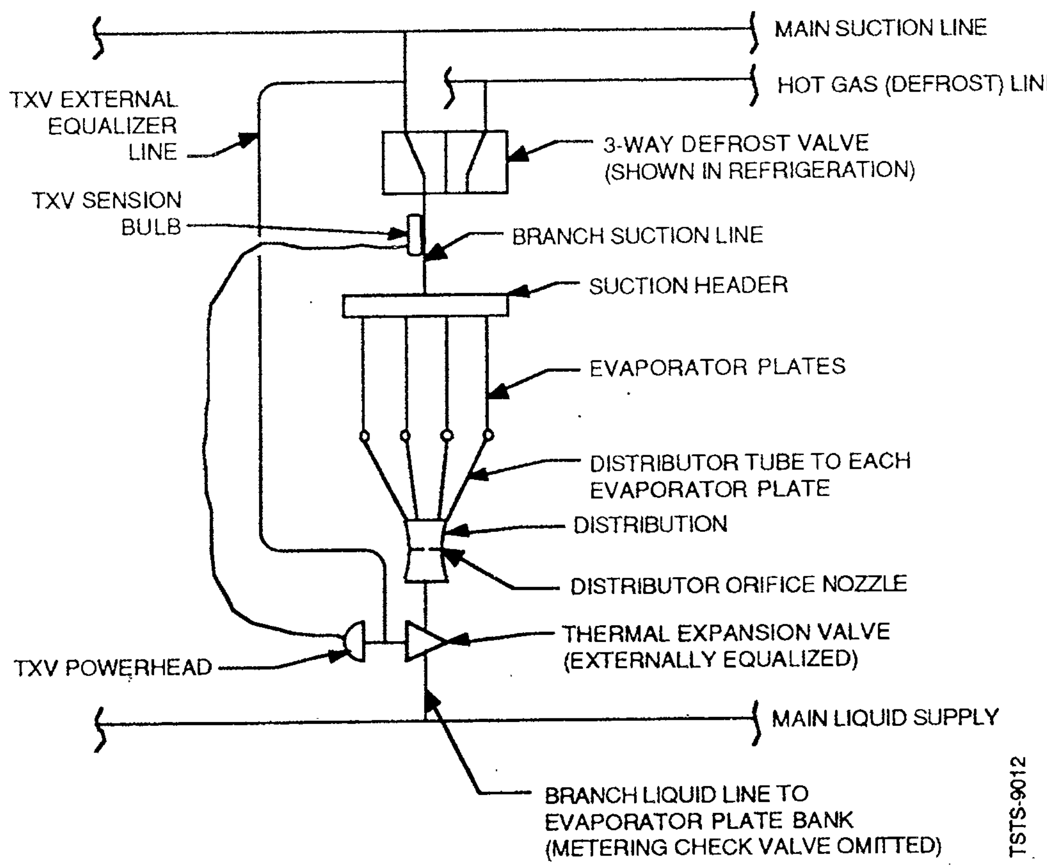


Figure 4-11 Typical Thermal Expansion Valve Installation

porator section).

If the WTT contact opens during operation, the icemaking/ defrost sequence will begin immediately as programmed in the PLC. However, if the WTT contacts are closed when the ice generator/chiller is started, a "wash-down" cycle of at least fifteen (15) minutes will occur before normal operation of the unit begins. The recirculating water pump (RWP) will start but the compressor will remain off until the "wash-down" cycle is completed. This ensures that the evaporator plates are clear of ice when the unit starts. Refer to the description of "wash-down" cycle for additional information.

As long as the WTT remains below the setpoint, the ice generator/chiller will remain in the icemaking mode.

Changes in the water temperature generally occur very gradually and with the 1°F deadband on the WTT, cycling between icemaking and chilling should not occur. However, when the water temperature on the plates does rise above the WTT setpoint, the PLC controls immediately return to the chiller mode. The ice remaining on the plates is melted away by the "warm" water flowing over the plates.

Icemaking-To-Chiller Mode

As described previously, the ice generator/chiller transition from chilling-to-icemaking is controlled by the WTT. Transition from icemaking-to-chilling is also controlled by the WTT. When the water temperature on the plates rises above the WTT setpoint, the ice generator/chiller immediately changes to the chiller mode. If a section is in defrost, the harvest of that section will be completed but the defrost sequence for the remaining sections will not be initiated. The ice generator/chiller will continue to operate as a chiller until the WTT changes or operation of the unit is terminated. Increase in the water temperature when the building recirculating water pump is turned on may cause the unit to switch to the chiller mode due to the return of "warm" water in the piping loop.

After a short period of operation, the unit will normally return to the icemaking mode if the water tank has ice available for cooling. In general, periodic change from icemaking-to-chilling and chilling-to-icemaking may be observed due to the operating sequence and conditions within the storage and building system. However, due to the deadband of the WTT and typical operating conditions, short or rapid cycling of WTT should not occur.

All safety devides are active in the chilling and icemaking modes.

Compressor Operation and Arrangement

All Turbo HP and IGC models are supplied standard as single circuit systems. A high side compression set is connected to common evaporator suction, hot gas, and liquid lines. When the unit is running, all sections are active. Models utilizing multiple compressors are also single circuit. The compressors are piped in parallel to a common suction and discharge. Both compressors must run and all evaporator sections are active. An oil management system is provided for both single and multiple compressor operations.

Optional dual circuit systems are available. Dual circuit systems are provided with multiple compressors or compressor capacity reduction controls along with two sets of liquid solenoids. In this configuration, with both liquid solenoids open, all evaporator sections are active and all compressors are operated. A 50% capacity reduction is obtained by closing either one of the liquid solenoids and turning off a compressor or initiating the capacity reduction step of the compressor. Therefore, only one-half of the system is operating. Suction and hot gas risers are utilized where required to ensure proper oil return and operation of the system.

Dual refrigerant circuits are also available as an extra cost option. In this configuration, two completely separate high sides, and refrigerant piping sets are combined in a single cabinet. Due to the space requirements for the second set of refrigeration components, unit sizes may be affected. Dual refrigerant circuits are recommended only in cases where physical limitations at the job site prevent the installation of two separate units.

Filter/Drier Piping

Turbo ice generator/chillers are all furnished with a filter/drier or filter/drier assembly when multiple filter/driers are required.

As the name indicates, the filter/drier has several purposes. Moisture in a freon refrigeration system can cause numerous problems which can result in the failure of or damage to the equipment. Therefore, a drier is installed in the main liquid line to remove moisture from the system. It should be noted that a properly evacuated and charged system will be free of moisture. If moisture enters the system when it is open for service, the drier will remove the moisture when the liquid passes through the drier cores.

Liquid line sight glasses with moisture indicators are installed to allow for visual inspection of the refrigerant condition. Refer to Table 4-1 for the sight glass/moisture indicator status. Properly charged systems will have a sight glass with a deep green

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Table 4-1 Sight Glass/Moisture Indicator Status

Liquid Level	Moisture Indicator Color	Condition/Action To Be Taken
Solid - No Bubbles	Dark Green	Normal.
Solid - No Bubbles	Greenish-Yellow	Moisture in system. Monitor and replace drier cores if condition continues.
Solid - No Bubbles	Yellow	Excessive moisture in system. Change drier cores immediately.
Bubbles In Liquid Stream	Dark Green	Excessive pressure drop due to plugged drier cores or low system charge. Change drier cores.
Bubbles	Greenish-Yellow	Moisture and debris in system. Replace drier cores.
Bubbles	Yellow	Moisture and debris in system. Replace drier cores. May have to repeat.
Glass Not Full	—	Refrigerant charge low. Add refrigerant.

TSTS-9006

color to indicate a moisture free system. Greenish-yellow sight glasses indicate some moisture in the system. A yellow sight glass generally indicates excessive moisture in the system, and the drier cores should immediately be changed. After the system has been operated for several hours the drier should be changed again if the sight glass does not return to a solid green color.

The second purpose of the filter/drier is to remove trash, scale, metal filings, dirt, or any other foreign objects that are trapped in the system during piping or service. Many of the valves and controls in a refrigeration system have small orifices or bleed holes that are required for proper operation. To prevent plugging of these passages, a filter is installed in the refrigerant liquid line. Typically, the drier cores which also act as part of the filtering system are replaced after the initial start-up. Turbo uses a combination filter/drier to filter and dry the refrigerant. These driers are sized to match the refrigerant flow rates. Excessive pressure drops through the filter/drier caused by undersizing or accumulation of debris will result in flashing of the liquid as it passes through the filter/drier. Flashing is observed as tiny bubbles passing through the liquid line sight glass. Flash gas in the main liquid line will result in reduced thermal expansion capacity and therefore reduced system capacity.

The key factors to remember when checking the filter/drier operation is to observe the condition of the liquid flow through the sight glass/moisture indicator.

Turbo uses filter/driers with high capacity moisture removal ratings.

Changing Drier Cores

When it becomes necessary to replace the drier cores in the filter/drier, the following procedure is recommended (refer to Figure 4-12).

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

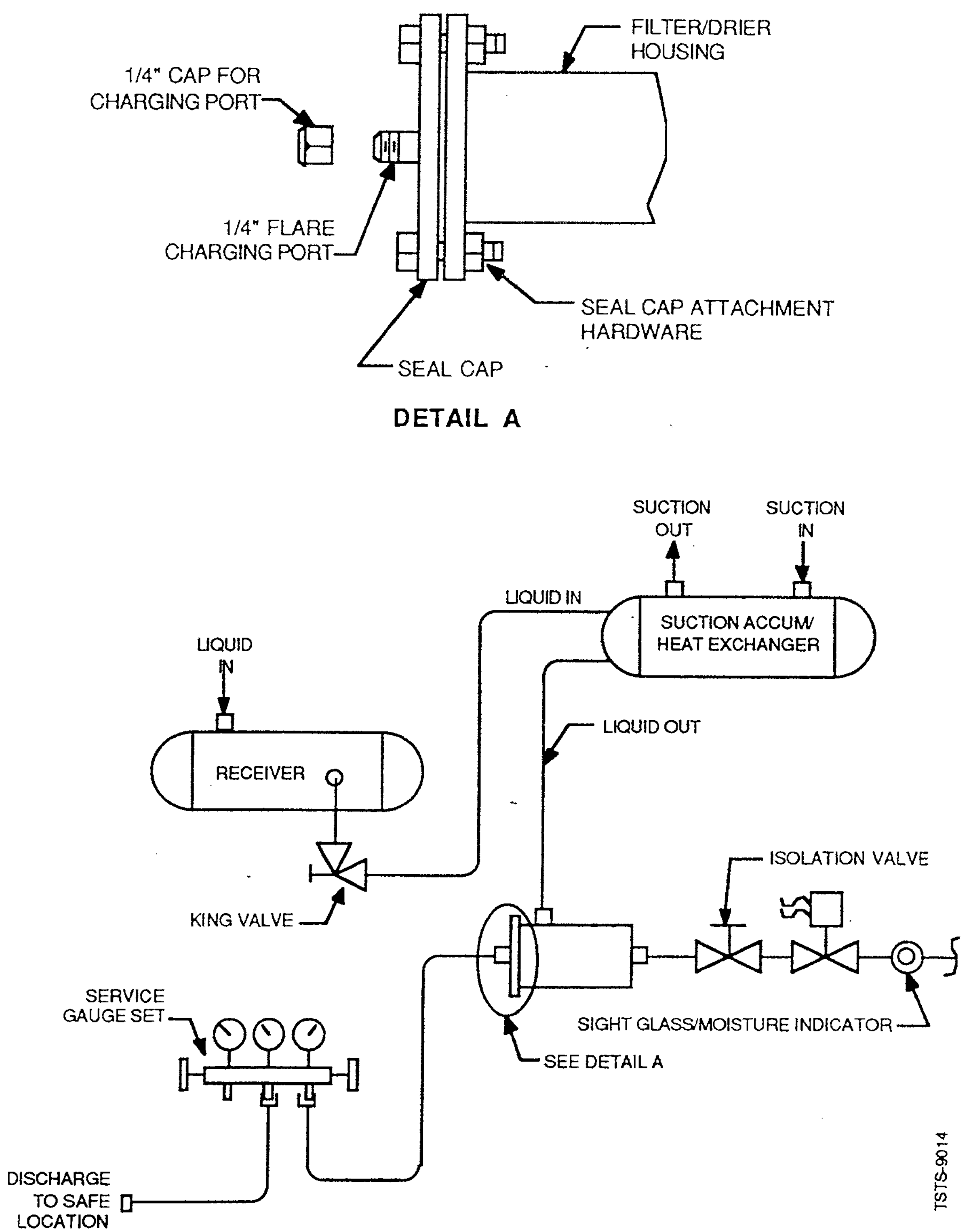


Figure 4-12 Typical Filter/Drier Installation

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

WARNING

All refrigeration service work should be provided by a qualified refrigeration technician or engineer. Filter/driers contain liquid refrigerant under high pressure. Failure to carefully follow these instructions could result in permanent injury or loss of life.

1. With the compressor operating, close the king valve (main valve on outlet of the receiver) to allow pump down of the liquid into the receiver.

2. After the ice generator/chiller operation is terminated by the low pressure safety switch, isolate the filter/drier assembly by closing the valve downstream of the filter/drier assembly.

3. Attach a service gauge manifold set to the Schrader (charging port) fitting in the seal cap (flathead) of the filter/drier assembly.

4. Open the service valve to release any liquid remaining in the filter/drier housing and the liquid line piping. Opening the valve also reduces the pressure inside the housing to atmospheric pressure. Discharge refrigerant to a safe location. Never point the hose in the direction of personnel.

Note:
If the seal cap (flat head) on the filter/drier housing does not contain a charge port, the bolts on the cover should be loosened slowly and evenly. Tap the cover as the bolts are loosened to allow the refrigerant to slowly escape. Do <u>not</u> remove the bolts until the cover is loose enough to ensure that all the refrigerant has escaped and the pressure inside the housing is at atmospheric pressure.

5. Once the refrigerant has been bled from the housing, slowly and evenly remove all the bolts attaching the seal cap.

6. Remove and replace the drier cores as outlined in the instructions supplied with the drier cores.

   - Do not open the drier core cans until you are ready to install the cores.

   - Place the "spent" cores in the can and properly dispose of the can and old drier cores. These cores may contain refrigerant oil or other combustible debris. Do not place in or near an open flame or incinerator.

7. Inspect the strainer screen for debris and clean as required.

8. After the drier cores have been replaced and the seal cap loosely attached with all of the bolts, slightly open the king valve to allow a very small amount of refrigerant to flow through the filter/drier housing and piping.

9. While the refrigerant is escaping, evenly tighten all the seal cap bolts. This will ensure that air and moisture is purged from the assembly before it is sealed.

10. Check for leaks around the seal cap.

11. If no leaks are found and the system is ready to go back on-line, open the king valve and isolation valve.

WARNING

Liquid refrigerant can burn or cause severe irritation of the skin. Crack the king valve slowly open. Do not attempt to hold the seal cap while opening the king valve. After a small refrigerant flow is obtained, position and tighten the seal cap. Always wear rubber gloves and eye protection when changing the drier cores. Failure to carefully follow these instructions could result in permanent injury or loss of life.

12. After the system is restarted, observe the condition of the liquid line sight glass/moisture indicator.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

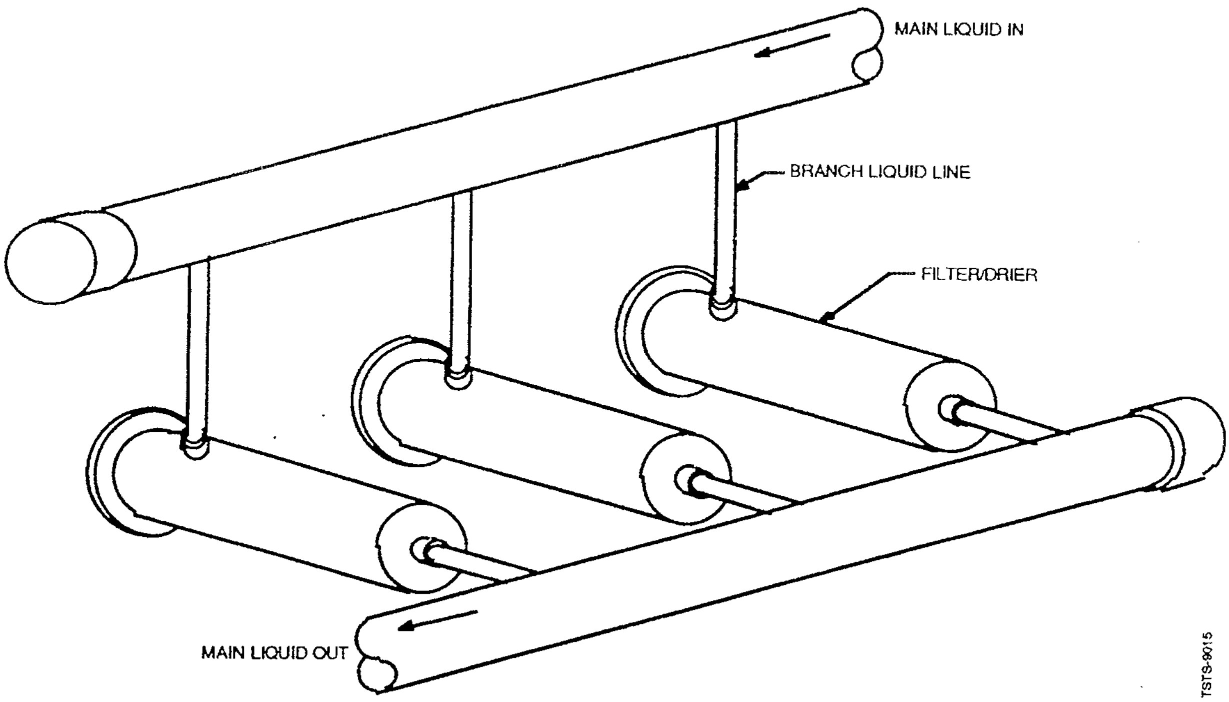


Figure 4-13 Typical Multiple Filter/Drier Installation

Multiple Filter/Drier Installation

Normally, a single filter/drier assembly is used. However, on some systems, multiple filter/driers are required to handle the specified refrigerant flow rate. In these cases, the same guidelines and service techniques are used. The only change will be in the piping configurations of the filter/drier bank. Multiple filter/driers are used to obtain the refrigerant flow required without excessive pressure drops. A typical arrangement is shown in Figure 4-13.

In Figure 4-13, three filter/driers are illustrated. The main liquid line in and out is sized to handle the maximum refrigerant flow rate that is specified. Each filter/drier and the branch liquid lines in and out are sized to handle one-third of the total flow rate.

Several options are available for the filter/drier assembly:

1. Filter/drier bypass - single or multiple filter/drier installations.

2. Inlet/outlet isolation valves located at the filter/drier.

Option 1 allows the filter/drier to be changed while the system is running. This is accomplished by temporarily diverting the liquid flow around the filter/drier (refer to Figures 4-14 and 4-15). The system should never be operated for extended time periods in the bypass mode (i.e. the drier cores should be immediately changed and the unit returned to its normal operating mode).

To change the drier cores, the system can either be pumped down as described previously or by the following procedure:

1. Open the bypass valve to allow liquid to flow around the filter/drier.

2. Close the two isolation valves at the inlet and outlet of the filter/drier.

3. Proceed with steps 1 through 12 under "Changing Drier Cores" on page 128.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

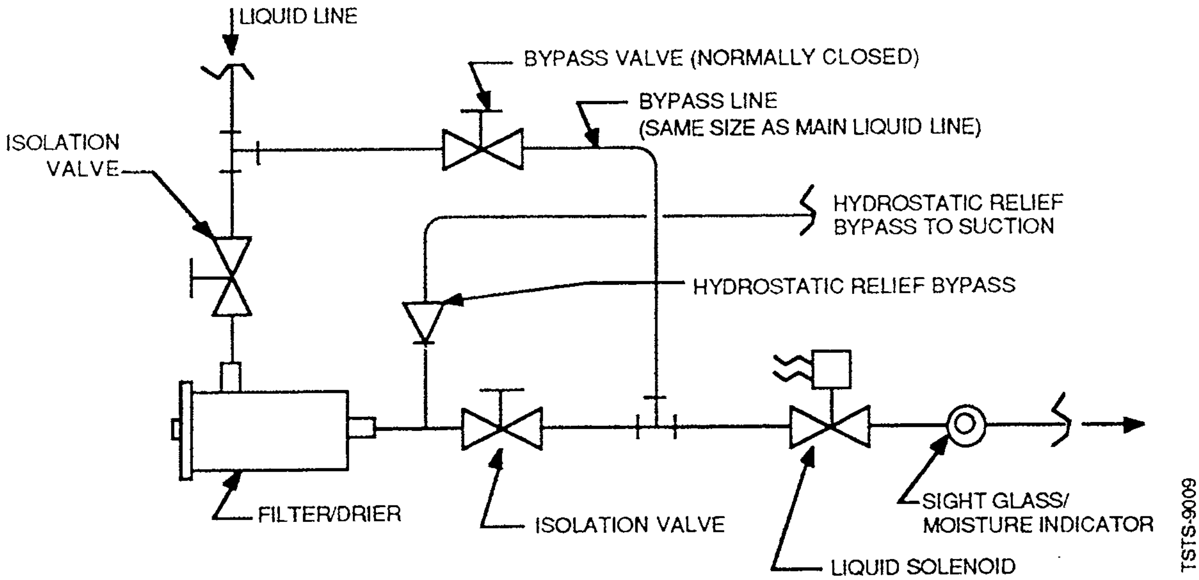


Figure 4-14 Filter/Drier Installation With Bypass Valves

After changing the drier cores:

1. Open the isolation valves at the outlet, then inlet to the filter/drier.

2. Close the bypass valve.

As noted in Figure 4-14, a hydrostatic relief valve should be used on the liquid line that is isolated. As the temperature of the liquid trapped between the two isolation valves rises, the pressure also increases. Since the liquid is noncompressible, high hydrostatic pressure can result. The high hydrostatic relief is a reseating relief device that safely vents excessive pressure by allowing the liquid to be drained to a low side vessel.

CAUTION

Never leave the isolation valves on a filter/drier liquid bypass closed. Excessive hydrostatic pressure can result. Failure to follow these instructions could result in severe physical injury and equipment failure or damage.

Option 2 includes extra isolation valves installed at the inlet and outlet to the filter/drier (reference Figure 4-16). This arrangement eliminates the need to pump the system down before changing the drier cores.

Units using multiple filter/driers require individual isolation valves at the inlet and outlet to each filter/drier. Installation of a common inlet and outlet valve could result in excessive liquid loss and difficulty in disposing of the large volume of refrigerant. Refer to Figure 4-17 for typical piping.

The arrangement in Figure 4-17 shows four filter/driers versus the three shown previously. For the example previously used, the total refrigerant flow could be divided between the three properly sized filter/driers. For the installation using the arrangement shown in Figure 4-17, assume that the total refrigerant flow can be handled by three of the four filter/driers. The fourth filter/drier becomes a spare allowing the drier core to be changed with the system running. In this arrangement,

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

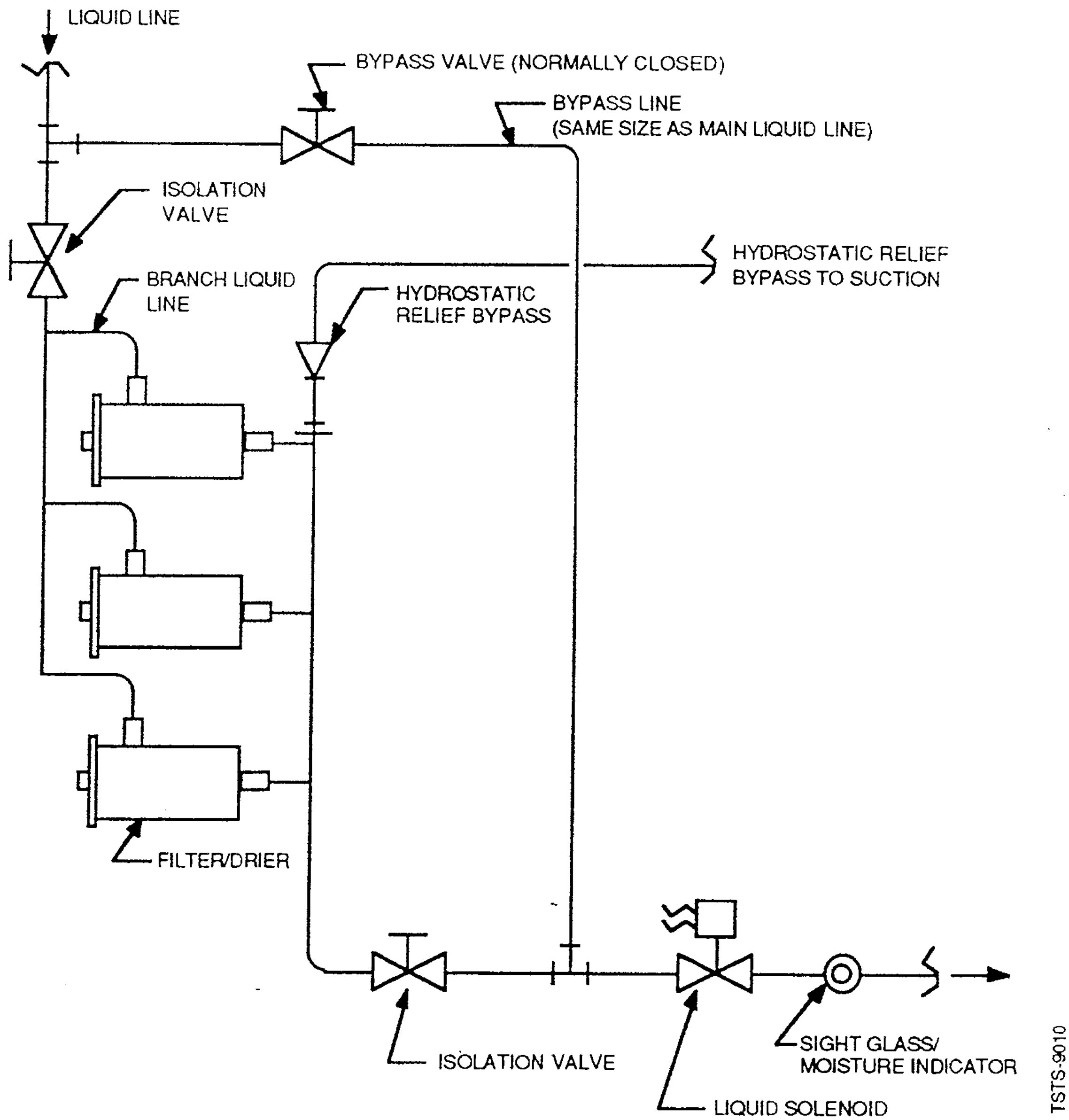


Figure 4-15 Multiple Filter/Drier Installation With Bypass

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

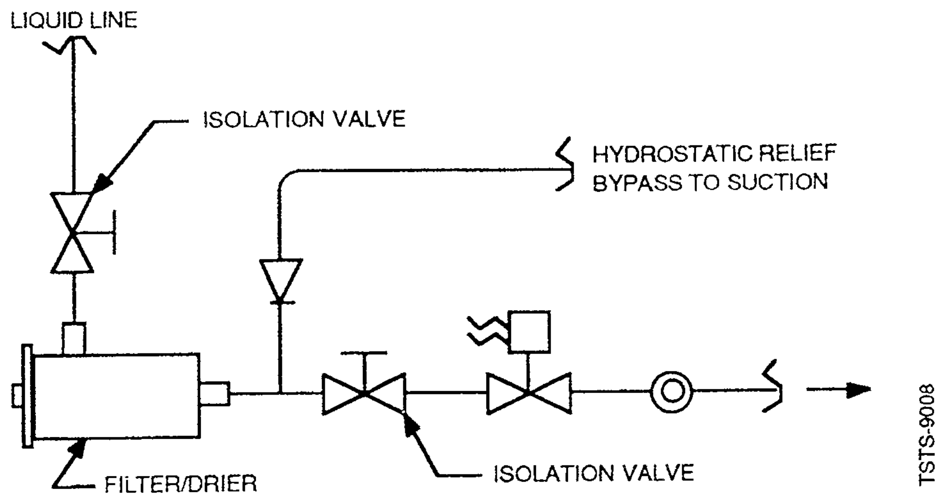


Figure 4-16 Typical Optional Filter/Drier Isolation Valve Installation

the need for a large liquid bypass line and large isolation valves is eliminated.

To change drier cores in this arrangement, the outlet valve to the spare filter/drier is opened, followed by opening the valve on the outlet side to the filter/drier. Then close the inlet valve to the filter/drier to be changed, followed by closing the outlet valve to isolate the filter/drier. Next, follow the same steps outlined in "Changing Drier Cores" on page 128.

1. Attach a service gauge manifold set to the Schrader (charging port) fitting in the seal cap (flathead) of the filter/drier assembly.

2. Open the service valve to release any liquid remaining in the filter/drier housing and the liquid line piping. Opening the valve also reduces the pressure inside the housing to atmospheric pressure. Discharge refrigerant to a safe location. Never point the hose in the direction of personnel.

Note:
If the seal cap (flat head) on the filter/drier housing does not contain a charge port, the bolts on the cover should be loosened slowly and evenly. Tap the cover as the bolts are loosened to allow the refrigerant to slowly escape. Do <u>not</u> remove the bolts until the cover is loose enough to ensure that all the refrigerant has escaped and the pressure inside the housing is at atmospheric pressure.

3. Once the refrigerant has been bled from the housing, slowly and evenly remove all the bolts attaching the seal cap.

4. Remove and replace the drier cores as outlined in the instructions supplied with the drier cores.

   - Do not open the drier core cans until you are ready to install the remove the bolts until the cover is loose enough to ensure that all the refrigerant has escaped and the pressure inside the housing is at atmosphercores.

   - Place the "spent" cores in the can and properly dispose of the can and old drier cores. These cores may contain refrigerant oil or other combustible debris. Do not place in or near an open flame or incinerator.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

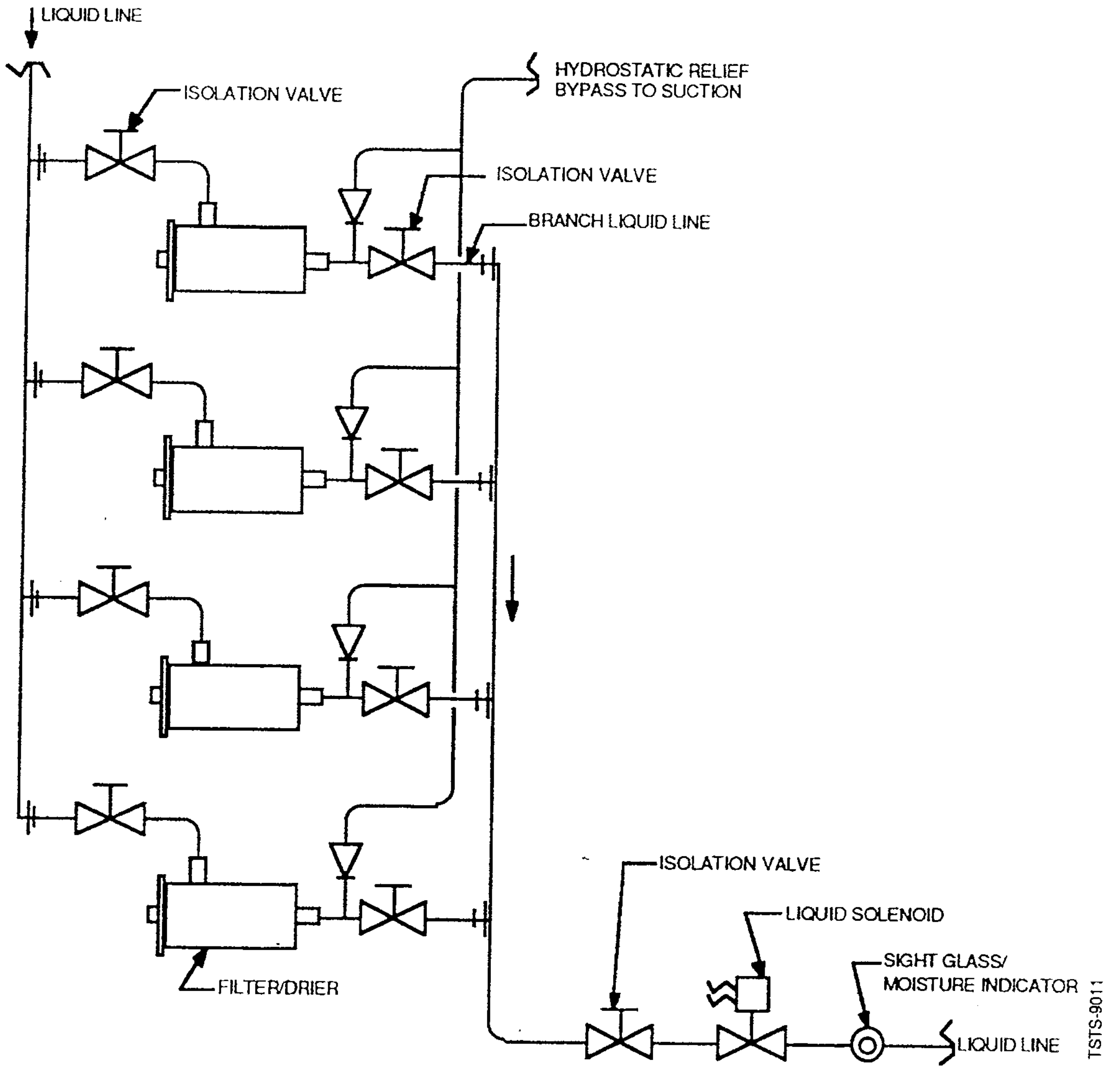


Figure 4-17 Typical Multiple Filter/Drier Piping With Inlet and Outlet Isolation Valves

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

5. Inspect the filter/drier inlet strainer screen for debris and clean as required.

6. After the drier cores have been replaced and the seal cap loosely attached with ic pressure.

7. While the refrigerant is escaping, evenly tighten all the seal cap bolts. This will insure that air and moisture is purged from the assembly before it is sealed.

