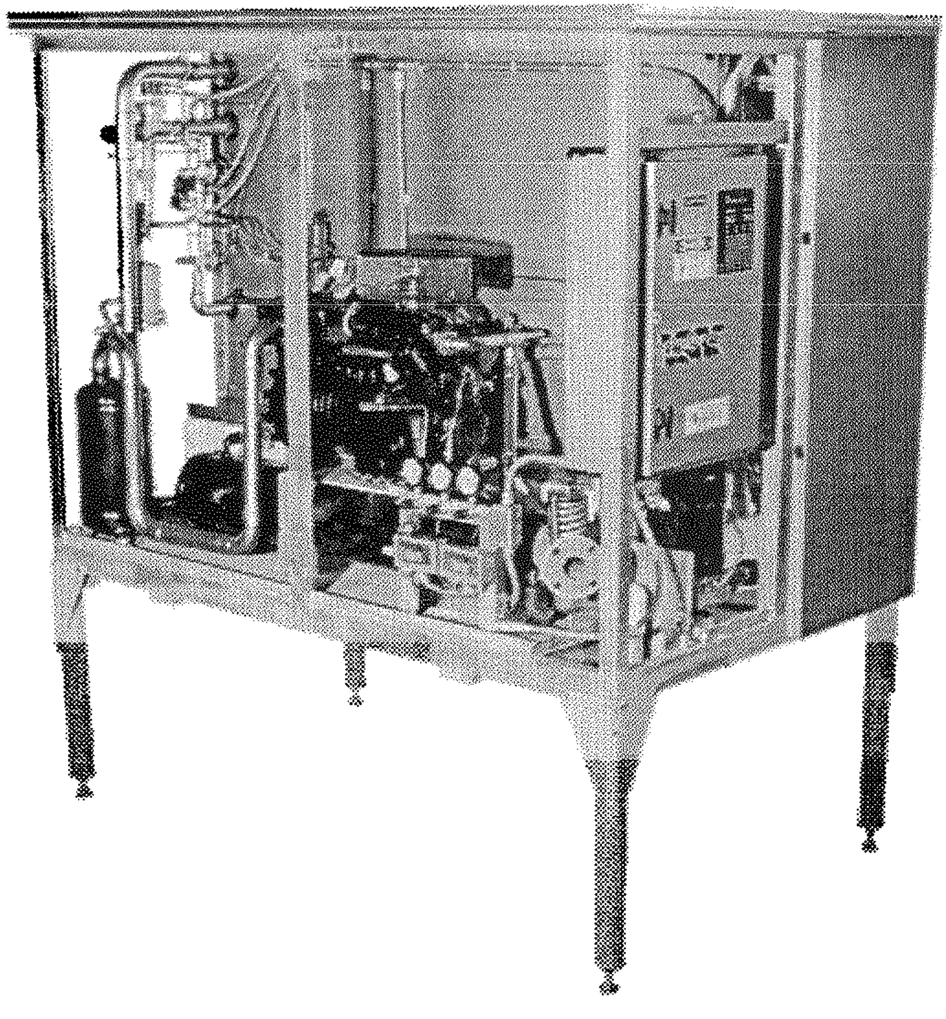
TURBO REFRIGERATING®

D-Line Ice Generator Manual



TURBO® REFRIGERATING

D-Line Ice Generator Manual

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Read Safety Section before installing or using equipment.

INTRODUCTION

Turbo Refrigerating, LLC is a supplier of ice making and ice storage equipment. TURBO does not engineer or design ice systems or ice plants.

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, LLC or one of its distributors to ensure that 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, LLC 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 products.

Turbo Refrigerating, LLC offers this manual as a guide to owners and operators of TURBO® equipment, to assist in maintaining the equipment in a reliable and efficient manner.

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 ensure 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, LLC has been producing equipment for the ice industry since 1960.

The ice generators described in this manual are part of a family of products designed specifically to meet the needs of the industrial ice users. The D-line series ice generators were introduced in 1998. Although they are the youngest member of the TURBO family, they are built with the same high quality standards of engineering used to develop the icemakers of the 60's. Many of the latest developments in technology are used to design the D-line series ice generators.

In applications where totally dry and uniform ice is not required, the D-line series offers **a low cost alternative.**

Icemakers Versus Ice Generators

There are several basic differences between TURBO icemakers (C-series), TURBO ice generators (TIG/TIGAR series) and the D-line series.

TURBO Icemakers

The traditional TURBO icemaker was designed to meet the needs of the packaged ice industry where dry, subcooled, uniform pieces of ice are essential. To meet these requirements, TURBO icemakers make ice on only one side the plate and warm water is used to harvest (some models are available with hot gas assist). The water to each section is cut off and a drying cycle is used. Both of the above ensure a dry, sub-cooled ice. As the ice separates from the plates, it is metered into a breaker assembly to ensure uniform ice size. The sizing system consists of:

- A rotating breaker bar
- An adjustable sizer bar
- A fixed sizer grate.

The unique sizing adjustment along with ice thickness controls allow the TURBO icemaker to produce a wide variety of ice nugget sizes.

TURBO TIG/TIGAR Ice Generators

The TURBO ice generators were designed to meet the needs of the industrial user requiring ice for its cooling effect rather than for consumption. TIG/TIGAR series units maintain the same operating technology and sanitation requirements as the icemakers maintain, while eliminating the icemaker features not essential to their applications. In the TIG/TIGAR, the drying cycle and warm water harvest are replaced by a hot gas harvest, and the ice breaker/sizer mechanism is replaced by an auger to break the ice into irregular sizes. As a result, a random shaped piece of fragmented ice is produced at **a lower cost per ton.**

TURBO D-Line Ice Generators

The best features of the TURBO C-series icemakers and TURBO ice generators (TIG series) were combined to provide an ice generator capable of delivering a dry product with a hot gas harvest. With the simple valve arrangement, standard oil return system and unique refrigeration system used in the D-line, a reliable harvest can be obtained without the water to the icemaking plates like the C-series while producing ice on both sides of the evaporator plates like the TIG series. The D-line has a drying cycle and built-in anti-slushing system as standard features.

Although a sizing system is not built into the ice generator discharge, the design allows for simple installation of a breaker bar system similar to the C-series or a screw conveyor similar to the TIG series. These methods provide random shaped, fragmented ice.

For installations requiring a more uniform ice fragment, a TURBO style ice sizer can be built into the discharge of the ice generator or used in conjunction with the breaker bar or screw conveyor style discharge. The D-line provides all of the above in a smaller footprint than the C-series or TIG series at **the lowest cost per ton.**

Model Descriptions

All D-line units are provided with:

- Aluminum exterior panels (evap. only)
- Control panel with programmable controller
- Stainless steel interior in icemaking section
- Stainless steel evaporator plates
- 230/3/60 or 460/3/60 motor with 115/1/60 controls
- Semi-hermetic compressor
- Stainless steel water distribution pan.

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

D-Line Series Models

SC (Self-Contained Water-Cooled)

- Completely self-contained including refrigerant charge.*
- Uses a water-cooled condenser with water regulating valves.
- Optional cooling tower and pump 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.

* Refrigerant charge is supplied for domestic shipments only; international orders are shipped with a holding charge only (all models).

SCAR (Self-Contained Air-Cooled Remote)

- Self-contained unit set up for remote air-cooled condenser.
- Air-cooled condenser and head pressure controls can be furnished as options.
- No refrigerant charge.
- Receiver and isolating valves are optional.

Capacities

The D-line series is available in a 6 U.S. tons of ice per day model only. All capacities are based on 60°F make-up water, 0°F evaporator and 105°F condensing temperatures with 60 hertz electrical power.

USDA Design

All TURBO icemakers and ice generators are designed and built to meet USDA's rugged design guidelines and industrial standards to make them the most reliable in the industry. Each system is designed to provide the safest and simplest operation, and easy access for cleaning as well as to minimize maintenance. TURBO equipment has been used in USDA inspected installations for many years with a proven record of meeting USDA requirements.

Basic Operation

The D-line ice generator produces ice in batches. Operation is controlled by a programmable controller, water level control and harvest pressure switch for simple reliable operation. The basic sequence is:

1. Turn the master control switch ON. The water tank automatically fills with fresh water and the ice production cycle begins.
2. Simple water level controls monitor the water level in the tank to initiate the drying cycle to cure the ice followed by the harvest cycle when the selected ice thickness is obtained. Ice thickness can be changed using the Ice Thickness Selector Switch on the control panel door.
3. After the ice is harvested from the plates, a harvest pressure switch terminates the harvest cycle and the ice generator begins the next icemaking cycle. The water tank was refilled during the harvest cycle and the water pre-chilled by the gas generator plate used to supply hot gas to the icemaking plates for harvest.
4. This sequence continues until the ice generator is turned off through the master control switch (or optional remote switch in MCS circuit).
5. When the MCS is turned off, the ice generator completes the current icemaking cycle and then goes through a pump-down of the refrigeration system to minimize refrigerant migration problems when the ice generator is off.
6. The drain valve on the water tank opens to drain the remaining water and suspended solids from the water system. This ensures fresh water and a clean tank at the start of each production run of the ice generator.

There are no refrigeration or defrost timers to set or change to obtain the desired ice thickness. The same thickness of ice will be obtained regardless of the make-up water temperature or refrigeration system operating conditions. Simple controls automatically adjust operation to the actual operating conditions. Design conditions are make-up water temperature of 60°F, evaporator temperature of 0°F and condensing temperature of 95°F.

Note:
Although the same ice thickness is obtained, capacity will vary with operating conditions that vary from design.

For example, with 80°F make-up temperature, the same ice thickness will be obtained but the capacity will decrease by approximately 10% due to the increased load of the warmer water. Conversely, if 50°F make-up water is supplied, the same thickness is obtained with approximately 6% increase in capacity. Both examples assume the other design conditions are the same.

Sanitary Ice

TURBO makes every effort possible to minimize the potential for contamination of the ice produced on the ice generators (as well as all other products). All water and ice contact areas are either stainless steel, PVC or hot-dipped galvanized. In addition, the stainless steel water distribution pan and water tank are easily accessible for cleaning.

The hole pattern in the water distribution pan acts as a secondary screening media for the water on the plates. A strainer is provided in the make-up water line. TURBO strongly urges each user to consult a local water treatment specialist to determine any water treatments that might be beneficial in obtaining the best ice possible.

Controls

TURBO ice generators use the latest controls available for simple, reliable operation. All models are supplied with:

- A programmable controller.
- Magnetic starters with overload protection (for all motors furnished with the ice generator – extra starters for remote equipment are optional).
- All selector switches required for automatic operation of the system.

All components are mounted in a stainless steel electrical enclosure (NEMA 3R). Control panels are UL approved.

Ice Delivery

Ice produced by the ice generator is delivered to a common discharge opening under the cabinet. Several methods of sizing and delivery to storage or the point of use can easily be adapted to the D-line. Ice can be:

- Discharged directly from the ice discharge opening of the ice generator into a storage building located below.
- Discharged into storage or point of use through a screw conveyor installed under the ice discharge opening.
- Discharged into a breaker bar or ice sizing mechanism and discharged either directly to storage or point of use or into a screw conveyor. For the screw conveyor method, any standard screw conveyor can be used. TURBO can provide any of the sizing mechanisms described as options.
- Discharged from either end of the ice generator or out the rear through a discharge transition. Front discharge is not available due to interference with the water piping under the ice generator and restriction of access to the front for cleaning and maintenance. On installations with multiple ice generators discharging into a common conveying system, the rear discharge is recommended.

The use of a discharge transition into a screw conveyor is recommended to prevent condensation, cleaning agents or water from being accidentally dumped into the storage or point of use.

IMPORTANT

All conveyors, transitions, or belt conveyors connected to the ice discharge opening should ensure access to the screw conveyor or other ice sizing methods (if used) is eliminated. See section 2. Safety for additional information on guards and covers.

Optional D-Line Features

Although TURBO designs and builds ice generators to be as flexible as possible, the standard models or features may not meet a particular application. TURBO can design special configurations and offers several optional features including:

- Winterizing kits with un-insulated compressor compartment panels.
- Weatherizing kits with enclosures for outdoor equipment including compressors for low ambient operation.
- Bin-O-Matic controls to automatically turn ice generators off when the delivery point is full.
- Special voltages and frequencies.
- Complete pneumatic systems to convey ice. Blower, rotary airlocks and two or three position diverter valves may be purchased separately.
- Cooling towers and cooling tower pumps with head pressure controls for all SC models.
- Air-cooled condenser with head pressure controls for SCAR models.
- Stainless steel auger and discharge transition.
- Ice sizing mechanism including screw conveyor, TURBO breaker bar assembly or TURBO ice sizers.

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

Turbo Refrigerating, LLC
P.O. Box 396
Denton, Texas 76202-0396
Phone: 940-387-4301
Fax: 940-382-0364
E-mail: info@turboice.com
Internet: www.turboice.com

Associated TURBO Equipment

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 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 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 while the larger automatic ice rakes range from 100 to 300 tons of ice storage.

All TURBO ice storage systems have been successfully installed in USDA inspected facilities. 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
- Emergency cooling loads
- Ice slurries

Read Safety Section before installing or using equipment.

- Catering trucks
- Salad bars or display ice food processing

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, LLC.

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.

Read Safety Section before installing or using equipment.

TERMS & CONDITIONS

Turbo Refrigerating (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 to which the Company objects. The Company's entry into this Agreement is made expressly conditional on Buyer's assent to the following terms and conditions.

1. Terms and Prices

a) Unless otherwise specified by the Company, 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 the Company. 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, and all export license fees, duties, customs or similar charges, 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 increase 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) Company's handling and storage charges then in effect, (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; 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 EXPRESSED 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 OR 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 (a) above and does not apply or extend, for example, to expendable items; refrigerant; 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 this 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) 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 satisfaction (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 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) PATENTS

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 an 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 insinuation 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, designs, material, construction, arrangement, or components.

8. Security Interest; Insurance

a) To secure payment of the purchase price, Buyer hereby grants 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. This agreement constitutes a security agreement and a carbon, photographic or other reproduction of this agreement shall be sufficient as a financing statement and may be filed as such. 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 payment of any 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, insurrection 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 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 TERMS OR CONDITIONS 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.

2

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
Indicates 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, screw trough extension, belt pulley guard and access panels should be followed. They are shown in Figures 2-1, 2-2, 2-3, 2-4.

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

Turbo Refrigerating, LLC
P.O. Box 396
Denton, Texas 76202-0396
Phone: 940-387-4301
Fax: 940-382-0364
E-mail: info@turboice.com
Internet: www.turboice.com

Involve Your People

Before operating equipment, have the people involved in the operation or maintenance of the equipment meet to discuss the dangers and safety aspects of the D-line equipment.

- Warn them of the danger of miscommunication.
- Turn electricity off and **lock it out** when working on the D-line equipment.

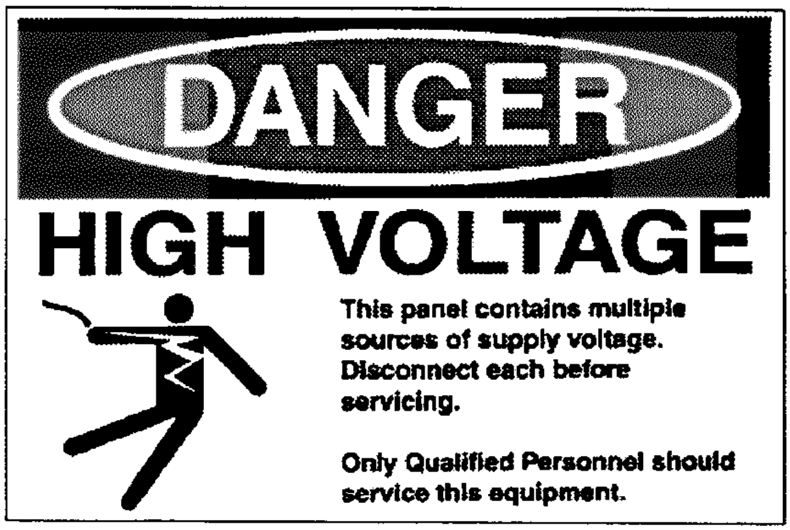


Figure 2-1 Warning Label On Control Panel

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

- Have a person trained and qualified in the equipment operation on duty to ensure that the electricity stays **locked out** to protect personnel working on the equipment.

WARNINGS

The D-line 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 D-line equipment unless all electrical power is disconnected and **locked out.**

The ice discharge opening has a warning label (refer to Figure 2-3). Field installation must ensure that a cover or guard (not supplied by TURBO) is in place on the ice discharge opening before operating to prevent entry into the screw conveyor or sizing mechanism.

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.

Figure 2-2 Warning Label On Screw Trough (optional harvest screw if supplied)

Figure 2-3 Warning Label On Access Panels

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

When changing oil in the compressor, make sure the pressure is bled off (relieved to atmospheric pressure) before opening the system.

Always wear eye protection when cleaning the system.

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 ice machine cleaners. Follow instructions and warnings supplied by the manufacturer of the cleaning agents.

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 D-line equipment, TURBO recommends that at least two (2) people be present at all times.

Although TURBO does not supply conveying equipment beyond the ice discharge opening, any conveyors used in association with the operation of TURBO equipment must be sufficiently guarded to prevent injury.

Notes:

1. Conveyor manufacturer's instructions and warnings are on pages 2-5 to 2-6.
2. Per the OSHA Hazard Communication Standard, material safety data sheets for refrigerant and refrigerant oils are on pages 2-9 to 2-14.

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

Figure 2-4 Warning Labels On Screw Conveyor Belt Pulley Guard

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

Control Switch

A selector switch is provided to control the D-line unit operations (on and off). To **lock out** the D-line unit controls:

1. Pull disconnect and **lock out** all electrical service.
2. Turn selector switch (provided) to the "OFF" position.

If you have questions, call Turbo Refrigerating, LLC:

1-940-387-4301.

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

Conveyor Manufacturer's Instructions and Warnings

Turbo Refrigerating, LLC does not install conveyors, consequently it is the responsibility of the contractor, installer, owner and user to install, maintain and operate the conveyor, components and assemblies in such a manner as to comply with the Williams-Steiger Occupational Safety and Health Act and with all state and local laws and ordinances and the American National Standard Institute (ANSI) safety code.

In order to avoid an unsafe or hazardous condition, the assemblies or parts must be installed and operated in accordance with the following minimum provisions.

1. Conveyors shall not be operated unless all covers and/or guards for the conveyor and drive unit are in place. If the conveyor is to be opened for inspection, cleaning, maintenance or observation, the electric power to the motor driving the conveyor must be locked out in such a manner that the conveyor cannot be restarted by anyone (however remote from the area) until conveyor cover or guards and drive guards have been properly replaced.
2. If the conveyor must have an open housing as a condition of its use and application, the entire conveyor is then to be guarded by a railing or fence in accordance with ANSI standard B20.1-1976, with special attention given to section 6.12.
3. Feed openings for shovel, front loaders or other manual or mechanical equipment shall be constructed in such a way that the conveyor opening is covered by a grating. If the nature of the material is such that a grating cannot be used, then the exposed section of the conveyor is to be guarded by a railing or fence and there shall be a warning sign posted.
4. Do not attempt any maintenance or repairs of the conveyor until power has been **locked out.**
5. Always operate conveyor in accordance with these instructions and those contained on the caution labels affixed to the equipment.
6. Do not place hands or feet in the conveyor.
7. Never walk on conveyor covers, grating or guards.
8. Do not use conveyor for any purpose other than that for which it was intended.
9. Do not poke or prod material into the conveyor with a bar or stick inserted through the openings.
10. Keep area around conveyor drive and control station free of debris and obstacles.
11. Always regulate the feeding of material into the unit at a uniform and continuous rate.
12. Do not attempt to clear a jammed conveyor until power has been **locked out.**
13. Do not attempt field modification of conveyor or components.

Turbo Refrigerating, LLC 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 or covers. We caution that use of secondary devices may cause employees to develop a false sense of security and fail to **lock out** power before removing covers or guards. This could result in a serious injury should the secondary device fail or malfunction.

There are many kinds of electrical devices for interlocking of conveyors and conveyor systems such that if one conveyor in a system or process is stopped, other equipment feeding it or following it can also be automatically stopped.

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

Electrical controls, machinery guards, railings, walkways, arrangement of installation, training of personnel, etc. are necessary ingredients for a safe working place. It is the responsibility of the contractor, installer, owner and user to supplement the materials and services furnished with these necessary items to make the conveyor installation comply with the law and accepted standards.

Conveyor inlet and discharge openings are designed to connect to other equipment or machinery so that the flow of material into and out of the conveyor is completely enclosed.

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

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 *must turn off all power to the unit or use energy isolating devices and apply his personal lock, and have the supervisor of that area*

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

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.

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: CHClF2

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.

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. LC50 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.

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).

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

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/ft3 @ 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

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.

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

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).

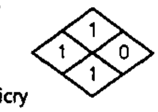
duPont, unpublished review, Haskell Laboratory (March, 1984).

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

NFPA		Fire	Reactivity
4 = extreme			
3 = high			
2 = moderate			
1 = slight			
0 = insignificant		Toxicry	Special



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, CO2 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

Appearance: Clear liquid

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

Melting Point: NA

% Volatile (by weight %): Negligible

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

pH As Is: NA

Odor: Petroleum

Color: Amber

Boiling Point: >500° F (>260° C)

Solubility in Water: Insoluble

Evap. Rate: Negligible

Vapor Density (air = 1): >10

Strong Acid ☐ Stable ■

Strong Base ☐ Unstable ☐

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

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:

■ Dry Chemical ■ CO2 ■ Waterfog

☐ Waterspray ■ Foam ■ Sand/Earth

☐ Other: ____________________

Section IV. Health Hazard Data

Permissable Concentrations (air): 5 mg/m3 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.

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

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

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. ■ 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: ____________________ Title: ____________________
Telephone: ____________________ Date: ____________________
Revision Date: ____________________ Sent To: ____________________
Supersedes: ____________________

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 TURBO assumes no responsibility for any loss, damage, or expense, direct or consequential, arising out of their use.

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 D-line ice generator unit for operation, you will need two (2) to four (4) people whose skills include mechanical, welding and plumbing capabilities as well as a qualified electrician.

This section includes step-by-step instructions on installing and connecting a your ice generator. Your ice generator has been tested and inspected at the factory prior to packing and shipping.

Installation Sequence

1. Delivery inspection
2. Hoisting or moving
3. Site preparation
4. Ice discharge openings (ice chutes) to storage
5. Electrical connections
6. Water connections
7. Refrigerant piping
8. Testing refrigeration system for leaks
9. Evacuating the system
10. Charging the unit with refrigerant oil
11. Refrigerant charging
12. Water-cooled condensers
13. Air-cooled condensers
14. Installation review

IMPORTANT

Pay special attention to bold print or boxed in paragraphs. Following this information is essential for a safe and efficient installation. Refer to section 2 - Safety for more information.

To Help You Get Started

Read instructions completely before installation.

Gather all required tools.

Establish front, rear, left and right positions of the ice generator by facing the compressor section (see Figure 3-1).

Components will be positioned as follows:

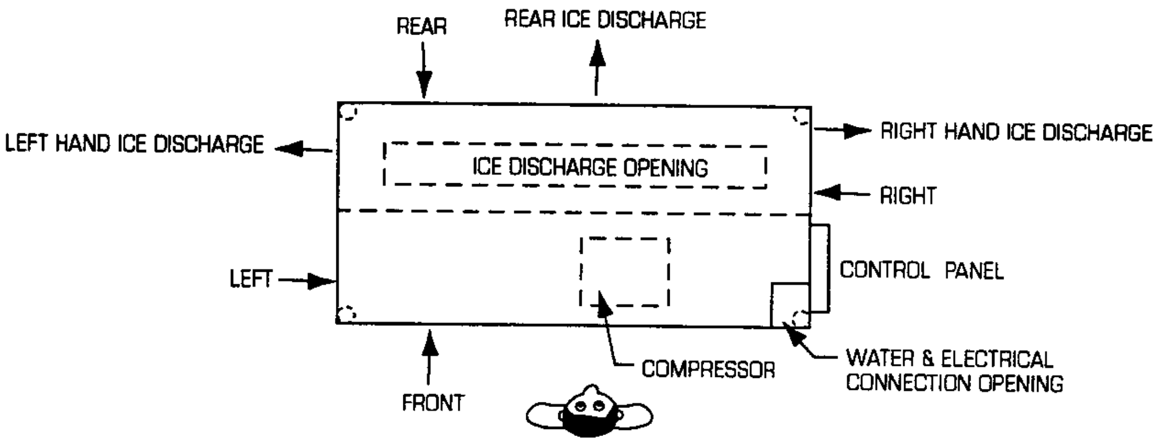
- The control panel is on the right end toward the top of the ice generator.
- The compressor is at the front near the middle of the ice generator. For water-cooled units, the combination condenser/receiver is located below the compressor. On air-cooled models, the high-pressure receiver replaces the condenser under the compressor. For SCAR models with field installed remote air-cooled condensers, the receiver is shipped loose for field installation.
- The refrigerant system control valves are located on the left end in the front half of the ice generator.
- The water tank in located in the middle of the ice generator.
- The icemaking plates and gas generator plate are located in the rear half of the ice generator.
- The water pump and water system control valves are located on the right end.
- All field connections (electrical and water) to the ice generator are made through the opening in the bottom of the base pan in the front right hand corner.

Use this method of describing the location of components when establishing installation requirements.

Helpful Hints

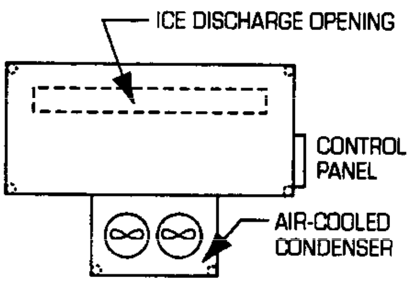
Ice can be discharged to the left, right or out the rear of the ice generator. For left-hand and right-hand discharge from directly under the ice generator, a screw conveyor can be attached directly to the bottom of the ice generator and ice discharged to the left or right. For rear discharge, a screw conveyor can be located at the bottom of the discharge transition and ice conveyed to the left or right. With the ice discharge opening located

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

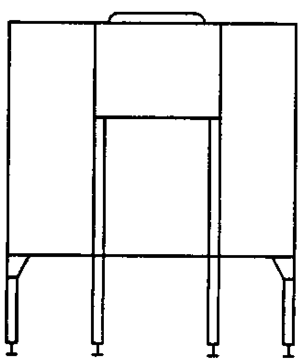


TYPICAL SC MODEL TOP VIEW

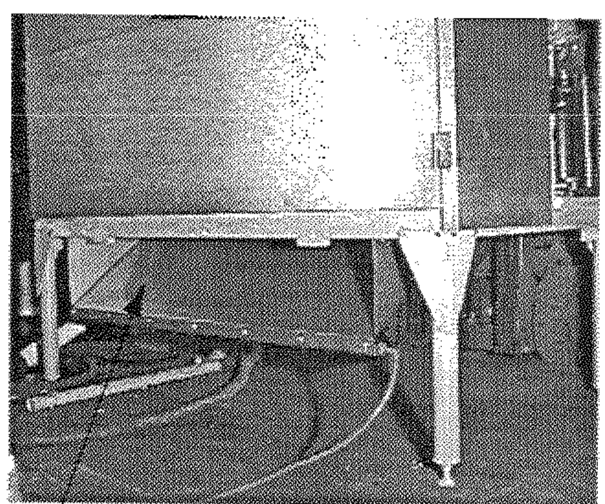
NOTE: ON SCA MODELS, THE AIR-COOLED CONDENSER IS ALSO MOUNTED ON THE TOP FRONT OF THE UNIT.



TOP VIEW



TYPICAL SCA MODEL ELEVATION



REAR DISCHARGE TRANSITION WITH SNOW SLIDE – SHOWN WITH TRANSITION TO SCREW CONVEYOR

Figure 3-1 D-Line Unit Orientation

under the ice generator, ice can also be discharged directly into a storage area located below the ice generator without the use of a screw conveyor or other conveying methods. For some applications this may be acceptable.

TURBO does not recommend direct discharge into the storage area. A screw conveyor can be used to drain water or condensate that collects inside the ice generator or on the ice slide. The screw conveyor should be pitched to drain:

- Melting snow from the harvest cycle.
- Ice fines (slivers of ice) too small to conveyor.
- Condensation.
- Water accidentally discharged from the ice generator plates due to fouling (dirty) of the plates.
- Cleaning solutions used to clean the interior of the evaporator section including the water distribution pans and piping.

Always remember –

SAFETY FIRST !!!

Tools

To install the ice generator, you will need two (2) to four (4) 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 ice generator:

- Wrenches and sockets (a full set up to 7/8″)
- Phillips (not cross-point and standard (slotted) screw drivers
- Level (4′ long)
- Tape measure (25′ long)
- Pry bar
- Chain hoists (1 ton) or two "come alongs: (1,000#)
- Allen wrenches (sizes 1/8″ to 1/2″)
- Chains (two 3/8″, minimum 10′ long)
- Amp probe
- Voltage tester
- Continuity tester
- Framing square
- Forklift or crane

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

1. Delivery Inspection

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

Inspect the ice generator 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 ice generator, 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.

Delivery Inspection Checklist

1. Panels.
2. Loose equipment and crate (open for inspection).
3. Evaporator plates.
4. Valves and piping.

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

2. Hoisting or Moving

Equipment Rigging Instructions

The ice generator is shipped without the legs attached. During the installation process, the unit must be elevated and the legs bolted to the ice generator frame. Each leg has an adjusting screw for leveling. This will be covered later in the installation process.

To lift or move the unit, a forklift or small crane can be used. The frame has blocks on each corner to elevate the frame enough to get a forklift under the frame. All lifting should be done from the middle of the unit and the forks should extend far enough under the frame to reach the center of the unit. A second frame member is located midway between the front and back of the unit. Since the center of gravity is toward the front of the unit, it is recommended that the unit be lifted from the front. If it is not possible to lift from the front, the unit may be lifted from the rear. Test the load for balance and then lift the unit approximately 40-48″ off the floor. This will allow room for installation of the legs.

If the unit is lifted by straps and a crane or other similar lifting devices, the capacity of the straps must be suitable for the load. In addition, blocks or spreaders may be required to prevent damage to the exterior of the unit. Refer to Figure 3-2. As indicated above, the load should be tested for balance before the unit is lifted above a few inches.

IMPORTANT

When using either a forklift or crane to lift the unit, use caution in the area on the right front end of the unit. Connections for the water piping to be installed later in the installation are located in this area.

Rollers (equipment moving dollies) may also be used under each corner of the unit to move it around on the floor. However, installation will require the unit to be lifted to complete the installation.

Hoisting or Moving

If the ice generator is installed in a location that requires the ice generator to be lifted by means of a crane, TURBO requires that the lifting and/or slinging be done from the bottom of the ice generator. Use a spreader at the top of the ice generator to prevent the unit panels from crushing. Refer to Figure 3-3. A competent rigging and hoisting contractor can handle the job without danger or damage to the ice generator.

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

IMPORTANT

Never lift or sling the ice generator with devices fastened to the top frame structure. Only lift the ice generator from the bottom.

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.

Leveling Legs

The ice generator is supported by four (4) legs located on each corner of the ice generator for the SC models. SCA models have two (2) additional legs located in the front to support the air-cooled condenser. These supports are required to provide clearance for the water piping and electrical connections made from under the unit later in the installation process.

Each leg is bolted to the frame using the pre-drilled and tapped holes in each cor-

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

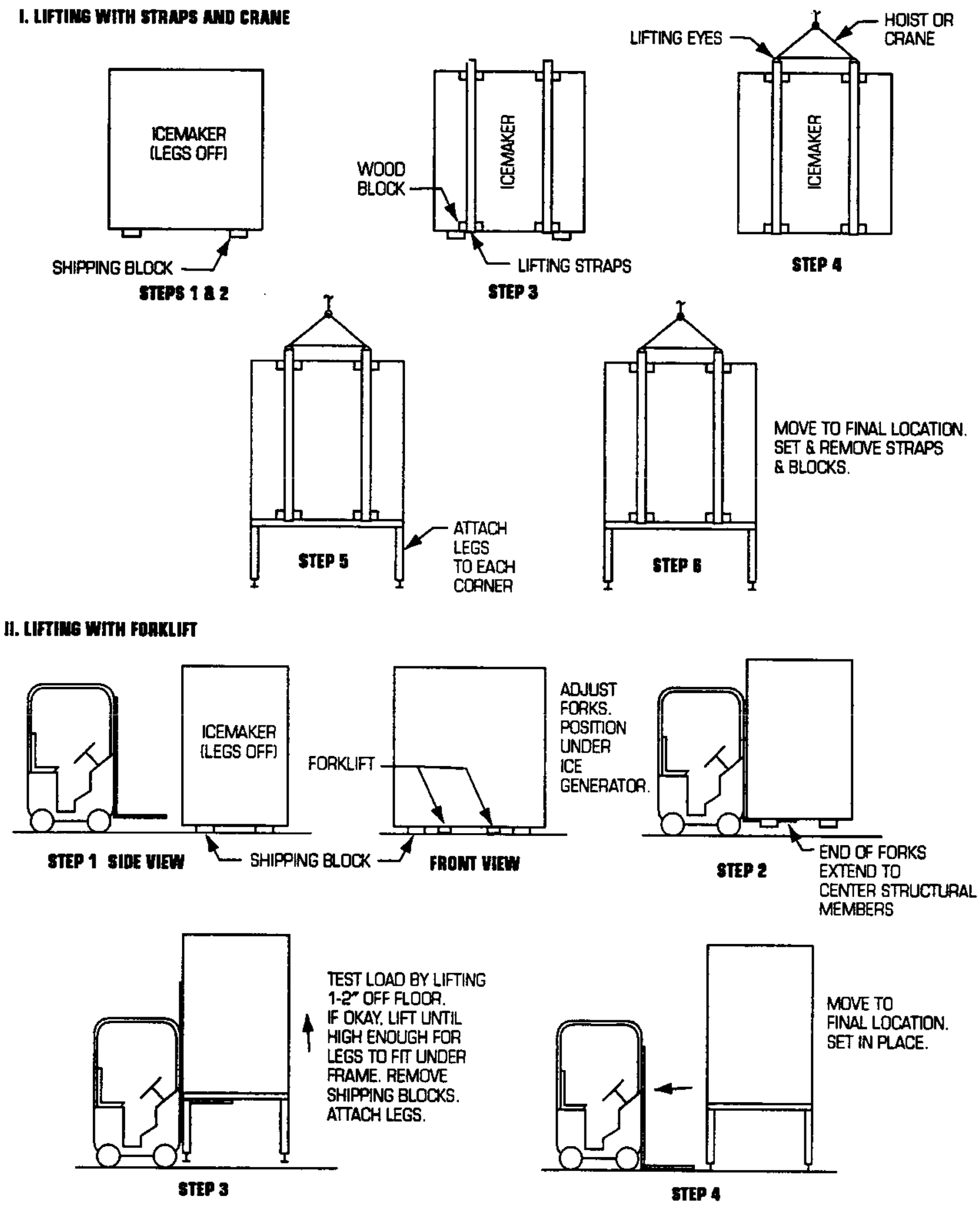


Figure 3-2 Hoisting/Moving Ice Generator - SC Models

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

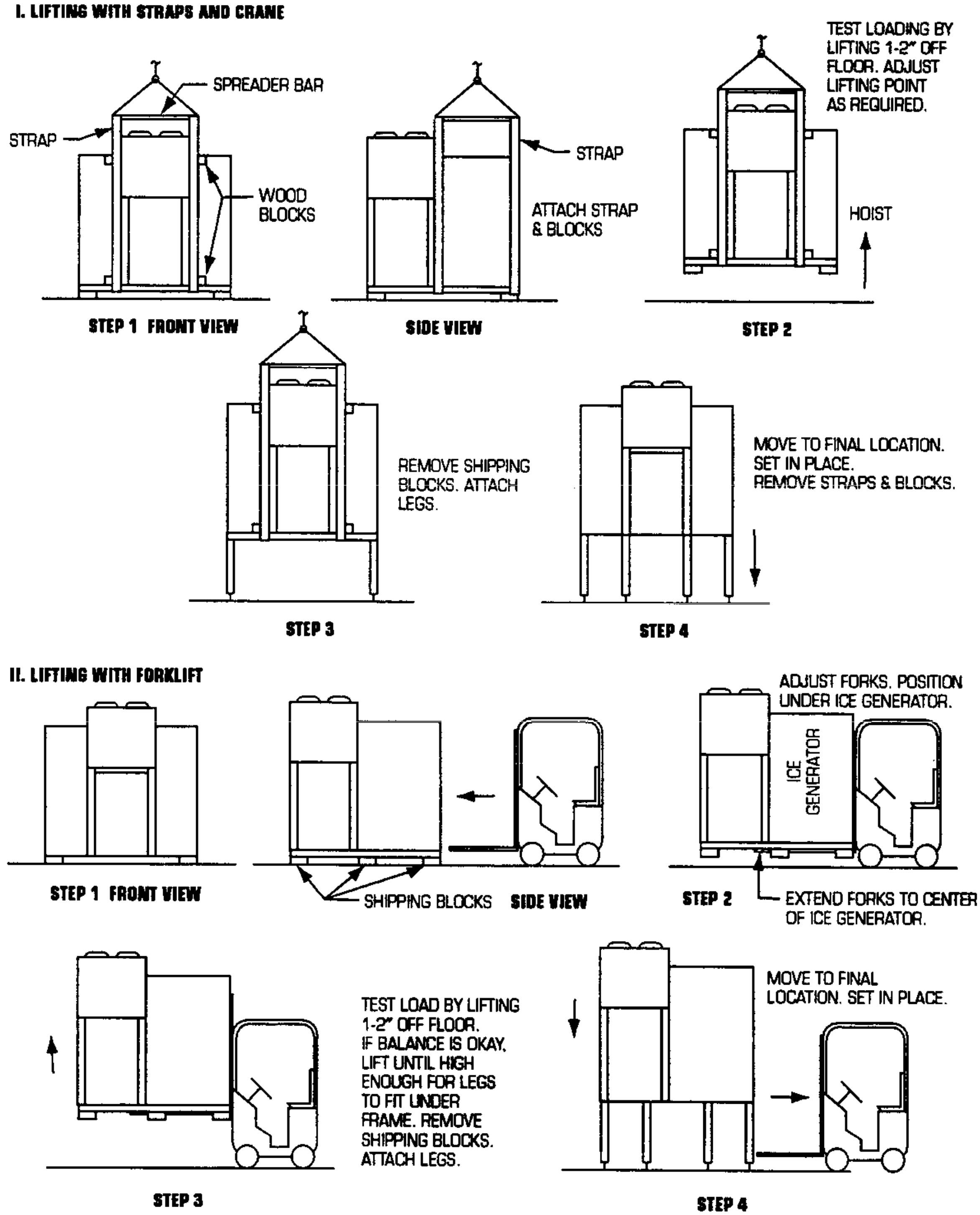


Figure 3-3 Hoisting/Moving Ice Generator - SCA Models

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

ner of the frame. Two bolts are used on each side of the leg to attach it to the frame. Each leg has an adjustment screw and pad on the bottom for use in leveling the unit. Leveling will be covered later in the installation instructions. The leveling pads on the legs will provide approximately two (2) inches of adjustment. Refer to step 3. Site Preparation on the requirements for the pad or floor that the unit is to be located on.

