16DF013-050
Hermetic Absorption Liquid Chillers/Heaters

Start-Up, Operation, and Maintenance Instructions

SAFETY CONSIDERATIONS

Absorption liquid chillers/heaters provide safe and reliable service when operated within design specifications. When operating this equipment, use good judgment and safety precautions to avoid damage to equipment and property or injury to personnel.

Be sure you understand and follow the procedures and safety precautions contained in the machine instructions as well as those listed in this guide.

⚠ DANGER

DO NOT USE OXYGEN or air to purge lines, leak test, or pressurize a machine. Use nitrogen.

NEVER EXCEED specified test pressures. For the 16DF machine, the maximum pressure is 12 psig (83 kPa). For the chilled/hot water and condensing water piping, the maximum pressure is stamped on the machine.

WEAR goggles and suitable protective clothing when handling lithium bromide, octyl alcohol, inhibitor, lithium hydroxide, and hydrobromic acid. IMMEDIATELY wash any spills from the skin with soap and water. IMMEDIATELY FLUSH EYES with water and consult a physician.

⚠ WARNING

DO NOT USE eyebolts or eyebolt holes to rig machine sections or the entire assembly.

DO NOT work on high-voltage equipment unless you are a qualified electrician.

DO NOT WORK ON electrical components, including control panels or switches, until you are sure ALL POWER IS OFF and no residual voltage can leak from capacitors or solid-state components.

LOCK OPEN AND TAG electrical circuits during servicing. IF WORK IS INTERRUPTED, confirm that all circuits are deenergized before resuming work.

NEVER DISCONNECT safety devices or bypass electric interlocks and operate the machine. Also, never operate the machine when any safety devices are not adjusted and functioning normally.

DO NOT REPEAT unsuccessful ignition attempts or restart after flame failure without assurance that post-purge and prepurge have eliminated combustible gas or all vapors from the combustion chamber. DO NOT EVER ATTEMPT IGNITION of a burner if there is shutdown leakage of gas or oil through the fuel shutoff valves or from the fuel lines.

DO NOT syphon lithium bromide or any other chemical by mouth.

BE SURE all hydrogen has been exhausted before cutting into purge chambers. Hydrogen mixed with air can explode when ignited.

WHEN FLAMECUTTING OR WELDING on an absorption machine, some noxious fumes may be produced. Ventilate the area thoroughly to avoid breathing concentrated fumes.

DO NOT perform any welding or flamecutting to a machine while it is under a vacuum or pressurized condition.

NEVER APPLY an open flame or live steam to a refrigerant cylinder. Dangerous overpressure can result. When necessary to heat a cylinder, use only warm (110 F [43 C]) water.

DO NOT REUSE disposable (nonreturnable) cylinders or attempt to refill them. It is DANGEROUS AND ILLEGAL. When cylinder is emptied, bleed off remaining gas pressure, loosen the collar and unscrew and discard the valve stem. DO NOT INCINERATE.

DO NOT ATTEMPT TO REMOVE fittings, covers, etc., while machine is under pressure or while machine is running, and DO NOT OPERATE or pressurize a machine without all cover plates or bolts in place.

⚠ CAUTION

→ CONNECT THE ABSORPTION CHILLER to an emergency power source to ensure that a constant power supply is maintained to the unit in the event that the main electrical power source is interrupted or temporarily lost. Failure to provide an emergency power source to the chiller could result in crystallization of the lithium bromide solution inside the machine, rendering it temporarily inoperative. A potentially lengthy decrystallization process might be required to return the chiller to normal operation depending on the severity of the crystallization and/or the length of time the machine was without power.

→ PROVIDE AN EMERGENCY POWER SOURCE to the chilled water and condenser water pumps to prevent the possibility of an evaporator freeze-up. Failure to provide emergency power to these pumps could result in machine operation with no flow of water through the tubeside of the evaporator, absorber and condenser sections thereby allowing the water inside the evaporator tubes to freeze. Further, a frozen evaporator tube can burst causing contamination of the lithium bromide solution and the inside of the chiller. A freeze-up in the evaporator will also result in a long period of chiller down time due to the extensive repairs required to bring the chiller and the lithium bromide solution back to its original condition.

DO NOT climb over a machine. Use platform, catwalk, or staging. Follow safe practices when using ladders.

DO NOT STEP ON machine piping. It might break or bend and cause personal injury.

USE MECHANICAL EQUIPMENT (crane, hoist, etc.) to lift or move inspection covers or other heavy components. Even if components are light, use such equipment when there is a risk of slipping or losing your balance.

VALVE OFF AND TAG steam, water, or brine lines before opening them.

DO NOT LOOSEN water box cover bolts until the water box has been completely drained.

DO NOT VENT OR DRAIN water boxes containing industrial brines, liquid, gases, or semisolids without permission of your process control group.

BE AWARE that certain automatic start arrangements can engage starters. Open the disconnects ahead of the starters in addition to shutting off the machine or pump.

INVESTIGATE THE CAUSE of flame failure or any other safety shutdown before attempting a restart.

KEEP EYES sufficiently away from sight tubes or burner openings, and wear a protective shield or safety glasses when viewing a burner flame.

USE only replacement parts that meet the code requirements of the original equipment.

DO NOT ALLOW UNAUTHORIZED PERSONS to tamper with burner equipment or machine safeties, or to make major repairs.

PERIODICALLY INSPECT all valves, fittings, piping, and relief devices for corrosion, rust, leaks, or damage.

PROVIDE A DRAIN connection in the vent line near each pressure relief device to prevent a build-up of condensate or rain water.

IMMEDIATELY wipe or flush the floor if lithium bromide or octyl alcohol is spilled on it.

BE SURE combustion air inlets to the equipment room are open and clear of any blockage.

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INTRODUCTION

Everyone involved in the start-up, operation, and maintenance of the 16DF machine should be thoroughly familiar with these instructions, the separate burner instructions, and other necessary job data before initial start-up, and before operating the machine or performing machine maintenance. Procedures are arranged in the sequence required for proper machine start-up and operation.

NOTE: In this manual, temperatures are shown in °C first, with °F given in parentheses ( ), when a temperature display is in °C or a control set point scale is in °C values.

MACHINE DESCRIPTION

Basic Absorption Cooling Cycle — The 16DF absorption chiller uses water as the refrigerant in vessels maintained under a deep vacuum. The chiller operates on the simple principle that under low absolute pressure (vacuum), water takes up heat and vaporizes (boils) at a low temperature. For example, at the very deep vacuum of 0.25 in. (6.4 mm) of mercury absolute pressure, water boils at the relatively cool temperature of only 40 F (4 C). To obtain the energy required for this boiling, it takes heat from, and therefore chills, another fluid (usually water). The chilled fluid then can be used for cooling purposes.

To make the cooling process continuous, the refrigerant vapor must be removed as it is produced. For this, a solution of lithium bromide salt in water is used to absorb the water vapor. Lithium bromide has a high affinity for water, and will absorb it in large quantities under the right conditions. The removal of the refrigerant vapor by absorption keeps the machine pressure low enough for the cooling vaporization to continue. However, this process dilutes the solution and reduces its absorption capacity. Therefore, the diluted lithium bromide solution is pumped to separate vessels where it is heated to release (boil off) the previously absorbed water. Relatively cool condensing water from a cooling tower or other source removes enough heat from this vapor to condense it again into liquid for reuse in the cooling cycle. The reconcentrated lithium bromide solution is returned to the original vessel to continue the absorption process.

Double Effect Reconcentration — With this chiller, reconcentration of the solution is done in 2 stages to improve the operating efficiency. Approximately half of the diluted solution is pumped to a high-temperature vessel (high stage) where it is heated for reconcentration directly from the combustion of gas or light oil. The rest of the solution is pumped to a low-temperature vessel (low stage) where it is heated by the hot water vapor generated in the high-temperature vessel. The low stage acts as the condenser for the high stage, so the heat energy first applied in the high-stage vessel is used again in the low-stage vessel. This cuts the heat input to almost half of that required for an absorption chiller with a single-stage reconcentrator.

Basic Heating Cycle — The heating cycle uses a different vapor flow path than that used for cooling, and does not use the absorption process. The high-temperature water vapor produced in the direct fired high-stage vessel is passed directly to the heating tubes where it condenses and transfers its heat into the circulating hot water. The condensed water then flows by gravity to mix with the concentrated solution which had returned from the high-stage vessel. This diluted solution then is pumped back to the high-stage vessel to repeat the vapor generation for the heating function.

Machine Construction — The major sections of the machine are contained in several vessels (Fig. 1- 4, Table 1).

The large lower shell contains the evaporator section in its upper part and the absorber section at the bottom. In the evaporator, the refrigerant water vaporizes in the cooling cycle and cools the chilled water for the air conditioning or cooling process. In the heating cycle, hot water vapor flows into the evaporator section where it condenses and heats the hot water for the heating process. The heat transfer tube bundle in the evaporator is used for both cooling and heating. In the absorber, vaporized refrigerant water is absorbed by lithium bromide solution in the cooling cycle. In the heating cycle, condensed refrigerant water from the evaporator drains into the absorber where it is mixed with the strong solution.

The short vessel with the burner, located next to the evaporator/absorber assembly, is the high-stage generator. The vessel above it is the separator. In both the cooling and heating cycles, approximately half of the diluted lithium bromide solution is heated directly from the combustion of gas or oil. The water vapor created in this process is released from the reconcentrated solution in the separator vessel.

The smaller shell above the evaporator/absorber assembly contains the low-stage generator and condenser. In the cooling cycle, about half of the diluted lithium bromide solution is heated and reconcentrated in the low-stage generator by high-temperature vapor from the high-stage generator. The water vapor released from the solution in this process is condensed to liquid in the condenser section. This vessel is not used in the heating cycle, although about half of the diluted solution does flow through the generator.

This chiller also has: 2 solution heat exchangers to improve operating economy; an external purge system to maintain machine vacuum by the continuous removal of noncondensables; 2 hermetic pumps to circulate the solution and refrigerant; various operation, capacity, and safety devices to provide automatic, reliable machine performance; and the ability to manually switch between cooling and heating operation.

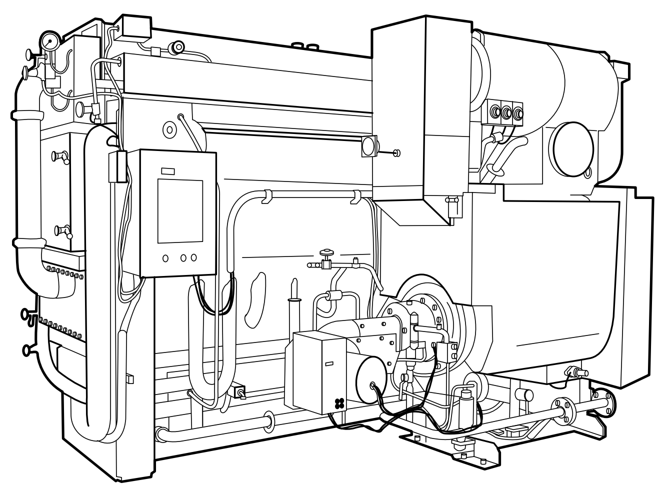


Fig. 1 — 16DF Machine, Front View

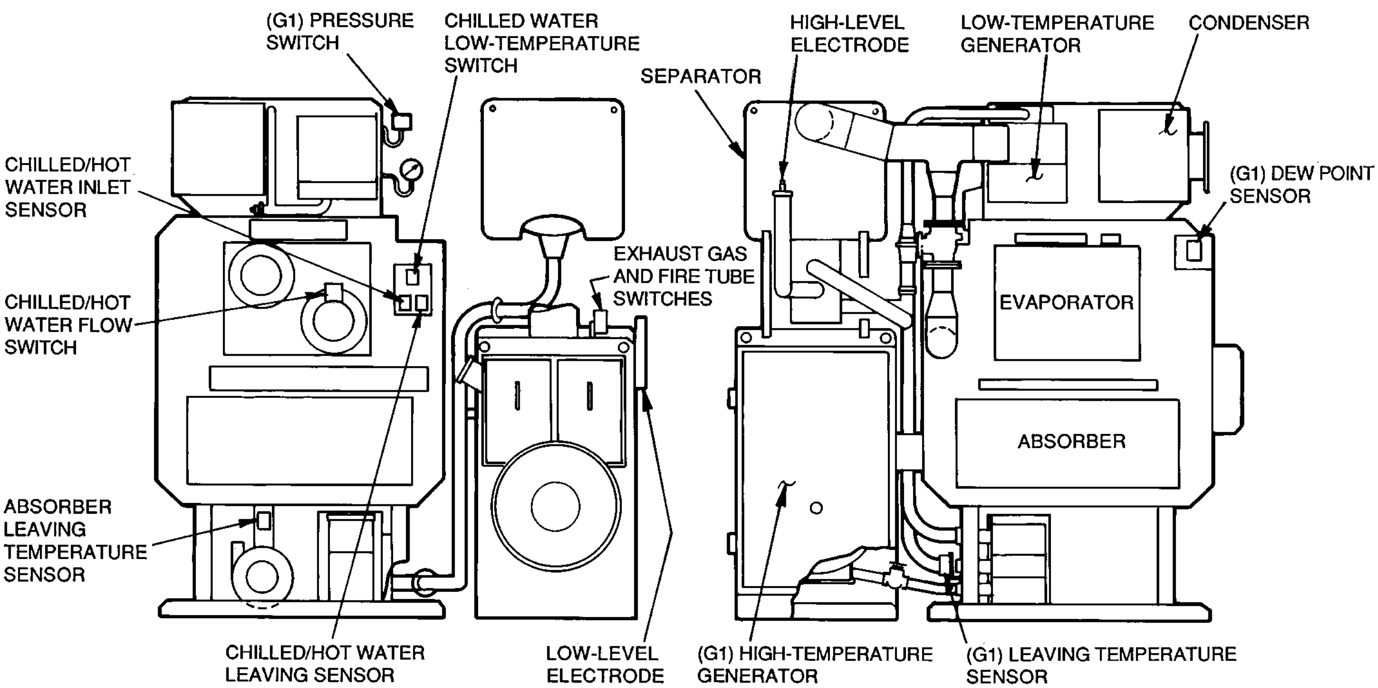


Fig. 2 — Machine Controls and Components, Schematic

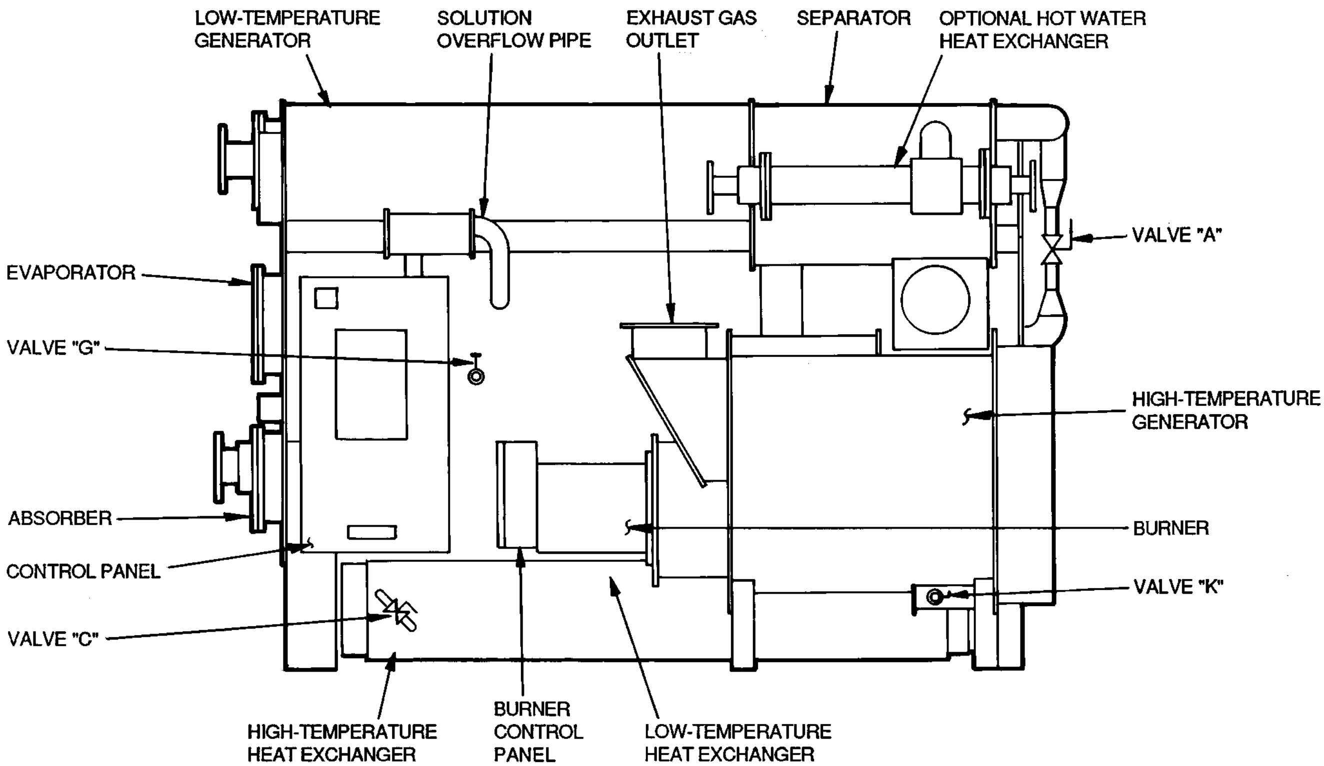


Fig. 3 — Valve and Component Locations, Front View

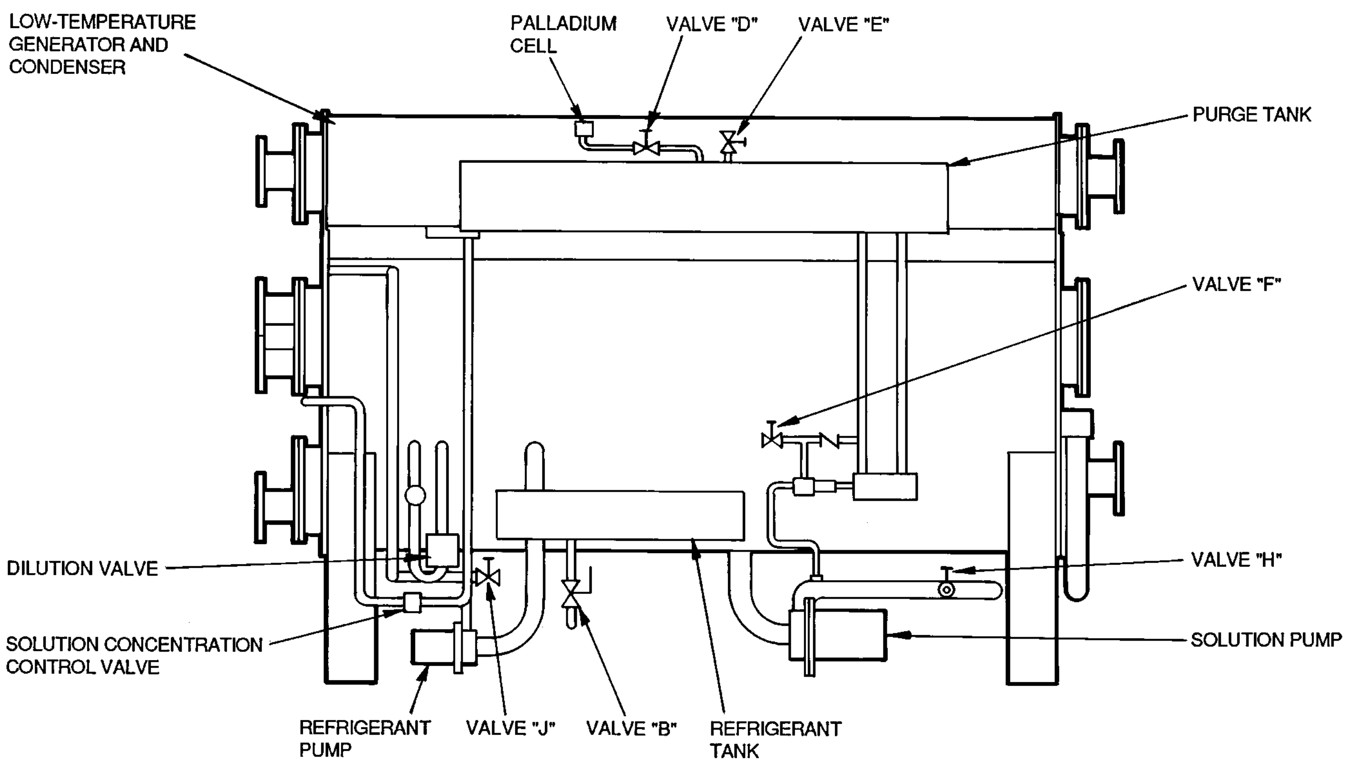


Fig. 4 — Valve and Component Locations, Rear View

Table 1 — Valve Descriptions

VALVE	USE
A	Heating/Cooling Vapor
B	Heating/Cooling Liquid
C	Heat Exchanger Service
D	Palladium Cell Isolation
E	Purge Storage Tank Evacuation
F	Auxiliary Evacuation
G	Vacuum/Pressure Gage
H	Solution Pump Service
J	Refrigerant Pump Service
K	High-Stage Generator Service

Cooling Cycle Flow Circuits — Figure 5 illustrates the basic flow circuits of the 16DF absorption chiller during the cooling cycle.

The liquid to be chilled is passed through the evaporator tube bundle and is cooled by the evaporation of refrigerant water sprayed over the outer surface of the tubes by the recirculating refrigerant pump. The refrigerant vapors are drawn into the absorber section and are absorbed by the lithium bromide-water solution sprayed over the absorber tubes. The heat picked up from the chilled liquid is transferred from the absorbed vapor to cooling water flowing through the absorber tubes.

The solution in the absorber becomes diluted as it absorbs water, and loses its ability to continue the absorption. It is then transferred by the solution pump to the generator sections to be reconcentrated. Approximately half of the weak (diluted) solution goes to the high-stage generator where it is heated directly by the combustion of gas or oil to boil out the absorbed water. The mixture of reconcentrated solution and vapor rises to the separator, where the vapor is released and is then passed to the low-stage generator tubes. In the low-stage generator, the rest of the weak solution is heated by the high-temperature vapor from the high-stage separator, to boil out the remaining absorbed water.

The resulting water vapor from the low-stage generator solution passes into the condenser section and condenses on tubes containing cooling water. This is the same cooling water which had just flowed through the absorber tubes. The condensed high-temperature water from the low-stage generator tubes is also passed over the condenser tubes where it is cooled to the condenser temperature. The combined condensed refrigerant liquid, from the 2 generators, now flows back to the evaporator to begin a new refrigerant cycle.

The strong (reconcentrated) solution flows from the 2 generators back to the absorber spray headers to begin a new solution cycle. On the way, it passes through solution heat exchangers where heat is transferred from the hot, strong solution to the cooler, weak solution being pumped to the generators. Solution to and from the high-stage generator passes through both a high-temperature heat exchanger and a low-temperature heat exchanger. Solution to and from the low-stage generator passes through only the low-temperature heat exchanger, mixed with the high-stage generator solution. This heat transfer improves solution cycle efficiency by preheating the relatively cool, weak solution before it enters the generators, and precooling the hotter, strong solution before it enters the absorber.