8. Check for leaks around the seal cap.

9. If no leaks are found and the system is ready to go back online, open the king valve and isolation valve.

WARNING

Liquid refrigerant can burn or cause severe irritation of the skin. Crack the king valve slowly open. Do not attempt to hold the seal cap while opening the king valve. After a small refrigerant flow is obtained, position and tighten the seal cap. Always wear rubber gloves and eye protection when changing the drier cores. Failure to carefully follow these instructions could result in permanent injury to loss of life.

10. After the system is restarted, observe the condition of the liquid line sight glass/moisture indicator.

Again, hydrostatic relief devices are shown in the piping between the isolation valves to prevent dangerous hydraulic pressure from developing due to the liquid trapped between the valves.

The above procedure is repeated with each of the filter/drier assemblies until all the drier cores have been changed.

IMPORTANT

Important factors to remember in the above example for multiple filter/driers with individual isolation valves are:

1. **Only three filter/driers are required to handle the total refrigerant flow. Therefore, when one of the four filter/driers installed is closed, there is no decrease in flow capacity (i.e. the remaining three filter/driers are sized to handle the full flow).**
2. **Hydrostatic relief must be provided for all filter/driers.**
3. **Isolation valves should <u>not</u> be left in the closed position.**

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Programmable Controller Program Changes
Saving and Loading Program

Introduction

The Turbo ice generator/ chiller is shipped with the operating program installed in the CPU. Changes are not required under normal operating conditions. However, should it become necessary to change a counter preset, save a program, or load a program, the following instructions and information should be followed.

Turbo thermal storage systems are not supplied with a hand held programmer (required to make changes). Service personnel attach the programmer when changes are required. Hand held programmers are available as an option. The hand held programmer should not be left on the CPU. Store the programmer and selector switch key in a dry, safe location.

Instructions are included describing the use of a cassette tape recorder to save a program to tape or load a program from tape.

A copy of the ladder logic for a typical ice generator/chiller is located in the back of this section.

Printout Explanation

While it would be impossible to go through the ladder diagrams for all of the individual units shipped from Turbo for thermal storage applications, the individual ladder diagrams share similar components. By knowing what type of information is available on the ladder diagrams, the user can have a headstart when searching for a particular piece of information.

Logicmaster Printout

In 1987, Turbo acquired General Electric's Logicmaster software. In addition to facilitating programming, the Logicmaster software allows for the addition of documentation and annotation (the labeling of individual coils and contacts), which allows the operator to look at the program and have a clear picture of how the logic is set up, and how it will operate. The General Electric Logicmaster software is compatible with both the General Electric (GE) and Texas Instruments (TI) programmable controllers used by Turbo.

The Logicmaster printout differs from the Printer Interface Unit printout in the fact that the Logicmaster printout has more detailed documentation available on it. The Logicmaster printout will have "GE FANUC LOGICMASTER 1F DOCUMENTATION Page xx" at the top line of each page. The Printer Interface Unit printout will have "Printer Interface Unit" at the top left corner of each page. Refer to Figure 4-23.

The Logicmaster printout can be dissected as follows:

Title Block
Refer to Figure 4-18. This will appear on all of the pages of the Logicmaster printout. The title is two lines long.

The first line will consist of:

- the program number
- the number of evaporator sections of the unit
- the number of compressors in the unit
- special comments about the unit.

The second line consists of:

- special comments which could not fit on the first line
- the date the program was written
- the programmer's initials.

Program Description
Refer to Figure 4-18. This will be found on the first page of the Logicmaster printout, and will briefly describe the type of unit the program was written for. This program description will be found as the rung explanation of Rung O.

Rung Explanation
Refer to Figure 4-19. This describes how that particular line of logic operates.

Name
Refer to Figure 4-19. This is a three line explanation which exists above a set of contacts,

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

relay, counter, etc. Each reference will have the same name.

Counter Preset Value
Refer to Figure 4-20. This is the value the counter must reach to "energize" it's relay.

I O Point Status Table
Refer to Figure 4-21. This is found at the end of the Logicmaster printout. It contains the I O point value, which defines the individual input or output point. The outputs will include real world outputs, as well as internal relays.

The Name/Nickname is the description given to the I O by the programmer. These generally correspond to the inputs or outputs to which the I O are physically tied to.

The Cross Reference tells the type of contact (normally open or normally closed) or output (relay, set/reset) used, and the rung where the contacts or outputs can be found.

Counter Status Table
Refer to Figure 4-22. This is similar to the I O point status table, except that the I O point value references counters.

Printer Interface Unit

Prior to 1987, all programs were printed out using the printer interface unit only. The printer interface unit printout may be attached behind the Logicmaster printout. The printer interface unit printout consists of the Boolean Printout. Refer to Figure 4-23.

The Boolean Printout will indicate the "line by line" steps required to program the unit with the hand held programmer. There will be a four digit number to the left of a colon. This number indicates the Address number of that word of logic.

A few things are not apparent from looking at the Boolean Printout:

1. Before any number is pressed with the hand held programmer, the SHF key must be pressed. The SHF key acts similar to the "shift" key of a typewriter.

2. After the entire line of logic has been punched into the hand held programmer, the ENT key must be pressed. This acts to enter the line of logic into the CPU's memory.

3. There are three symbols which appear on the Boolean Printout which do not correspond to any of the keys on the hand held programmer.

   * This denotes where either a constant preset value or a sequence operator preset exists.

   # This indicates the end of a rung of logic (except for rungs which contain counters).

   (D) This indicates the location of a sequence operator.

The *, #, and (D) are only useful for looking for specific points in the Boolean Printout, and they need not be entered when programming the CPU with the hand held programmer.

Refer to Figure 4-23.

Using The Hand Held Programmer

Mode Switch

Refer to Figure 4-28.

RUN
Allows program execution with outputs enabled. The CPU scans its stored logic and allows timer/counter and relay contacts to be displayed. In the RUN mode, changes to the logic are not allowed; however, the preset values for timers and counters may be changed.

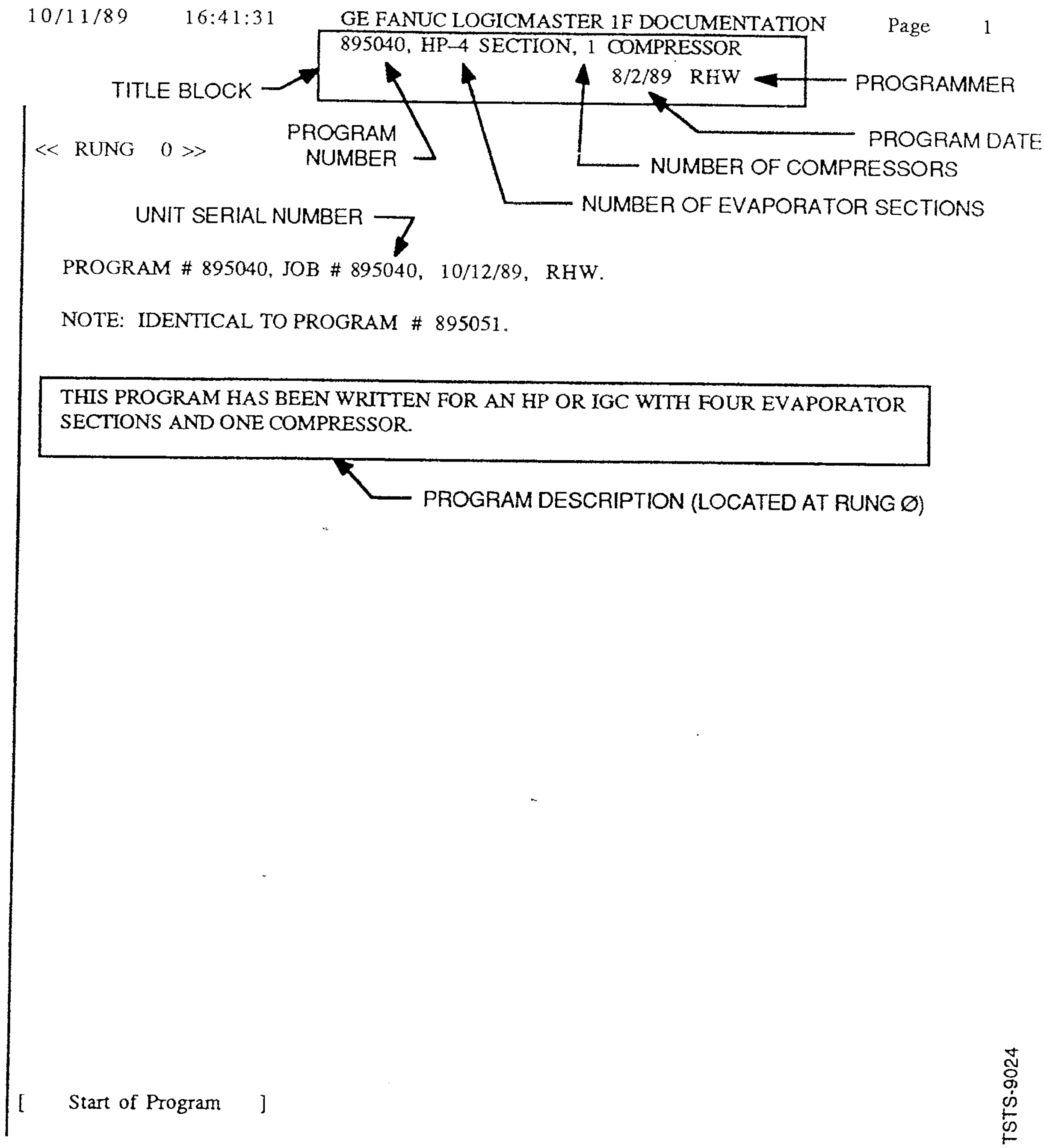
PRG
New programs can be entered into memory, and previously entered logic can be altered; however, no solving of the logic is performed.

LOAD
This connects the programmer to an external device such as a tape recorder through the adjacent tape port. Logic is not solved while in this position.

Ladder Logic Cover Sheet

Refer to Figure 4-24 for a typical first page of the ladder logic programs.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.


10/11/89 16:41:31 GE FANUC LOGICMASTER 1F DOCUMENTATION Page 1

895040, HP-4 SECTION, 1 COMPRESSOR

8/2/89 RHW

<< RUNG 0 >>

PROGRAM # 895040, JOB # 895040, 10/12/89, RHW.

NOTE: IDENTICAL TO PROGRAM # 895051.

THIS PROGRAM HAS BEEN WRITTEN FOR AN HP OR IGC WITH FOUR EVAPORATOR SECTIONS AND ONE COMPRESSOR.

[Start of Program]

Figure 4-18 Logicmaster Printout - Page 1

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

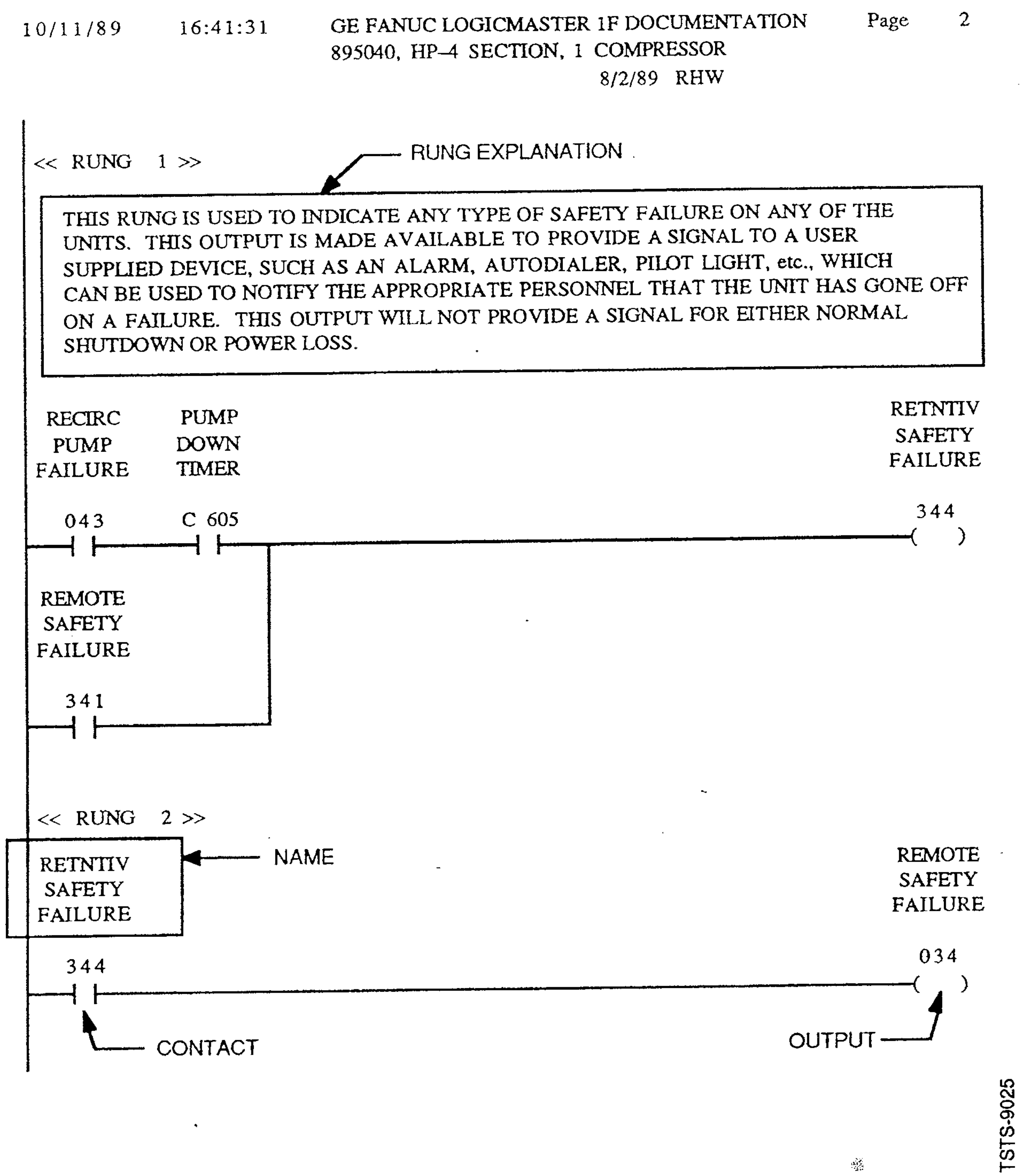


Figure 4-19 Logicmaster Printout - Page 2

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

10/11/89 16:41:31 GE FANUC LOGICMASTER 1F DOCUMENTATION Page 6
895040, HP-4 SECTION, 1 COMPRESSOR
8/2/89 RHW

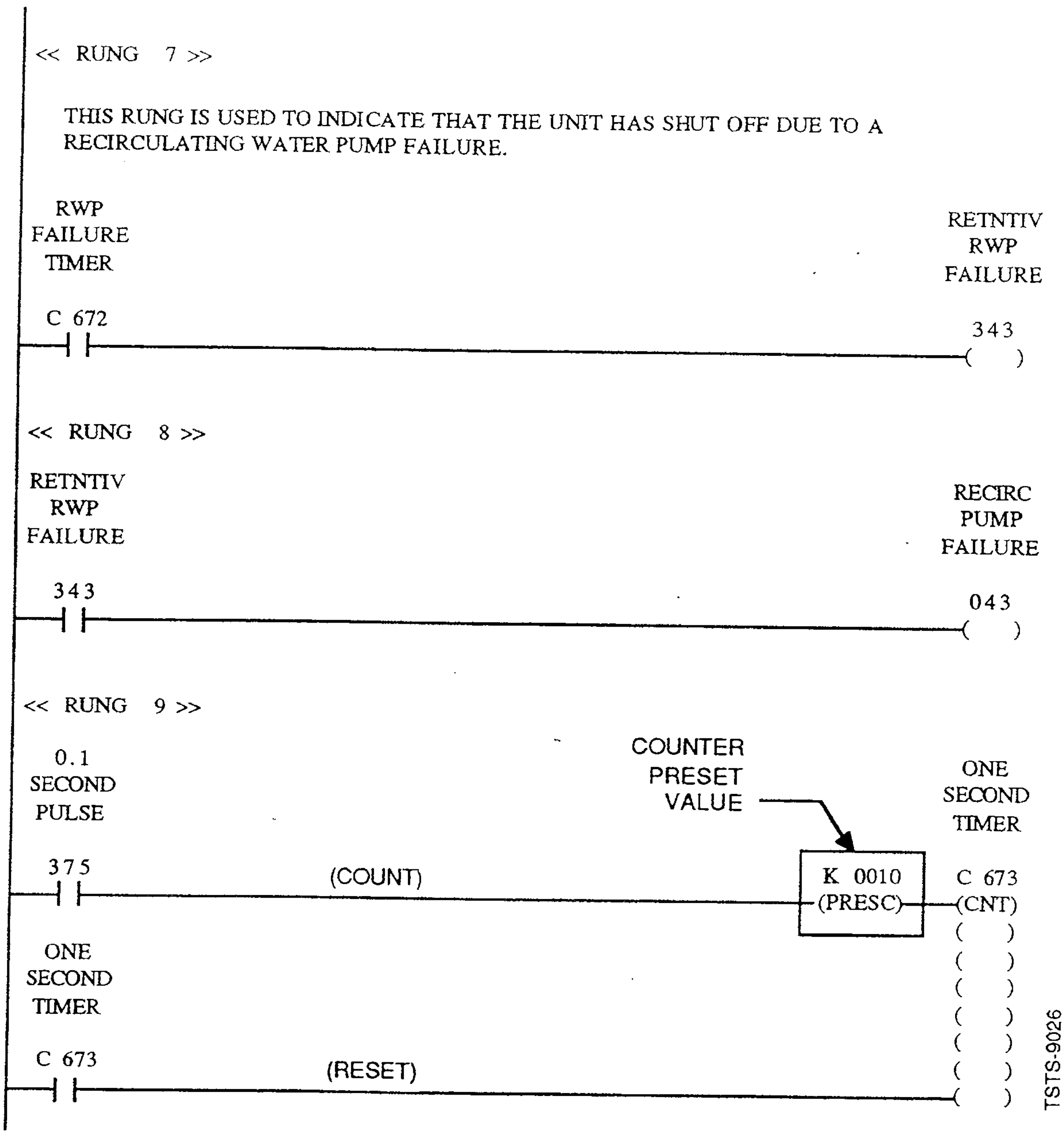


Figure 4-20 Logicmaster Printout - Page 6

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

10/11/89 16:52:07 GE FANUC LOGICMASTER 1F DOCUMENTATION Page 43
895040, HP–4 SECTION, 1 COMPRESSOR
8/2/89 RHW

***** IO POINT STATUS TABLE *****

IO POINT VALUE	NAME/ NICKNAME		CROSS REFERENCE	RUNGS WHERE I/O ARE USED
000	OFF/ RESET	:	] [	6, 21, 22, 23, 37, 45, 50, 54, 55, 56, 59
001	MASTER CONTROL SWITCH	:	] [ ]/[	5, 35 35, 56, 68
002	WATER TEMP T'STAT	:	] [	15
003	HI ICE LEVEL SWITCH	:	] [ ]/[	45 45, 46
004	COMPR MOTOR CONTACT	:	] [ ]/[	6, 10, 11, 12, 36, 38, 48, 55, 60, 63, 66, 67, 73 5, 10, 46, 53, 56, 62, 73
005	RECIRC PUMP CONTACT	:	] [ ]/[	6 6
011	LOW DISCHG PRES SW	:	] [ ]/[	26, 27 26
012	OIL TEMP T'STAT	:	] [ ]/[	63 62, 63
013	HIGH REFRIG LVL SW	:	]/[	48
020	LIQUID SOL #1	:	( )	36
021	HOT GAS SOL #1	:	] [( )	28 39
022	HOT GAS SOL #2	:	] [( )	28 40

NORMALLY OPEN

NORMALLY CLOSED

TYPE OF I/O

TSTS-9027

Figure 4-21 I O Point Status Table

10/11/89 16:53:31 GE FANUC LOGICMASTER 1F DOCUMENTATION Page 49
895040, HP-4 SECTION, 1 COMPRESSOR
8/2/89 RHW

***** COUNTER STATUS TABLE *****

IO POINT VALUE	NAME/ NICKNAME		CROSS REFERENCE	
C 600	REFRIG	:	] [	12, 13, 22, 38, 44
	CYCLE		(CTR)	11
	TIMER			
C 601	DEFROST	:	] [	16, 17, 18, 22, 26, 44
	CYCLE		(CTR)	10
	TIMER			
C 602	AUX REF	:	] [	13
	CYCLE		(CTR)	12
	TIMER			
C 603	SAFETY	:	] [	55, 56, 58
	FAILURE		]/[	54, 55
	TIMER		(CTR)	54
C 604	SAFETY	:	] [	52, 54, 58
	FAILURE		]/[	51, 55, 56, 56
	COUNTER		(CTR)	56
C 605	PUMP	:	] [	1, 52, 55, 58
	DOWN		]/[	57
	TIMER		(CTR)	57
C 606	HI ICE	:	] [	45, 46
	ON		(CTR)	46
	TM DEL			
C 607	HI ICE	:	] [	46, 47
	OFF		]/[	45, 45
	TM DEL		(CTR)	45
C 620	LOW	:	] [	27
	P DISCH		]/[	26
	DEF EXT		(CTR)	26
C 630	LIQUID	:	] [	13, 53, 56
	SOL		]/[	36, 37
	TM DEL		(CTR)	37
C 631	LOW OIL	:	] [	64
	TEMP		(CTR)	63
	TM DEL			
C 632	OIL	:	] [	60, 62
	DRAIN		(CTR)	60
	SOL TMR			

TSTS-9028

Figure 4-22 Counter Status Table

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Printer Interface Unit
BOOLEAN PRINTOUT

USER PROGRAM LISTING V3.1

SERIES ONE, ONE PLUS/SR-20, SR-21

PAGE 0001

ADDRESS NUMBER

0000:	STR	043	0050:	STR	160	0100:	CNT	636#	0150:		* 0015
0001:	AND CNT	605	0051:	CNT	600#	0101:		* 0060	0151:	STR CNT	620
0002:	OR	341	0052:		* 0120	0102:	STR CNT	636	0152:	OR	011
0003:	OUT	344#	0053:	STR NOT	165	0103:	SET	165#	0153:	OUT	175#
0004:	STR	344	0054:	AND CNT	600	0104:	STR	(D) 637	0154:	STR	021
0005:	OUT	034#	0055:	AND CNT	673	0105:		* 0001	0155:	OR	022
0006:	STR CNT	673	0056:	AND	004	0106:	OR	(D) 637	0156:	OR	023
0007:	AND NOT CNT	670	0057:	STR	160	0107:		* 0002	0157:	OR	024
0008:	STR	374	0058:	CNT	602#	0108:	OR	(D) 637	0158:	OUT	170#
0009:	CNT	670#	0059:		* 0123	0109:		* 0003	0159:	STR NOT	170
0010:		* 0090	0060:	STR NOT	165	0110:	AND	(D) 635	0160:	MCS	
0011:	STR	375	0061:	AND CNT	602	0111:		* 0000	0161:	STR	040
0012:	STR CNT	671	0062:	OR	165	0112:	AND	(D) 600	0162:	OUT	171#
0013:	CNT	671#	0063:	AND CNT	630	0113:		* 0030	0163:	STR	041
0014:		* 0600	0064:	AND CNT	600	0114:	AND NOT CNT	636	0164:	OUT	172#
0015:	STR	351	0065:	SET	166#	0115:	OR	000	0165:	STR	043
0016:	AND	001	0066:	STR	160	0116:	RST	165#	0166:	OUT	173#
0017:	AND NOT	350	0067:	RST	166#	0117:	STR	165	0167:	STR	042
0018:	AND NOT	040	0068:	RST	164#	0118:	AND CNT	601	0168:	OUT	174#
0019:	AND NOT	004	0069:	STR	002	0119:	AND CNT	600	0169:	MCR	
0020:	OR	031	0070:	AND NOT	165	0120:	AND	160	0170:	STR	170
0021:	AND NOT	034	0071:	OUT	340#	0121:	STR CNT	635	0171:	AND NOT	001
0022:	OUT	030#	0072:	STR	166	0122:	OR	000	0172:	OR	001
0023:	STR	004	0073:	AND CNT	601	0123:	CNT	635#	0173:	AND NOT	171
0024:	AND CNT	673	0074:	AND	175	0124:		* 0004	0174:	AND NOT	172
0025:	AND NOT	005	0075:	AND	164	0125:	STR CNT	635	0175:	AND NOT	173
0026:	STR NOT CNT	672	0076:	STR	340	0126:	AND	165	0176:	AND NOT	174
0027:	OR	031	0077:	AND NOT	170	0127:	STR NOT	165	0177:	AND	163
0028:	AND	005	0078:	OR STR		0128:	OR	000	0178:	OUT	161#
0029:	OR	000	0079:	OUT	160#	0129:	CNT	637#	0179:	STR	004
0030:	CNT	672#	0080:	STR NOT	165	0130:		* 0003	0180:	OR NOT CNT	630
0031:		* 0010	0081:	AND	166	0131:	STR	(D) 637	0181:	AND	031
0032:	STR CNT	672	0082:	AND CNT	601	0132:		* 0003	0182:	AND	(D) 605
0033:	OUT	343#	0083:	STR	165	0133:	AND	(D) 635	0183:		* 0000
0034:	STR	343	0084:	AND CNT	634	0134:		* 0000	0184:	AND NOT	170
0035:	OUT	043#	0085:	OR STR		0135:	AND	(D) 600	0185:	OR	167
0036:	STR	375	0086:	SET	164#	0136:		* 0030	0186:	OUT	020#
0037:	STR CNT	673	0087:	STR CNT	601	0137:	AND	165	0187:	STR	031
0038:	CNT	673#	0088:	AND CNT	673	0138:	SET	342#	0188:	AND CNT	673
0039:		* 0010	0089:	AND	165	0139:	STR	342	0189:	AND NOT CNT	630
0040:	STR	166	0090:	STR NOT	165	0140:	OUT	041#	0190:	STR NOT	031
0041:	AND CNT	673	0091:	OR	160	0141:	STR CNT	634	0191:	OR	000
0042:	AND	004	0092:	CNT	634#	0142:	OR NOT	165	0192:	CNT	630#
0043:	STR	160	0093:		* 0045	0143:	AND NOT	011	0193:		* 0015
0044:	OR NOT	166	0094:	STR	010	0144:	AND CNT	673	0194:	STR	161
0045:	OR NOT	004	0095:	AND CNT	673	0145:	AND CNT	601	0195:	AND CNT	600
0046:	CNT	601#	0096:	AND NOT CNT	636	0146:	AND NOT CNT	620	0196:	AND	004
0047:		* 0045	0097:	AND	(D) 605	0147:	STR	011	0197:	AND	166
0048:	STR	004	0098:		* 0000	0148:	OR	160	0198:	MCS	
0049:	AND CNT	673	0099:	STR NOT	010	0149:	CNT	620#	0199:	STR	(D) 661

TSTS-9029

Figure 4-23 Boolean Printout

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Program Checking and Error Codes

When entering ladder logic programs with the programmer, the CPU automatically performs many checks on the data and operations selected by the programmer. Functions entered are checked for proper key sequence, proper range of references entered, etc. Errors detected during these checks are indicated in the data display by the letter E followed by a two digit code (01–99). The CPU also performs a partial program error check any time that the PC is switched to the RUN mode. After entering a program, a manual error check should be performed, which checks the entire program. Refer to Table 4-2.

Printout Annotation Explanation

Several items appearing on the printouts in Figures 4-26 and 4-27 are explained for clarification. The ladder diagram printout in Figure 4-26 has a circled number (1–5) next to each annotation, which corresponds to the number preceding the explanation of each annotation below. In Figure 4-27, the circled numbers (6–7) appear before an annotation on the Boolean printout. The circled numbers that appear in Figures 4-26 and 4-27 are for discussion purposes only and do not normally appear on a printout.

1. The type of printout on each page appears on this line, either LADDER DIAGRAM PRINTOUT, BOOLEAN PRINTOUT, or CROSS REFERENCE PRINTOUT.

2. This annotation (V x.x) is the version of the system operating software contained in PROM memory in the Printer Interface Unit.

3. The model of PC selected by the user will be on this line. The annotation will be either SERIES ONE JR/SR-10 for a Series One Junior PC or Series One, One Plus/SR-20, ST-21 for a Series One or Series One Plus PC.

4. The page number of the ladder diagram printout or Boolean printout will appear here as a 4-digit decimal number, starting with PAGE 0001.

5. Refers to ladder diagram printout only. This 4-digit decimal number is the user program memory address at the start of each rung of logic. This number is assigned by the controller and is not part of the programming keystrokes. The first element in the rung is stored at that address. In the example in Figure 4-26, the memory address of the start of the first rung is 0000. The first element in that rung is a normally open contact referenced as 001 (reference number is printed directly above the contact). The memory address at the start of the second rung is 0013, the first element in this rung is a normally open contact referenced as 040.

6. Refers to Boolean printout only (Figure 4-27). The # sign immediately following a numerical value in the Boolean printout listing, indicates that the value is a reference assigned to an element at the end of a rung.

7. The * symbol preceding a numerical value in a Boolean printout, indicates that the value is a constant.

Sample Printout

A sample of each of the previously described printouts is shown in Figures 4-26 and 4-27. For this group of printouts, a program was entered into a Series One Plus PC.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

TURBO REFRIGERATING COMPANY

Thermal Storage Ladder Logic Program

Project Number: ______________________

Model Number: ______________________

Program Number: ______________________

Wiring Schematic: ______________________

Programmable Controller Counter Setpoints		
Function	Counter	Preset
Refrigeration Cycle Timer	600	305 seconds
Defrost Cycle Timer	601	* 55 seconds
Wash Down Time Delay	603	900 seconds
Hi Ice #1 On Delay	641	300 seconds

* Defrost cycle timer preset denotes maximum defrost time under low suction and low discharge pressure states (applies only to programs written after January 1, 1990).

To change the Refrigeration Cycle Timer preset:

Turn the keyswitch on the Hand Held Programmer to the RUN mode. Locate the preset by pressing the following key sequence:

CLR CNT SHF 600 SCH NXT NXT

The current preset value for the counter will now appear on the Address/Data screen. Next, press the following key sequence, replacing the YYY with the new counter's preset:

SHF YYY ENT

To change the Normal Defrost Time:
(Applies only to programs written after January 1, 1990.)

Place the Hand Held Programmer in the RUN mode. Locate the Normal Defrost Sequencer by pressing the following key sequence:

SHF NXT AND SHF 601 SCH NXT NXT

The current defrost value will appear in the Address/Data screen. Next, press the following key sequence, replacing the ZZZ with the new defrost time.

SHF ZZZ ENT

To monitor a counter:

Place the Hand Held Programmer in the RUN mode. Enter:

CLR SHF 6xx MON

The Address/Data screen will now display the cumulative value of the counter entered.