Table 3-1 Hoisting Weights

Model	Equipment Shipping Weight (lbs.)
SC	3,200
SCA	3,700
SCAR	3,150

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

3. Site Preparation

IMPORTANT

Next to the selection of the proper equipment for the process or application, the most important pre-delivery task is the job site preparation for the installation of the ice generator and associated equipment.

When selecting the installation site, consideration should be given to the accessibility of the ice generator under all possible operating conditions; i.e., if the unit requires service and a severe thunder storm is in process, can you wait to perform the service or is immediate access required? If the delivery of ice is critical to the process or plant operation the answer may be no, immediate action is required. In this case, consideration should be given to an indoor installation or some type of covering over the equipment to provide safe conditions for the work to be done in.

Particular attention should be given to shading the control panel in outdoor installations. Optional weatherizing and winterizing panels are also available as options for outdoor installations. For indoor installations, the compressor compartment panels are not required. Weatherizing panels are required for outdoor installations to provide shading from direct sunlight and adverse weather conditions.

Although the ambient compensation for control devices is typically 120-140°F, direct sunlight on the control panel can produce temperatures in excess of these limits resulting in control system problems.

TURBO recommends indoor installation to provide a stable operating environment for the equipment. This will provide more uniform ice production, less maintenance and longer equipment life. However, as indicated above, the equipment is suitable for outdoor installation. The following guidelines should assist in properly preparing for installation of the TURBO supplied equipment as well as associated equipment required to complete the system. Questions concerning site preparation should be discussed with a qualified TURBO distributor or TURBO application engineer.

Location

Refer to Figures 3-4 and 3-5. The ice generator may be installed indoors or outdoors. See general requirements for each installation below. Outdoor installations require optional compressor compartment panels.

Indoor Installations
General Requirements
Access by a forklift or overhead hoist should be provided to the equipment room for removal of large components such as the compressor.

Install the 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 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 draininge must be available. Refer to step 6. Water Connections.

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.

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

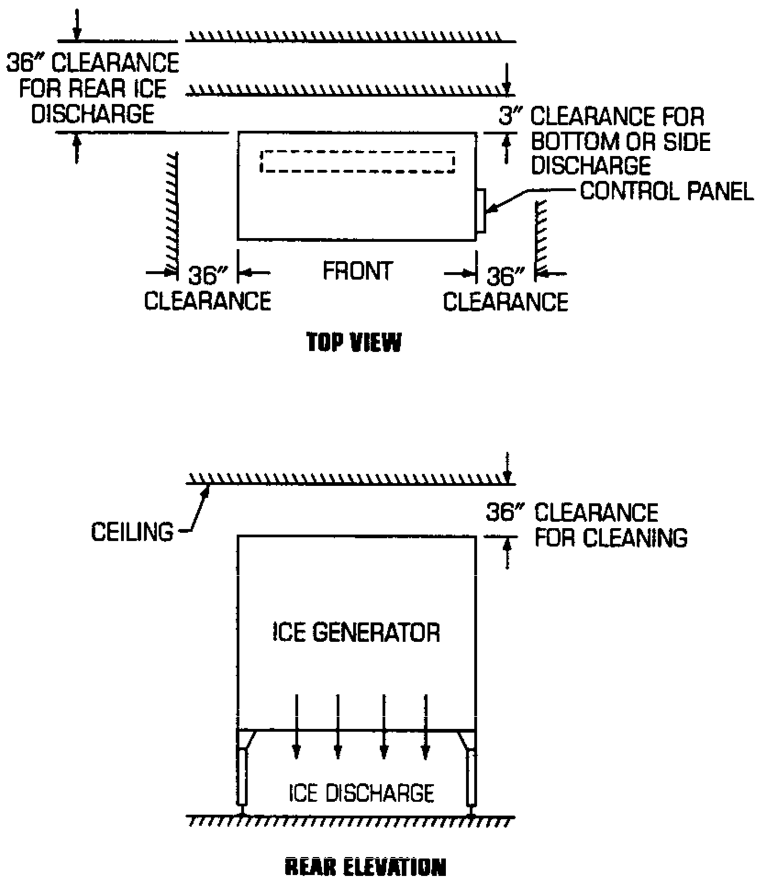


Figure 3-4 Typical Installation Clearances - Indoor and Outdoor

- 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.

- Adequate space should be allowed on all sides and the top for cleaning and service.

Note:
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. The rear of the unit does not require access for service and maintenance. This clearance can be reduced as necessary except installations with rear ice discharge.

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

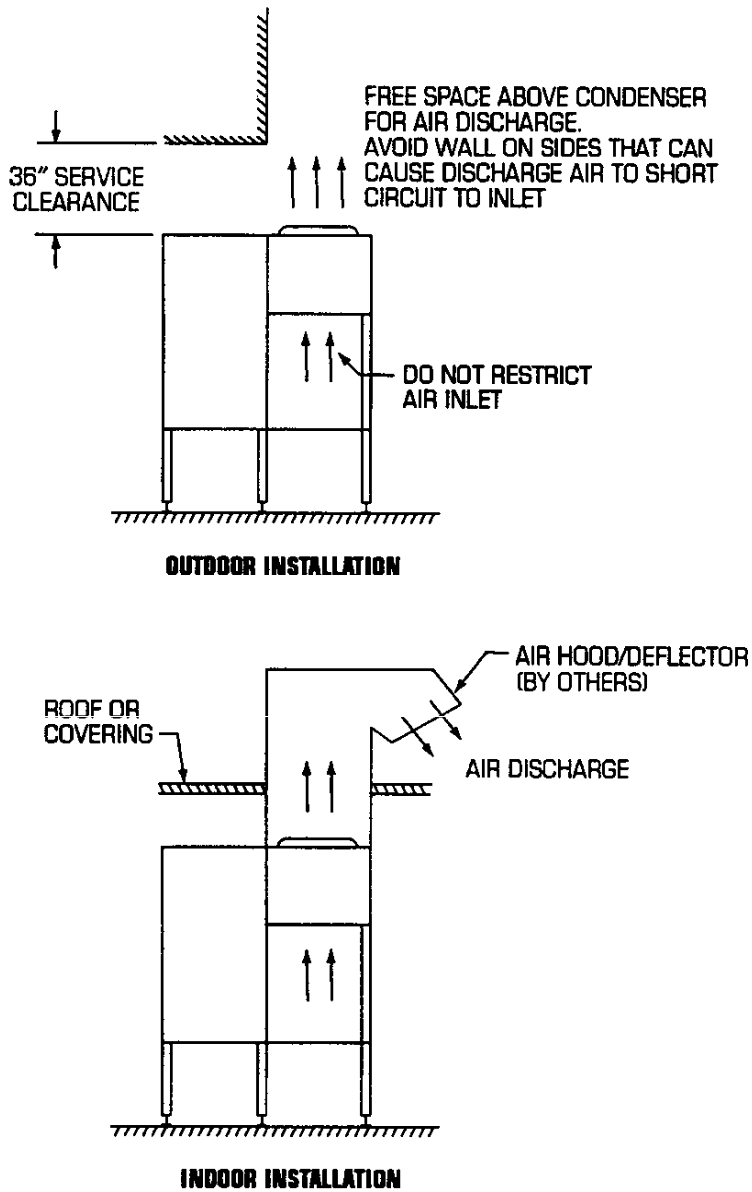


Figure 3-5 SCA Model Air Discharge

- Provisions for interfacing 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 Requirements

In general, the same requirements exist for outdoor installations as indoor installation. 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 be 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 shut-down in low ambient (below 40°F) conditions.
- Provisions must be made for access to the equipment with forklifts, cranes or other service equipment during all types of weather conditions (i.e., paving up to to equipment when surrounding area is muddy, etc.).
- Access to ladders and stairways 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 to limit access by authorized personnel only (refer to section 2 – Safety).

Concrete Slab

If the ice generator is to be mounted on a concrete slab, the surface of the slab must be level to within 2″ per 10.′ The adjusting pads on each leg provide a maximum 2″ adjustment over the length of the unit.

IMPORTANT

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

The flooring for the ice generator can be pitched to improve drainage if wash-down of the area is part of the standard operating procedure for the plant. However, as indicated above, the ice generator must be level to ensure proper operation. The footing pattern for the legs on the ice generator are shown in Figure 3-6 for both the SC and SCA models. Mounting pads to match this pattern can be used to obtain the proper leveling of the ice generators in an area with uneven flooring.

Raised Curbing

A raised curbing around the outside of the unit is recommended to contain any condensate, leakage or cleaning fluid from the unit. A maximum curbing height of 3/4″ is all that would be needed.

The ice generator has a pan in the bottom of the compressor compartment and under the water pump and water pump piping. This pan has a drain connection to the overflow drain connection (field installed). However, during wash-down or cleaning of the ice generator, some water may not be retained by the pan. If this is a factor in the equipment room or area the unit is installed, construction of a curbing should be considered.

Elevated Installation

Some installations may require mounting the ice generator above grade on a steel platform or other structural systems. Space below the ice generator for the water piping and electrical connections is still required and must be considered in designing the structure to elevate the ice generator. For elevated installations, the adjusting pads on the bottom of the legs may be welded in place after the unit is leveled. The pads may also be removed, the unit leveled and the legs welded to the structure.

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. Refer to Figure 3-6.

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

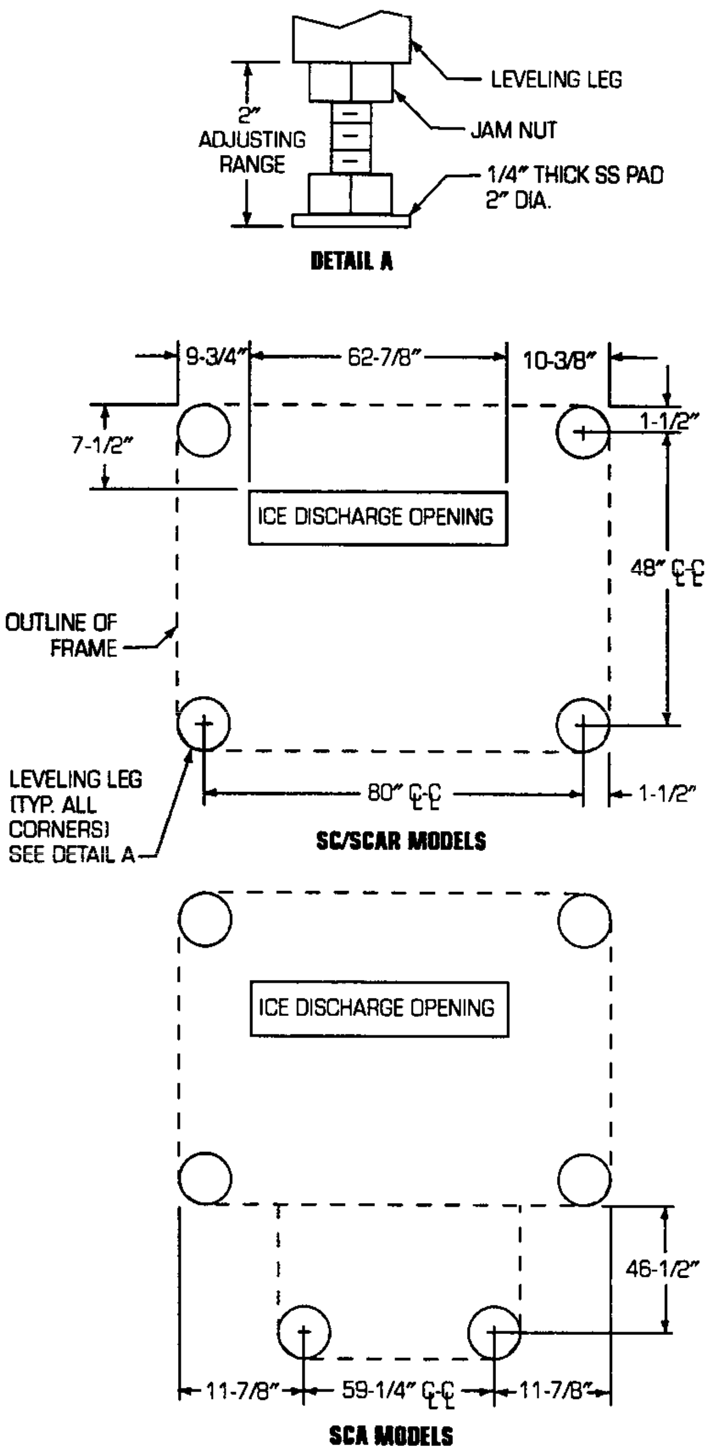


Figure 3-6 Bottom View of Ice Generator and Ice Discharge Opening - SC/SCA/SCAR Models

Access, Service, and Air Space

Refer to Figures 3-4 and 3-5. 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 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 and cooling towers (by others), 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 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.

Drain/Overflow Connection

Water may be used to wash down the interior of the ice generator, flush water piping and clean the water distribution system prior to start-up or during service or maintenance activities. Every effort should be made to keep the interior and all related parts of the ice generator in contact with the product (water and ice) as clean as possible to prevent fouling of the icemaker evaporator plates and water distribution system. To properly clean the system, it will be necessary to drain the water tank and control the discharge of water from the ice discharge opening located under the icemaking plates.

The water distribution system can be cleaned without dumping water down the ice discharge opening. However, during maintenance of the ice generator, hose down and cleaning of the interior is recommended.

To remove the water from the tank during cleaning and normal shut-down, a 3″ drain connection is provided on the bottom of the unit. The piping to the 3″ connection is field installed using a hose and clamps provided with the ice generator. An overflow (standpipe) pipe is inserted into the drain connection on the interior of the tank. For normal operation, the tank automatically drains when the ice generator is turned off. If the water does not drain, the standpipe inserted into the drain connection may be removed to drain the water.

Drain requirements are:

- 3″ drain/overflow connection
- Hose connection; hose and clamps provided
- 30 gallons per minute
- Line sized for minimal pressure drop; piping from drain connection to the field piping and drain connection must be consistent with internal piping to ensure proper draining

Note:
The piping and valve arrangement used to automatically drain the tank is connected to the drain/overflow piping supplied with the ice generator. Field installation of the piping assembly is required.

IMPORTANT

The piping from the drain/overflow must be connected to a plant drain line suitable for draining the overflow without creating a back pressure that would prevent proper draining. Maximum flow through the drain/overflow piping is 30 gallons per minute.

Water Supply/Pressure – Icemaker

The D-line ice generator is a batch production type system. Water is converted to ice during the icemaking process and replaced during the harvest cycle. Water flow of 28 gallons per minute at 6.5 PSI (at water connection) is required to refill the water tank during the harvest cycle. The water source to the ice generator should be capable of delivering this volume to the 1″ make-up water connection on the ice generator. Pressure losses through the water distribution system including the strainer, water solenoids and piping are approximately 6.5 PSIG. Proper water supply for icemaking should be:

- 28 gallons per minute
- 6.5 PSIG minimum pressure at the icemaker make-up water connection

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

Most cooling towers 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 (by others) 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 equipment above the cooling tower. Refer to step 12. Water-Cooled Condensers for details.

Water Filtration

A strainer is provided in the make-up water line to remove solids or debris in the incoming water. This should provide filtration for most systems. However, due to the variation in water conditions, water quality and water sources, additional filtration or water treatment may be required to reduce cleaning frequency of the strainer and the water distribution system. The strainer is located on the right end of the ice generator and can be easily cleaned by closing the isolation valve upstream of the strainer, unscrewing the cap on the strainer, removing the screen, cleaning with clean water and replacing. The filtration system consists of:

- 20 mesh strainer
- 1″ water strainer connections
- Recommended cleaning frequency – every 100 hours or more frequently based on actual performance requirements

If water borne solids continue to cause frequent maintenance of the filtration system to obtain proper operation beyond the first 100 hours of operation, the water source and water system should be checked to determine the source of the contaminants. It may be necessary to contact a water treatment specialist. Operating personnel should check the tank regularly for floating debris.

Water Supply/Pressure – Condenser (SC Models)

In addition to the water supplied to the ice generator for the production of ice, SC models require a water source for the water-cooled condenser. Most of the requirements for the cooling water that is used in the condensing unit are similar to the potable water supply used for icemaking. Separate field connections to the condensing water source is required. A 2″ PVC inlet and 2″ PVC outlet connection is supplied for connection to the condenser circuit. The water-regulating valve required for discharge pressure control is factory installed. Field piping is required to the cooling tower or other water sources providing a constant water temperature to the condenser. For standard installations, the water-cooled condenser is designed for supply of 85°F water from the cooling tower or a source of constant temperature water.

The condensing unit is designed for 85°F entering water temperature. The water-regulating valve will modulate water flow to maintain discharge pressure as the load varies during the cycle. Since a modulating valve is used, lower entering water temperatures can be used. The water-regulating valve will reduce the flow with the cooler supply water to maintain the same discharge pressure. Low water velocity through the condenser can result in accelerated fouling of the condenser surface causing poor performance. If the water supply is below 70°F, consult the factory. A smaller condenser with adequate velocity to prevent accelerated fouling can be provided.

Conversely higher water temperatures can result in excessively high velocity through the condenser. Although fouling is reduced, the higher velocity can cause erosion of the surface due to the abrasive action of the water at the increased flow rates. If the water supply is above 90°F, consult the factory. Larger condensers with adequate surface to maintain the condensing pressure without high water flow (velocity) through the condenser can be provided.

Water requirements for water-cooled condensers are:

- 38 gallons per minute
- Condenser circuit pressure drop 6 PSIG (includes condenser, condenser piping, and water-regulating valve; does not include external piping losses to cooling tower or elevation above cooling tower)

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

When selecting the cooling tower pump, use the data above and add the losses for external piping and vertical lift; if applicable, between cooling tower pump and condenser.

Example:
A system with the ice generator located inside a building 10′ above the cooling tower and cooling tower pump located on the ground. Assume 100′ of 2″ piping is used:

Pressure drop
2″ piping..............1.4 PSIG

Pressure drop condenser
circuit...................6.0 PSIG

Water regulating valve
pressure drop........10 PSIG

10′ vertical lift
62.4 lbs./cu. ft......4.3 PSIG

Total pressure
losses.................21.7 PSIG

21.7 PSIG would be equivalent to 50 foot head. Therefore, for this example, the cooling tower pump would be selected to provide 38 gallons per minute at a 50 foot head. This would be the minimum selection. If exact losses are unknown, it may be desirable to increase the total pump head required as a safety factor to ensure adequate flow to the condenser at all times.

Example:
Select a pump to provide 38 GPM at a 55-60′ head. This allows for additional 2-4 PSIG pressure drop and in most cases, the pump horsepower will not change.

Water Treatment

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

Consultation with a qualified water treatment company can identify the needs of your system based on their experience with other operations in your area. 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 and cleaning due to the highly corrosive effect on all materials including stainless steel.

Electrical Supply

See step 5. Electrical Connections for guidelines on the electrical requirements for the ice generator.

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

4. Ice Discharge Openings (Ice Chutes) To Storage

Ice produced by the ice generator is delivered to a common discharge located under the cabinet. Several methods of sizing and delivery to storage or the point of use can easily be adapted to the D-line. Ice can be:

- Discharged directly from the ice discharge opening of the ice generator into a storage building located below. Refer to Figure 3-7.
- Discharged into storage or point-of-use through a screw conveyor installed under the ice discharge opening of the ice generator. Refer to Figures 3-8 and 3-9.
- Discharged into a TURBO breaker bar or TURBO ice sizing mechanism and discharged either directly to storage or point-of-use or into a screw conveyor. For the screw conveyor method, any standard screw conveyor can be used. TURBO can provide any of the sizing mechanisms described as options. Refer to Figures 3-10, 3-11 and 3-12.
- Discharged from either end of the ice generator or out the rear through a discharge transition. Front discharge is not available due to interference with the water piping under the ice generator and restriction of access to the front for cleaning and maintenance. On installations with multiple ice generators discharging into a common conveying system, the rear discharge is recommended. Refer to Figures 3-11 and 3-12.

The use of a discharge transition into a screw conveyor is recommended to prevent condensation, cleaning agents or water from accidentally dumping into the storage or point-of-use.

IMPORTANT

All conveyors, transitions, or belt conveyors connected to the ice discharge opening should ensure access to the screw conveyor or other ice sizing methods (if used) is eliminated; i.e., properly covered. Refer to section 2 – Safety for additional information.

Typical Installations

Figures 3-7 through 3-12 show various ice discharge configurations. These are for reference onlly. The final configuration should be selected for the site conditions based on all the site selection factors including plans for future expansion.

Figures 3-13 and 3-14 show typical ice delivery to a storage point and suggestions for design of the ice discharge transitions. Ice discharge transitions are available as an option for single and multiple unit installations.

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

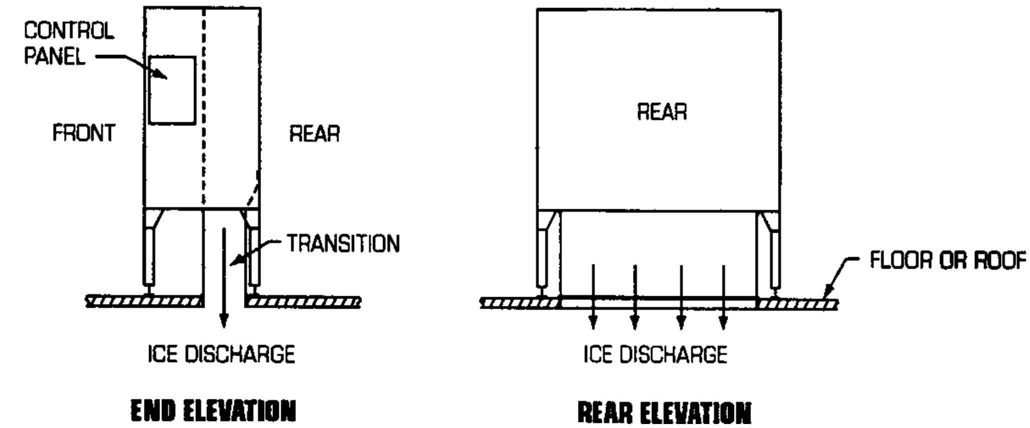


Figure 3-7 Discharge Without Screw Conveyor – Single Ice Generator

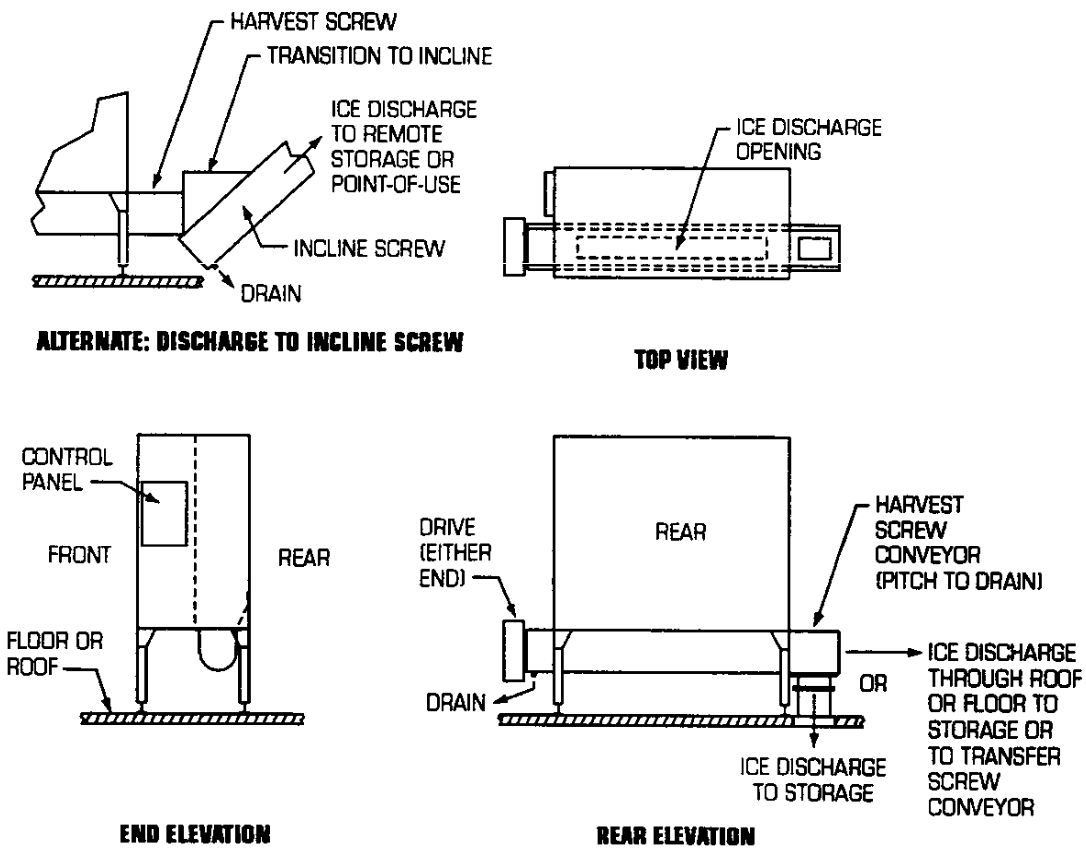


Figure 3-8 Discharge With Screw Conveyor Under Ice Generator – Single Ice Generator

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

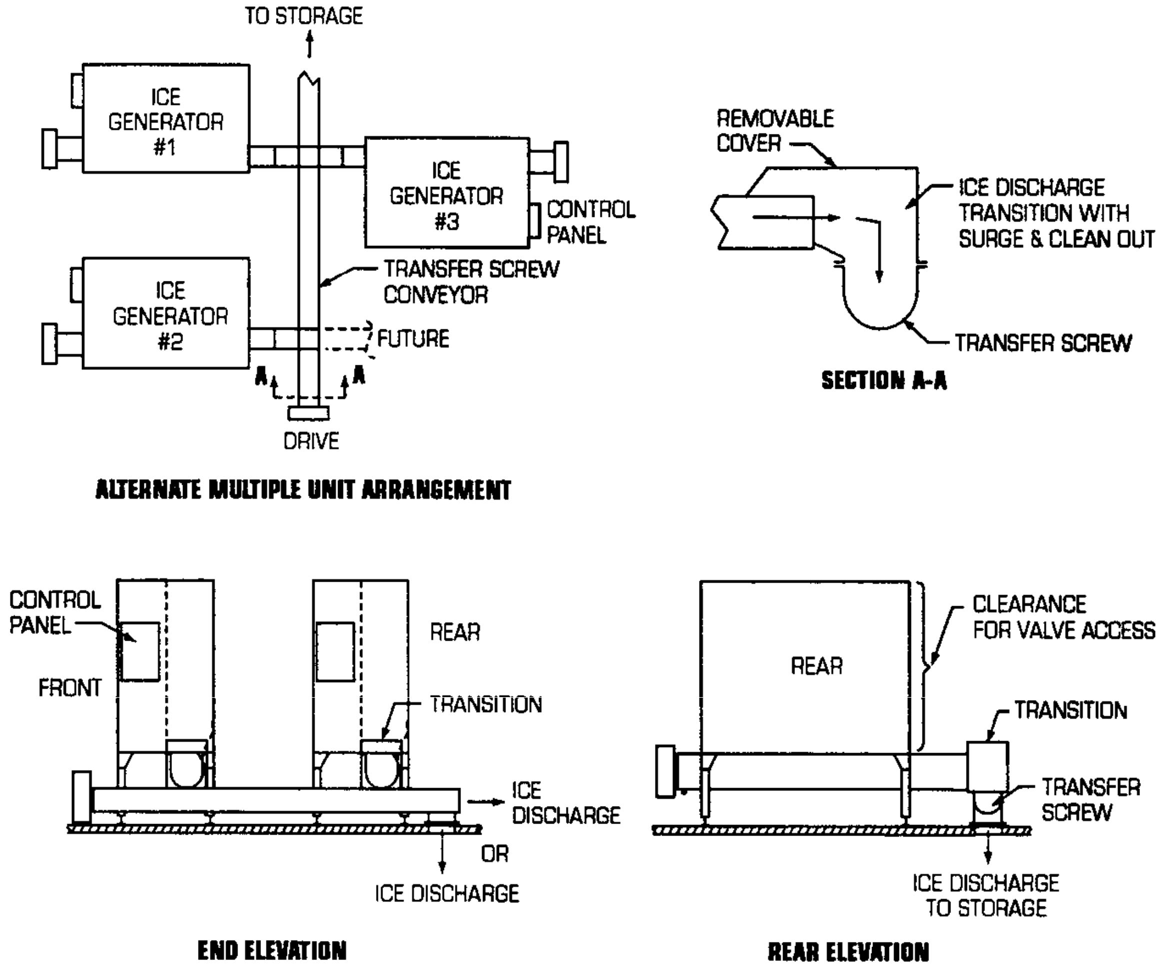


Figure 3-9 Discharge With Screw Conveyor Under Ice Generator – Mulitple Ice Generators

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

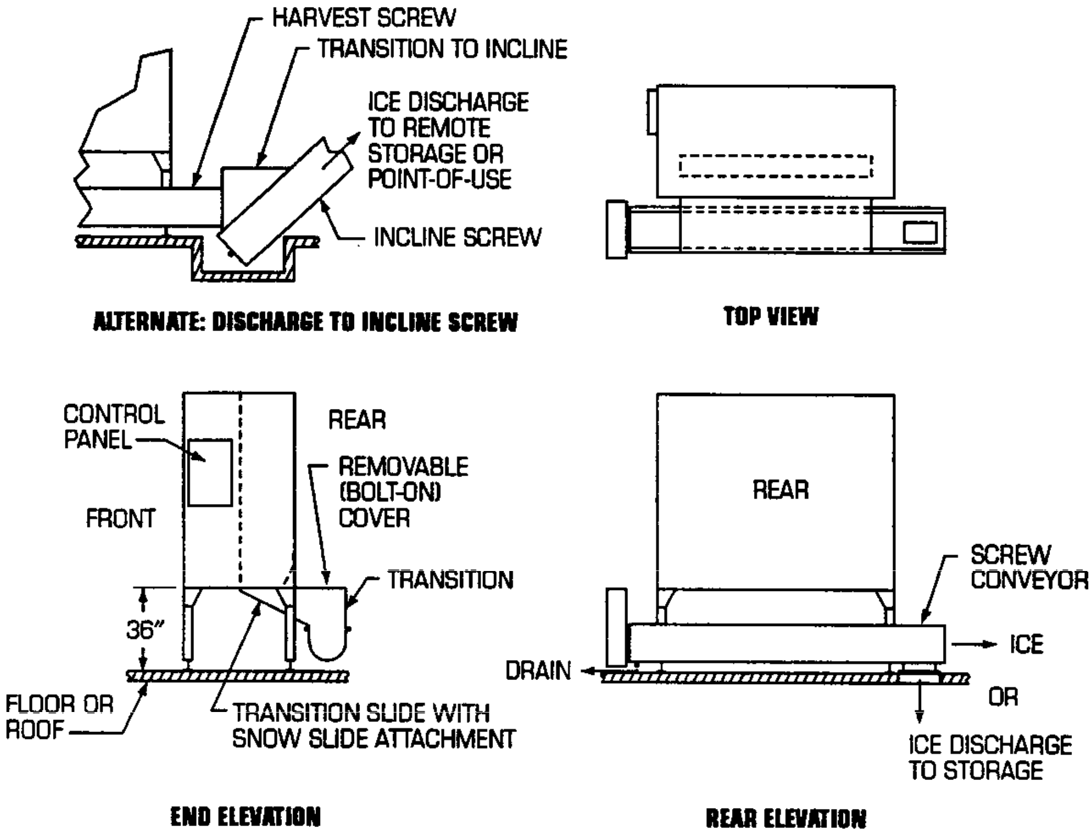


Figure 3-10 Rear Discharge – Single Ice Generator

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

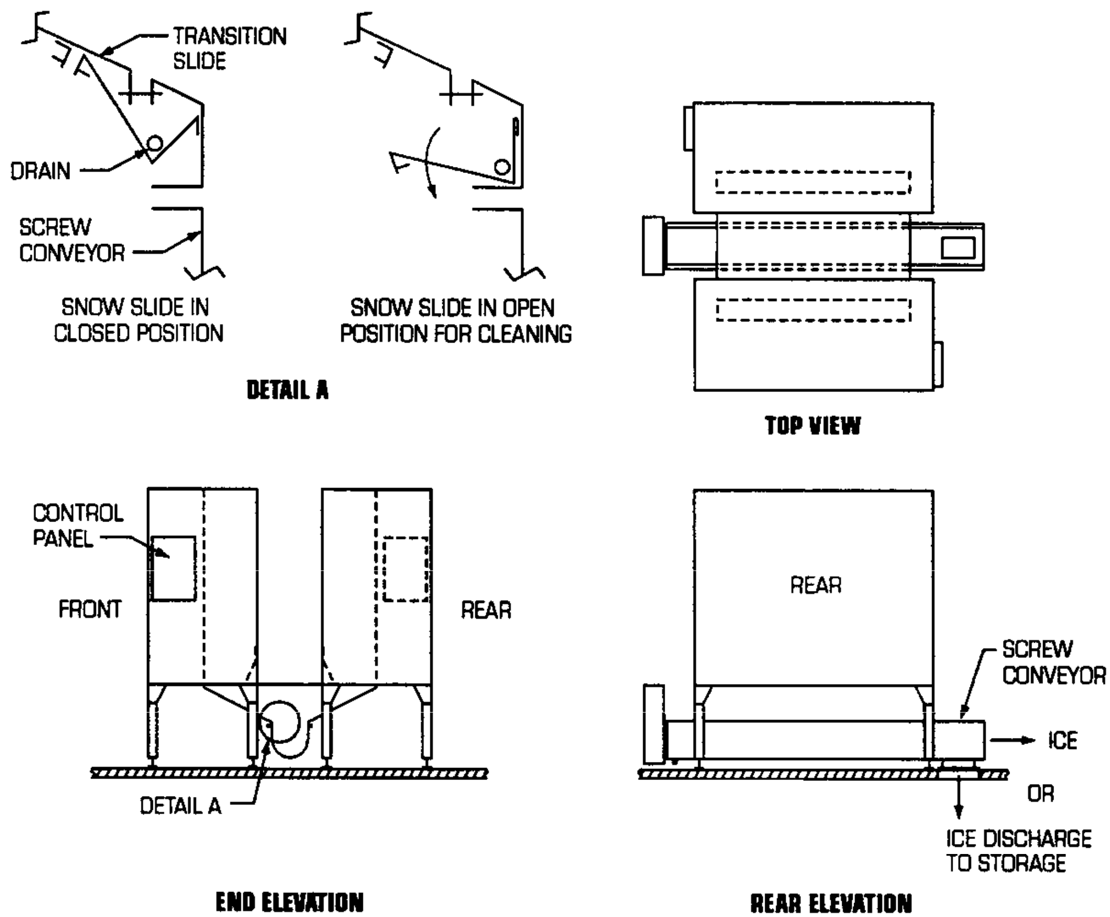


Figure 3-11 Rear Discharge – Multiple Ice Generators

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

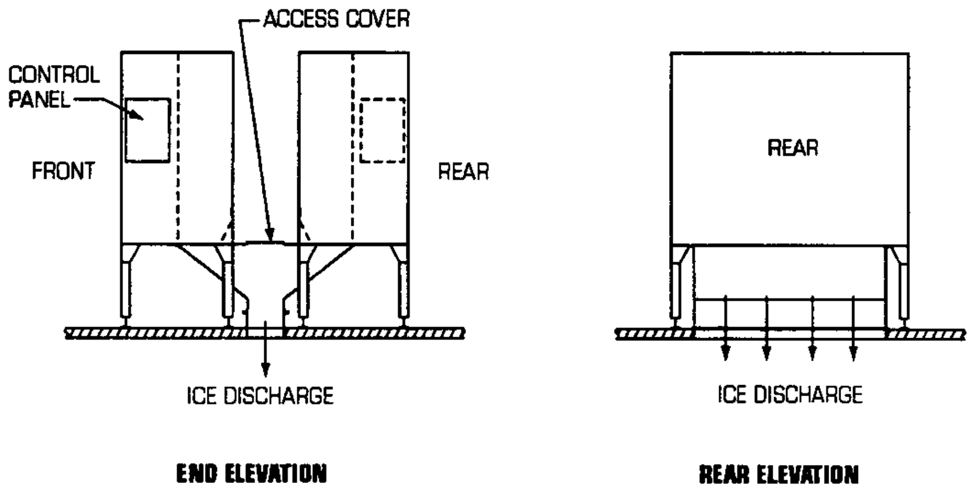


Figure 3-12 Rear Discharge Without Screw Conveyor

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

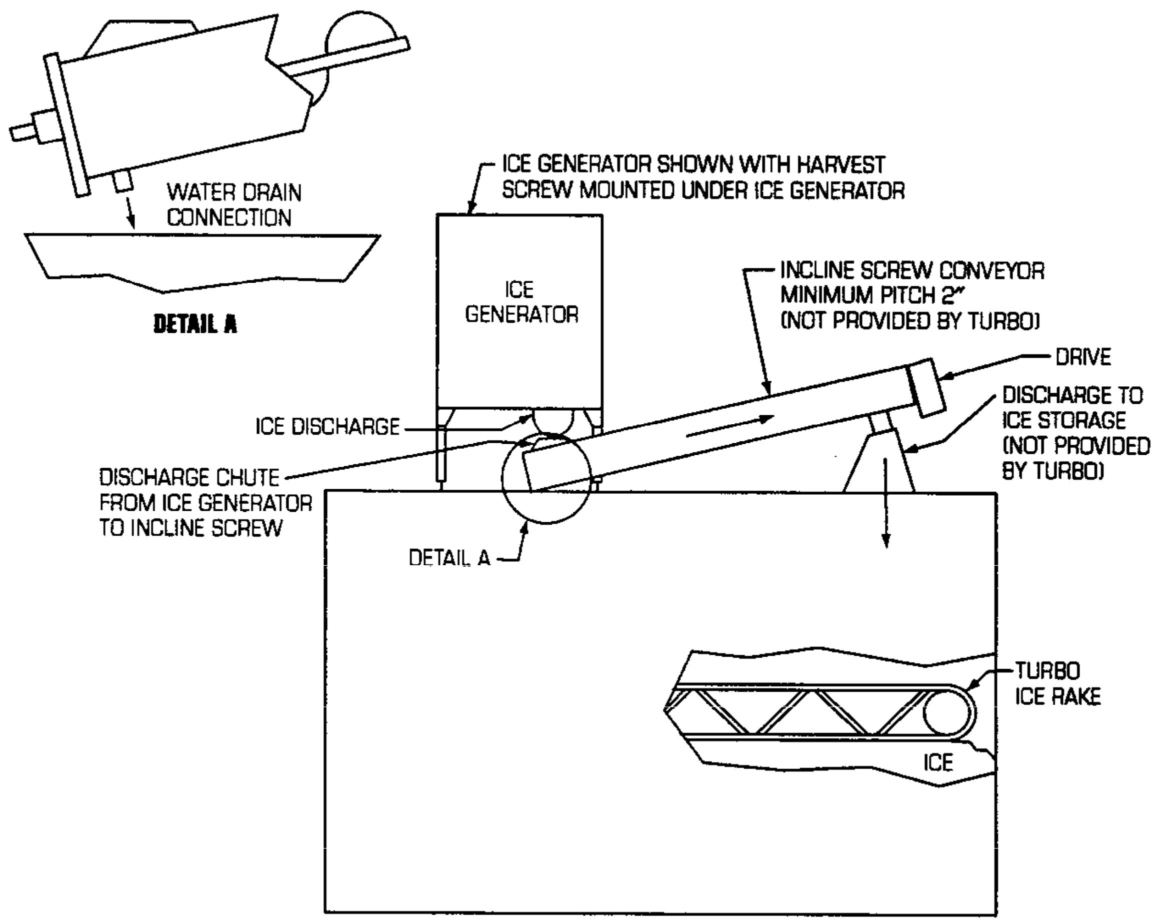


Figure 3-13 Typical Ice Delivery To Storage

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

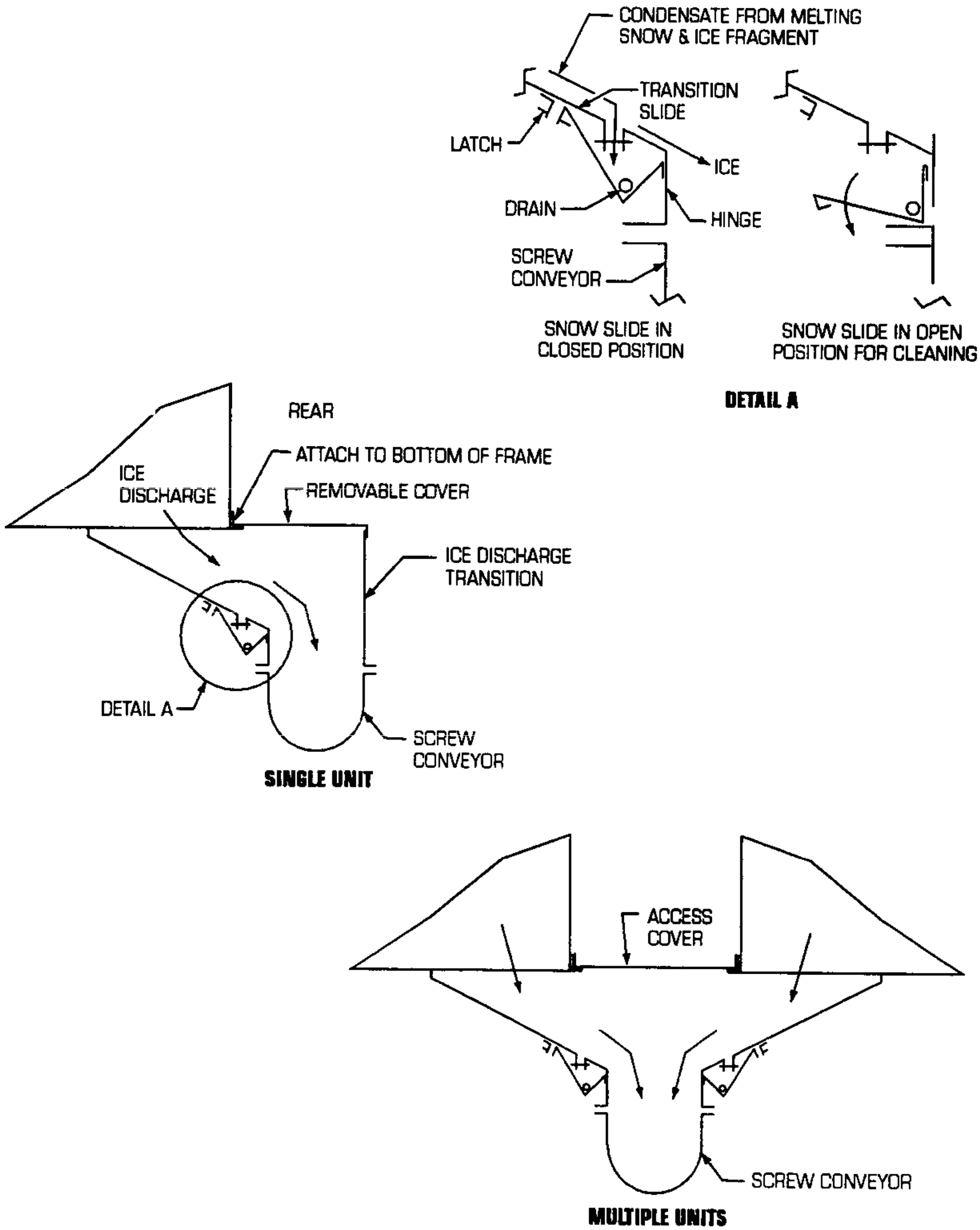


Figure 3-14 Rear Ice Discharge Transition/Snow Slide

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

5. Electrical Connections

WARNING

A qualified electrician should do all electrical work. Do NOT turn power on at this time. Electrical connections and rotation should be done at the completion of the installation process. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Table 3-2 Maximum Continuous Run Amps for Standard Models

Single-phase control circuit	115/1/60	10 amps
Three-phase power	230/3/60	460/3/60
Water-cooled	67.1 amps	33.5 amps
Air-cooled (SCA)	79.2 amps	39.6 amps
Remote air-cooled (SCAR)[1]	70.8 amps	35.4 amps

[1] Standard continuous for factory supplied air-cooled condenser is 8.4 amps at 230/3/60. For remote air-cooled condensers supplied by others, the actual continuous run amps of the condenser supplied must be added to the load shown for SCARs to obtain the full load for SCAR models.