During high-load cooling operation, some abnormal conditions can cause the lithium bromide concentration to increase above normal. When this happens, a small amount of refrigerant is transferred by an evaporator overflow pipe into the absorber solution to limit the concentration. This is necessary to keep the strong solution concentration away from crystallization (see Solution Cycle and Equilibrium Diagram section, page 9).

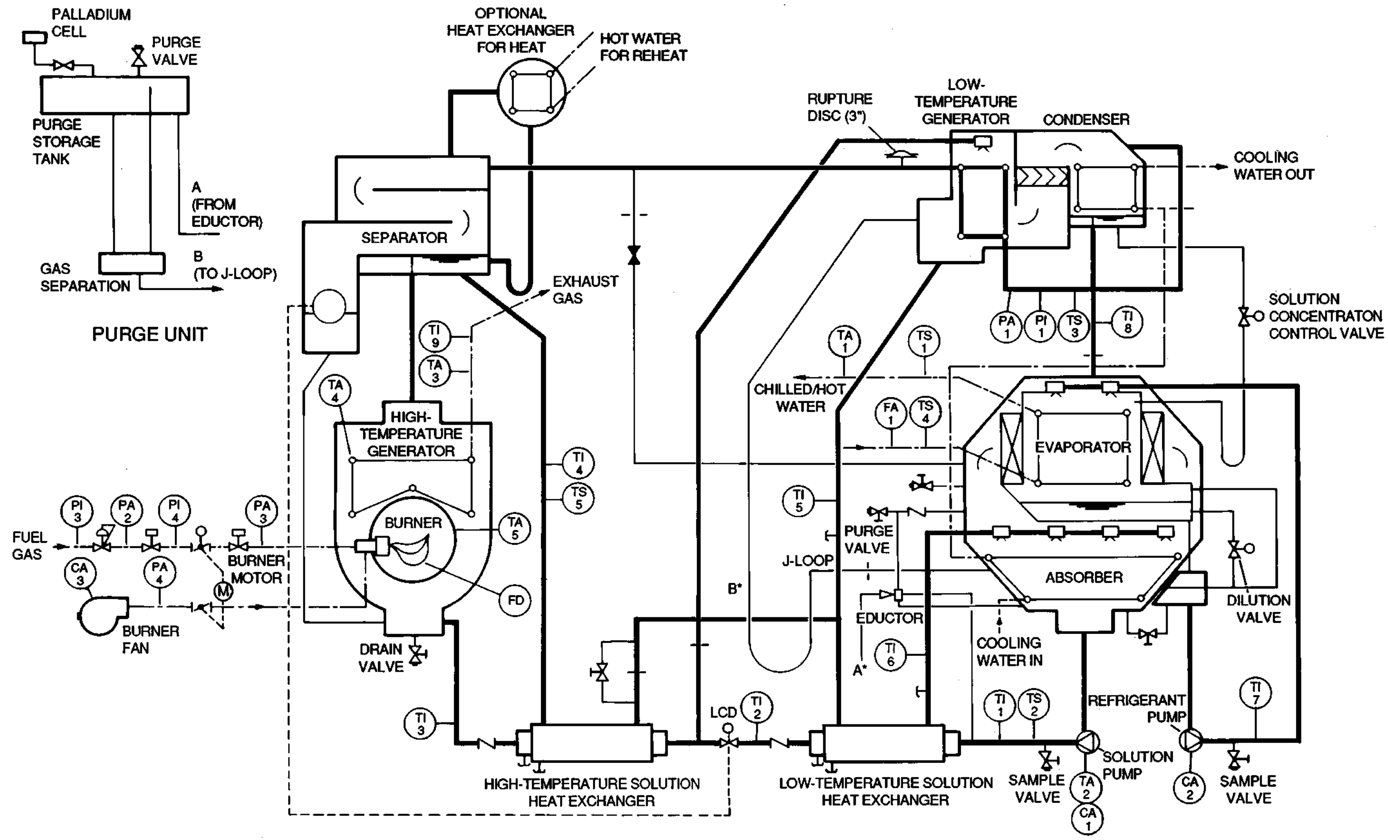
The evaporator refrigerant level is directly related to machine solution concentration. As the concentration increases (has less water), so does the refrigerant level. As the solution concentration increases beyond a safe limit, the refrigerant level rises to the level of the overflow pipe and some spills over to flow into the absorber. The concentration at which the refrigerant overflows is determined by the amount of refrigerant (water) which is charged into the machine.

If, for some reason, the machine controls and evaporator overflow do not prevent strong solution crystallization during abnormal operating conditions, and flow blockage occurs, the strong solution overflow pipe will reverse or limit the crystallization until the cause can be corrected. The overflow pipe is located between the low-temperature generator discharge box and the absorber, bypassing the heat exchangers.

If crystallization occurs, it generally takes place in the shell side of the low-temperature heat exchanger, blocking the flow of strong solution from the generators. The strong solution then backs up in the discharge box and spills over into the overflow pipe, which returns it directly to the absorber sump. The solution pump then returns this hot solution through the heat exchanger tubes, automatically heating and decrystallizing the shell side.

Heating Cycle Flow Circuits — Figure 6 illustrates the basic flow circuits of the 16DF absorption chiller during the heating cycle.

The liquid to be heated is passed through the evaporator tube bundle and is heated by condensation of hot water vapor from the high-stage generator. The solution flowing from the absorber, through the heat exchangers to the generators via the solution pump, and then back through the heat exchangers to the absorber sprays is basically the same as in the cooling cycle. However, the solution is heated and reconcentrated only in the high-stage generator. The heating refrigerant water cycle is quite different from that of the cooling cycle. The cooling water flow is turned off, as is the refrigerant recirculating pump. The high-temperature water vapor from the high-stage generator is diverted to the evaporator, and the condensed vapor in the evaporator is drained directly to the absorber solution.



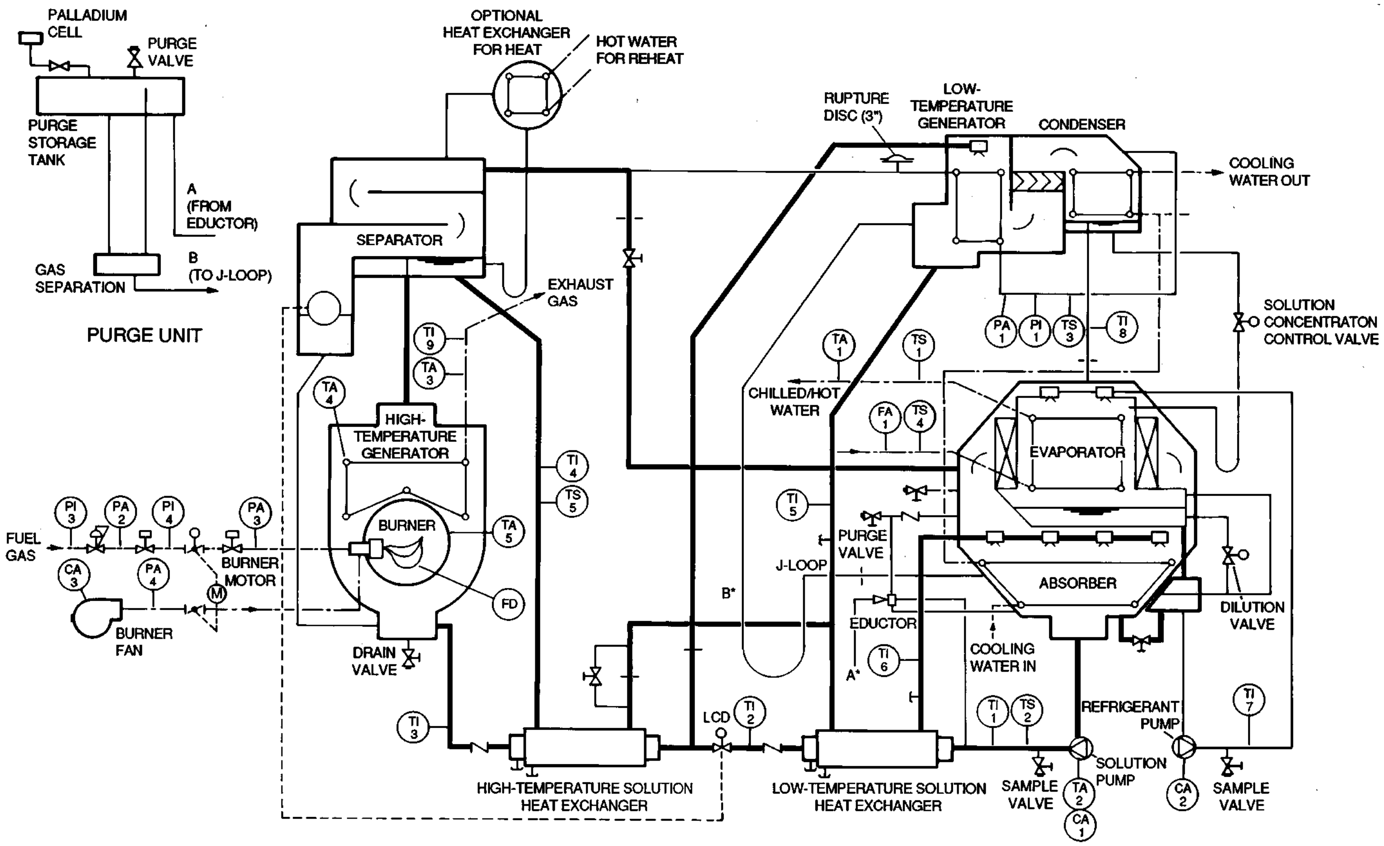
LEGEND

A,B — Connecting Piping from Purge Unit Diagram to Machine Cycle Diagram
CA1 — Solution Pump Motor Overload
CA2 — Refrigerant Pump Motor Overload
CA3 — Burner Blower Motor Overload
FA1 — Chilled/Hot Water Flow Switch
FD — Burner Flame Detector
LCD — Level Control Device
M — Burner Firing Rate Positioning Motor
PA1 — High-Temperature Generator High-Pressure Switch
PA2 — Low Gas Pressure Switch
PA3 — High Gas Pressure Switch
PA4 — Low Combustion Air Pressure Switch
PI1 — High-Temperature Generator Pressure Gage
PI3 — Supply Gas Pressure Gage
PI4 — Regulated Gas Pressure Gage
TA1 — Chilled/Hot Water Temperature Limit
TA2 — Solution Pump Motor High-Temperature Limit
TA3 — Exhaust Gas High-Temperature Limit
TA4 — Fire Tube High-Temperature Limit
TA5 — Return End Refractory High-Temperature Limit
TI1-3 — Weak Solution Temperature Measurement Wells
TI4-6 — Strong Solution Temperature Measurement Wells
TI7 — Refrigerant Temperature Measurement Well
TI8 — Refrigerant Condensate Temperature Measurement Well
TI9 — Exhaust Gas Temperature Measurement Gage
TS1 — Leaving Chilled/Hot Water Temperature Sensor
TS2 — Weak Solution Temperature Sensor
TS3 — High-Temperature Generator Vapor Temperature Sensor
TS4 — Entering Chilled/Hot Water Temperature Sensor
TS5 — High-Temperature Generator Strong Solution Temperature Sensor

*See Purge Unit insert.

NOTE: Service valve connections are ½-in. NPT.

Fig. 5 — Cooling Cycle with Data Points



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TS5 — High-Temperature Generator Strong Solution Temperature Sensor

*See Purge Unit insert.

NOTE: Service valve connections are ½-in. NPT.

Fig. 6 — Heating Cycle with Data Points

Solution Cycle and Equilibrium Diagram — The solution cycles for cooling and heating operation can be illustrated by plotting them on a basic equilibrium diagram for lithium bromide in solution with water (Fig. 7 and 8). The diagram is also used for performance analyses and troubleshooting.

The left scale on the diagram indicates solution and water vapor pressures at equilibrium conditions. The right scale indicates the corresponding saturation (boiling or condensing) temperatures of the refrigerant (water).

The bottom scale represents solution concentration, expressed as percentage of lithium bromide by weight in solution with water. For example, a lithium bromide concentration of 60% means 60% lithium bromide and 40% water by weight.

The curved lines running diagonally left to right are solution temperature lines (not to be confused with the horizontal saturation temperature lines). The single curved line beginning at the lower right represents the crystallization line. The solution becomes saturated at any combination of temperature and concentration to the right of this line, and it will begin to crystallize (solidify) and restrict flow.

The slightly sloped lines extending from the bottom of the diagram are solution-specific gravity lines. The concentration of a lithium bromide solution sample can be determined by measuring its specific gravity with a hydrometer and reading its solution temperature. Then, plot the intersection point for these 2 values and read straight down to the percent lithium bromide scale. The corresponding vapor pressure can also be determined by reading the scale straight to the left of the point, and its saturation temperature can be read on the scale to the right.

PLOTTING THE COOLING SOLUTION CYCLE — An absorption solution cycle at typical full load conditions is plotted in Fig. 7 from Points 1 through 12. The corresponding values for these typical points are listed in Table 2. Note that these values will vary with different loads and operating conditions.

Point 1 represents the strong solution in the absorber, as it begins to absorb water vapor after being sprayed from the absorber nozzles. This condition is internal and cannot be measured.

Point 2 represents the diluted (weak) solution after it leaves the absorber and before it enters the low-temperature heat exchanger. This includes its flow through the solution pump. This point can be measured with a solution sample from the pump discharge.

Point 3 represents the weak solution leaving the low-temperature heat exchanger. It is at the same concentration as Point 2 but at a higher temperature after gaining heat from the strong solution. This temperature can be measured. At this point, the weak solution is split, with approximately half of it going to the low-stage generator, and the rest of it going on to the high-temperature heat exchanger.

Point 4 represents the weak solution in the low-stage generator after being preheated to the boiling temperature. The solution will boil at temperatures and concentrations corresponding to a saturation temperature established by the vapor condensing temperature in the condenser. This condition is internal and cannot be measured.

Point 5 represents the weak solution leaving the high-temperature heat exchanger and entering the high-stage generator. It is at the same concentration as Points 2 and 3, but at a higher temperature after gaining heat from the strong solution. This temperature can be measured.

Point 6 represents the weak solution in the high-stage generator after being preheated to the boiling temperature. The solution will boil at temperatures and concentrations corresponding to a saturation temperature established by the vapor condensing temperature in the low-stage generator tubes. This condition is internal and cannot be measured.

Point 7 represents the strong solution leaving the high-stage generator and entering the high-temperature heat exchanger after being reconcentrated by boiling out refrigerant. It can be plotted approximately by measuring the temperatures of the leaving strong solution and the condensed vapor leaving the low-stage generator tubes (saturation temperature). This condition cannot be measured accurately.

Point 8 represents the strong solution from the high-temperature heat exchanger as it flows between the 2 heat exchangers. It is the same concentration as Point 7, but at a cooler temperature after giving up heat to the weak solution. It is an internal condition and cannot be measured.

Point 9 represents the strong solution leaving the low-stage generator and entering the low-temperature heat exchanger. It is at a weaker concentration than the solution from the high-stage generator, and can be plotted approximately by measuring the temperatures of the leaving strong solution and vapor condensate (saturation temperature). This condition cannot be measured accurately.

Point 10 represents the mixture of strong solution from the high-temperature heat exchanger and strong solution from the low-stage generator after they both enter the low-temperature heat exchanger. It is an internal condition and cannot be measured.

Point 11 represents the combined strong solution before it leaves the low-temperature heat exchanger after giving up heat to the weak solution. This condition is internal and cannot be measured.

Point 12 represents the strong solution leaving the low-temperature heat exchanger and entering the absorber spray nozzles, after being mixed with some weak solution in the heat exchanger. The temperature can be measured but the concentration cannot be sampled. After leaving the spray nozzles, the solution is somewhat cooled and concentrated as it flashes to the lower pressure of the absorber.

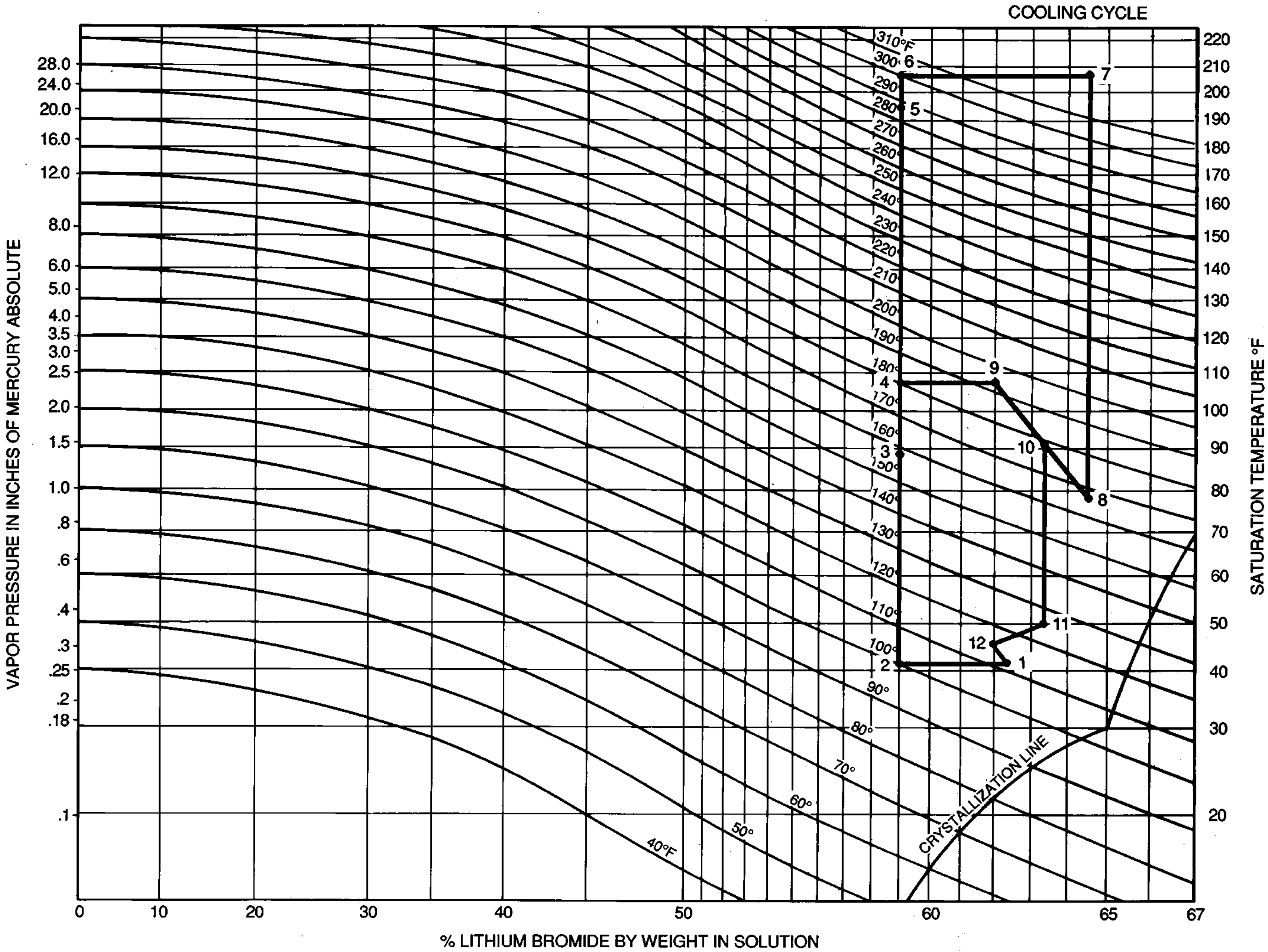


Fig. 7 — Equilibrium Diagram, Cooling Cycle

Table 2 — Typical Full Load Cooling Cycle Equilibrium Data

POINT	SOLUTION TEMPERATURE °F	SOLUTION TEMPERATURE °C	VAPOR PRESSURE in. Hg	VAPOR PRESSURE mm Hg	SOLUTION PERCENTAGE LITHIUM BROMIDE	SATURATION TEMPERATURE °F	SATURATION TEMPERATURE °C
1	111	44	0.26	6.6	62.2	41	5
2	100	38	0.26	6.6	59.0	41	5
3	158	70	1.20	30.0	59.0	84	29
4	181	83	2.20	56.0	59.0	104	40
5	289	143	23.00	584.0	59.0	198	92
6	300	149	27.00	686.0	59.0	208	98
7	332	167	27.00	686.0	64.5	208	98
8	167	75	0.80	20.3	64.5	72	22
9	194	90	2.20	56.0	62.0	104	40
10	178	81	1.30	33.0	63.4	86	30
11	126	52	0.39	9.9	63.4	51	11
12	117	47	0.30	7.6	62.0	45	7

PLOTTING THE HEATING SOLUTION CYCLE — A heating solution cycle at typical full load conditions is plotted in Fig. 8 from Points 1 through 11. The corresponding values for these typical points are listed in Table 3. The heating cycle operates with lower (more dilute) solution concentrations than used with the cooling cycle because most of the refrigerant water is drained from the evaporator into the solution. Note that these values will vary with different loads and operating conditions.

Point 1 represents the strong solution in the absorber after being sprayed from the absorber nozzles, before it begins to mix with condensed water vapor draining from the evaporator. The temperature of the solution to the spray nozzles can be measured, but the concentration cannot be sampled.

Point 2 represents the diluted (weak) solution, with the condensed water, leaving the absorber and entering the low-temperature heat exchanger. This point can be measured with a solution sample from the pump discharge.

Point 3 represents the weak solution as it leaves the low-temperature heat exchanger. It is at the same concentration as Point 2 but at a slightly warmer temperature after gaining some heat from the strong solution. This temperature can be measured. At this point, the weak solution is split, with approximately half of it going to the low-stage generator, and the rest of it going to the high-temperature heat exchanger. Although the solution sent to the low-stage generator is not used in the heating function, the solution distribution and flow rates are maintained approximately the same as in the cooling cycle to minimize piping and control differences.

Point 4 represents the weak solution as it leaves the high-temperature heat exchanger and enters the high-stage generator. It is at the same concentration as Points 2 and 3, but at a higher temperature after gaining heat from the strong solution. This temperature can be measured.

Point 5 represents the weak solution in the high-stage generator after being preheated to the boiling temperature. The solution will boil at temperatures and concentrations corresponding to a saturated temperature established by the vapor condensing temperature in the evaporator. This condition is internal and cannot be measured.

Point 6 represents the strong solution leaving the high-stage generator and entering the high-temperature heat exchanger after being reconcentrated by boiling out refrigerant water. The heat energy in the vapor produced in this process is used directly for heating the circulating hot water in the evaporator. The leaving strong solution temperature can be measured but the saturation temperature cannot be measured accurately to plot the point.

Point 7 represents the strong solution from the high-temperature heat exchanger as it flows between the two heat exchangers. It is the same concentration as Point 6, but at a cooler temperature after giving up heat to the weak solution. It is an internal condition and cannot be measured.

Point 8 represents the weak solution leaving the low-stage generator and entering the low-temperature heat exchanger. It is at a slightly higher concentration than the entering solution because it has picked up some heat from the hot vapor in the generator tubes, as an incidental occurrence in the flow process.

Point 9 represents the mixture of strong solution from the high-temperature heat exchanger and the weak solution from the low-stage generator after they both enter the low-temperature heat exchanger. It is an internal condition and cannot be measured.

Point 10 represents the combined strong solution before it leaves the low-temperature heat exchanger, after giving up heat to the weak solution. This is an internal condition and cannot be measured.

Point 11 represents the strong solution leaving the low-temperature heat exchanger and entering the absorber spray nozzles, after being mixed with some weak solution in the heat exchanger. The temperature can be measured, but the concentration cannot be sampled. After leaving the spray nozzles, the solution is somewhat cooled and concentrated as it flashes to the lower pressure of the absorber.