TSTS-9034

Figure 4-24 Typical First Page of Ladder Logic Program

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

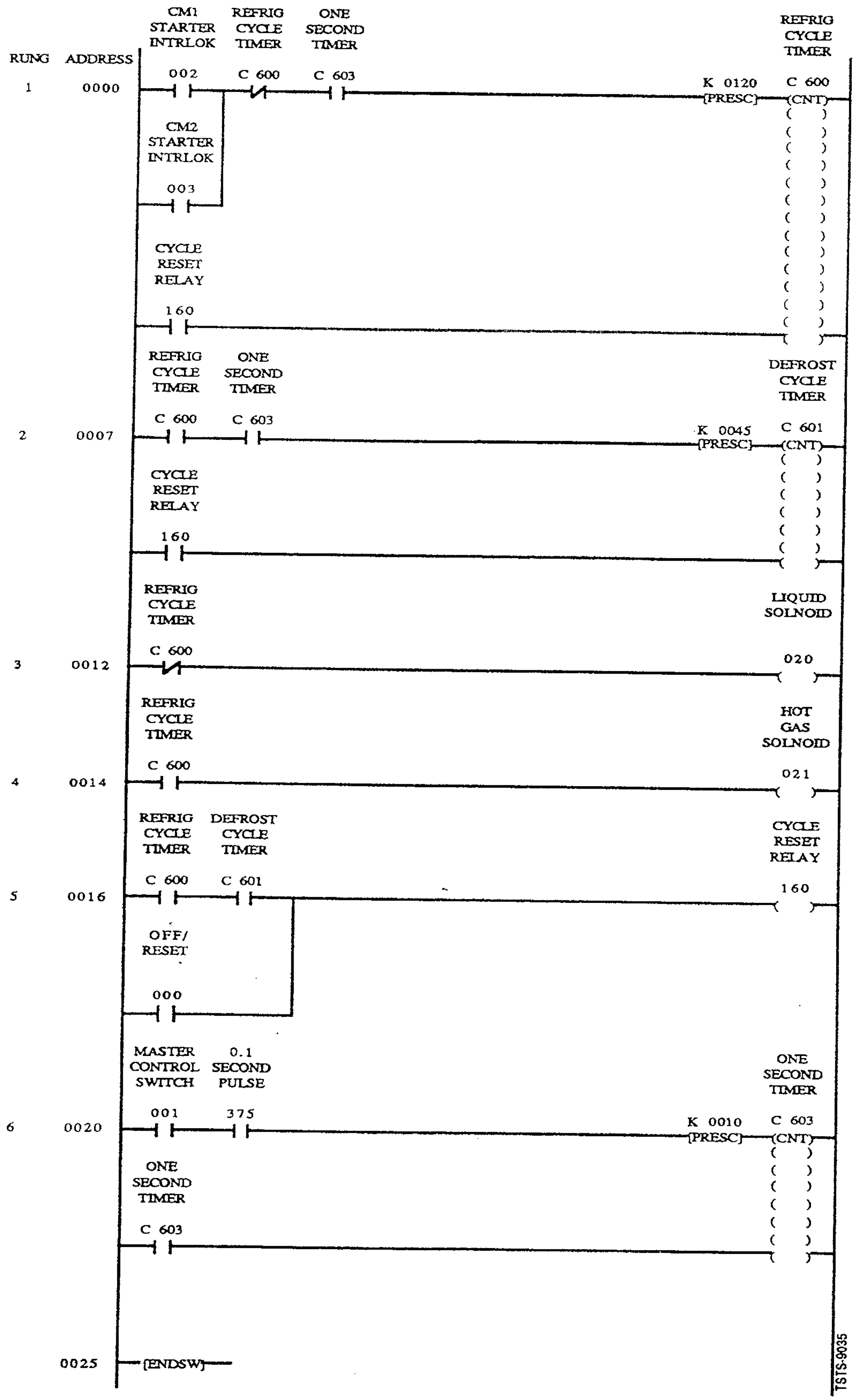


Figure 4-25 Sample Practice Program Printout

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Table 4-2 Error Code Definitions Chart

	Applicable Mode					
Code	Run	Prog	Load	Significance	Cause	Corrective Action
E1	X	X	X	Incorrect Operation.	Operator attempted to perform illegal operation such as changing program in RUN mode.	Examine operation. Depress CLR. Reinitiate proper function.
E2	X			Fault in Program Structure. Series One.	CPU has detected error in program when placed into RUN mode. Example: Input module reference used as coil.	Go to Program mode. Depress CLR. Address of faulty logic will be shown. Depress NXT to display content.
E2	X			Fault in Program Structure. Series One Plus.	CPU has detected error in program when placed into RUN mode. Example: Input module reference used as coil.	Go to Program mode. Depress CLR-SCH-CLR. Address of faulty logic will be shown. Depress NXT to display content.
E3	X			Stack Capacity Exceeded.	More than eight status levels attempted to be stored in pushdown stack.	Go to Program mode. Depress CLR. Programmer will display location of first 9th STR error. Examine logic and reprogram as necessary.
E5	X			Duplicate Coil Reference.	Coil (output, internal, timer, or counter) used as an OUT more than once.	Go to Program mode. Depress CLR. Programmer will display location of second coil of pair using same reference. Enter another coil reference.
E6	X			Incomplete Master Control.	More MCR references than MCS in program.	Go to Program mode. Depress CLR. Programmer will display first unmatched MCR. Correct program by deleting MCR or adding MCS.
E7	X			Incomplete Counter or Shift Register.	All control lines not provided to one or more Counters and/or Shift Registers.	Go to Program mode. Depress CLR. Programmer will display errant function. Add required reset, clock or clear lines.
E8		X		Incorrect Operation.	Operator attempted to write instruction on second word of a 2-word instruction.	Depress CLR.
E9	X			Incomplete Logic.	Relay ladder line not connected to coil; relay contact(s) left incomplete or hanging.	Go to Program mode. Depress CLR. Programmer will display first unfinished logic element. Add logic to tie this element into stored logic, or delete element(s) to remove incomplete logic.
E11		X		Memory Full.	Operator attempting to add logic to CPU already at limit.	Depress CLR. Restructure program so that logic limits will not be exceeded.
E21	X	X		Parity Failure.	CPU has detected a fault in the parity structure of its internal memory.	Go to Load Mode. Depress CLR. Reload memory from previously recorded tape or clear entire memory and reload manually. If BATT light not ON and fault cannot be cleared, replace CPU module.
E25			X	Faulty Comparison.	External device such as tape cassette has content that does not agree with CPU memory.	Depress CLR. Verify correct program number or tape. If correct, either re-record tape or reload CPU
E28			X	Weak Record Signal.	Playback Signal level, such as from tape recorder, is below acceptable level.	Adjust volume level on tape recorder or other peripheral device. If ON steady for extended period of time, restart function to obtain reliable operation.
E99	X	X		Unsuccessful Search.	Search function has reviewed all memory and has not located required.	Depress CLR. To cause an additional search, re-enter function and restart.