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.

Electrical Service Connections

The ice generator is supplied with a UL listed control panel containing all the control devices required for operation of the ice generator. All components (motors, solenoids, etc.) provided with the ice generators are factory wired. Wiring is provided from the bottom of each motor starter or contactor to the factory installed motor.

Field installation of external disconnects and/or circuit breakers and wiring from disconnects and/or circuit breakers is provided and installed by others. The installer is responsible for ensuring that all connections, installations and other devices or requirements necessary to meet local, state, federal or country codes and regulations are met. Field electrical service connections are required to the:

- L1, L2 and L3 connections on each of the motor starters/contactors (three-phase)
- L11 and L2 connections of the control circuit (single-phase)

All factory installed wiring is copper. TURBO does not recommend the use of aluminum wiring. Electrical data for selection of wiring loads can be found on the data plate located on the control panel door. Refer to Table 3-2.

If optional devices (motors) are supplied, refer to the data plate for the requirements of all the components supplied.

All electrical connections are made through the opening in the frame located on the right front corner. Connections are provided for:

- Single phase circuit 1/2″ conduit
- Three-phase circuit 1-1/2″ conduit connection

Refer to Figure 3-15.

Checking Rotation

WARNING

Make sure the screw conveyor is clear of all obstacles and debris and warn personnel to stay clear of the screw conveyor when the rotation is being checked and during operation after installation is completed. 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.

The compressor can rotate in either clockwise or counter-clockwise rotation. Proper rotation of the water pump is established by the volute of the pump. An arrow is placed on the pump fan housing to indicate the proper rotation. During installation, the water pump starter can be "bumped" (momentarily energized) and the rotation of the fan on the pump motor can be observed through the fan guard. If the fan is rotating in the proper direction, nothing further is required since the phasing of both the water pump and compressor were the same when factory wired; i.e., if the water pump is correct, the compressor will also be correct when the phasing to the top of the starter and contactor are the same.

If a screw conveyor (option) is supplied with the ice generator or by others, the direction of rotation must also be established. This will be done in the field by observing the rotation of the screw conveyor shaft when the screw conveyor starter is "bumped."

Note:
When checking the rotation, only the power to the water pump should be on. Turn the power to the compressor off. The screw conveyor (if supplied) rotation can be checked with the compressor and water pump power off.

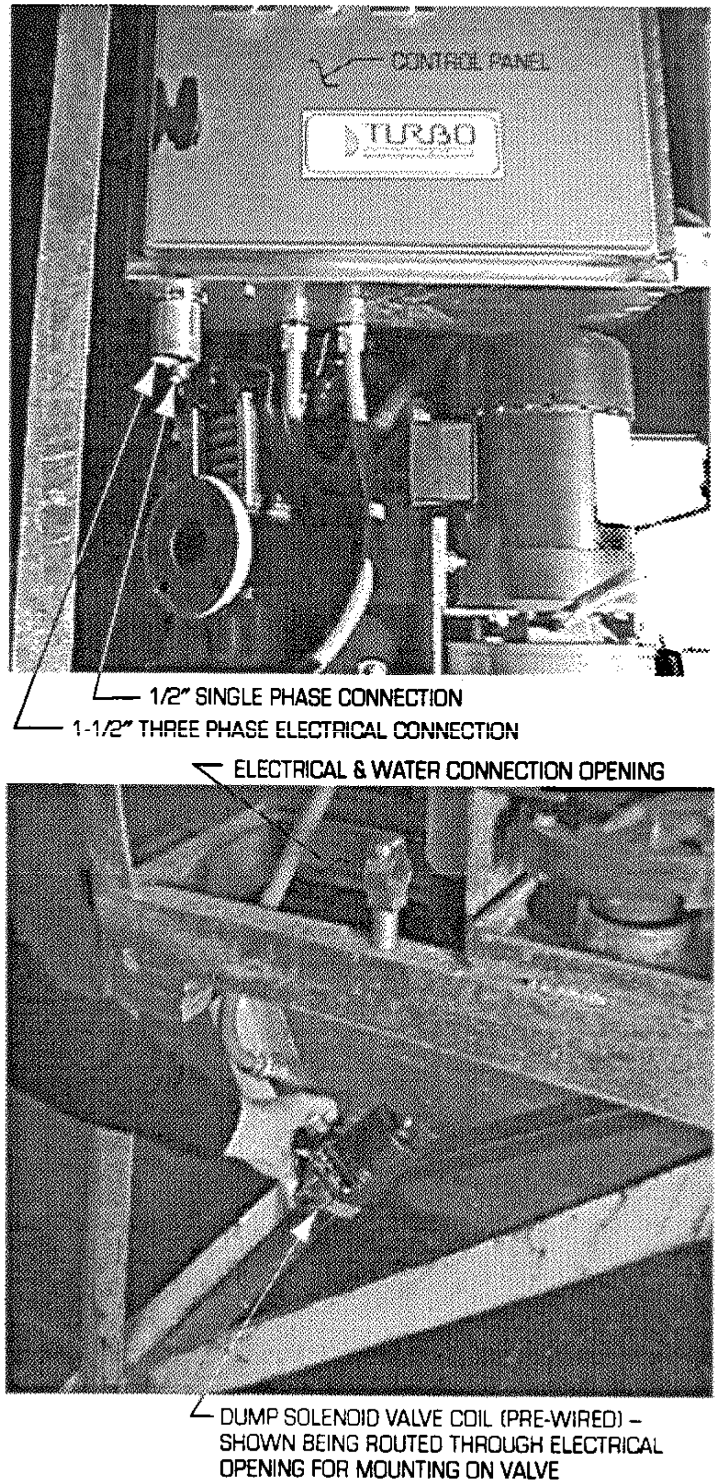


Figure 3-15 Electrical Connections

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

6. Water Connections

Make-Up Water

The source of make-up water and its' temperature are important. The make-up water is the supply water from which the ice is made. The quality of the ice will depend on the type of water supplied.

Water Type

The ice can be no better than the water from which it is made. Extremely hard water will tend to make cloudy, softer ice and will leave deposits within the machine, necessitating frequent cleaning. Hard water will not harm the ice generator, but it will increase the maintenance necessary to keep the machine clean.

Water Temperature

The temperature of the water is an important factor in determining the icemaking capacity of the ice generator unit. All icemaking capacities are based on a design make-up water temperature of 60°F. As the water temperature increases, the icemaking capacity will decrease due to the additional cooling load on the refrigeration system. Conversely, as the make-up water temperature decreases, the icemaking capacity will increase since less refrigeration is required to remove the heat from the water. Correction factors for different water temperatures are shown in Table 3-3. For temperatures outside the range shown in the table, consult the factory.

Make-Up Water Connection

Refer to Figures 3-16, 3-17, 3-18 and 3-19. All standard D-line ice generators use a 1″ make-up water connection. Make-up water flow required is 28 gallons per minute (6 ton model).

Make-Up Water Pressure

The solenoid valves used in the make-up water line are typically rated for a maximum water pressure of 150 PSIG and 125°F fluid temperature.

Minimum water pressure should be approximately 6.5 PSIG at the inlet connection to the ice generator to ensure continuous water feed at all times.

IMPORTANT

Never undersize a make-up water line. Ice capacity cannot be reached without the proper make-up water line size.

Drains

There are three drain connections.

Pan Drain

A water tight pan is provided to collect condensate, etc. Connect a drain line of proper size to the pan drain. This line will normally be dry or contain only a small amount of water.

Overflow Drain

Blowdown or overflow of water in the tank can be adjusted from 0 to 25% to reduce concentration of residual solids. The icemaking process tends to concentrate (freeze-out) minerals and suspended solids in the water. Depending on the water quali-

Table 3-3 Correction Factor for Feedwater Temperature

Water Temperature	35°F	40°F	50°F	60°F	70°F	80°F	90°F
Ice Capacity Multiplier	1.17	1.13	1.06	1.00	0.94	0.89	0.85

Example:
Ice generator with 40°F make-up water.
Nominal capacity with 60°F water = 6 tons/day.
Correction factor for 40°F water = 1.13.
Corrected ice capacity = 6 x 1.13 = 6.8 tons/day.

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

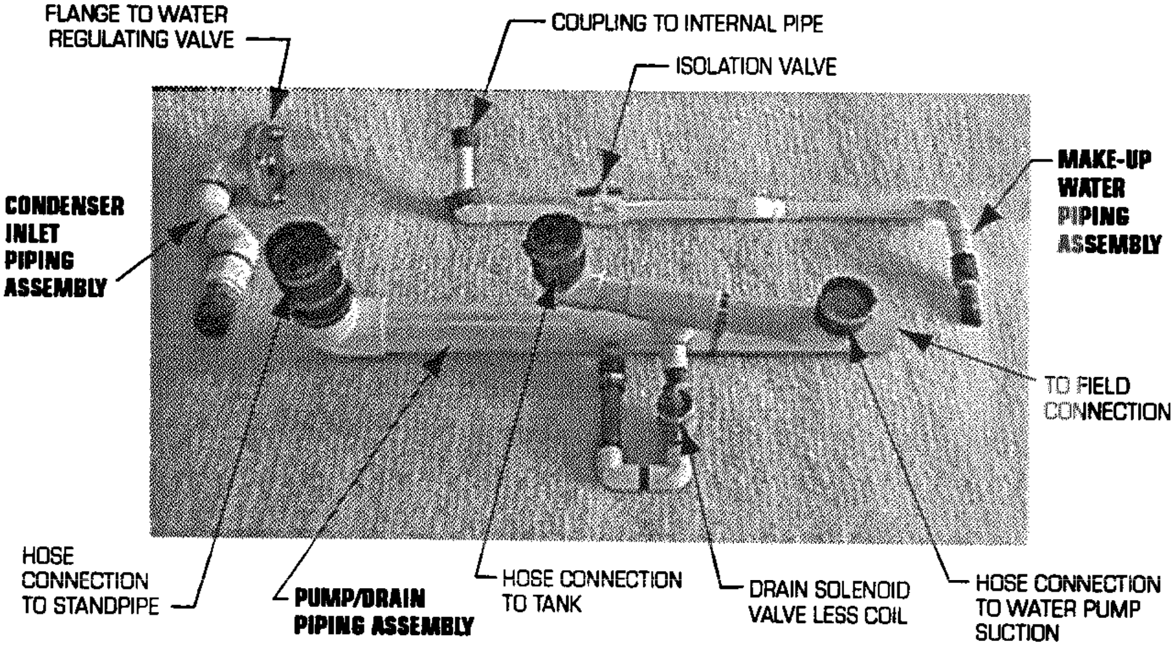


Figure 3-16 Water System Components

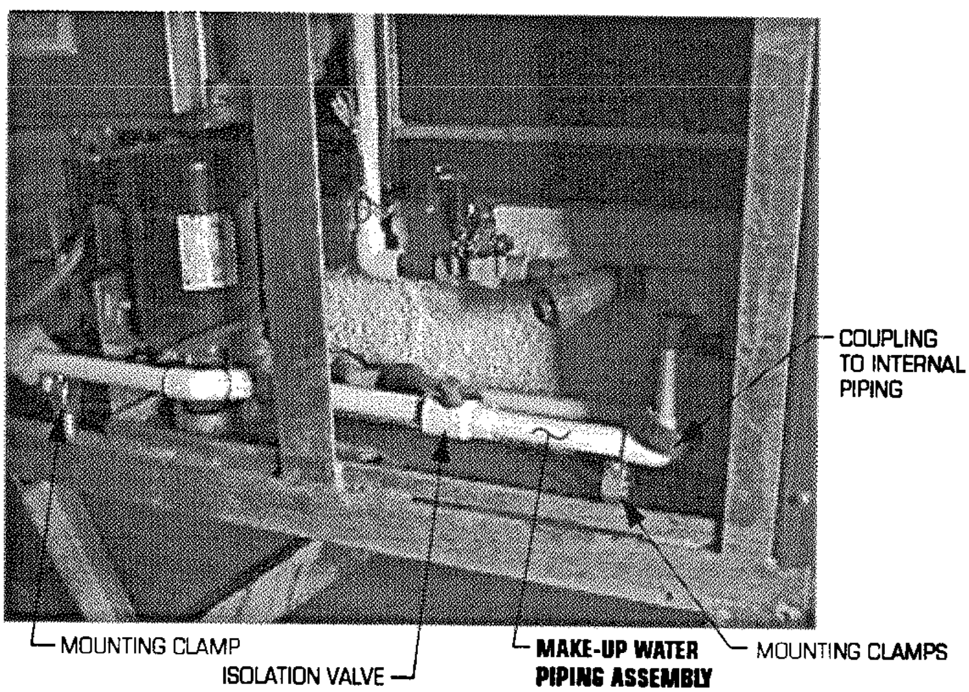


Figure 3-17 Make-Up Water Piping Installation

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

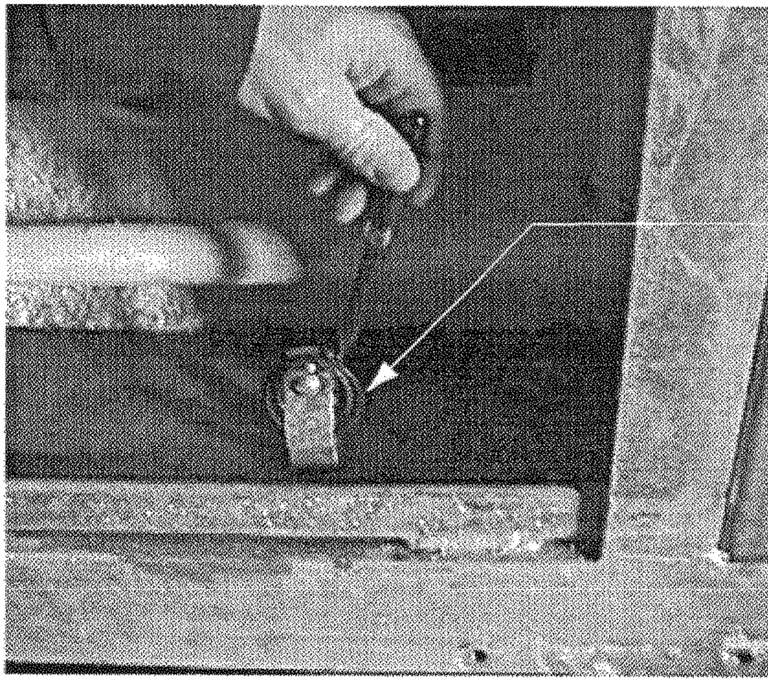


Figure 3-18 Make-Up Water Piping O-Rings

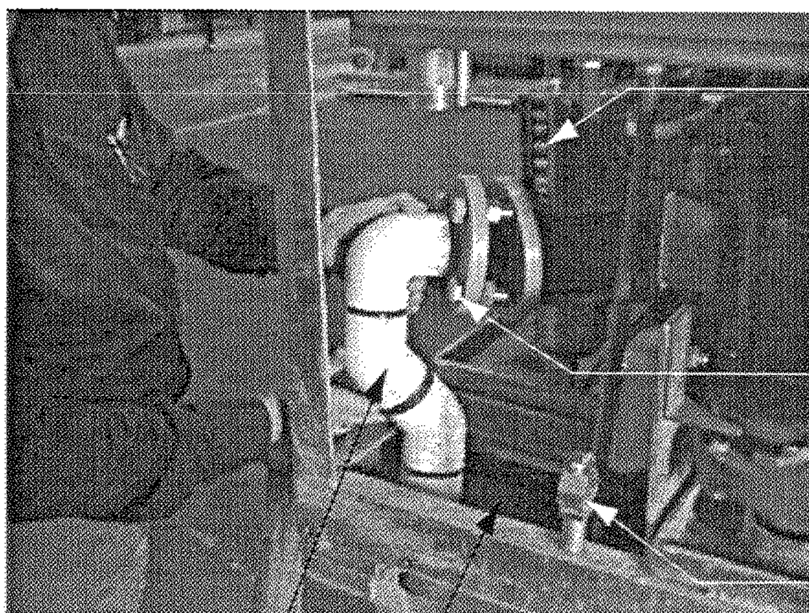


Figure 3-19 Condenser Inlet Piping

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

ty (hardness, etc.), this can cause enough concentrations in the water tank to produce white or cloudy ice. A time delay on the make-up water line solenoid is provided to allow adjustment of the overflow or blowdown rate on a continuous basis.

Decreasing the MWS time delay reduces the overflow rate, while increasing the time delay allows more water to overflow.

At start-up, adjustments can be made to obtain the desired blowdown rate. Periodic checks should be made to ensure that deposits are not building up in the tank.

A local consultant on water treatment is also advisable 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 drain lines must be exposed to freezing temperatures.

Water-Cooled Condensers

Water condensers supplied 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 @ 10°F SET/105°F SDT divided by 15,000 BTU/ton.

Water Regulating Valve (SC Models Only) Optional

A water regulating valve is furnished and factory installed and piped. A 1/4" SAE flare type valve is provided on the compressor and connected to the bellows on the water-regulating valve. This provides the discharge pressure signal used to modulate the water flow.

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 ice generators are installed in an area where the ambient falls below freezing, refer to section 8 – Optional Features & Accessories for Winterizing.

Water Flow Rate

Standard SC models require 38 gallons per minute flow to the condenser at the design conditions stated above.

Water Pressure

The water pump selected for the condenser circuit must include the pressure drop through the condenser, water-regulating valve and piping. For standard SC models, the pressure drop is 18 PSIG (does not include vertical lift). To obtain the required flow through the condenser, both the flow and pressure stated must be available at the condenser connections on the ice generator. Refer to example on page 3-18.

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

7. 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.

Avoid trapping the lines except for specific purposes. If traps are used, the horizontal dimension should be as short as possible to avoid excessive trapping of oil.

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.

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.

Soldering

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

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

8. 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 ASA B.9 Code Brochure entitled "Safety Code for Mechanical Refrigeration." 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.

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 ice generator 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.

IMPORTANT

No repairs should be made to welded or soldered joints while the system is under pressure.

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

9. 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 ice generator before charging it with refrigerant. If air, water vapor, or non-condens-ables 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°F 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.

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.

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

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.
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 the 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).
6. Evacuate the system below the 500 micron figure and charge with the refrigerant being used for the system.

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

10. 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). Other equipment such as the oil filter or oil coolers (when used) also require oil charge. Therefore, the oil level in the compressor 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.

Periodic Checks and 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
- 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.***

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.

Oil Charge
4 cylinder semi-hermetic compressor – 152 fluid ounces.

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

11. Refrigerant Charging

Possible Leaks

Self-contained water-cooled, evaporative-cooled, and air-cooled ice generators 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 8. Testing Refrigeration System for Leaks.

Adding Refrigerant

IMPORTANT

Before adding refrigerant or placing the unit in operation, evacuate the entire system to insure a completely dry system. See step 9. Evacuating the System.

Whenever refrigerant is added to any ice generator, extreme care should be taken in admitting the refrigerant to the system. Refer to Figures 3-20 and 3-21.

1. The ice generator 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 213 PSIG, 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 ice generator is fully charged. The ice generator nameplate lists the unit model, refrigerant type, and refrigerant charge. Always monitor and record how much refrigerant is added. Never 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 Units

Self-contained units furnished for use with remote air-cooled condensers (SCAR) 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.

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 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 3-22 and 3-23.

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

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

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

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

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 $= f\,DL_1$

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

Example:

DF6SC uses a 10-3/4″ diameter x 36″ receiver.

Design relief pressure is 350 PSIG.

Refrigerant is R-22.

Therefore, $C = f\,DL = (1.6)\,\frac{(10\text{-}3/4)}{12}\,\frac{(36)}{12}$ = 4.3 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:

$$L = \frac{9P^2d^5}{16C^2} = \frac{(9)\,(9{,}985)\,(0.38)}{(16)\,(18.49)} = 115.1'$$

where:

P = 0.25 [(350) (1.1) + 14.7] = 99.9

P^2 = 9,985

d = 0.824″ (3/4″ sch40 pipe)

d^5 = 0.38

C = 4.3 pounds of air per minute

C^2 = 18.49

Therefore, a 3/4″ sch40 pipe is completely adequate for normal installations with relief valve discharge piping less than 115′ long. If longer piping is required, a larger size piping would be required.

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

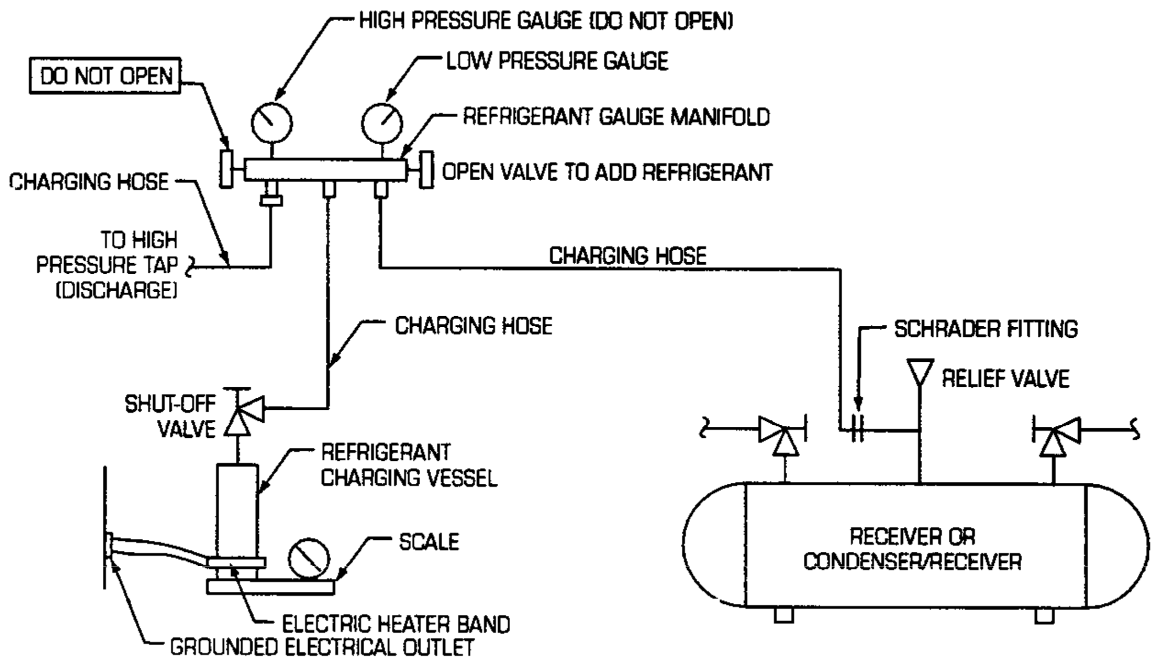


Figure 3-20 Typical Connections For Initial Refrigerant Charge

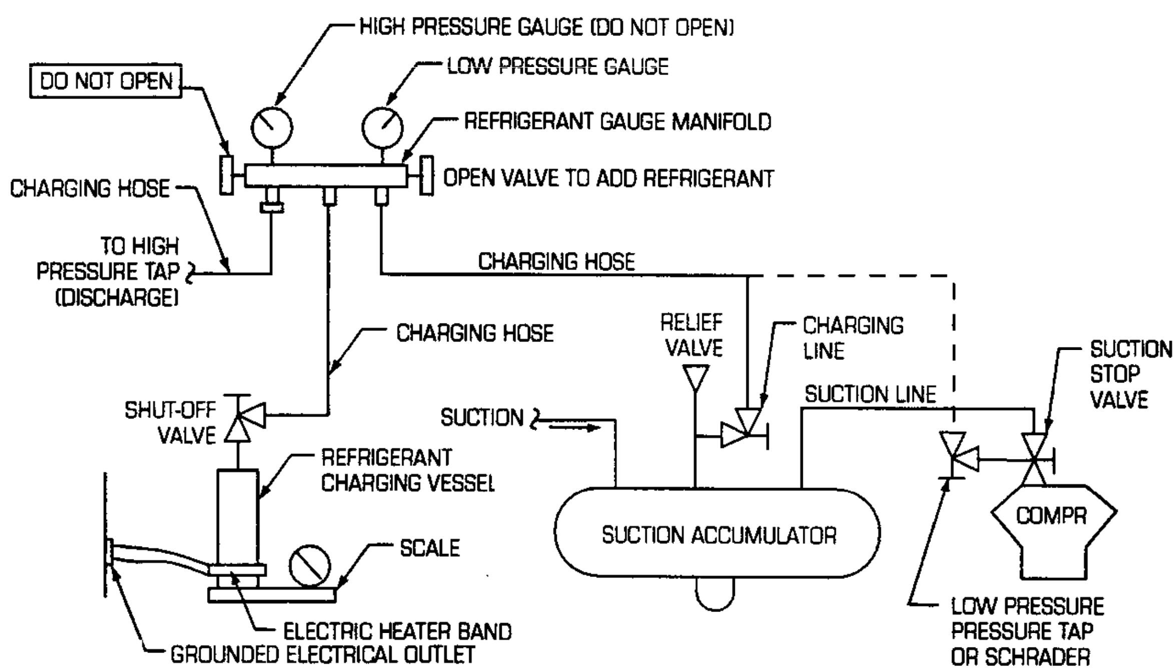


Figure 3-21 Adding Refrigerant To Existing Charged System

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

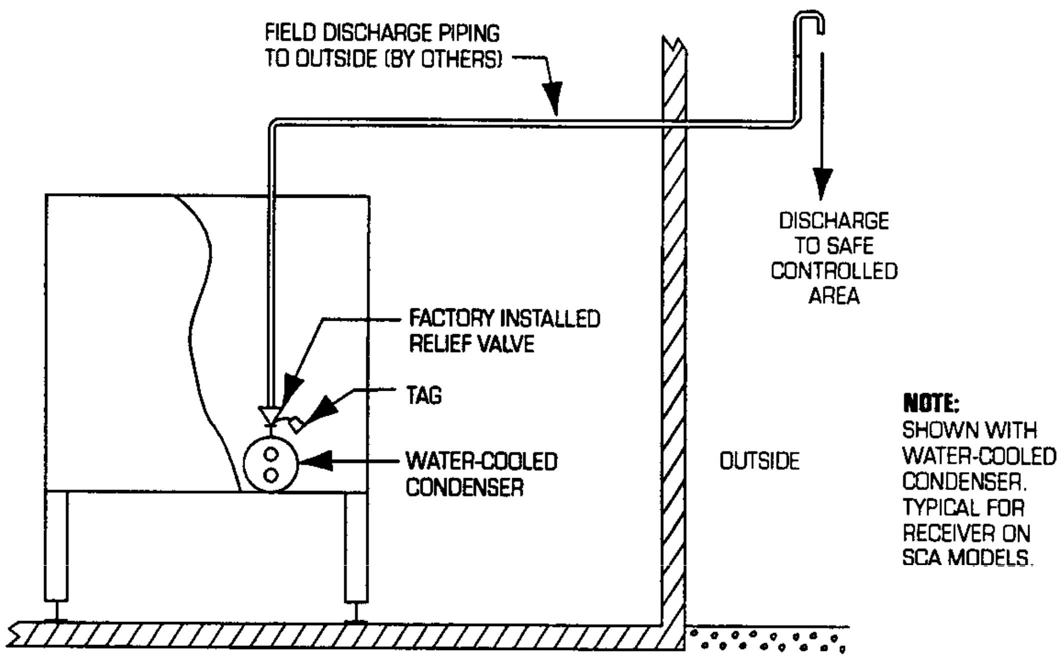


Figure 3-22 Typical Indoor Installation Relief Valve Piping

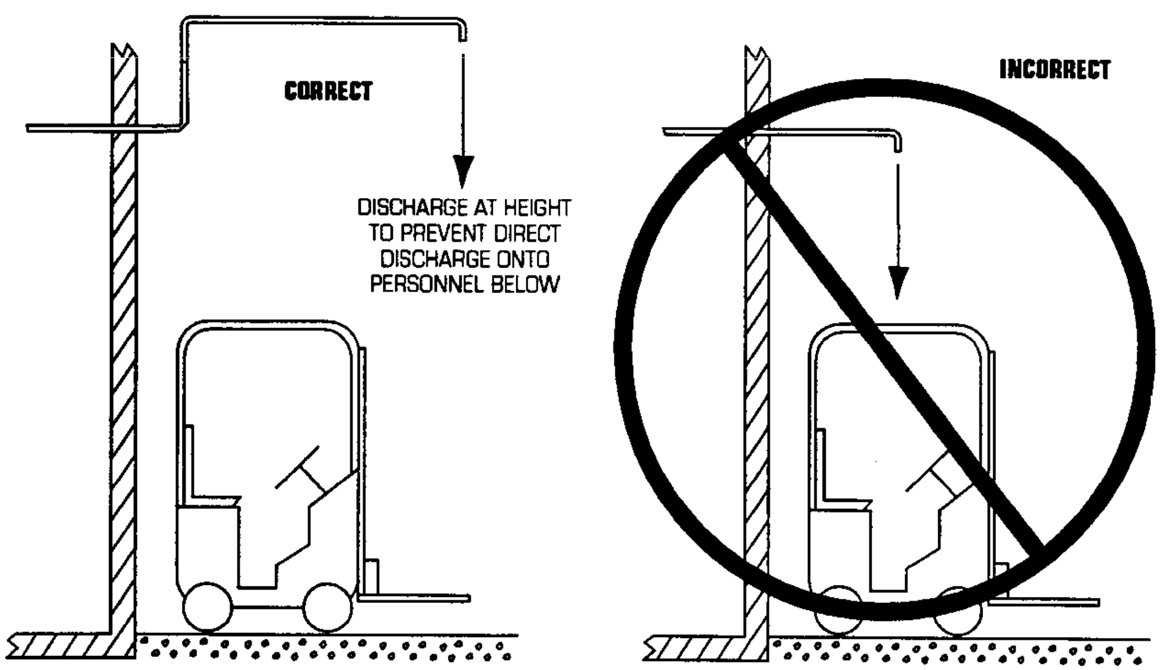


Figure 3-23 Correct and Incorrect Relief Valve Discharge Piping

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

12. Water-Cooled Condensers

Mounting

Water-cooled condensers supplied SC models are mounted on a common base frame with the evaporator. The condenser is located on a structural support directly under the compressor assembly. A compressor discharge line is piped to the condenser inlet and a liquid line connection is piped to the evaporator.

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)
- 10°F saturated evaporator

THR (total heat of rejection) = (evaporator load at 10°F SET and 105°F SDT in BTUH) + (heat of compression in BTUH)

Example:
DF6SC with 4DJ300 compressor

Compressor capacity @ 10°F SET and 105°F SDT = 13.7 tons = 164,000 BTUH

Compressor KW @ 10°F/105°F = 18.6

THR = (164,000) + (18.6) (3,413) = 227,500 BTUH

Tower gpm = (THR ÷ 15,000 BTUH/tower ton)
(3.0 GPM/tower ton) = (227,500/15,000) (3.0)
= 45.5 = 45 GPM

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.

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 head 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.

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 (by others)
- Cooling tower pump (by others)

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

- Low discharge pressure switch (by others)

1. A switch sensing the discharge pressure closes at 150 PSIG to start the cooling tower 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 setpoint (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. 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 counterclockwise 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 3-24, 3-25 and 3-26 for typical water-cooled condenser piping and wiring.

General Information

1. The shell-and-tube condenser used is also used as a receiver to hold the system refrigerant operating charge when the unit is pumped down (i.e., a separate receiver is not required).
2. A safety relief is provided on each condenser. Refer to step 11. Refrigerant Charging for guidelines on relief valve venting.

Installation

All components are factory installed and pre-wired.