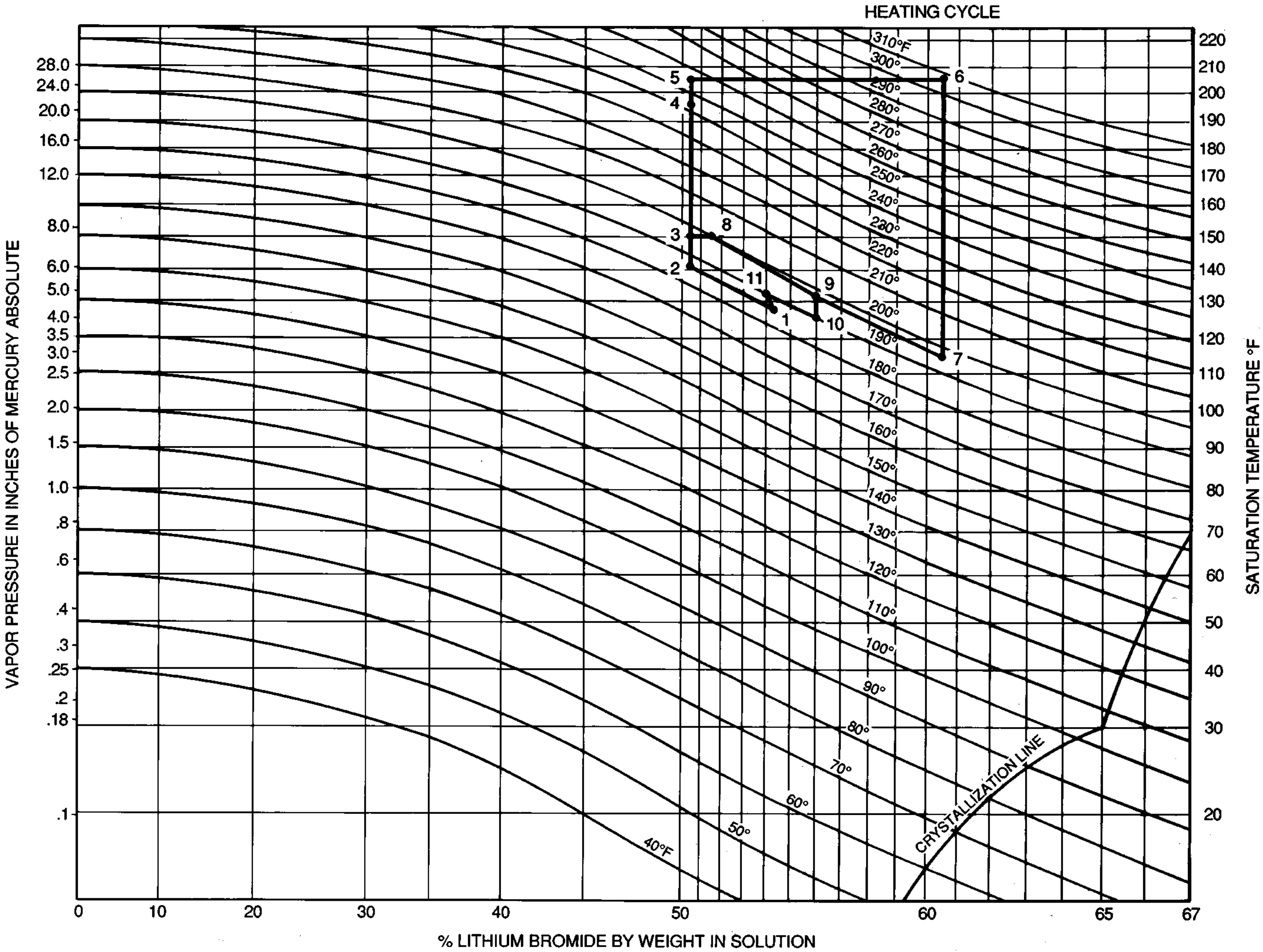


Fig. 8 — Equilibrium Diagram, Heating Cycle

Table 3 — Typical Full Load Heating Cycle Equilibrium Data

POINT	SOLUTION TEMPERATURE		VAPOR PRESSURE		SOLUTION PERCENTAGE LITHIUM BROMIDE	SATURATION TEMPERATURE	
	°F	°C	in. Hg	mm Hg		°F	°C
1	188	87	4.1	104	54.4	127	53
2	188	87	6.4	163	50.5	142	61
3	199	93	8.0	203	50.5	152	67
4	248	120	21.0	533	50.5	199	93
5	255	124	24.0	610	50.5	207	97
6	307	153	24.0	610	60.6	207	97
7	195	91	2.8	71	60.6	113	45
8	202	94	8.0	203	51.5	152	67
9	198	92	4.7	119	56.0	130	54
10	190	88	4.0	102	56.0	125	52
11	190	88	4.9	124	54.0	131	55

Purge — The basic components and flow circuits of the motorless purge are shown in Fig. 9.

The purge system automatically removes noncondensables from the machine and transfers them to a storage chamber where they cannot affect machine operation. Noncondensables are gases which will not condense at the normal chiller operating temperatures and pressures (N_2, O_2, H_2, etc.) and, because they reduce the machine vacuum, they would also reduce the machine capacity.

Hydrogen (H_2) gas is liberated within the machine during normal operation, and its rate of generation is controlled by the solution inhibitor. The presence of most other gases in the machine would occur either through a leak (the machine is under a deep vacuum) or during service activities.

While the machine is operating, any noncondensables accumulate in the absorber which is the lowest pressure area of the machine.

For purging, noncondensables are continuously drawn from the absorber into the lower pressure of an eductor, where they are entrained in solution flowing from the solution pump. The mixture then continues on to the purge storage tank. The noncondensables are released in a separator and the solution flows back to the absorber by way of the generator overflow pipe. Typically most of the noncondensable gas is hydrogen, which is automatically passed out to the atmosphere through a heated palladium membrane cell.

Any other gas accumulates in the purge storage tank where it is isolated from the rest of the machine. It is then removed from the storage tank, when necessary, by a vacuum pump connected to the tank exhaust valve. If the machine is maintained in a leak-tight condition, as it should be, the storage tank is normally exhausted once or twice a year, during a normal shutdown period or seasonal changeover. When it is necessary to remove noncondensables directly from the machine, such as after service work, a vacuum pump can be connected to the auxiliary evacuation valve, which is connected directly to the absorber through an isolation check valve.

Operation Status Indicators — The 16DF absorption chiller/heater is equipped with several instruments and sight glasses for direct observation of its operation in addition to a digital display of the temperature sensed for machine control and for codes (Tables 4 and 5).

Table 4 — 16DF Instruments

DESCRIPTION	LOCATION	FUNCTION
High-Temperature Generator Compound Gage	Low-Temperature Generator Steam Chamber	High-Temperature Generator Vessel Pressure
Exhaust Gas Thermometer	High-Temperature Generator Exhaust Stack	Exhaust Gas Discharge Temperature

Table 5 — 16DF Sight Glass

DESCRIPTION	LOCATION	FUNCTION
Absorber Sight Glass	Evaporator Refrigerant Overflow Pipe	Absorber Liquid Level Refrigerant Overflow
High-Temperature Generator Sight Glass	High-Temperature Generator Level Control Device Box	High-Temperature Generator Liquid Level
Combustion Chamber Sight Glass	High-Temperature Generator Combustion Chamber Return End	Combustion and Refractory Insulation Status

Burner — The burner is a packaged, forced-draft type, with modulating firing rate control. It is supplied with components selected for operation with either gas, light oil, or both fuels, and with appropriate safety and control components to comply with specified code, insurance, and jurisdictional agency requirements.

Specific information is contained in the burner manual accompanying each burner.

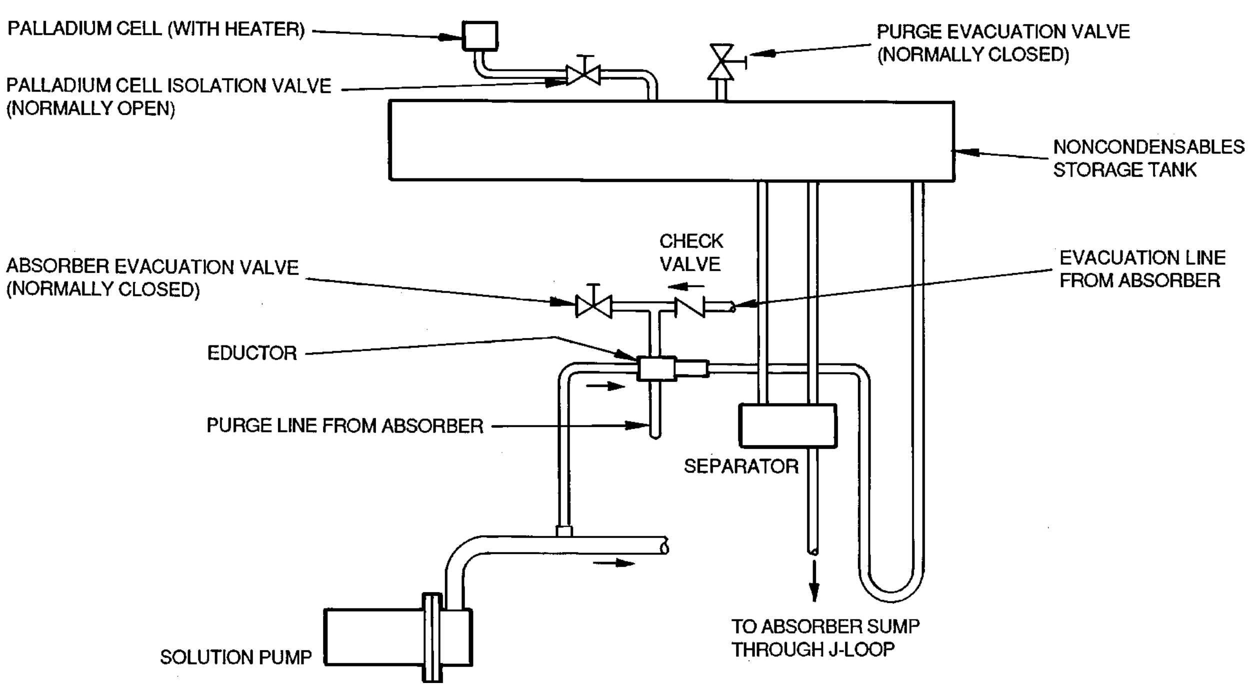


Fig. 9 — Purge System

MACHINE CONTROLS

⚠ WARNING

This machine uses a microprocessor control system. Do not short or jumper between terminations on printed circuit boards. Control or board failure may result. Also, when performing welding, wiring, or an insulation resistance test on the machine, disconnect wiring to the CPU (Control Processing Unit) board to avoid risk of voltage damage to the board components.

Be aware of electrostatic discharge (static electricity) when handling or making contact with the printed circuit boards. Always touch a grounded chassis part to dissipate body electrostatic charge before working inside the control center.

Use extreme care when handling tools near boards and when connecting or disconnecting terminal plugs. Circuit boards can easily be damaged. Always hold boards by edges and avoid touching components and pin connections. Always store and transport replacement or defective boards in anti-static bags.

General — The 16DF machine uses a microprocessor-based control center which monitors and controls all operations of the machine. It also has a separate burner control center, under direction of the machine control center, to provide burner sequence control and combustion supervision. The integrated control system matches the cooling and heating capacities of the machine to the respective cooling and heating loads, while providing state-of-the-art machine protection.

The system controls the machine output temperatures within the set point deadband by sensing the leaving chilled and hot water temperatures and regulating the burner heat input accordingly. Machine protection is provided by continuously monitoring critical conditions and performing control overrides or safety shutdowns, if required.

Start-Stop System — The type of start-stop system is selected by the customer. The most commonly used systems are described below. Review the descriptions and determine which system applies to your job.

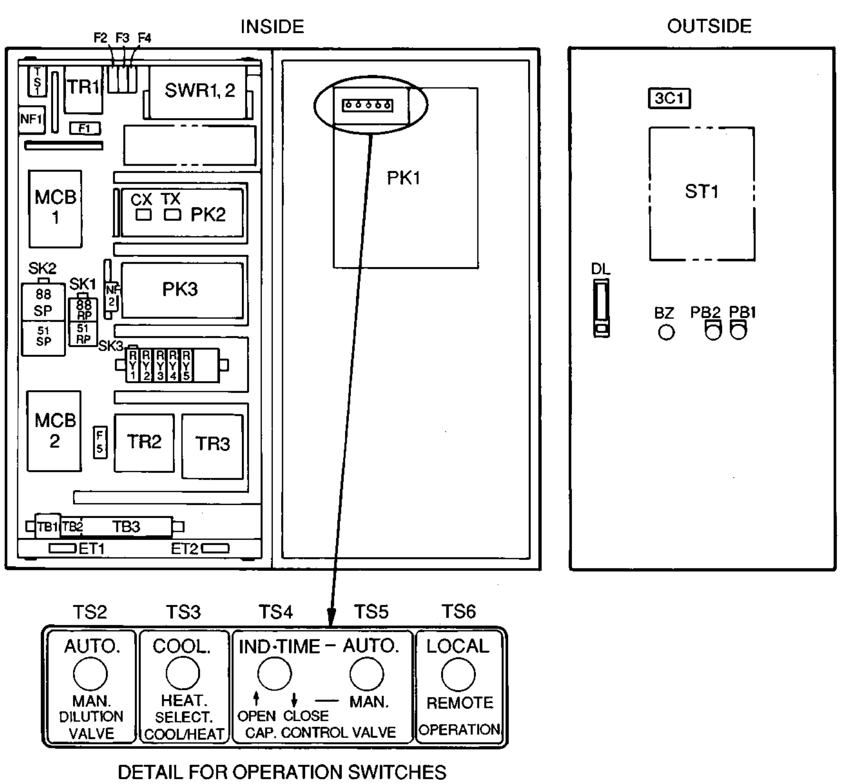
SEMIAUTOMATIC START-STOP — In this basic system, auxiliary equipment is wired into the machine control circuit and machine is started and stopped manually with the machine Start and Stop switches. Two variations are used:

With Pilot Relays — The coils for the chilled/hot water and condensing water pump starters (or other auxiliary equipment) are wired into the machine control circuit so that the auxiliary equipment operates whenever machine operates. The starter contacts and starter overloads remain in the external pump circuits. The pump flow switch(es) and auxiliary starter circuits are also wired into the machine control circuit and must be closed for the machine to operate.

With Manual Auxiliaries — With this system, the auxiliaries must be started manually and independently from the machine start, and they must be operating before the machine can start. As with the pilot relay system above, the flow switch(es) and auxiliary starter contacts are in the machine control circuit and must be closed for the machine to operate.

FULL AUTOMATIC START-STOP — This system is basically the same as the semiautomatic system with pilot relays described above. Machine and auxiliary start and stop, however are controlled by a field-supplied thermostat, timer, or other automatic device when the TS6 Local/Remote switch is in the REMOTE position, and the machine Start switch has been depressed.

Machine Control Panel — The 16DF standard control panel is shown in Fig. 10.



LEGEND

3CI	— Three-Character Indicator
51RP	— Refrigerant Pump Overcurrent Relay
51SP	— Solution Pump Overcurrent Relay
88RP	— Refrigerant Pump Electromagnetic Contactor
88SP	— Solution Pump Electromagnetic Contactor
BZ	— Alarm Buzzer
CX	— Remote Control Auxiliary Relay*
DL	— Door Latch
ET1,2	— Grounds
F0	— End-Contact Fuse
F1-5	— Enclosed Fuses
MCB1,2	— Main Circuit Breakers
NF1,2	— Line Noise Filters
PB1	— Start Pushbutton Switch
PB2	— Stop Pushbutton Switch
PK1	— Central Processing Unit (CPU) Board
PK2	— Input Terminal Module
PK3	— Output Terminal Module
RY1	— External Emergency Stop Auxiliary Relay
RY2-5	— Burner Safety Shutdown Auxiliary Relays
SK1-3	— Surge Suppressors
ST1	— Display Code Identification Sticker (see also Fig. 11)
SWR1,2	— Switching Regulators
T1	— Burner Safety Shutdown (“Off” Delay Timer)
TB1-3	— Terminal Boards
TR1	— Transformer
TR2	— Direct Current Control Circuit Transformer
TR3	— Alternating Current Control Circuit Transformer
TS2-6	— Operation Switches
TS1	— Direct Current Power Supply (On/Off)
TX	— Remote Control Circuit Auxiliary Relay*

*CX,TX auxiliary relays for remote operation are optionally installed signals.

Fig. 10 — Control Panel

Status Indicator Sticker — The sticker shown in Fig. 11 is located on the front of the control panel. It identifies the basic codes for machine operating status and safety shutdown, as displayed by the 3-character indicator on the front of the control panel.

NOTE: See Digital Temperature Display, page 16, and Adjustment Switches, below, for switch selections that display temperatures being measured by the machine sensors as well as the machine cumulative run time.

Adjustment Switches — These are located on the circuit board on the inside panel door.

TOGGLE SWITCHES (Fig. 12) — These are summarized in Table 6 and discussed in greater detail in various sections throughout this manual.

Table 6 — Control Panel Toggle Switches

SYMBOL	TOGGLE SWITCH	DESCRIPTION
TS1	On-Off	Direct Current Power Supply
TS2	Auto.-Manual	Dilution Valve
TS3	Cool-Heat	Select Cool/Heat
TS4	Open-Close	Capacity Control Valve
TS5	Auto.-Manual	Capacity Control Valve
TS6	Remote-Local	Operation

NOTES:
1. Time display selection shows the cumulative machine operating time in hours on the panel door operating status indicator. With the capacity control valve selection in the AUTO. position, momentarily depressing the switch to OPEN displays the first 3 digits of the time, and depressing the switch to CLOSE displays the last 2 digits and decimal. Example:
   OPEN position indicates = 012
   CLOSE position indicates = 345
   Cumulative run time = 01234.5 hours
2. With capacity control valve selection in the MANUAL position, momentarily depressing the switch to OPEN or CLOSE will move the burner fuel control valve and air damper proportionally open or closed.

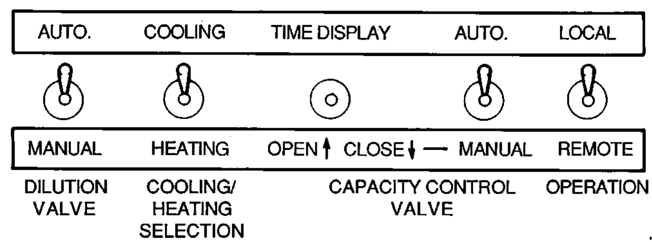


Fig. 12 — Control Panel Toggle Switches

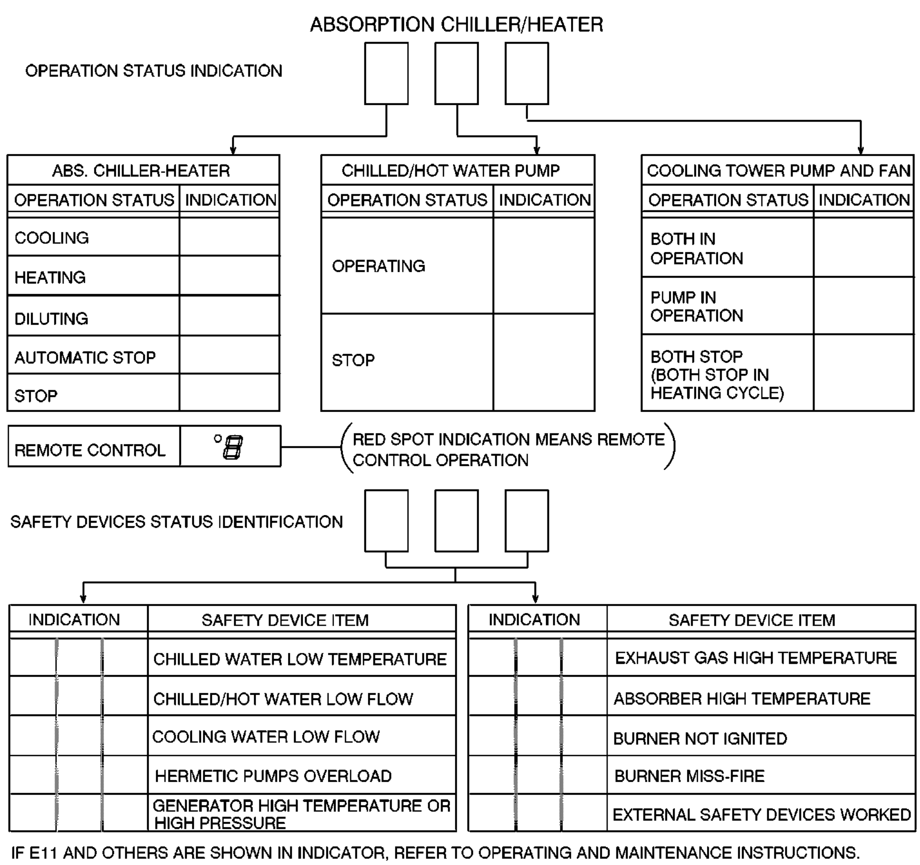


Fig. 11 — Control Panel Status Indicator Sticker

SET POINT AND DIP (Dual In-Line Package) SWITCHES (Fig. 13-16) — These switches are used to adjust chilled water and hot water capacity control temperature set points (also see Automatic Capacity Control section, page 31); to select the type of remote control signal; to display temperatures of the various machine temperature control sensors; and for service selections.

Chilled/Hot Water Control Location — SW11 switch 2 (Fig. 16) determines whether the capacity controller will use the chilled/hot water inlet nozzle sensor (UP position), or the outlet nozzle sensor (DOWN position).

NOTE: DOWN is the typical selection.

Chilled Water Capacity Control Temperature Set Point — The chilled water control temperature is determined by the setting on SW2 (Fig. 13, right side). The settings are increments of 1° C (1.8° F) from 0° to 9° C (0° to 16° F), and the control temperature is the SW2 setting above a base temperature of 5 C (41 F), for an adjustable range of 5 to 14 C (41 to 57 F). For example, a selection of 2 on SW2 would be a setting of 2° C plus 5 C (7 C total) (3.6° F plus 41 F = 44.6 F total).

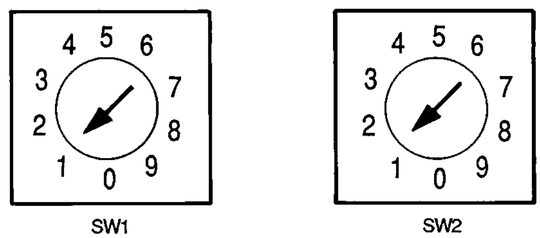
Hot Water Capacity Control Temperature Set Point — The hot water control temperature is determined by the settings on SW1 (Fig. 13, left side) and on SW10 switches 1 and 2 (Fig. 15). The SW1 settings are increments of 1° C (1.8° F) from 0° C to 9° C (0° to 16° F). The SW10 1 and 2 selections are for a base temperature of either 40 C (104 F), 50 C (122 F), 60 C (140 F), or 70 C (158 F). The control temperature is the SW2 setting above the selected base temperature, for an adjustable range of 40 to 79 C (104 to 174 F). For example, a selection of 2 on SW1 and placing both SW10 switches in the UP position would be a setting of 2° C plus 70 C (72 C total) (3.6 F plus 158 F = 161.6 F total).