TSTS-9031

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

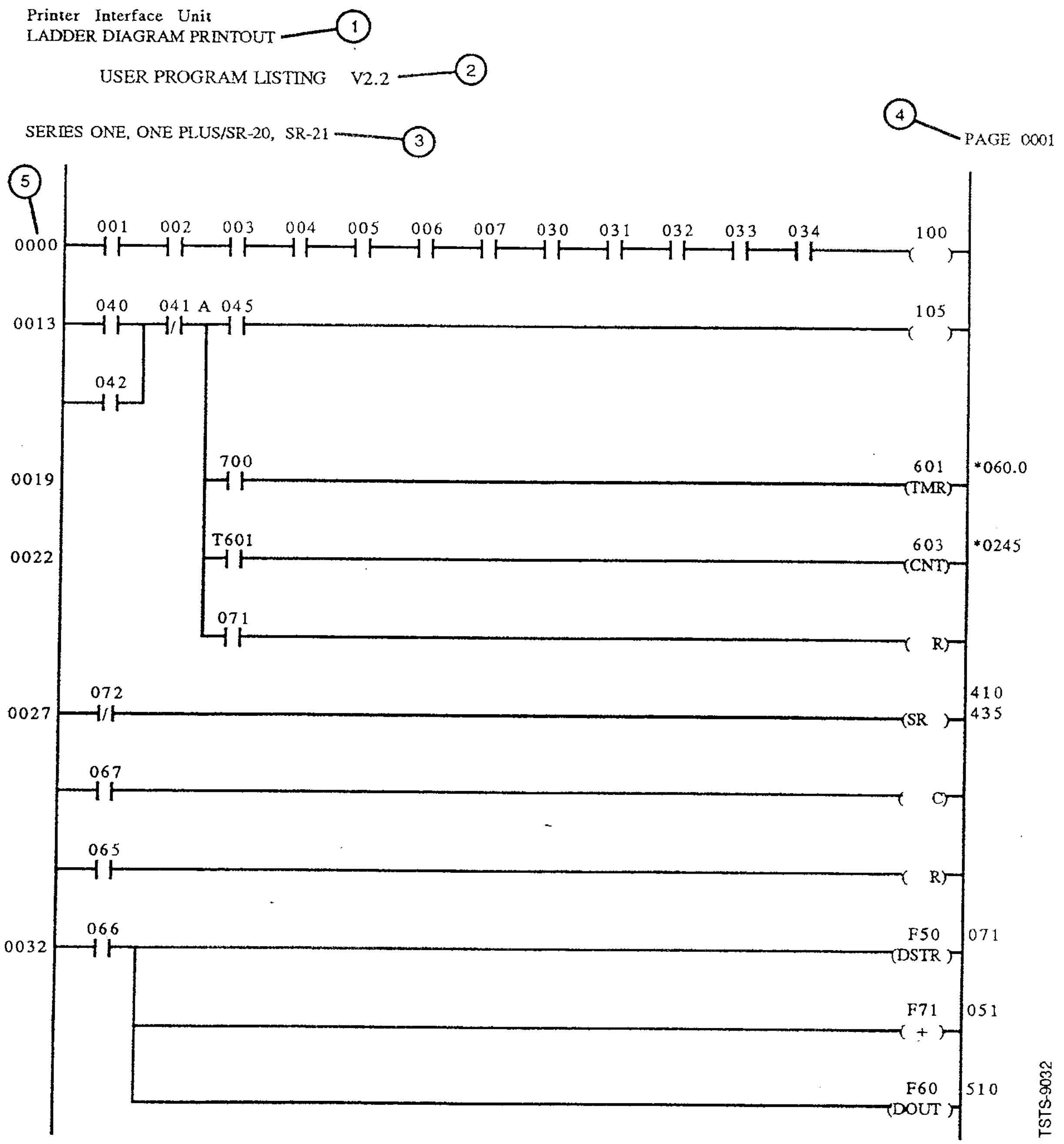


Figure 4-26 Sample Ladder Diagram Printout

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

inter Interface Unit
OOLEAN PRINTOUT

USER PROGRAM LISTING V2.2

PAGE 0001

SERIES ONE, ONE PLUS/SR-20, SR-21

```
0000: STR        001
0001: AND        002
0002: AND        003
0003: AND        004
0004: AND        005
0005: AND        006
0006: AND        007
0007: AND        030
0008: AND        031
0009: AND        032
0010: AND        033
0011: AND        034
0012: OUT        100#
0013: STR        040
0014: OR         042
0015: AND NOT    041
0016: MCS
0017: STR        045
0018: OUT        105#
0019: STR        700
0020: TMR        601#
0021:           *060.0
0022: STR TMR    601
0023: STR        071
0024: CNT        603#
0025:           *0245
0026: MCR
0027: STR NOT    072
0028: STR        067
0029: STR        065
0030: SR         410#
0031:            435#
0032: STR        066
0033: DSTR   (F50)
0034:            071
0035:   +    (F71)
0036:            051
0037: DOUT   (F60)
0038:            510#
0039: -
0040: -
0041: -
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TSTS-9033

Figure 4-27 Sample Boolean Printout

> **Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.**

Cassette Tape Operation of the General Electric Series 1 and Series 1+ Programmable Controllers

Note:
The following tape operation instructions are a condensed version of the instructions found in the "GE Series One and Series One Plus User's Manual". Should any difficulties arise during tape operation, please refer to the "Operation With Peripheral Devices" located in section 4 of the user's manual.

Introduction

The programs used for the General Electric Series 1 and Series 1+ programmable controllers may be stored on standard audio cassette tapes. It is wise to keep a tape copy of the program handy in the event that the CPU either becomes defective, or somehow loses its memory. For tape operation, the following items are required:

- GE Hand Held Programmer, IC610PRG105. This includes the key for the Hand Held Programmer, along with the audio cable which is gray with a red tracer.
- Audio cassette recorder. This is a standard size cassette tape recorder which has both microphone and earphone jacks. Optionally, this should have a digital counter and a tone control.
- Standard audio cassette tape. The "micro cassette" tapes generally do not have the audio quality required and should not be used.

Common Problem

The most common problem incurred during Tape Operation is confusion over the proper key to depress on the hand held programmer. The shifted function keys on the programmer are shown in Figure 4-28. The shifted function always corresponds to the key directly below it.

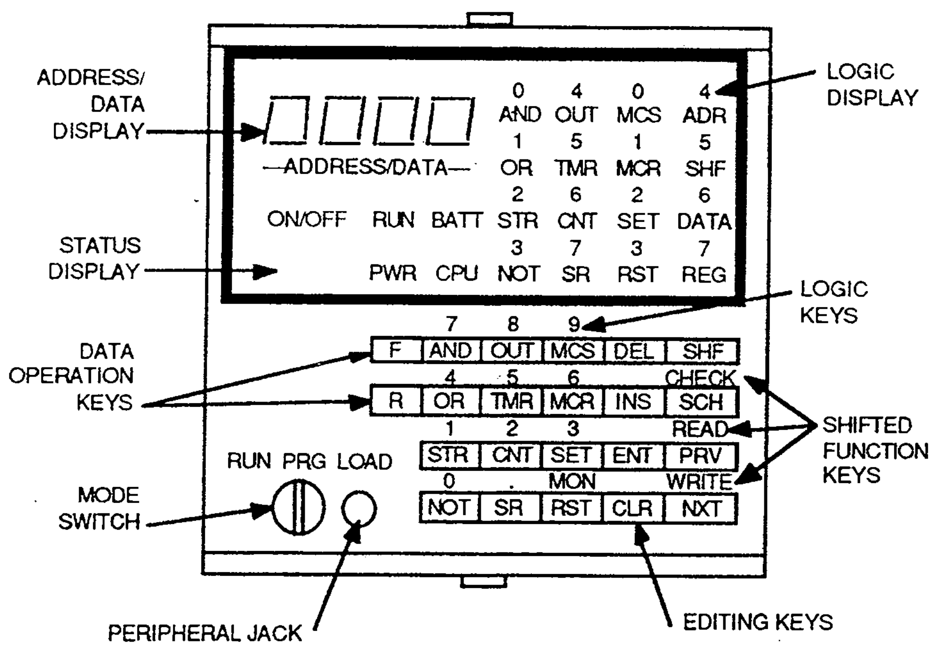


Figure 4-28 Programmer Features

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Tape Operation

Save/Record A Program Onto Tape (WRITE)

a. Install the Programmer onto the CPU and apply AC power to the PC.

b. Turn the mode switch on the Programmer to the LOAD position.

c. Connect the Programmer (TAPE port) to the tape recorder (MICROPHONE input) with the audio cable (gray with red tracer).

d. Rewind the tape to the beginning or to the desired record position if multiple programs are to be placed on one tape. Programs require approximately 1.5 to 4 minutes of tape per program. Note counter position.

e. For identification of a program, if desired, enter a four digit number (0000-9999) on the Programmer. When tape is accessed later to load the CPU, this number can be used to identify the correct program prior to altering CPU data. If a program number is not as expected, the operator can terminate the load operation and get the correct tape without loss of existing program or delay incurred by loading a wrong program. However, THIS IDENTIFICATION NUMBER IS OPTIONAL.

f. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it as well to 75% of the maximum setting.

g. Begin the tape recorder operation by depressing the RECORD PLAY buttons.

h. Depress the WRITE key on the Programmer. The record operation will now begin.

i. The ON/OFF light on the Programmer will come on.

j. When the record is complete, the Programmer will display End in the Address/Data display and the ON/OFF LED will be off. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

k. Depress the CLR (Clear) key on the Programmer to end the record operation.

l. It is recommended that the tape be rewound to where the recording began and that the Verify operation described later be performed to ensure data integrity.

Load A Program Onto CPU (READ)

a. Prior to loading a program onto the CPU, the existing program must be cleared from the CPU memory.*

To do this, turn the mode switch to the PRG mode and press the following key sequence:

CLR SHF 348 DEL
NXT NXT

The program has now been cleared from the CPU.

b. Install the Programmer onto the CPU and apply AC power to the PC.

c. Turn the mode switch on the Programmer to the LOAD position.

d. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

e. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if applicable).

f. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it as well to 75% of the maximum setting.

g. Depress the READ key on the Programmer.

h. Begin the tape recorder operation by depressing the PLAY button.

i. The Address/Data screen of the Programmer will flash an E28 briefly.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

j. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

k. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a program number different from the one entered in step e, the Address/Data screen of the programmer will display PASS.

l. When the load is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

m. Depress the CLR (Clear) key on the Programmer to end the record operation.

***WARNING**

It is wise to make a tape copy of the program existing in memory before erasing it to load the new program. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Check A Program With The Tape Copy (CHECK)

a. Install the Programmer onto the CPU and apply AC power to the PC.

b. Turn the mode switch on the Programmer to the LOAD position.

c. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

d. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if previously recorded).

e. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it as well to 75% of the maximum setting.

f. Depress the CHECK key on the Programmer.

g. Begin the tape recorder operation by depressing the PLAY button.

h. The Address/Data screen of the Programmer will flash an E28 briefly.

i. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

j. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a mismatch between the contents of the tape and the CPU logic, the Address/Data screen of the programmer will display E25. A steady E28 indicates that the play level of the recorder is wrong. The CHECK operation should be stopped, the volume/tone readjusted, and the operation restarted.

k. When the check is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

l. Depress the CLR (Clear) key on the Programmer to end the record operation.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

TROUBLE-SHOOTING

This section lists common problems and suggests solutions. Many problems are easy to solve - if you know what caused them.

If your problem is more complex and not stated in this section, contact Turbo Refrigerating Company at:

PHONE: 940-387-4301
TOLL FREE: 800-775-8648

Ask for the service department.

The following pages describe problems you might encounter and provide diagnostic instructions and solutions.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

PROBLEMS AND SOLUTIONS

Problem	Causes	Solutions
Compressor will not start.	No three-phase or control circuit power, tripped circuit breaker.	Check fuses and disconnect. Reset tripped circuit breakers.
	Blown fuse.	Reset or replace manual reset.
	Oil failure tripped.	Determine cause of low oil pressure before restarting (see low oil pressure in Section 3. "Installation & Pre-Start-Up Requirements").
	Defective dual pressure switch.	Check switch wiring on controller. Replace.
	Improper signal at the programmable controller.	The run and power lights must be on for unit to operate. Check for loose connection and control circuit power to controller.
	MCS turned off.	Turn switch to "ON" position.
	Starter coil defective.	Check starter coil for burnout or loose wiring. Replace as required.
	Oil temperature safety.	Compressor off on high oil temperature. Determine cause of high oil temperature before resetting (see high oil temp in Section 3. "Installation & Pre-Start-Up Requirements").

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	**Causes**	**Solutions**
Compressor will not start (continued).	Overload relay on magnetic starter tripped.	Determine cause of motor overload. Depress manual reset button.
Unit drawing high amps.	Loose terminal connections.	Tighten connections (qualified electrician).
	Defective motor bearings or motor.	Replace. Check compressor/motor alignment and mounting bolts before restarting.
	Refrigerant system overcharged causing high discharge pressure.	Determine actual refrigerant charge and remove refrigerant as required.
	Condenser inoperative - high discharge pressure.	Check condenser head pressure control operation. Check electrical and/or pressure connections to controls.
	Air or non-condensables in system.	Replace refrigerant charge.

Notes:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Unit will not make ice or is not producing full sheet of ice.	High discharge pressure:	
	– Defective water regulating valve (water cooled).	Check pressure sensing connection to regulator. Replace.
	– Fouling at condenser (water cooled).	Clean condenser by brushing and/or acid treatment. Consult manufacturer for water treatment recommendations.
	– Faulty water pump (water or evaporative cooled).	Replace pump. Check pump suction and discharge for obstructions.
	– Fouling at condenser (air cooled).	Clean with air, water hose, or brushing. Remove debris from condenser inlet.
	– Flood back valves out of adjustment (air or evaporative cooled).	Adjust to maintain 180 psig (see section 3, step 14. Air-Cooled Condensers on page 83).
	– Belt worn or loose causing belts to slip (air or evaporative cooled).	Adjust, replace belts.
	– Fan turning too slow (air cooled).	Change sheave to increase speed up to FLA of motor. Consult factory before restarting. Check for restrictions.
	Low on freon.	Add refrigerant to eliminate bubbles. Search for leak and repair.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Unit will not make ice or is not producing full sheet of ice (continued).	Leaking defrost valve allowing hot gas bypass.	Repair with valve kit or replace.
	Thermal expansion valve improperly adjusted.	Adjust expansion valve superheat to 8–10°F. Check TXV power head. If defective, replace.
	Plugged or restricted filter drier.	Replace drier cores.
	Moisture in system (yellow sight glass).	Replace drier cores. May require replacement of refrigerant charge. Determine source of water contamination.
	Air or other non-condensables in refrigerant system.	Bleed air from condenser. Replace refrigerant charge.
	Restriction in piping.	Check all isolation valves for proper position - open or closed.
	Power off to condensing unit.	Check power, breaker, and disconnects to all motors, starters, and control switches.
	Insufficient water flow to condenser (water cooled):	
	– Strainer plugged.	Clean or replace.
	– Float valve defective (make-up water line to cooling tower).	Check adjustment. Replace if required.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Unit will not make ice or is not producing full sheet of ice (continued).	Condenser pump prime lost - low water level in sump.	Add water to cooling tower. Determine cause of water loss.
	Condenser water make-up valve closed or restricted.	Clean, repair, open, or replace valve.
	Recirculating water pump off:	
	– Motor overloads tripped.	Check pump for restrictions. Reset starter overload relay.
	– Recirculating pump prime lost. Low water level in reservoir.	Locate water feed restriction. Add water to tank.
	– Strainer plugged.	Remove and clean.
	– Check valve stuck closed.	Remove and clean.

Notes:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Unit will not defrost.	Hot gas solenoid inoperative.	Check wiring to coil. Check for burned out coil and replace.
	Pilot solenoid for gas powered check inoperative.	Check wiring to coil. Check for burned out coil and replace.
	Insufficient water over plates.	Check distribution pans for fouling and clean. Clean strainer if so equipped, clean screen on pick-up at pump. Check pump for proper rotation.
	Too low discharge pressure.	Check condenser pressure controls.
	Gas powered check inoperative.	Valve dirty, clean. Pilot solenoid inoperative.
	Leaking defrost valve or valve inoperative (models using 3-way defrost valve). Valve will not shift.	Repair or replace valve. Check wiring to coil. Check for burned out coil. Disassemble and clean.
	Ice building on ends of plate causing bridging.	Check heat tapes for operation if so equipped. Check for low water flow caused by dirty pan.

Notes:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Low suction pressure.	Low on refrigerant.	Check for leaks, repair. Add refrigerant.
	Obstruction or dirty in filter drier.	Replace filter drier.
	Low water flow over plates.	Check water distribution pan for dirt, pump for performance.
	Expansion valves improperly adjusted or defective (starving).	Check expansion valve adjustment. Replace if required.
High suction pressure.	Too high water temperature.	Water temperature above 60°F.
	Leaking defrost valve.	Repair or replace.
	Expansion valve improperly adjusted (overfeeding refrigerant).	Check expansion valve adjustment (close to reduce refrigerant valve). Set superheat at 8–10°F.

Notes:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
High discharge pressure.	Refrigerant system overcharged.	Verify actual charge. Reduce charge as required.
	Dirty condenser.	Clean.
	Non-condensables in refrigerant.	Air in system. Remove by purging.
	Head pressure controls improperly set.	Readjust to correct setting. Normally 180 - 210 psig for eater cooled; 170 - 190 psig for evaporative cooled; 210 - 250 psig for air cooled.
	Discharge line check valve inoperative.	Check and replace if required.
	Check position of all isolation valves and pressure controls.	Open all valves fully. Make sure all pressure controls are properly adjusted and pressure regulator are in automatic position.

Notes:

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Low oil pressure.	Oil pump off.	Check starter OL reset. Reset if required.
	Oil not returning from accumulator.	Check pump drive coupling.
	Plugged or stopped up oil strainer.	Clean. Purge line.
	Low level in oil separator.	Add oil, observe sight glass. Refer to the Reco Manual for the proper level. Determine cause of oil loss.
	Oil filter clogged.	Replace.
	Oil return valve closed or not open enough.	Adjust oil return valve - open.
	Liquid carryover to compressor.	Adjust thermal expansion valve.
	Oil level in reservoir too high.	Remove oil until proper oil level is obtained (refer to the Reco Manual).
	Differential regulator set too low or stuck open.	Adjust regulator to higher setting. Repair or replace if necessary.

Notes:

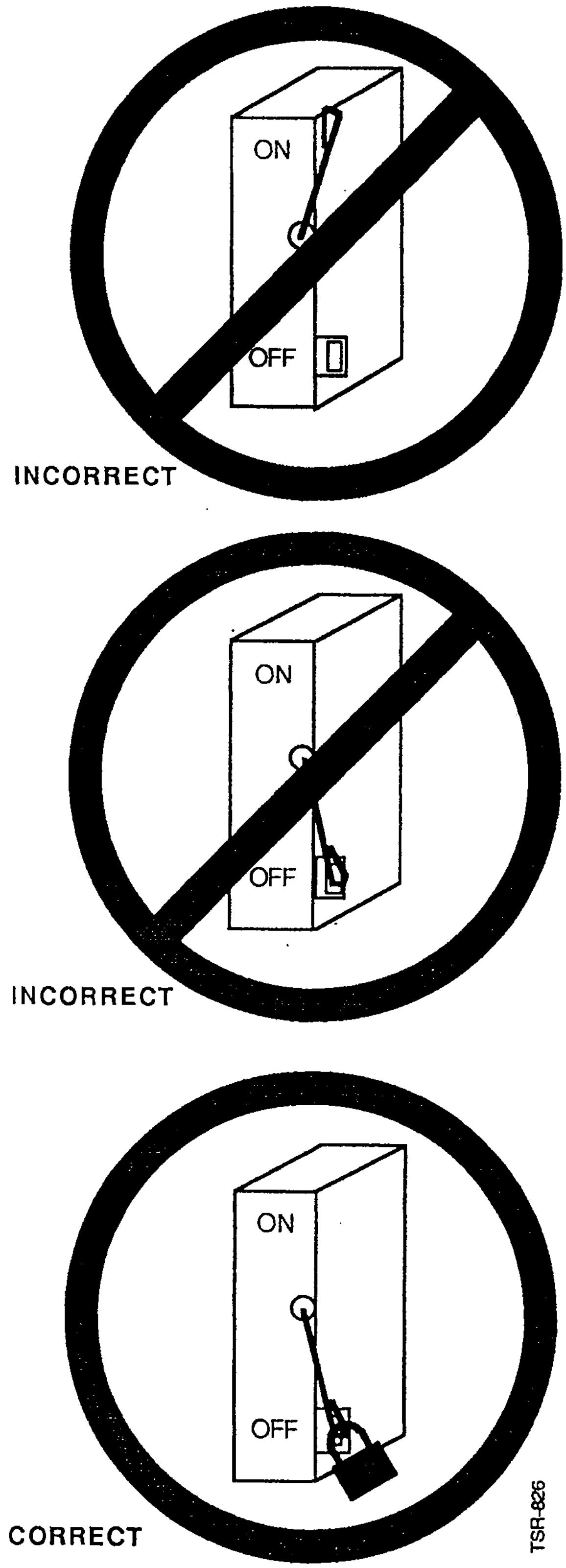
Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Problem	Causes	Solutions
Excessive vibration of motor and compressor.	Misalignment.	Realign to within specifications (see section 3, step 9. Aligning Reciprocating Compressors and Motors on page 67).
	Loose motor/compressor hold down bolts.	Tighten.
	Flooding of compressor.	Adjust TXV. Check mounting of remote bulb and position on the suction line.
	Defective or worn bearing.	Remove coupling and check bearing.
	Structural support under unit insufficient.	Reinforce structural support. Shim as required.
Excessive motor temperature.	Voltage drop at motor starter/contactor.	Phase imbalance. Consult electric company.
	Loose connection at starter/contactor causing high amp draw.	Tighten connection (qualified electrician).
	Restricted air ventilation.	Clean obstructions.

Notes:

DISCONNECTING POWER & LOCK OUT

Turbo Refrigerating Company insists that **disconnecting** and **locking out** the power to the motor driving the unit provides the only real protection against injury. Other devices should not be used as a substitute for **locking out** the power prior to removing guards, covers, or other safety devices. Turbo warns that the use of secondary devices may cause employees to develop a false sense of security and fail to **lock out** power before removing guards, covers, or other safety devices. This could result in a serious injury should the secondary device fail or malfunction.



TSR-826

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

MAINTENANCE

Preventive Maintenance

Periodic maintenance and service is required on any refrigeration system to ensure efficient, safe operation. Lack of maintenance can shorten the life of components, affect system performance, result in equipment malfunction and unnecesary replacement of components as well as increase the cost of operating the equipment. A list of normal maintenance checks for Turbo ice generators/chillers is attached and should be used as a guideline for setting up a regular equipment maintenance program.

If questions concerning maintenance procedures are not covered, please contact the Turbo service department for information.

WARNING

Only qualified service or maintenance technicians who have read the safety and operating sections should perform maintenance or service on the equipment. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Daily Inspection

In most installations, the ice generator/chiller starts and stops automatically. It is recommended that the unit be checked daily, preferably during or immediately after start-up takes place.

1. Observe that the discharge, suction, and oil pressure are stable and within operating specifications (verify that pressures are correct and gauge readings are stable).
2. If the unit is in the icemaking mode, observe the defrost sequence for proper operation.
3. Check water flow over plates.

Weekly Inspection

- Check the oil level in the compressor.
- Check for signs of oil leakage.
- Check the liquid line sight glass for full charge and moisture indication.
- Check the receiver. Inspect valve packings and relief valve for indications of refrigerant loss.
- Check the receiver level indication while the unit is running. It should indicate 20–40%.
- Visual inspections should include but is not limited to: leaks, vibration of piping or other components, capillary tubes rubbing, unusual noises, bolts and screws tight, and general neat housekeeping appearance.

After Initial Ten Hours of Operation

- Check and retighten fasteners and hardware (including compressor coupling).
- Clean oil return strainer.
- Clean water distribution pan.
- Check compressor oil level.
- Check storage tank water level and for signs of tank leaks.

After Initial Fifty Hours of Operation

- Repeat 10 hour inspection.
- Check motor/compressor coupling.
- Check electrical connections, wiring and lugs on magnetic starts for loose connections.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

WARNING

Only a qualified electrician should perform the electrical inspection. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Every Six Weeks

- Lubricate pumps, motors and drives.
- Check for scale or fouling of evaporator plate surface.
  - Verify chemical treatment is in balance.
  - Perform water analysis.
- Check water strainers.
- Check storage tank water level.

Lubricants and Fluids List

Refrigerant Charge
R-22, see data sheets on page 13 for quantity.

Compressor Oil Charge
Suniso 3GS, refer to the Compressor Service Manual for quantity.

Compressor Motor Bearing Grease
Shell Dolium R.

Evaporative Condenser Bearing Grease
Any of the following greases may be used:

Exxon:	Beacon #325
Shell:	Aeroshell #7
Mobil:	Mobilgrease #28
American:	Rycon Premium #3.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance Chart

The following chart details the typical maintenance items to be performed, frequency of maintenance, and estimated time to perform. It is intended as a guideline only and should be used with good judgement and experience to ensure that all necessary maintenance work is performed. This will improve the operation and safety of the equipment.

Maintenance	Frequency	Time Required
1. Clean oil return strainer. a. Close isolation valve and hand expansion valve b. Remove strainer element. Clean and replace. c. Fully open isolation valve. d. Open expansion valve 3/4 to full open.	As necessary. This strainer will require cleaning after the first 60 hours of operation, and thereafter as indicated by monthly inspection of oil return sight glass.	30 minutes
2. Clean distribution pan. a. Remove top panels over evaporator section (do not stand on panels over engine compartment). b. Using a wet-vac type cleaner, vacuum debris that collects (should be done with no water flowing into pan). c. Replace top panels.	As necessary.	2 hours

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
3. Clean hot gas strainer. a. Turn MCS to off. Wait for pump-down cycle to complete. b. Lock out power to compressors. c. Close discharge service valves on both compressors. d. Close king valve on receiver. e. Carefully relieve pressure from strainer. f. Remove strainer element. Clean and replace. g. Fully open service valve and king valve. h. Restore power to compressors. i. Return MCS to proper position	Rarely -- as necessary. Under normal circumstances this strainer should not require cleaning.	1 1/2 hours
4. Check oil and refrigerant levels. a. While unit is running, open access door over oil level sight glass on compressor. b. Inspect sight glass. A level of oil should be visible in the glass. c. Inspect refrigerant level indicator on receiver. Level should be between 20 and 40 percent.	Weekly.	10 minutes

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
5. Change oil. a. Turn MCS to off. Wait for pump-down cycle to complete. b. Lock out power to ice-maker. c. Close king valve, service valves on both compressors, and oil reservoir isolation valves. d. Carefully relieve pressure from both compressors and oil reservoir. e. Remove drain plugs from compressors and from oil reservoir. Collect oil in container for disposal. See Compressor Maintenance and Service Manual for location of oil reservoir drain plug. f. Replace drain plugs. g. Add required amount of new oil to compressor crankcase. See Compressor Maintenance and Service Manual for location of the oil filler plug. h. Connect vacuum pump to compressor service valve gauge port and pull vacuum on compressor and oil reservoir. Turn off pump. i. Repeat step "h" for remaining compressor. j. Open all service valves and isolation valves, including king valve. k. Restore power to ice-maker.	As indicated by oil analysis.	

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
l. Return MCS to proper position. m. Carefully monitor oil level during first few days after changing. Add and remove oil as necessary until level stabilizes.		
6. Check refrigerant charge. a. While unit is running, between defrost periods, open the door in the evaporator compartment where the liquid line sight glass is located. There are a number of sight glasses in the evaporator compartment – this is the large one in the same line as the liquid solenoid valve. b. Inspect sight glass. If there are bubbles in the glass, it indicates one of two things: 1. Low refrigerant charge – check receiver level – add refrigerant if necessary. 2. Obstruction in the liquid line – this normally occurs at the filter/drier. Check pressure drop – replace cores if necessary.	Monthly.	2 minutes
7. Lubricate motor bearings. a. Clean tip of grease fitting. b. Apply grease gun. c. Use 3 to 4 strokes to fully lubricate bearings.	Every 9 months.	15 minutes

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
8. Lubricate condenser shaft bearings. a. Clean grease fitting. b. Apply grease gun. c. Slowly feed grease to bearing. d. Refer to Condenser Maintenance Guide in the Appendix & Notes section for complete maintenance requirements.	Every 6 months.	15 minutes
9. Analyze refrigerant sample. a. Obtain a Carrier "Totaltest" refrigerant test kit or equilavent. b. Follow the instructions within the kit for obtaining and testing a sample of the refrigerant. c. If moisture or acid conditions exist, follow clean up procedures detailed in the test kit instructions.	Yearly.	20 minutes
10. Clean condenser water pump strainer. a. Remove strainer. b. Using water, hand clean. c. Replace strainer.	Weekly.	5 minutes
11. Flush condenser pan. a. Turn off the Turbo unit. b. Drain the pan. c. Using a water hose, flush out any accumulation of dirt. d. Refill the pan up to one inch below the overflow connection. e. Restart the Turbo unit.	Monthly.	10 minutes

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
12. Check condenser water make-up system. a. Turn off the Turbo unit. b. Turn on condenser pump only. c. Observe the water level through the access door in the condenser. Level should be 3 to 4 inches below the overflow conneciton. d. Restart the Turbo unit.	Monthly.	10 minutes
13. Check bleed-off valve. Valve should normally be wide open, unless it has been determined that it can be partially closed without causing scale or corrosion.	Weekly.	2 minutes

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Maintenance	Frequency	Time Required
14. Replace filter/drier cores.	As indicated by refrigerant analysis.	1 hour

a. Turn off the Turbo unit and lock off power to the unit.
b. Isolate the filter/drier.
c. Loosen the bolts around the cover to relieve pressure.

CAUTION

The filter/drier contains liquid refrigerant, which can cause freeze burns. Avoid contact with exposed skin.

d. Once pressure is dissipated, remove cover.
e. Replace drier cores in accordance with manufacturer's instructions.
f. Replace gasket (included with the new cores), and cover.
g. Open valves that were closed to isolate the filter/drier.
h. Return power to the Turbo unit and restart.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Daily Ice Generator Log Sheet

Week Beginning: ___/___/___
Week Ending: ___/___/___

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1. Tank Water Depth, FT (note 1)							
2. Circulating Water Temperature, °F							
3. Discharge Pressure, PSIG							
4. Suction Pressure, PSIG							
5. Oil Pressure, PSIG							
6. Operating Mode (check)							
Icemaking							
Chilling							
7. Checked By							
8. Liquid Line Sight Glass							
Flow (note 2)							
Moisture Indicator (note 3)							

Comments: ______________________________

Notes:
1. Tank water level should be recorded when no ice is in the tank.
2. F = full (normal); P = partial flow; B = bubbles.
3. G = green (normal); GY = greenish yellow; Y = yellow.

TSTS-9001

Figure 6-1 Daily Ice Generator Log Sheet

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Winter Shut-Down & Re-Start Procedure

Shut-Down

1. Pump the system down:

   - Lower the cutout setting of the low pressure safety switch to 0–5 psig.

   - Close the 'king' valve on the receiver outlet line.

   - After the unit pump down is complete and the unit has gone off on the low pressure safety switch, turn MCS (Master Control Switch) to the "off" position.

   - Turn the MCS to the "manual" position. Allow 10–15 minutes for any refrigerant left in the system to raise above the cut-in setpoint of the low pressure safety switch. This will ensure that a complete pump down has been obtained.

   - Turn the MCS switch back to the "off" position after 15 minutes or the second pump down sequence.