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

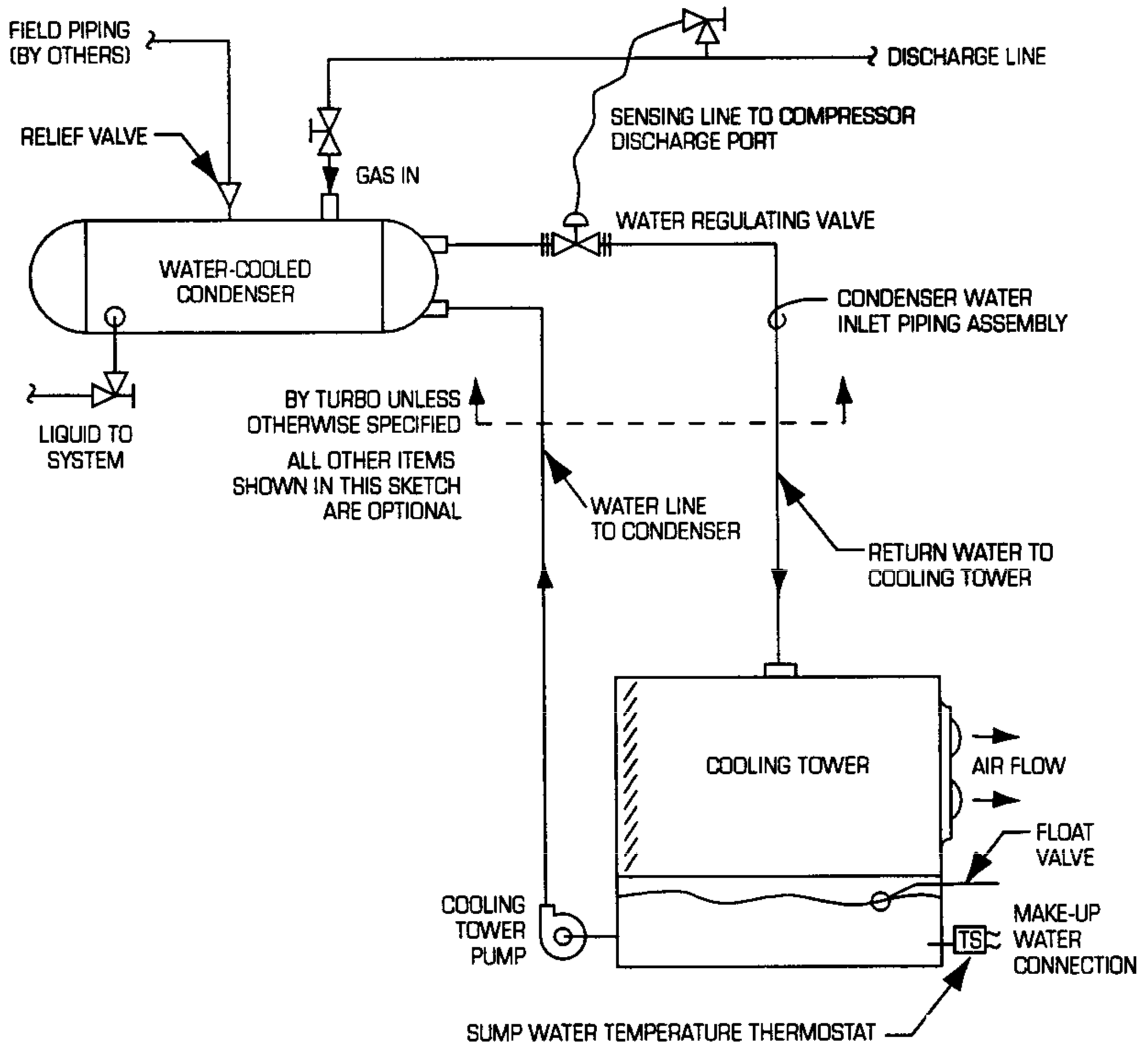


Figure 3-24 Typical Water-Cooled Condenser Piping

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

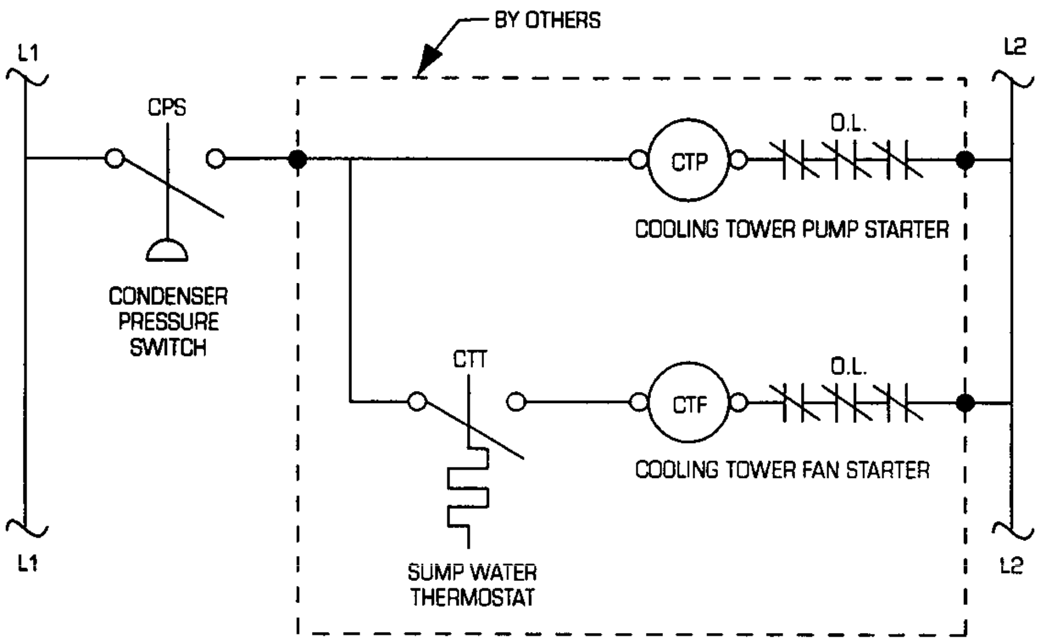


Figure 3-25 Typical Wiring For Water-Cooled System

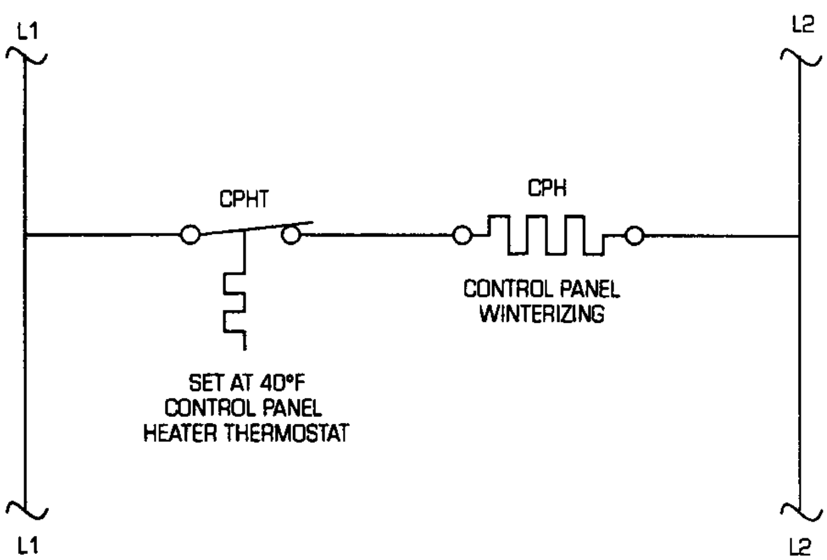


Figure 3-26 Control Panel Winterizing Wiring

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

13. 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)
- 10°F saturated evaporator temperature, SET
- THR total heat of rejection (evaporator load in BTUH at 10°F SET and 120°F SDT) + (heat of compressor in BTUH)

Example:
DF6SCA with 4DJ-3000 compressor.

Compressor capacity at 10°F SET and 120°F SDT = 12.2 tons = 146,000 BTUH

Compressor KW at 10°F SET and 120°F SDT = 20.318

THR = (146,000) + (20.318) (3,413) = 215,345 BTUH

Condenser selection would be based on 215,345 BTUH with 20°F TD.

Mounting

Air-cooled condensers supplied with 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 (SCAR models), 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 - Discharge Pressure Controls

Refer to Figure 3-27. 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 3-13):

- 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 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

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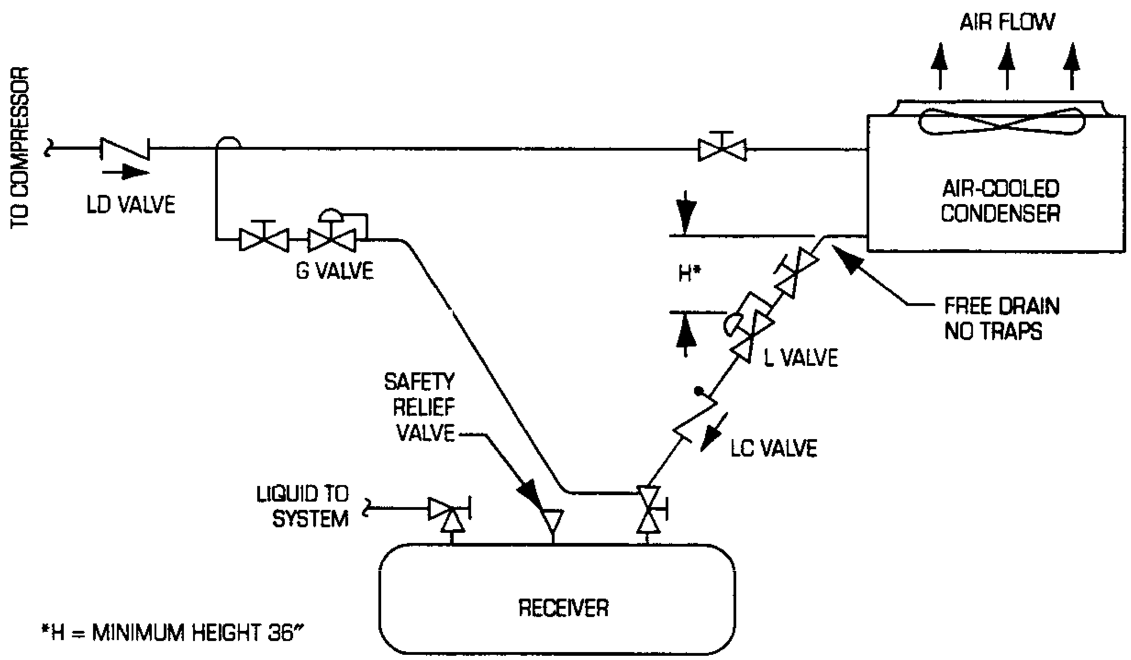

Figure 3-27 Typical Air-Cooled Control & Winter Control Valve Piping (Flood-Back Method)

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 condenser drain line from the air cooled condenser to the receiver) is the modulating upstream pressure regulator. Its' 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 liquid to pass into the receiver. 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 counterclockwise 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 refrigerant 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 thermostatic 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 above the setpoint and then closes. 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 insure 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, refrigerant gas will not 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 high pressure in the warm receiver through valves "L" and "G" back into condenser (because of low ambient at a low pressure). A check valve "LC" is placed in the drain to prevent migration of the liquid back to the condenser. Without the "LC" valve, the pressure in the receiver would drop.

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"

Valve "LD" is also a check valve which must be installed in the discharge line as close to the compressor as possible. Valve "LD" ensures that no gas in the condenser will migrate to the compressor head. Refer to Figure 3-27 for valve arrangement.

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

Refer to Figure 3-28. 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 setpoint.

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

VSM controllers can also be

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

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 3-28 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.

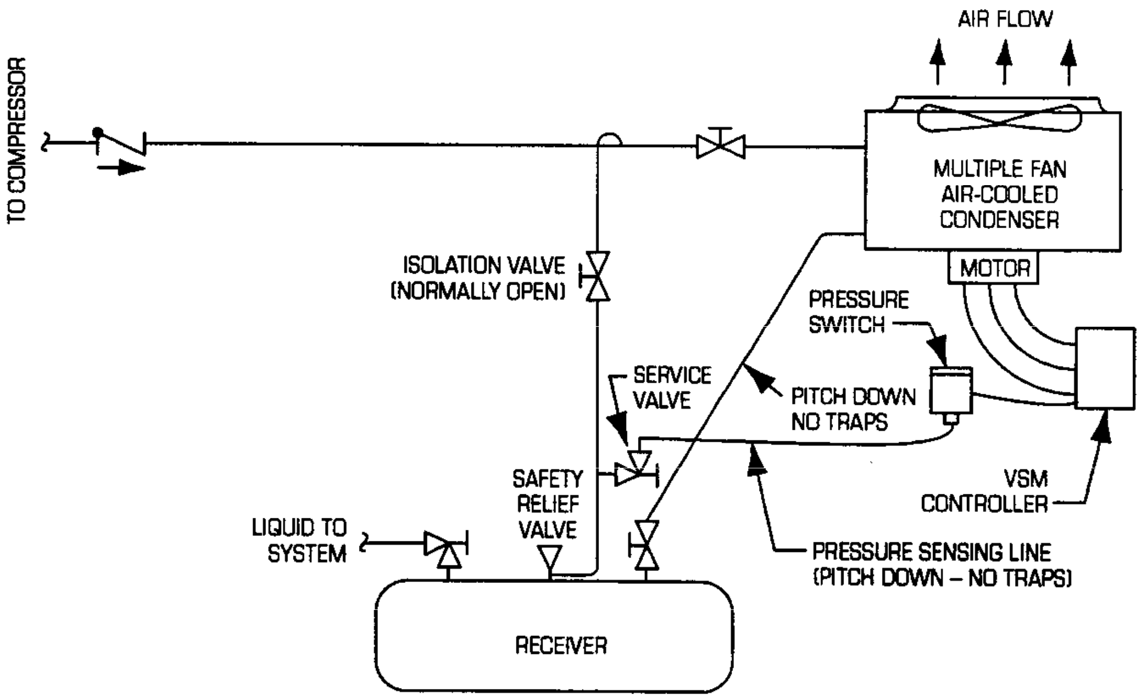

Figure 3-28 Typical Piping for Fan Cycling or Variable Speed Fan Motor (VSM) Controls

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

14. Installation Review

Before starting the installation proceedure and again before the initial start-up of the ice generator, all steps of the installation procedure should be reviewed and checked off:

Completed

1. All tools are available and personnel are instructed on installation procedure and safety instructions. .... ☐
2. Electrical and mechanical contractors properly licensed and insured. .... ☐
3. Flooring or steel platform ready for installation. .... ☐
4. Water source identified and meets flow and pressure requirements. .... ☐
5. Electrical source identified and meets power requirements; disconnects and/or circuit breakers ordered or available. .... ☐
6. Adequate space and access for service and maintenance under all operating conditions is available. .... ☐
7. Equipment for unloading equipment upon delivery and moving into place are available. .... ☐
8. Provisions are made for transferring ice from ice discharge to storage or point-of-use; safety guards and transition are available. .... ☐
9. Personnel available to leak check refrigerant system; evacuate and charge if required. .... ☐
10. Start-up personnel available and trained (read Operating & Maintenance Manual); factory or factory authorized distributor/representative telephone numbers are available for start-up assistance if required. .... ☐
11. Walk through of water, electrical and refrigeration system work completed and construction debris is cleaned up. .... ☐
12. Water lines and conveying system to storage or point-of-use clean and washed out. .... ☐

4

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

OPERATING INSTRUCTIONS

This section describes the D-line ice generator operating sequence and the function of the ice generator components and control panel components. Operating hints are provided for safe, efficient and reliable operation of the equipment. Only standard features are discussed in this section. For optional features and accessories, refer to section 8.

Specifications

Refrigerant
R-22

Evaporator Temperature (Icemaking)
0°F (24 PSIG)

Discharge Pressure

Water-Cooled Condenser
105°F condensing (210 PSIG). 85°F water in/105°F water out. 78°F design wet bulb.

Air-Cooled Condenser
120°F (250 PSIG) condensing. Based on THR at 10°F evaporator/120°F condensing. 100°F design dry bulb.

Discharge Pressure Control

Water-Cooled Condenser
Pressure actuated water regulating valve(s). Cooling tower and cooling tower pumps are not supplied (optional).

Air-Cooled Condenser
Fan cycling with flood back control consisting of upstream regulator in drain line of condenser to receiver. Downstream regulator in a hot gas bypass line to the inlet of the receiver.

Refrigerant Feed
Externally equalized thermal expansion valve.

Superheat Setting*
10-15°F

* Superheat is defined as the temperature of the suction gas measured at the thermal expansion valve bulb less the saturated suction gas temperature at the pressure indicated at the TXV bulb.

Example:
Measured 12°F at the TXV bulb, evaporator suction pressure is 24 PSIG. This equals to 0°F saturated suction temperature.

12°F – 0°F = 12°F superheat

Make-Up Water

Make-Up Water Temperature
60°F at water distribution header inlet.

Make-Up Water Pressure Required
8 PSIG minimum at inlet to water distribution header.

Make-Up Water Flow
Each plate requires 7 GPM (an adjustable water flow control valve is provided to make final adjustment of the water flow). 6 ton model: 28 GPM total required at make-up water connection.

Make-Up Water Feed
Solenoid valve with water level control relay. Minimum flow is 3 GPM. Maximum flow is 15 GPM.

Make-Up Water Blow-Down
0-50% adjustable.

Safety Switch Settings

Low Pressure Cut-Off
5 PSIG

High Pressure Cut-Out
275 PSIG water and evaporative cooled. 300 PSIG air-cooled.

Oil Pressure (Net)
25 PSIG oil pressure above suction. One (1) minute time delay manual reset.

Relief Valve (Receiver, Condensers)
350 PSIG nonadjustable.

Motor Full Load Amps (FLA)
Refer to section – 10 Appendix & Notes.

Operating Refrigerant Charges
40 pounds water-cooled.
94 pounds air-cooled. Factory installed except for international shipments. Holding charge only for international shipping.

Condenser Sizing
Refer to section 10 – Appendix & Notes.

Evaporator Plates

304 Stainless Steel
Hydraulically blown to inflate to proper rise.

Design Operating Pressure
200 PSIG

Burst Pressure
1,500 PSIG

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

Controls

All D-line models (SC, SCA, SCAR) operate in the same basic way and control panel components are the same except for size (number of magnetic starters, etc.) Each control panel contains:

- Programmable controller
- Magnetic starter for the water pump
- Magnetic contactor with motor protection module for the compressor
- Master control switch with illuminated failure indicator
- Ice thickness selector switch
- Wash cycle controls switch
- Water level control relay
- Control relays
- Magnetic starters for optional equipment (if supplied) including:
  - Screw conveyor, breaker bar or ice sizer
  - Cooling tower pump and fan (SC models only)
  - Air-cooled condenser motor fans (air-cooled models only)
- Screw type terminal strip connections for ease of field wiring

Note:
Controls required for the distribution of ice to remote storage or points of use are not furnished by TURBO.

Additional controls can be provided as optional equipment. Consult factory for additional information.

Control Panel Door

Refer to Figure 4-1. The control panel door contains:

- Master control selector switch "ON/OFF-RESET" (two position switch)
- Ice thickness selector switch, 3/8", 1/2", 5/8" (three position switch)
- Wash cycle control selector switch "ON/OFF" (two position selector switch)
- Warning labels (refer to safety section)
- Data nameplate (serial number, motor and electrical data)

Refer to section 2 – Safety for a listing of all warning labels that should be on the control panel door. If any labels are missing, contact TURBO immediately to obtain replacements for the missing labels.

Think SAFETY!

Note:
The serial number on the data nameplate should be referenced when inquiring about the control or operation of the equipment. A file is maintained under this serial number to ensure that all information required to assist you with problems can be handled quickly and accurately.

WARNING

The master control switch (MCS) is not a service disconnect. Lock out electrical power to the controls before performing service. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Electrical Component Description

Master Control Switch-Illuminated (MCS) ON/OFF-Reset; Failure Indicator

A two-position cam operated switch with a lighted insert, normally closed (NC) and a normally open (NO) contact block is provided to input a signal to the programmable logic controller (PLC). This MCS signal is used to initiate the logic required to start the ice generator and to terminate operation of the ice generator. Turning the MCS switch to the "OFF-Reset" position initiates a shutdown sequence that includes a pump down of the system refrigeration charge into the combination condenser receiver for water-cooled models or a receiver for air-cooled models. Actual termination of operation occurs when the low-pressure safety switch opens at a preset suction pressure.

The illuminated indicator is used to provide information on the type of failure that has occurred. During normal

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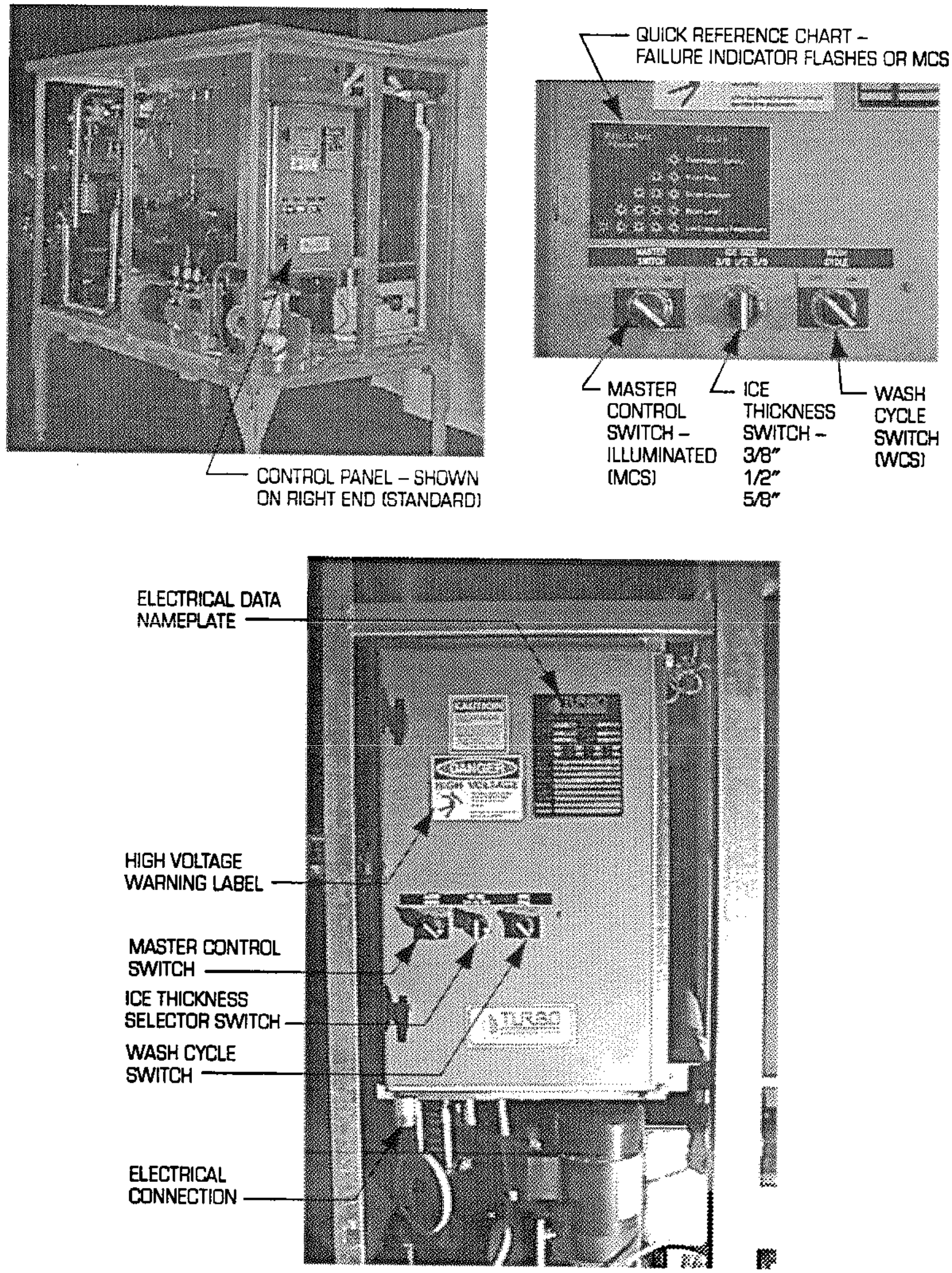

Figure 4-1 Control Panel Door – Exterior

operation, the green light remains ON at all times. If a failure occurs, the light will flash intermittently to indicate the failure code.

Failure Codes

Number of Flashes	Failure
1	compressor
2	water pump
3	screw conveyor
4	low water level
5	low crankcase temperature

Refer to section 5 – Trouble-Shooting for additional information.

If a failure occurs, the illuminated switch will start to flash. For example, if the water pump fails, the switch will blink twice and then pause, then blink twice again, etc. This sequence will continue until the MCS switch is turned to the OFF/Reset position. Before resetting the MCS switch, the failure code (number of flashes) should be noted.

OFF-RESET

For normal termination of the ice generator operation, the system will complete the next cycle, go through harvest, the liquid solenoid closes and the unit will go through a pump down cycle. Operation is terminated when the low pressure (LP) safety switch contacts open. If conditions exist requiring immediate shut down of the ice generator, the MCS switch can be turned OFF, then back ON and OFF again. This switch sequence will terminate operation without completing the cycle but the ice generator will pump down.

WARNING

The master control switch (MCS) is not a service disconnect or safety switch. Lock out electrical power to controls before performing service. Have a qualified electrician perform all service. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Ice Size Selector Switch

A cam operated three-position selector switch is used to select the desired ice thickness. Ice thickness is based on water consumption (water level in the tank) and has been factory set. Selecting the ice thickness is as simple as turning the switch to the desired thickness. For example, if 1/2″ thick ice is desired, turn the selector switch to the middle position marked 1/2″. In this position, the switch selects the circuit in the water level control circuit (WLC) to initiate harvest when the ice thickness is 1/2″. For more information see WLC below.

The ice thickness can be selected at any time during operation or with the ice generator OFF. If the setting is changed during operation, the ice generator may initiate defrost immediately. This will occur if a thinner ice thickness is selected and the water level is below the probe of the new level selected. For example, the original selection was 5/8″ thick ice and the selector switch is changed to 3/8″ thick. If the water level is already below the 3/8″ probe (ice is already thicker than 3/8″ but less than 5/8″), the ice generator will immediately initiate harvest since the water level is below the 3/8″ thick probe. The ice thickness for the next cycle would be the 3/8″ thickness selected.

Wash Cycle Switch (WCS)

A two-position ON/OFF selector switch is provided for manual operation of the water circuit. During normal operation the WCS switch is in the OFF position and the water system is controlled by the PLC.

The WCS is used for maintenance only. With the MCS switch OFF and the WCS switch in the ON position, the water pump will operate independently of the PLC. Water is circulated over either the icemaking plates or the gas generator plate or both, depending on the setting of the manual operators on the icemaking plates water solenoid (IWS) and the gas generator water solenoid (GWS).

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

Note:
When WCS is turned ON, the drain solenoid is de-energized to allow filling of the tank during the cleaning cycle.

Dilute icemaker cleaner is added to the water tank and circulated through either water circuit or both water circuits to clean all surfaces in the ice generator (evaporator plates, water tank, internal piping surfaces, etc.).

At the conclusion of the cleaning cycle, the fresh water feed solenoid should be manually opened to feed water into the tank. With the MWS solenoid manually open, the tank will overflow and wash the cleaning fluids and debris from the tank. When the WCS is turned OFF, the drain solenoid (DS) will open to drain the tank and the water solenoids are returned to the automatic position. Refer to section 6 – Maintenance for additional information on cleaning the ice generator.

Note:
If the WCS switch is left ON during normal operation, the ice generator will function properly. If the IWS and/or GWS solenoids are left in the manual position, the ice generator will function normally. However, since the water will continue to run over the ice-making plates during the harvest cycle (IWS manually open), the ice will be wet and some water may carry over into the ice discharge.

Control System Components

The components listed below are located in the stainless steel electrical enclosure supplied with the ice generator. All components are factory wired to a terminal strip for ease in making field connections for remote devices and controls. Refer to Figure 4-2.

Control Circuit Protection

A ten (10) amp fuse is located inside the control panel to protect the control circuit power. The fuse holder is located below the programmable controller. Standard control circuit power is 115/1/60. Other voltages and 50 hertz frequency are available as options. For optional 220/1/60 voltage, a step-down transformer (220/1/60 primary; 115/1/60 secondary) is typically provided and all components in the control panel (relay coils, starter coils, solenoid coils, etc.) are 115/1/60. Relay coils, starter coils and solenoids rated 220/1/60 are also available as an option without the control circuit transformer described above. For 220/1/60 controls without transformer, a second 10 amp fuse is installed in the L2 leg of the control circuit; (i.e., both L1 and L2 are fused). Separate circuit breakers (by others) are required for the transformer and electrical panel service.

Control circuit overloads or shorts can cause the fuse to "blow" or the circuit breaker to trip interrupting electrical power to the control circuit. This will also terminate operation of the ice generator.

WARNING

Even with the control circuit off or tripped, the three-phase power to the compressor and water pump is still on. The three-phase and single-phase power must be locked out before performing service. Have a qualified electrician perform all service. Failure to carefully follow these instructions could result in permanent injury or loss of life.

If the fuse is blown, it must be replaced prior to restarting. If the circuit breaker (provided by others) trips, it must be reset. After the fuse has been replaced and/or the circuit breaker reset have a qualified electrician check the following before restarting the ice generator:

- Check all components in the electrical panel and on the ice generator to determine the cause of the overload or short. Correct all defects or problems immediately.
- Never bypass the circuit breaker or fuse even on a temporary basis.

Compressor Contactor (CM)

The compressor is provided with a magnetic contactor to

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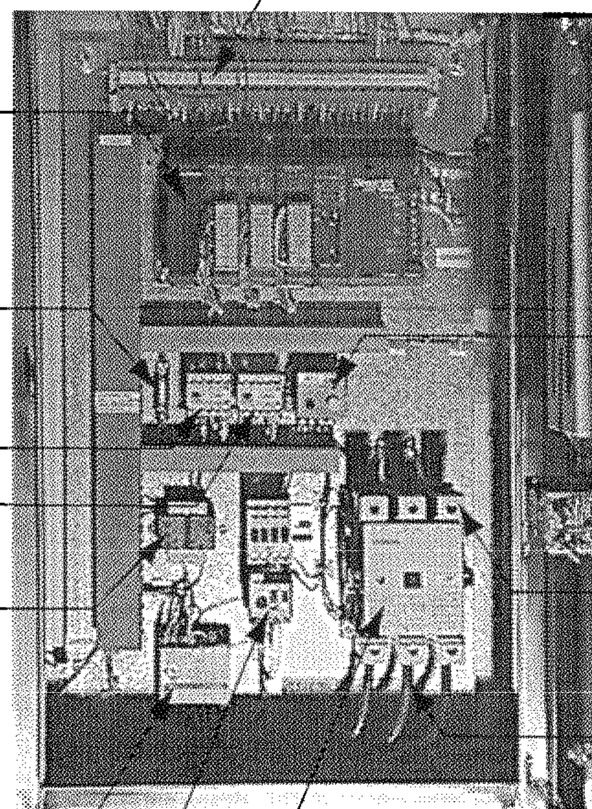


Figure 4-2 Control Panel Door – Interior

control three-phase power to the compressor. A separate inherit motor protection module is used to protect the semi-hermetic compressor motor from overload. See Motor Protection Module (MP) description for additional information.

All magnetic contactors are IEC rated and are supplied with dual voltage/frequency coils (115 or 230; 50/60 hertz). Standard wiring for the coils is 115/1/60.

All compressor contactors meet or exceed NEMA, EEMAC, UL, CSA, IEC, CE, VDE, and other international standards.

Compressor Contactor Interlocks (CM-1 & CM-2)

CM-1

A normally open (N.O.) contact of the compressor contactor is used to input a signal to the PLC. The ice generator will not start if this signal is not present. The CM-1 contact also supplies power to the cooling tower pump(s) and fan(s) for SC (water-cooled) models and to the condenser fan(s) on SCA (air-cooled) models. Cooling towers and cooling tower controls are optional on SC models. The air-cooled condenser and condenser head pressure controls are standard on SCA models and optional on SCAR models with remote condensers.

CM-2

A normally closed contact (N.C.) used to turn the crankcase heater (CCH) on, and open the drain solenoid (DS) when the ice generator is OFF. During shut-down, the N.C. contact is closed and power is supplied to the crankcase heater and drain solenoid. During operation (ice generator ON), the compressor interlock opens, terminating power to the heater and drain solenoid.

Motor Protection Module (MP)

The motor protection module (MP) and has a normally closed (N.C.) set of contacts to protect the winding of the semi-hermetic compressor motor. The compressor motor will have some type of temperature sensors imbedded (typically a common [C] and three sensors [S1, S2, S3]) in the windings of the motor or in some cases, the temperature sensor will monitor the compressor discharge temperature. When the temperature of the windings or compressor discharge exceeds the limit set by the motor protection module, the N.C. contacts will open to stop the compressor motor. These contacts will automatically reset after the temperature drops. However, the system will not automatically restart until the PLC is reset (turn Master Control Switch OFF, then back ON to reset).

IMPORTANT

The cause of the compressor overheating should be determined before the compressor is restarted. Refer to section 5 – Trouble-Shooting. Operation should be closely monitored after the compressor is restarted to ensure normal operation has resumed.

Motor Protection Module Contact (MP-1)

A normally closed (N. C.) contact of the motor protection module labeled MP-1 (overload) is located on the MP module. The control circuit is connected to terminals M1 and M2. If an overload occurs, the N.C. contacts will open to terminate operation of the compressor. This contact will automatically reset when the windings cool off and the temperature is below the setpoint of the MP module. All settings of the MP module are factory set by the compressor manufacturer. No adjustments are required.

Power to the module is taken directly off the L1 and L2 power source to the control panel. This provides power to the module at all times. Power connections are made to terminals T1 and T2.

The thermal sensors are connected from the C, S1, S2 and S3 compressor connections in the compressor terminal box to the C, S1, S2 and S3 connections on the MP module located in the control panel.

Refer to the compressor manufacturers manual and the section 5 – Trouble-Shooting for additional information on the module.

Water Pump Magnetic Starter (WP)

The water pump is provided with a contactor with a bimetallic overload relay to protect the pump motor from overload and control three-phase power to the water pump. The bimetallic overload relay has an adjustable trip point that is factory set based on the full load current rating of the pump motor. Manual reset of the overload relay is required if a trip (overload) occurs. Before resetting the overload relay, determine the cause of the overload and correct it before restarting. Monitor operation after resetting to ensure normal operation.

To reset the overload, push the reset button located on the overload module. The overload setting should never exceed the full load or continuous run amps of the motor. Lower settings can be used to achieve faster trip of the relay on lightly loaded applications.

A test button, trip indicator and snap-on protective cover are provided. The overload relay is ambient temperature compensated from –25°C to +55°C (–1°F to +131°F). The overload relay is a block type

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

with terminals for easy installation on the contactor. Overload relays provide protection against overload, phase loss or phase unbalanced load conditions. All magnetic starters are IEC rated and are supplied with dual voltage frequency coils (115 or 230; 50/60 hertz). Standard wiring for the coils is 115/1/60.

The contactor and overload relays meet or exceed NEMA, EEMAC, UL, CSA, IEC, CE, VDE and other international standards.

Water Pump Interlock (WP-1)

The water pump starter has a normally open (N.O.) interlock used to input a signal to the PLC. During normal operation, the interlock closes to indicate the water pump is ON. If the signal to the PLC is not made, the unit will not start. If the ice generator is in operation and the signal is lost, the ice generator will shut off.

Control Relay (CR1)

A control relay is supplied in the output of the PLC for operation of the screw conveyor required to remove ice during harvest. During the harvest cycle, the CR1 relay is energized and ice is conveyed to a remote storage location by the screw conveyor(s). The PLC has an internal time delay to allow the screw conveyor(s) to operate for a preset time after the harvest cycle is terminated. This allows all ice to be purged from the screw conveyor(s) before they stop. Refer to the PLC section of the manual for instructions on changing timer presets.

Control Relay Contact (CR1-1)

A normally open (N.O.) contact of CR1 is provided for control of the magnetic starter used for the harvest screw conveyor(s). When the CR1 relay is energized, the contact of CR1 closes to supply power to the customer supplied conveyor system starter(s) used to remove ice. If the harvest screw conveyor fails to energize, the system will fail and the ice generator will immediately turn OFF. Refer to Screw Conveyor Interlock (SCR-1) for additional information.

Note:
Controls for conveying systems and screw conveyor(s) are available as optional equipment. Contact TURBO or a TURBO representative for additional information.

Programmable Logic Controller (PLC)

The ice generator is a completely automatic machine. Control of all devices and cycles required to produce and harvest ice is provided through the logic of a solid state logic controller. The PLC has inputs and outputs used for specific control functions.

A UL listed programmable logic controller (PLC) is used to control the operating sequence of the ice generator. The PLC consists of:

- Power supply
  - 115/1/60 main
  - 24 VDC (water solenoids)
- Central processing unit (CPU)
- Input/output modules (I/O)
  - 115/1/60 for all I/Os except 24 VDC output module for water solenoids

Each electrical device or group of devices is connected to an I/O contact. Standard inputs are:

- Master control switch (MCS)
- Wash cycle switch
- Compressor interlock
- Water pump interlock
- Screw conveyor interlock (by others); field wired
- Water level control (through WLC relay)
- Compressor crankcase temperature thermostat (CTS)
- Harvest pressure switch

Outputs include:

- Each electrical motor starters/contactors
- Refrigerant liquid solenoid (LS) – 115/1/60
- Hot gas solenoid (HG) – 115/1/60
- Icemaker suction solenoid (ISS) – 115/1/60

- Icemaker water solenoid (IWS) – 24 VDC
- Gas generator plate water solenoid (GWS) – 24 VDC
- Make-up water solenoid (MWS) – 24 VDC
- Water pump magnetic starter coil (WP) – 115/1/60
- Screw conveyor control relay
- Master control switch failure indicator light – 115/1/60

Additional I/Os can be provided for remote equipment operation, discharge (head) pressure controls and other optional equipment.

All icemaking, harvest and time functions are programmed into the PLC. Certain time and time-delay presets can be easily field adjusted through the PLC programmer pad supplied. Refer to the PLC section for information on changing timer presets. The PLC programmer pad may be removed to prevent unauthorized access or changes to the preset time and counter values.

For the D-line ice generator, two voltage supplies are required as indicated above. The CPU is supplied 115-volt single-phase 50 or 60 hertz power (110/115/1/50/60) for the processing function. Primary power (115 volts) is supplied to terminals C1 and C2 of the PLC input and output modules. This same power supply is also supplied to a transformer providing a 24-volt supply secondary for the low voltage coils used on the water solenoid valves.

Refer to section 9 – Optional Appendix for additional information on PLCs .

Other Electrical Components

Compressor Crankcase Heater (CCH)

Refer to Figure 4-3. The semi-hermetic compressor supplied with the ice generator includes a crankcase heater. The heater is factory installed in the compressor. Low wattage heaters (15 watt) are typically used and require approximately 24 hours after they are turned on to "dry" out the crankcase and prevent liquid migration to the compressor. For new installations or after heater elements are replaced, the power to the crankcase heater should be left on at least 24 hours prior to starting to ensure no liquid refrigerant is present in the crankcase. Damage to the compressor can result if the compressor is started with liquid refrigerant present in the crankcase. Refer to Crankcase Temperature Thermostat (CTT) for additional information on compressor protection.

Compressor Cooling Fan (CF)

The semi-hermetic compressor used for the ice generator requires a cylinder head cooling fan. A 50 watt fan operates on power from two legs (230 or 460 single-phase) of the three-phase power to the compressor. The cooling fan is turned ON by the compressor contactor and operates at all times the compressor is running.