Chilled and Hot Water Temperature Limit Settings on SW9 (Fig. 14) and Capacity Control Response Speed on SW10 (Fig. 15) — The purpose and selection of these settings are explained in the Automatic Capacity Control section.

Remote ON/OFF Signal — When the Local/Remote Operation toggle switch (Fig. 12) is in the REMOTE position, SW11 switch 1 (Fig. 16) will determine whether the remote signal is to be a remotely powered on/off voltage signal to the machine control circuit (UP position), or is from machine control circuit power through remote dry contacts (DOWN position).

Digital Temperature Display — The temperatures being measured by the machine's analog sensors will be displayed in °C by the 3-character indicator on the front of the control panel when DIP switch 6 on SW11 (Fig. 16) is placed in the UP position. Otherwise this switch should be left in the DOWN position for normal operating status indication. The temperatures will be shown in 8 sequential displays, with the first of the 3 characters indicating the channel (sensor) and the second and third characters showing the temperature. The first 6 channels indicate temperatures of 0° to 99 C (32 to 210 F) directly, and the seventh indicates, by code, 0° to 200 C (32 to 392 F). See Table 7.

Indicator LEDs — Fig. 17 shows the status of the machine's light-emitting diode (LED) indicator lights for DIP switch 5 of SW11 (Fig. 16).



SW1 — Hot Water Temperature Setting
SW2 — Chilled Water Temperature Setting

Fig. 13 — Load Water Temperature Adjustment Switches

Table 7 — Digital Temperature Display Codes

FIRST CHARACTER CHANNEL NUMBER	SECOND AND THIRD CHARACTERS (TEMPERATURE IN °C)	CONDITION SENSED
0	00 to 99	Chilled/hot water leaving temperature
1	00 to 99	Weak solution leaving absorber temperature
2	00 to 99	High-stage generator vapor temperature
3	00 to 99	Chilled/hot water entering temperature
4	—	Not used at this time
5	—	Not used at this time
6	—	Not used at this time
7	Code display	High-stage generator leaving solution temperature

CHANNEL 7 TEMPERATURE CODE	SECOND CHARACTER CODE	BASE TEMPERATURE		THIRD CHARACTER
		C	F	
7	A	100	212	This is the unit of temperature in 1° C increments (1.8° F) added to the base temperature*
	B	110	230	
	C	120	248	
	D	130	266	
	E	140	284	
	F	150	302	
	H	160	320	

*Example: A display showing 7C3 means channel 7 measures 123 C (253.4 F).

DIP SWITCHES

Switches 7 and 8

7	8	Hot water/auto. high-temperature limit setting above operating set point
UP	UP	Hot water target temperature +1° C (1.8° F)
DN	UP	Hot water target temperature + 2° C (3.6° F)
UP	DN	Hot water target temperature + 3° C (5.4° F)
DN	DN	Hot water target temperature + 4° C (7.2° F)

Switches 5 and 6

5	6	Hot water/high-temperature limit reset below operating set point
UP	UP	Hot water target temperature - 2° C (3.6° F)
DN	UP	Hot water target temperature - 3° C (5.4° F)
UP	DN	Hot water target temperature - 4° C (7.2° F)
DN	DN	Hot water target temperature - 5° C (9° F)

Switches 3 and 4

3	4	Chilled water/low-temperature limit set point
UP	UP	5 C (41 F)
DN	UP	6 C (42.8 F)
UP	DN	7 C (44.6 F)
DN	DN	8 C (46.4 F)

Switches 1 and 2

1	2	Chilled water/low-temperature limit reset above operating set point
UP	UP	Chilled water target temperature + 2° C (3.6° F)
DN	UP	Chilled water target temperature + 3° C (5.4° F)
UP	DN	Chilled water target temperature + 4° C (7.2° F)
DN	DN	Chilled water target temperature + 5° C (9° F)

Fig. 14 — Switch SW9

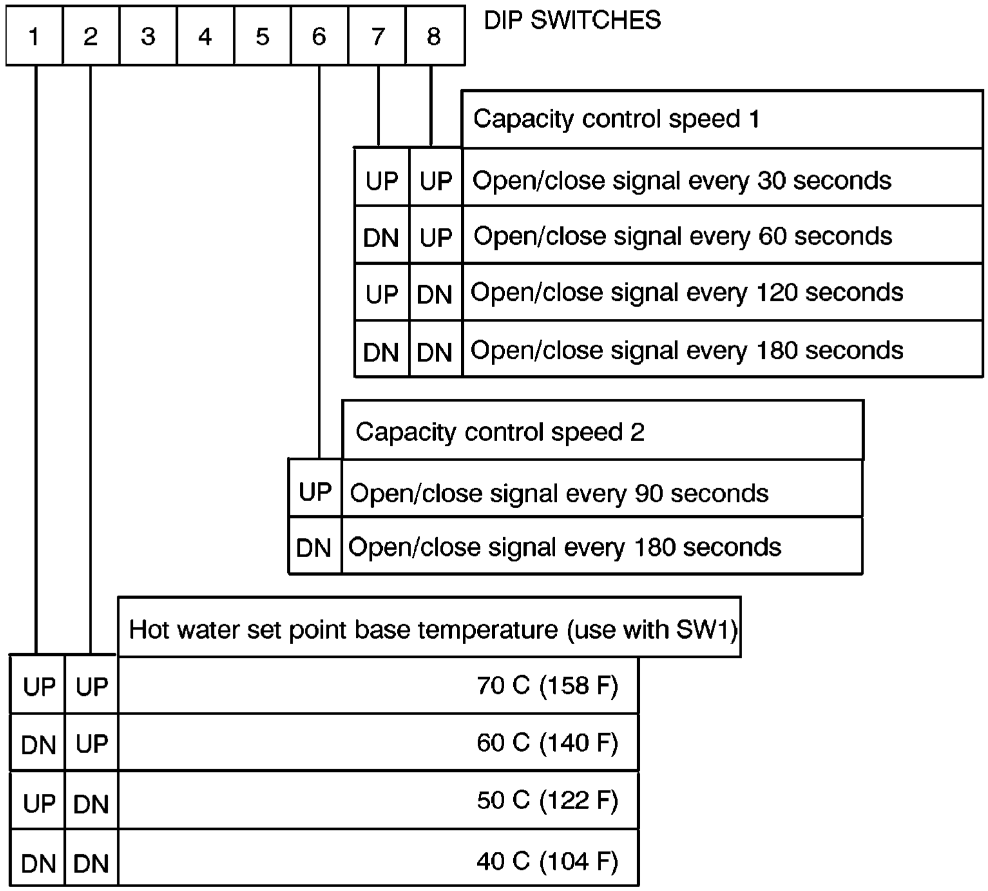
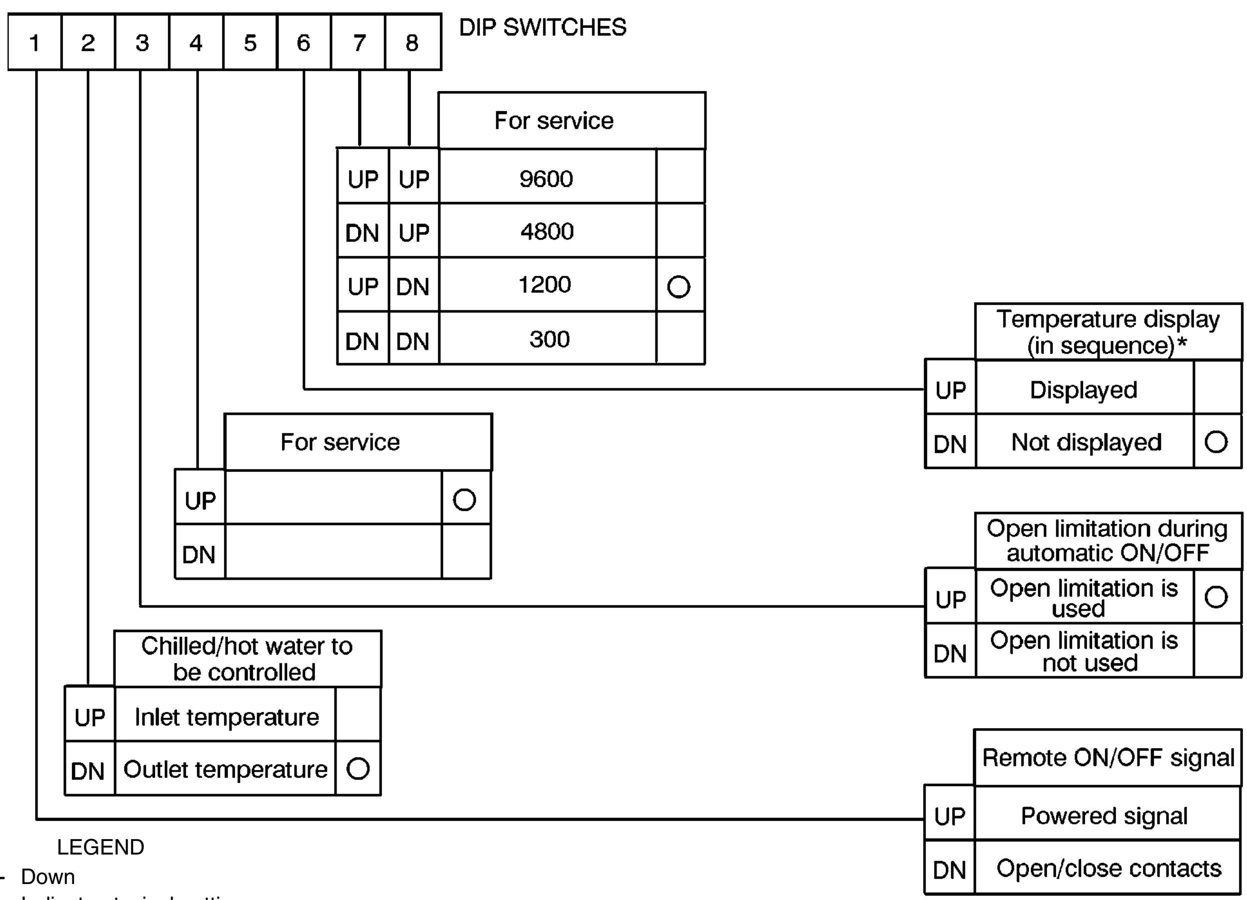


Fig. 15 — Switch SW10



LEGEND

DN — Down

◯ Indicates typical setting

* — Priority over error number

Fig. 16 — Switch SW11

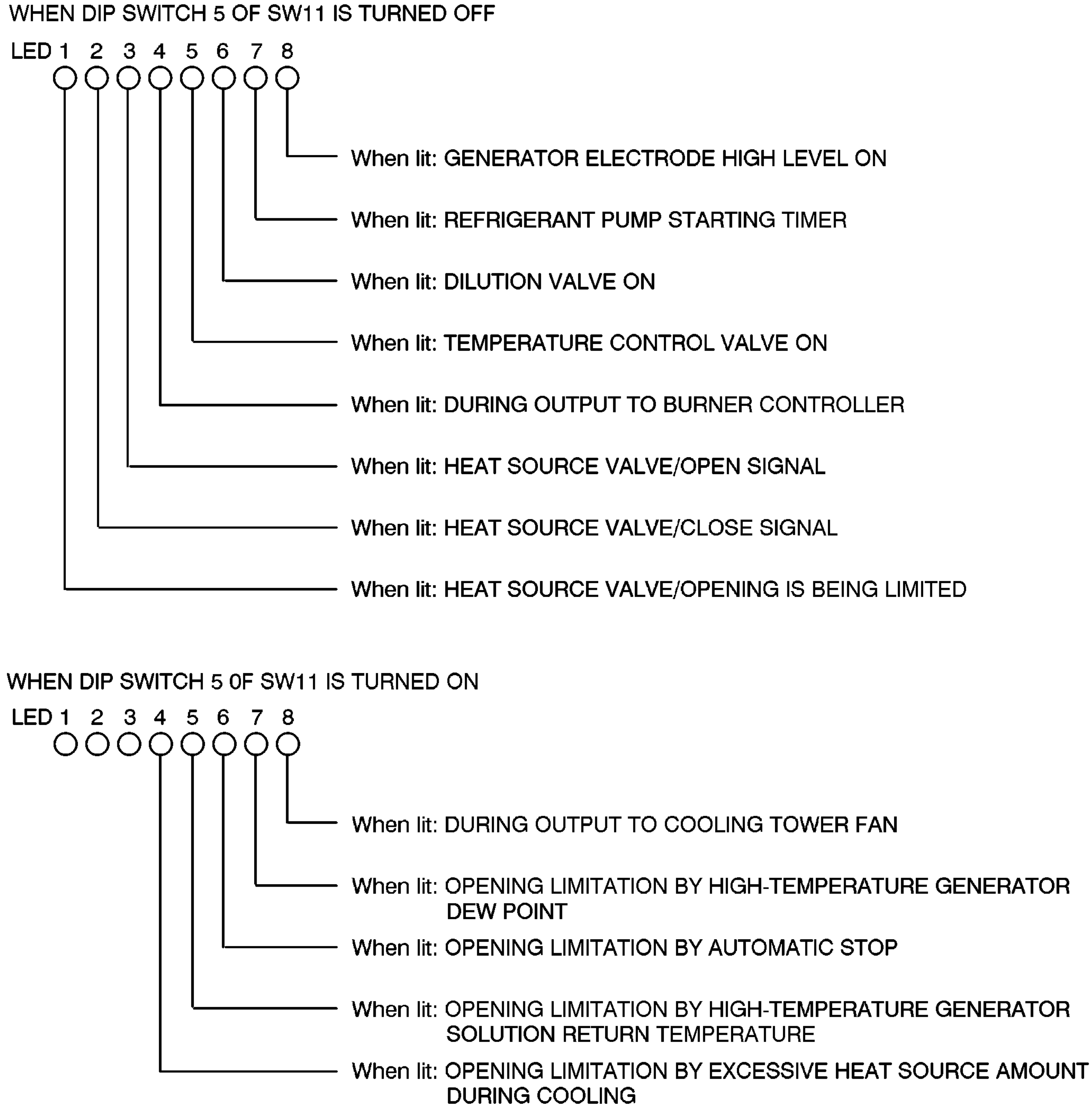


Fig. 17 — LED Indicator Lights Status

Remaining Time Indication for Dilution Cycle — To view remaining time in minutes on the control panel indicator, depress the Stop button (PB2) during the shutdown dilution cycle operation. It will be displayed only while the button is depressed.

The following example indicates 12 minutes still remain before dilution cycle is completed:

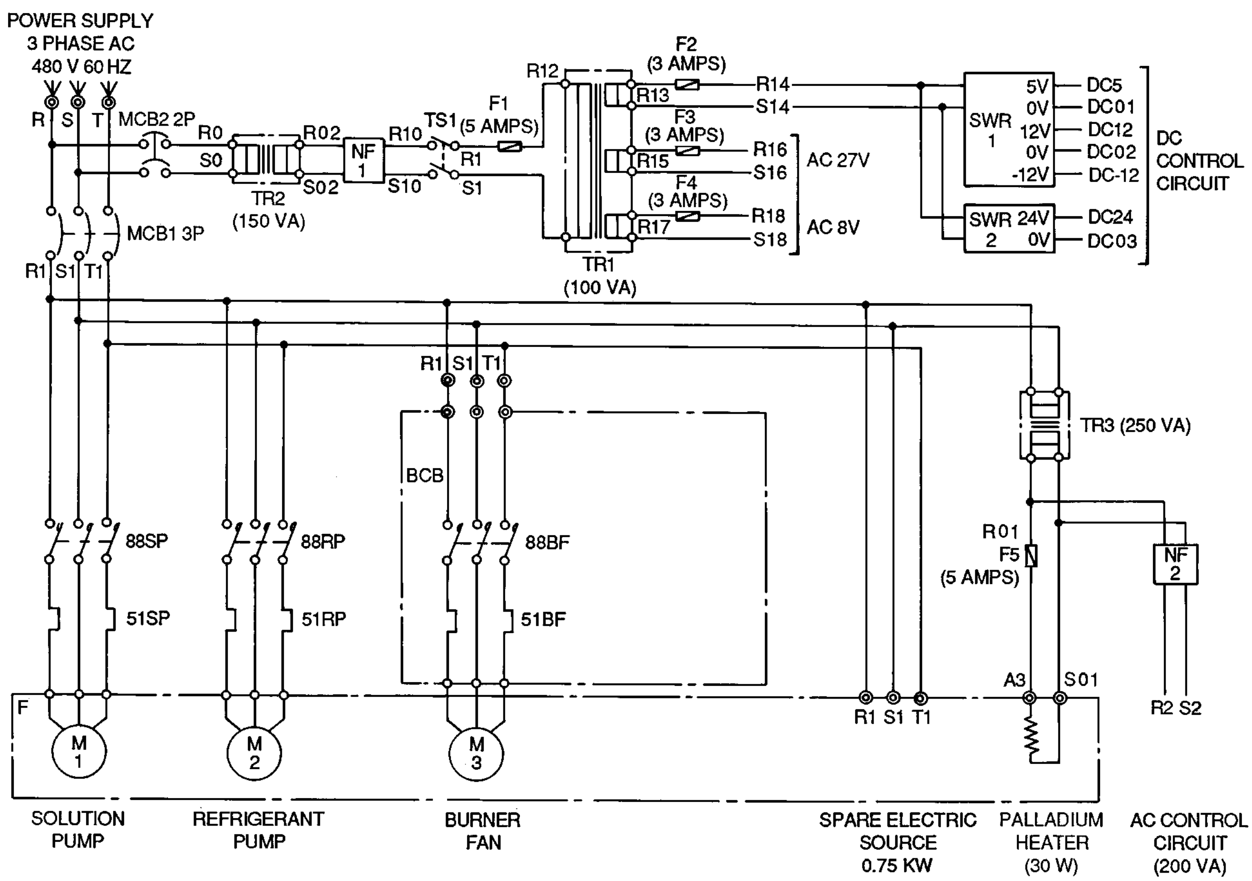
Dilution Cycle Indication — dPP
Depress Stop Button (PB2)
Remaining Time Indication — d12

Control Wiring — Figures 18-23 represent typical machine wiring schematics and component identification. See machine control panel diagram (Fig. 10) for component location. Refer to burner manufacturer's manual for burner control wiring diagram and component identification.

LEGEND FOR WIRING DIAGRAMS (Fig. 18 - 23), Pages 20 - 25

3CI — Three-Character Indicator
20CCV — Concentration Control Valve Positioner
21CV — Burner Capacity Control Positioner
20DV — Dilution Valve
26CA — Fire Tube High-Temperature Switch
26EH — Burner Exhaust Gas High-Temperature Switch
26SP — Solution Pump High Motor Temperature Switch
51BF — Burner Blower Motor Overload Relay
51RP — Refrigerant Pump Overload Relay
51SP — Solution Pump Overload Relay
69CW 1,2 — Chilled Water and Cooling Water Flow Switches
86X — Burner Safety Auxiliary Relay
88BF — Burner Blower Motor Starter
88CP — Cooling Water Pump Starter
88EP — Chilled/Hot Water Pump Starter
88CT — Cooling Tower Fan Starter
88RP — Refrigerant Pump Starter
88SP — Solution Pump Starter
AR1-8 — Machine Control Relays
BCB — Burner Control Box
BZ — Alarm Buzzer
C/H — Chiller/Heater
CX — Remote Control Auxiliary Relay*
CN1-10 — Wiring Cable Connectors
ET1,2 — Grounds
F0 — End-Contact Fuse
F1-5 — Enclosed Fuses
G1 — High-Stage Generator
GH — High-Stage Generator, High-Solution Level Switch
M1-3 — Three-Phase Motors
MCB1,2 — Main Circuit Breakers
MCP — Machine Control Panel
NF1,2 — Line Noise Filters
PB1 — Start Pushbutton
PB2 — Stop Pushbutton
PK1 — Main Circuit Board
PK2 — Input Terminal Circuit Board
PK3 — Output Terminal Circuit Board
RY1 — External Emergency Stop Auxiliary Relay
RY2-5 — Burner Safety Shutdown Auxiliary Relays
SK1-3 — Surge Suppressors
ST1 — Display Code Identification Sticker
SWR1,2 — Switching Regulators
T1 — Burner Safety Shutdown ("Off" Delay Timer)
T3H, T4H — Temperature Sensors
TB — Terminal Boards
TR1 — Transformer
TR2 — Direct Current Control Circuit Transformer
TR3 — Alternating Current Control Circuit Transformer
TS1 — Direct Current Power Supply (On/Off)
TS2-6 — Operation Switches
TX — Remote Control Circuit Auxiliary Relay*
——— Factory Wiring
- - - - Field Wiring
—-— Optional Wiring

*CX, TX auxiliary relays for remote operation are optionally installed signals.



NOTES:
1. BCB — installed in burner control box.
2. F — installed on chiller/heater.