2. If a tape backup of the program is not available, a backup should be made at this time. Follow the procedure outlined in section 4. Operating Instructions (Cassette Tape Operation of the General Electric Series 1 and Series 1+ Programmable Controllers) on page 151.

   Store the tape in a safe, dry and cool location for use during restart of the equipment (it may be required, but most likely not).

3. Lock out the three-phase power to the unit(s). Pull the main disconnect and lock it out.

Note:
For guidelines on locking out electrical power, refer to section 2. Safety (Safety Lockout Procedure) on page 21.

4. Lock out the single-phase control power. Pull the main disconnect and lock it out.

IMPORTANT

Winterizing or heat tracing may be connected to the single phase service making it impossible to pull the main disconnect on the single phase. Turn off the single phase to all devices and controls except for winterizing control and heat tracing.

Note:
For guidelines on locking out electrical power, refer to section 2. Safety (Safety Lockout Procedure) on page 21.

5. Replace and secure all seal caps and check the packing on all valve stems. These should be checked monthly during extended shut downs for leakage. Tighten as required. Close the compressor suction stop valve.

6. Close the inlet valve to the receiver to isolate the refrigerant charge and prevent migration to other parts of the system.

WARNING

When the receiver is isolated, excessive hydrostatic pressure can develop in the receiver if it is exposed to direct sunlight or excessive heat. All receivers must be equipped with a safety relief valve that is piped to a safe discharge location. Refer to section 3, Installation & Pre-Start-Up Requirements on page 23. Failure to carefully follow these instructions could result in permanent injury or loss of life.

7. Lock the control and three-phase panels and remove the key from the MCS.

8a. For water-cooled units, the water-cooled condenser must be drained to prevent freeze-up.

   - This procedure is recommended for extended shutdown even if the unit is equipped with an optional winterizing

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

heater in the compressor compartment. Interruption of electrical power could result in freeze-up of the condenser.

- The evaporator water distribution pans are self-draining and require no additional draining.

8b. Drain cooling tower and cooling tower pump(s). For self-contained SCE or SCER models with remote evaporative condensers, drain the sump and recirculating water pump of the evaporative condenser.

9. Close and secure all access panels and doors to the equipment and storage tank.

WARNING

Lock tank access. Failure to carefully follow these instructions could result in permanent injury or loss of life.

10. Make-up water lines to cooling towers, evaporative-cooled condensers, water-cooled condensers, storage tank water fill lines, etc. must either be drained or heat traced to prevent freeze-up.

Start-Up

1. Remove and clean all water line strainers and filters.

2. Refill all water lines, sumps, cooling towers, etc.

Note:
It may be necessary to wash or flush cooling tower sumps and evaporative condenser sumps before refilling.

3. Clean the water distribution pans.

Note:
Check the condition of the water in the storage tank before using recirculating pump to wash down pans. Debris should be removed.

WARNING

If it is necessary to remove debris from the tank, proper safety measures should be followed to prevent serious injury or even death due to drowning. Never enter the tank without personnel outside of the tank in direct contact with the person inside. Failure to carefully follow these instructions could result in permanent injury or loss of life.

4. Have an analysis made of the water in the storage tank to determine if chemical treatment is required for proper water condition. Bacteria, algae, or other biological growth could affect the water system, air-handlers, etc.

5. Check the oil level in the compressor(s). If the level is visible in the sight glass, turn the single phase power to the unit "on". This will turn the crankcase heaters on to remove any refrigerant accumulation in the compressor crankcase.

IMPORTANT

The compressor crankcase heaters must be on for twenty-four (24) hours prior to any attempt to start the unit. Failure to do so could result in failure or damage to the compressor.

6. Replace the filter/drier cores.

7. Open the inlet valve to the receivers.

8. Open the 'king' valve on the receiver.

9. Open the compressor suction stop valve.

10. Turn the three-phase power to the unit "on".

Note:
The MCS should be in the "off" position.

11. Reset the low pressure safety cutout to 15–20 psig (refer to the manual for setting).

12. Turn the MCS to "manual" and observe the start-up sequence of the unit.

    - Verify that suction pressure, discharge pressure, and oil pressure are within specifications.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Note:
Since the unit has been shutdown, the water in the storage tank may be at a temperature above the design limits. If so, consult the factory for part-load operation of the compressor(s) until the tank temperature can be pulled down within the operating specifications. Failure to do so could result in overload of the compressor motor and failure of the compressor and/or motor.

13. Check the sight glass/ moisture indicator in the liquid line.

    – Sight glass should indicate a solid (full) level. If not, refrigerant must be added to clean the sight glass.

Note:
If it is necessary to add refrigerant, the source of the refrigerant loss must be determined before automatic operation is resumed. Failure to do so could result in loss of the complete refrigerant charge and evaporator freeze-up..

    – If the sight glass moisture indicator is yellow and does not clear up after the unit has operated for 10–15 minutes, the drier cores should be changed again.

14. Monitor the oil level in the compressor and frost line on the compressor suction inlet.

    – If proper oil return is not obtained, it may be necessary to clean the strainer(s) in the oil return lines.

    – If frost appears on the compressor, indicating excessive liquid return, the 'king' valve should be closed and the system pumped down again. After restart, if the liquid carry-over continues, adjustment of the thermal expansion valves may be required.

15. Manually stop the high ice level switch(es) to determine if the automatic shut down on high ice level is functioning properly.

16. After satisfactory operation is observed in the "manual" position, the MCS should be returned to either the "off" or "automatic" position.

17. Reprogram the Programmable Time Clock (if used).

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

SPARE PARTS LIST

It is a good idea to keep spare parts on hand in case of emergencies. You will save operation time and money because you will not have to wait for parts to be ordered and delivered.

Part numbers may change without notice. When ordering or specifying parts, the serial number and model of the unit must be referenced.

Legend

SI = Items that should be stocked to maintain safe equipment operation, for normal maintenance, or frequent replacement items that can cause interruption of operation.

RI = Replacement items that are normally not subject to normal maintenance or replacement.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

OPTIONS APPENDIX

Options Appendix contents are provided only when optional accessories are purchased.

TURBO®

PROGRAMMABLE CONTROLLER USERS MANUAL

WARNING

To ensure that the equipment described by this manual, as well as all equipment connected to and used with it, operates satisfactorily and safely, all applicable local and national codes that apply to installing and operating the equipment must be followed. Since codes can vary geographically and can change with time, it is the user's responsibility to determine which standards and codes apply, and to comply with them.

FAILURE TO COMPLY WITH APPLICABLE CODES AND STANDARDS CAN RESULT IN DAMAGE TO EQUIPMENT AND/OR SERIOUS INJURY TO PERSONNEL.

All equipment should be installed and operated according to all applicable sections of the National Fire Code, National Electrical Code, and the codes of the National Electrical Manufacturer's Association (NEMA) as a minimum. Contact your local Fire Marshall and Electrical Inspector to determine which codes and standards apply to your specific case.

Personnel who are to install and operate the equipment should carefully study this manual and any others referred to by it prior to installation and/or operation of the equipment.

If you have any questions regarding the installation or operation of the equipment, or if more information is desired, contact your authorized Applications Engineering Distributor (AED) or for 24-hour service assistance or emergency parts, call (615) 461-2501.

Siemens Industrial Automation, Inc. authorizes Turbo Refrigerating Company to reproduce the following sections of the SIMATIC TI Series 305-8101 Users Manual (published by SIA), P/N 2593546-0030 on July 27, 1992.

Siemens Industrial Automation, Inc.
P.O. Box 1255
Johnson City, Tennessee 37605-1255

Siemens Industrial Automation, Inc.
3000 Bill Garland Road
Johnson City, Tennessee 37601

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MODULAR CPUs

Quick Start

The Model TI325/TI330 is a modular CPU used in the Series TI305 modular I/O system. The CPU is installed in a Series TI305 base which can be a 5, 8, or 10-slot base. It provides up to 168 I/O points, of which 96 can be remotely mounted up to 3280 feet (1000 m) from the local base.

The purpose of Quick Start section is to get the experienced user started in the shortest possible time.

1. Unpack the equipment.
2. Insert a CPU module into slot 1 adjacent to the power supply, an input module, or input simulator (305-01S), into slot 2, and an output module into slot 3.

CAUTION

Do not connect the 220 VAC neutral terminal when powering the unit with 110 VAC. The unit is damaged if 110 VAC operation is attempted with this terminal connected.

3. Connect the controller to an AC power source. See Figure 1-1.

WARNING

To minimize risk of potential shock hazard, be sure the unit is properly installed in the enclosure to minimize access of electrically live terminals. Only persons knowledgeable in the safe use of high voltage should perform this test.

4. Place the mode select switch in the PRG position (program mode).
5. Turn unit power on. The POWER LED on the CPU illuminates.
6. Connect the TI305 programmer to the front of the CPU. The programmer display reads 0.0.0.0. and the ADR LED illuminates. See Figure 1-2.
7. Clear program memory using the TI305 programmer:

   CLR SHFT 3 4 8
   DEL NXT

8. Place the mode select switch on the programmer in the RUN position (run mode). The RUN LED illuminates.

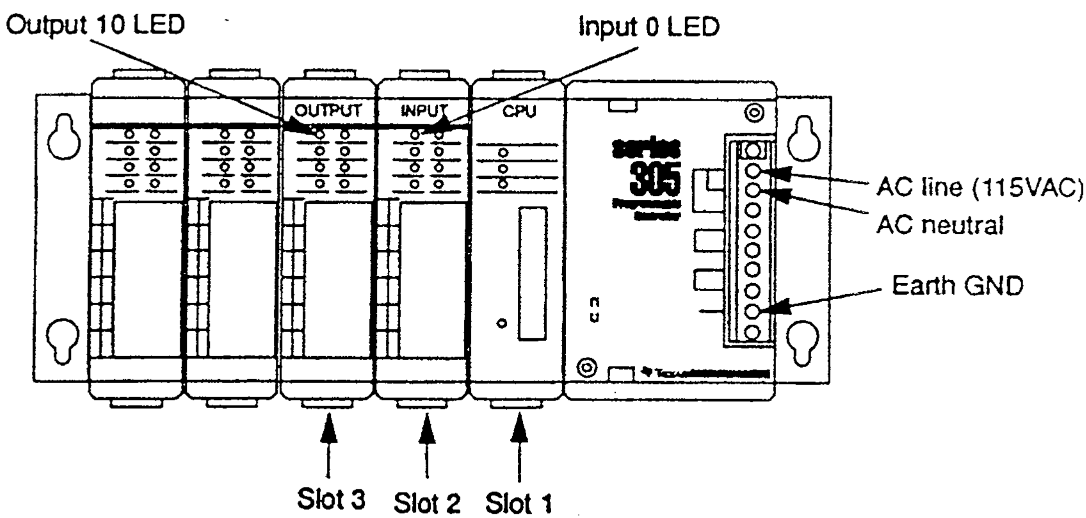


Figure 1-1 Model TI325/TI330 Controller

9. Test an output using the output module installed in slot 2.

   - Enter the following instruction from the programmer to force an output on. For this test, use output 10.

     SET SHFT 1 0 ENT

   - Output 10 LED on the output module illuminates. See Figure 1-1.
   - Turn output 10 off using the programmer as follows:

     RST SHFT 1 0 ENT

10. Test an output using an input module. If an input module is installed in slot 1, proceed as follows:

   - Turn controller power off.
   - Hard-wire an input device, such as a switch, to the first terminal on the input module.
   - Turn controller power on.
   - Place TI305 Programmer mode select switch in the PRG position (program mode). See Figure 1-2.
   - Enter the following keystrokes from the programmer:

     STR SHFT 0 ENT

     OUT SHFT 1 0 ENT

   - Place TI305 programmer mode select switch in the RUN position (run mode).
   - Close the switch hard-wired to the input module. The LED labeled 0 on the output module illuminates. See Figure 1-1.

11. If you encounter problems with the procedure, repeat steps 5–10. If the problems persist, refer to section 2 – Trouble-Shooting & Maintenance.

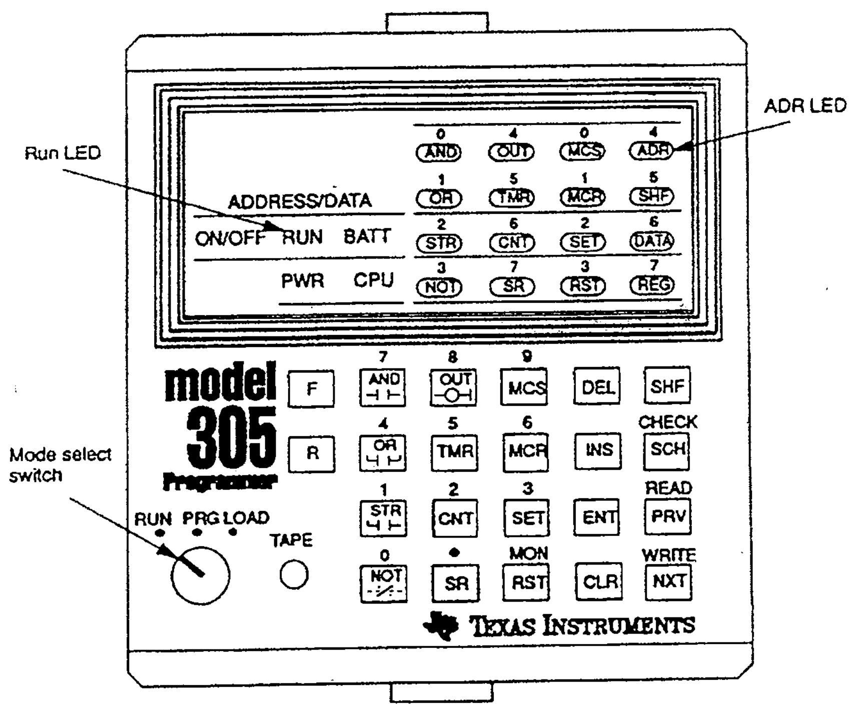


Figure 1-2 TI305 Programmer

Characteristic Specifications

Except where noted, specifications apply to both TI325 and TI330 models.

Table 1-1 Characteristic Specifications

Item	Rating
Programming	Relay ladder logic
Scan rate	Average 12 ms, 1k words
Program capacity, TI325	0.7k RAM 1.7k Expansion RAM 1.7k EPROM
Program capacity, TI330	3.7k RAM 3.7k EPROM
Program memory	CMOS RAM (lithium battery backup, 5 years) Option: EPROM HN27256G-25 or TI part (325-ROM)
I/O points	168 maximum
Control relays	140 (28 selectable for memory retention)
Shift register bits	128 (retentive)
Timer/Counters	64 timer/counters Timer: 0.1–999.9 sec or 0.01–99.99 sec Counter: 1–9999 (4 timer/counters are for external setting with thumbwheels or timer/counter setpoint unit)
Special internal relays	0.1 sec clock Battery low Pause relay Internal reset
Battery backup	Lithium battery
Diagnostic checks	CPU Memory Battery Grammatical error I/O base voltage
Status display	I/O internal relay Shift register 16-point display T/C accumulated value On-off status CPU error Battery low
Cassette tape interface	830 baud (75 seconds average time per 1.7k words)

Diagnostics

The TI325/TI330 models are equipped with self-diagnostics for the following functions.

Supply Voltage Low
The CPU stops base operations in the event of a voltage drop. If the voltage drop occurs in an expansion base, the CPU shuts down only the affected base.

CPU Error LED
If CPU failure occurs, the RUN output is turned off and program execution is stopped. All displays become blank except for the power and CPU indicators.

Parity Error
If a parity error is detected when the power is applied or the RUN mode is selected, the CPU stops operations and error code **E21** is displayed.

Battery Voltage Low
If, at any time, the battery voltage drops below 2.5V, the BATT light comes on. Normal CPU operation continues. Internal relay 377 energizes when the battery voltage is low.

Programming Error
Any of the following cause the programmer to display a corresponding error code:

- Invalid instruction sequence.
- I/O address errors.
- Incorrect cassette tape recorder operation.

Note:
Error code breakdown may be found in section 4 – Programming Error Messages.

I/O Circuit Check
The I/O display or monitoring feature helps define whether trouble occurred in the controller operation, I/O module operation, or field side.

Note:
You can use the programmer to turn output signals on and off. To force the state of an I/O reference, refer to section 3 – System Programming.

Model TI325/TI330 CPUs

The CPU module (TI325-07 or TI330-37) is the heart of the programmable controller. It consists of the program memory, system ROM, arithmetic section, and backup battery.

Note:
The CPU module is active only when it is inserted immediately to the left of the power supply unit. It does not work in any other location. See Figure 1-3.

Table 1-2 explains the CPU module operation status display shown in Figure 1-4.

Table 1-2 CPU Status LED Display

LED	Status
RUN	Shows that the CPU is in the RUN mode when on.
BATT	Shows that the lithium backup battery voltage for RAM backup is low. When this LED is lit, replace the battery as soon as possible.
CPU error	Lights when the watchdog timer is not processed within 180 mS because of some failure of CPU operation. Should this happen, the RUN output from the power supply also turns off.
POWER supply	Reflects the condition of the 5 V power supply. It is on when DC power is within the correct operating range.

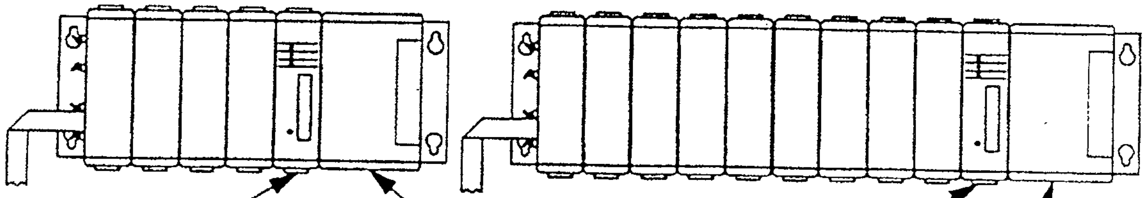


Figure 1-3 CPU Mounting Location

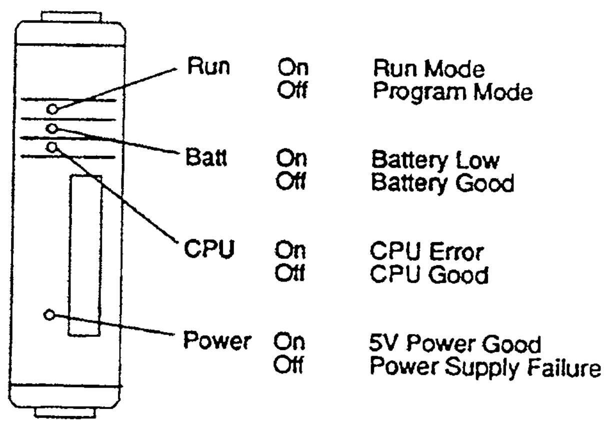


Figure 1-4 CPU Module Status Display

Note:
The program memory has a parity bit for use in parity checking when the power source is turned on or when the operation mode is changed to RUN. If this check is completed satisfactorily, the controller enters RUN mode. If a parity error is detected, the controller does not enter RUN mode until the error is cleared; however, the CPU error LED remains unlit. Error code **E21** is displayed if programmer TI305-PROG is mounted.

Use caution when storing and transporting the CPU module.

When removing the CPU module from the base, observe the following precautions.

- Allow the internal voltage to drop to zero before removing the CPU. This takes about 30 seconds after the AC power supply is shut off.
- Avoid shorting the module, since this can result in an alteration of RAM.
- Place the CPU module in a thick, soft paper bag or protect it by other suitable means. Never wrap it in conductive plastic or an antistatic bag, as is usually done with IC cards.

Model TI325/TI330 Major Component Identification Expansion

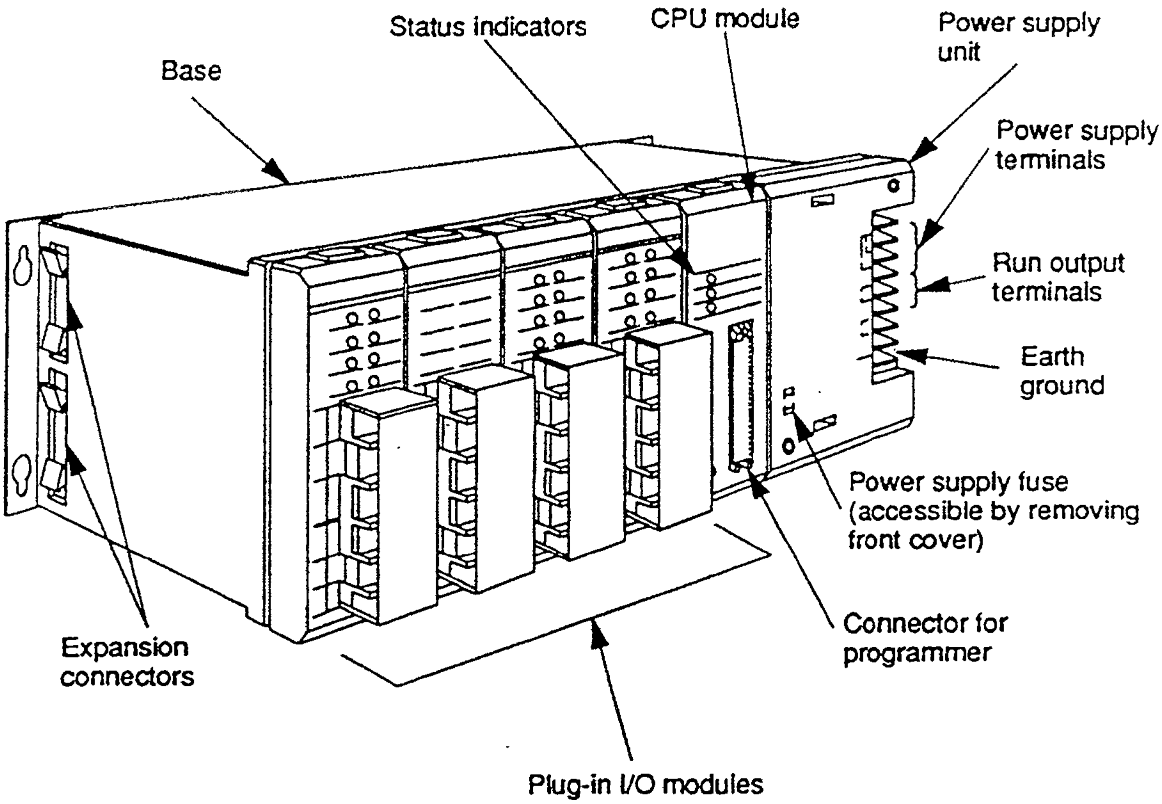


Figure 1-5 Series TI305 Controller Major Component Identification

TI325/TI330 I/O Processing

The CPU processes data by cyclic operation execution; the response time from receiving a signal to sending it varies with the input timing and program contents. See Figure 1-6.

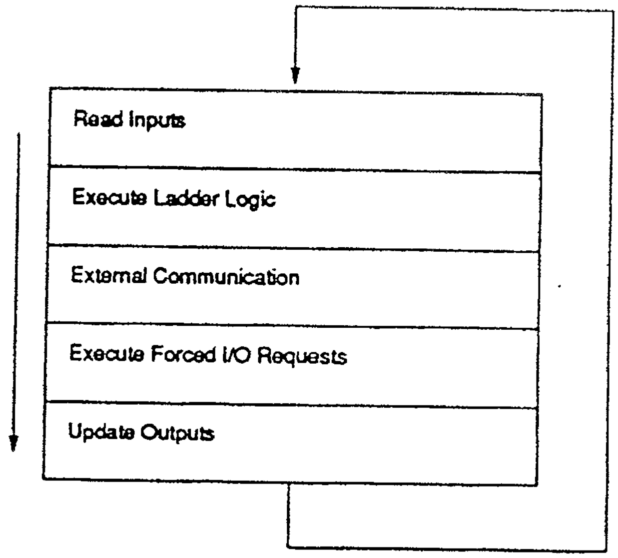


Figure 1-6 CPU Processing

TROUBLE-SHOOTING & MAINTENANCE

Overview

This section contains instructions for trouble-shooting the Series TI305 System to isolate faulty functions and components. Specific procedures are included for battery replacement and subsequent restoration to normal operation.

Trouble-shooting and maintenance must be done only by authorized personnel who are trained and experienced in electrical and electronics safety practices.

Trouble-shooting the Series TI305 System consists of observing system operation for malfunction symptoms and isolating the fault. Table 2-1 lists the most probable causes for typical malfunction symptoms. A reference to a detailed trouble-shooting procedure is listed for each probable cause.

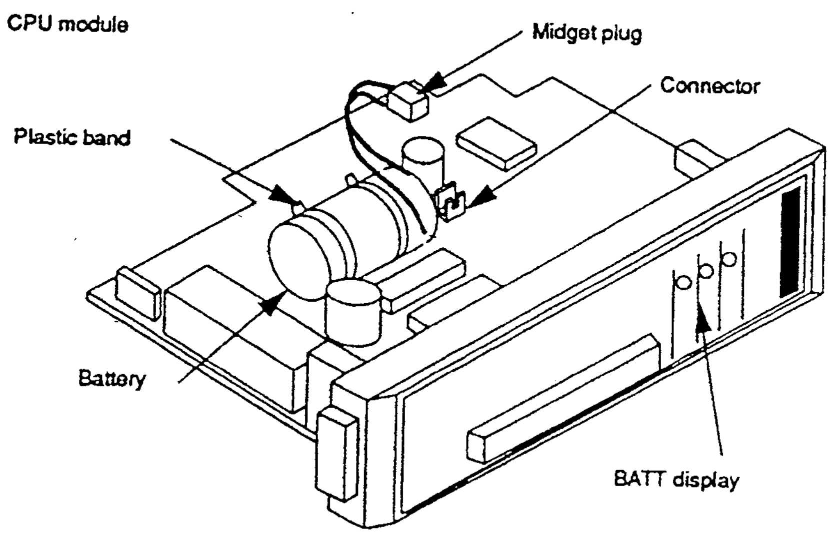


Figure 2-1 Replacing Battery in Model TI325/TI330 Controller

Table 2-1 Trouble-Shooting Symptoms

Symptom	Probable Cause	Paragraph
BATT LED indicator on	Low battery voltage	Replacing Controller Battery
Run LED OFF	Place system in Run mode	(2)
	CPU failure	(3)
Single input point defective	Input module faulty	(5)
	Mounting base faulty	(7)
	Programming error	(8)
	CPU faulty	(3)
Single output point defective	Output module faulty	(6)
	Mounting base faulty	(7)
	Programming error	(9)
	CPU faulty	(3)
Multiple inputs or outputs on one base defective	Mounting base faulty	(7)
	Programming error	(9)
	CPU faulty	(3)
Multiple I/O defective	Input module faulty	(5)
	Output module faulty	(6)
	Mounting base faulty	(7)
	Programming error	(9)
	CPU faulty	(3)
All I/O past a single point defective	Mounting base faulty	(7)
	Interconnection cable faulty	(8)
	Scrambled memory	(2)
No LEDs on	AC power off	Ensure AC power is on
	Power supply fuse blown	(7)
CPU LED off	CPU failure	(3)

Replacing The Model TI325/TI330 Controller Battery

The battery maintains RAM memory during times when AC power is turned off to the controller. It is important that battery replacement takes place within 10 days after the BATT LED indicators turn on. Otherwise, RAM memory might be lost.

During the period between disconnecting the old battery and connecting the new one, RAM memory is maintained by the charge on a capacitor. Connect the new battery as quickly as possible to avoid discharge of the capacitor and subsequent loss of RAM memory. Capacitor charge maintains RAM memory for approximately 10 minutes.

Replace the battery using the following procedure:

1. Turn off AC power to the controller.
2. Remove CPU module.
3. Cut plastic bands that hold battery to the CPU board or remove battery from the battery clip.
4. Disconnect battery leads by removing midget plug from board connector.
5. Connect new battery and secure it with new plastic bands to the CPU board or place the battery in the battery clip on the CPU board.
6. Install CPU module and turn on power to controller.
7. Check BATT LED indicators to make sure that they are out. (Both controller and programmer LEDs must be off.)

See Figure 2-1 on page 9.

Trouble-Shooting Models TI315/TI325/TI330

Introduction (1)

During normal operating conditions, the power source (PWR) and RUN LEDs on the unit are on and the CPU and BATT LEDs are off.

A lighted BATT LED indicates a failing battery. Replace the battery using the procedure on this page.

A lighted CPU LED will occur 100 ms after a CPU problem is detected. The 100 ms delay is introduced by the internal watchdog timer.

If the CPU error is caused by a parity error, **E21** appears in the ADDRESS/DATA display section of the programmer. Parity error checking and correction are covered in paragraph 2.

If a parity error is not involved, the CPU itself has failed or has generated false data for some reason. CPU trouble-shooting is covered in paragraph 3.

Checking Program Memory Error (2)

A program memory error is indicated by the message **E21** appearing in the programmer ADDRESS/DATA display section. The error message is displayed when switching from the PRG mode to the RUN mode.

To display the error, switch the CPU to the PRG mode and press CLR SCH. The address at which an error was found is displayed. To display the invalid instruction, press NXT and re-enter the correct instruction. The CPU can be switched to the RUN mode. If **E21** reappears, repeat the previous steps to correct the remaining error locations.

All invalid instructions must be cleared before the controller enters the RUN mode. Error **E21** could indicate that the CPU memory has been scrambled. To correct the problem may require clearing the memory. After the memory has been cleared, switch the CPU to the RUN mode. If the RUN LED comes on, the CPU is most likely functioning properly. If the RUN LED does not come on, the CPU could be defective. If the RUN LED comes on, switch the CPU to the PRG mode and re-enter the program.

If error **E21** is re-occurring under normal operation, the CPU could be defective or electrical noise could be causing the CPU memory to be scrambled.

Trouble-Shooting A CPU Error (3)

If the CPU LED is lighted and no parity error is indicated, turn off AC power momentarily, then turn AC power back on.

If normal run operation resumes, the cause of the problem is excessive noise introduced by the AC power wiring. Take measures necessary to shield the wires against noise.

A CPU error is detected by the watchdog timer approximately 100 ms after the error occurs. The watchdog timer turns off the outputs and, at the same time, resets the CPU and I/O modules.

Following a CPU error shutdown, momentarily turn off AC power, then turn it back on. If the error remains, the CPU may be defective. If normal operation resumes but re-occurs periodically, the CPU could be defective or electrical noise could be causing the CPU error.

I/O Circuit Check (4)

For greatest accuracy, make the I/O circuit check through the multi-point operation status monitoring method, using the 305-PROG programmer. This method allows signals to be displayed exactly as they are applied to the CPU.

Note:
TI305 Modular I/O Input Status LEDs indicate the condition of the input terminal and not the condition of the controller logic. An input module can be defective even if the input status LED shows proper operation. The modular I/O input status LED should be compared with the corresponding programmer I/O indication. If there is a difference between the two, the input module probably is defective.

WARNING

To minimize the risk of personal injury or property damage, disable all power to the system before installing or removing I/O modules.

Trouble-Shooting Input Modules (5)

When you suspect a module is defective, first try the module in a different slot. If the module does not work in a slot you know is operative, check for wiring problems and trouble-shoot the user-power supply as follows:

1. Measure the voltage across the input terminals. If the voltage is not within the specified range, check for a problem with the input module user-supplied power source.

2. If the voltages at module terminals are correct, measure voltage at input devices. If the correct voltages are not present, the problem is in the field wiring.

Trouble-Shooting Output Modules (6)

When you suspect a module is defective, try the module in a different slot. If the module does not work in a slot you know is operative, check for wiring problems and trouble-shoot the user-power supply as follows:

1. Measure the voltage across the output terminals. If the voltage is not within the specified range, check for a problem with the output module user-supplied power source.

2. If the voltages at module terminals are correct, measure voltage at output devices. If the correct voltages are not present, the problem is in the field wiring.

Trouble-Shooting TI305 Module I/O Mounting Base (7)

Fuse Replacement
If there is correct input power to the base, none of the status LEDs on the programmer turns on, and the controller is inoperative, the problem may be a blown fuse. If the fuse is not blown, the base is most likely defective and must be replaced. Procedure for checking the fuse:

1. Disconnect power from the base.

2. Remove programmer and peripherals from base.

3. Remove power supply cover by unscrewing two screws.

4. Remove fuse and check with an ohmmeter.
5. If fuse is an open circuit, replace it with the proper amperage fuse contained in the 305-ACK-2 accessory kit or equivalent fuse.
6. Reinstall power supply cover and re-connect system.

Checking Cables (8)

The easiest way of checking cables is to replace the suspected cable with a known good cable. If a known good cable is not available, check cable and connector ends for damaged pins. Check continuity using an ohmmeter. Also check for pin-to-pin shorts.

Programming Errors (9)

In the event of a programming error, compare each step against the documentation to ensure accuracy of the program in RAM.

If you are programming with TISOFT, check the program contents. Observe for proper operation of outputs, timers and counters with respect to inputs.

If only the 305-PROG Programmer is available, observe the on/off indicator as each contact is turned on. Refer to section 3 – System Programming for more information.

SYSTEM PROGRAMMING

TI305 Programmer

The TI305 programmer (Figure 3-1) provides the programming interface for the controller. With the programmer, you can perform these tasks:

- Enter program instructions into the memory of the controller.
- Edit existing programs or instructions.
- Trouble-shoot program operation.
- Test the controller for proper internal operations.

Note:
As an alternative to using the TI305 programmer, you can use the TISOFT operating system with an IBM XT/AT-compatible computer. You can order TISOFT and the *TI-SOFT User's Manual* (part number PC305-6201). A Data Communications Unit is also needed to interface the unit to the TI305. There are two versions:

1. 305-03DM — this RS-232 version will connect directly to the RS-232 port on your computer by using a null modem cable (TI P/N VPU200-3605).
2. 305-02DM — this RS-422 version will connect to a RS-422 port. To interface the 305-02DM to a RS-232 port, you can use a RS-232 to RS-422 converter (FACT Engineering 305-DCU-U or equivalent). This converter mounts directly on the 03DM; TI cable P/N 500-3602 will connect the converter to your computer.

For additional information, contact your distributor, or call 24-hour service assistance or emergency parts at (615) 461-2501.

Modes Of Operation

The programmer has three modes of operation, determined by the switch position:

Run Mode
In run mode, the controller scans and executes the ladder logic program. You can monitor program functions (operation codes) and parameters, but you cannot alter the program while in run mode.

Program Mode
In program mode, the controller does not scan or execute ladderlogic programs. You can enter or edit instructions or parameters while in the program mode. In program mode, the run indicator is off.