IMPORTANT

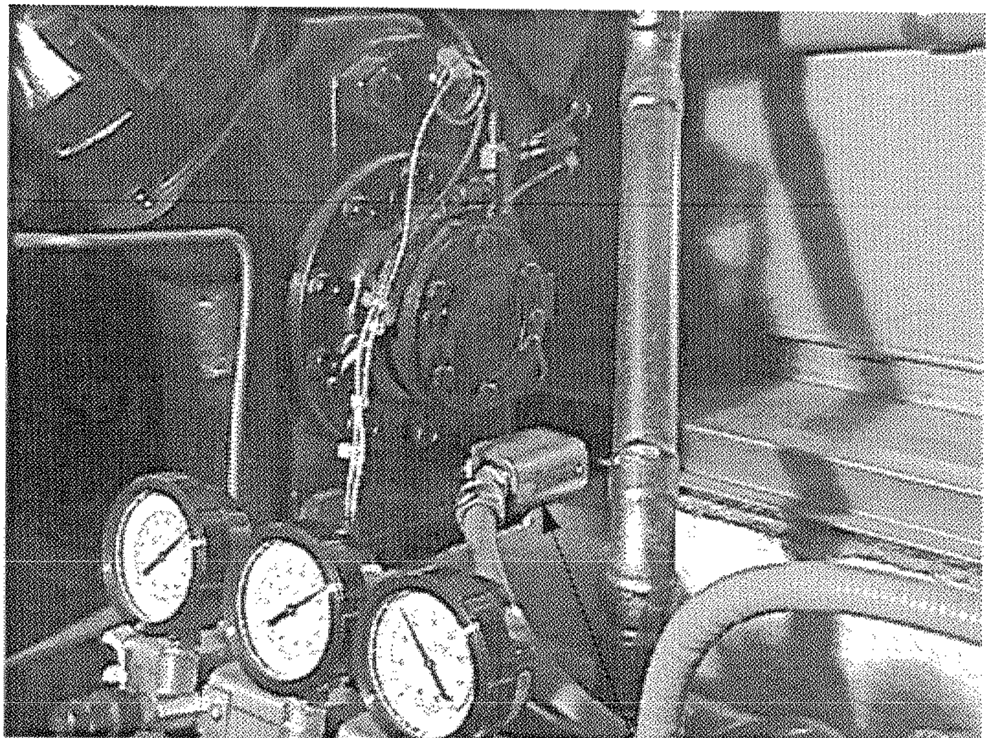
Under design conditions the compressor is applied in this application, proper cooling of the compressor requires use of the cooling fan. If the fan fails, it should be replaced immediately to prevent excessive discharge temperatures. Failure to follow these instructions could result in compressor failure or damage.

Low Voltage Transformer

The water solenoid valves used for the ice generator are 24 volt coils. Power for the solenoids is provided through the PLC outputs. A 40 VA transformer with 115 volt AC primary and 24 volt DC secondary is supplied for these coils. The secondary of the transformer is connected to terminal C1 and the secondary of the coils. Refer to the wiring diagram supplied with the ice generator for additional information.

Control Panel Fan (CPF)

A single-phase cooling fan is installed on the side of the control panel enclosure to vent the heat generated by the controls. A foam filter is



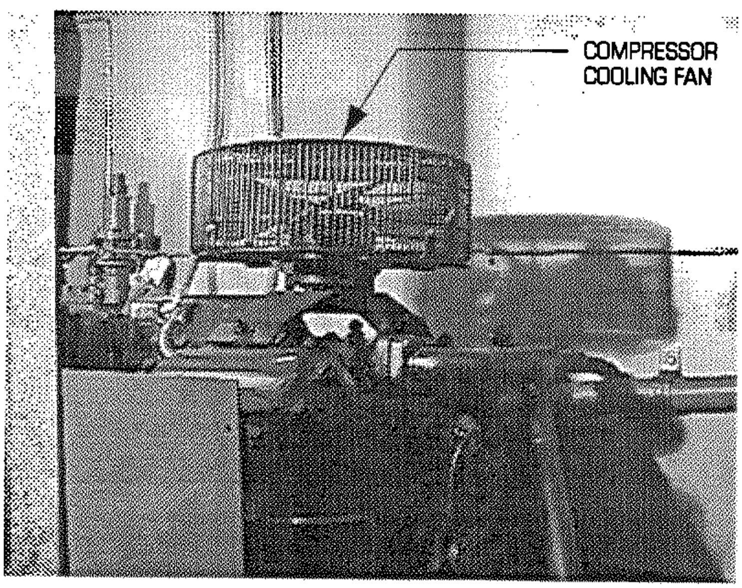


Figure 4-3 Compressor Crankcase Heater/Cooling Fan

placed on the inlet screen to filter dust and debris. This filter should be cleaned periodically to ensure proper ventilation of the electrical enclosure. The cooling fan is designed for use in a maximum ambient of 100°F and is suitable for indoor and outdoor use.

IMPORTANT

For outdoor installations, the electrical enclosure should be covered to prevent exposure to direct sunlight. Due to the stainless steel construction of the enclosure, temperature inside the enclosure can exceed the limits for proper operation of the electronic components, including the PLC.

Water Level Controller (WLC)

Refer to Figure 4-4. The ice generator water level is controlled by a water level column and water level relay.

Water Level Column

A PVC water column is located in the water tank in the area below the refrigerant connections to the evaporator plates. A total of five stainless steel wires (probes) are inserted through the top of the tube into the tube column:

Common

Longest probe used as a reference for all the other probes. This probe will always be in contact with the water in the tank during normal operation.

Note:
The common probe must always be below the other four probes for proper operation.

5/8″ Thick Ice Probe

This is the second longest probe in the column since thicker ice production will consume more water.

1/2″ Thick Ice Probe

This is the third longest.

3/8″ Thick Ice Probe

This is the second shortest probe since less water is consumed for 3/8″ thick ice than 1/2″ or 5/8″.

High Level Probe

This is the shortest of the five probes. The high probe is used to fill the tank after harvest. When the water contacts the high probe, water feed to the ice generator is terminated by the PLC time delay used to set blow-down.

The probe levels are factory set and should not require field adjustment. If the ice thickness obtained with the standard settings needs to be changed to obtain a different ice thickness, the wire probe(s) can be adjusted. Move the probe down to obtain thicker ice. Move the probe(s) up to obtain thinner ice.

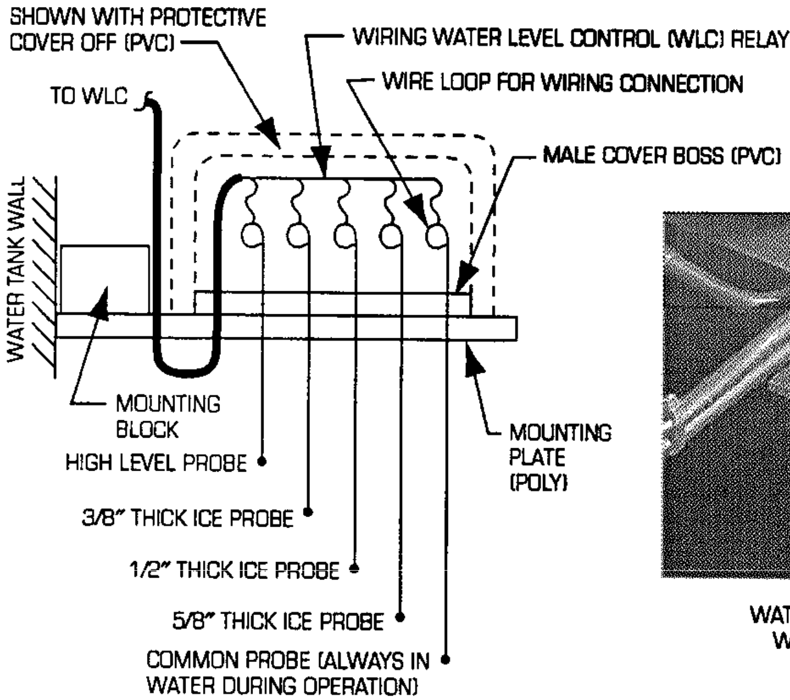
Water Level Control Relay

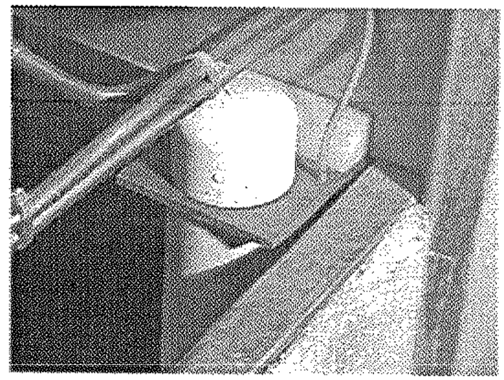
Refer to Figure 4-5. The signal from the water level column probes is input into the water level control relay. When the water level is in contact with the high level water probe, the water solenoid feeding fresh water to the ice generator de-energizes. As water is converted to ice, the water level drops until the probe selected is uncovered. For example, if the 1/2″ ice thickness position is selected, the water level will drop until the 1/2″ water probe is no longer in contact with the water. Note the 3/8″ probe is also out of the water. Since the ice thickness selector switch is in the 1/2″ position for the example, the 3/8″ probe signal is ignored. The red light on the relay turns on to indicate the level is at the desired consumption level (low level). The contacts of the WLC relay reverse to initiate a harvest cycle and refill the tank. As indicated above, the water solenoid will open to refill the tank and until the water is in contact with the high probe. The WLC relay and pilot light will reset (light turns OFF) when the water level reaches the high probe.

R-1 Contacts (by others)

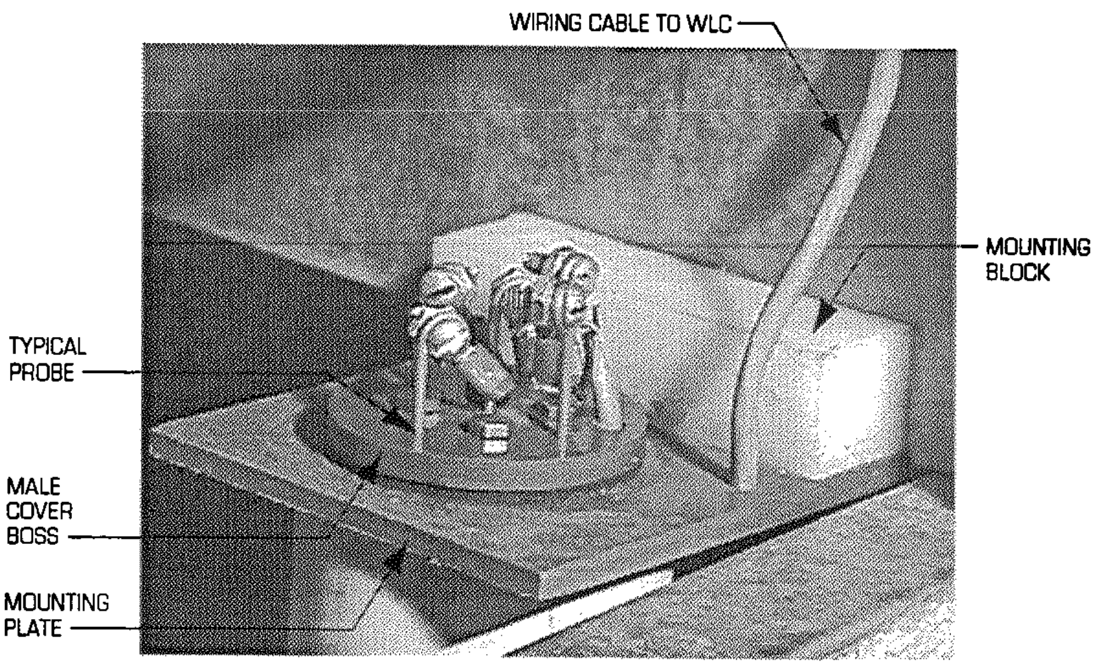
A set of normally closed (N.C.) contacts from a remote relay or switch can be installed in the control power supply to terminate all control functions in the control panel. The contacts are not provided with the ice generator. A jumper is factory installed between the terminal blocks. If the switch is used, the jumpers must be removed.

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





WATER LEVEL CONTROL COLUMN WITH PROTECTIVE COVER ON



WATER LEVEL CONTROL COLUMN WITH PROTECTIVE COVER OFF

Figure 4-4 Water Level Controller – WLC, Columns, Probes

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

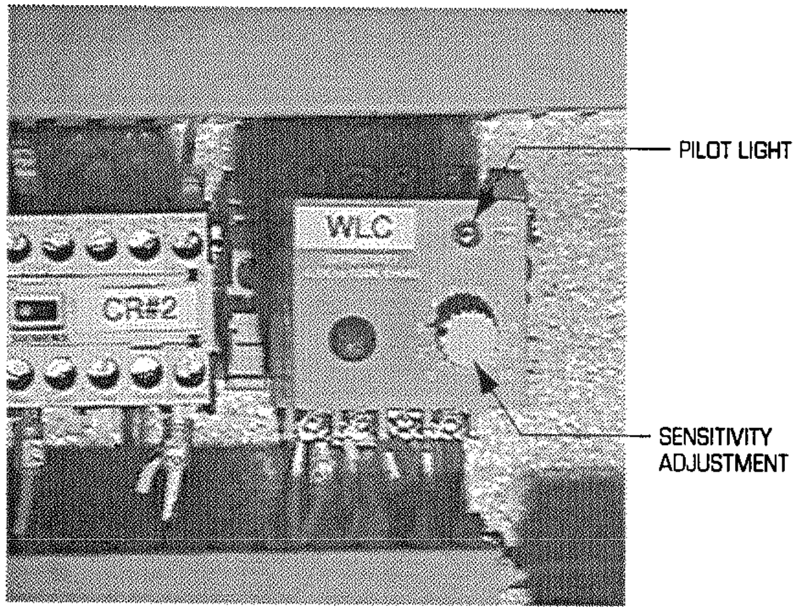


Figure 4-5 Water Level Control Relay

WARNING

Although this switch would act as an emergency stop switch, it is not a service disconnect and should not be used in place of lock out when performing service work. Failure to carefully follow these instructions could result in permanent injury or loss of life.

Bin Level Switch (BLS) (by others)
Jumpers are installed in the master control switch (MCS) circuit for use with remote devices to terminate operation of the ice generator. This device can be a remote ON/OFF switch or a bin level switch to the storage bin to indicate when the storage into which the ice is being discharged is full. Optional bin level switches and other types of controls can be supplied as options. This switch has the same function as the master control switch to start and stop operation of the ice generator. If the optional devices are used, the factory installed jumper must be removed.

A break-on-rise switch is normally used for the bin level switch since it is in series with the MCS switch.

Screw Conveyor Interlock (SCR-1)(by others)
During the harvest cycle, the PLC will energize the CR1 control relay to start the harvest screw conveyor (HSC). After the CR1-1 contact closes, the customer supplied magnetic starter for the harvest screw conveyor will be energized. If the HSC starts, the normally open (N.O.) interlock of the starter will close. This interlock is field wired into the PLC input module and is used to verify the HSC is in operation. If the signal (closure of SCR-1) is not received by the PLC within 2 (two) seconds, the system will fail to prevent the ice from accumulating in the inactive screw conveyor.

Note:
If the ice generator fails on a harvest screw conveyor fail-

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

ure, the master control switch must be turned to the OFF-Reset position before the ice generator can be restarted.

If a harvest screw conveyor is not used, a jumper must be installed in the terminal strip between L1 and 13. This will maintain the signal to the PLC during harvest and allow normal operation. Refer to the wiring diagram to confirm the terminal strip connections for the jumper.

CAUTION

The jumper should not be used on systems with screw conveyors connected to it for removal of the ice. The jumper will prevent a failure from stopping the ice generator if the harvest screw conveyor is not operating. Failure to follow these instructions could result in personal injury or equipment failure or damage.

Defrost Pressure Switch (DPS)

Refer to Figures 4-6 and 4-7. Harvest of the ice from the ice generator plates is initiated by the water level controls (WLC). Harvest is terminated by a pressure switch that senses the defrost pressure at the evaporator outlet. At the completion of the harvest, the evaporator outlet pressure will increase. When the pressure reaches the setpoint of the DPS switch, the normally

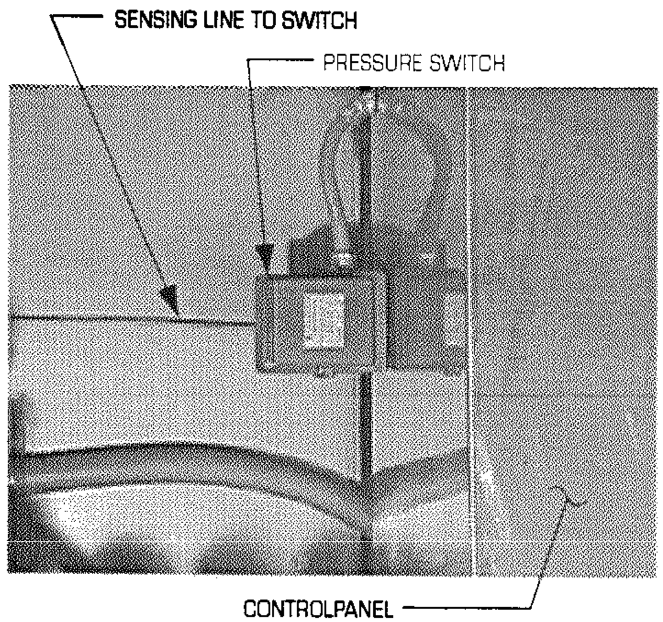


Figure 4-6 Defrost (Harvest) Pressure Switch

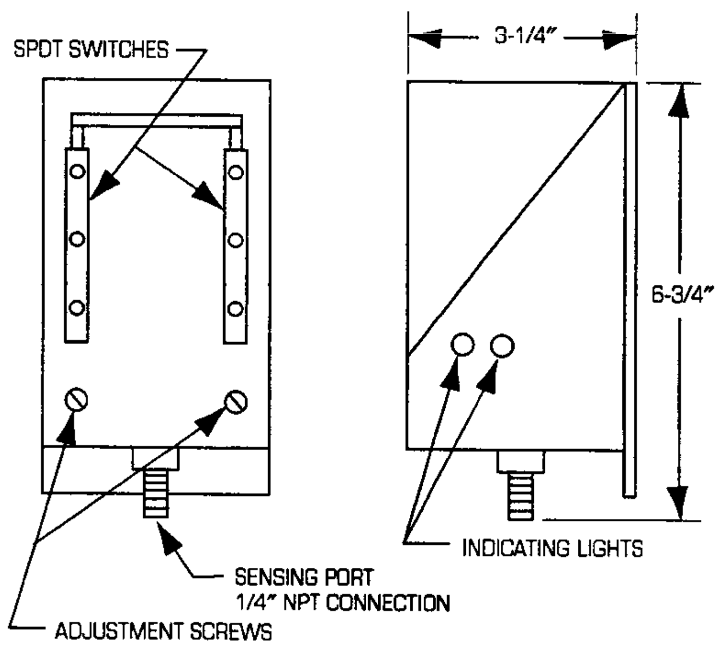


Figure 4-7 Differential Pressure Switch

open (N.O.) contacts of the make-on-rise switch will close. The contact closure inputs a signal into the PLC. This signal terminates the harvest and initiates the next ice-making cycle if the master control switch (MCS) is ON. If the MCS is in the OFF position, operation of the ice generator will terminate when the pump-down cycle is completed and the low pressure safety switch contacts open. Refer to the Typical Shut-Down/Final Harvest Sequence in this section for additional information.

The DPS is located on the bulkhead directly behind the control panel. A 1/4″ stainless steel or copper sensing line is routed from the bottom of the switch to the evaporator suction header. The sensing line also connects to the defrost pressure regulator sensing port.

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 4-7.

Crankcase Temperature Switch (CTS)

Refer to Figure 4-8. A double-pole/double-throw (DPDT) snap action temperature switch is strapped to the bottom of the compressor crankcase. The Klixon switch monitors the temperature of the suction gas entering the crankcase. Under normal operation, only superheated suction gas is returned to the compressor via the suction line from the suction accumulator/heat exchanger.

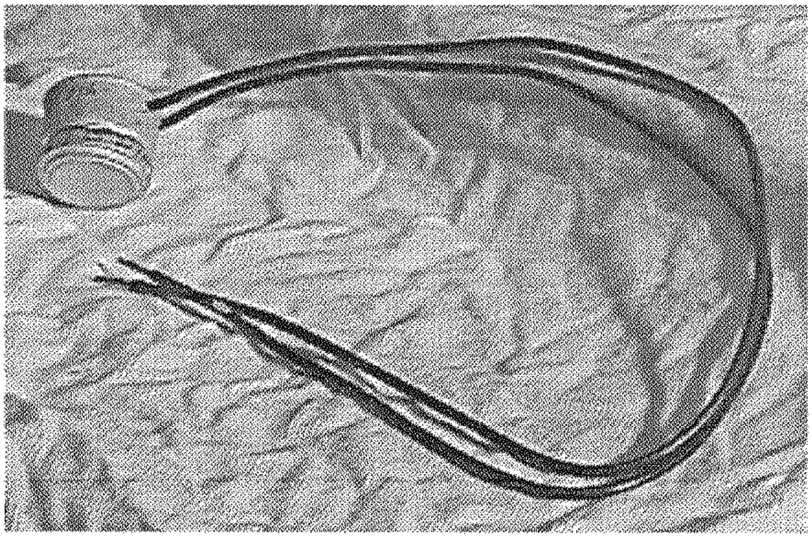
Abnormal conditions, such as improper adjustment of the thermal expansion valve (low superheat or low refrigeration load resulting from erratic water flow over the plates) can cause overfeed of refrigerant to the suction accumulator/heat exchanger. If this condition is not corrected, saturated liquid refrigerant will be carried over in the suction line to the compressor. As the refrigerant liquid entrained with the suction vapor enters the compressor crankcase, it causes a cooling effect as it boils off. Under extreme conditions, this condition will result in oil carry over to the system. As the refrigerant boils off in the crankcase, it entrains the oil with the vapor that is flashed in the crankcase. When the crankcase temperature drops below the setpoint of the crankcase temperature switch (CTS), the normally closed (N.C.) break-on-rise contacts of the thermostat open. At the same time, the normally open (N.O.) contacts of the thermostat close to input a signal into the PLC and terminates operation of the ice generator.

The setpoint of the thermostat is factory set and is not adjustable. The thermostat will trip at 65°F and has a 15°F differential (resets at 80°F). This prevents operation of the compressor under conditions with excessive liquid carry-over. Liquid carry-over can damage compressor valves and dilute the refrigeration oil used for lubrication of the compressor. Dilution or lack of oil will result in excessive wear and/or premature failure of the compressor.

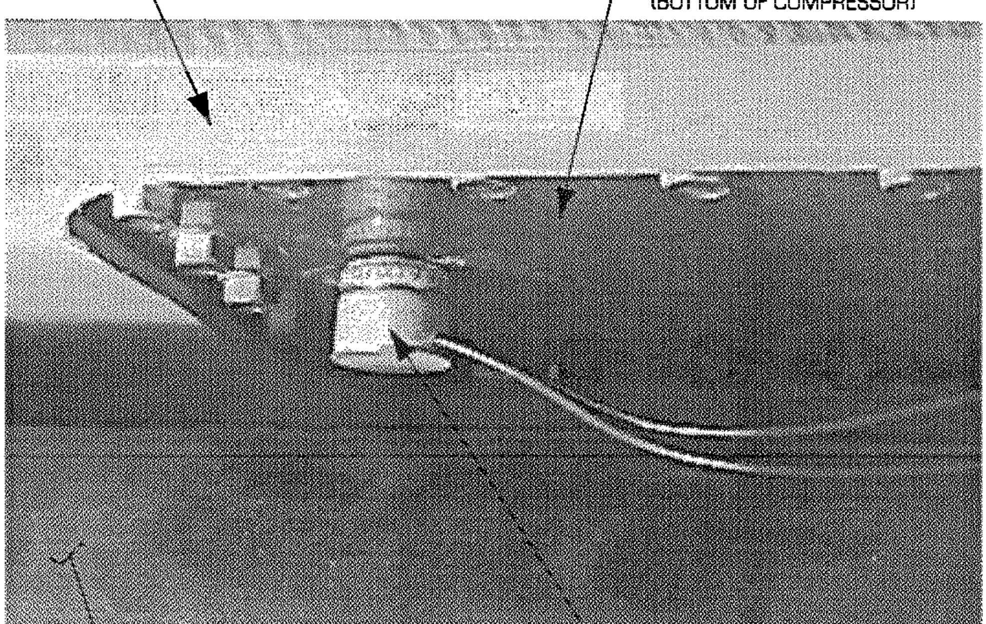
The CTS will also prevent start-up if the crankcase temperature is below 65°F. During shut-down of the compressor, a crankcase heater (CCH) is energized to keep the crankcase warm. This prevents refrigerant migration to the compressor and boils off any refrigerant in the crankcase. If the crankcase heater fails, the crankcase temperature can drop below the trip point if the ambient temperature is below 65°F. Under these conditions, the compressor will not start until the crankcase is warmed up.

- If the ambient temperature is above 65°F and the crankcase is free of liquid refrigerant, the CTS should not trip and a normal start-

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



CRANKCASE TEMPERATURE SWITCH



NOTE: SHOWN WITHOUT MOUNTING BRACKET AND ELECTRICAL CONDUIT.

Figure 4-8 Crankcase Temperature Switch

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

up should occur. Replace the crankcase heater and allow the crankcase to warm up before starting the compressor.

- If the ambient temperature is above 65°F but the crankcase has excessive liquid in the crankcase, the CTS should trip at start-up of the compressor. Under some conditions with "light" refrigerant loading of the crankcase, the temperature may be above the thermostat setpoint and the compressor will start. However, the liquid in the crankcase will flash when the compressor starts causing a drop in the crankcase temperature. This drop in temperature will cause a trip if enough liquid is present to cause damage.
- In either case, replace the crankcase heater and allow the crankcase to warm up before starting the compressor to ensure that the crankcase is free of refrigerant under all conditions.

Safety and Gauge Console

Before the initial start-up of the ice generator, the safety switches and controls should be reviewed and verified. Refer to Figure 4-9.

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 Switch Settings

LP cut-out:	5 PSIG
LP cut-in:	10 PSIG
HP cut-out:	275 PSIG (SC) 300 PSIG (SCA/SCAR)
HP cut-in:	250 PSIG (SC) 275 PSIG (SCA/SCAR)

Refer to section 10 – Appendix and Notes for additional information on dual pressure

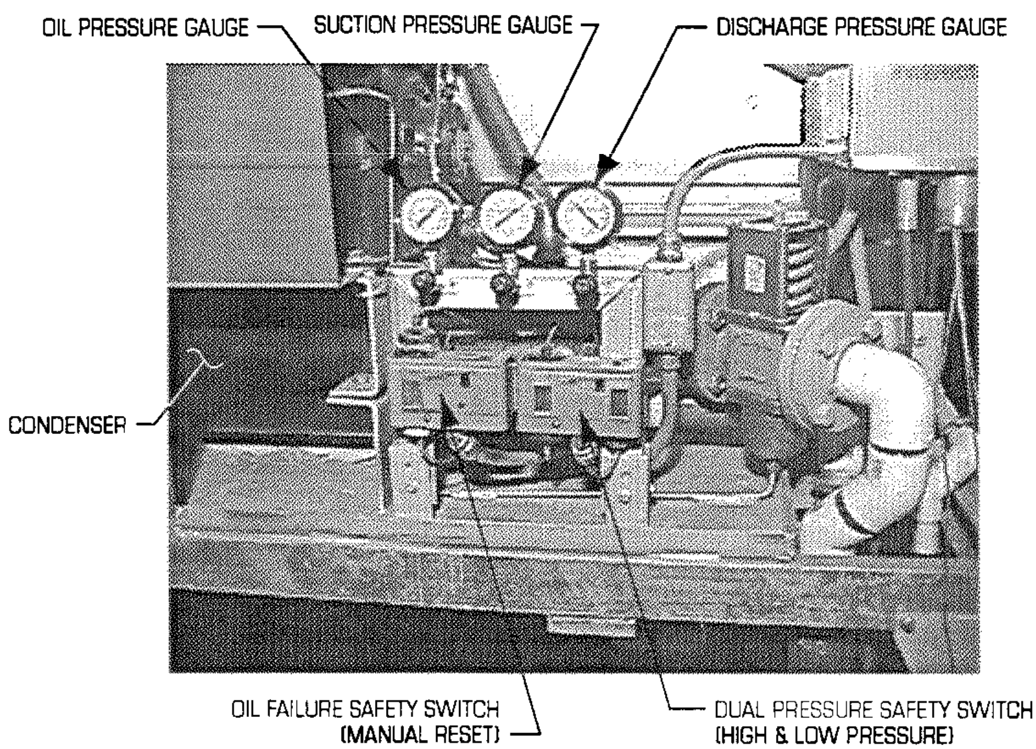


Figure 4-9 Safety and Gauge Console

switches. Figure 4-1 shows the typical safety and gauge console arrangements for each compressor supplied.

Oil Pressure Failure Switch

The oil pressure failure switch used to ensure proper lubrication consists of an oil pressure switch (OPS), oil pressure time delay (OPTD) and oil pressure time delay heater (OPTDH). The function of each part of the switch is described below.

Oil Pressure Time Delay Heater (OPTDH)

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.

Oil Pressure Time Delay (OPTD)

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.

Oil Pressure Switch (OPS)

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.

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).

The typical setting for the oil failure switch is 15 PSIG. Normal net oil pressure for the compressor (Copeland semi-hermetic) used by TURBO on ice generators is 25 PSIG.

Actual net oil pressure is determined by subtracting the reading of the suction gauge from the oil pressure gauge.

Example:

Copeland 4DJ1-3,000 compressor, oil pressure gauge reading is 50 PSIG, suction pressure gauge is 25 PSIG. Net oil pressure is:

Oil pressure	50 PSIG
Suction pressure	−25 PSIG
Net oil pressure	25 PSIG

Refrigerant Control Valves

Thermal Expansion Valve (TXV)

Refer to Figure 4-10. 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.

Therefore, as the suction gas

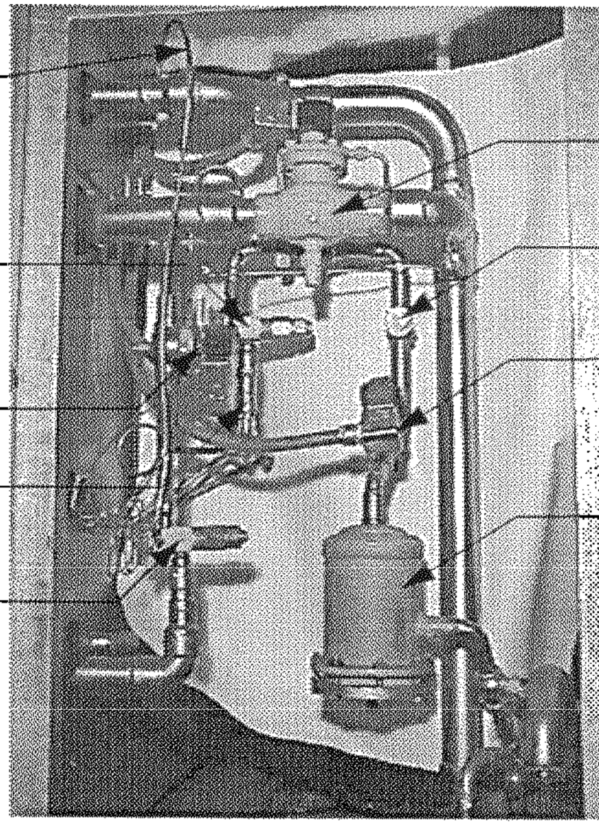


Figure 4-10 Thermal Expansion Valve, Refrigerant Valve, and Distributor Tubes - Icemaker

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.

Example:
A typical D-line ice generator operates at 24 PSIG evaporator pressure which corresponds to a saturated temperature of 0°F. If the temperature of the suction line from the evaporator at the location of the TXV sensing bulb is measured at 15°F, the superheat would be 15°F (15°-0°F).

Typical TURBO ice generators should operate between 10-15°F. Too high a superheat setting will result in reduced evaporator capacity and possible overheating of the 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.

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

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 4-11 for TXV installation.

Figure 4-11 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.

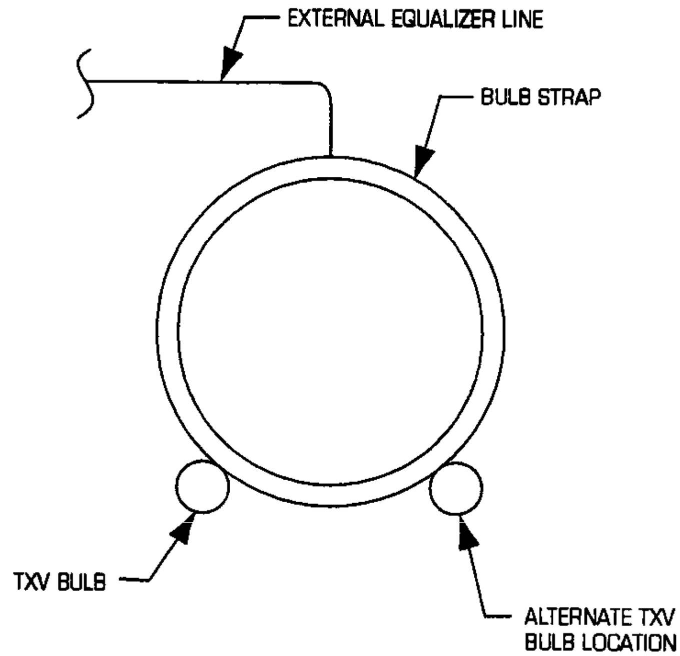


Figure 4-11 Thermal Expansion Valve Bulb Installation

Refrigerant Distributor
Refer to Figure 4-10. A refrigerant distributor is installed on the outlet of the TXV valve. The distributor consists of an orifice nozzle and multiple outlets 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
Refer to Figure 4-10. 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.

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

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

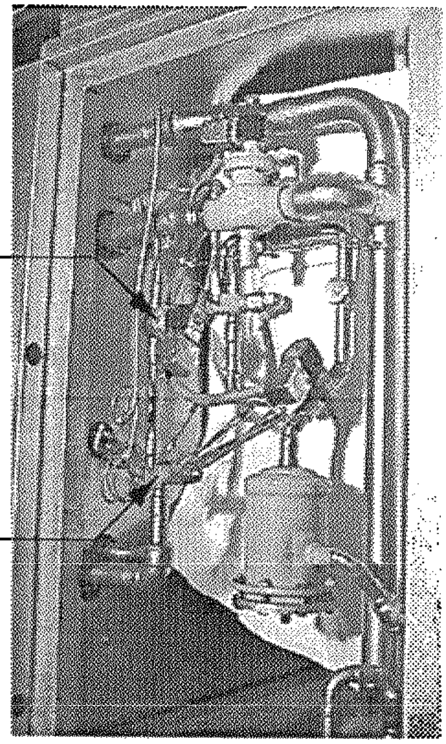


Figure 4-12 Metering Valve – Gas Generator Plate

temperature above the saturated temperature. This is known as superheat.

Gas Generator Plate Metering Valve

Refer to Figure 4-12. During the harvest cycle, condensed liquid refrigerant from the icemaking plates is fed to the gas generator plate. The metering valve installed at the inlet to the plate controls the refrigerant flow through the gas generator plate. A thermal expansion valve is used as the metering device to control the evaporator temperature during the harvest cycle in the same manner as the thermal expansion valve is used for the ice-making plates during the ice-making process. The gas generator valve has an adjusting stem on the bottom of the valve. For typical applications, no adjustment of the valve should be required. Sizing of the gas generator plate, metering valve and piping are used to obtain the proper pressure drop and refrigerant flow without the need for adjustment.

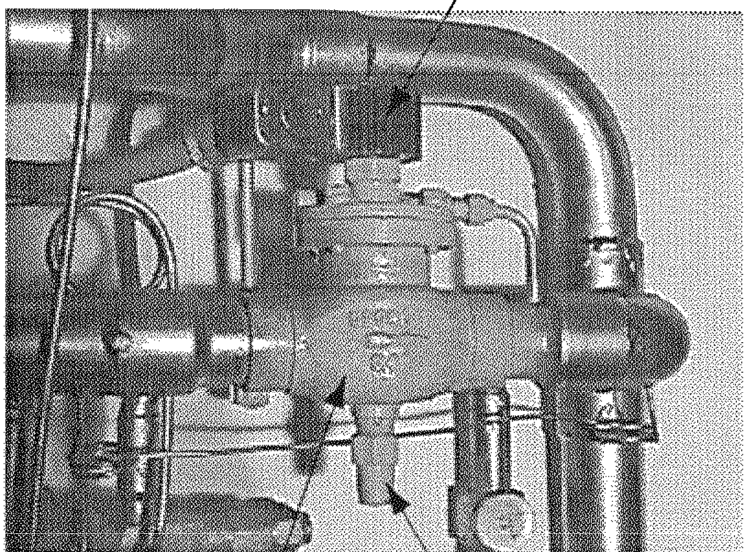
Liquid Solenoid (LS)

Refer to Figure 4-13. A two-way solenoid valve is mounted in the liquid lines of the ice generator. TURBO ice generators utilize a pump-down cycle which requires a means of shutting off the liquid supply to the evaporators.

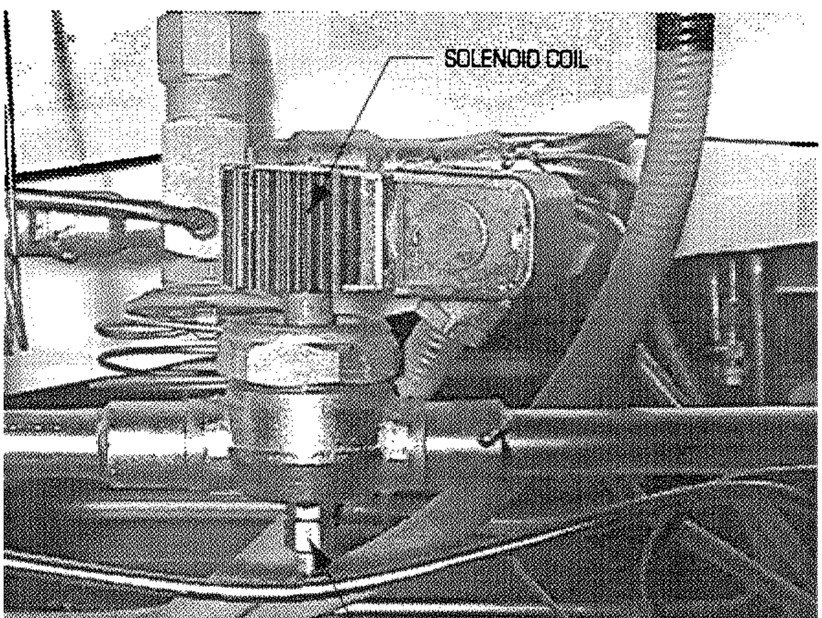
Through the logic of the PLC, the liquid solenoid valve is de-energized (closed) during pump-down and remains closed during shut-down to prevent liquid migration. During the start-up sequence, the liquid solenoid is opened (energized) to allow liquid refrigerant to the evaporator plates through the thermal expansion valves.

The liquid solenoid is mounted in the liquid line between the filter/drier assembly and the TXVs.

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



TYPICAL LARGE SOLENOID VALVE



TYPICAL SMALL SOLENOID VALVE

Figure 4-13 Refrigerant Solenoid Valves – LS, HG, ISS, GGS

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

Hot Gas Solenoid (HG)
Refer to Figure 4-13. During the icemaking mode, the hot gas supply to the evaporator is isolated from the evaporator. When the harvest sequence is initiated, the HG opens to supply hot gas to the evaporator plates.

Icemaker Suction Solenoid (ISS)
Refer to Figure 4-13. During the icemaking 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 is installed in the suction line of the evaporator section to isolate the evaporator plates during the harvest cycle.