Fig. 18 — Control Panel Power Wiring Schematic

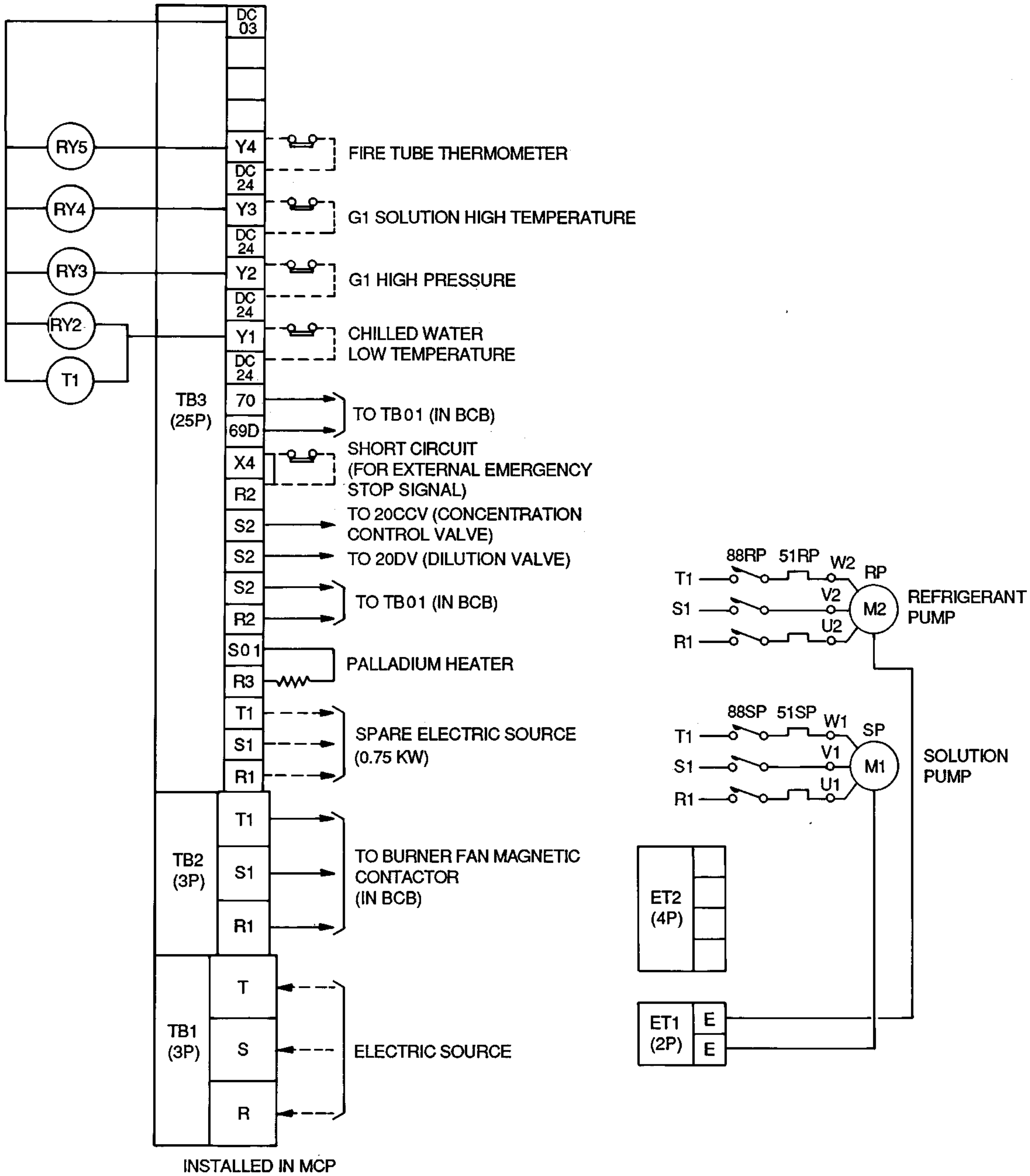


Fig. 19 — Terminal Strip, External Wiring Connections

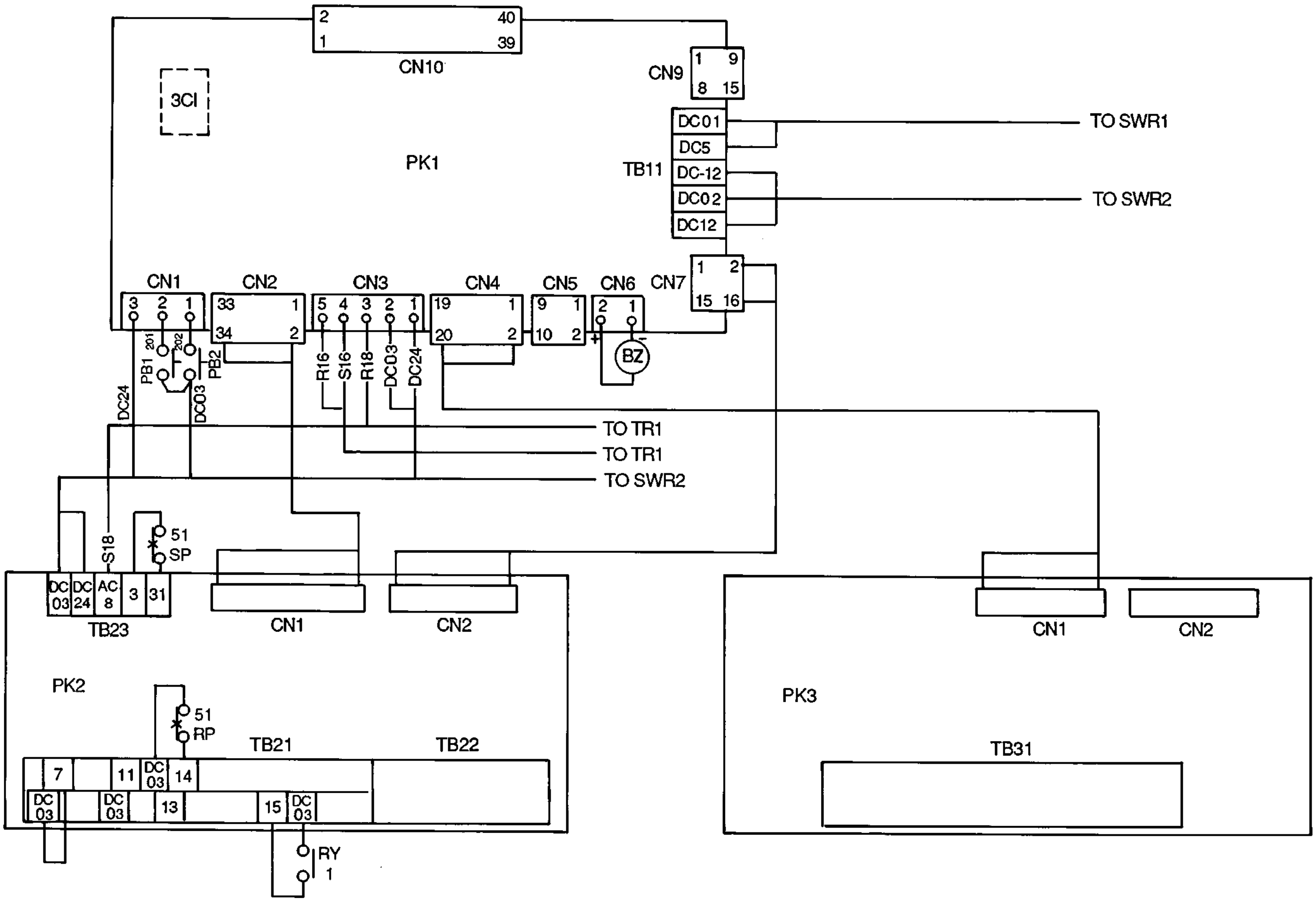
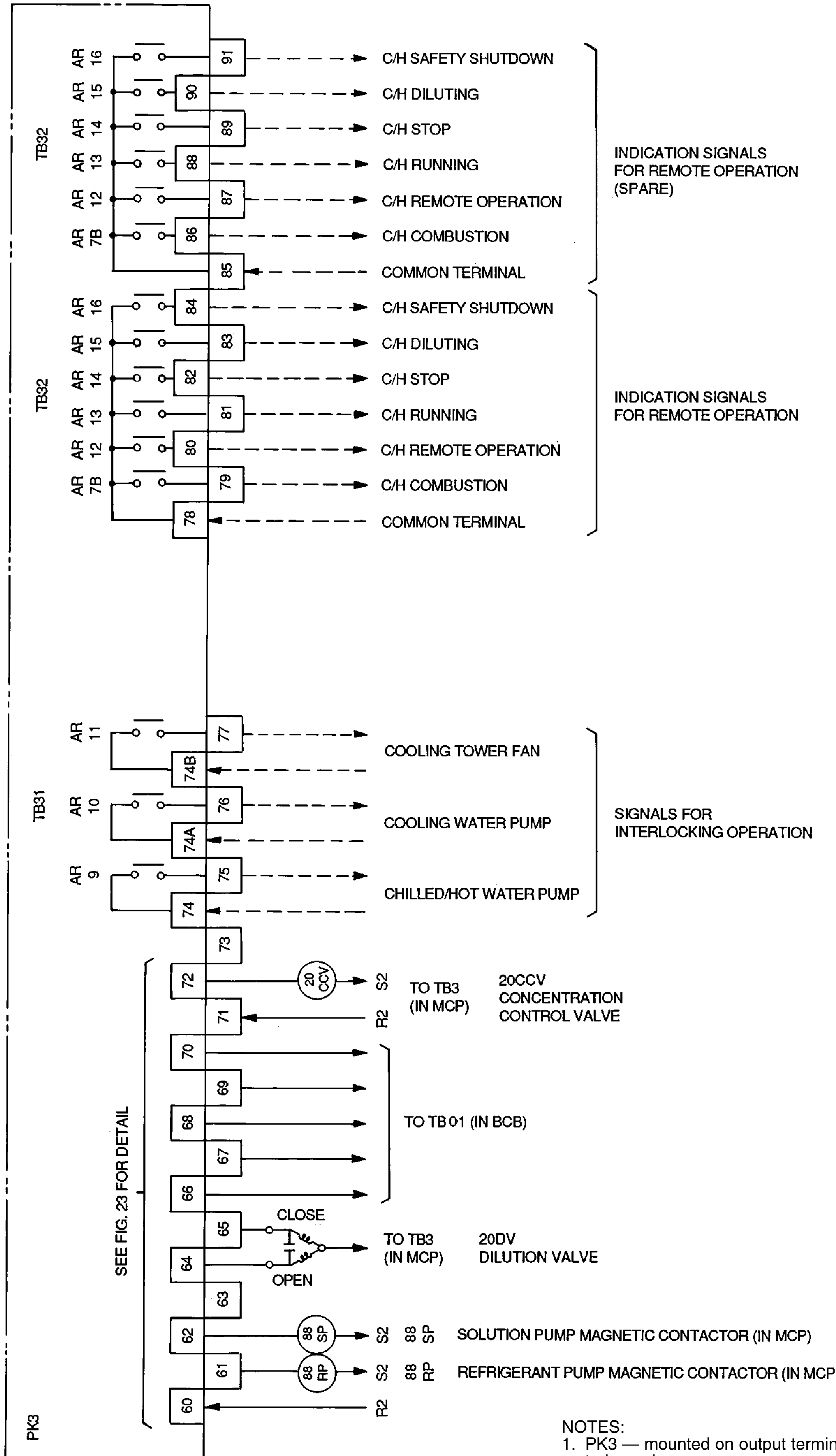


Fig. 20 — Circuit Board Wiring Locations



NOTES:
1. PK3 — mounted on output terminal module in control panel.
2. Legend on page 20.

Fig. 21 — PK3 Circuit Board Output Wiring Connections

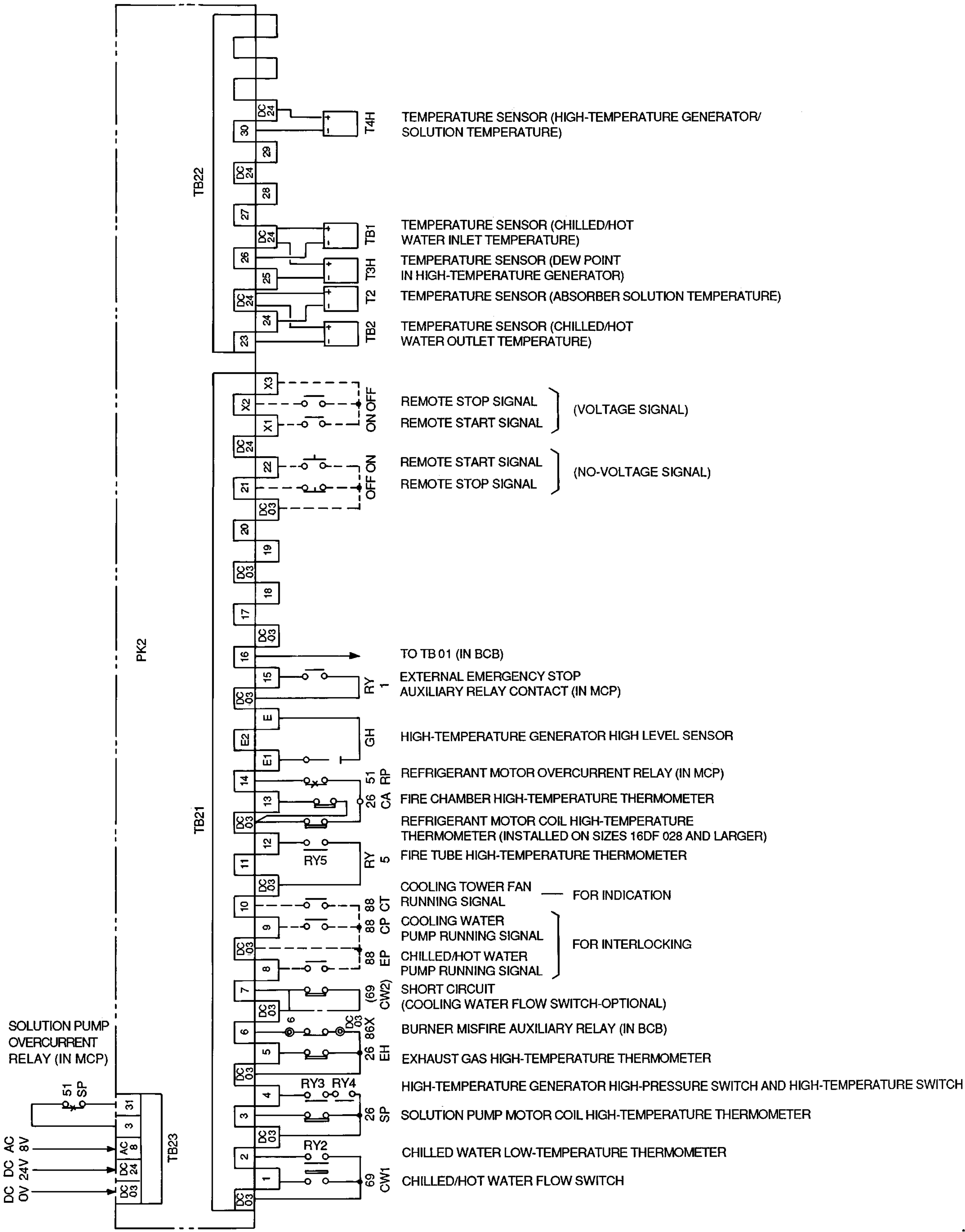
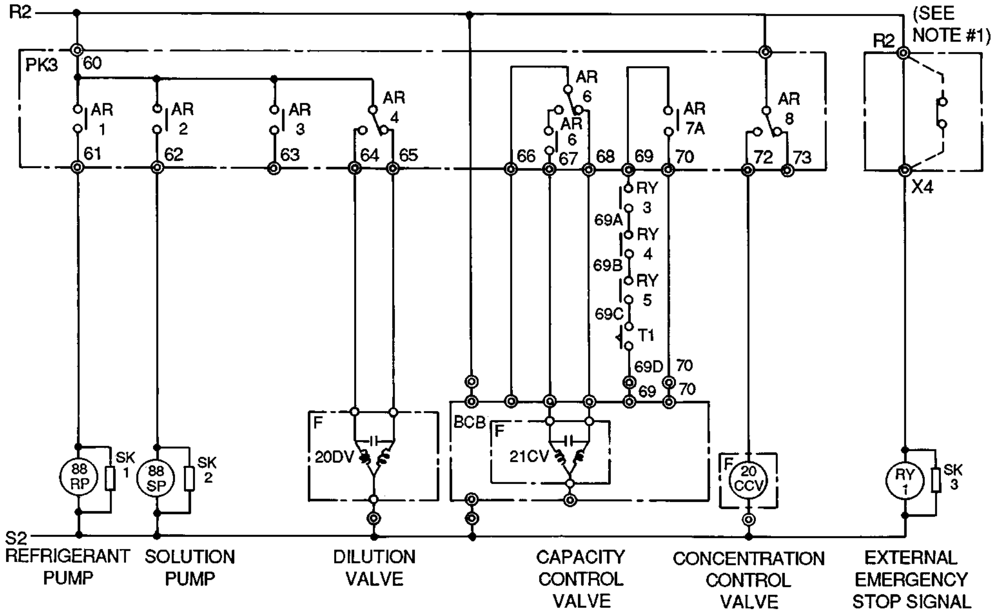
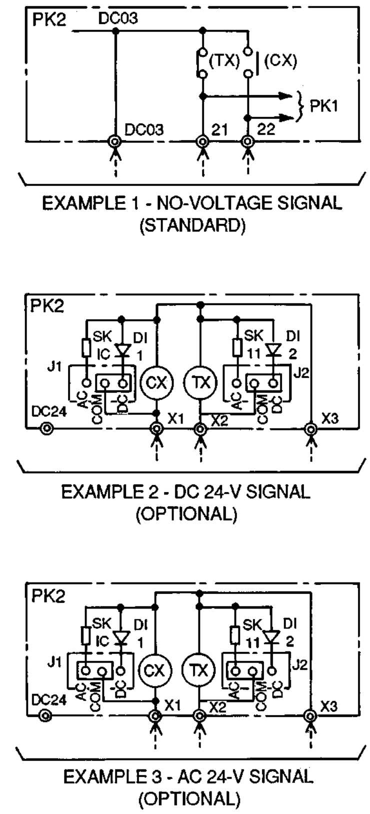


Fig. 22 — PK2 Circuit Board Input Wiring Connections



NOTES:
1. When the contacts of external emergency stop signals are connected, remove the jumper wire between terminal R2 and X4 and connect external contacts to these terminals.
2. BCB — installed in burner control box.
3. F — Positioning motor.
4. PK2 — input terminal module in control panel.
5. PK3 — output terminal module in control panel.



REMOTE OPERATION CIRCUIT

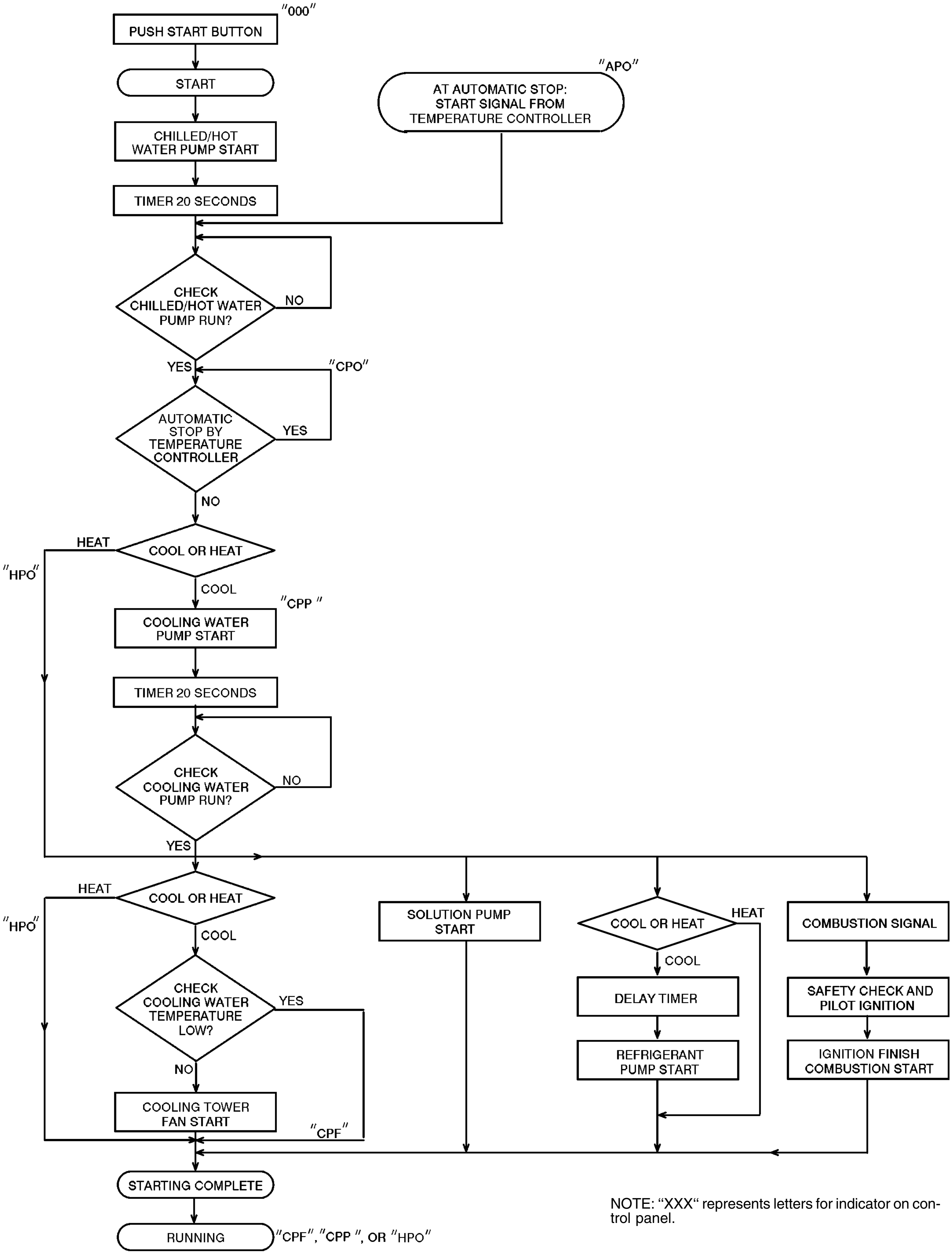
Fig. 23 — PK2 and PK3 Partial Wiring Connections

Typical Control Sequence — Normal Cooling Start (Fig. 24)

1. When power is supplied to the chiller control panel and the machine is not in operation, the status indicator will display “000”.
2. For starting, the machine and burner switches should be positioned as shown in Table 8, and the manual cooling/heating valves positioned for cooling (Table 9).
   NOTE: The Cool switch selection must be made before the Start button is depressed.
3. When the Start button is depressed, the microprocessor will initiate the timed starting and system checks sequence. The chilled water pump will be started, if not already running. After 20 seconds, the pump run interlock(s) will be checked to verify if the pump is running. If it is, the status indicator will display “CPO”. If not, the sequence will be halted until the interlocks show the pump is running.
4. The capacity controller then will be queried to see if there is a need for cooling. If not, the sequence will be halted. If cooling is required, the cooling water pump will be started, if not already running. After 20 seconds, the pump run interlock(s) will be checked to verify it is running. If it is, the start sequence will proceed. If not, the sequence will be halted until the interlocks show the pump is running. When the pump is running, the status indicator will display “CPP”.
5. The cooling water temperature will be checked and, if it is not too low, the cooling tower fan will be started, if not already running. The status indicator will now display “CPP”. At the same time, the solution pump and burner will be started. The refrigerant pump will be started after a short time delay. The chiller is now in normal operation. The control system will continuously monitor the capacity controller for load requirements, the safety interlocks for abnormal conditions, and operating limits for override control when necessary.

Typical Control Sequence — Normal Heating Start (Fig. 24)

1. When power is supplied to the chiller control panel and the machine is not in operation, the status indicator will display “000”.
2. For starting, the machine and burner switches should be positioned as shown in Table 8, and the manual cooling/heating valves positioned for heating (Table 9).
   NOTE: The Heat switch selection must be made before the Start button is depressed.
3. When the Start button is depressed, the microprocessor will initiate the timed starting and system checks sequence. The hot water pump will be started, if not already running. After 20 seconds, the pump run interlock(s) will be checked to verify it is running. If it is, the status indicator will display “HPO”. If not, the sequence will be halted until the interlocks show the pump is running.
4. The capacity controller then will be queried to see if there is a need for heating. If not, the sequence will be halted. If there is, the start sequence will proceed.
5. The solution pump and the burner will be started. The status indicator will display “HPO”. The heater is now in normal operation. The control system will continuously monitor the capacity controller for load requirements, the safety interlocks for abnormal conditions, and operating limits for override control when necessary.



NOTE: "XXX" represents letters for indicator on control panel.