Load Mode
In load mode, you can record a program in CPU memory onto a cassette tape, or you can load a program from a cassette tape into the CPU memory.

Operation

The programmer provides the means for entering program instructions into the controller memory and for initiating nonprogramming functions. The function keys, mode selection switch, and display are shown in Figure 3-1.

Instruction LEDs

ADR
This LED is on when an address is being displayed.

SHF
This LED is on when you press SHF. The illuminated LED means that future key functions correspond to the labels above the selected key.

DATA
This LED is on when you are monitoring the contents of a register; the address/data display shows a four-digit BCD value in that register.

REG
This LED is on when you are monitoring the contents of a register; the address of the selected register is shown in the address/data display.

Keylock Switch

Keylock switch selects the operating mode of the controller. It can be turned to any position during programming, program execution, or load operations without turning controller power off.

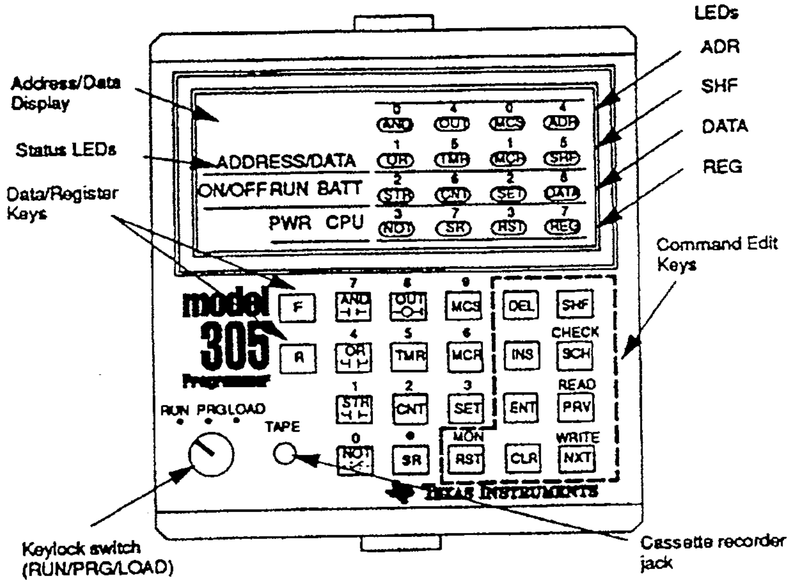


Figure 3-1 TI305 Programmer

Command Keys

CHECK allows you to verify that a program was successfully recorded from CPU memory to an audio cassette recorder, or loaded from an audio cassette recorder to CPU memory.

READ allows you to load a program from an audio cassette recorder to CPU memory.

WRITE allows you to save (record) from CPU memory to an audio cassette tape.

MON in run mode, allows you to monitor 16 I/O references at one time; you can also monitor current values of timers and counters.

Edit Keys

DEL when a program instruction is displayed in the address/data area, pressing DEL PRV deletes that instruction from CPU memory.

INS allows you to insert logic instructions between existing logic instructions.

ENT completes a logic entry.

CLR clears previously entered instructions.

SHF changes the command keys to numeric keys, and the function keys SCH, PRV, and NXT to the functions labeled above those keys.

SCH allows you to locate logic instructions, or reference numbers (contact points), for a memory address.

PRV causes the previous memory address or instruction to be displayed. Other uses are described throughout this section.

NXT causes the next memory address or instruction to be displayed. Other uses are described throughout this section.

Data/Register Keys

F allows you to enter a two-digit data operation or function value.

R selects a data register or a timer/counter accumulated data register, or selects a group reference number when programming data operation instructions.

Status LEDs

ON/OFF reflects the status of CPU memory for the instruction being displayed.

RUN is on when the mode selector switch is in the RUN position (run mode).

PWR is on when controller power supply is functioning properly.

BATT is on when internal battery is at a low power level and must be replaced.

CPU is on when there is an internal hardware fault.

Address/Reference Display is a four-digit display showing the location of either the memory address or the programmed instruction. When an address is displayed, periods appear at the bottom right corner of each digit, and the ADR LED is on.

Example: **0.0.0.1.**

Programmer Functions

Table 3-1 lists the functions, the keystrokes required to enter them, and the modes in which the function can be performed. Function operations are fully explained in sections that follow the table.

Table 3-1 TI305 Programmer Functions

Function	**Keystrokes**	**Mode** RUN	PRG	LOAD
Go to Run mode.	Turn mode select switch to the RUN position.		•	
Go to Program mode (PRG).	Turn mode select switch to the PRG position	•		•
Clear memory.	CLR SHF 3 4 8 DEL NXT		•	
Go to beginning of program.	SHF NXT	•	•	
Display an address.	SHF [Address] NXT	•	•	
Display next address.	NXT	•	•	
Clear display.	CLR [Clears previously entered command and present address is displayed]	•	•	
Display program.	[Instruction] NXT [Previous instruction] PRV	•	•	
Write instruction.	[Instruction] SHF [Data] ENT		•	
Edit instruction.	[Instruction] SHF [Data/Memory] ENT		•	
Insert instruction.	[Address or Instruction] SHF [Data] INS NXT		•	
Delete instruction.	Display the instruction to delete and press DEL PRV		•	
Insert End.	CLR SHF INS NXT		•	
Search for a specific instruction.	Display address by entering [Instruction] SHF [Data] SCH Display the instruction by pressing NXT	•	•	

Table 3-1 TI305 Programmer Functions (continued)

Function	Keystrokes	Mode		
		RUN	PRG	LOAD
Search for a specific reference.	Display address by pressing NXT Display the reference number by pressing SHF [Memory reference] SCH Display next used reference by pressing SCH again Use grammar check to locate vacant address	• •	• •	
Multiple status operation.	SHF [Memory reference] MON			
Monitors 16 bits from specified starting address.	Change range of display by pressing PRV or NXT	•		
Timer/counter accumulated value or data registers. Monitors one timer or counter accumulated value or data register.	SHF 6 [Memory reference] MON		•	
On/off status. If the instruction is displayed, the on/off coil display LED reflects the status of the contact or coil.		•		
Force discrete references*.	On = SET SHF [Memory reference] ENT Off = RST SHF [Memory reference] ENT	•		
Force timer/counter* accumulated value.	Display address and press SHF [Value] ENT	•		
Force data register value*.	R [Reg number] MON RST SHF [New value] ENT	•		
Check program grammar.	CLR SCH	•	•	
Cassette Operation				
Record data to cassette tape.	[File No.] WRITE NXT			
Load memory from cassette tape.	[File No.] READ PRV			
Verification of cassett tape.	[File No.] CHECK SCH			•

* Force operates for only one scan.

Note:
The I/O references in the Series TI305 controllers are numbered in octal, which is also known as base 8. I/O points are counted as usual from 0 to 7. Since 8 and 9 are not used, the next point after 7 is numbered 10. When the count reaches 17, the next point is 20. The point following 77 is numbered 100, and so on.

Clear Program Memory

To clear entire contents of logic memory, place the programmer in PRG mode and enter the following keystrokes:

CLR SHF 3 4 8 DEL NXT

After all memory has been cleared, the address/data display is **0.0.0.0.** and the ADR LED is on. To cancel the clear function, press CLR instead of NXT.

Display User Memory

When operating in the program or run mode, this function sequence allows you to select and display a specified memory address, and the logic content of that address.

Displaying Address 0
Press SHF NXT at any time.

Displaying A Specified Address
To display, for example, the logic in address 123, press SHF 1 2 3 NXT. The selected address, **0.1.2.3.**, is displayed.

Locating An Unused Address Or Grammar Check
Press CLR SCH to locate the first available location (end statement).

Changing From Address Display To Instruction Display
To change the address display to an instruction display, press NXT. The logic content of the memory is displayed.

Write/Edit An Instruction

To change memory data at a particular location:

1. Place the mode selector switch in the PRG position.
2. Press PRV or NXT until the instruction to be changed is displayed. Enter the new instruction; for example: AND SHF 4.
3. Press ENT. The new instruction replaces the previous instruction at that memory location, and the next address is displayed.

Insert An Instruction

To insert an instruction between two existing instructions, follow these steps:

1. Place the mode selector switch in the PRG position.
2. Press PRV or NXT to display the instruction before which the new instruction is to be inserted.
3. Enter the new instruction; for example: AND SHF 4.
4. Press INS. The address display shows a lower case **i** in the left digit of the display.
5. Press NXT to confirm the insert. The display shows the address of the next instruction.

Delete An Instruction

To delete an instruction, use these steps:

1. Place the mode selector switch in the PRG position.
2. Press PRV or NXT to display the instruction to be deleted.
3. Press DEL. The address display shows a lower case **d** in the left digit of the display.

Note:
To cancel the delete function, press CLR before performing step 4. The display returns to the instruction being considered for deletion.

4. Press PRV to confirm the delete function. The next address is displayed. The remaining instructions automatically back up one address location toward **0.0.0.0.** to fill the empty memory.

Monitoring I/O Status

You can monitor a total of 16 I/O references at any time, beginning with an address you select. Each reference is within a group of eight references. The I/O status of the group with the selected reference, and the next higher group of eight, is indicated by illuminated LEDs.

1. Place the mode selector switch in the RUN position.

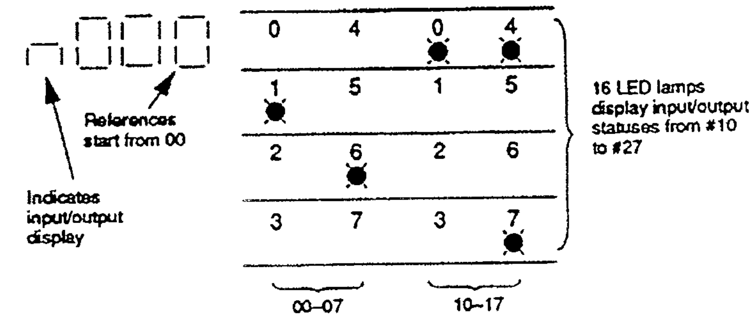


Figure 3-2 I/O Monitoring With LEDs

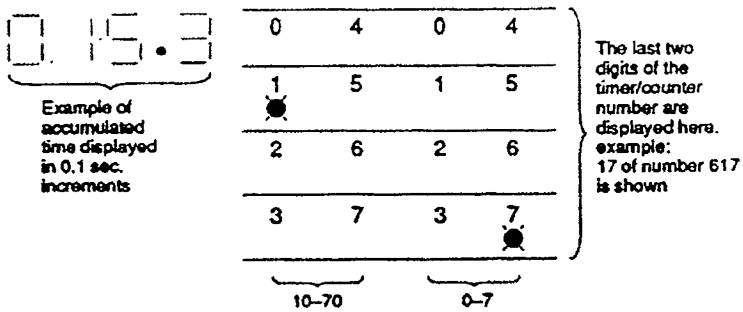


Figure 3-3 Timer/Counter Accumulated Value Display

2. Select the reference to be monitored. For example, to monitor input 6, press SHF 6.

3. Press MON. The display shows a character followed by the lowest reference in that group. From the example in step 2, the value **000** is displayed.

   The first eight LEDs represent the status of the group with the selected memory reference; the status of the next memory reference is indicated by the last eight LEDs. I/O monitoring with LEDs is shown in Figure 3-2.

4. You can use PRV and NXT to scroll forward or backward in increments of eight.

Monitoring Timer Or Counter Values

To monitor the accumulated value of a timer or counter:

1. Place the mode selector switch in the RUN position.

2. To specify the timer/counter number, press SHF and the identifier keys. For example, to monitor the operating value of timer 617, press:

   SHF 6 1 7 MON

The current accumulated value of the specified timer/counter is displayed in the address/data area, and the LEDs representing the last two digits of the timer or counter are illuminated. Accumulated time is displayed in 0.1 second increments. See Figure 3-3 for an example.

Monitoring Data Register Values

To monitor the value of a data register, place the mode selector switch in the RUN position. Specify the required data register. For example, to monitor the value of data register 400, press R 4 0 0 MON. The value of the data register is displayed in the address/data area.

Changing Timer/Counter Accumulator Values Or Data Specified Data Register Values

1. Monitor the specified timer/counter reference or the specified data register by typing the following keystrokes:

   data register
   CLR R 4 0 0 MON

   or

   timer/counter reference
   CLR R 6 0 0 MON

2. Change the value of the specified timer/counter reference or the specified data register by pressing:

   data register
   SHF New Value ENT

   or

   timer/counter reference
   SHF New Value ENT

Searching

The search operation allows you to locate logic instructions or reference numbers (contact points) for memory addresses. To search for an instruction, use the following procedure.

1. Place the mode selector switch in either the PRG or RUN position.
2. Enter the instruciton whose memory is to be searched. For example, press OUT SHF 2 0 SCH. The first memory address for the instruction is displayed. If the instruction is nonexistent, error code **E99** is displayed.
3. Press NXT to verify the instruction for the address displayed.
4. Pressing CLR causes the address to be displayed again.
5. If you continue to press SCH while the memory address is displayed, the controller searches for other addresses that have the same instruction. If searching is continued to the end of the program, it wraps around to memory address zero until an instruction-address match is detected.

To search for a particular reference (contact point), use the following procedure.

1. Place the mode selector switch in either the RUN or PRG position.
2. Enter the contact point. For example, to find the memory address for contact point 10:

   Press SHF 1 0 SCH. The memory address for the contact point is displayed. If the contact point is nonexistent, error code **E99** is displayed.
3. Press NXT to display the contact point number for the address location displayed.
4. If you continue to press SCH while the memory address is displayed, the controller searches for other addresses that have the same contact point.

   If searching is continued to the end of the program, it wraps around to memory address zero until a contact point-address match is detected.

Monitoring A Program

Checking Status Of I/O Designators

To check the status of the I/O designators:

1. Place the mode selector switch in the RUN position.
2. Select reference to be monitored by pressing SHF and the beginning memory reference number and pressing MON. The display shows a character followed by the lowest reference in that group. The references are divided into groups of 10 (octal system), but there are only eight references in each group. For example, 0–7, 10–17, etc.

   The instruction/numeric LEDs show the status of 16 references. The first eight LEDs represent the status of the group with the selected reference; the second set of eight LEDs are for the next higher group.
3. Pressing NXT increases the displayed reference group by 10. Pressing PRV decreases the displayed reference group by 10.

4. Pressing the CLR clears the monitor display.

   Example of monitoring reference 105, press:

   SHF 1 0 5 MON

   The Address/Data area displays **100**. The instruction/numeric LEDs tells you the status of references 100 through 107, and 110 through 117. If the LED display is as shown in Figure 3-4, you can determine that references 101, 106, 110, 114, and 117 are on.

Checking T/C Accumulated Value

To check the timer/counter accumulated value:

1. Place the mode selector switch in the RUN position.

2. Enter the desired timer/counter number and press MON. The current accumulated value of the selected timer/counter is displayed in the Address/Data area, and the LEDs representing the last two digits of the timer or counter is illuminated in the instruction/numeric area. Accumulated time is displayed in seconds to within 0.1 seconds.

3. Pressing CLR clears the monitor display.

To see an example of checking timer 617 with an accumulated value of 15.3 seconds:

Press SHF 6 1 7 MON.

Figure 3-5 shows the Address/Data display and instruction/numeric LED display for this example situation.

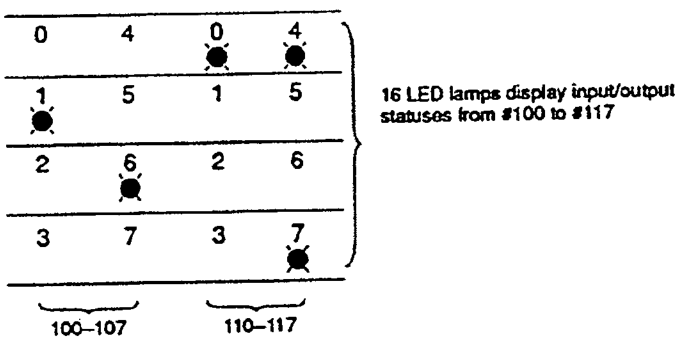


Figure 3-4 Example Of Monitoring I/O Reference Status

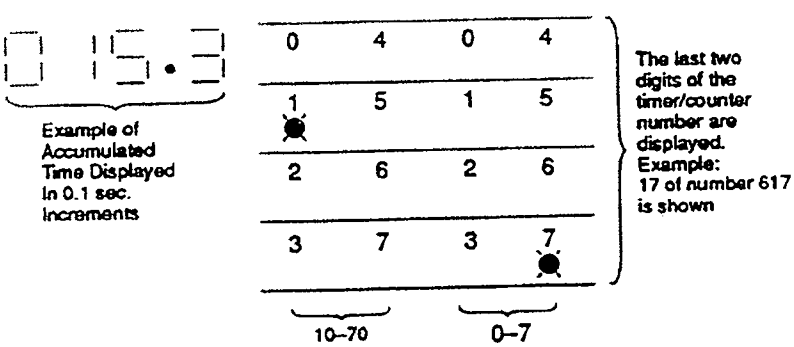


Figure 3-5 Example Of Monitoring T/C Accumulated Value

Changing Timer/Counter Accumulator Values Or Specified Data Register Values

To change timer/counter values or specified data register values:

1. Monitor the specified timer/counter reference or the specified data register by typing the following keystrokes:

   data register
   CLR R 4 0 0 MON

   or

   timer/counter reference
   CLR R 6 0 0 MON

2. Change the value of the specified timer/counter reference or the specified data register by pressing:

   data register
   SHF New Value ENT

   or

   timer/counter reference
   SHF New Value ENT

PROGRAMMING ERROR MESSAGES

Incorrect programmer operation and cassette recorder operation (recording/playing) are detected and displayed on the programmer.

Invalid Operation Detected	Display Code
Incorrect program syntax.	E01
Reference number out of range.	E01
Program memory is full.	E11
Program verification error with cassette.	E25
Cassette volume not adjusted correctly.	E28
Instruction being searched for does not exist.	E99

Program Syntax Error	Display Code
The reference number or a slot containing an input module was used as an output.	E02
Stack overflow: More than eight levels of logic have been programmed. Check the use of AND STR/ORSTR/MCS/MCR.	E03
Duplicate output or timer/counter number.	E05
MCS/MCR PAIRS do not match.	E06
An input contact is missing from before a CNT or SR instruction.	E07
Missing TMR or CNT preset or shift register range.	E08
The rung does not terminate in an OUT or box instruction.	E09
Program memory is full.	E11
Program memory parity error.	E21

A program syntax check can be made either in the RUN mode or PRG mode.

Additional TI315 Errors	Display Code
Maximum number of high speed counter preset points exceeded.	E13
Lost communication between TI315 and I/O expansion.	E30
Communications framing error between TI315 and I/O expansion.	E31
Communications parity error between TI315 and I/O expansion.	E32
I/O expansion does not respond to TI315.	E33

CASSETTE RECORDER OPERATION

IMPORTANT

It is wise to make a tape copy of the program existing in memory before erasing it to load the new program.

Introduction

The programs used for TURBO programmable controllers may be stored on standard audio cassette tapes. It is wise to keep a tape copy of the program handy in the event that the CPU either becomes defective, or somehow loses its memory.

Items Required For Tape Operation

Hand Held Programmer
This includes the key for the hand held programmer, along with the audio cable which is gray with a red tracer.

Audio Cassette Recorder
This is a standard size cassette tape recorder which has a microphone jack, earphone jack, and a volume control. Optionally, this should have a digital counter.

Standard Audio Cassette Tape (Type I)
The "micro cassette" tapes generally do not have the audio quality required and should not be used.

Common Problem

The most common problem incurred during tape operation is confusion over the proper key to depress on the hand held programmer. The shifted function keys on the programmer are shown in Figure 5-1. The shifted function always corresponds to the key directly below it.

Tape Operation

Save/Record A Program Onto Tape (WRITE)

1. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

2. Turn the mode switch on the Programmer to the LOAD position.

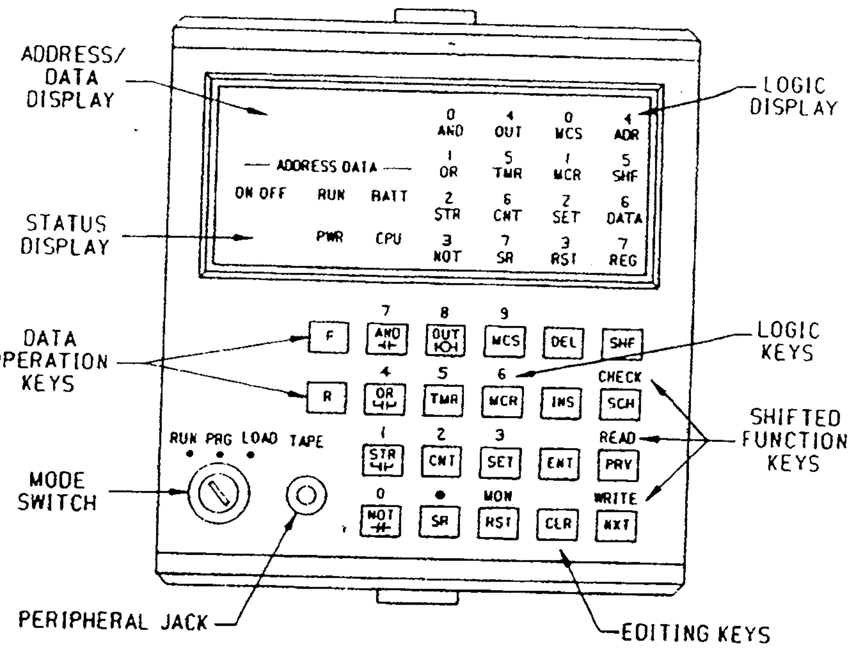


Figure 5-1 Programmer Features

3. Connect the Programmer (TAPE port) to the tape recorder (MICROPHONE input) with the audio cable (gray with red tracer). Refer to Figure 5-2.

4. Rewind the tape to the beginning or to the desired record position if multiple programs are to be places on one tape. Programs require approximately 1.5 to 4 minutes of tape per program. Note counter position.

5. For identification of a program, if desired, enter a four digit number (0000-9999) on the Programmer. When tape is accessed later to load the CPU, this number can be used to identify the correct program prior to altering CPU data. If a program number is not as expected, the operator can terminate the load operation and get the correct tape without loss of the existing program or delay incurred by loading a wrong program. THIS IDENTIFICATION NUMBER IS OPTIONAL.

6. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

7. Begin the tape recorder operation by depressing the RECORD PLAY buttons.

8. Depress the WRITE key on the Programmer. The record operation will now begin.

9. The ON/OFF light on the Programmer will come on.

10. When the record is complete, the Programmer will display End in the Address/Data display and the ON/OFF LED will be off. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

11. Depress the CLR (Clear) key on the Programmer to end the record operation.

12. It is recommended that the tape be rewound to where the recording began and that the "Check A Program" (described later) be performed to ensure data integrity.

Load A Program Onto CPU (READ)

1. Prior to loading a program onto the CPU, the existing program must be cleared from the CPU memory. To do this, turn the mode switch to the PRG mode and press the following key sequence:

   CLR SHF 348 DEL
   NXT NXT

   The program has now been cleared from the CPU.

2. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

3. Turn the mode switch on the Programmer to the LOAD position.

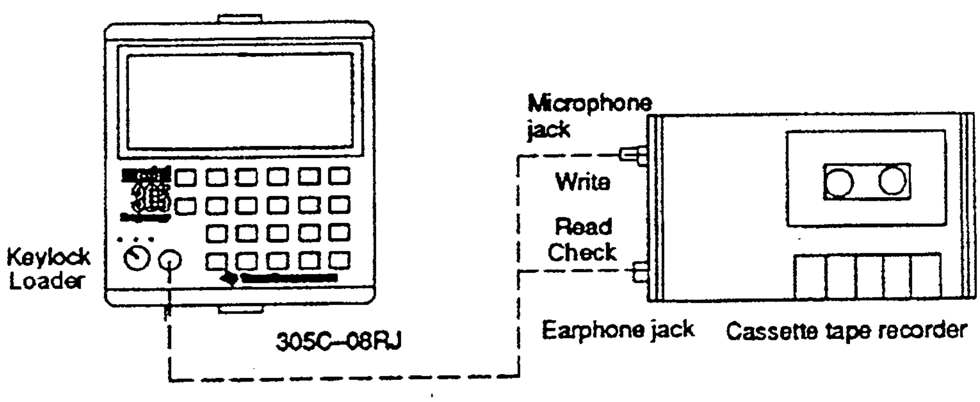


Figure 5-2 Writing From Controller To Tape

4. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

5. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if applicable).

6. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

7. Depress the READ key on the Programmer.

8. Begin the tape recorder operation by depressing the PLAY button.

9. The Address/Data screen of the Programmer will flash an E28 briefly.

10. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

11. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a program number different from the one entered in step 5, the Address/Data screen of the programmer will display PASS.

12. When the load is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

13. Depress the CLR (Clear) key on the Programmer to end the record operation.

Check A Program With The Tape Copy (CHECK)

1. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

2. Turn the mode switch on the Programmer to the LOAD position.

3. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

4. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if previously recorded).

5. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

6. Depress the CHECK key on the Programmer.

7. Begin the tape recorder operation by depressing the PLAY button.

8. The Address/Data screen of the Programmer will flash an E28 briefly.

9. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

10. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a mismatch between the contents of the tape and the CPU logic, the Address/Data screen of the programmer will display E25. A steady E28 indicates that the play level of the recorder is wrong. The CHECK operation should be stopped, the volume/tone re-adjusted, and the operation restarted.

11. When the check is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

12. Depress the CLR (Clear) key on the Programmer to end the record operation.

TI305 QUICK REFERENCE GUIDE

Memory Functions	TI325/TI330 Mem Ref	Dec	TI315 Mem Ref	Dec
I/O Points	000-157	112	000-137	96
	700-767	56		
Control relays				
Non-retentive	160-337	112	140-277	96
Retentive	340-373	28	300-372	59
Shift registers	400-577*	128	140-372	155
Timers/counters	600-677	64	600-623	20
Sequencers	600-677	64	600-623	20
Data registers	400-577*	64	N/A	

Programming Error Messages

E01	Programming error
E02	Data/memory reference error
E03	Stack overflow
E05	Output or TMR/CNT duplicated
E06	MCS/MCR mismatch
E07	CNT or SR missing element
E08	TMR, CNT, or SR missing value
E09	Rung not complete
E11	Memory full (RAM)
E21	Memory parity error
E25	Tape/CPU verify error
E28	Records volume level incorrect
E99	Instruction being searched not in program memory

External TMR/CNT Memory Reference Ranges

TI325/TI330 = 647-677
TI315 = 600-623

Shift and Data Register References

* Shift register references 400-577 are discrete references. Data register references 400-577 are byte references (TI325/TI330 only).

Special Function Relays

Set retentive control relays	373[2]
First scan reset	374
0.1 second clock	375
Disable all outputs	376
Battery status	377
Set 0.01 second timer	770[1]
External diagnostic coil	771[1]

Data Operation Relays

Accumulator is <	772[1]
Accumulator is =	773[1]
Accumulator is >	774[1]
Accumulator carry/borrow	775[1]
Accumulator is zero	776[1]
Accumulator overflow	777[1]

[1] Valid in TI325/TI330 models only.
[2] Valid in TI315 model only.

Programmer Functions

Clear memory	CLR	SHF	3	4	8	DEL	NXT		
Display address	CLR								
Display instruction	NXT								
Goto address	SHF	—	—	—	NXT				
Edit instruction	—	—	—	SHF	—	—	—	ENT	
Insert instruction	—	—	—	SHF	—	—	—	INS	NXT
Delete instruction		Display instruction =			DEL	PRV			
Insert end	CLR	SHF	INS	NXT					
Search	—	—	—	SHF	—	—	—	SCH	
Monitor	SHF	—	—	—	RST				
Force ON	SET	SHF	—	—	—	ENT			
Force OFF	RST	SHF	—	—	—	ENT			
Syntax check	CLR	SCH							

Data Instructions

F50 (D*STR) – Load 2 bytes into accumulator
F51 (D*STR1) – Load 1 byte into accumulator
F52 (D*STR2) – Load high bits into accumulator
F53 (D*STR3) – Load low 4 bits into accumulator
F55 (D*STR5) – Load 16/mdl into accumulator
F60 (D*OUT) – Write accumulator to 2-byte reference
F61 (D*OUT1) – Write accumulator (low byte) to 1-byte reference
F62 (D*OUT) – Write accumulator (low 4 bits) to 1-byte reference (high 4 bits)
F63 (D*OUT3) – Write accumulator (low 4 bits) to 1-byte reference (low 4 bits)
F65 (D*OUT5) – Write accumulator to 16/mdl (out)
F70 (CMP) – Compare 2-byte reference/4-digit constant to accumulator
F71 (ADD) – Add 2-byte reference/4-digit constant to accumulator
F72 (SUB) – Subtract 2-byte reference/4-digit constant from accumulator
F73 (MUL) – Multiply 2-byte reference/4-digit constant by accumulator

F74 (DIV) – Divide accumulator by 2-byte reference 4-digit constant
F75 (D*AND) – Bit AND 2-byte reference/4-digit constant with accumulator
F76 (D*OR) – Bit OR 2-byte reference/4-digit constant with accumulator
F80 (SR) – Accumulator shift right "n" times
F81 (SL) – Accumulator shift left "n" times
F82 (DEC) – Accumulator (low 4 bits) are decoded to a decimal number. A "1" is placed in the corresponding bit in the accumulator (1-15)
F83 (ENC) – Accumulator (1 bit on) is encoded to a 4-bit code representing the decimal number 1-15
F84 (INV) – Logically invert accumulator
F85 (BIN) – Convert BCD to binary
F86 (BCD) – Convert binary to BCD
F20 (FAULT) – Display BCD number on programmer display

Notes: All Math instructions use BCD format.
Results of Math instructions are stored in the accumulator.
Multiply and Divide instructions store the result in 4 bytes.
The accumulator and data registers 576 and 577 are used to store the result.

TI325/TI330 CPU Jumper And Dipswitch Settings

TI325	Memory Specifications		
Switch	Standard Equipment RAM (701 words)	Expansion RAM (1.723 words)	EPROM (1.723 words)
Dipswitch 2	ON 2	ON 2	OFF 2
Jumper 1			
Jumper 2			

TI330	Memory Specifications	
Switch	3.7k RAM	3.7k EPROM
Dipswitch 2	ON 2	OFF 2
Jumper 1		
Jumper 2		
Jumper 3		

Dipswitch Functions

Dipswitch 1	On Off	Retain coils Clear coils
Dipswitch 2	On Off	CMOS memory PROM memory

Note:
All TURBO models shipped after October 1993 contain a model 335 or 340 CPU with an EEPROM chip which contains the user program. TURBO has enabled the EEPROM and retentive control relays by using the following CPU configuration (refer to Table 7-1 and Table 7-2):

1. Dip switches 1 and 2 ON.
2. All other dip swiches OFF.
3. Jumper in the middle (2) position.

The 335/340 CPU is equipped with standard RAM memory for user program storage. You can install an optional EEPROM or EPROM. The user program stored in the standard RAM memory will not be destroyed even if the EEPROM or EPROM is installed, as long as it is backed up by battery. To help ensure equipment compatibility, use only the EEPROM/EPROM model supplied by your distributor.

Program Storage In EEPROM

The 335/340 CPU offers the option for saving your RLL program in a non-volatile form using an Electrically Erasable Programmable Read-Only Memory (EEPROM, Industry #28C64; Siemens, PPX:2587681-8029, quantity 1) integrated circuit. A separate programming device is not necessary. Once programmed, an EEPROM can be removed and used in any 335/340 CPU as required. If desired, you can disable the 335/340 CPU from writing to the EEPROM.

You can edit the EEPROM with TISOFT or the HHP. While editing a program in the PRG mode, the editing result is temporarily stored in RAM. After finishing the program edit, perform either of the following operations to transfer the edit to EEPROM:

- Syntax check
- Mode change from PRG to RUN

For the operations listed below, the 335/340 CPU automatically writes to the EEPROM after the operation is performed.

- All clear of the entire user program. The program in the EEPROM is cleared, but the program in the RAM is not cleared.
- On-line change of TMR/CNT preset value while in RUN mode.
- Downloading of user program through cassette interface or TISOFT.