When the coil is energized during the harvest sequence, the valve shifts to isolate the suction line; at the same time, the hot gas supply to the evaporator section in the harvest opens (refer to Hot Gas Solenoid). At the end of harvest, the coils de-energize and the solenoid valves return to the refrigeration position.

Gas Generator Solenoid (GGS)
Refer to Figure 4-13. During harvest and the start of the icemaking cycle, the gas generator plate is used to generate hot gas for harvest. Condensed liquid created in the icemaking plates during harvest is also metered to the gas generator plate through the gas generator solenoid (GGS). A normally closed solenoid valve is located in the suction line of the icemaking plate. During the harvest cycle, the solenoid opens at the end of the harvest cycle. GGS closes for the next icemaking cycle.

Common Features of Solenoid Valves Used
The liquid solenoid (LS), hot gas solenoid (HG), icemaker suction solenoid (IMS) and gas generator suction (GSS) are normally closed (N.C.) solenoid valves supplied with a 115 volt and 60 hertz coils. The coils will also operate on 220 volts and 50 hertz. Standard control voltage is 115/1/60.

A manual operator is located on the bottom of the valve. In automatic, the stem should be screwed out counterclockwise. If the stem is screwed in (flat on the stem even with the valve body), the stem will mechanically lift the valve seat, permitting flow through the solenoid even if voltage is not applied to the coil.

IMPORTANT

The manual operator should not be left in the manual position when the ice generator is in use. In the manual position, the solenoid valve will not close during icemaking or harvest cycles. The ice generator will not operate properly in this mode and will shut down on a failure. Failure to follow these instructions could result in damage or failure of the compressor.

Water System Control Valves

Refer to Figure 4-14.

Make-Up Water Solenoid (MWS)
Refer to Figure 4-15. A solenoid valve located in the make-up water line controls feed water used for ice production. The normally closed (N. C.) solenoid valve (MWS) is controlled by the PLC logic based on input from the water controls (consisting of the relay and water level probes. Refer to the Water Level Controls for additional information). The MWS will open under two conditions:

1. If the unit is OFF, the MWS will open when the master control switch (MCS) is turned to the ON position. This will begin the tank fill cycle. After the water level reaches the high probe, the MWS will de-energize (close), the compressor will start, and the icemaking cycle begins.
2. During normal operation, the water level in the tank will drop as the water is converted to ice in the

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

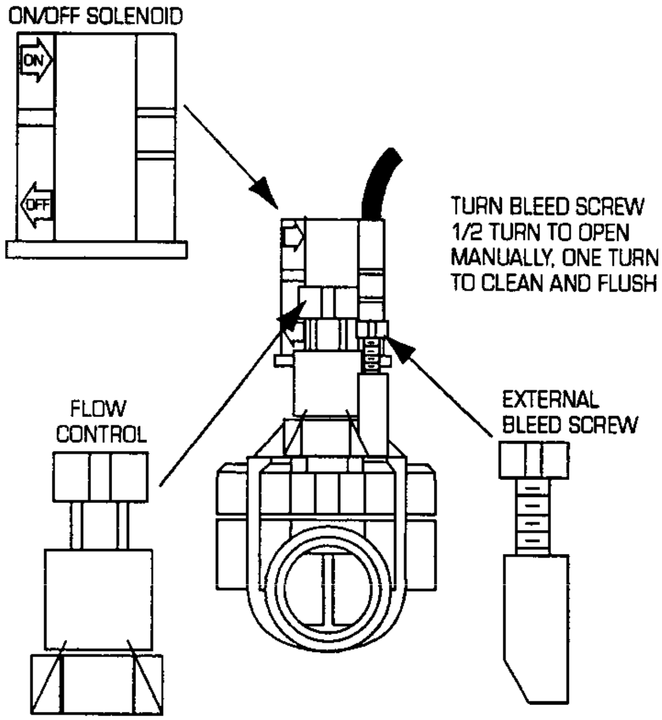


Figure 4-14 Water Solenoid Valve Detail – MWS, IWS, GWS

freezing process. When the water level is below the WLC setpoint, the coil of the solenoid is energized to open the valve allowing incoming water to enter the system to refill the tank for the next cycle. Refer to Figure 4-5.

MWS is located on the control panel end of the ice generator to the right of the water pump. Refer to Figure 4-3. All fresh water entering the unit is directed over the gas generator plate during the tank fill cycle and the harvest cycle. The solenoid opens on a low water level signal and closes on a high water signal.

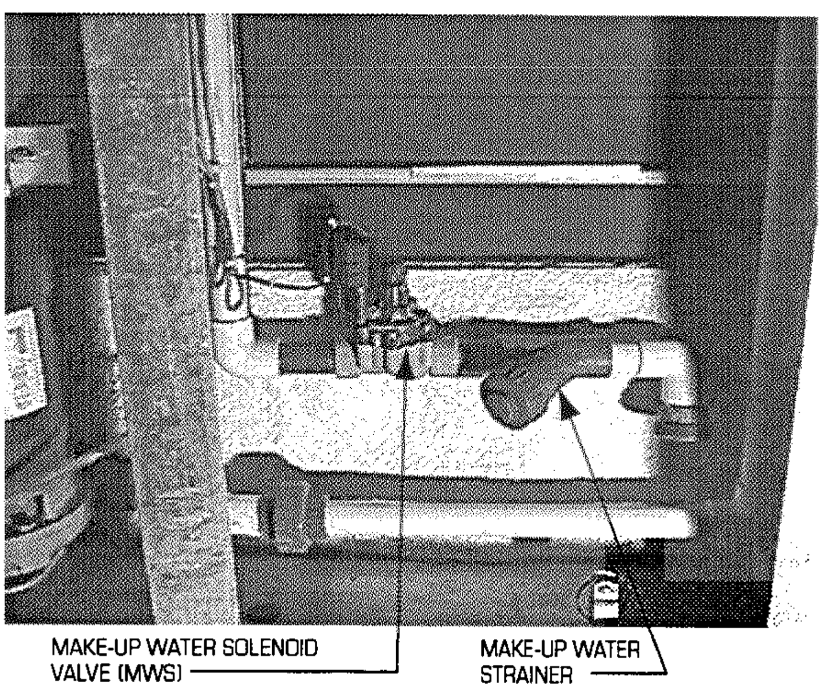


Figure 4-15 Make-Up Water Solenoid and Water Strainer

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

Icemaker Water Solenoid (IWS)

Refer to Figure 4-16. During the icemaking cycle, water from the tank is directed over the icemaking plates. The normally closed (N.C.) solenoid valve (IWS) is controlled by the PLC logic based on input from the water level controls. The IWS remains energized (open) until the water level control initiates a drying cycle followed by the harvest cycle. IWS closes during the "Drying Cycle" to allow the water pan to drain and the ice to dry before it is removed from the plates. Refer to Typical Icemaking Sequence for more information on the drying cycle.

IWS is located on the control panel end of the ice generator next to the water pan inside of the GWS valve. Refer to Figure 4-4.

Gas Generator Plate Water Solenoid (GWS)

Prior to the harvest cycle, the Gas Generator Plate Water Solenoid (GWS) is used to provide water flow over the gas generator plate to generator harvest gas. The normally closed (N.C.) solenoid valve is controlled by the PLC logic based on input from the water level controls. The GWS opens a preset time before the harvest cycle begins to establish flow over the gas generator plate and remains open during the entire harvest cycle and for a preset time after harvest to provide a load for the gas generator plate during the pump out process following harvest. During the PLC controlled time preset, both the IWS and GWS are open and water is circulated to all the plates.

GWS is located on the control panel end of the ice generator next to the water pan outside of the IWS. Refer to Figure 4-5.

Common Features of MWS, IWS and GWS Solenoid Valves

Refer to Figure 4-16. All the solenoid valves used in the water system with the exception of the drain solenoid (DS) are all PVC with stainless steel internal parts. Each valve is supplied with a manual operator and flow control valve. The coils are 24 volt

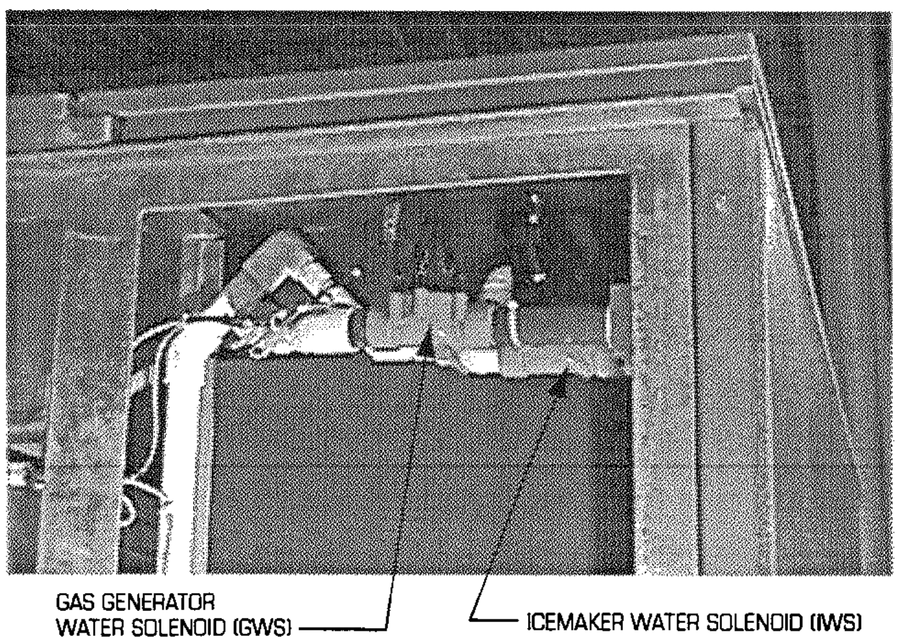


Figure 4-16 Icemaker and Gas Generator Water Solenoids

DC and are supplied with quick connects for easy replacement.

Manual Operator
Refer to Figure 4-16. The solenoid valves can be manually opened to obtain flow without the application of electrical power by turning the solenoid valve coil 1/4 turn counterclockwise. Automatic operation is obtained with the coil turned until hand tight in the clockwise direction. Refer to Figure 4-6.

IMPORTANT

The manual operator is for service only. For proper operation of the ice generator, the solenoid valves should always be in the Automatic position.

Flow Control
Refer to Figure 4-16. The flow rate through the solenoid can be adjusted using the flow control valve located next to the coil. This is the larger of the two adjusting stems. Refer to Figure 4-7. To increase the flow, the valve is turned counterclockwise to open the valve and clockwise to reduce the flow. The flow control valve can also be used to manually turn flow through the solenoid off.

IMPORTANT

The flow control shut off is for service only. For proper operation of the ice generator, the flow control valve should always be open. Refer to Typical Operating Sequences for additional information on setting (adjusting) the water flow for each solenoid.

External Bleed Screw
Refer to Figure 4-16. The stem on the solenoid can be used to either manually open the solenoid by turning the stem 1/2 turn counterclockwise or to clean and flush the area above the diaphragm by turning the stem one full turn counter-clockwise. For normal operation, the bleed screw should be turned all the way in clockwise to close the bleed port.

IMPORTANT

The bleed control is for service only. For proper operation of the ice generator, the bleed control valve should always be closed.

Drain Solenoid (DS)
When the icemaking process for the ice generator is completed and the master control switch is turned OFF, the ice generator will complete the icemaking cycle, harvest and then pump down. At the completion of the pump down cycle, the low pressure safety switch (LP) will open and the water drain solenoid (DS) will be energized (open) to drain all the water remaining in the system. The normally closed (N.C.) solenoid valve is controlled by the PLC logic.

DS is located in the drain/overflow piping field installed under the ice generator. The DS is the only water control valve using a 115 volt single-phase coil. DS is a brass pilot operated valve with a zero opening differential pressure for drain purposes. Selection of the solenoid is based on sewer flow (low velocity and essentially zero pressure drop). The DS automatically removes the water from the tank eliminating the possibility of water pump corrosion, water system freeze-up or stagnant water when the ice generator operation is resumed.

Water Strainer
A PVC strainer is factory installed in the make-up water line to remove larger suspended solids and debris to prevent fouling of the ports in the water solenoid valves and the holes in the water distribution pan. A 20 mesh PVC strainer in a Y-type housing is used in the make-up water line to provide for easy cleaning when the isolation valve supplied is closed.

Condenser Circuit Components

Refer to section 3 – Installation & Pre-Start-Up Requirements for additional information.

SC Models
The water-cooled condensing circuit consists of a con-

denser/receiver, water regulating valve, safety relief valve, cooling tower, cooling tower circulating pump and interconnecting piping. The water-cooled condenser/receiver, water regulating valve, and safety relief valve are supplied and factory installed. All other components are provided by others and require field wiring and piping. The components supplied are described below:

Water-Cooled Condenser

Refer to Figure 4-9. A shell-and-tube water-cooled condenser with removable heads for easy cleaning is factory installed. Refrigerant flows through the steel shell side of the condenser. Water is circulated through the copper tubes located on the inside of the shell. A two-pass water circuit is used. Water enters and leaves the condenser from the same end. Refrigerant connections for the inlet (discharge gas) and outlet (liquid) are located on the top of the vessel. A combination condenser/receiver is used. During pump-down of the ice generator, the refrigerant charge is stored in the condenser/receiver.

The vessel is rated for an operating pressure of 350 PSIG and is ASME coded. Design entering and leaving water temperatures are 85°F in and 95°F out for 105°F condensing. Design water flow is approximately 38 gallons per minute for 6 ton models. For condenser sizing, the total heat of rejection for selection is based on a design condition of 10°F saturated evaporator temperature (SET) and 105°F saturated condensing temperature (SCT).

All piping to the refrigerant connections is copper. All water piping is PVC.

Water Regulating Valve

Refer to Figure 4-9. Discharge (head) pressure is maintained by a pressure-actuated modulating valve located on the outlet of the condenser water circuit. The pressure actuated water regulating valve is used to modulate water flow through the water-cooled condenser. A sensing line from the bellows of the regulator is connected to discharge pressure at a port on the compressor. As the discharge pressure increases, the regulator opens to increase the water flow to the condenser to reduce the pressure.

Conversely, as the discharge pressure decreases, the regulator closes to reduce the water flow, resulting in an increase in the discharge pressure. This process is continuous and automatic. To change the pressure setting for the regulator, adjust the tension on the spring located above the bellows diaphragm. Turning the square stem on the top of the regulator counterclockwise will increase the tension on the spring. Therefore, more force is required to open the regulator and the setpoint pressure is increased. If the adjusting stem is turned clockwise, the spring tension will be decreased, and the pressure setpoint will be decreased.

Example:

The discharge is monitored after the initial pull down (approximately 3-5 minutes into the icemaking cycle following a harvest). The discharge pressure reading is 220 PSIG. To lower the operating pressure, the adjusting stem is turned clockwise to reduce the spring pressure until the desired discharge pressure is obtained. Allow the regulator time to balance after the initial adjustment and check the discharge pressure again at the same time during the next cycle.

The design pressure for a SC model is 105°F saturated condensing temperature. This corresponds to a discharge pressure of 210 PSIG for refrigerant R-22.

IMPORTANT

The 210 PSIG design pressure is used for equipment rating. Lower discharge pressure can be used to increase the refrigeration capacity (and ice capacity) of the ice generator. However, discharge pressures below 165 PSIG may result in erratic operation or poor performance. The thermostatic expansion

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

valves selection is based on a minimum valve inlet pressure of 150 PSIG. Discharge pressure below 165 PSIG and normal fluctuations in the water regulating valve could result in low pressure and inadequate liquid feed to the system.

The water regulating valve and pressure sensing line to the regulator are factory installed. Flanged water connections from the regulator to the condenser water lines to the regulator are supplied.

For normal operation, a pressure drop of 12-15 PSID through the regulator is used for calculation of pressure losses when selecting cooling tower pumps and water line sizes (by others).

Safety Relief Valve

Refer to Figure 4-17. A non-reseating atmospheric type safety relief valve set for 350 PSIG is provided on the condenser. This valve is not adjustable and must not be plugged or restricted in any way. Refer to section 3 – Installation & Pre-Start-Up Requirements for guidelines on selecting the relief valve vent lines (field piped by others).

Refer to section 3 – Installation & Pre-Start-Up Requirements for additional information on water cooled condensers.

SCA Models

Refer to Figure 4-18. The air-cooled condensing circuit consists of an air-cooled condenser, high pressure receiver, discharge pressure control valves and safety relief valve. All components are provided and factory wired and piped. The components supplied are described below (see note below for SCAR models):

Air-Cooled Condenser

A standard fin and tube type air-cooled condenser is provided. Typical construction is aluminum fins with copper tubes for refrigerant R-22 systems. A galvanized sheet metal frame is also standard. Air is drawn across the coil

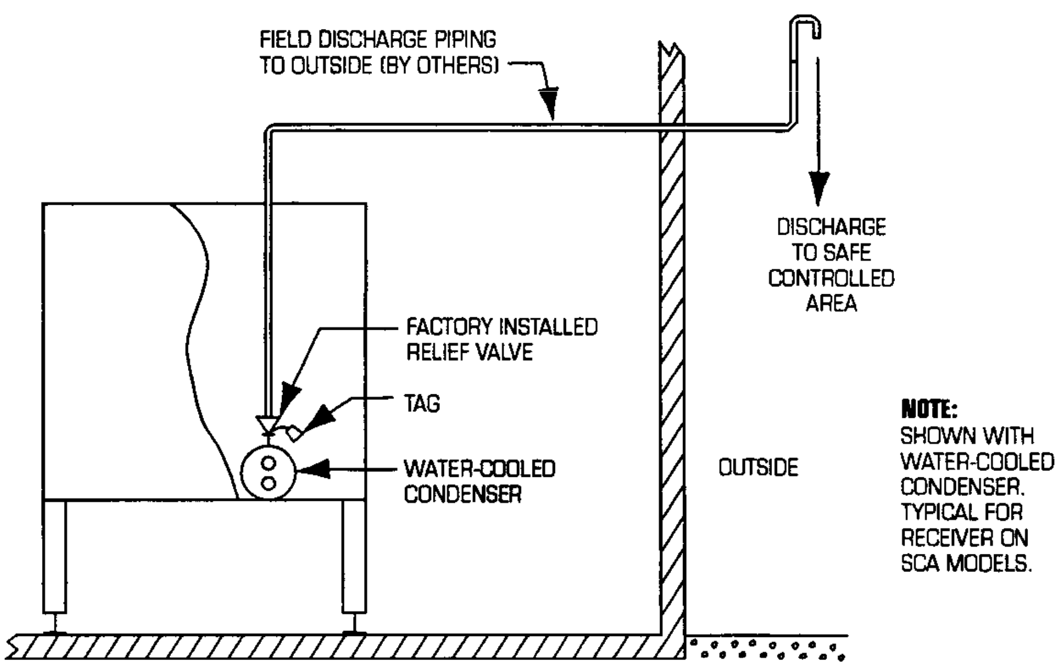
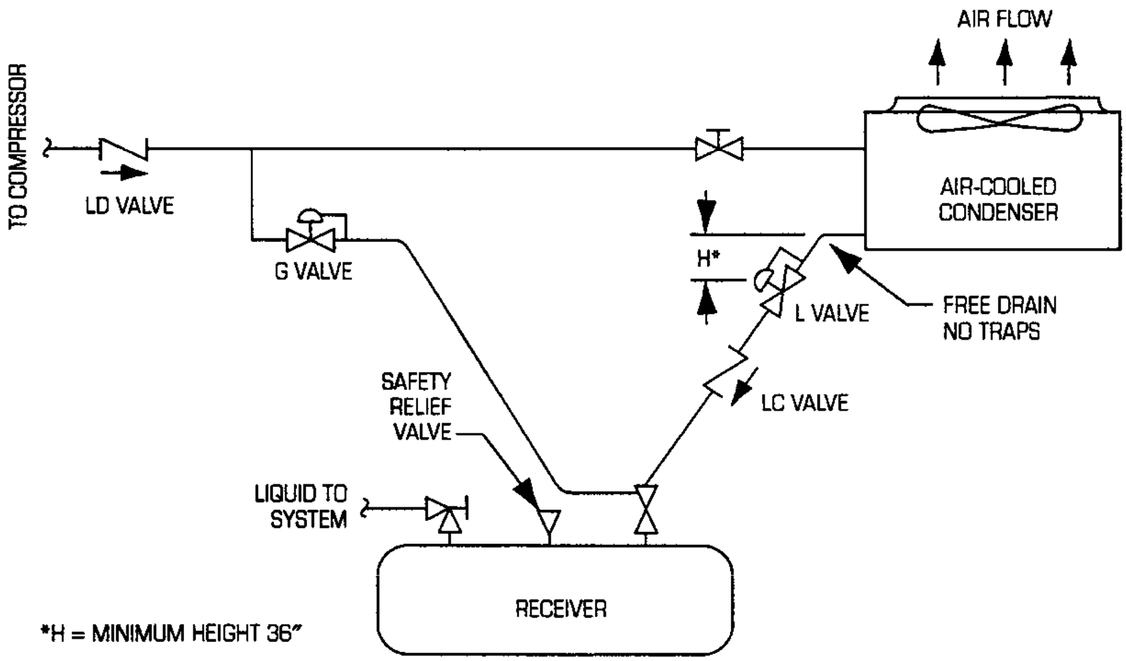
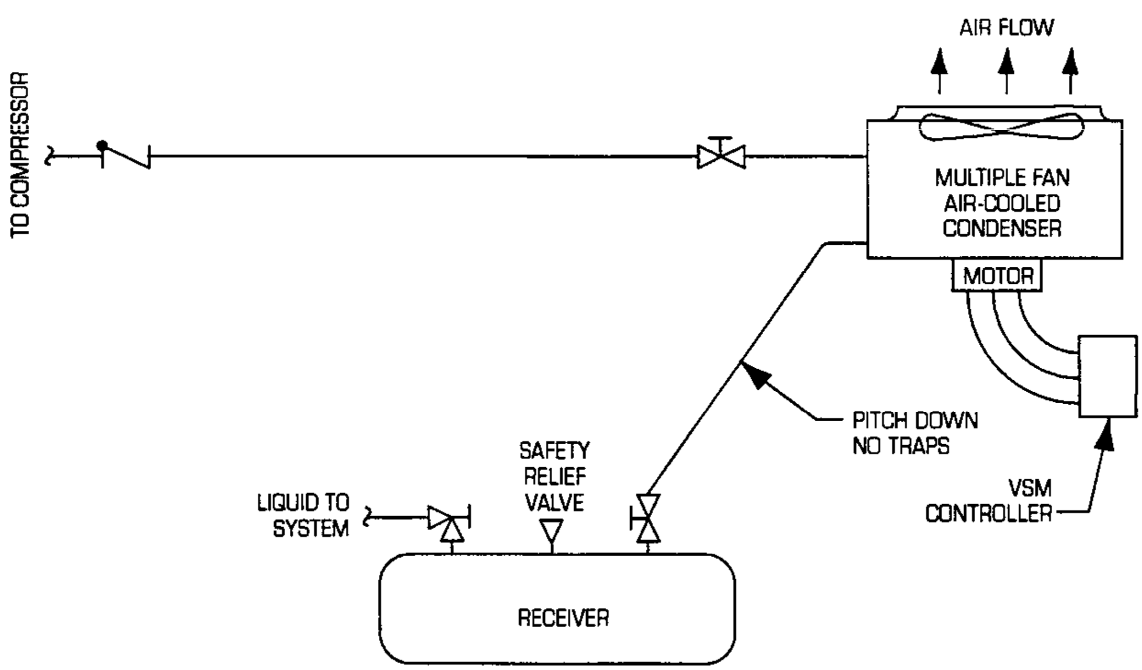


Figure 4-17 Safety Relief Valve – Pressure Vessels

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



TYPICAL AIR-COOLED CONTROL & WINTER CONTROL VALVE PIPING (FLOOD-BACK METHOD)



TYPICAL PIPING FOR FAN CYCLING OR VARIABLE SPEED FAN MOTOR (VSM) CONTROLS

Figure 4-18 Typical SCA Model Condenser and Condenser Controls from the bottom and discharged from the top by fan(s) located above the coil. Horizontal air flow is also used. In this arrangement, air is drawn in from one side and discharged from the opposite side. Refrigerant connections are made to two copper headers; the upper header is the gas inlet and the lower header is the liquid outlet.

All condensers are supplied with 230/460/3/60 motors. Standard operating pressure rating of the coil is 380 PSIG. Design conditions for selection are 100°F ambient (dry bulb) air entering, 110°F air leaving for a design condensing temperature of 120°F (approximately 260 PSIG for refrigerant R-22). For condenser sizing, the total heat of rejection for selection is based on a design condition of 10°F saturated evaporator temperature (SET) and 120°F saturated condensing temperature (SCT).

High Pressure Receiver

The condensed liquid from the air-cooled condenser is drained to a high pressure receiver. The flow-through type receiver is used to supply liquid refrigerant to the system during normal operation and as a storage vessel when the ice generator is pumped down at the termination of operation. The drain line from the condenser to the receiver is sized for "sewer" flow to ensure free draining of all liquid under design conditions.

During low ambient operation, the coil of the condenser is partially flooded to maintain the discharge pressure by reducing the internal surface of the coil. Refer to Discharge (Head) Pressure Controls. During normal operation, the total coil surface is required.

The vessel is rated for an operating pressure of 350 PSIG and is ASME coded. Connections (ODS) are provided on the top of the vessel for the liquid in, liquid out and a safety relief valve. All piping between the condenser and receiver is copper.

Discharge (Head) Pressure Controls

Fan Cycling

For most warm weather operation, cycling the condenser fan(s) with a condenser pressure switch (CPS by others on SCAR models) will provide adequate discharge pressure control. The pressure switch is used to turn the fan(s) off at a preset discharge pressure and then back on as the discharge pressure rises with the fan(s) off. This provides control within the differential of the pressure switch (typically 15°F). For example, on a typical system, the fan(s) would be turned off until the discharge pressure reaches the design pressure of 260 PSIG. If the entering air temperature is below the design conditions (100°F), the CPS contacts will open to turn off the fan(s) when the discharge pressure drops below the differential of the CPS (245 PSIG). With the fan(s) off, the pressure will begin to rise. The rate of the pressure drop will depend on the entering (ambient) air temperature. On design days (100°F entering air), the fan(s) may run continuously.

Conversely, on cool days, the fan(s) will tend to short cycle (turn off and on rapidly) due to the low entering air temperature and the setpoint of the pressure switch. To avoid short cycling, the internal volume of the condenser coil must be reduced to decrease the capacity of the coil. This method of control is known as flood back. Refer to Flood Back Controls.

For operating conditions with entering air (dry bulb ambient) temperatures below 40°F, fan cycling alone will not provide adequate discharge pressure control.

Flood Back Controls

Refer to Figure 4-18. Flood back controls typically consists of a drain line check valve, upstream pressure regulator in the drain line from the condenser to the receiver, gas bypass regulator in a line from the discharge line to the receiver and a discharge line check valve. The operation of each valve and the flood back system is described below.

Discharge Line Check Valve (Valve LD)

When flood back controls are used, a check valve is added

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to the discharge line to prevent liquid migration from the condenser circuit to the compressor. A standard inline spring actuated check valve is used.

Pressure drop through the check valve under design conditions is 1/2 to 3/4 PSIG.

Upstream Regulator (Valve L)

In order to flood the condenser circuit, an upstream pressure regulator is installed in the condenser drain line to the receiver. In low ambient conditions, the regulator closes when the pressure is below the setpoint of the regulator. This causes liquid to stack in the condenser to reduce the active surface and increase the discharge pressure. As the condenser temperature and liquid level in the condenser stabilize, the regulator will modulate to control the discharge pressure; i.e., if the pressure increases, the regulator opens to reduce the flooding charge and the discharge pressure. Conversely, if the pressure drops, the regulator throttles the flow to increase the coil flooding and increase the discharge pressure.

Check Valve (Valve LC)

If the discharge pressure is low at start-up and the 'G' valve opens to bypass into the receiver, the higher pressure at the outlet of the 'G' valve versus the condenser pressure will close the check valve in the drain line. This will keep the condenser from draining and hot gas from short-circuiting to the condenser. As a result, the coil will flood until a balance is obtained and the drain line pressure exceeds the outlet pressure of the 'G' valve. After the condenser temperature stabilizes, the check valve should remain open.

Discharge Bypass Regulator (Valve G)

During low ambient start-up, the pressure in the high-pressure receiver will be low. The large volume of the condenser combined with low entering air temperatures will cause the system to shut-down on low pressure. To prevent this condition from occurring, a hot gas bypass regulator is installed in a line between the compressor discharge and the inlet to the receiver to bypass directly into the receiver. This keeps the system pressure high enough during "cold" start-ups to prevent failure on low pressure. The downstream regulator ('G') under these conditions will remain open until enough heat (pressure) is added to the condenser to open the 'L' valve. Once the 'L' valve opens, the higher pressure drives the bypass regulator closed. After the system has operated for a short period of time and the temperatures have stabilized, the 'G' valve should remain closed.

The flooding of the coil and modulation of the 'L' valve will maintain the discharge pressure.

Safety Relief Valve

Refer to Figure 4-17. A non-reseating atmospheric type safety relief valve set for 350 PSIG is provided on the condenser. This valve is not adjustable and must not be plugged or restricted in any way. Refer to section 3 – Installation & Pre-Start-Up Requirements for guidelines on selecting the relief valve vent lines (field piped by others-field).

Refer to section 3 – Installation & Pre-Start-Up Requirements for additional information on air-cooled condensers.

SCAR Models

Models for remote air-cooled condensers (SCAR) utilize the same components described above for SCA models. For SCAR models, the high pressure receiver is supplied but all other components required for field installation of the remote air-cooled condenser are provided by others.

Wiring and piping between the condenser and receiver and from the ice generator to the condenser is field installed by others. SCAR models are shipped without a refrigerant charge.

Note:
The refrigerant charge is supplied with SCA models for domestic shipment only; international SCA models are shipped without a refrigerant charge.

Refer to section 3 – Installation

& Pre-Start-Up Requirements for additional information on air-cooled condensers.

Electric Motors

Standard open, drip-proof 230/460/3/60 motors are used for the water pump. The compressor is a semi-hermetic type with an integral electric motor.

Optional 208 voltage motors (60 hertz) and 220/380 voltage 50 hertz motors are available as options. Each motor is bottom wired to a magnetic starter or contactor at the factory. Top wiring to the contactor and starter (incoming power) and motor disconnects and/or circuit breakers for all devices should be furnished as required (by others) to meet all local, state, federal and country codes.

Typical Operating Sequences

Typical start-up, icemaking cycle, harvest cycle and final cycle before pump-down are described below. The sequences described are typical for SC, SCA and SCAR models. Recommended procedure for extended shut-down periods is also described.

Typical Daily Start-Up Sequence

All power, water and electrical connections have been previously completed and the ice generator is ready for start-up.

1. Select the desired ice thickness, 3/8″, 1/2″ or 5/8.″
2. Verify the wash cycle switch is in the OFF position.
3. Turn the master control switch (MCS) to the ON position.
4. Since the water tank is drained anytime the ice generator is off, it must be refilled before the unit will start. With the MCS on and the water level control (WLC) at the low level, the make-up water solenoid (MWS) opens to begin the fill process.
5. After the tank fill is complete, the make-up water solenoid (MWS) closes and the following sequence occurs:

   • Liquid solenoid (LS) opens to reset the low pressure safety switch used to terminate operation. If the low pressure switch does not reset within 20 seconds, the system will fail. Refer to section 5 – Trouble-Shooting.

   • Compressor (CM) starts

   • Water pump (WP) starts

   • Icemaker suction solenoid (ISS) opens

   • Icemaker water solenoid (IWS) opens
6. With the water pump ON and IWS open, water is pumped to the water distribution pan and distributed to each of the plates.
7. The water circulates over the icemaking plates only to provide a load for the compressor and produce ice. With water flow over the plates, the compressor will begin the pull down of the temperature of the water tank.

   Water in the tank is typically 33-35°F after the system has operated for one complete cycle. During the initial pull down (first cycle), the temperature of the water in the tank will be at the same temperature as the water source (typically city water at 50-80°F). The first cycle will be longer than normal due to this extra water temperature load. The ice thickness will be normal since the harvest is initiated by water consumption not time.
8. Ice will begin to form on both sides of the icemaking plates.
9. When the water level in the tank reaches the level of the WLC probe selected, a harvest sequence will be initiated to remove the ice.

Typical Icemaking Sequence

Refer to Figures 4-19 and 4-20. Following the first cycle described above, the icemaking sequence will continue until the MCS switch (or remote signal) is turned OFF. The following components continue to operate during the icemaking and harvest sequence: compressor and water pump.

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

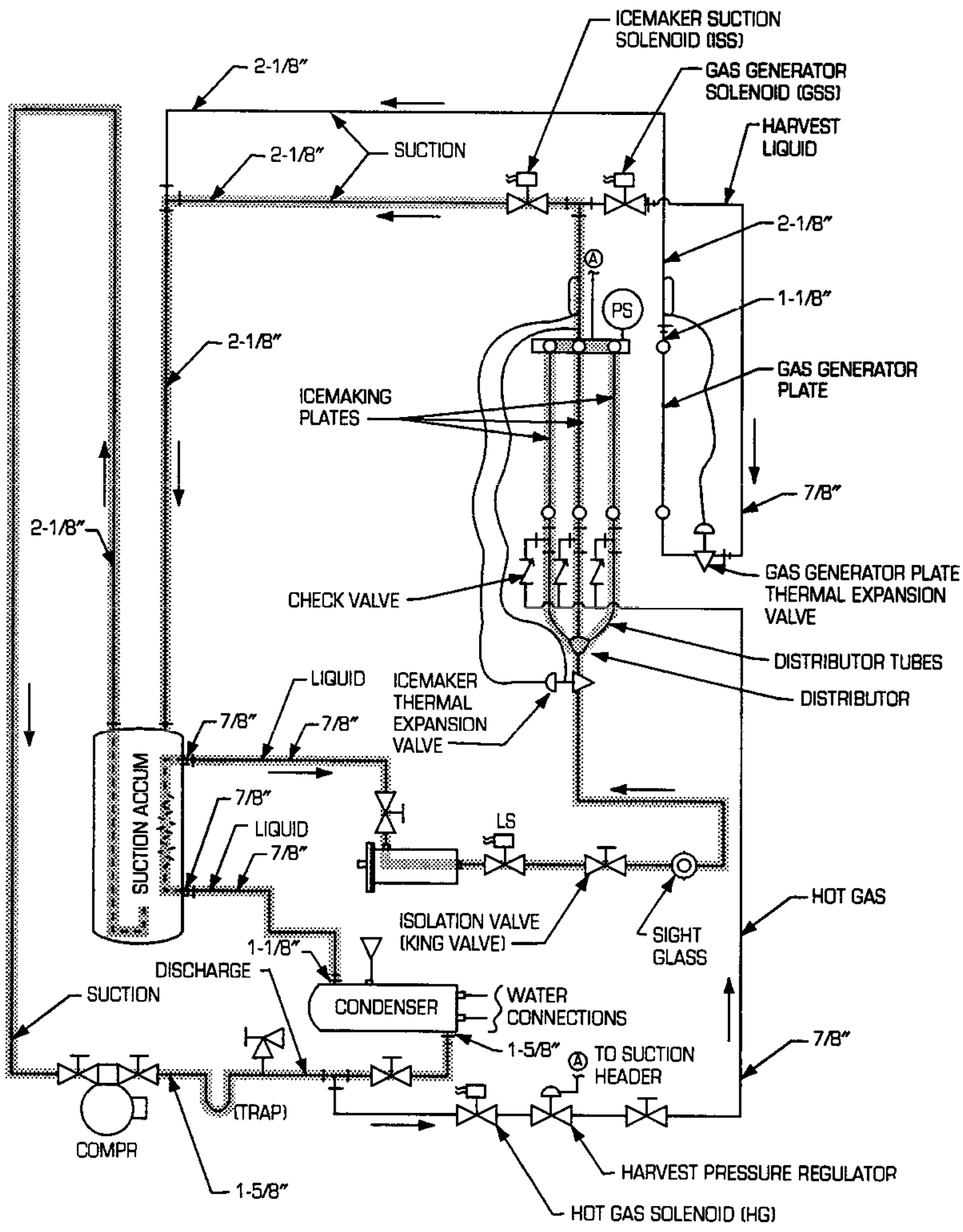

Figure 4-19 Typical Icemaking Sequence – Refrigerant Circuit

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

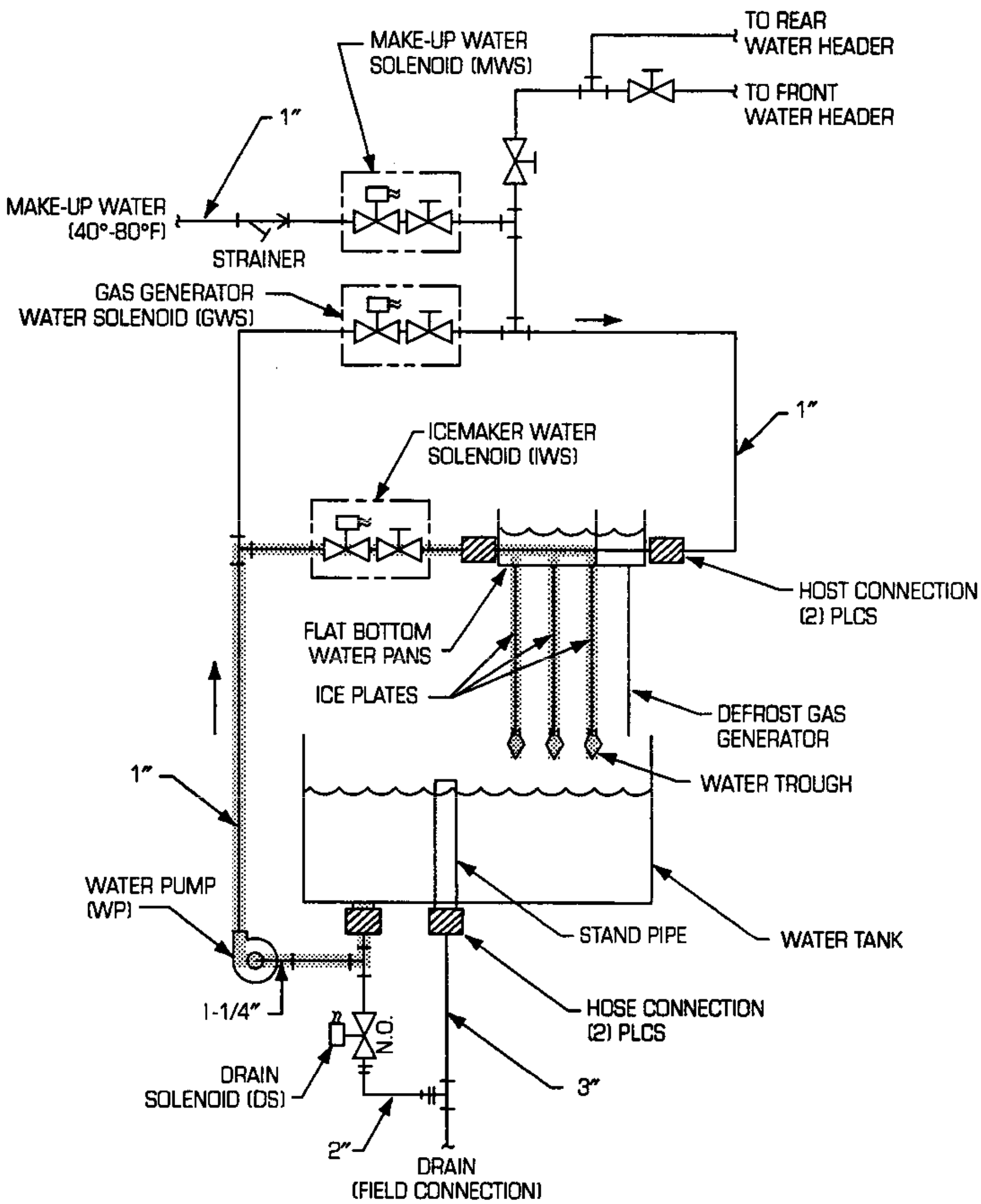

Figure 4-20 Typical Icemaking Sequence – Water Circuit

The icemaking sequence is:

1. After the first cycle including harvest is completed, the ice generator will start the next icemaking cycle if the master control switch (MCS) is in the ON position.
2. Harvest is terminated by the defrost pressure switch (DPS), the liquid solenoid (LS) and icemaker suction solenoid (ISS) open. As indicated above, the compressor and water pump are already running.