Fig. 24 — Normal "Start" Flow Chart

Table 8 — Switch Positions for Start-Up

MACHINE CONTROL PANEL

SYMBOL	DESCRIPTION	TOGGLE SWITCH	SETTING
TS1	Direct Current Power Supply	On-Off	ON
TS2	Dilution Valve	Auto.-Manual	AUTO.
TS3	Select Cool/Heat	Cool-Heat	COOL OR HEAT
TS4	Capacity Control Valve	Open-Close	(NEUTRAL)
TS5	Capacity Control Valve	Auto.-Manual	AUTO.
TS6	Operation	Remote-Local	REMOTE OR LOCAL

BURNER CONTROL PANEL

DESCRIPTION	TOGGLE SWITCH	SETTING
Burner Control	On-Off	ON
Firing Rate Selector	Auto.-Manual	AUTO.
Firing Position	Open-Stop-Close	STOP
Fuel Selection (if used)	Gas-Oil	GAS OR OIL

Table 9 — 16DF Valves

MANUAL VALVES

NO.	SYMBOL	DESCRIPTION	LOCATION	OPERATION*	
1	A	Heating/Cooling Vapor Valves	High-Temperature Vapor Discharge Pipe	Cooling Cycle	C
				Heating Cycle	O
2	B	Heating/Cooling Liquid Valve	Underside Refrigerant Tank	Cooling Cycle	C
				Heating Cycle	O
3	C	Heat Exchanger Bypass	Solution Heat Exchanger	Normal Operation	C
				Service	O
4	D	Palladium Cell Isolation	Palladium Cell Connection Pipe	Normal Operation	O
				Service	C
5	E	Purge Storage Tank Evacuation	Purge Tank	Normal Operation	C
				Purge Discharge	O
6	F	Auxiliary Evacuation	Purge Pipe	Normal Operation	C
				Machine Evacuation	O
7	G	Vacuum/Pressure Gage Connection	Absorber Shell	Normal Operation	C
				Vacuum/Pressure Check	O
8	H	Solution Pump Service	Solution Pump Discharge	Normal Operation	C
				Service	O
9	J	Refrigerant Pump Service	Refrigerant Pump Discharge	Normal Operation	C
				Service	O
10	K	High-Stage Generator Service	Underside High Temperature Generator	Normal Operation	C
				Service	O

*Valve positions — O = FULLY OPEN; C = FULLY CLOSED.

AUTOMATIC VALVES

NO.	SYMBOL	DESCRIPTION	LOCATION	OPERATION*	
1	21CV	Capacity Control Valves	Burner Fuel Line and Air Damper	Proportional between high fire and low fire	
2	—	Fuel Valves	Burner Fuel Line	Burner On	O
				Burner Off	C
3	20DC	Dilution Valve	Evaporator Refrigerant Overflow Pipe	Dilution Cycle	O
				Normal Operation	C
4	20CCV	Concentration Control Valve	Condenser Refrigerant Return Pipe	Concentration Control Cycle	O
				Normal Operation	C
5	LCD	Solution Flow Control	Weak Solution Pipe	Reduces flow for low loads and low cooling water temperature.	

*Valve positions — O = FULLY OPEN; C = FULLY CLOSED.

Typical Control Sequence — Normal Cooling Stop (Fig. 25)

1. The timed shutdown sequence begins when the Stop button is depressed or the capacity controller senses there is insufficient load for continued operation. The status indicator will display ‘‘dPP’’.
2. The burner control is given a signal to move to the low-fire position, and, after 30 seconds, combustion is stopped and the burner goes through its post-purge shutdown sequence.
3. The refrigerant pump is stopped, and the dilution valve is opened to drain refrigerant from the evaporator into the absorber solution. The valve remains open until the shutdown is complete, and the refrigerant flow continues until the evaporator level reaches the level of the drain pipe.
4. Five minutes after the stop sequence is initiated, the solution temperature is checked to be sure it is cool enough to stop the cooling water flow. When it is, the cooling tower fan and cooling water pump are stopped if they are connected to the control circuit for automatic operation.
5. Fifteen minutes after the stop sequence is initiated, the solution pump is stopped, and the machine shutdown is completed. The pump remains in operation during the dilution period to mix refrigerant through the solution.
6. If the chilled water pump is connected to the control circuit for automatic operation, and the shutdown was initiated by the capacity controller, the chilled water pump will continue running to be ready for a restart, and the status indicator will display ‘‘APO’’. With a manual stop, the chilled water pump will be stopped and the status indicator will display ‘‘000’’.

> IMPORTANT: With manual pump control, the chilled water pump must not be stopped until the shutdown cycle has been completed.

Typical Control Sequence — Normal Heating Stop (Fig. 25)

1. The timed shutdown sequence begins when the Stop button is depressed or the capacity controller senses there is insufficient load for continued operation. The status indicator will display ‘‘dPO’’.
2. The burner control is given a signal to move to the low-fire position, and, after 30 seconds, combustion is stopped and the burner goes through its post-purge shutdown sequence.
3. Fifteen minutes after the stop sequence is initiated, the solution pump is stopped, and the machine shutdown is completed. The pump remains in operation during the shutdown period to cool the solution and machine.
4. If the hot water pump is connected to the control circuit for automatic operation, and the shutdown was initiated by the capacity controller, the hot water pump will continue running to be ready for a restart, and the status indicator will display ‘‘APO’’. With a manual stop, the hot water pump will be stopped and the status indicator will display ‘‘000’’.

> IMPORTANT: With manual pump control, the hot water pump must not be stopped until the shutdown cycle has been completed.

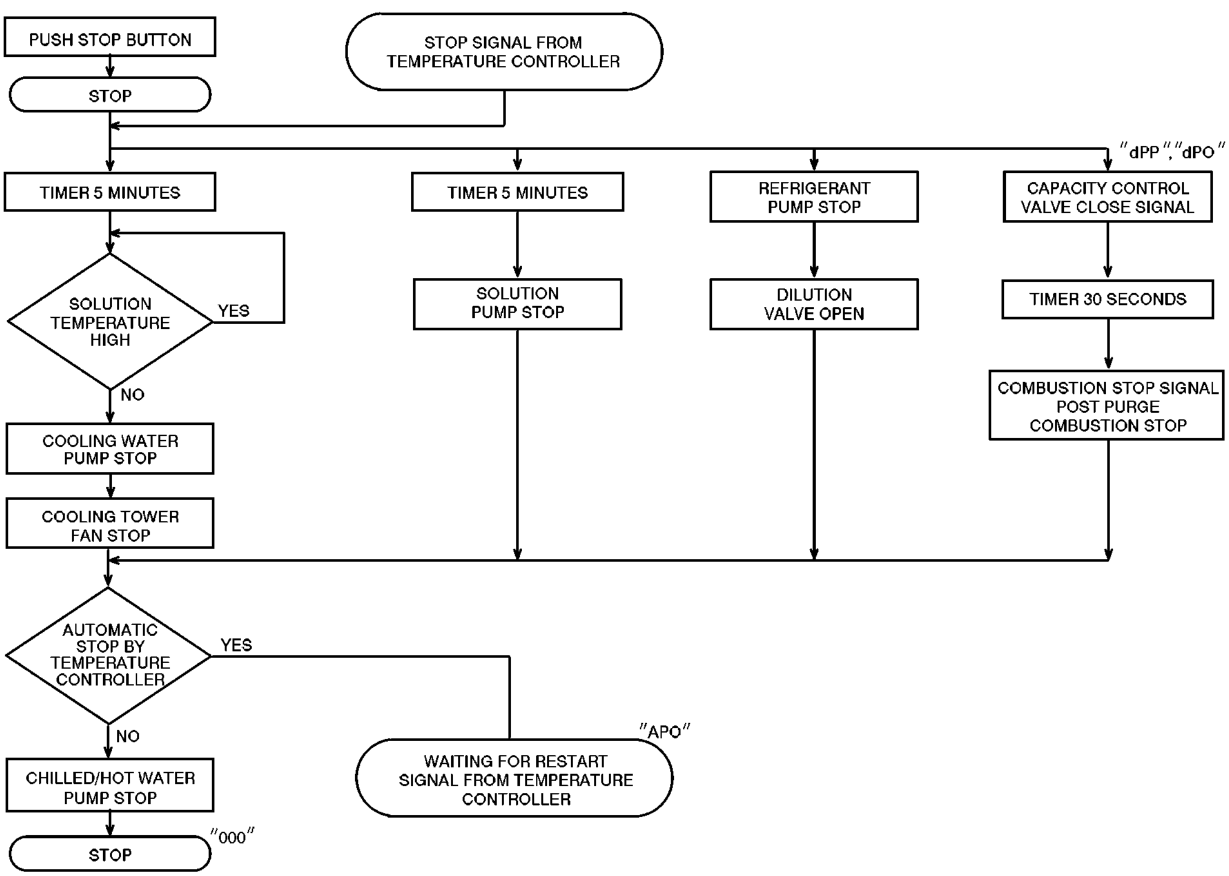


Fig. 25 — Normal “Stop” Flow Chart

Abnormal Shutdown (Fig. 26 and Table 10) — During operation, various conditions are monitored by the control system to protect the machine and to ensure safe operation. When any of these conditions exceed their normal safe operating limit, the machine will be shut down automatically and the audible alarm on the front of the control panel will buzz.

The cause of the limit shutdown will be displayed in code by the 3-character indicator on the front of the control panel. These are listed in Table 7. The alarm can be silenced by depressing the Stop button, after the cause of the shutdown has been noted. This will reset the control circuit for a restart after the shutdown sequence has been completed and the cause of the shutdown has been corrected. Combustion failures are also indicated by an alarm light on the burner panel. A combustion failure can be reset by pressing the reset button on the burner combustion controller in the burner control panel.

Some conditions will allow the burner to first modulate to the minimum firing position for a normal low-fire shutdown. Others will close the fuel valve immediately. Most of the conditions will allow a normal dilution period before shutdown, but several will stop the machine immediately without dilution. The latter conditions should be corrected as quickly as possible to allow a restart or manual dilution before solution crystallization occurs.

The shutdown follows the typical cooling or heating stop sequence, with the immediate combustion stop or lack of dilution exceptions as listed. Also with low chilled water temperature or flow, the dilution cycle is delayed until after the cooling tower fan and cooling water pump are stopped.

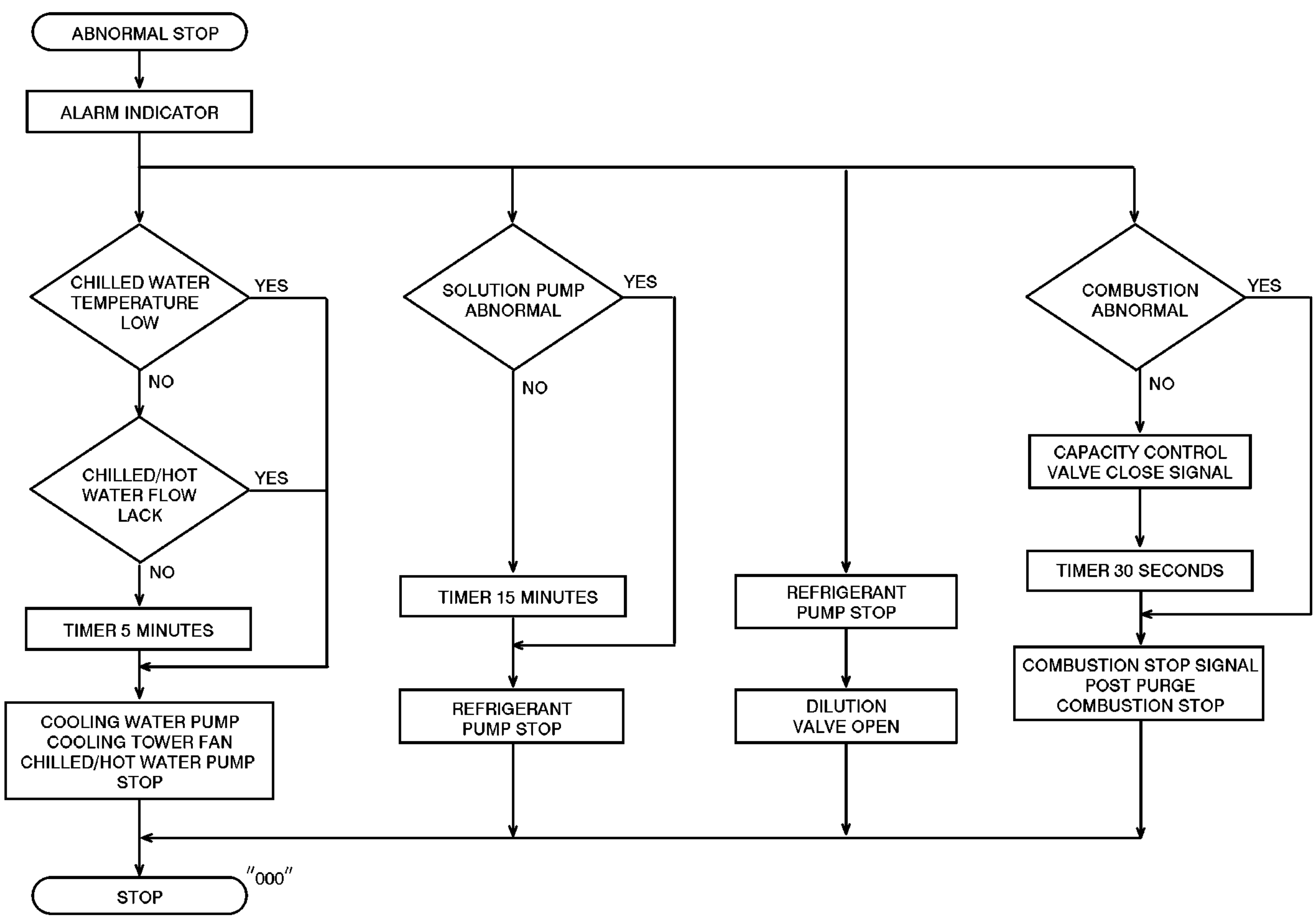


Fig. 26 — Abnormal "Stop" Flow Chart

Table 10 — Abnormal Shutdown Conditions

AUTO. LIMIT CONDITION	LIMIT SETTING	CONTROL SYMBOL	STOP CODE	LOW FIRE	DILUTION
Low leaving chilled water temperature cutout (cooling only)	4 C (39 F)	26CW	E01	No	Yes
High-temperature generator high-solution temperature switch	170 C (338 F)	T4H	E05	No	Yes
High-temperature generator high-pressure switch	-20 mm Hg (-.8 in.)	63GE	E05	No	Yes
Exhaust gas high-temperature switch	300 C (572 F)	26EH	E06	No	Yes
Fire tube high-temperature switch	300 C (572 F)	26TH	E06	No	Yes
Burner combustion failure/limit • Within 3 minutes of machine start • After 3 minutes of machine start	Per device	86X	 • E08 • E09	No	Yes
External emergency limit switch	Per device	SE	E10	No	Yes
Refractory high-temperature switch	150 C (302 F)	26CA	E06	No	Yes
Solution pump motor overloads	Rated amp	51SP	E04	Yes	No
Solution pump motor high-temperature switch	135 C (275 F)	26SP	E04	Yes	No
Refrigerant pump motor overloads (cooling only)	Rated amp	51RP	E04	Yes	Yes
Refrigerant pump motor high-temperature switch (larger size chillers, cooling only)	135 C (275 F)	26RP	E04	Yes	Yes
High-absorber; weak solution temperature sensor (cooling only)	45 C (113 F)	T2	E07	Yes	Yes
Chilled/hot water low flow	50% design	69CW1	E02	Yes	Yes
Cooling water low flow (optional) (cooling only)	50% design	69CW2	E03	Yes	Yes
Chilled/hot water pump interlock	Open circuit	88EP	E02	Yes	Yes
Cooling water pump interlock (cooling only)	Open circuit	88CP	E03	Yes	Yes
Sensor error (7 conditions)	Out of range	—	E13-34	Yes	Yes

Operating Limit Controls — Several special features allow the machine to continue to run in limited operation with certain abnormal conditions, until those conditions either are corrected to resume normal operation or deteriorate to a point where the machine is automatically shut down:

HIGH-TEMPERATURE GENERATOR, HIGH SOLUTION LEVEL — An immersion electrode with a switched output continuously monitors the high-stage generator solution level. If a problem causes a high level and the condition continues for 5 minutes, the solution pump is turned off to stop solution supply to the generators. If the temperature of the solution leaving the high-stage generator is below 212 F (100 C) the solution pump is restarted after 60 seconds. If the solution temperature is 212 F (100 C) or higher, the pump is restarted after 30 seconds.

If the high level continues for 10 minutes, meaning it was not corrected by stopping the pump, the alarm buzzer will sound, the status indicator will display safety shutdown code E13 for ''electrode fault'', and the machine will shut down with the normal dilution cycle. The solution pump will continue operating through the shutdown sequence.

HIGH-TEMPERATURE GENERATOR, HIGH LEAVING SOLUTION TEMPERATURE — When this temperature reaches 311 F (155 C), the capacity control signal to the burner is limited to prevent an increase in the heat input. If the temperature continues to rise, a ''close'' signal is given to the burner control for 2 or 3 seconds for each incremental increase of 0.5° F (0.3° C).

If this temperature rises above 329 F (165 C), the close signal is given in increments for 5 seconds. If the temperature continues to rise to 338 F (170 C), the burner will be stopped immediately, the alarm buzzer will sound, the status indicator will display safety shutdown code E05 for ''high strong solution temperature'', and the machine will shut down with the normal dilution cycle.

HIGH-TEMPERATURE GENERATOR, HIGH-SATURATION (VAPOR) TEMPERATURE — When this temperature reaches 199 F (93 C), the capacity control signal to the burner is limited to prevent an increase in the heat input. If the temperature continues to rise, a ''close'' signal is given to the burner control for 2 or 3 seconds for each incremental increase of 0.4° F (0.3° C). If this temperature rises above 203 F (95 C), the close signal is given in increments for 5 seconds.

CONCENTRATION CONTROL VALVE — When the temperature of the solution leaving the absorber drops below 91 F (33 C) during cooling operation, because of low cooling water temperatures, the concentration control valve is opened. This valve is located in a condensate line between the bottom of the condenser and the evaporator and, when open, drains extra refrigerant into the evaporator. This is to prevent possible refrigerant pump cavitation and damage due to loss of refrigerant with the low solution concentrations which can occur with cooling water temperatures below design. The valve closes when the solution temperature rises above 95 F (35 C).

The concentration control valve is also opened during the shutdown dilution cycle and during heating operation.

COOLING TOWER CONTROL — When the temperature of the solution leaving the absorber drops below 77 F (25 C) during cooling operation, because of low cooling water temperatures, the tower fan is turned off. When the solution warms to 86 F (30 C), the fan is turned back on.

If the solution temperature rises to 113 F (45 C), because of very high cooling water temperatures or poor heat transfer, the alarm buzzer will sound, the status indicator will display E07 for ''high weak solution temperature'', and the machine will shut down with the normal dilution cycle.

Automatic Capacity Control — The machine automatic capacity control system senses the chilled water or hot water temperature, compares it to selected cooling or heating temperature set points, and regulates the burner to adjust the machine capacity for maintaining the chilled or hot water temperature at the set points.

Figure 27 schematically shows the automatic capacity control system. Temperature sensors are located in both leaving and entering chilled/hot water piping, the burner is regulated by modulating the fuel and air, and the system is controlled by the machine microprocessor.

At full load conditions, the burner will be at or near the maximum firing rate. As the load decreases, the burner will be modulated to a reduced firing rate in proportion to the load. When the heat input required for the load is below the minimum firing rate, the burner will be cycled off and on.

TEMPERATURE CONTROL SETTINGS — The control point settings for automatic control of the chilled water and hot water temperatures are factory preset for typical operating conditions, but can be reset in 1° C (1.8° F) increments with the machine adjustment switches.

Cooling and heating operation each require 3 temperature settings. They include operating temperature settings for the burner modulating range, limit temperature settings to cycle the burner off with low load conditions, and limit reset temperature settings for cycling the burner back on at low load conditions. There are also selections to use either the leaving or entering water temperature sensor, and the capacity control change signal rate. See Set Point and DIP Switches section, page 16 for temperature selection instructions.

<u>Chilled water operating temperature (burner modulation)</u> — SW2 — Factory set at 7 C (44.6 F), adjustable from 5 to 14 C (41 to 57.2 F).

<u>Chilled water low-temperature limit (low load, burner off)</u> — SW9 (switches 3 and 4) — Factory set at 6 C (42.8 F), adjustable from 5 to 8 C (41 to 46.4 F). Must be set below the chilled water operating temperature, typically 1°C (1.8° F) below.

<u>Chilled water low-temperature limit reset (low load, burner on)</u> — SW9 (switches 1 and 2) — Factory set at +4° C (+7.2° F) above operating set point, adjustable from +2 to +5° C (+3.6 to +9° F).

⚠ CAUTION

Never allow the leaving chilled water temperature to fall below 5 C (41 F). If it does, readjust the temperature set points upwards.

<u>Hot water operating temperature (burner modulation)</u> — SW10 (switches 1 and 2) plus SW1 — Factory set at 60 C (140 F), adjustable from 40 to 79 C (104 to 174.2 F).

<u>Hot water high-temperature limit (low load, burner off)</u> — SW9 (switches 7 and 8) — Factory set at +2° C (+3.6° F) above the operating set point, adjustable from +1 to +4° C (+1.8 to +7.2° F).

<u>Hot water high-temperature limit reset (low load, burner on)</u> — SW9 (switches 5 and 6) — Factory set at -5° C (9° F) below operating set point, adjustable from -2 to -5° C (-3.6 to -9° F).

<u>Control sensor</u> — SW11 (switch 2) — Selects either the outlet (leaving) sensor or inlet (entering) sensor for controlling the chilled water and hot water temperatures. It is factory selected for outlet temperature, and that setting should be used for normal applications.

<u>Capacity control speed</u> — SW10 (switches 7 and 8 for speed 1, and switch 6 for speed 2) — This determines the capacity control response rate to ensure timely adjustment to load changes without system control cycling. Capacity control speed 1 is factory selected for open/close signal increments every 60 seconds, adjustable for 30, 60, 120, or 180 second intervals. Capacity control speed 2 is factory selected for open/close signal increments every 90 seconds, adjustable for 90- and 180-second intervals. The factory settings should be used for normal applications.

Example Cooling Temperature Control — With the factory temperature setting selections listed above, the capacity would be controlled by the leaving chilled water temperature sensor. The burner would modulate between the maximum and minimum firing rates to hold the chilled water temperature at the 7 C (44.6 F) setting.

When a low load requires less than the minimum burner firing rate, the chilled water temperature will gradually fall until it reaches the low limit setting of 6 C (42.6 F), and the burner will be stopped. Then, with the burner off, the chilled water temperature will gradually rise until it reaches the +4° C (+7.2° F) reset setting of 11 C (51.8 F), and the burner will be restarted.

Example Heating Temperature Control — With the factory temperature setting selections listed above, the capacity would be controlled by the leaving hot water temperature sensor. The burner would modulate between the maximum and minimum firing rates to hold the hot water temperature at the 60 C (140 F) setting.

When a low load requires less then the minimum burner firing rate, the hot water temperature will gradually rise until it reaches the +2° C (+3.6° F) high limit setting of 62° C (143.6° F), and the burner will be stopped. Then, with the burner off, the hot water temperature will gradually fall until it reaches the -5° C (-9° F) reset setting of 55 C (131 F), and the burner will be restarted.

CHILLED/HOT WATER TEMPERATURE DISPLAY — The temperatures being measured by the chilled/hot water sensors can be displayed in °C, along with the temperatures of the other machine sensors, by the 3-character indicator on the front of the control panel. This is done by placing DIP switch 6 on SW11 in the UP position. The leaving chilled or hot water temperature is displayed by channel 0 (first character), and the entering water temperature is channel 3. See Table 7, Digital Temperature Display Codes.