Installing EEPROM

Follow instructions in this section to install an EEPROM in your 335/340 CPU.

Note:
If you are installing an EEPROM and intend to keep the user program currently in RAM memory, ensure that a good backup battery is installed and enabled. Controller power must be turned OFF and, without a functioning backup battery, your program may be lost when power is restored.

1. Turn off all user-supplied power to the Series 305 base.
2. Remove the 335/340 CPU from the base assembly.
3. Insert the EEPROM, aligning the notches on the EEPROM and the socket. Refer to Figure 7-1.
4. Check that all pins are seated properly in the socket.
5. Set Switch 2, Position 1 and the jumper according to Table 7-1. If you intend to write to the EEPROM, ensure that jumper is in position 2. If you do not intend to write to the EPPROM and want to disable this feature, ensure the jumper is in position 1.
6. Re-install the CPU in the base and turn the base power on.

Mode After Power-Up

If no HHP or DCU is connected to the parallel port, a 335/340 CPU configured for EEPROM operation will attempt to power up in the RUN mode. If an HHP is connected and online, with or without a DCU, the HHP keyswitch determines the operating mode. If a DCU is connected, but no HHP is online, the power-up mode is determined by a switch setting of the DCU. Refer to the Series 305 Data Communications Manual. (PPX:305-8102) for details.

CR340-373 can be retentive or non-retentive. Retentive memory will retain the last state through a power cycle. Set switch 2, position 2 in the ON position to make CR340-373 retentive; OFF for non-retentive. Refer to Table 7-2.

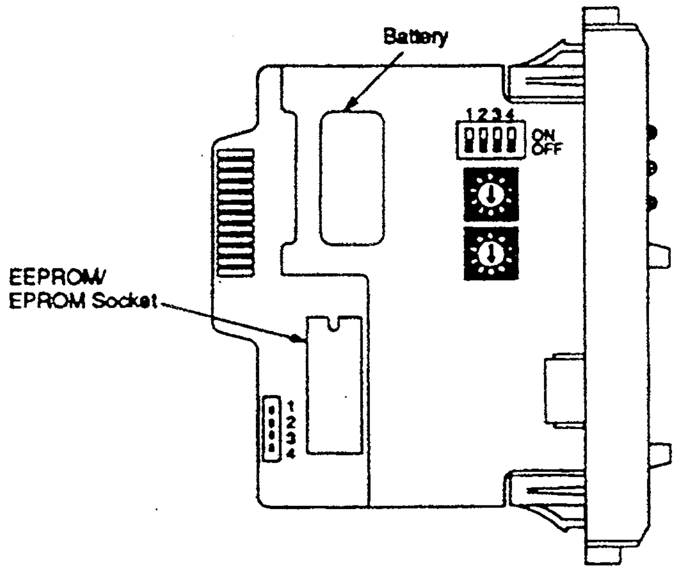


Figure 7-1 EPROM/EEPROM Socket Location

Table 7-1 Selecting Memory Type

	RAM	EEPROM	EEPROM Write Protected	EPROM
Memory IC Socket	Empty	28C64 Installed	28C64 Installed	27C256 Installed
Switch 2	1 2 3 4 ON OFF	1 2 3 4 ON OFF	1 2 3 4 ON OFF	1 2 3 4 ON OFF
Jumper Pin	1 2 3	1 2 3	1 2 3	1 2 3

Table 7-2 Selecting Retentive Control Relays

CR 340-373	Retentive	Non-Retentive
Switch 2	1 2 3 4 ON OFF	1 2 3 4 ON OFF

APPENDIX & NOTES

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

APPENDIX A: RECIRCULATING WATER FLOW

Tables A-1 and A-2 contain the recommended recirculating water flow rates to standard Turbo thermal storage units. All flow rates are based on a minimum 3 psig at the water inlet connection.

Minimum Flow
The flow required to fully wet the plate and maintain flow between the distribution pan and the plate surface. Failure to maintain minimum flow could result in insufficient water head in the distributor pan to maintain flow between the pan and plate. Reduced capacity and evaporator plate freeze-up will result.

Recommended Flow
This flow ensures the minimum flow is available to the plates with minimal losses due to dirty filter strainers, filters, heat exchanges, minimum variations in pump output, etc.

Maximum Flow
The flow at which the water distribution pan will not overflow. Splashing caused by high water discharge velocity from the water distribution header is reduced to a minimum. Splashing due to high water flow can result in ice build-up on piping and other components in the evaporator component.

Table A-1 HP Series Recirculating Water Flow Rates

MODEL	MINIMUM FLOW (GPM)	RECOMMENDED FLOW (GPM)	MAXIMUM FLOW (GPM)
HP 100	83	95	156
HP 150	125	144	234
HP 200	188	216	312
HP 300	250	287	468
HP 400	333	383	624
HP 600	500	575	936
HP 800	667	767	1248
HP 1000	834	959	1560
HP 1200	924	1063	1716
HP 1400	1008	1159	1872

TSTS-9036

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Table A-2 IGC Series Recirculating Water Flow Rates

MODEL	MINIMUM FLOW (GPM)	RECOMMENDED FLOW (GPM)	MAXIMUM FLOW (GPM)
IGC 55	306	360	612
IGC 65	306	360	612
IGC 80	408	480	816
IGC 100	510	600	1020
IGC 110	612	720	1224
IGC 130	612	720	1224
IGC 140	680	800	1360
IGC 160	816	960	1632
IGC 170	680	800	1360
IGC 175	816	960	1632
IGC 195	918	1000	1700
IGC 245	1200	1380	2400
IGC 300	1440	1656	2880

TSTS-9037

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

APPENDIX B: OIL RECOVERY SYSTEMS

Depending on the thermal storage unit configuration, one of two oil recovery systems will be utilized:

- gravity oil return system
- pressurized oil return system.

Note:
Some early model Turbo units utilized a gravity type system with a P-trap. This system has been phased out. Contact Turbo for information on this system.

Each system including typical operations is described below. Before reviewing each system, it should be noted that all systems are equipped with a suction accumulator/heat exchanger. This device is used to "collect" all liquid refrigerant and oil returning from the evaporators. A coil located inside the accumulator at the bottom provides a constant source of heat to evaporate the refrigerant and leave an oil rich mixture in the accumulator. Due to the wide range of operating conditions (including "upset" conditions), a separate oil recovery system with its own source of electrical resistance heat is also provided.

Gravity Oil Return System

Units which have enough static head to allow oil to go from the oil reservoir through the oil level float and into the crankcase will use the gravity oil return system. This system is shown in Figure B-1.

If the oil temperature thermostat (OTT) senses that the temperature of the oil in the oil reservoir is above the setpoint of the OTT, it will keep the oil reservoir heater (ORH) off. The oil reservoir solenoid (ORS) will stay open and the oil drain solenoid (ODS) will pulse. This will allow the oil to drain into the oil reservoir and then be supplied to the crankcase, as required by the oil float valve.

A hand expansion valve is located in the oil drain line from the accumulator to the oil pot. On the gravity oil return system, this valve is normally wide open to allow the oil to drain to the oil pot. It is also used as an isolation valve when servicing of the oil drain solenoid valve or strainer is required.

The temperature in the oil reservoir should be maintained between 85–100° F.

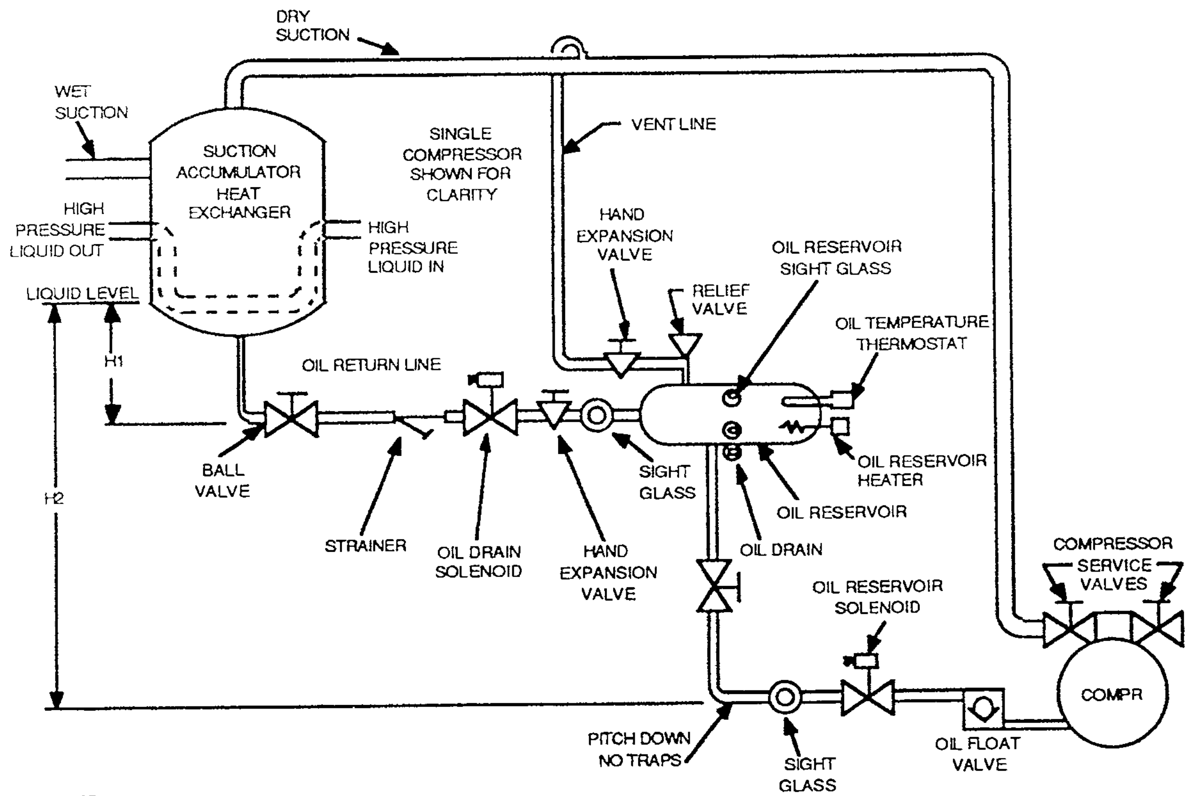
If the temperature of the oil in the reservoir drops below the setpoint of the OTT, the ORS and ODS will close, the ORH will energize to bring the oil temperature back up and the PC will start a timer. If the oil temperature rises above the setpoint of the OTT within 30 minutes, the PC timer will reset, and the unit will return to normal operation. If the temperature does not rise above the OTT setpoint within 30 minutes, the unit will shut down on a low oil temperature failure. In order for the unit to be restarted, the temperature of the oil in the reservoir must be raised above the setpoint of the OTT, and the MCS turned to the OFF/RESET position, and then back to either the 'manual' or 'auto' position. Before restarting, the heater (ORH) should be checked and replaced if it is defective.

Note:
The oil reservoir is equipped with a sight glass. Under normal operating conditions, oil should be observed in all sight glasses at all times.

IMPORTANT

At start-up or after service is performed, it may be necessary to add oil to the oil reservoir. Never operate the system without oil in the oil reservoir. Damage to the oil reservoir heater and/or compressor could result.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.



NOTE:
ARRANGEMENT IS THE SAME WITH BOTH THE VERTICAL (SHOWN) AND HORIZONTAL SUCTION ACCUMULATOR/HEAT EXCHANGERS.
H1 - VERTICAL HEIGHT REQUIRED TO ENSURE REFRIGERANT OIL MIXTURE WILL DRAIN TO OIL POT.
H2 - VERTICAL HEIGHT REQUIRED TO RETURN OIL TO COMPRESSOR THROUGH FLOAT VALVE (I.E. STATIC HEAD TO OVERCOME Δ P IN FLOAT VALVE, SOLENOID VALVE, AND PIPING).

Figure B-1 Gravity Oil Return System

Typically, the oil reservoir should be full at all times. Oil is removed from the oil reservoir through the crankcase float valve. Since only a small amount of oil is added to the compressor crankcase each time, only a small amount of refrigerant and oil from the accumulator is added to the oil reservoir. The large mass of warm oil already in the oil reservoir is used to absorb the mixture added and reduce the time required to bring it back up to temperature.

Note:
The refrigerant/oil mixture added is at suction temperature — typically 20–35° F.

Low watt density heaters are used to prevent overheating of the oil and burning of the oil on the heater element.

The hand expansion valve or ball valve in the vent line from the oil reservoir to the dry suction line is normally open only a few turns to ensure that the oil reservoir and suction accumulator/heat exchanger are equalized allowing the oil to drain. It is not necessary to open this valve all the way.

All safety pressure relief devices should be piped to a safe discharge location (refer to section 2. Safety).

Oil is returned to the compressor crankcase through an external mechanical float valve located on the side of the compressor. Most models are equipped with an adjustment screw to allow for minor adjustments of the oil level. As

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

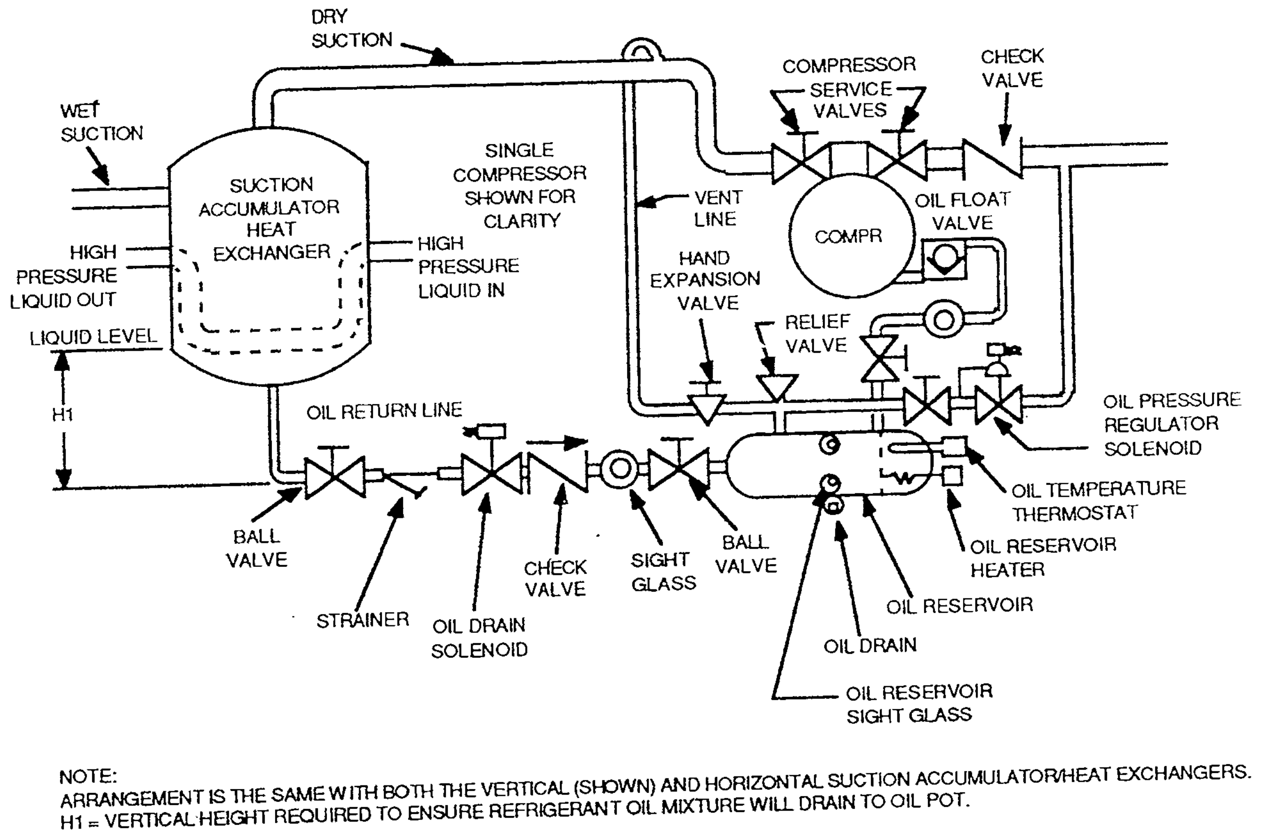


Figure B-2 Pressurized Oil Return System

the oil level in the float chamber of the oil float valve decreases, the float ball begins to drop and slowly open the valve to allow oil to flow. As the oil level in the float chamber increases, the float ball rises and closes the valve. The oil level is maintained by the travel of the float ball. A positive shut is obtained when the float chamber is full.

Pressurized Oil Return System

Units which cannot use the gravity oil return system because of physical constraints must use the pressurized oil return system. This is shown in Figure B-2. The only difference between the gravity and the pressurized oil return systems is that in the absence of enough static head to allow oil return through the oil float valve, the oil reservoir is periodically pressurized by energizing the oil pressure regulator solenoid (OPRS).

A line is connected from the high pressure discharge line through a downstream pressure regulator. Oil drains to the oil reservoir through the oil drain solenoid which is pulsed by the programmable controller based on the input of the oil temperature thermostat. As noted on the gravity oil return system, the oil reservoir is normally full and the oil reservoir heater remains on until the setpoint of the OTT is reached. Oil cannot drain to the oil float valve until the OTT allows the oil drain soloenoid valve to open. This prevents refrigerant rich oil from bypassing directly to the float valve.

The hand expansion valve in the oil drain line from the accumulator to the oil reservoir is normally wide open and is also used as an isolation valve when service of the oil drain solenoid valve or strainer is required.

Unlike the gravity oil return system, the hand expansion valve in the vent line from the oil reservoir to the dry suction must not be opened all the

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

way. The valve should be opened only one turn or less to prevent liquid from being discharged through the vent line when the pressure regulator is energized.

IMPORTANT

If the pressure regulator is not properly adjusted (too high) and the vent valve is wide open, the refrigerant/oil mixture will be returned through the suction line to the compressor. Slugging of the compressor could result and damage to the compressor could occur.

To pressurize the oil reservoir, a downstream pressure regulator with electric shut-off is used. When the pilot coil is deenergized, the regulator provides a positive shut-off. Through the programmable controller, the coil is energized. In this condition, the valve acts as a downstream pressure regulator to increase the pressure in the oil reservoir. The regulator should be set approximately 5–10 psig above the highest normal suction pressure the system will operate at. In this manner, sufficient pressure is provided to push the oil out of the oil reservoir to the float valve without excessive pressure driving oil out of the vent line.

For example, if the system operates at a 20° F evaporator (43 psig) in the icemaking mode and 35° F (62 psig) in the chiller mode, the pressure regulator should be set at approximately 72 psig. If the unit operates only as an icemaker, then the setting would be 53 psig.

IMPORTANT

If the pressure regulator is set too high (above 85 psig) on multiple compressor models, and a compressor is inactive, it is possible to force oil past the inactive float valve. This results in the filling of the inactive compressor crankcase and loss of oil to the active compressor(s). Failure to properly adjust the vent line valve and the pressure regulator could result in damage to the compressor.

When oil is draining from the accumulator to the oil reservoir, a small trickle of fluid should be observed in the oil return line sight glass. The same flow should be observed in the oil line to the float valve when the pressure regulator is energized. Flow in this line will stop when the oil float valve chamber is full. Oil is metered back to the compressor in the same manner as the gravity system (i.e. as the float ball drops, oil is added and as the float ball rises in the float chamber, the flow is closed off to maintain an oil level). Adjustable float valves are also used on the pressurized oil return systems.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

APPENDIX B: *Revised 2/93*
OIL RECOVERY SYSTEMS

Depending on the thermal storage unit configuration, one of three oil recovery systems will be utilized:

- gravity oil return with mechanical float
- gravity oil return with electronic level control
- pressurized oil return system.

Note:
Some early model Turbo units utilized a gravity type system with a P-trap. This system has been phased out. Contact Turbo for information on this system.

Each system including typical operations is described below. Before reviewing each system, it should be noted that all systems are equipped with a suction accumulator/heat exchanger. This device is used to "collect" all liquid refrigerant and oil returning from the evaporators. A coil located inside the accumulator at the bottom provides a constant source of heat to evaporate the refrigerant and leave an oil rich mixture in the accumulator. Due to the wide range of operating conditions (including "upset" conditions), a separate oil recovery system with its own source of electrical resistance heat is also provided.

Gravity Oil Return System – Electronic and Mechanical

Units which have enough static head to allow oil to go from the oil reservoir and into the crankcase will use the gravity oil return system.

If the oil temperature thermostat (OTT) senses that the temperature of the oil in the oil reservoir is above the setpoint of the OTT, it will keep the oil reservoir heater (ORH) off. The oil reservoir solenoid (ORS) will stay open and the oil drain solenoid (ODS) will pulse. This will allow the oil to drain into the oil reservoir and then be supplied to the crankcase, as required by the oil float valve.

A ball valve is located in the oil drain line from the accumulator to the oil pot. On the gravity oil return system, this valve is normally wide open to allow the oil to drain to the oil pot. It is also used as an isolation valve when servicing of the oil drain solenoid valve or strainer is required.

The temperature in the oil reservoir should be maintained between 85–100° F.

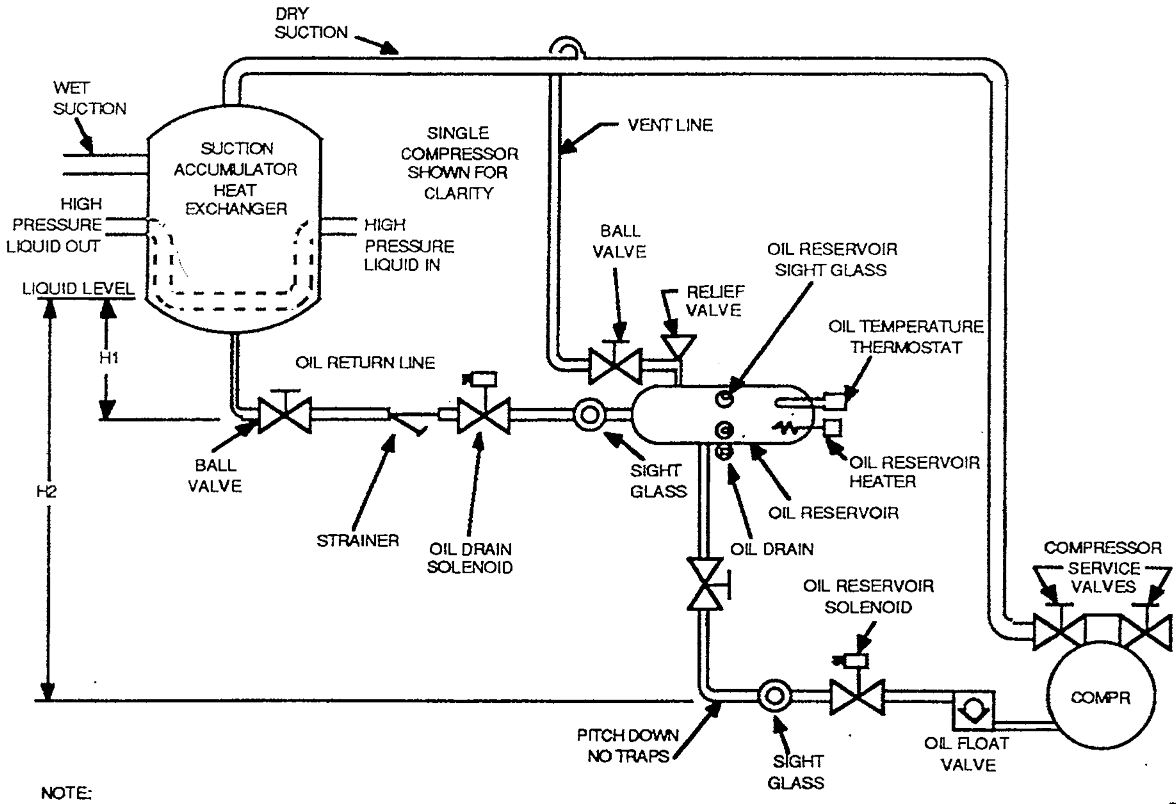
If the temperature of the oil in the reservoir drops below the setpoint of the OTT, the ORS and ODS will close, the ORH will energize to bring the oil temperature back up and the PC will start a timer. If the oil temperature rises above the setpoint of the OTT within 30 minutes, the PC timer will reset, and the unit will return to normal operation. If the temperature does not rise above the OTT setpoint within 30 minutes, the unit will shut down on a low oil temperature failure. In order for the unit to be restarted, the temperature of the oil in the reservoir must be raised above the setpoint of the OTT, and the MCS turned to the OFF/RESET position, and then back to either the 'manual' or 'auto' position. Before restarting, the heater (ORH) should be checked and replaced if it is defective.

Note:
The oil reservoir is equipped with a sight glass. Under normal operating conditions, oil should be observed in all sight glasses at all times.

IMPORTANT

At start-up or after service is performed, it may be necessary to add oil to the oil reservoir. Never operate the system without oil in the oil reservoir. Damage to the oil reservoir heater and/or compressor could result.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.



NOTE:
ARRANGEMENT IS THE SAME WITH BOTH THE VERTICAL (SHOWN) AND HORIZONTAL SUCTION ACCUMULATOR/HEAT EXCHANGERS.
H1 - VERTICAL HEIGHT REQUIRED TO ENSURE REFRIGERANT OIL MIXTURE WILL DRAIN TO OIL POT.
H2 - VERTICAL HEIGHT REQUIRED TO RETURN OIL TO COMPRESSOR THROUGH FLOAT VALVE (I.E. STATIC HEAD TO OVERCOME ΔP IN FLOAT VALVE, SOLENOID VALVE, AND PIPING).

Figure B-1 Gravity Oil Return System With Mechanical Float

Typically, the oil reservoir should be full at all times. Oil is removed from the oil reservoir through the crankcase float valve. Since only a small amount of oil is added to the compressor crankcase each time, only a small amount of refrigerant and oil from the accumulator is added to the oil reservoir. The large mass of warm oil already in the oil reservoir is used to absorb the mixture added and reduce the time required to bring it back up to temperature.

Note:
The refrigerant/oil mixture added is at suction temperature — typically 20–35° F.

Low watt density heaters are used to prevent overheating of the oil and burning of the oil on the heater element.

The ball valve in the vent line from the oil reservoir to the dry suction line is normally wide open to ensure that the oil reservoir and suction accumulator/heat exchanger are equalized allowing the oil to drain. It is not necessary to open this valve all the way.

All safety pressure relief devices should be piped to a safe discharge location (refer to section 2. Safety).

Gravity Oil Return System With Mechanical Float

Refer to Figure B-1. Oil is returned to the compressor crankcase through an external mechanical float valve located on the side of the compressor.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

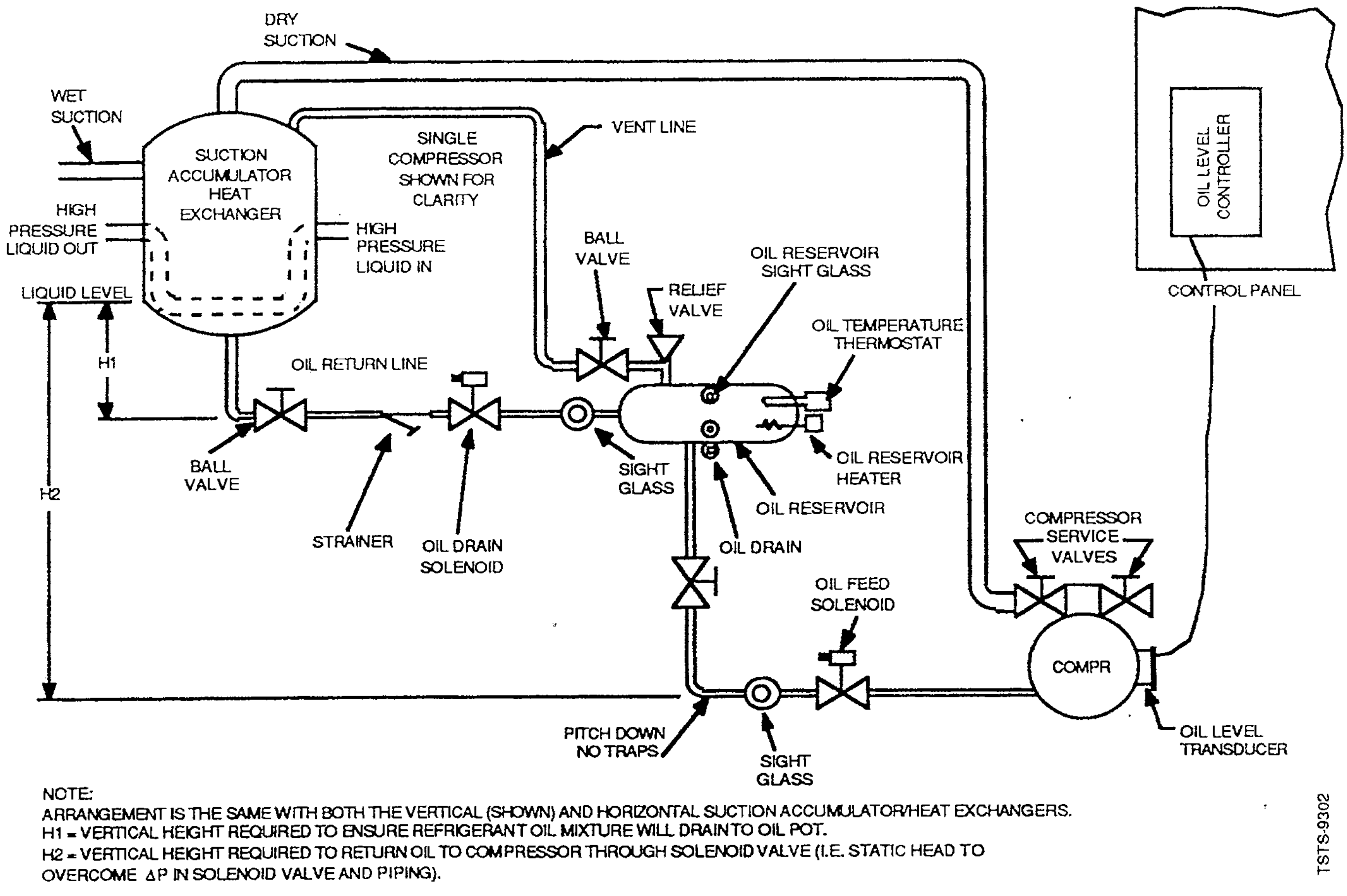


Figure B-2 Gravity Oil Return System With Electronic Level Control

Most models are equipped with an adjustment screw to allow for minor adjustments of the oil level. As the oil level in the float chamber of the oil float valve decreases, the float ball begins to drop and slowly open the valve to allow oil to flow. As the oil level in the float chamber increases, the float ball rises and closes the valve. The oil level is maintained by the travel of the float ball. A positive shut is obtained when the float chamber is full.

Gravity Oil Return With Electronic Level Control

Refer to Figure B-2. The crankcase oil level required by the compressor is set at the oil level controller. This setting is electronically compared with the level signal received from the oil level transducer that is mounted on the side of the compressor. If the level of oil in the compressor is below the setpoint of the controller, the controller will pulse the oil feed solenoid, allowing oil to flow into the crankcase from the oil receiver until the level reaches the setpoint.

The oil level controller incorporates time delays that prevent momentary low level conditions from overfilling the crankcase.

The oil level in the crankcase is adjusted on the oil level controller by setting the angle of the "adjustment arrow" on the potentiometer to the corresponding mark on the controller faceplate. To increase the

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

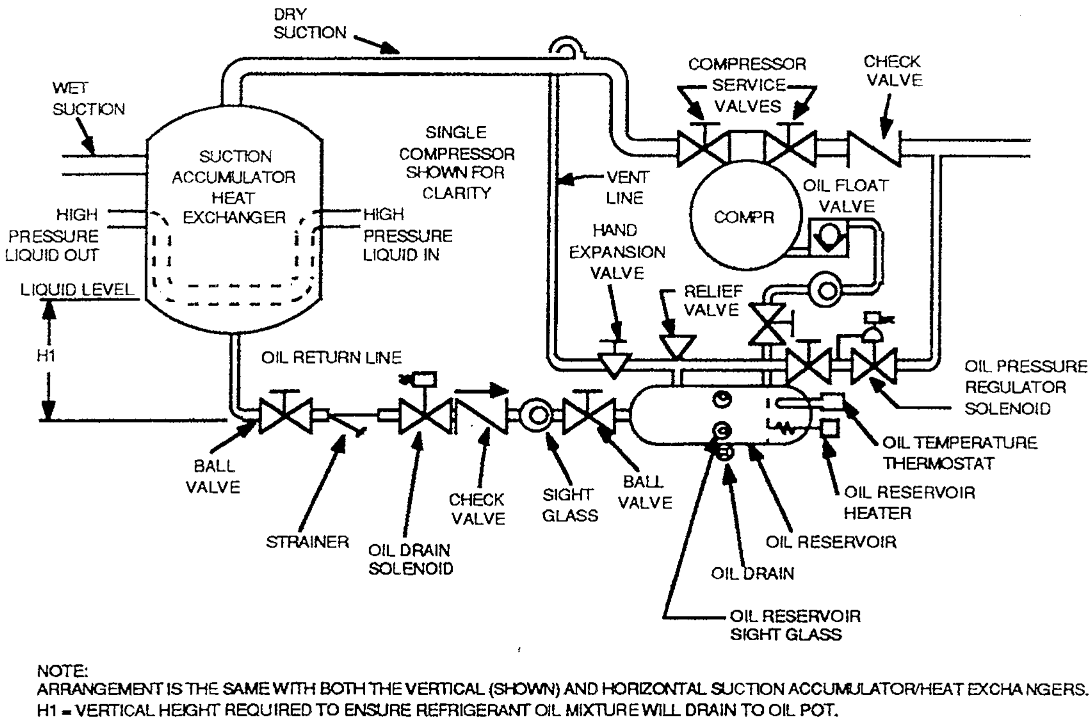


Figure B-3 Pressurized Oil Return System

oil level, turn the adjusting screw to a higher level indication.

The electronic oil level controller can control the oil level on up to four different compressors.

Pressurized Oil Return System

Units which cannot use the gravity oil return system because of physical constraints must use the pressurized oil return system. This is shown in Figure B-3. The only difference between the gravity and the pressurized oil return systems is that in the absence of enough static head to allow oil return through the oil float valve, the oil reservoir is periodically pressurized by energizing the oil pressure regulator solenoid (OPRS).

A line is connected from the high pressure discharge line through a downstream pressure regulator. Oil drains to the oil reservoir through the oil drain solenoid which is pulsed by the programmable controller based on the input of the oil temperature thermostat. As noted on the gravity oil return system, the oil reservoir is normally full and the oil reservoir heater remains on until the setpoint of the OTT is reached. Oil cannot drain to the oil float valve until the OTT allows the oil drain solenoid valve to open. This prevents refrigerant rich oil from bypassing directly to the float valve.

The hand expansion valve in the oil drain line from the accumulator to the oil reservoir is normally wide open and is also used as an isolation valve when service of the oil drain solenoid valve or strainer is required.

Unlike the gravity oil return system, the hand expansion valve in the vent line from the oil reservoir to the dry suction must not be opened all the way. The valve should be opened only one turn or less to prevent liquid from bein' discharged through the ven. line when the pressure regulator is energized.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

IMPORTANT

If the pressure regulator is not properly adjusted (too high) and the vent valve is wide open, the refrigerant/oil mixture will be returned through the suction line to the compressor. Slugging of the compressor could result and damage to the compressor could occur.

To pressurize the oil reservoir, a downstream pressure regulator with electric shut-off is used. When the pilot coil is deenergized, the regulator provides a positive shut-off. Through the programmable controller, the coil is energized. In this condition, the valve acts as a downstream pressure regulator to increase the pressure in the oil reservoir. The regulator should be set approximately 5–10 psig above the highest normal suction pressure the system will operate at. In this manner, sufficient pressure is provided to push the oil out of the oil reservoir to the float valve without excessive pressure driving oil out of the vent line.

For example, if the system operates at a 20° F evaporator (43 psig) in the icemaking mode and 35° F (62 psig) in the chiller mode, the pressure regulator should be set at approximately 72 psig. If the unit operates only as an icemaker, then the setting would be 53 psig.

IMPORTANT

If the pressure regulator is set too high (above 85 psig) on multiple compressor models, and a compressor is inactive, it is possible to force oil past the inactive float valve. This results in the filling of the inactive compressor crankcase and loss of oil to the active compressor(s). Failure to properly adjust the vent line valve and the pressure regulator could result in damage to the compressor.

When oil is draining from the accumulator to the oil reservoir, a small trickle of fluid should be observed in the oil return line sight glass. The same flow should be observed in the oil line to the float valve when the pressure regulator is energized. Flow in this line will stop when the oil float valve chamber is full. Oil is metered back to the compressor in the same manner as the gravity system (i.e. as the float ball drops, oil is added and as the float ball rises in the float chamber, the flow is closed off to maintain an oil level). Adjustable float valves are also used on the pressurized oil return systems.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

APPENDIX C:

WATER REGULATING VALVE (SC MODELS ONLY) THREE-WAY VALVE

Figure 3-40 on page 97 (in section 3 of this manual) illustrates a means of controlling the water regulating valves on multiple condenser installations. Operation where one or more condensers is inactive means that water flow to that circuit is no longer required. This requires that either a pump for each condenser must be installed or some means of bypassing the inactive circuit is provided.

Figure C-1 shows a typical single circuit machine with a three-way water regulating valve. In this arrangement, a constant water flow is maintained through the water-cooled condenser. The three-way valve modulates to return the water to the cooling tower or recirculates the flow to bypass the cooling tower. Water temperature entering the condenser varies and the flow remains the same.

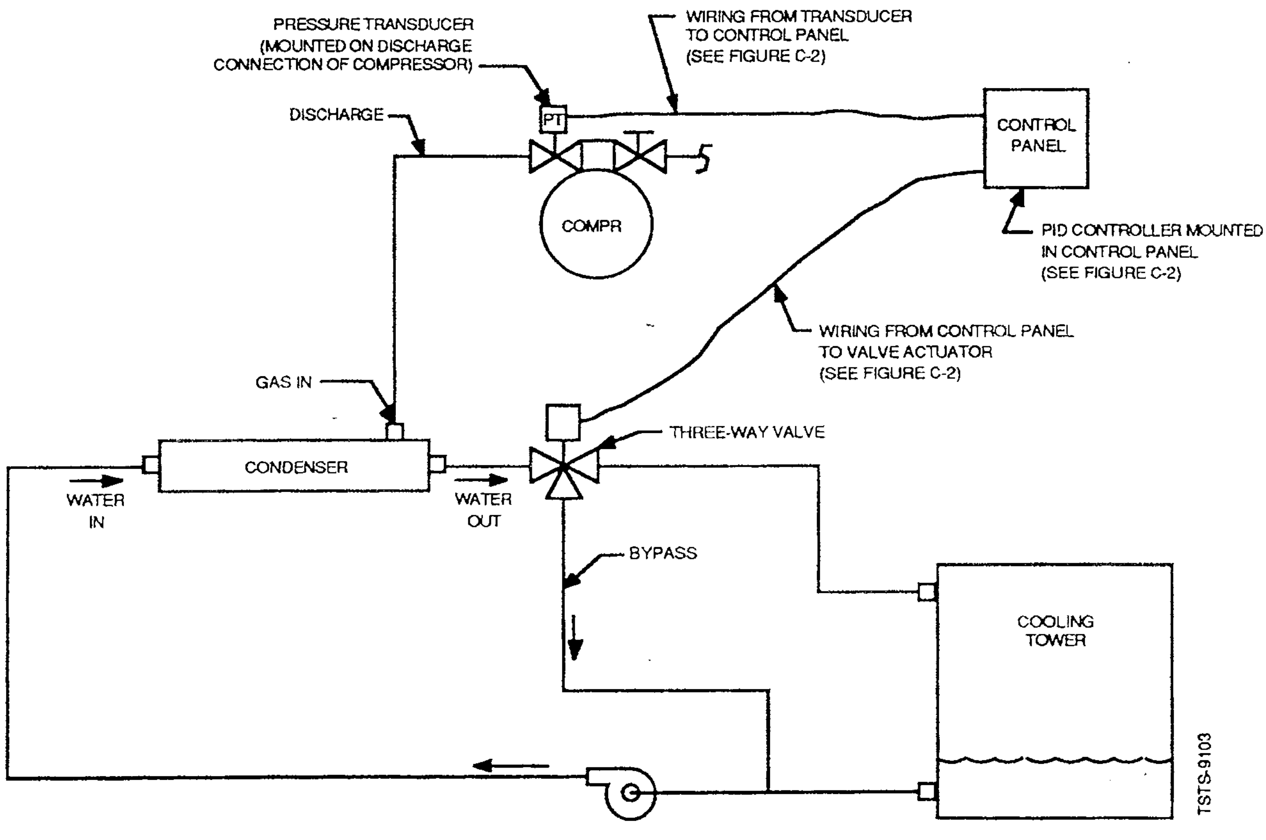


Figure C-1 Condenser With Three-Way Water Regulating Valve

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

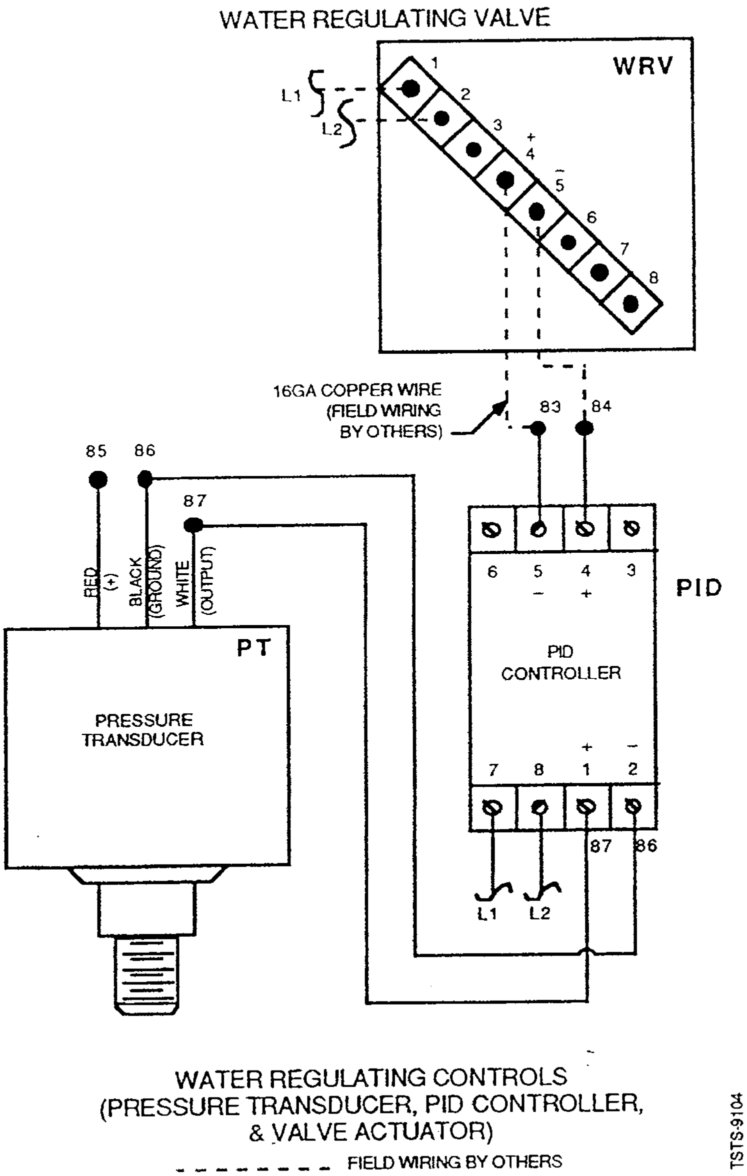


Figure C-2 Water Regulating Controls

A signal from a pressure transducer mounted on the discharge service valve is transmitted to a PID controller located in the control panel (refer to Figure C-2).

The controller drives a valve actuator to open or close the valve as required. For example, if the pressure transducer senses an increase in pressure, the controller will open the port to the cooling tower and close the bypass port. Flow to the cooling tower increases and lower temperature water is supplied to the condenser inlet to lower the discharge pressure. On the other hand, if the discharge pressure starts to decrease, flow to the cooling tower is restricted and the bypass flow is increased to raise the temperature of the water. Continuous modulation of the valves maintains the discharge pressure at the controller setpoint.

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Multiple condenser installations can be set up the same (refer to Figure C-3). Operation of each circuit is the same as described above. If a circuit (compressor) is inactive, the pressure transducer will sense the decrease in pressure as the compressor cools and equalizes. After the valve actuator reduces the flow from the inactive condenser, the active condensers continue to modulate to control the entering water temperature to the active condensers.

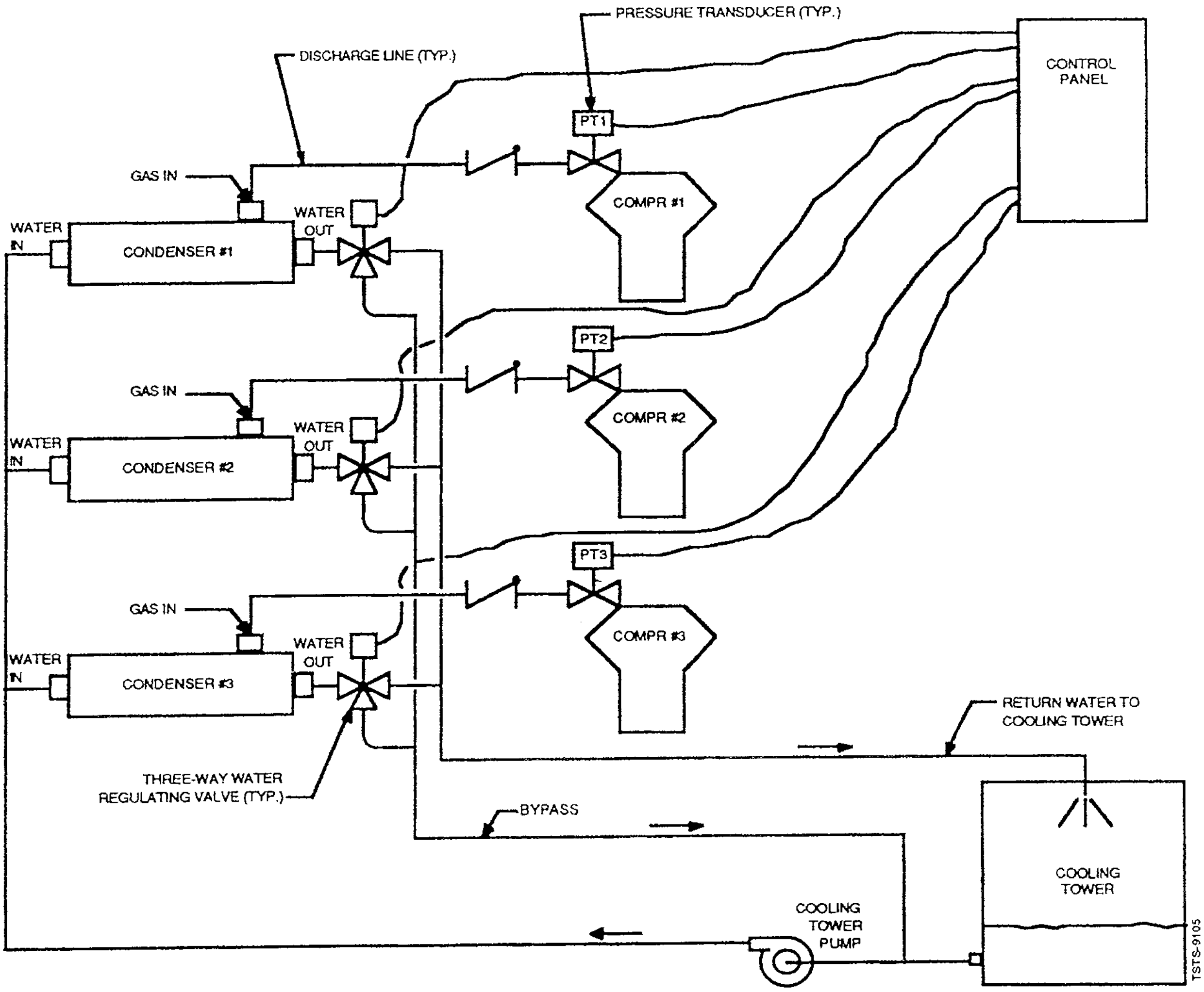


Figure C-3 Multiple Condenser Installation With Three-Way Water Regulating Valves

Read Safety Section before this section. Failure to carefully follow these instructions could result in permanent injury or loss of life.

APPENDIX D: CASSETTE RECORDER OPERATION

IMPORTANT

It is wise to make a tape copy of the program existing in memory before erasing it to load the new program.

Introduction

The programs used for TURBO programmable controllers may be stored on standard audio cassette tapes. It is wise to keep a tape copy of the program handy in the event that the CPU either becomes defective, or somehow loses its memory.

Items Required For Tape Operation

Hand Held Programmer

This includes the key for the hand held programmer, along with the audio cable which is gray with a red tracer.

Audio Cassette Recorder

This is a standard size cassette tape recorder which has a microphone jack, earphone jack, and a volume control. Optionally, this should have a digital counter.

Standard Audio Cassette Tape (Type I)

The "micro cassette" tapes generally do not have the audio quality required and should not be used.

Common Problem

The most common problem incurred during Tape Operation is confusion over the proper key to depress on the hand held programmer. The shifted function keys on the programmer are shown in Figure D-1. The shifted function always corresponds to the key directly below it.

Tape Operation

Save/Record A Program Onto Tape (WRITE)

1. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

2. Turn the mode switch on the Programmer to the LOAD position.

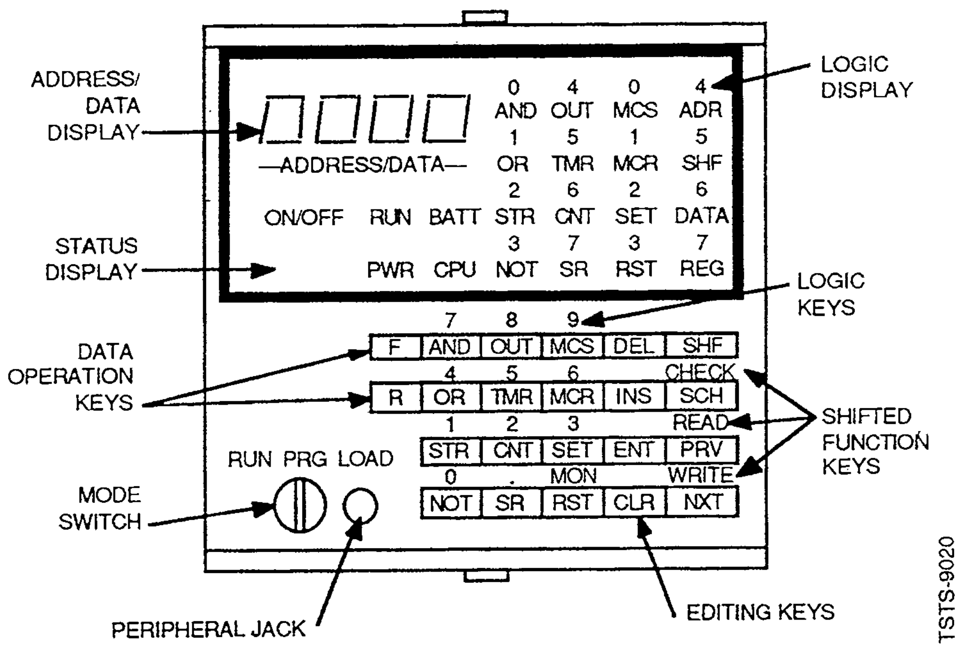


Figure D-1 Programmer Features

3. Connect the Programmer (TAPE port) to the tape recorder (MICROPHONE input) with the audio cable (gray with red tracer).

4. Rewind the tape to the beginning or to the desired record position if multiple programs are to be placed on one tape. Programs require approximately 1.5 to 4 minutes of tape per program. Note counter position.

5. For identification of a program, if desired, enter a four digit number (0000-9999) on the Programmer. When tape is accessed later to load the CPU, this number can be used to identify the correct program prior to altering CPU data. If a program number is not as expected, the operator can terminate the load operation and get the correct tape without loss of the existing program or delay incurred by loading a wrong program. THIS IDENTIFICATION NUMBER IS OPTIONAL.

6. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

7. Begin the tape recorder operation by depressing the RECORD PLAY buttons.

8. Depress the WRITE key on the Programmer. The record operation will now begin.

9. The ON/OFF light on the Programmer will come on.

10. When the record is complete, the Programmer will display End in the Address/Data display and the ON/OFF LED will be off. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

11. Depress the CLR (Clear) key on the Programmer to end the record operation.

12. It is recommended that the tape be rewound to where the recording began and that the "Check A Program" (described later) be performed to ensure data integrity.

Load A Program Onto CPU (READ)

1. Prior to loading a program onto the CPU, the existing program must be cleared from the CPU memory. To do this, turn the mode switch to the PRG mode and press the following key sequence:

   CLR SHF 348 DEL NXT NXT

   The program has now been cleared from the CPU.

2. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

3. Turn the mode switch on the Programmer to the LOAD position.

4. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

5. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if applicable).

6. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

7. Depress the READ key on the Programmer.

8. Begin the tape recorder operation by depressing the PLAY button.

9. The Address/Data screen of the Programmer will flash an E28 briefly.

10. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

11. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a program number different from the one entered in step 5, the Address/Data screen of the programmer will display PASS.

12. When the load is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

13. Depress the CLR (Clear) key on the Programmer to end the record operation.

Check A Program With The Tape Copy (CHECK)

1. Install the Programmer onto the CPU. Verify that the programmable controller has AC power.

2. Turn the mode switch on the Programmer to the LOAD position.

3. Connect the Programmer (TAPE port) to the tape recorder (EARPHONE input) with the audio cable (gray with red tracer).

4. Rewind the tape to the beginning of a previously recorded program. Enter the program identification number (if previously recorded).

5. Adjust the volume setting on the tape recorder to approximately 75% of the maximum setting. If a tone control is available, adjust it to 75% of the maximum setting.

6. Depress the CHECK key on the Programmer.

7. Begin the tape recorder operation by depressing the PLAY button.

8. The Address/Data screen of the Programmer will flash an E28 briefly.

9. The LED corresponding to the 7/REG on the lower right hand side of the Programmer will light up for approximately 10 to 15 seconds.

10. The Address/Data screen of the Programmer will display an F when the program has been found. If the CPU detects a mismatch between the contents of the tape and the CPU logic, the Address/Data screen of the programmer will display E25. A steady E28 indicates that the play level of the recorder is wrong. The CHECK operation should be stopped, the volume/tone re-adjusted, and the operation restarted.

11. When the check is complete with no errors, the Programmer will display END in the Address/Data display. Stop the recorder and note the counter position so that the amount of tape used for that program can be determined.

12. Depress the CLR (Clear) key on the Programmer to end the record operation.

TURBO®

Service Bulletin
October 1993

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Water Distribution System Flat Bottom Pans

Product Lines

- TIG/TIGAR Industrial Models
- HP and IGC Thermal Storage Models

V-Bottom Water Distribution System

Prior to the development and testing of the flat bottom pans, a V-bottom water distribution system has been utilized. Refer to Figure 1. This system consisted of a stainless steel V-bottom water distribution pan and PVC water distribution header for each bank of evaporator plates. This system provided water distribution to each evaporator plate in the plate bank and filtration of debris from the circulating water system. Due to the "corrugated" construction of the pan, cleaning debris that collected in the pan was difficult. Due to the wide range of flow rates and water levels in the pans, splashing was a possibility if the pans were not clean. Splashing contributes to freeze-up problems if not corrected and frequent cleaning was often required in debris prone systems.

Flat Bottom Pan System

The new flat bottom pan design eliminates these problems. Refer to Figure 2. A stainless steel water distribution pan and PVC water distribution header are still the standard materials used, but the new design has provided improvements in several areas:

- Cleaning is much easier due to the flat design of the pan.
- A cleanable media material pad has been added to filter out debris before it gets to the holes in the water distribution pan which makes maintenance and cleaning easier.
- The media pad reduces the possibility of splashing, thus reducing the mist that can cause freeze-ups.
- USDA approval is pending on the media pad.
- Cleaning is as simple as removing the media pad and washing it out. The media pad is cleanable and reusable. If you want to shorten your cleaning time even more, keep a spare media pad available for each pan. Pull the dirty media pad out and insert the clean media pad. Clean the dirty media pad and store for the next clean up. Replacement media pads will be about $15 each (list price).
- Since the area in the media pad is many times the cross sectional area of the holes in the pans, frequency of cleaning is much less. In severe cases, it may change from weekly cleaning to every four months or longer.
- The media pad is treated to prevent the growth of bacteria even with the longer interval between cleaning. *Note:* In USDA applications, regular cleaning is recommended.
- The PVC water distribution system and header reduce splash and are easily removed and dismantled for cleaning.
- The new design improves performance by increasing the wetted surface area of the evaporator plate while decreasing misting and splash. Both contribute to increased reliability.

Effective Date

The flat bottom pan will be standard equipment on the models listed beginning in November 1993.

Retrofit

Existing TIG/TIGAR, HP, and IGC models built with V-notch water distribution pans can be converted to flat bottom pan systems. The factory should be consulted for pricing. Most systems can be converted for approximately $750 per pan assembly. Each assembly consists of the flat bottom pan and the PVC water distribution header. Typical systems consist of three to ten pan assemblies per unit.

Technical Information

Water flow requirements remain the same. Minimum, recommended, and maximum flow rates remain the same as previously published, although the new system allows for a greater reduction (flow shortage) before splashing and freeze-ups become a problem.

On flat bottom pan water systems, the filter material is not optional. The material must be in place for proper water distribution.

A float level is available to monitor the water level in the water distribution pan. Should water flow be decreased for some reason, the flow switch will turn off the machine. This is available as an option. Please consult the factory for details.

Additional Information

Contact: Henry Vogt Machine Company
Refrigeration Division – Turbo Refrigerating
Aftermarket Sales/Service Department

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

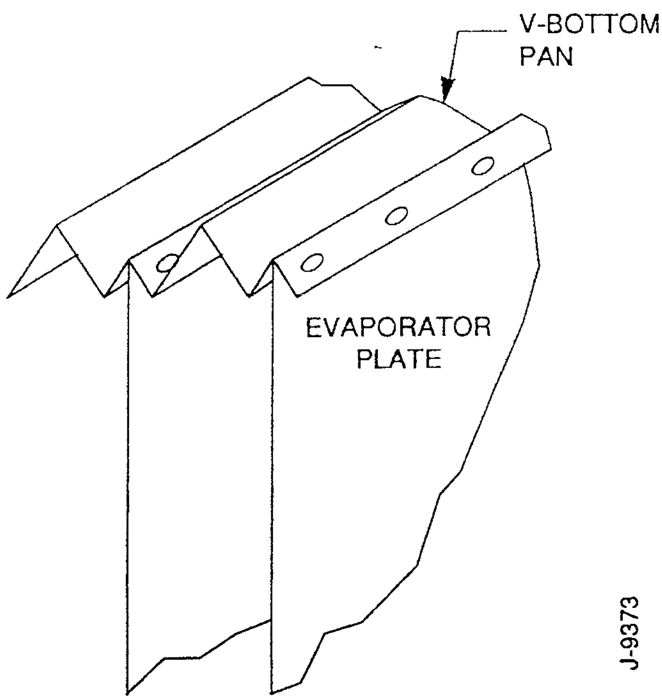


Figure 1 Typical V-Notch Pan Section

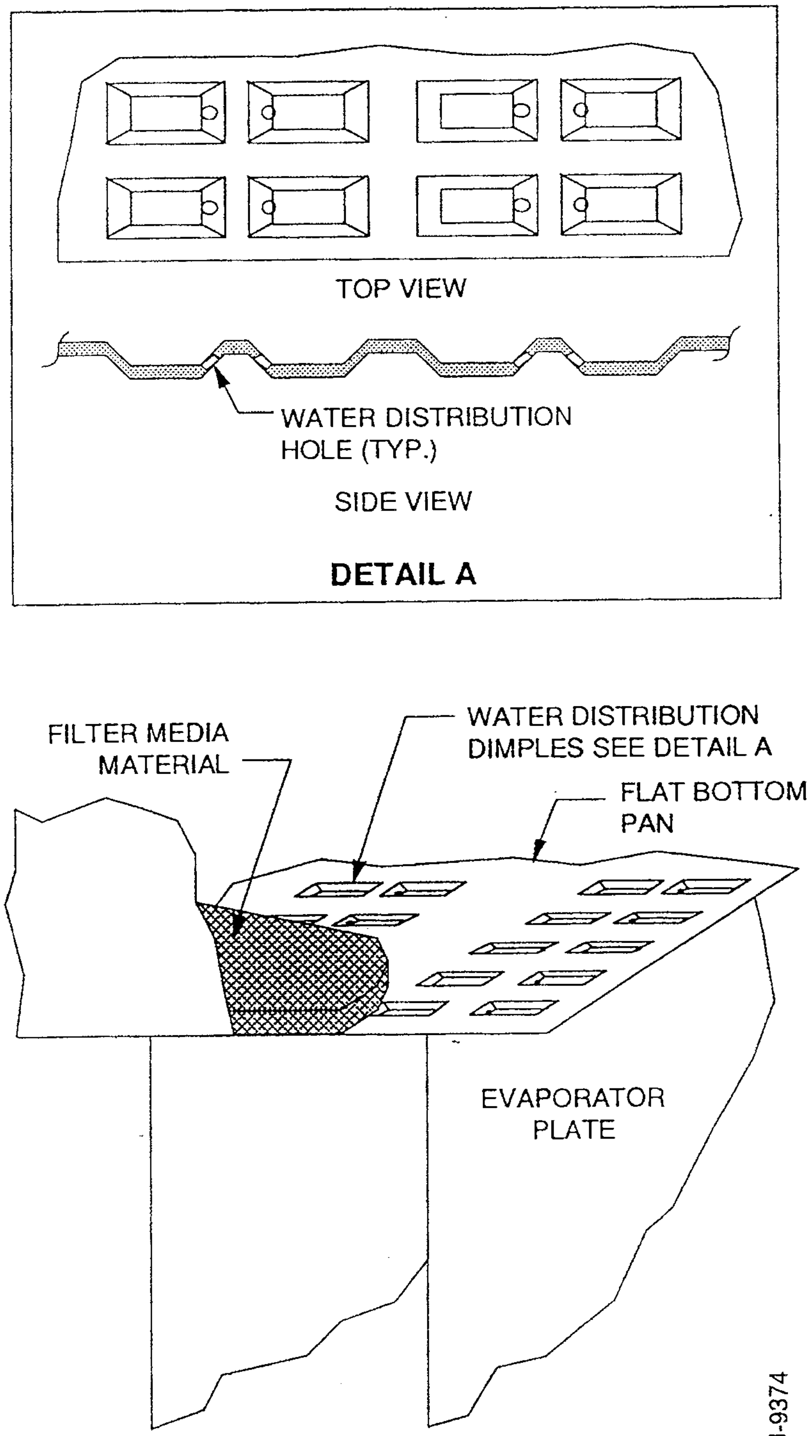


Figure 2 Typical Flat Bottom Pan Section With A Section Of Filter Media Pad

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SERVICE BULLETIN

MARCH 1994

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Flat Bottom Pan Water Distribution Header:

Flow Control Orifice Ring Assembly Installation and Adjustment Instructions

A flow control orifice assembly is installed in the inlet connection to each of the PVC spray headers providing water to the water distribution pan. Refer to Figure 1. As shipped, the orifice ring assembly is set for maximum flow (full open). Refer to Figure 2. During start-up of the system, adjustment of the orifice ring assembly may be required to obtain the desired flow to the water distribution pan without overflowing the pan.

REMOVING THE ORIFICE RING ASSEMBLY

1. Loosen the hose clamps on both ends of the radiator hose connecting the spray header to the main water distribution header.
2. Slide the hose down the PVC spray header inlet connection until the orifice ring assembly is accessible for removal.
3. Remove the orifice ring assembly.

ADJUSTING THE ORIFICE RING ASSEMBLY

1. Loosen the nut holding the three PVC rings together.
2. Rotate one (or two, if required) of the rings (clockwise or counterclockwise) to reduce the free opening through the assembly. To increase the flow, rotate the rings to increase the free area. Refer to Figure 2. To decrease the flow, rotate the rings to decrease the free area. Refer to Figure 3.
3. Tighten the nut to secure the setting of the orifice ring assembly.

INSTALLING THE ORIFICE RING ASSEMBLY

1. Replace the orifice ring assembly in the opening between the main water header and the spray header inlet connection.

   Note: Install the orifice ring assembly with either the nut or bolt head on the inlet side of the flow.
2. Slide the hose connection over the orifice ring assembly and on to the main water header connection stub.
3. Secure the two hose clamps on the main header side.
4. Push the PVC spray header inlet toward the main water header to ensure that the orifice ring assembly is wedged between the PVC connections (i.e., the orifice ring assembly cannot move between the two ends of the PVC pipe).
5. Secure the two hose clamps on the spray header inlet connection while holding pressure against the spray header inlet connection to ensure that the orifice ring assembly remains in place while tightening the clamps.

After completing adjustments, restart the system and observe the flow. If required, repeat the procedure until the desired flow is obtained. If you have any questions, contact:

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

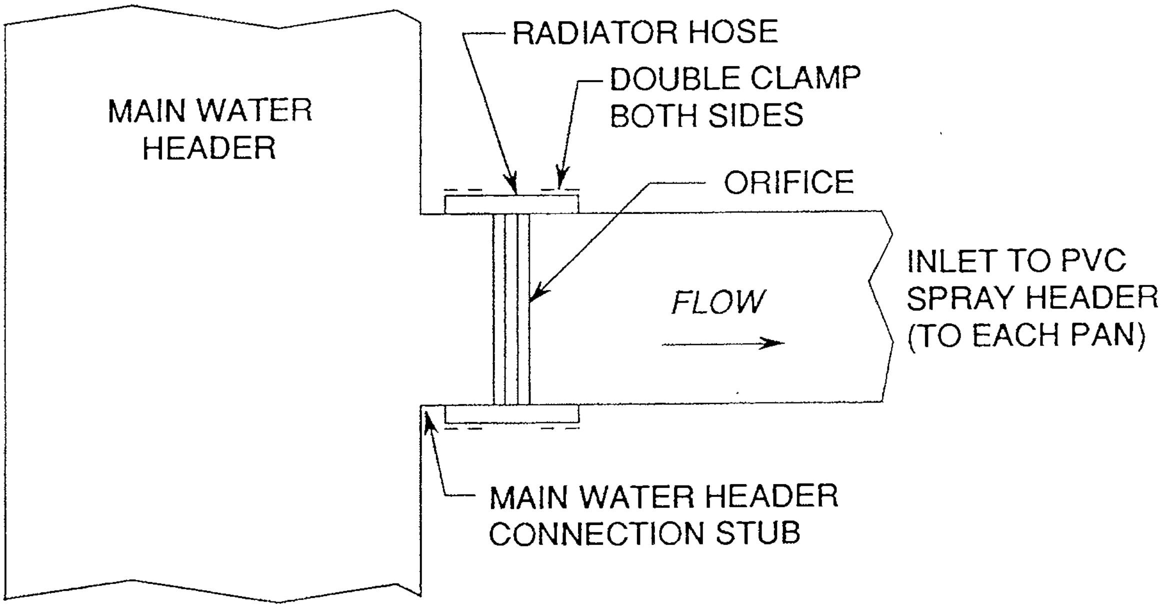

Figure 1
INSTALLATION LOCATION

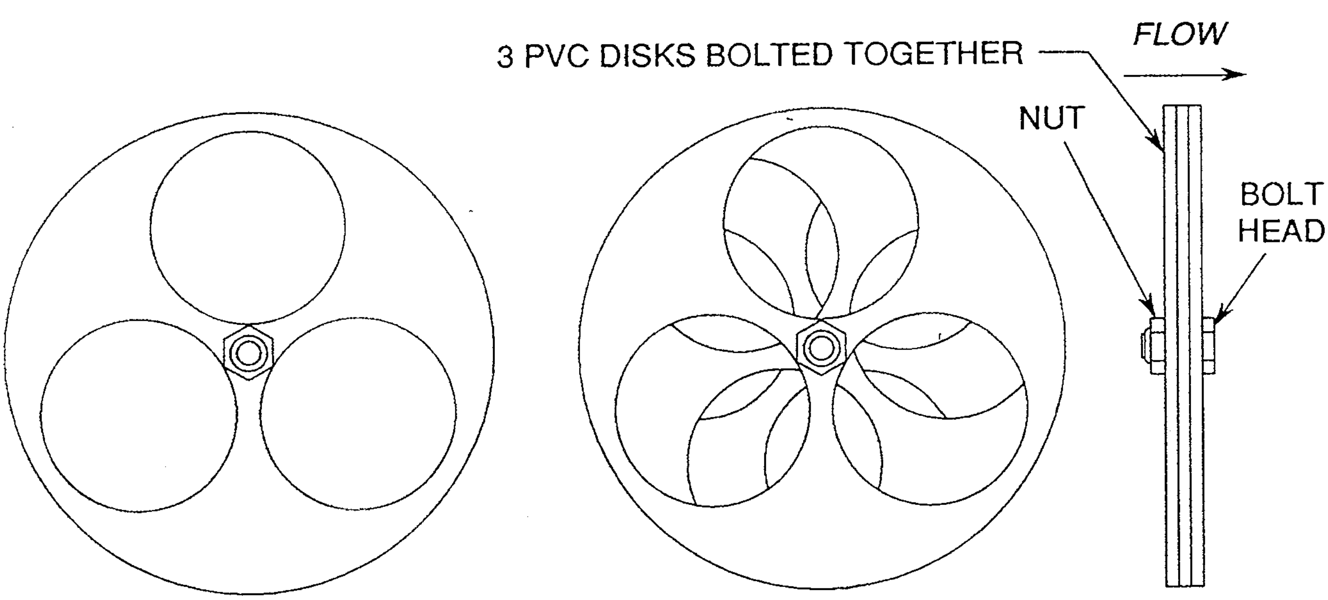

Figure 2
MAXIMUM FLOW ADJUSTMENT

Figure 3
MINIMUM FLOW ADJUSTMENT

SIDE VIEW

TURBO®

TECHNICAL BULLETIN
AUGUST 1994

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1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Vessel & Piping Insulation Guidelines

TURBO provides a variety of refrigerant vessels and refrigerant piping with insulation to control condensation and heat infiltration. TURBO uses a black, closed cell, rubber insulation material (similar to Armaflex®) secured to the vessel or piping with an adhesive.

No other material or jacketing is supplied over the insulation material because of:

- Variations in jacketing materials to match other jacketed piping or vessels in the installation.
- Possible damage during shipment or installation.

The insulation material provided by TURBO does not require jacketing on most installations, but jacketing is recommended:

- Where the insulation material is exposed to direct sunlight (outdoor installations).
- Where ultraviolet light will cause the insulation material to become brittle.
- Where the insulation material is exposed to cleaning agents or contact by personnel performing normal maintenance and service work on indoor or outdoor installations.

TURBO does not provide jacketing as a standard, but it can be provided as an option. Quotes can be obtained for individual requirements and will vary according to the type of jacketing requested (i.e., fiberglass, stainless steel, or aluminum). Alternate insulation materials (plaster, rigid or flexible foam, fiberglass, and other rubber products) can be quoted for special order. TURBO may choose not to provide some requested jacket or insulation materials due to application methods and/or incompatibility with other materials or fluids used in or around the equipment.

Insulation On Equipment Exterior Piping & Vessels:

- Equipment may be ordered without insulation on exterior piping or components.

Insulation On Equipment Interior Piping & Vessels:

- Insulation of certain piping or vessels inside the icemaker or ice generator is factory installed because insulation of such areas may not be practical in the field. Areas in which insulation is provided are listed below.
- Jacketing and alternate insulation materials for interior piping and vessels are available as options.

FACTORY INSULATED PIPING & VESSELS: AMMONIA SYSTEMS APPLICATIONS

<u>CAR Models</u>

- Evaporator refrigerant suction and liquid line piping
- Recirculating water suction and discharge lines in the lower section only (upper water piping is not insulated)

<u>CAR-LR Models</u>

- Evaporator refrigerant suction piping
- Built-in recirculator vessel and piping
- Recirculating water suction and discharge lines in the lower section only (upper water piping is not insulated)

TIGAR Models

- Evaporator refrigerant suction and liquid line piping
- Recirculating water suction and discharge lines in the lower section only (upper water piping is not insulated)
- High side skids refrigerant suction piping
- Refrigerant recirculation system (if supplied)

Packaged Chillers (units with factory installed high side and/or refrigerant recirculation units)

- External refrigerant piping
- Refrigerant recirculation vessel (if supplied)
- High side refrigerant suction piping
- Leaving water lines (entering water line is not insulated unless specified)
  Note: Surge drum (low pressure receiver) for flooded models that are shipped loose are uninsulated.

HP, IGC, & ATS Recirculated Thermal Storage Equipment

- Recirculation system (if supplied)
- Evaporator refrigerant piping
- High side refrigerant suction piping
- Surge drum on flooded models for packaged units (see note below)
  Note: Surge drum (low pressure receiver) for flooded models that are shipped loose are uninsulated.

Chillers (evaporator only)

- All piping and vessels are shipped uninsulated.

FACTORY INSULATED PIPING & VESSELS: R-22 SYSTEMS APPLICATIONS

CF Models

- Recirculating water suction and discharge lines in the lower section only (upper water piping is not insulated)

TIG Models

- Recirculating water suction and discharge lines in the lower section only (upper water piping is not insulated)

High Side Skids

- Refrigerant suction piping

Packaged Chillers (units packaged with high side or refrigerant recirculation units)

- External refrigerant piping
- Refrigerant recirculation vessel (if supplied)
- High side refrigerant suction piping (if supplied)
- Leaving water lines (entering water line is not insulated unless specified)
  Note: Surge drum with standard chillers (evaporator only) is shipped loose and uninsulated.

HP, IGC, & FTS Thermal Storage Equipment

- Suction accumulator/heat exchanger
- High side refrigerant suction piping
- Refrigerant recirculation system (if supplied)
- Hot gas line inside evaporator compartment

Chillers (evaporator only)

- All piping and vessels are shipped uninsulated.

ADDITIONAL INFORMATION

For information about available insulation options or special requirements, contact:

Sales Department
TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

TECHNICAL BULLETIN 9412A

OCTOBER 1994

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

Oil Recovery System Wiring & Operation

Products/Models Affected:

All HP and IGC models with open drive Royce or Carrier compressors (refrigerant R-22).

Description of Possible Problem:

Although the probability of any of the following problems occurring is unlikely, the changes described below are recommended to eliminate any possibility of oil dilution to the compressor:

1. The oil temperature thermostat (OTT) is used to monitor the oil temperature and terminate operation of the compressor if the OTT does not close the thermostat within a preset time interval. The presence of a signal from the make on rise (MOR) contact of OTT indicates a rise in the oil temperature to the desired level for return to the compressor crankcase. The above sequence indicates proper operation of the oil recovery system in the current oil recovery logic.

   An interruption of power to the OTT thermostat such as a blown fuse, failure of the thermostat, or failure of the oil pot heater will also result in the absence of the OTT signal to the PLC during the preset time. Oil will not be returned to the compressor and the unit will shut down on a safety failure when the oil temperature fails to rise during the required time interval.

2. The oil feed solenoid (OFS) that controls the return of oil to the compressor crankcase opens on a signal from the electronic oil level controller (See note below. Item #2 does not apply to these units). In the current arrangement, oil can be drained to the compressor crankcase even if the oil temperature is below the required minimum temperature. If the crankcase level is low and the OLR-1 contacts close, the OFS will open since it is connected to L1. A refrigerant rich mixture could be metered into the compressor crankcase as a result of insufficient recovery time or failure of the oil pot heater to boil off the refrigerant. Refer to Figure 1 for typical wiring of the current HP and IGC controls.

   Note: Older models used a Phillips mechanical float switch to control the flow of oil to the compressor crankcase.

3. Power to the electronic oil return controls feeding oil to the compressor crankcase is on at all times. Liquid (oil or refrigerant) from the oil pot can drain to the compressor crankcase even if the compressor is off. If all other controls are functioning properly, only oil would drain to the idle compressor based on demand from the electronic level control. However, if the heater fails or other conditions exist that permit refrigerant to migrate to the oil pot, refrigerant could drain to the compressor crankcase instead of oil. Refer to Figure 1 for typical wiring of the current HP and IGC controls.

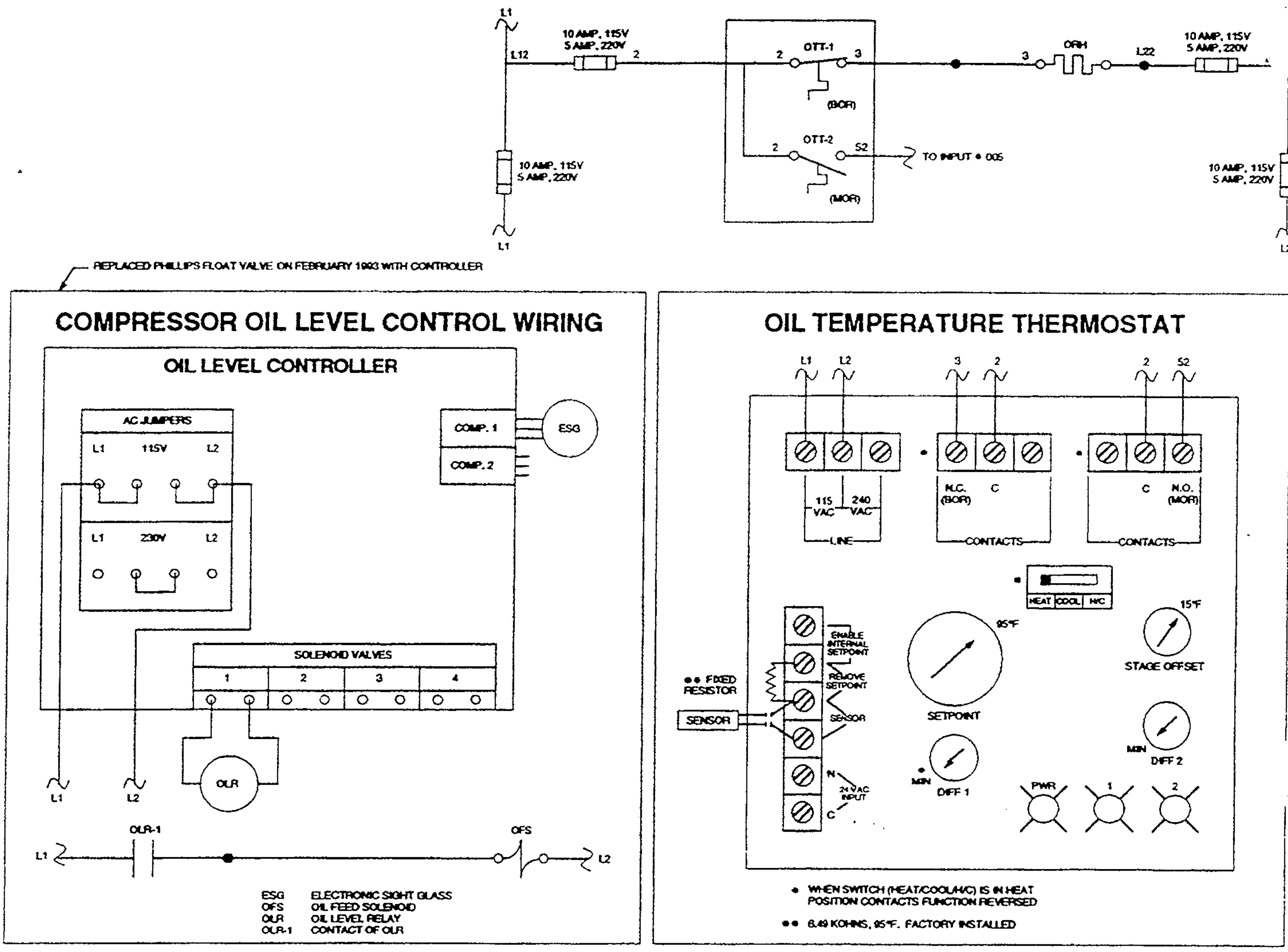

Figure 1 Current/Past Design HP/IGC

Recommended Changes:

As indicated previously, the probability of these conditions occurring simultaneously or separately are remote. To eliminate all possibilities of a refrigerant rich mixture returning to the compressor crankcase and to ensure long term reliable operation, the following changes are recommended:

Condition #1

As shown in Figure 2, wire number L1 to OLR-1 is changed to wire number 52. This provides control of the OFS through the OTT-2 at all times. If the 10 amp fuse to the oil pot heaters blows or the heater does not function properly, the absence of the OTT-2 signal to the PLC will indicate an abnormal condition. With this arrangement, operation of the unit will terminate after a preset time interval and the OFS will be disabled to prevent the return of refrigerant to the compressor. With this logic, the compressor safety circuit uses the low oil pressure failure (OPTD) as a secondary control instead of the primary means of terminating compressor operation. Operation will terminate when the heater circuit is no longer able to provide oil to the compressor crankcase at the proper temperature. Refer to the wiring diagram provided with your equipment to confirm the actual wire numbers to be changed on your equipment. On some units, wire numbers may differ from the typical wiring shown.

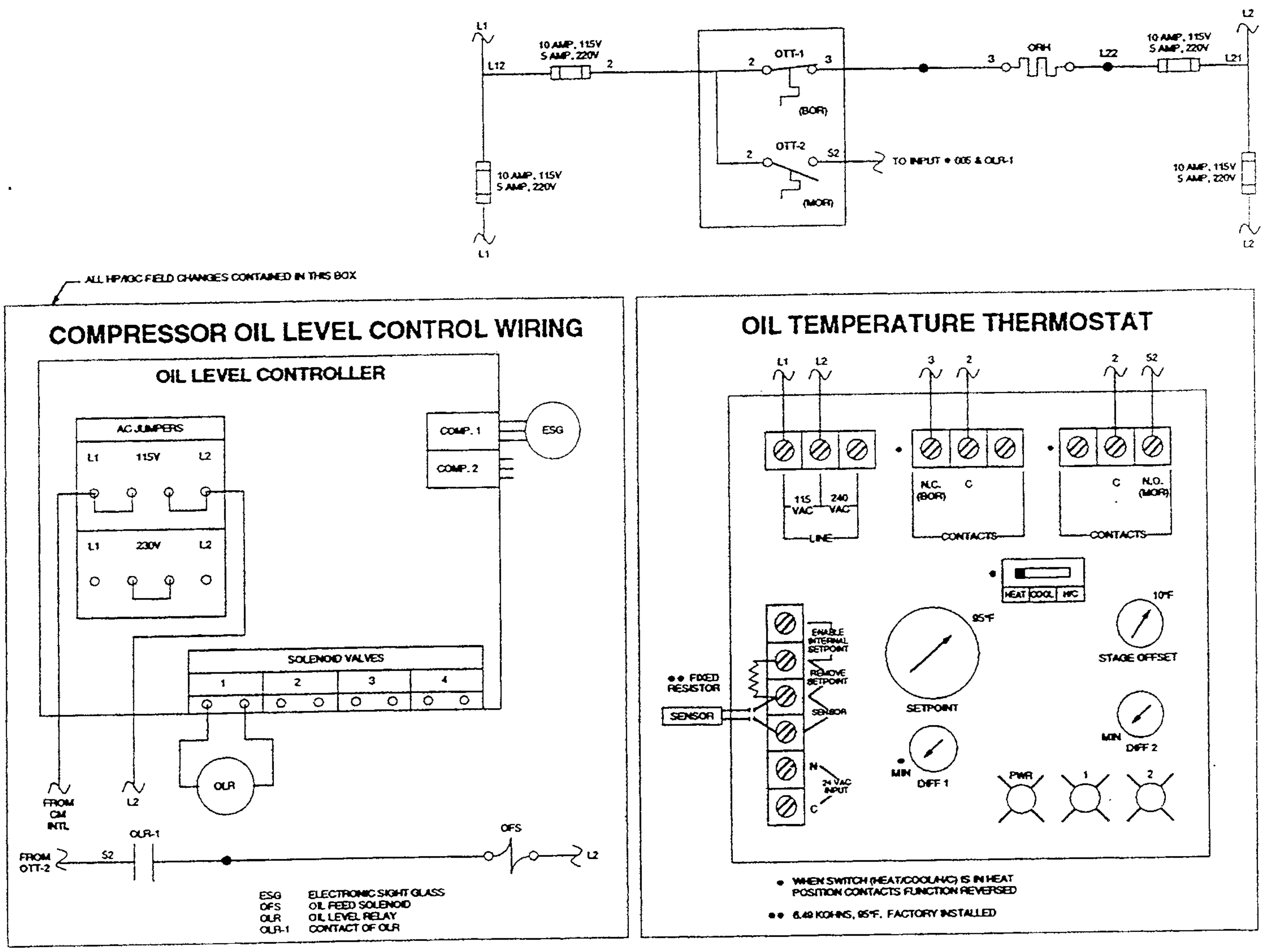

Figure 2 Modifications To HP/IGC Field Units

Condition #2

To eliminate the possibility of a refrigerant rich mixture to the compressor when the oil level control indicates a decrease in the crankcase oil level, the OFS will be controlled through the OTT thermostat. In this arrangement, the oil must be at the minimum required temperature before oil can be returned to the compressor crankcase. When the OLR-1 contact closes on an oil level decrease, the oil feed solenoid valve will not open unless the oil temperature is above the setpoint of the OTT-2. OFS will open only if the OLR-1 contact is closed and the OTT-2 contact breaks on a temperature rise. Actual wiring changes are described above.

For HP and IGC models, refer to Figure 2 for the required wiring changes. Control of the OFS is still through the OTT. However, the HP and IGC models have always used a fail safe logic in which the thermostat makes-on-rise (MOR). To rewire these models requires removing the L1 wire from the OFS solenoid and connecting wire 35.

Note: The HP and IGC models have always used a fail safe logic in which the thermostat makes-on-rise (MOR). To rewire these models requires removing wire number L1 from the OFS solenoid and connecting wire number 52.

Condition #3

The power to the electronic oil level control has always been from the main control power (L1) on the HP and IC models. To prevent of the OFS from opening with the unit off, remove the L1 wire from the power connection on the oil level controller and connect a wire from a compressor motor starter interlock as shown in Figure 2.

On most models, a terminal strip connection is provided on the control panel terminal strip for operation of condenser pumps, cooling tower controls, evaporative condenser controls, etc. This terminal strip connection is typically connected to a compressor interlock to provide power to these devices when the compressor is operating. This connection can also be used for the OFS. Refer to the wiring diagram furnished with the equipment for the location of this terminal strip connection. As indicated above, a new wire would be connected from this terminal strip connection to the oil level controller power block. Upon completion of this wiring change, power to the oil level controller and the OLR relay that opens the OFS solenoid is ON only when the compressor is in operation.

What To Do:

1. Identify the type of oil control wiring installed in your equipment. Compare the typical wiring schematics shown in Figure 1 to determine if your unit is wired as shown.
2. If your unit is wired as indicated, refer to Figure 2 for modifications to HP and IGC models.
3. Turn off the circuit breakers or disconnects to the unit and LOCK OUT all electrical service before proceeding with the changes recommended. All electrical work should be performed by a qualified electrician.
4. Upon completion of the recommended changes, monitor the operation of the oil return control to ensure that they are operating properly.
5. If you have a question or are not certain of the required changes or wire numbers on your unit, contact the TURBO Service Department at

PHONE: 940-387-4301
TOLL FREE: 800-775-8648

Typical Operating Sequence

As indicated above, the operation of the oil return controls should be monitored and verified upon completion of the recommended changes. To assist in determining if the controls are operating properly, the operating sequence for the various models is described below.

1. A refrigerant/oil mixture is returned to the oil reservoir pot via the suction accumulator/heat-exchanger ODS located in the piping from the bottom of the accumulator to the oil pot. Refer to Figure 3.
2. The oil pot contains a low watt density heater controlled by an OTT. The OTT has a sensor located in the bottom of the oil pot.
3. An electronic oil level controller is located in the control panel of the unit. A transducer is mounted in the side plate of the compressor crankcase to monitor the oil level in the crankcase. This transducer is denoted as ESG on the wiring diagrams. The controller compares the signal received from the transducer to the oil level setpoint, and energizes and de-energizes the OLR as required.
4. The OLR-1 contact opens and closes the OFS to maintain the desired oil level in the compressor crankcase. To open OFS, the oil level in the crankcase must be low and the oil temperatuer must be above the OTT setpoint.

5. During normal operation, oil is carried over to the refrigerant system and the level in the crankcase will decrease. The oil is collected in the accumulator and returned to the oil pot.

6. The purpose of the oil pot is to separate the refrigerant from the oil. As indicated above, an electric resistance heater is located in the oil pot to elevate the mixture temperature and boil off the refrigerant leaving only oil for return to the compressor.

7. As the oil level in the compressor crankcase decreases, the transducer transmits a signal to the oil level controller. The controller compares this signal to the preset value and energizes the OLR relay. When the relay is energized, the normally open OLR-1 contact closes. If the oil in the pot has reached the minimum oil temperature of 85°F, the OTT-2 contacts will close (MOR). When the OTT thermostat closes, a signal is input to the PLC to indicate that the heater is working, and power is supplied to the OFS circuit. The OFS opens to meter oil into the crankcase until either the oil level is satisfied or the OTT thermostat opens, indicating a drop in temperature of the liquid in the oil pot.

8. When the thermostat reaches 95°F, the OTT-1 contact opens to turn off the heater (ORH). The stage offset between the first stage (OTT-1) and second stage (OTT-2) is 15°F. With the first stage (OTT-1) setpoint set for 95°F, the second stage setpoint will be 80°F for control of the OFS. With the 95°F setpoint and 5°F differential for the first stage, the heater will maintain the oil temperature between 90–95°F (the 5°F differential is set on "DIFF 1" adjustment knob). OTT-2 controls the oil return to the compressor. With the 15°F stage offset and the 5°F differential for stage 2, the controller will permit the oil to return with oil temperatures between 80–85°F (the 5°F differential is set on "DIFF 1" adjustment knob). Oil return will not be permitted to the compressor with oil temperatures below 80°F.

9. The oil level in the crankcase sight glass should be half full. In verifying the operation of the oil return system, this level should remain constant with minor variations in the level as the oil leaves the crankcase and is returned through the oil recovery system. Oil level in the sight glass should remain between 3/8–1/2 full during normal operation.

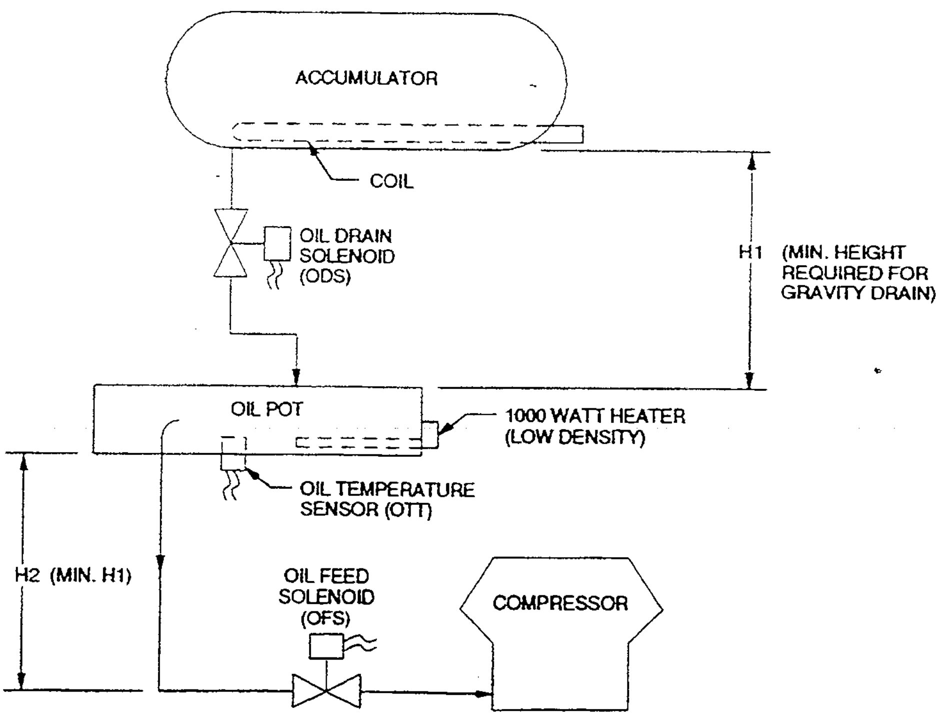

Figure 3 Piping Schematic

Vogt Ice LLC

Web site: www.vogtice.com

Tube-Ice

Tube Ice, LLC

1000 W. Ormsby Ave.

Suite #19

Louisville, KY 40210

Phone: 502-635-3000

Fax: 502-634-0479

TURBO REFRIGERATING

Turbo Refrigerating, LLC

TURBO REFRIGERATING CO
1000 WEST ORMSBY AVENUE
SUITE 19
LOUISVILLE, KY 40210
PHONE: 940-387-4301
TOLL FREE 800-775-8648

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THERMAL STORAGE OPERATION & MAINTENANCE MANUAL

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