   Note:
   Water flow over the icemaking plates is terminated during the harvest cycle. Refer to Typical Harvest Sequence.
3. After a short preset delay (factory set at 5 seconds) the water over the icemaking plates is turned back on by opening the icemaker water solenoid (IWS).

   • The time delay for circulating water over the icemaking plates allows the suction temperature in the plates to drop (cool) before a load is applied. This prevents the formation of slush (suspended ice crystals) at the start of the icemaking cycle.

   • Slushing will result in a loss of water from the water tank.

   The mass of the suspended ice crystals in the flow over the plates breaks the surface tension between the water and plate surface causing the water and crystals to bypass the water collection trough located below the icemaking plate.

   • The D-line control sequence ensures that a full batch (thickness) of ice is produced every cycle.
4. TURBO provides a screw conveyor purge delay for the harvest screw supplied by others. The purge timers maintains a signal to the harvest screw controls after the harvest cycle is complete. This ensures sufficient time to purge all ice for the screw conveyor(s) used to transport the ice to storage or other remote delivery points. Therefore, the harvest screw will continue to run at the start of the next icemaking cycle.
5. Ice will begin to form on both sides of the icemaking plates.
6. When the icemaker suction solenoid opens, the gas generator suction solenoid closes.
7. After a preset time delay (factory set at approximately 8 minutes), the gas generator water solenoid closes.
8. The ice build on the plates continues.
9. When the water level in the tank reaches the level of the WLC probe selected, a harvest sequence will be initiated to remove the ice.

Typical Harvest Sequence

Refer to Figures 4-21 and 4-22. This sequence is typical for the initial start-up, all cycles that follow and the final shut-down cycle.

1. The water level in the tank reaches the setting of the ice thickness probe selected. For example, the 1/2″ ice thickness was selected on the control panel door at start-up. When the water level reaches the third probe from the bottom, the WLC relay will input a signal to the PLC to indicate the icemaking cycle is complete.

   • A red light on the WLC relay inside the control panel turns ON to indicate a low-level condition.

   • If the ice thickness is changed during the icemaking cycle, a harvest sequence may be initiated. The ice thickness can be selected at any time during operation or with the ice generator OFF. If the setting is changed during operation, the ice generator may initiate defrost immediately. This will occur if a thinner ice thickness is selected and the water level is below the probe of the new level selected. For example, the original selection was 5/8″ thick ice and the selector switch is

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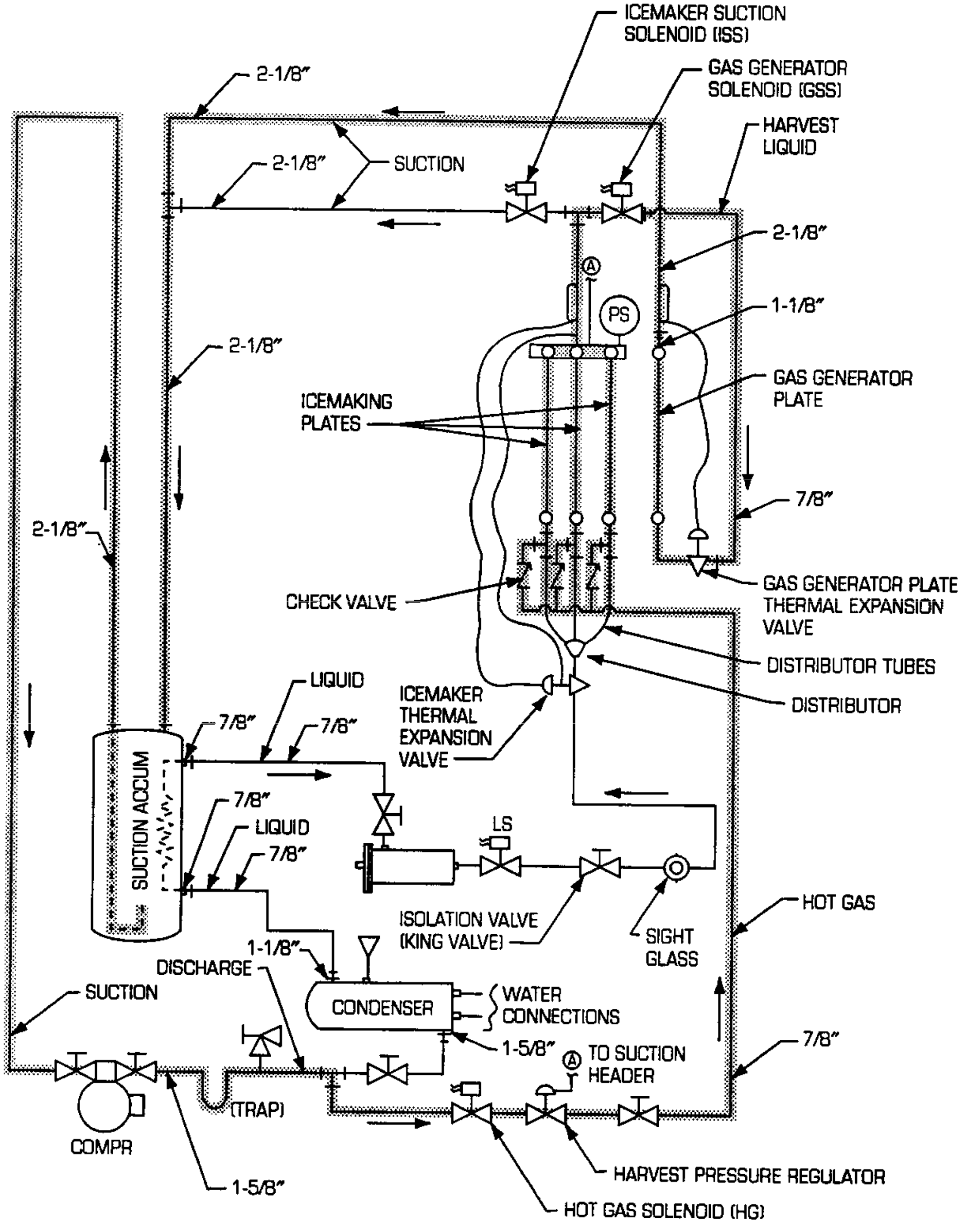


Figure 4-21 Typical Harvest Sequence – Refrigerant Circuit

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

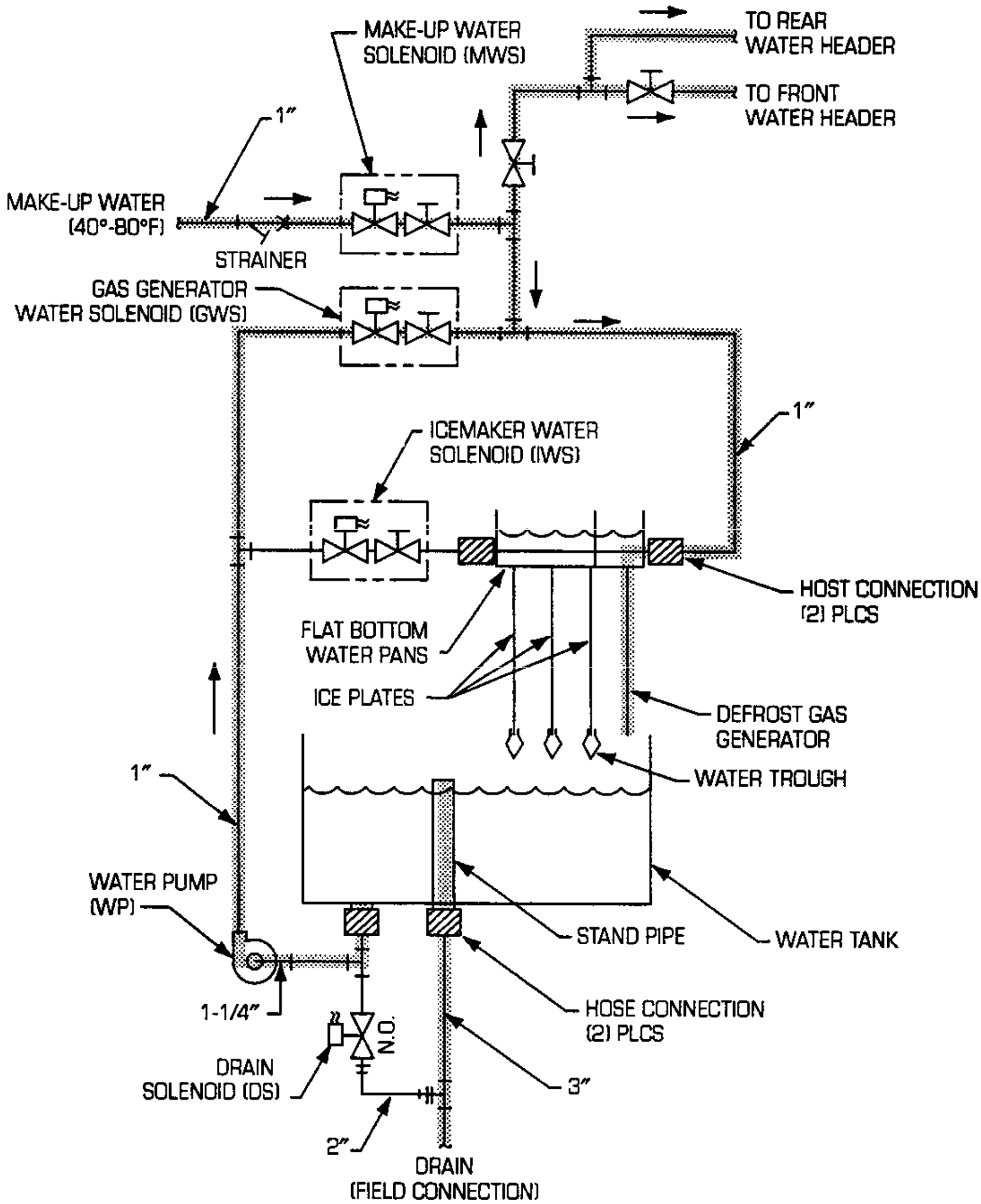


Figure 4-22 Typical Harvest Sequence – Water Circuit

changed to 3/8″ thick. If the water level is already below the 3/8″ probe (ice is already thicker than 3/8″ but less than 5/8″), the ice generator will immediately initiate harvest since the water level is below the 3/8″ thick probe. The ice thickness for the next cycle would be the 3/8″ thick selected.

2. The gas generator plate water solenoid (GWS) opens to establish water flow over the gas generator plate.
3. After a 5 second delay, the IWS solenoid closes to allow the water remaining in the water distribution pan to drain and the surface of the ice to dry. This is called the "drying cycle". The factory preset is 5 seconds for the "dry cycle".

   • At the same time IWS closes, the liquid solenoid (LS) also closes.
4. After a second 5 second delay, the following sequence occurs:

   • Make-up water solenoid (MWS) opens to begin refilling the water tank with fresh water.

   Note:
   This water can be at temperatures between 40 and 85°F. Consult factory for temperatures outside this range.

   • Hot gas solenoid (HG) opens to feed harvest gas to the icemaking plates harvest pressure regulator used to limit the pressure at the plate inlet.

   Note:
   When operating at design pressures (below 260 PSIG) the regulator operation is not required. For abnormal conditions or periodic operation at higher discharge pressures, the regulator must be adjusted to limit the inlet pressure.

   • As the hot gas is condensed to a liquid by the "cold" plate, the gas generator plate solenoid valve (GGS) opens and the condensed liquid is metered to the gas generator plate through the gas generator plate thermal expansion valve.

   • The output supplying the signal to the harvest screw conveyor(s) supplied by others turns to activate the harvest screw conveyor system. If the harvest screw fails, the ice generator will complete the harvest cycle but will not resume icemaking even if the MCS is still ON.
5. As the hot gas warms the icemaking plates above the freeze, a thin layer of ice is melted and the sheet of ice separates from the plate.

   • During the thaw of the ice layer on the plates, the condensed liquid entering the gas generator plate from the icemaking plates is removing the heat added to the tank by the warmer defrost water added to refill the water tank.
6. At this point, water is being circulated over both the icemaking plates and the gas generator plate. Hot gas is supplied to the icemaking plates for harvest and condensed liquid to the gas generator plate for generation of a load for the compressor and to chill the incoming water for the next cycle.

   • Although water is flowing to all the plates, the make-up water solenoid (MWS) will close when the tank is full; i.e., the water level reaches the high probe of the WLC switch.
7. As the ice separates from the icemaking plates, the pressure in the icemaking plates begins to increase. This pressure is monitored by the defrost pressure switch (DPS). After the last sheet of ice drops, the pressure will exceed the setpoint of the DPS switch (factory set at 100 PSIG). The closure of the DPS contact to the PLC terminates the harvest sequence and the next icemaking cycle begins if the MCS is still ON.
8. Although the harvest sequence has been terminated, the water flow to the

gas generator plate will continue for a preset time period (factory set at 8 minutes) into the next ice-making cycle to continue the water chilling cycle and evaporate the remainder of the liquid in the gas generator plate.

Typical Shut-Down / Final Harvest Sequence

Refer to Figure 4-23. The operation of the ice generator can be terminated at any time including during a harvest cycle by turning the master control switch (MCS) or other remote switches connected in series with the MCS circuit OFF (refer to the MCS description above for additional information). The shut-down sequence will be the same regardless of when the MCS is turned OFF.

1. Turn the master control switch to the OFF position.

   • If the ice generator is the icemaking mode, the unit will continue to build ice until a normal harvest sequence is initiated by the water level controls (WLC).

   • If the ice generator is already in harvest, the harvest sequence will continue, followed by a pump-down of the ice generator.

   • If immediate shut-down without a final harvest is desired, the MCS switch is turned OFF, then back ON and OFF a second time in a continuous sequence (OFF-ON-OFF). This bypasses the normal sequence and immediately stops the compressor and water pump.

2. The gas generator plate water solenoid (GWS) opens to establish water flow over the gas generator plate.

3. After a 5 second delay, the IWS solenoid closes to allow the water remaining in the water distribution pan to drain and the surface of the ice to dry. This is called the "drying cycle". The factory preset is 5 seconds for the "dry cycle".

   • At the same time IWS closes, the liquid solenoid (LS) also closes.

4. After a second 5 second delay, the following sequence occurs:

   • Make-up water solenoid (MWS) opens to begin refilling the water tank with fresh water.

   Note:
   This water can be at temperatures between 40 and 85°F. Consult factory for temperatures outside this range.

   • Hot gas solenoid (HG) opens to feed harvest gas to the icemaking plates harvest pressure regulator used to limit the pressure at the plate inlet.

   Note:
   When operating at design pressures (below 260 PSIG), the regulator operation is not required. For abnormal conditions or periodic operation at higher discharge pressures, the regulator must be adjusted to limit the inlet pressure.

   • As the hot gas is condensed to a liquid by the "cold" plate, the gas generator plate solenoid valve (GGS) opens and the condensed liquid is metered to the gas generator plate through the gas generator plate thermal expansion valve.

   • The output supplying the signal to the harvest screw conveyor(s) supplied by others turns to activate the harvest screw conveyor system. If the harvest screw fails, the ice generator will complete the harvest cycle but will not resume ice-making even if the MCS is still ON.

5. As the hot gas warms the icemaking plates above the freeze point, a thin layer of ice is melted and the sheet of ice separates from the plate.

   • During the thaw of the ice layer on the plates, the condensed liquid entering the gas generator plate from the icemaking plates is removing the heat added to the tank by the warmer make-up water added to refill the water tank.

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

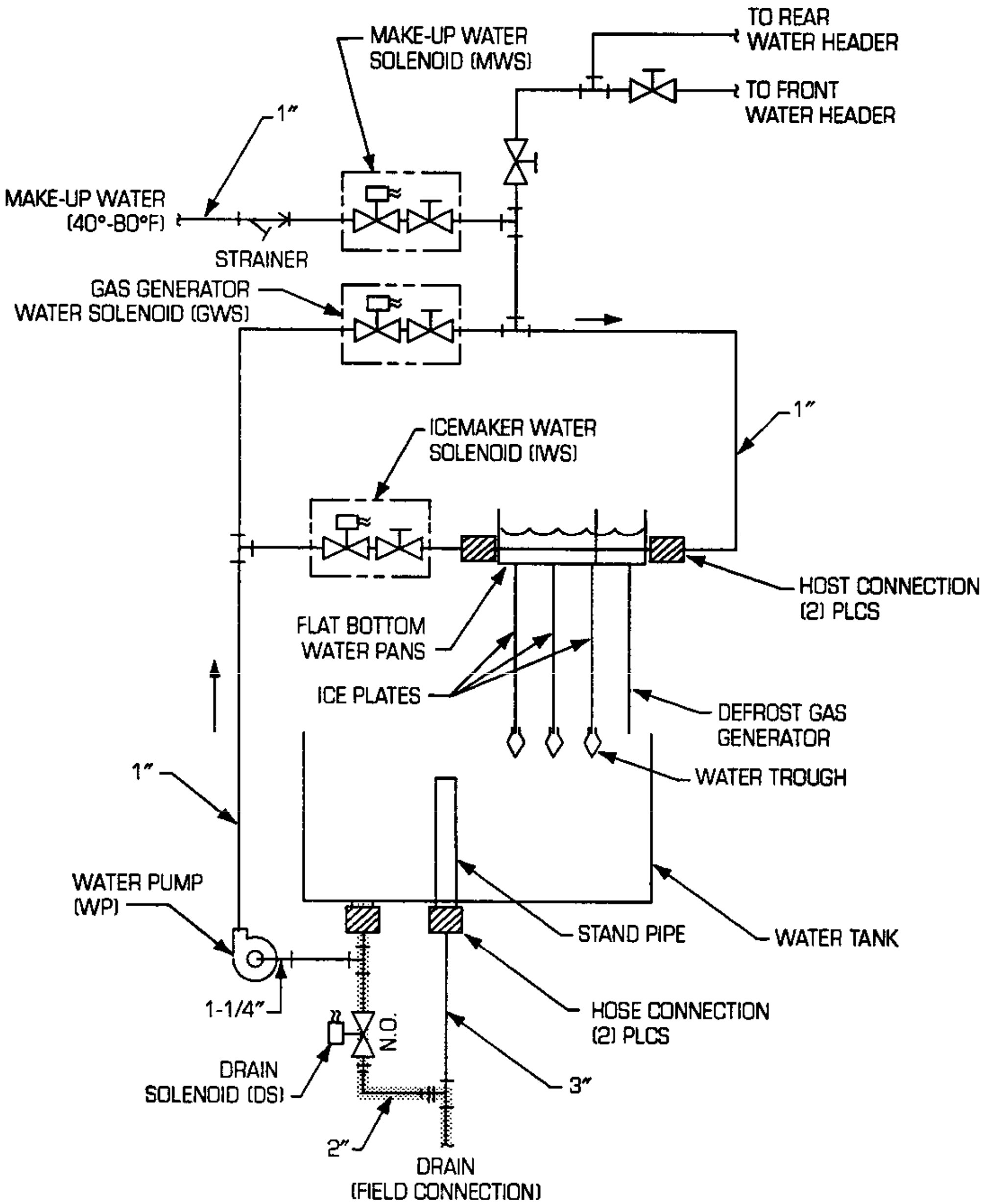


Figure 4-23 Typical Shut-Down/Final Harvest

6. At this point, water is being circulated over both the icemaking plates and the gas generator plate. Hot gas is supplied to the icemaking plates for harvest and condensed liquid to the gas generator plate for generation of a load for the compressor and to chill the incoming water for the next cycle.

   • Although water is flowing to all the plates, the make-up water solenoid (MWS) will close when the tank is full; i.e., the water level reaches the high probe of the WLC switch.

7. As the ice separates from the icemaking plates, the pressure in the icemaking plates begins to increase. This pressure is monitored by the defrost pressure switch (DPS). After the last sheet of ice drops, the pressure will exceed the setpoint of the DPS switch (factory set at 100 PSIG). The closure of the DPS contact to the PLC terminates the harvest sequence and the shut-down cycle begins if the MCS is still OFF.

8. The liquid solenoid (LS) was closed at the start of the harvest cycle. During the final harvest sequence it will remain closed at the end of the harvest cycle even though the defrost pressure switch closes to start the next cycle.

   • The hot gas solenoid (HG) closes.

   • The water pump (WP) turns OFF.

   • The icemaker water solenoid (IWS) closes.

   • The gas generator plate water solenoid (GWS) closes.

   • The harvest screw conveyor continues to run to purge all ice from the conveyor system.

9. The icemaking suction solenoid (ISS) will open to begin the pump out of the refrigerant in both the icemaking plates and the gas generator plate.

10. Since the supply of refrigerant has been terminated by closing LS, the suction pressure will begin to decrease as the refrigerant is pumped into the combination condenser/receiver for water-cooled models or the high pressure receiver for air-cooled models.

11. When the suction pressure drops below the setting of the low pressure safety switch (LP) at approximately 5-10 PSIG, the contacts of the LP opens to remove the signal to the compressor safety circuit.

    • In the shut-down sequence with the MCS switch OFF, the compressor shut-down "failure" does not occur since the MCS switch was in the OFF position. This would be a normal sequence.

    • If the master control switch (MCS) was ON, opening the contacts, the LP switch would shut the compressor off and "fail" the system preventing further operation.

12. When compressor has turned off on low pressure, the harvest screw conveyor will also stop when the cleanout time delay (PLC) terminates.

13. Steps 10 and 11 are typically referred to as the "pump-down cycle" meaning the operating refrigerant charge of the system has been transferred to the receiver for storage.

    • The ice generator has a continuous "pump-down cycle." If the refrigeration system pressure increases above the reset point of the LP switch, the compressor will turn ON to pump the system back down. Operation will again terminate when the contacts of LP open.

WARNING

The ice generator starts and stops automatically even if the MCS switch is in the OFF position. Never service the equipment without proper lockout of all electrical power. Failure to care-

fully follow these instructions could result in permanent injury or loss of life.

Water Circuit

The water pump operates continuously to supply water to the icemaking plates or both the gas generator plate and icemaking plates during harvest. Water distribution to the icemaking plates and gas generator plate as well as the water tank is controlled by a set of solenoid valves. Refer to Figures 4-20 and 4-22.

Make-Up Water

When the ice generator is turned on, the make-up water (MWS) solenoid valve opens to fill the water tank. Water from a city water supply or others sources is piped to the make-up connection located next to the water pump under the control panel. The PVC water line is connected to a isolation valve and strainer. During the harvest sequence, the MWS opens to replace the water converted to ice. The solenoid valve remains open until the water level control (WLC) high probe level is reached.

During the refill of the tank, some blow-down will occur. Blow-down is the overflow of water to the drain to prevent the concentration of solids in the water tank. The amount of blow-down required to maintain good ice quality will depend on the quality of the incoming water supply. Blow-down can be increased by changing the time preset on the MWS solenoid closure after the WLC relay contact indicate the tank is full. By increasing the time delay, additional water is overflowed and more suspended solids are rejected. Field adjustment will be required to get the best quality with the least blow-down.

Note:
If the water level relay does not reset (tank fill completed) within 3 minutes, the system will "fail."

Icemaking Plate Water Flow

When the icemaking water solenoid (IWS) opens, water flows through a PVC water header into a stainless steel water distribution pan. Refer to Figure 4-24. The distribution pan has a series of holes located along the entire length of the active plate surface on both sides of each plate. Water is collected at the bottom of the plate in a water trough and returned to the water tank. Refer to Figure 4-25.

Water is circulated back over the icemaking plates until the water level controls initiate a harvest cycle. The water flow over the icemaking plates is terminated prior to opening the hot gas solenoid to allow time for the water pan to drain and the surface of the ice on the plates to dry.

The holes in the water distribution pan provide additional filtering of the water as well as distribution. Periodic cleaning of the icemaking plates and water pan is required to provide optimum performance at all times.

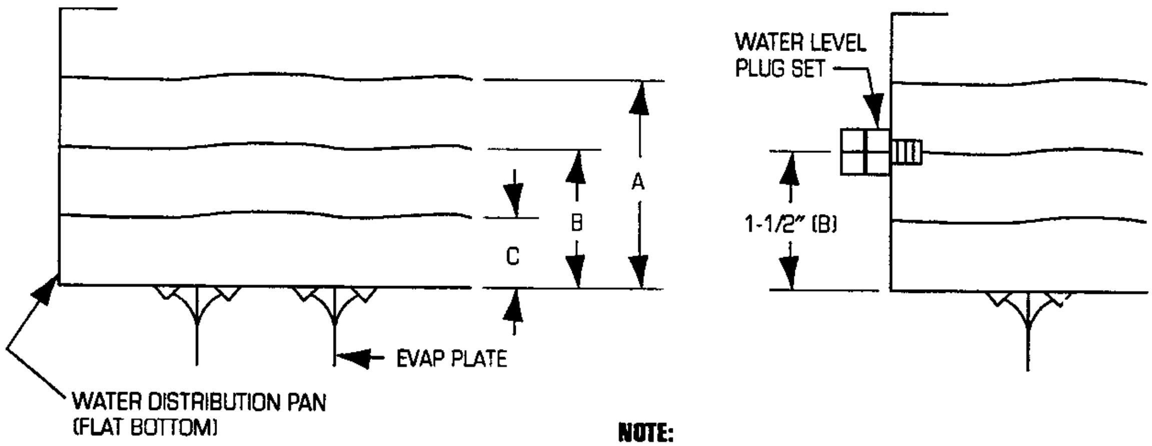
Gas Generator Plate Water Flow

When the gas generator plate water solenoid (GWS) opens, water flows through a PVC water header into a stainless steel water distribution pan. The distribution pan has a series of holes located along the entire length of the active plate surface on both sides of the plate. The gas generator plate is located directly over the water tank and water is returned directly into the water tank. Water is circulated back over the gas generator plate until the water level controls initiate the next icemaking cycle and the PLC time delay for the water chilling cycle has elapsed. The time delay is factory preset at 8 minutes.

The holes in the water distribution pan provide additional filtering of the water as well as distribution. Periodic cleaning of the gas generator plate pan is required to provide optimum performance at all times.

Overflow Drain/Blow-Down Water Circuit

The freezing process tends to separate the suspended solids in the water used to produce the ice on the plates. If the concentration of solids is allowed to continue without



A = MAXIMUM WATER LEVEL IN PAN ~ 2" SEE NOTE
B = NORMAL WATER LEVEL IN PAN ~ 1-1/2"
C = MINIMUM WATER LEVEL IN PAN ~ 5/8"

NOTE:
WATER LEVEL SHOULD BE SET TO LEVEL B.
TO SET: REMOVE WATER LEVEL PLUG;
ADJUST FLOW TO ICEMAKER PAN UNTIL WATER STARTS TO OVERFLOW (FLOW TO GAS GENERATOR PAN SHOULD BE OFF); REPLACE PLUG. FLOW SHOULD NOT EXCEED LEVEL A FOR PROPER OPERATION. LEVELS ABOVE 2" WILL REDUCE ICE PRODUCTION.

Figure 4-24 Typical Water Distribution Pan

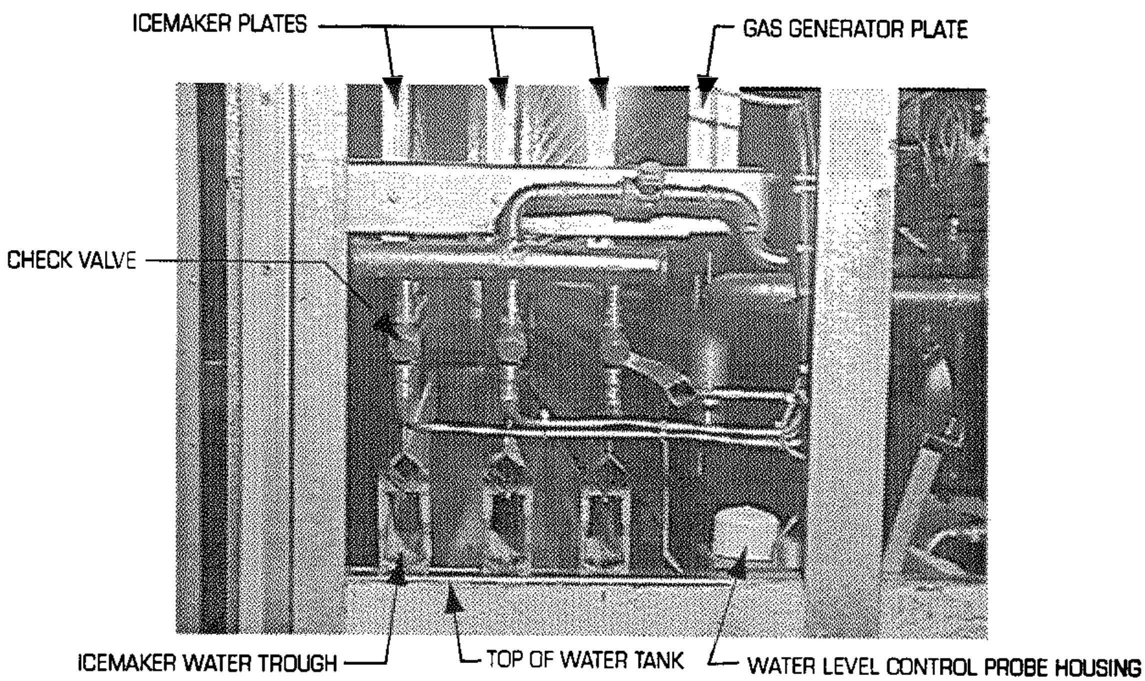


Figure 4-25 Stand-Pipe and Blow-Down Siphon

removal, the ice will become cloudy and the concentrated solids will eventually cause erratic operation of the water solenoids as the ports in the valves become clogged. Water quality and other operating conditions can cause a wide variation in the concentration of solids and effect on the ice quality. Refer to Figure 4-26. To prevent the concentration of solids in the water tank and provide consistent quality, the D-line provides that:

- A small amount of overflow is used during harvest to remove the solids suspended in the tank. This is adjustable through the PLC time preset of the make-up water solenoid (MWS).
- The water tank is drained when operation is terminated. This helps flush the bottom of the tank.
- A siphon type stand pipe is used to "vacuum" solids from the tank when water is overflowed. A vented tube is placed over the standpipe connected to the drain line. As the vent on the siphon tube is closed off by the raising water level, a siphon affect is created when the water starts to overflow the inner tube. This creates a flushing action that removes the solids from the tank.

As indicated above, the water quality is the major factor is determining the amount of "blow-down" required. With excellent water quality, the blow-down should at a minimum and may require short time delays on the MWS solenoid. In some cases, the siphon tube over the tank standpipe may also be removed. For example, if the water source was from a reverse osmosis (R/O) system, the water quality would be excellent. The need for blowdown would be minimal and the siphon tube may not be required. R/O systems are typically too expensive for most applications making blowdown the most economic alternative.

As the water quality decreases in quality, the amount of blowdown also increases. TURBO recommends contacting a local water treatment expert to evaluate your system and determine the best combination of water treatment if needed and setting of the blow-down timer.

Field piping is required from the overflow drain connection located on the bottom of the unit to a suitable disposal point. Line sizing for the drain must provide "sewer" flow in the drain to ensure free flow. Small lines may cause excessive back pressure and improper draining during the harvest cycle and at the termination of operation.

Note:
Information on the operation of the solenoid valves is described above under the description of the components.

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

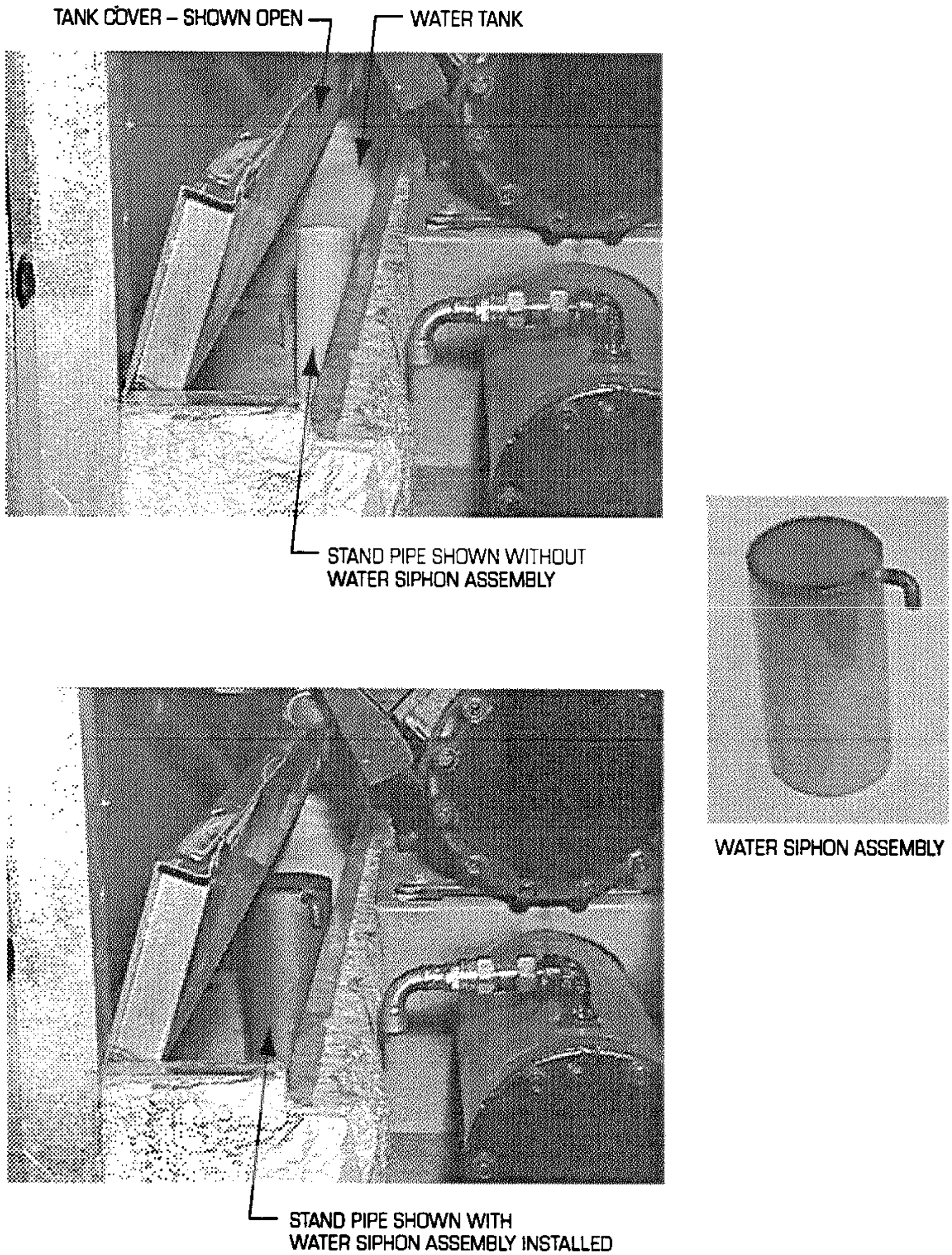


Figure 4-26 Icemaker Water Trough and Water Level Control

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

TROUBLE-SHOOTING

The following pages describe problems you might encounter and provide diagnostic instructions and solutions. Many problems are easy to solve – if you know what caused them.

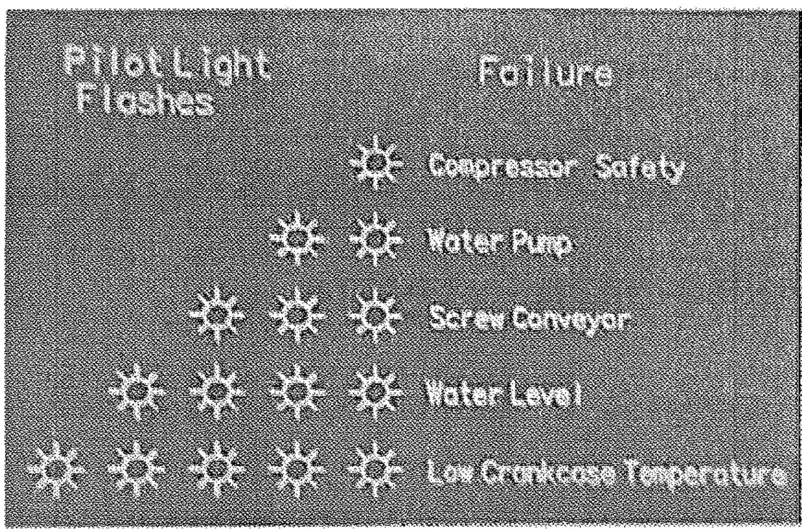

Figure 5-1 Control Panel Decal

If your problem is more complex and not stated in this section, contact Turbo Refrigerating, LLC at:

1-940-387-4301

Ask for the Service Department.

Refer to the wiring and piping schematics when using this section.

Table 5-1 Failure Codes

Number of Flashes	Failure
1	compressor
2	water pump
3	screw conveyor
4	low water level
5	low crankcase temperature

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.	Replace.
	Oil failure tripped.	Determine cause of low oil pressure before restarting (see low oil pressure in Section 3. Installation & Pre-Start-Up Requirements). Manual reset required.
	Defective dual pressure switch. Low pressure switch does not reset on pressure rise.	Check switch wiring on controller. Replace as required.
	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.

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).	Compressor crankcase temperature too low (CTS tripped).	Check crankcase heater. Reset and restart. Monitor operation to determine if liquid rich mixture returning to compressor. • Check liquid solenoid; unit not maintaining pump-down.
	Overload relay on motor protection module (MP) tripped.	Determine cause of motor overload. Depress manual reset button.
	Liquid solenoid failed to open; LP switch will not reset.	Check liquid solenoid (LS) coil; check output to liquid solenoid.
Unit drawing high amps.	Loose terminal connections.	Tighten connections (qualified electrician).
	Defective motor bearings or motor.	Replace.
	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.