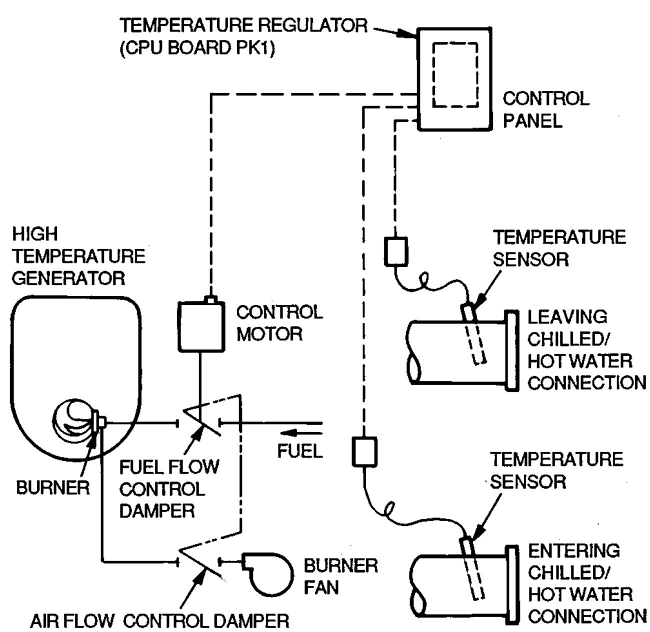


Fig. 27 — Automatic Capacity Controller

Burner Control — The burner system has its own control panel and circuits for sequence control and combustion supervision, but it operates under direction of the chiller/heater control center for start/stop, firing rate, and low load on/off instructions. The burner controls will vary some with different sizes, fuels (single or dual fuel), and special codes. See the separate burner manual for detailed control information.

COMBUSTION CONTROL — Normal operation occurs with the manual control switch ON, the firing rate selector switch in AUTO., the fuel selector switch in the desired position, and the appropriate manual fuel valves open.

The ignition sequence begins when the machine control center closes the run relay contacts in the burner control circuit. The burner panel ''Call For Heat'' light illuminates and the blower motor starts. The firing rate motor will drive to the low fire position, and an interlock switch must close to prove it is at the low fire position before the sequence will continue.

When the airflow switch closes to prove combustion air and the flame safeguard control in the burner control panel has checked itself and the burner safety conditions, the safeguard control will begin a timed pre-purge period to be sure any combustible gases are removed from the combustion chamber.

At the end of pre-purge, the pilot gas valve and ignition transformer are energized to establish the pilot ignition flame. The ''Ignition On'' light will illuminate. If the pilot flame is proven by the flame sensor, at the end of the pilot trial period the ignition spark will be deenergized and the main fuel valve(s) will be energized. The ''Fuel On'' lamp will light. After a short trial for main flame, the pilot gas valve will be deenergized to discontinue the pilot flame, and the ''Ignition On'' lamp will be off. The firing rate positioning motor will now be released from the low fire position for normal operation.

If the flame sensor does not prove the continued presence of flame at any time during the trials for pilot and main flame or during normal operation, safety shutdown and lockout will occur and the ''Alarm'' light will illuminate. Then, the safety switch on the flame safeguard control must be manually pressed for restart after the cause of failure has been corrected.

With a normal shutdown, the machine control center will first send a control signal to drive the firing rate motor to the low fire position before the flame is extinguished, but with some safety shutdown conditions, the burner will be stopped immediately. The burner will stop when the machine control center opens the burner run relay contacts. The main fuel valve(s) will be deenergized immediately. On smaller sizes the blower is also stopped immediately, but on larger sizes, it will remain in operation through a timed post-purge period. The flame safeguard control will then remain in a standby mode, waiting for a signal to restart.

FIRING RATE CONTROL — The burner firing rate is automatically adjusted to match the heat input with that required for the chilling or heating load. The burner will be at or near the maximum firing rate at full load conditions, and will be modulated to a reduced firing rate as the load decreases. The burner will be cycled off and on when the heat required for the load is below the minimum firing rate.

The machine automatic capacity control provides signals directly to the burner for firing rate positioning and low load off/on cycling. The machine control center will override these signals for start, stop, and special limit conditions, and the burner itself will override for low fire ignition.

Manual rate positioning can be done with selector switches in both the machine control center and the burner control panel. However, automatic temperature limits will override the chiller manual control if the selected heat input rate is greater than that required for the load.

The modulated firing rate is provided by an air damper and fuel valve which are positioned simultaneously through adjustable control linkage with the firing rate positioning motor. The linkage connections for the damper and valve(s) are adjusted to provide good fuel-to-air ratios for controlled, clean combustion throughout the complete firing range.

BEFORE INITIAL START-UP

⚠ CAUTION

Do NOT charge the lithium bromide solution and refrigerant water into the machine during these preliminary checkout activities. The liquids MUST remain OUT of the machine until just before it is initially started, when the burner can be operated for a while at the full combustion rate. This is essential to develop a corrosion-resistant film on the internal steel surfaces.

Job Data and Tools Required

- job specifications and job sheets, including list of applicable design temperatures and pressures
- machine assembly and field layout drawings
- controls and wiring drawings
- 16DF Installation Instructions and burner manual
- mechanic's hand tools
- absolute pressure gage or water-filled wet-bulb vacuum indicator graduated with 0.1-in. (2-mm) of mercury increments. *Do not use manometer or gage containing mercury.*
- auxiliary evacuation pump, 5 cfm (2.5 L/s) or greater, with oil trap, flexible connecting hose, and connection fittings
- compound pressure gage, 30-in. vacuum to 30 psig (75-cm vacuum to 200 kPa)
- digital volt-ohmmeter and clamp-on ammeter
- leak detector

Inspect Field Piping — Refer to the field piping diagrams and inspect the chilled/hot water and cooling water piping. (See Fig. 28 for typical piping arrangement.)

1. Verify location and flow direction of the water lines as are specified on the drawings.
2. Check that all water lines are vented and properly supported to prevent stress on water box covers or nozzles.
3. Make sure all water box drains are installed.
4. Ensure that water flow through the evaporator and condenser meet job requirements. Measure the pressure drops across both cooler and condenser water tube bundles when the system has been charged with water and the pumps can be operated.
5. Make sure chilled/hot water temperature sensors are installed in the leaving and entering chilled/hot water piping. Also check that appropriate thermometers or temperature wells and pressure gage taps have been installed in both entering and leaving sides of the evaporator, absorber, and condenser water piping.

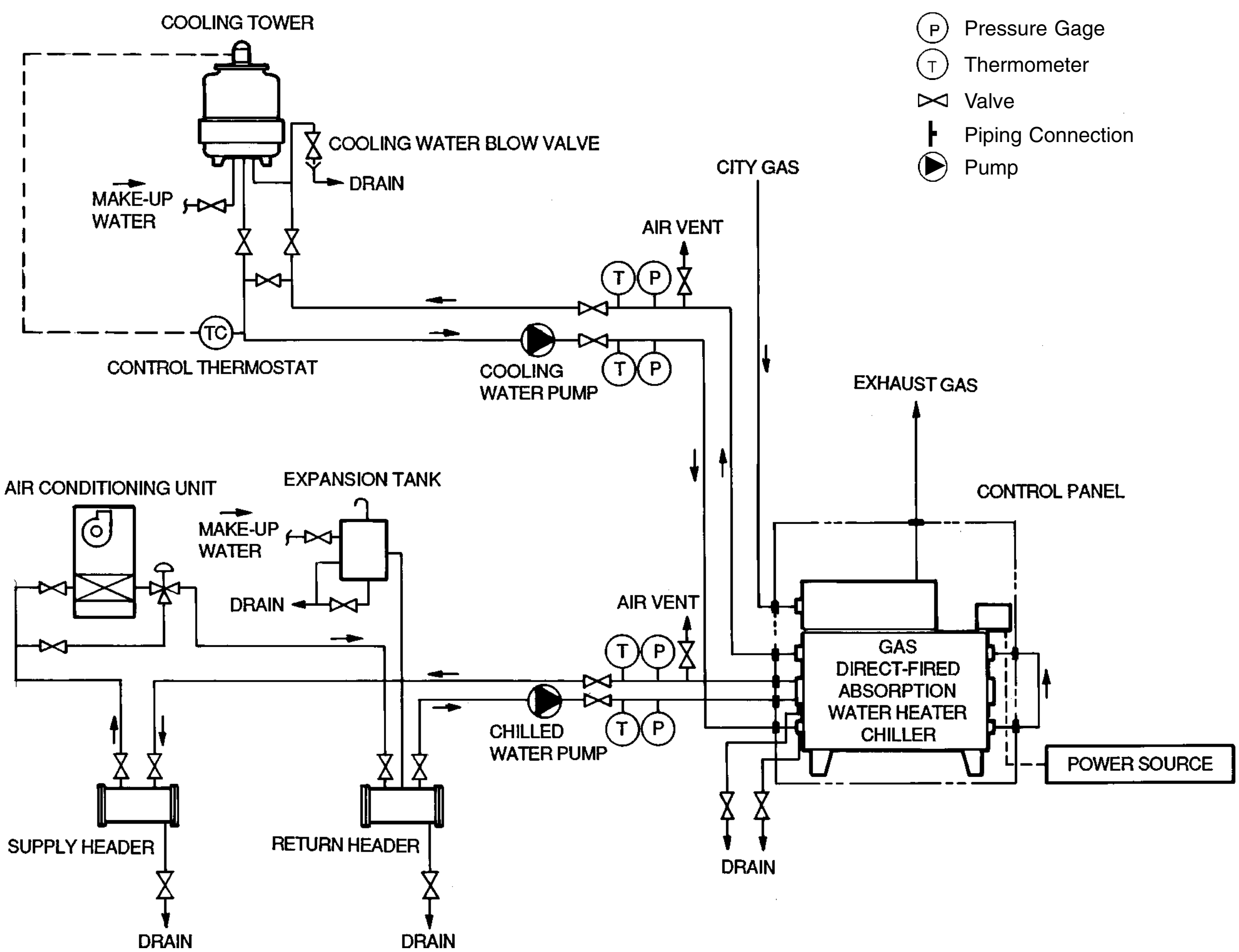
Inspect Field Wiring — Refer to the field and machine wiring diagrams and inspect the wiring for both power supply and connections to other system equipment (cooling tower, water supply pumps, auto. start if used, etc.).

⚠ CAUTION

Do not connect or disconnect any wiring, and do not touch any bare wires or wiring terminals unless power supply disconnects have been locked open and tagged.

Do not apply power to hermetic pumps or attempt to start the machine until it has been charged with lithium bromide solution and refrigerant at initial start-up. The pumps will be severely damaged if rotated without the full liquid charge. Open disconnects in control panel if power is to be applied.

1. Examine wiring for conformance to job wiring diagrams and applicable electrical codes.
2. Check pump and motor nameplates and control panel for agreement with supply voltage and frequency (hertz).
3. Verify correct overload and fuse sizes for all motors.
4. Check that electrical equipment and controls are properly grounded in accordance with applicable electrical codes.
5. Make sure customer/contractor has verified proper operation of water pumps, cooling tower fan, and associated auxiliary equipment. This includes ensuring that motors are properly lubricated and have correct electrical power supply and rotation.



NOTE: See manufacturer's burner manual for fuel line components.

Fig. 28 — Typical Piping and Wiring

Inspect Machine Controls — Visually inspect components in machine and burner control panels, automatic valves and positioners, and sensors for physical condition and secure mounting. Also be sure all wiring connections are correct and tight. See Fig. 2-4 for machine component and sensor locations, and Fig. 10 for control panel component identification and location. See the manufacturer's burner manual for burner component locations.

The purpose of the following checkout procedure is to ensure that the controls have not been affected by shipping or installation damage or altered in the process of making field wiring connections.

⚠ CAUTION

The temperature and pressure limit controls have been calibrated and precisely adjusted at the factory. Do not attempt to readjust them unless they are not operating properly.

Follow the checkout sequence in detail. It will be done before the machine has been charged with solution and refrigerant. The pump motors must not be powered at this time.

Control circuit wiring and switch continuity and component on/off status can be checked with a voltmeter while the control circuit is energized, with the meter set up for 24 v dc.

PREPARATION

1. Open the control panel and place the circuit breakers and dc power supply switch in the OFF position to deenergize the circuits.
2. Disconnect wiring leads for the solution pump motor and refrigerant motor at the secondary side (motor side) of the starter terminals. *Mark each wire for proper identification at reinstallation,* and wrap the ends of the disconnected wires with electrical tape.
3. Close all manual fuel valves, and disconnect oil pump drive (if used).
4. Place temporary jumper wires at the switch terminals (not at the control panel terminals) of limit controls which are normally closed during operation, but would be open during this pre-start test:
   a. Chilled/hot water flow switch;
   b. Cooling water flow switch, if used;
   c. High-temperature generator low solution level electrode; and,
   d. Fuel gas low-pressure switch.
5. Remove fuses from starters for chilled/hot water pump motor, condensing water pump motor, and tower fan motor so these motors will not operate during this check-out test. Starters for these motors are field supplied and are not located in the machine control panel.

CHECK COOLING CYCLE START

1. Place the control panel circuit breakers and dc power supply switches in the On position to energize the control circuits. The status display on the front of the machine control should read ''000''.
2. Place the switches on the inside of the machine control panel door in the positions described in Table 11.
3. Place the burner control panel switches in the positions described in Table 12.
4. Depress the Start button momentarily to start the control circuit. The microprocessor will initiate the timed starting and system checks sequence. As it progresses through the sequential component start cycle, the control panel status indicator will display ''CPO'', then ''CPF'' or ''CPP''. The normal start sequence is explained in Typical Control Sequence, Machine Controls section, page 25.

   If a system problem occurs, the fault category will be displayed on the control panel status indicator and the alarm buzzer will sound. If so, note the fault code and depress the Stop button momentarily to silence the buzzer and reset the control system. The fault codes are listed in Abnormal Shutdown, Machine Controls section.

Table 11 — Cooling Cycle Start, Machine Control Panel Switch Positions

SWITCH		SELECTIONS	POSITION
Symbol	Name		
TS-2	Dilution valve	Auto.-Manual	Auto.
TS-3	Select cool/heat	Cool-Heat	Cool
TS-4	Capacity control valve	Open-Neutral-Close	Neutral
TS-5	Capacity control valve	Auto.-Manual	Auto.
TS-6	Operation control	Local-Remote	Local

Table 12 — Cooling Cycle Start, Burner Control Panel Switches

SWITCH	SELECTIONS	POSITION
Operation control	On-Off	Off
Fuel selection (when appropriate)	Gas-Oil	Gas
Firing rate mode	Auto.-Manual	Auto.
Firing rate control	Open-Stop-Close	Stop

CHECK HERMETIC PUMP STARTERS AND SHUTDOWN CYCLE

1. Make sure the solution and refrigerant pump starters are energized (relay pulled in to close the starter contacts).
2. Depress the Stop button momentarily. Verify that the refrigerant pump starter deenergizes immediately, and the dilution valve is energized.
3. Verify that the solution pump starter and dilution valve deenergize after about 15 minutes, and the status indicator shows ''000''. The remaining time of the dilution period will be displayed in minutes on the status indicator when the Stop button is depressed during the shutdown period.

CHECK HERMETIC PUMP MOTOR OVERLOADS

1. Depress the Start button to restart the control circuit.
2. After the start cycle has completed, push the trip bar on the solution pump starter overload. Both pump starters will deenergize, the alarm buzzer will sound, and an ''E04'' fault code will be displayed.
3. Press the Stop button to silence the alarm and the starter reset button to reset the overload. Press the Start button after the shutdown cycle has completed to restart the control circuit.
4. After the start cycle has completed, push the trip bar on the refrigerant pump starter overload. The refrigerant pump starter will deenergize, the alarm buzzer will sound, and an ''E04'' fault code will be displayed. The machine will proceed through a normal dilution shutdown cycle.
5. Press the Stop button to silence the alarm and the starter reset button to reset the overload.

CHECK BURNER INTERLOCKS

1. Depress the Start button to restart the control circuit.
2. Place burner operation control switch to ON. The burner blower should start and the ignition sequence begin. Because the fuel valves are closed, at the end of the ignition trial period the burner alarm light will illuminate, the machine alarm buzzer will sound, and an ''E08'' fault code will be displayed.
3. Depress the reset switch on the combustion controller in the burner control panel and the machine Stop button to silence the alarm.
4. Place burner operation control switch to OFF to prevent a restart.

CHECK LOW CHILLED WATER TEMPERATURE CUTOUT

1. Place low chilled water temperature cutout sensor bulb with a thermometer in a cool water bath not colder than 45 F (7 C).
2. Depress Start button to start control circuit.
3. Slowly stir in ice to chill the water, and note the temperature. The low chilled water temperature cutout is factory set to shut the machine down at about 39 F (4 C), and will display a fault code of ''E01''.
4. Depress the Stop button to silence the alarm, and return the sensor bulb to its well in the chilled water outlet pipe. The switch will reset automatically when the sensor warms 13° F (7° C).

CHECK HEATING CYCLE START AND STOP

1. While the control operation is off, place the TS-3 select cool/heat switch (located on the inside of the control panel door) in the HEAT position.
2. Depress the Start button momentarily to begin the timed starting and system checks sequence. As it progresses through the sequential component start cycle, the control panel status indicator will display ''APO'', then ''HPO''. The refrigerant pump, condensing water pump, and tower fan are not used for heating operation.
3. Depress the Stop button momentarily. Verify that the solution pump starter deenergizes after a period of approximately 15 minutes and the status indicator shows ''000''.

CHECK WATER FLOW SWITCHES

1. Place the dc power supply switch in the OFF position to deenergize the control circuit.
2. Remove the test jumper wire from the chilled/hot water flow switch terminals.
3. Place the dc power supply switch in the ON position to energize the control circuit. Depress the Start button momentarily to start the control start sequence. Within about 20 seconds, the alarm buzzer will sound and the ''E02'' fault code will be displayed.
4. Depress the Stop button momentarily to silence the alarm.
5. Place the dc power supply switch in the OFF position to deenergize the control circuit.
6. Reconnect the temporary jumper wire on the flow switch terminals.
7. Repeat Steps 2 through 6 with the cooling water flow switch, if used, for an ''E03'' fault code after about 40 seconds.

CHECK HIGH-STAGE GENERATOR LOW SOLUTION LEVEL SWITCH

1. Remove the test jumper wire from the low solution level electrode on the high-stage generator.
2. Place the dc power supply switch in the ON position to energize the control circuit. Depress the Start button momentarily to start the control start sequence. After about one minute, place the burner operation switch in RUN. The burner should not start.
3. Depress the Stop button momentarily to stop the control sequence.
4. Place the dc power supply switch in the OFF position to deenergize the control circuit.
5. Reconnect the temporary jumper wire on the electrode terminals.

CHECK HIGH COMBUSTION TEMPERATURE SWITCHES

1. Place the dc power supply switch in the ON position to energize the control circuit.
2. Depress the Start button momentarily to start the control start sequence. After about one minute, turn the set point adjustment knob on the exhaust gas high-temperature switch down to a setting below ambient temperature. The alarm buzzer will sound and the ''E06'' fault code will be displayed.
3. Depress the Stop button momentarily to silence the alarm.
4. Reset the set point knob to the normal limit setting at 572 F (300 C).
5. Repeat Steps 2 through 4 with the fire tube high-temperature switch.
6. Repeat Steps 2 and 3 with the refractory high-temperature switch.
7. Reset the set point knob to the normal limit setting of 1472 F (800 C).

CHECK HIGH-STAGE GENERATOR TEMPERATURE SWITCH — The switch is factory set to open on a rise in temperature above 338 F (170 C) and close on a cooling below 325 F (163 C). Verify the approximate scale position setting (338 F [170 C]) and closed switch contacts. The switch range is 122 to 608 F (50 to 320 C).

NOTE: The switch operation setting cannot be easily checked in the field. It requires a precise scale adjustment, so do not reposition if not necessary.

CHECK HIGH-STAGE GENERATOR PRESSURE SWITCH — The switch is factory set to open on a rise in pressure above -8 in. Hg (-20-mm Hg G) and close with a reduction in pressure below -8 in. Hg (-205 mm Hg G). Verify the approximate scale position setting (-0.8 in. Hg [-20 mm Hg G]) and closed switch contacts. The switch range is -20 in. Hg (-500 mm Hg G) to 85 psig (6 kg/cm^2).

NOTE: The switch operation setting cannot be easily checked in the field without breaking machine vacuum. It requires a precise scale adjustment so do not reposition if not necessary.

RESTORATION

1. Place the control panel circuit breakers and dc power supply switch in the OFF position to deenergize the circuits. *Open and tag power supply disconnects to machine control panel.*
2. Reconnect the wiring leads for the solution pump motor and refrigerant pump motor according to the identification markings applied during the test preparation.
3. Remove jumper wires from flow switch(es), high-temperature generator low solution level electrode, and fuel gas low-pressure switch.
4. Replace fuses in starters for chilled/hot water pump motor, condensing water pump motor, and tower fan motor.

Burner System — Check the following combustion system items against field piping and wiring drawings and the burner manual instructions:

GENERAL

1. Burner is installed in accordance with applicable installation instructions.
2. Three-phase motor(s) have been properly wired and checked for proper rotation.
3. Control wiring connections to the machine control center have been completed and are accurate according to the machine wiring diagrams.
4. All combustion controls and safeties have been properly wired and are functional.
5. The exhaust stack and the boiler breeching connections have been completed and they are open and unobstructed.
6. Provisions have been made to supply adequate combustion air.

GAS FIRING

1. All gas train components have been installed and have been properly selected, sized, and assembled. No Teflon tape has been used on pipe threads (loose tape can cause valve leakage and is a safety hazard).
2. Properly sized vent lines have been installed on all gas train components that require venting. These include such items as pressure regulators, normally open vent valves, diaphragm valves, low and high gas pressure switches, etc.
3. Piping and components have been leak tested and proven gas tight, and the gas line has been purged.
4. The required gas pressure is available at the inlet to the gas train.

OIL FIRING

1. The oil tank has been installed and filled with the correct type of oil, and there is absolutely no water in the tank.
2. The oil supply and return lines have been properly sized and installed to meet the maximum capacity of the pump, and the system has been leak tested and purged. No Teflon tape has been used on connection threads (loose Teflon tape can cause valve leakage and is a safety hazard).

Standing Vacuum Test — Before machine is energized or placed in operation, check for air leaks with a standing vacuum test. Examine the test procedures described below and select the one that applies to your job situation.

LONG INTERVAL TEST — Use this test procedure if an absolute pressure reading has been recorded at least 4 weeks previously and the reading was not more than 1 in. (25 mm) of mercury.

1. Connect an absolute pressure gage to the absorber gage valve and record the pressure reading. (Do not use mercury gage.)
2. If the pressure has increased by more than 0.1 in. (2.5 mm) of mercury since the initial reading, an air leak is indicated. Leak test the machine as described in the Maintenance Procedures section, page 46, then perform the short interval test which follows.

SHORT INTERVAL TEST — use this test procedure if:

1. No previous absolute pressure readings have been recorded, OR
2. Previous absolute pressure reading was made less than 4 weeks ago, or reading indicated a machine pressure of more than 1 in. (25 mm) of mercury, OR
3. Machine had to be leak tested after long interval test.

<u>Procedure</u>

1. Connect absolute pressure gage to absorber gage valve and record pressure reading.
2. If the reading is more than 1 in. (25 mm) of mercury absolute, evacuate the machine as described in the Maintenance Procedures, Machine Evacuation section, page 48.
3. Record the absolute pressure reading and the ambient temperature.
4. Let machine stand for at least 24 hours.
5. Note the absolute pressure reading when ambient temperature is within 15° F (8° C) of the ambient temperature recorded in Step 3.
6. If there is any noticeable increase in pressure, an air leak is indicated. Leak test the machine as described in Maintenance Procedures section, page 46, then repeat short interval vacuum test to ensure results.

Machine Evacuation — When machine absolute pressure is greater than 1 in. (25 mm) of mercury absolute, machine must be evacuated as described in Maintenance Procedures, Machine Evacuation section, page 48.