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 if defective.
	– Fouling at condenser (water-cooled).	Clean condenser by brushing and/or acid treatment. Consult manufacturer for water treatment recommendations.
	– Faulty water pump.	Replace pump. Check pump suction and discharge for obstructions.
	– Faulty cooling tower water pump.	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-cooled).	Adjust to maintain 180 PSIG (see Section 3. Installation & Pre-Start-Up Requirements, step 13. Air-Cooled Condensers).
	– Belt worn or loose causing belts to slip (air-cooled or evaporative-cooled)	Adjust, replace belts.

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).	– 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.
	Leaking defrost valve allowing hot gas bypass.	Repair with valve kit or replace.
	Thermal expansion valve improperly adjusted.	Adjust expansion valve superheat to 10-15°F. Check TXV power head. If defective, replace.
	Plugged or restricted filter drier.	Replaced 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-condensable in refrigerant system.	Bleed air from condenser. Replace refrigerant charge.
	Restriction in piping.	Check all isolation valves for proper position - open or closed.

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).	Power off to condensing unit.	Check power, breaker, and disconnects to all motors, starters, and control switches.
	Insufficient water flow to condenser (water-cooled) causing high discharge pressure:	
	– Strainer plugged.	Clean or replace.
	– Float valve defective (make-up water line to cooling tower).	Check adjustment. Replace if required.
	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 sump.

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).	– Strainer plugged.	Remove and clean.
	– Check valve stuck closed.	Remove and clean.
Unit will not defrost.	Hot gas solenoid inoperative.	Check wiring to coil. Check for burned out coil and replace.
	Gas generator solenoid valve (GSS) inoperative.	Check wiring to coil. Check for burned out coil and replace.
	Insufficient water over gas generator plate.	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.
	Harvest gas pressure regulator inoperative.	Valve dirty, clean. Rebuild if necessary. For temporary operation, manually open regulator.
	Ice building on ends of plate causing bridging.	Check defrost water header on each end of plates. Check for low water flow caused by dirty pan.

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 dirt 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.	Make-up water solenoid stuck open or in manual position. Clean valve; reset to automatic position.
	Leaking defrost valve (HG).	Repair or replace.
	Expansion valve improperly adjusted (overfeeding refrigerant).	Check expansion valve adjustment (close to reduce refrigerant valve). Set superheat at 10-15°F.

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 water-cooled; 170-190 PSIG for evaporative-cooled; 210-250 PSIG for air-cooled.
	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 not returning from accumulator.	Adjust hand expansion valve open to 1/4 turn open from fully closed. Observe sight glass for flow. Adjust superheat after oil level returns to normal.
	Low oil in crankcase.	Add oil, observe sight glass. Maintain 1/8 to 1/2 sight glass. If oil returns above 1/2 sight, remove excessive oil.
	Defective compressor oil pump.	Replace as required. Refer to manufacturer's installation, start-up and service instructions in Section 10. Appendix & Notes.
	Weephole in suction accumulator plugged.	Contact factory.

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.	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.
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 or failed compressor cooling fan.	Clean obstructions. Replace cooling fan motor

Notes:

6

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

MAINTENANCE

To help you get the best performance from your ice generator, follow the maintenance instructions listed below.
If you have questions concerning the maintenance or upkeep of your equipment, contact the service department of Turbo Refrigerating, LLC (1-940-387-4301).

Daily Inspections

1. Inspect the icemaker at least twice a shift to determine that the unit is operating properly.
2. At the start, observe that the discharge and suction pressures are correct on the gauges and are stable.

Weekly Inspections

Check the oil level in the compressor.

Check for signs of oil leakage.

Check the sight glass for full charge and moisture indication.

Unit should be checked at least once a week. A visual inspection should include and not be limited to: leaks, vibration of piping on other components, capillary tubes rubbing, unusual noises, bolts, nuts, screws tight, and general neat housekeeping appearance.

After Initial Ten Hours of Operation

Check and clean water strainer.

After Initial Fifty Hours of Operation

Retighten all bolts.

Have a qualified electrician check the control panel for loose connections or loose lugs on the magnetic starter.

Flush water tank.

Every Six Weeks

One of the main problems with any icemaker is water: scale build up, solids forming on the plates, build-up of solids in the pan, and solids building up on the interior of the water-cooled condenser, if so equipped. To avoid these problems, consult a local water treatment consultant and follow the following guidelines:

Icemaking Surface Cleaning

Scale on the icemaking plates resulting from mineral deposits in the water and other sources of contamination can reduce the efficiency of the plate. If left untreated, it may result in deterioration of the metal surface thus reducing the life of the plates.

The life and efficiency of the plates are dependent on proper care and cleaning of the surface. Since conditions and installation of equipment vary from location to location, it is difficult to provide a simple solution to selecting a cleaning and sanitizing method. To obtain the best care for your unit, contact a local reputable supplier of chemical and cleaning sanitizing products. Based on the knowledge of the local water conditions, the material to be cleaned (304 stainless steel) and the operating conditions of the equipment, they can recommend a cleaning and sanitizing product to meet your specific needs.

Helpful Hints

1. Chlorine will attack stainless steel. Most water supplies contain chlorine but in levels too low to cause concern. Some cleaning agents contain high levels of chlorine and should be avoided unless the cleaning process can be closely controlled and a thorough rinsing of the plates and any other parts coming in contact with the cleaning agent can be ensured every time.
2. Water scale can be removed using dilute nitric acid under 1% or phosphoric acid under 5% at temperatures no higher than 140°F or citric acid. These solutions must be free of salt and thoroughly flushed from all surfaces immediately after use with 1/4%

caustic and plain water flush.

3. Hydrochloric muratic and sulphuric acid should not be used.

Scale and Solids Forming In Water Tank

Flush the water tank at least once a week. Solids can stop up the holes in distribution pans. Clean pan by using an air hose, a vacuum cleaner, or a brush. If excessive or frequent cleaning is required, adjust water make-up blowdown (increase blow-down to reduce concentrations in tank).

Clean strainer in make-up water line.

Dirty or scaled tubes in water-cooled condensers can cause high discharge pressure. Periodly remove the condenser head and use a condenser tube cleaning brush to remove scale. Acids or chemical additives can also be used. Care should be exercised when using acid. Follow directions on the container (consult local chemical treatment supplier).

Cooling towers should be treated for scale and on algecide where needed. For additional information on water-cooled condensers, refer to guidelines in Section 10. Appendix & Notes.

Air-cooled condensers can be washed out using a water hose and flushing out against the air flow. Prior to performing this service insure that the electric circuit is disconnected. Lubricate fan bearing and tighten belts where so equipped according to the manufacturer's specification.

Note:
TURBO recommends that warnings and labels for any additional equipment not supplied by TURBO need to be added to the weekly inspection sheet.

Electrical Apparatus (Motors)

The fundamental principle of electrical maintenance is to keep the apparatus clean and dry. This requires a periodic inspection of the apparatus (the frequency depending upon the type of apparatus and the service).

Helpful Hints

1. Windings should be dry and free of dust, grease, oil and dirt. Clean windings with suction cleaners or by wiping. Nozzles on suction type cleaners should be nonmetallic. Remove gummy deposits of dirt and grease by using a commercially available low volatile solvent. Do not use gasoline or other inflammable solvents.

   Never oil any part of the magnetic control.

2. Terminal connections, assembly screws, bolts and nuts should be tight. They may loosen if the motor is not securely bolted and tends to vibrate.

3. Check the insulation resistance of motors in service periodically (at approximately the same temperature and humidity conditions) to determine possible deterioration of the insulation. When measurements at regular intervals indicate a wide variation, determine the cause.

4. Grease lubricated motors are properly lubricated at the time of manufacture and it is not necessary to lubricate at installation. If the motor has been in storage for a period of six months or greater, lubricate before starting. A type of grease recommended and tested by the motor manufacturer should be used whenever possible. To lubricate, remove the filler plug and grease with clean lubricant (1/2 to 1 cubic inch of grease is sufficient). For the relubrication period, follow the instruction plate on the motor.

5. Periodically clean the enclosure by blowing out accumulated dust.

6. Check the surrounding area for new sources of dust, oil or corrosive vapors not present at the time of installation. A general purpose enclosure may have been satisfactory when the control was installed but the proximity of new produc-

tion equipment or processes might make it necessary to change enclosures or to shield the existing one from oil spray or excessive dust.

7. Inspect the insulation on wires. The conductors must be clear of all moving parts.
8. Examine the contact. Cleaning is not required because the contact material is a special pre-oxidized silver cadmium oxide alloy. Replacement is required when the contact material is almost worn down to the backing. Parts kits, including a complete set of stationary and movable contacts and contact springs are available. Replace the silver and the contact spring on a given pole to assure proper contact mating for maximum life.
9. Check the magnet pole faces for oil deposits. If oil is present, carefully clean the pole faces with carbon tetrachloride. This prevents accumulation of dust and a potentially sticky magnet.

Changing Drier Cores

When it becomes necessary to replace the drier cores in the filter/drier, the following procedure is recommended. Refer to Figure 6-1.

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 receiver) to allow pump down of the liquid into the receiver.
2. After the icemaker operation is terminated by the low pressure safety switch, lock out the electrical, then 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 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 (flathead) 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 not remove the bolts until the cover is loose enough to ensure that all of 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 of 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

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

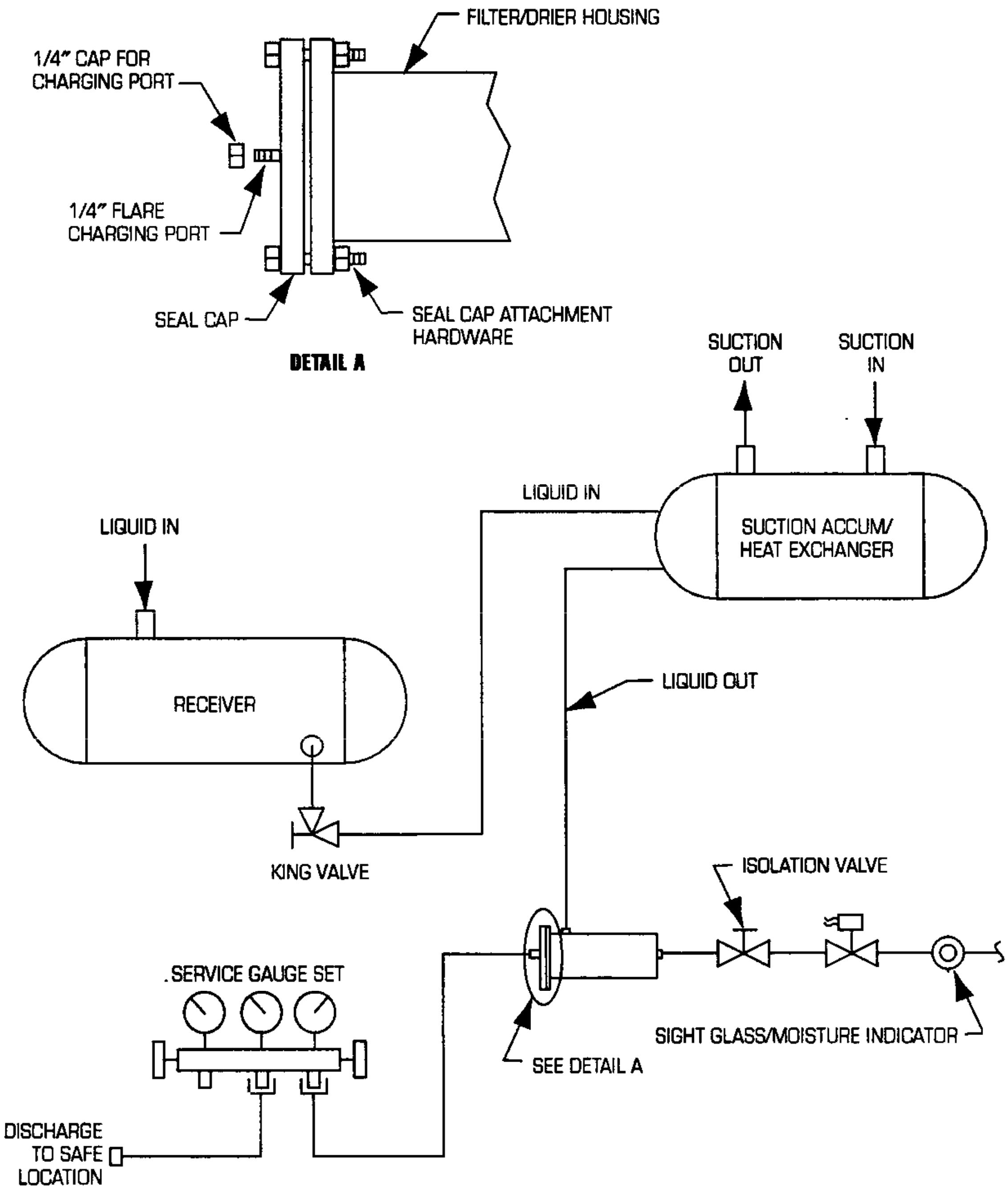

Figure 6-1 Typical Filter/Drier Installation

of 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/moisure indicator.

Water Distribution Pans

In order to ensure proper water distribution over the evaporator plates, the water distribution pans must be level as discussed in section 3. Installation & Pre-Start-Up Requirements. Equally important is the water level maintained in the water distribution pans. All systems have minimum water flow requirements that ensure this level is correct.

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

- 6.5 PSIG pressure is available at the recirculating water connections on the unit.
- Water level in the water distribution pan is a minimum 5/8″ above the bottom of pan. Refer to Figure 4-25. 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 cause variations in ice production.

Standard flow rates for each evaporator plate is 7.0 GPM/plate.

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

Table 6-1 Sample Daily Ice Plant Log Sheet

Date: ______________

	Ice Depth	Storage Vault Temp.	Icemaker Head Pressure	Icemaker Suction Pressure	Compressor Oil Pressure	Make-Up Water Temp	Make-Up Water Pressure	Ambient Temp.
First Shift Start								
First Shift End								
Second Shift Start								
Second Shift End								
Third Shift Start								
Third Shift Start								

Operators

First Shift ______________________________

Second Shift ______________________________

Third Shift ______________________________

Liquid Line Icemaker Sight Glass

First Shift			
Second Shift			
Third Shift			

Remarks

First Shift ______________________________

Second Shift ______________________________

Third Shift ______________________________

7

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.

Placing Orders

When ordering spare or replacement parts, use the serial number on the TURBO nameplate on the electrical control panel.

Part numbers may change without notice. When ordering or specifying parts, the serial number and model of the unit must be referenced.

Orders for parts should be placed by contacting:

Turbo Refrigerating, LLC
P.O. Box 396
Denton, Texas 76202-0396
Phone: 940-387-4301
Fax: 940-382-0364
E-mail: info@turboice.com
Internet: www.turboice.com

All orders should be accompanied by a purchase order.
Terms are net 30 days.
All shipments are FOB, Denton, Texas.

TURBO Equipment

The attached spare parts list cover replacement and spare parts for the following equipment:

- Evaporator
- Low Side
- High Side
- Electrical and Controls
- Miscellaneous
- Major Components

Parts Categories

Replacement Parts (RI)

Replacement parts indicates components that may or could be replaced due to normal wear or damage during the normal life of the equipment. In general, these parts are not considered critical to day-to-day equipment operation. Therefore, on-site stocking is not considered necessary. The customer may choose to stock some or all of these based on other factors unique to the operation of this installation.

Quantities indicated represent the number of components required to replace all of the items indicated per unit.

Stock Items (SI)

Stock items indicates components that are subject to normal replacement during periodic or annual maintenance or components critical to or required for normal day-to-day operation. Therefore, on-site stocking is recommended to prevent time delays in returning the equipment to operation when replacement is required.

Quantities indicated represent the number of components recommended by each supplier for replacement or rebuild of each component. The customer may choose to stock additional or less parts than specified based on other factors unique to the operation of this installation. All stock items should be replaced as the stock is depleted.

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

6 Ton Model Water System

Part Number	Quantity SI	RI	Description
DLINE-SW	1		Solenoid Valve
014-1600-01	1		Strainer
DLINE-PUMP		1	Pump
DLINE-WLR		1	Water Level Relay
012-5000-0701		1	Drain Solenoid

Electrical Control Panel 230/460/3/60 Power 115/1/60 Controls

Part Number	Quantity SI	RI	Description
DLINE-ELE01	1		Relay Coil
DLINE-ELE03	1		Starter Coil
027-0003-01		1	Cooling Fan - Control Panel
DLINE-ELE04		1	Relay
DLINE-ELE05		1	Starter Water Pump 230 Volt
DLINE-ELE06		1	Starter Water Pump 460 Volt
DLINE-ELE07		1	Compressor Contactor
022-0201-02		1	Overload Module (MP) - Compressor
DLINE-ELE08		1	Overload Relay - Water Pump
035-0501-43	1		Coil - Drain Solenoid (DS)
035-8500-75		1	Contactor - 70 Amp

Electrical Switches & Controls

Part Number	Quantity SI	RI	Description
035-0305-00	1		Contact Block N.O.
035-0305-01	1		Contact Block N.C.
DLINE-ELE09	1		Tape with Back-Up Program
DLINE-ELE10	1		Tape Player (for program loading/back-up)
080-0000-12		1	Programmable Logic Controller
080-0000-10		1	CPU
080-0000-24		1	Input Module
080-0000-25		1	Output Module
080-0000-11		1	Programmer (hand held)

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

Safety Switches

Part Number	Quantity SI	RI	Description
018-0000-11	1		High/Low Dual Pressure Switch
018-0000-12	1		Oil Failure
017-0709-01		1	Gauge (high pressure 30-400 PSIG)
017-0709-00		1	Gauge (low pressure 30-300 PSIG)
017-0709-03		1	Gauge (oil pressure 30-300 PSIG)

Refrigerant System

Part Number	Quantity SI	RI	Description
022-0900-05	1		Compressor Crankcase Heater
012-0602-03	1		Relief Valve
DLINERS01	1*		Air-Cooled Condenser Motor
DLINERS02	1		Air-Cooled Condenser Head Pressure Controls
014-0100-02		3	Drier Cores
035-0502-01	1		Solenoid Coil - LS, ISS, GSS, HG
013-0700-04	1		Thermal Expansion Valve - Icemaker (OVE10C)
013-0700-07	1		Thermal Expansion Valve - Gas Generator (OVE20C)
022-0000-23		1	Compressor
013-0001-36	1		Thermal Expansion Valve Power Head
013-0701-14		3	Thermal Expansion Valve Internal Parts Kit (OVE10C)
013-0701-20		1	Thermal Expansion Valve Internal Parts Kit (OVE20C)
012-0400-0502		3	Check Valve
012-4200-02		1	Hot Gas Solenoid Valve - HG
012-4200-14		1	Suction Solenoid - ISS
218-0000-01		3	Evaporative Plate
DLINE-GASPLT		1	Gas Generator Plate
012-4200-02		1	Gas Generator Suction Solenoid
012-4200-03		1	Liquid Solenoid Valve

* Quantity may vary due to variation in condenser selections for different ambient conditions.

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

Condenser Group (SC Model) 85/95/105°F SDT & (SCA/SCAR Models) 100/120°F SDT

Part Number	Quantity SI	Quantity RI	Description
021-0002-00		1	Water Regulating Valve (SC model)
DLINECON01		1	Condenser Gasket Set (SC model)
DLINECON02		1	Air-Cooled Condenser 100°F ambient, 120°F SDT
DLINECON03		1	Cooling Tower Fan (SC model)
DLINECON04		1	Cooling Tower Pump (SC model)
DLINECON05		1	Cooling Tower Thermostat (SC model)
DLINECON06		1	Fan Motor (SCA model)

Miscellaneous

Part Number	Quantity SI	Quantity RI	Description
057-0102-00	1 gallon		Refrigerant Oil
072-1200-00		1	Refrigerant (R-22) 30 lb. drum
022-0200-0001		1	Compressor Cooling Fan 230V
022-0200-0002		1	Compressor Cooling Fan 460V
018-0000-23		1	Defrost Pressure Switch

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

OPTIONAL FEATURES & ACCESSORIES

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.

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Johnson City, Tennessee 37605-1255

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3000 Bill Garland Road
Johnson City, Tennessee 37601

CONTENTS

FIGURES & TABLES

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.

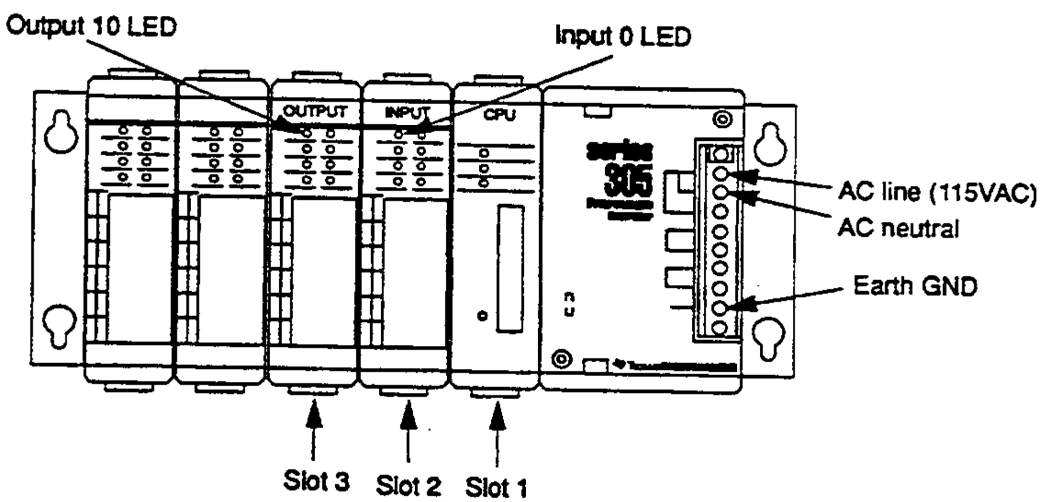

Figure 1-1 Model TI325/TI330 Controller

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.

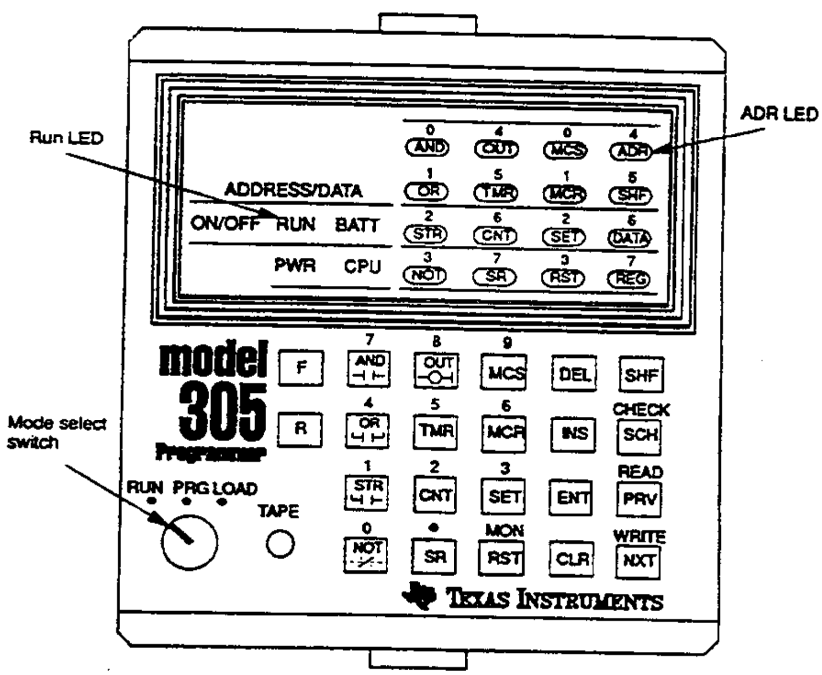

Figure 1-2 TI305 Programmer

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.

Model TI325/TI330 Major Component Identification Expansion

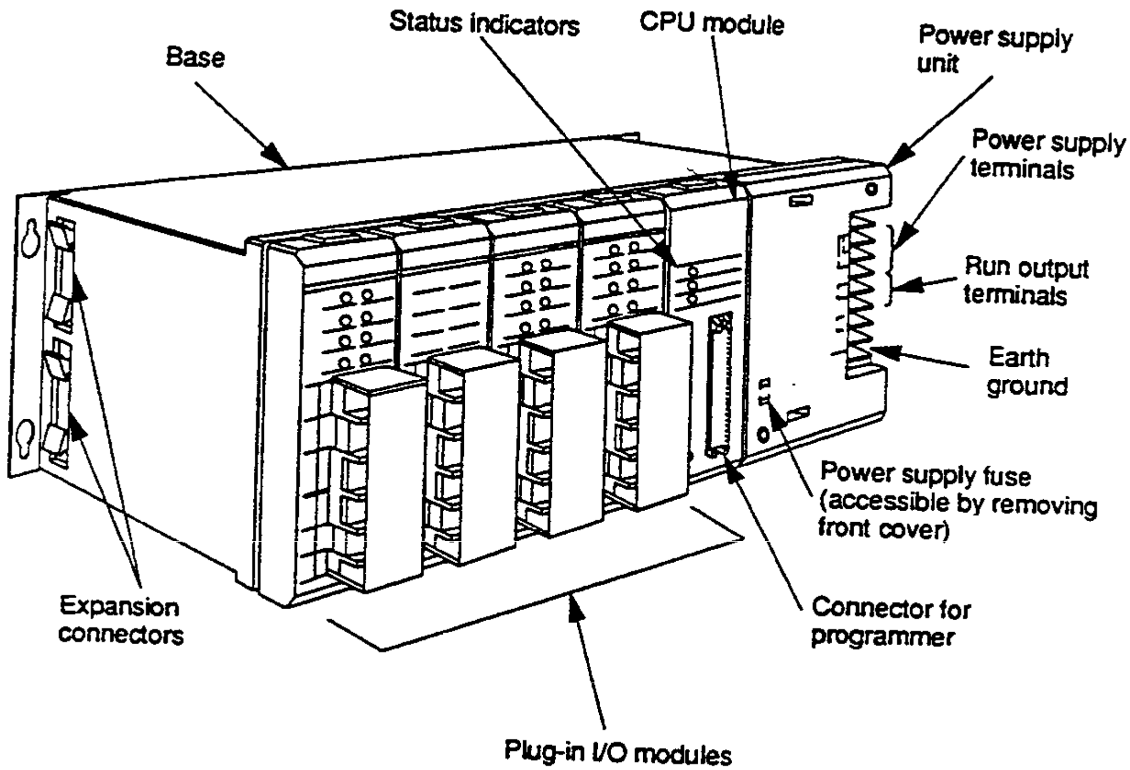

Figure 1-5 Series TI305 Controller Major Component Identification

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.

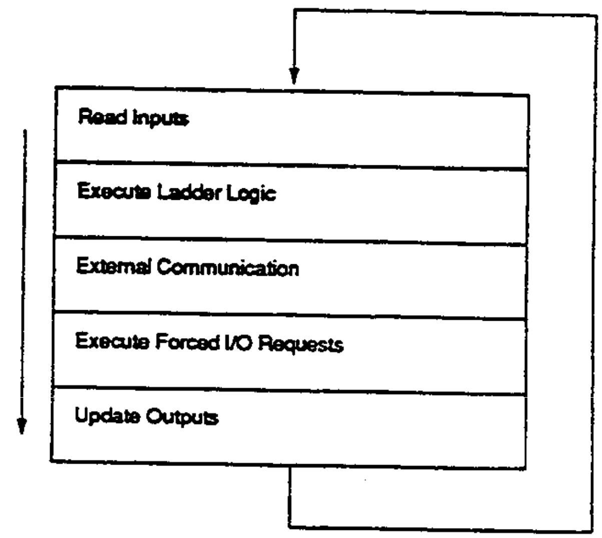

Figure 1-6 CPU Processing

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.

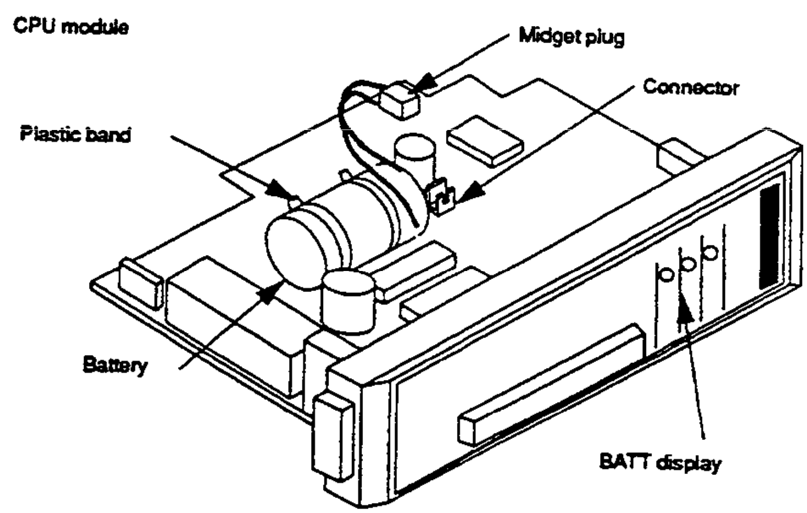

Figure 2-1 Replacing Battery in Model TI325/TI330 Controller

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.

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.

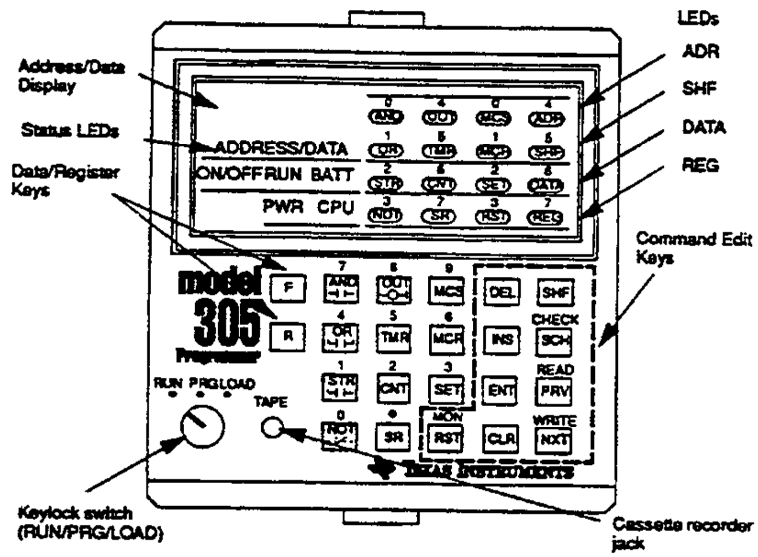

Figure 3-1 TI305 Programmer

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	Mode PRG	Mode 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	Mode PRG	Mode 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.

<u>Displaying Address 0</u>
Press SHF NXT at any time.

<u>Displaying A Specified Address</u>
To display, for example, the logic in address 123, press SHF 1 2 3 NXT. The selected address, **0.1.2.3.**, is displayed.

<u>Locating An Unused Address Or Grammar Check</u>
Press CLR SCH to locate the first available location (end statement).

<u>Changing From Address Display To Instruction Display</u>
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.

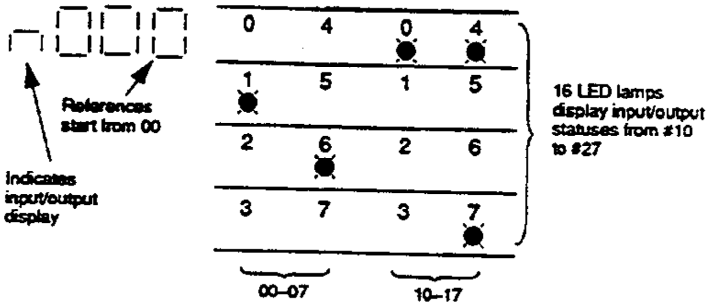

Figure 3-2 I/O Monitoring With LEDs

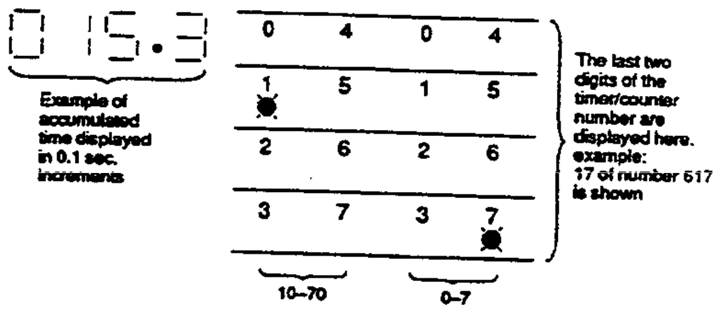

Figure 3-3 Timer/Counter Accumulated Value Display

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.

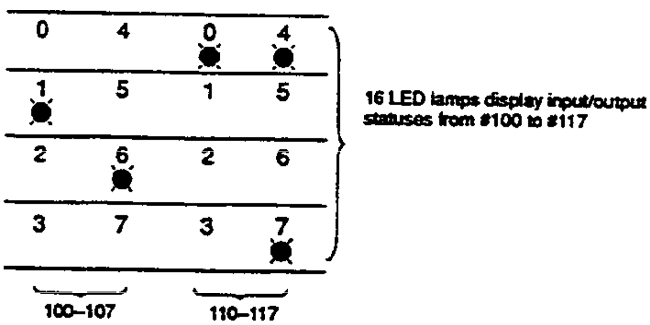

Figure 3-4 Example Of Monitoring I/O Reference Status

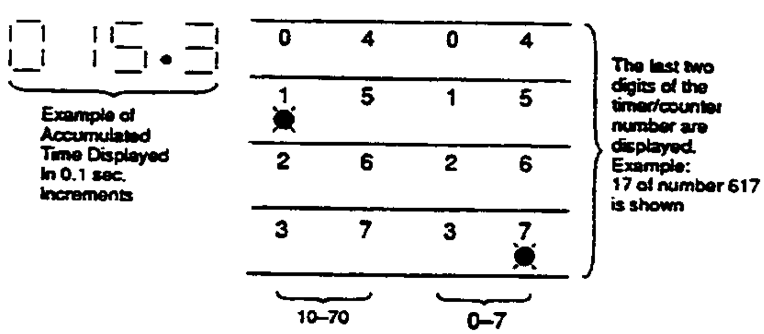

Figure 3-5 Example Of Monitoring T/C Accumulated Value

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.

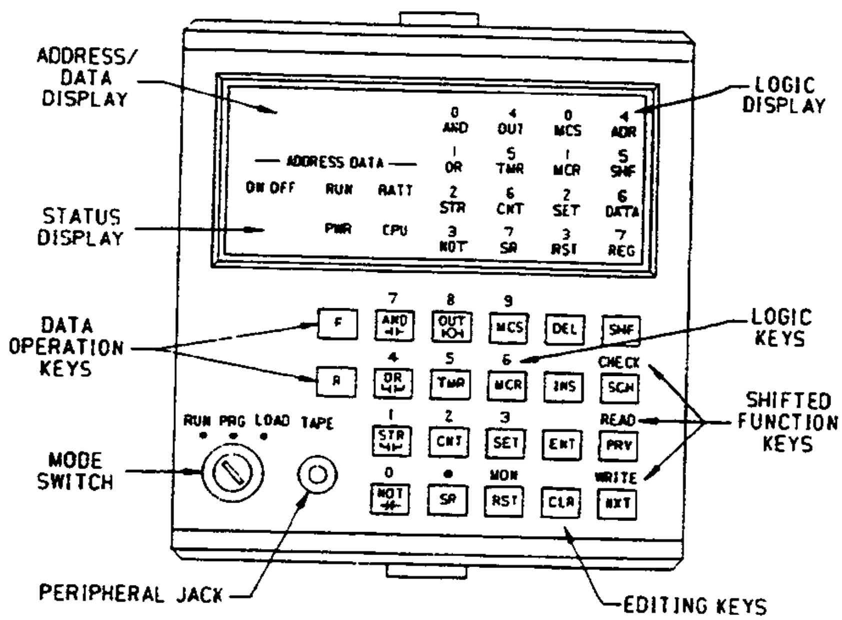

Figure 5-1 Programmer Features

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.

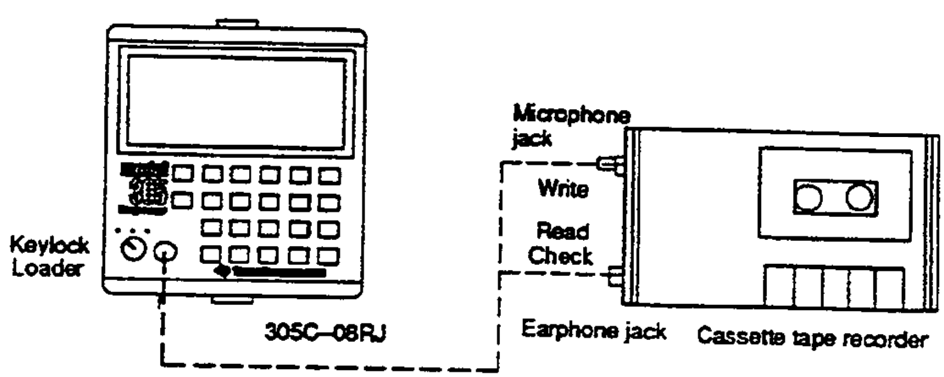

Figure 5-2 Writing From Controller To Tape

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	000-157 700-767	112 56	000-137	96
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

Switch	Memory Specifications: Standard Equipment RAM (701 words)	Memory Specifications: Expansion RAM (1.723 words)	Memory Specifications: EPROM (1.723 words)
Dipswitch 2	ON 2	ON 2	OFF 2
Jumper 1			
Jumper 2			

TI330

Switch	Memory Specifications: 3.7k RAM	Memory Specifications: 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.

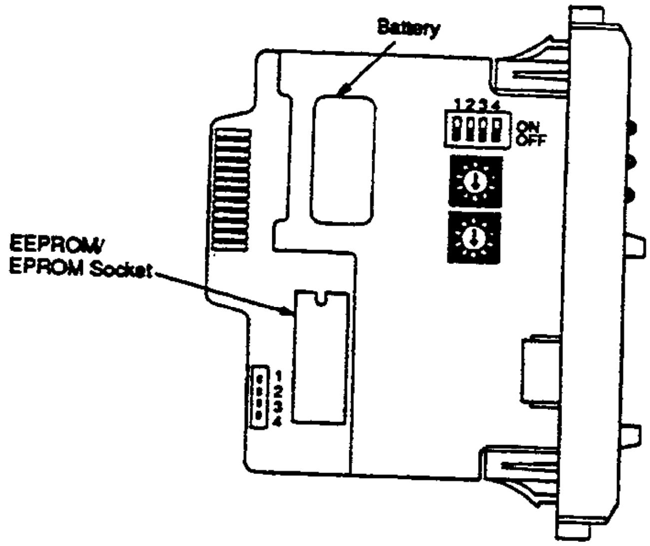

Figure 7-1 EPROM/EEPROM Socket Location

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

9

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

OPTIONAL APPENDIX

10

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

APPENDIX & NOTES