INITIAL START-UP

Job Data and Tools Required

- reference information and tools listed under Before Initial Start-Up, page 32
- hydrometer(s) — specific gravity range 1.0 to 2.0
- thermometer set — range 30 to 300 F (0° to 150 C)
- liquid charging hose consisting of flexible ¾-in. (20-mm) hose connected to a 3 ft (1 m) long x ½-in. (15 mm) pipe trimmed at a 45-degree angle at one end, with a ½-in. MPT connector.

⚠ CAUTION

Follow the start-up sequence in detail and in the order described. To ensure the quick, even formation of a solid protective film on the internal steel surfaces, and particularly in the high-temperature direct fired generator, the burner must be operated at the full firing rate for an extended period within one day after the refrigerant and lithium bromide have been charged into the machine. A vacuum pump also must be in operation during the entire charging and start-up period. This protective film is required to prevent local corrosion in the machine during normal operation.

Also do not apply power to hermetic pumps or attempt to start the machine until it has been charged with lithium bromide solution and refrigerant. The pumps will be severely damaged if rotated without the full liquid charge.

Noncondensable Evacuation — Connect a vacuum pump with an oil trap to the absorber evacuation valve as described in the Maintenance Procedures section, page 46. A cold trap should be used to improve the pump capacity and to minimize the need for frequent replacement of the pump oil charge because of water vapor contamination. The suction vacuum of the pump should be checked with a deep vacuum gage both initially and periodically while the pump is in use to be sure that it is below 0.1 in. Hg (2.5 mm Hg) absolute.

The vacuum pump must be in operation continuously while the refrigerant and lithium bromide solution are charged into the machine. The evacuation should then be continued for at least one additional hour to be sure any air which might have entered the machine has been removed. The refrigerant and solution pumps must remain off to prevent damage to them until the liquids have been fully charged, but then must be operated during the evacuation period following the charging to separate any entrained air from the liquids.

The vacuum pump also must be used during the initial high fire run in period, typically lasting 3 to 5 days. This is to remove noncondensables which are generated during initial start-up, occasionally at a rate greater than can be transferred by the machine's hermetic purge alone.

Solution and Refrigerant Charging

⚠ WARNING

Lithium bromide and its lithium chromate inhibitor can irritate the skin and eyes. Wash off any solution with soap and water. If solution enters the eye, wash the eye with fresh water and consult a physician immediately. Lithium bromide is a strong salt solution; do not syphon by mouth.

Liquid materials that are added to lithium bromide solution such as lithium hydroxide, hydrobromic acid, octyl alcohol, and lithium chromate inhibitor, are classified as hazardous materials. These materials, and any lithium bromide solution they are in, must be handled in accordance with Occupational Safety and Health Administration and Environmental Protection Agency regulations.

HANDLING LITHIUM BROMIDE SOLUTION — Solutions of lithium bromide and water are nontoxic, nonflammable, nonexplosive, and can easily be handled in open containers. The solution is chemically stable and does not undergo any appreciable change in properties even after years of use in the absorption machine. Its general chemical properties are similar to those of table salt.

IMPORTANT: Because lithium bromide salt can corrode metal in the presence of air, wipe off any solution spilled on metal parts or tools and rinse the part with fresh water as soon as possible. After rinsing, coat the tools with a light film of oil to prevent rust. After emptying metal containers of solution, rinse the container with fresh water to prevent corrosion. Immediately wipe or flush the floor if lithium bromide or octyl alcohol is spilled on it.

Lithium bromide for absorption machine use should be kept only in the original container or in a completely clean container. Used lithium bromide solution should be disposed of by a reputable chemical disposal company.

The total charge of lithium bromide solution and distilled or softened water must be available on site before any is charged into the machine. This is to be sure the charging process and initial start-up can continue uninterrupted. The nominal volumes are shown in Table 13.

NOTE: The 16DF machine uses 55% concentration of lithium bromide solution, with different properties than the 53% concentration solution used in single-effect absorption chillers.

CHARGING SOLUTION — Solution must be charged separately into both the high-temperature generator and the absorber, while the hermetic pumps remain off. The should be done very soon before the burner is to be started, and no more than one day before initial burner operation. To minimize chance of air entering the machine, the solution should *not* be drawn directly from a small container. The vacuum pump should remain in operation continuously while the solution is being charged into the chiller.

1. Fully close the cooling/heating selection valve in the lower part of the evaporator.
2. Connect a flexible hose to a ½-in. MPT adapter and a ½-in. pipe. The pipe should be longer than the height of the solution container. Fill both pipe and hose with water to minimize any air entry into the machine.
3. Insert the ½-in. pipe into the container (be sure it goes to the bottom) and connect the flexible hose to the drain valve (valve K), at the bottom of the high-temperature generator (Fig. 29).

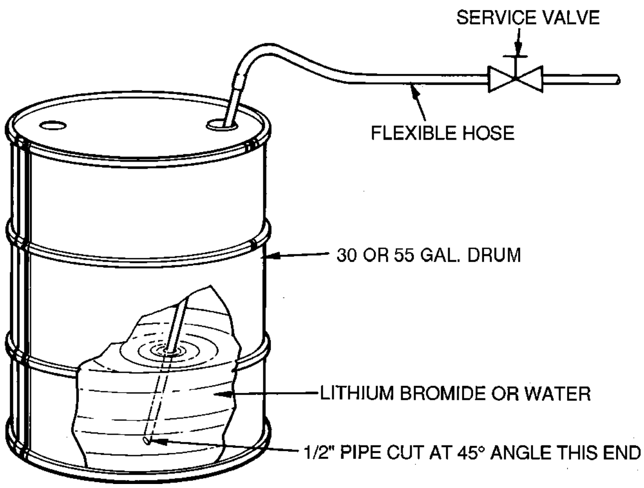


Fig. 29 — Charging Solution and Refrigerant

4. Open the drain valve. Continue charging until solution level is near bottom of container and quickly close the valve. *Do not allow air to be drawn into machine.*
5. Repeat with other containers as required until the amount specified in Table 13 has been charged into the high-temperature generator.
6. Disconnect the hose from the generator drain valve, fill the hose and pipe with water, and reconnect the hose to the solution pump service valve.
7. Repeat previous steps, until the remaining solution charge specified in Table 13 has been charged into absorber.
8. Remove the hose and immediately continue with the refrigerant charging.

INITIAL REFRIGERANT CHARGING — The refrigerant charge must be either distilled or softened water. Do not use tap water without first having it deionized or tested for the following requirements:

pH	7.0 ± 0.2 at 77 F (25 C)
Hardness $CaCO_3$	2.0 ppm or less
Silica	0.2 ppm or less
Ammonia NH4 +	None
Specific Resistance	5 x 10 to the fifth ohms/cm at 77 F (25 C)

To charge refrigerant into the evaporator, fill clean solution containers with the distilled or softened water. Charge the water through the refrigerant pump service valve, following the appropriate steps in Charging Solution section, above.

Charge in at least the amount listed in Table 13 under Initial Refrigerant amount. This charge must be adjusted after start-up to achieve optimal refrigerant overflow conditions to limit the maximum solution concentration (which prevents solution crystallization). However, any extra refrigerant charge should be limited because the normal refrigerant pump discharge pressure is below atmospheric pressure and a vacuum bottle is required to remove refrigerant (see Refrigerant Charge Final Adjustment section, page 40).

When the solution and refrigerant charging has been completed, power up the control circuit, turn on both hermetic pumps, and operate the vacuum pump to remove any noncondensables.

Table 13 — Nominal LiBr Solution and Refrigerant Charges

UNIT 16DF SIZE	TOTAL LiBr		HIGH-TEMPERATURE GENERATOR LiBr		INITIAL REFRIGERANT	
	Gal.	Kg	Gal.	Kg	Gal.	Kg
013,015	166	1015	83	508	60	240
018,020	211	1295	106	648	88	350
023,025	257	1575	129	788	100	400
028,032	349	2135	175	1068	125	500
036,040	423	2590	212	1295	143	570
045,050	514	3150	257	1575	116	460

Operational Controls Check and Adjustment —

Functional check and adjustment of the machine controls is to be done immediately after the solution and refrigerant have been charged into the machine, and just before the initial combustion heat-up period. If possible, the controls check should be done on the cooling operation to verify the operation of all controls and pumps.

PREPARATION

1. Supply control power to the machine control panel. Close TS-1 control panel circuit switch and the control panel circuit breakers. The status indicator on the front of the control panel should display ''000''.
2. Verify that chilled/heating and cooling water circuits are filled and operative, and that the pumps are powered. For manual system operation, start the chilled/heating water pump. With cooling operation, also start the cooling water pump and cooling tower fan.
3. Place the machine control panel switches in the following positions:
   a. TS2 dilution valve at AUTO.;
   b. TS3 select cool/heat switch on either, but preferably on COOL;
   c. TS5 capacity control switch at AUTO.; and,
   d. TS6 operation switch at LOCAL.
4. Place the burner on/off switch in OFF until the machine controls have been checked out.
5. Depress the Start button. For cooling, the status indicator will display ''CPO'' and then ''CPF'' and all pumps should start. For heating it will display ''HPO'' and only the solution and heating water pumps will operate. The burner should remain off at this time.

WATER PUMP STARTERS AND OVERLOADS

1. Starters for chilled/heating water and cooling water pump motors should be checked individually according to the manufacturer's instructions. When the pump motor trips out, the machine will shut down on the dilution cycle, the alarm buzzer will sound, and the status indicator will display the ''E02'' fault code for the chilled/hot water pump and ''E03'' for the condensing water pump (cooling only).
2. Depress the Stop button to silence the buzzer and reset the machine control. Reset the overloads. Depress the Start button to restart the machine.

HERMETIC PUMP ROTATION

1. Confirm that the solution and refrigerant pump starters are energized and the pump motors are running.
2. Install a compound pressure gage on the refrigerant pump service valve.
3. Open the valve and record the refrigerant pump discharge pressure. Close the valve. Also notice any pump sound. Depress the Stop button.

   NOTE: The solution pump starter trip bar can be depressed to bypass the shutdown dilution cycle.
4. Open the main disconnect switch (MCB1) and reverse any 2 motor power leads on the secondary side of the refrigerant pump starter.
5. Close the main disconnect switch and depress the Start button to restart the machine and pumps.
6. Repeat Step 3. Compare the 2 discharge pressures. Use the power lead arrangement that produced the higher discharge pressure and least noise.
7. Repeat Steps 2 through 6 for the solution pump.

Initial Combustion — Combustion must be started within one day after the solution and refrigerant have been charged into the machine. To establish the internal protective film, the burner must be operated for several days at the maximum firing rate, as soon as the machine controls have been checked out. It may be necessary to induce an artificial load for the chilling/heating water, or to carefully raise the leaving cooling water temperature if on cooling operation.

Start the burner while the machine is in operation, according to start-up instructions in the separate burner manual. The burner and fuel system should have been checked previously according to the Before Initial Start-Up instructions, page 32. The firing rate control should be on MANUAL to hold at the low fire position during the initial check. Use the burner manual positioning switches instead of the chiller/heater manual positioning switches for the initial burner tests.

⚠ DANGER

Do not operate the burner if there is any fuel leakage, or any known problems with the burner operating or safety controls, or if the flame is unstable.

Generally, the initial burner start should include the following:

1. Open only the pilot gas valve and place the burner switch at ON to initiate the pilot flame. Using the flame safeguard control run/test switch, hold the sequence at ignition trial to adjust the pilot, if necessary, and to verify the flame signal.

   NOTE: This switch also can be used to hold the sequence on pre-purge to make preliminary air damper linkage adjustments.
2. With the manual main fuel valve closed, release the flame safeguard to RUN. Safety shutdown and lockout will occur and the Alarm light will illuminate because of main flame failure. The machine control panel indicator will display the ''E08'' fault. Depress the machine Stop button to silence the alarm.
3. Depress the safety reset switch on the flame safeguard and the machine Start button to restart the chiller and burner. Open the main fuel valve during the ignition period. If the fuel line has not been completely purged of air, it may take repeated attempts to establish the main flame at low fire.
4. With the main flame held at low fire, measure the fuel rate, verify the flame signal, and take flue gas samples to check the fuel-to-air ratio.
5. Close the manual main fuel valve to verify flame failure sensing response. Safety shutdown and lockout will occur and the Alarm light will illuminate. The machine control panel indicator will display the ''E09'' fault. Depress the machine Stop button to silence the alarm.
6. Depress the safety reset switch on the flame safeguard and the machine Start button to restart the chiller and burner. Open the manual main fuel valve.
7. Manually increase the firing rate in increments and repeat Step 4 at each increase until the high firing rate is reached. Periodically check chilled/hot water temperature to be sure the burner heat input does not exceed the chiller/heater load.
8. If adjustments to the modulating air damper of fuel valve linkage or to the fuel pressure regulator(s) are necessary, make gradual changes and repeat Steps 4 and 7 after each change.
9. Switch the firing rate to AUTO. on the burner control panel, and use the machine control panel TS4 and TS5 capacity control switches to manually open and close the burner fuel valve and damper in order to verify chiller/heater control of the burner firing rate.

10. Place the burner on full AUTO. control and provide enough load on machine for continued operation at high fire for 3 to 5 days. Periodically check the weak solution concentration (see Solution or Refrigerant Sampling in Maintenance Procedures section, page 48) to be sure the strong solution is not approaching crystallization. It may be necessary to leave the TS2 dilution valve on MANUAL during cooling operation if there is not enough load for continued burner operation at high fire.

Add Octyl Alcohol — When the initial start-up is performed during cooling operation, add the amount of initial octyl alcohol specified in Table 14 before normal operation is started. When starting during heating operation, do not add the initial octyl alcohol charge until the machine is switched over to cooling.

Add the alcohol through the high-temperature generator drain valve according to the instructions under Adding Octyl Alcohol in the Maintenance Procedures section page 49, *do not allow air to be drawn into the machine.*

Table 14 —Octyl Alcohol Initial Charge

16DF	OCTYL ALCOHOL	
	Gal.	L
013,015	2	7.6
018,020	2	7.6
023,025	2	7.6
028,032	3	11.4
036,040	3	11.4
045,050	4	15.2

Initial Start Operation — When the initial combustion run-in period has been completed, normal operation may begin. Start machine following the procedures described in Operating Instructions section for Start-Up After Extended Shutdown, page 43. Evacuate the machine to remove noncondensables if the absorber loss is above 5° F (2.8° C). If the absorber loss is below 5° F (2.8° C), the machine may be placed in AUTO. control for normal operation.

Capacity Control Adjustments — The control set points for the leaving chilled water and hot water temperatures are factory set but may be adjusted, if necessary, according to the Automatic Capacity Control explanations in the Machine Controls section, page 31.

Refrigerant Charge Final Adjustment — The refrigerant charge final adjustment must be made to ensure that normal solution concentrations can be achieved for full capacity and that refrigerant overflow will occur with excessive solution concentrations to prevent crystallization. The adjustment should be made only when:

1. machine is operating on cooling with stable temperatures at 40 to 100% of full load;
2. absorber loss is 3° F (1.7° C) or less; and,
3. refrigerant specific gravity is 1.02 or less.

Proceed as follows:

1. Remove a solution sample from the solution pump service valve and measure the specific gravity and temperature.
2. Locate the intersection point of the specific gravity and temperature values on equilibrium diagram (Fig. 30A or 30B). Read down from this point to the solution concentration scale to determine the percent lithium bromide by weight in the weak solution.
3. Determine the approximate percent of full load on the machine by comparison of chilled water temperature spread and flow in relation to design. Enter Table 15 at this percent load and find the corresponding weak solution concentration required for refrigerant charge adjustment under nominal conditions.
4. Adjust machine operating conditions until machine operates *with stable temperatures* at either of the weak solution concentrations (±0.1%) listed in Table 15 under the selected percent load.

   To increase the concentration:

   a. Increase the load.

   b. Lower chilled water temperature (set point adjustment)

   c. Raise condensing water temperature (or reduce condensing water flow).

   After adjusting conditions, repeat Steps 1 and 2 to verify solution concentration.
5. Check the relative temperature of the evaporator refrigerant overflow pipe.

   a. If it is cold (about the same temperature as the refrigerant pump discharge), the machine may have too much refrigerant. Remove about 3.8 L (1 gal.) of water through the refrigerant pump discharge valve. Continue to remove water in 3.8 L (1 gal.) increments until the overflow stops. Wait about 10 minutes between reductions to allow for temperature changes to be noted. Refrigerant overflow will change machine operating conditions, so repeat Steps 1 through 4 periodically.

   b. If it is warm (close to ambient temperatures, the machine may have too little refrigerant. Add about 3.8 L (1 gal.) of water through the refrigerant pump service valve. *Do not allow air to be drawn into the machine.* Continue to add water in 3.8 L (1 gal.) increments until overflow just starts. Wait about 10 minutes between additions to allow for temperature changes to be noted.

Table 15 — Weak Solution Concentration For Refrigerant Charge Adjustment

PERCENT LOAD ON MACHINE	100	90	80	70	60	50	40
WEAK SOLUTION CONCENTRATION	60.0	60.4	60.8	61.2	61.6	61.9	61.2

Check Machine Shutdown — Press the Stop button to verify normal shutdown sequencing. The burner should drive to low fire and then stop. The machine will go through a dilution shutdown period and the pumps will stop according to the Typical Control Sequence for Normal Cooling Stop or Normal Heating Stop described in the Machine Controls section, page 28.

OPERATING INSTRUCTIONS

Operator Duties

1. Become familiar with absorption machine and related equipment before operating. See Introduction and Machine Description sections, page 3.
2. Start and stop machine as required.
3. Inspect equipment; make routine adjustments; maintain machine vacuum and proper refrigerant level; exhaust purge as required; check and maintain combustion system.
4. Keep log of operating conditions and recognize abnormal readings.
5. Protect system against damage during shutdown.

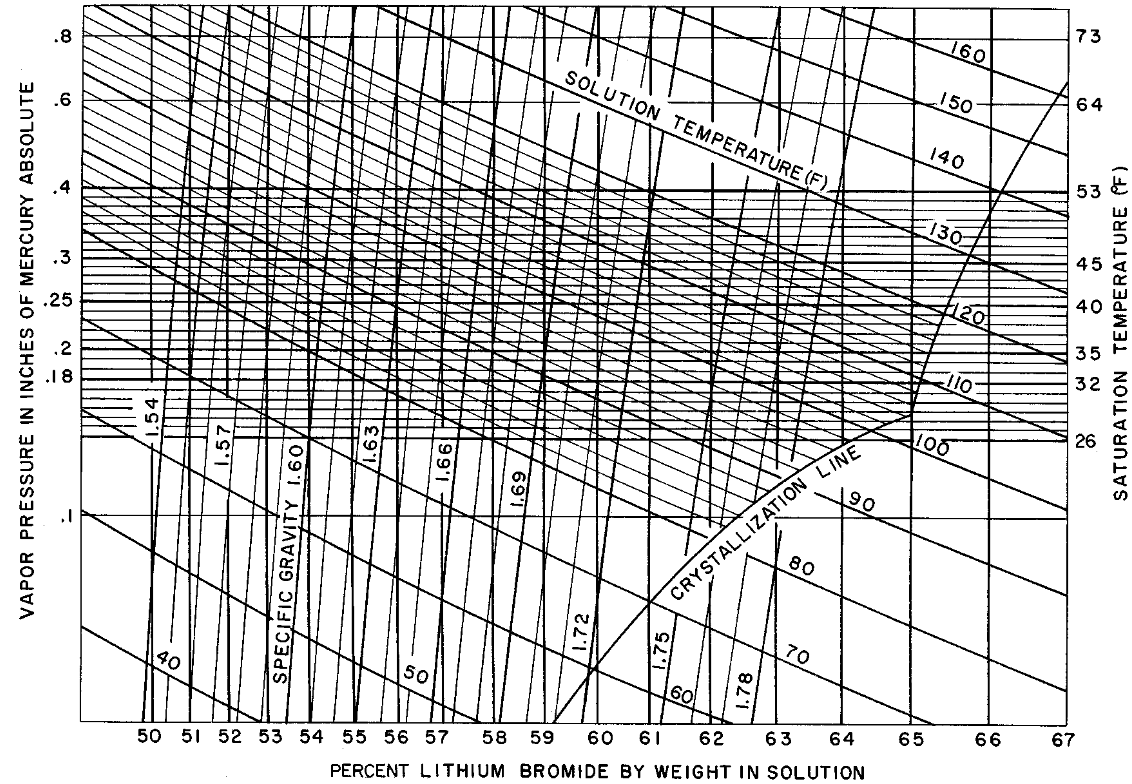


Fig. 30A — Equilibrium Diagram for Lithium Bromide in Solution (°F)

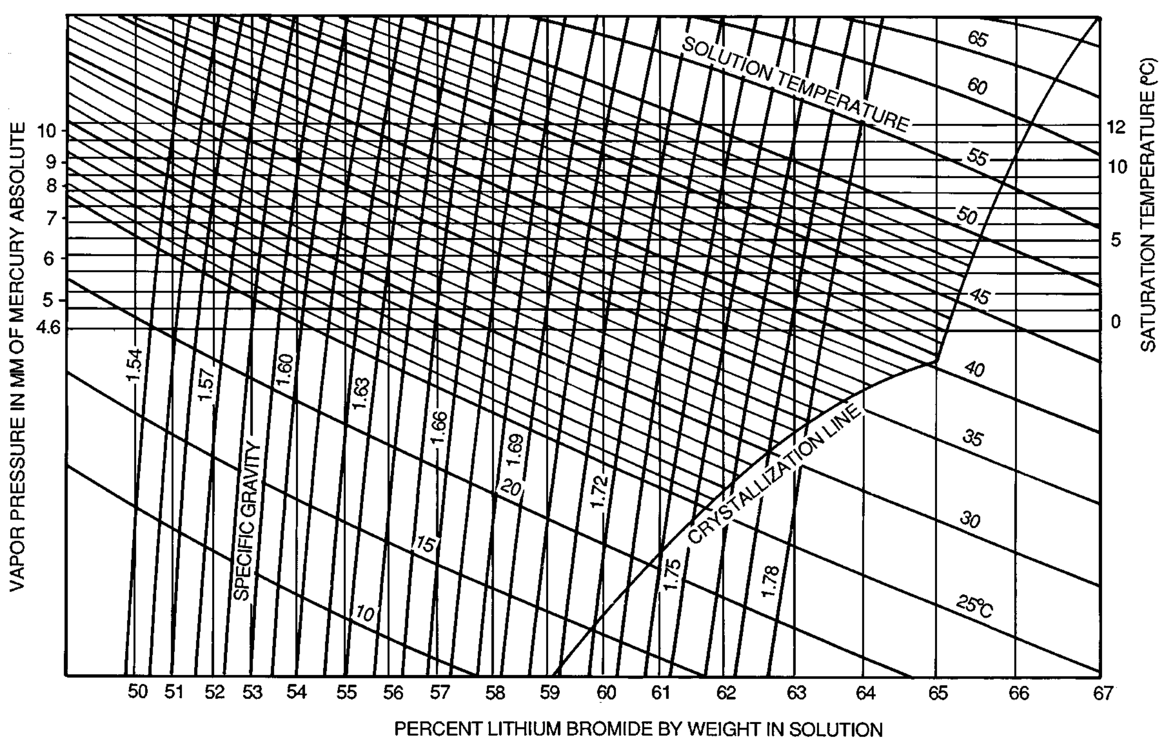


Fig. 30B — Equilibrium Diagram for Lithium Bromide in Solution (°C)

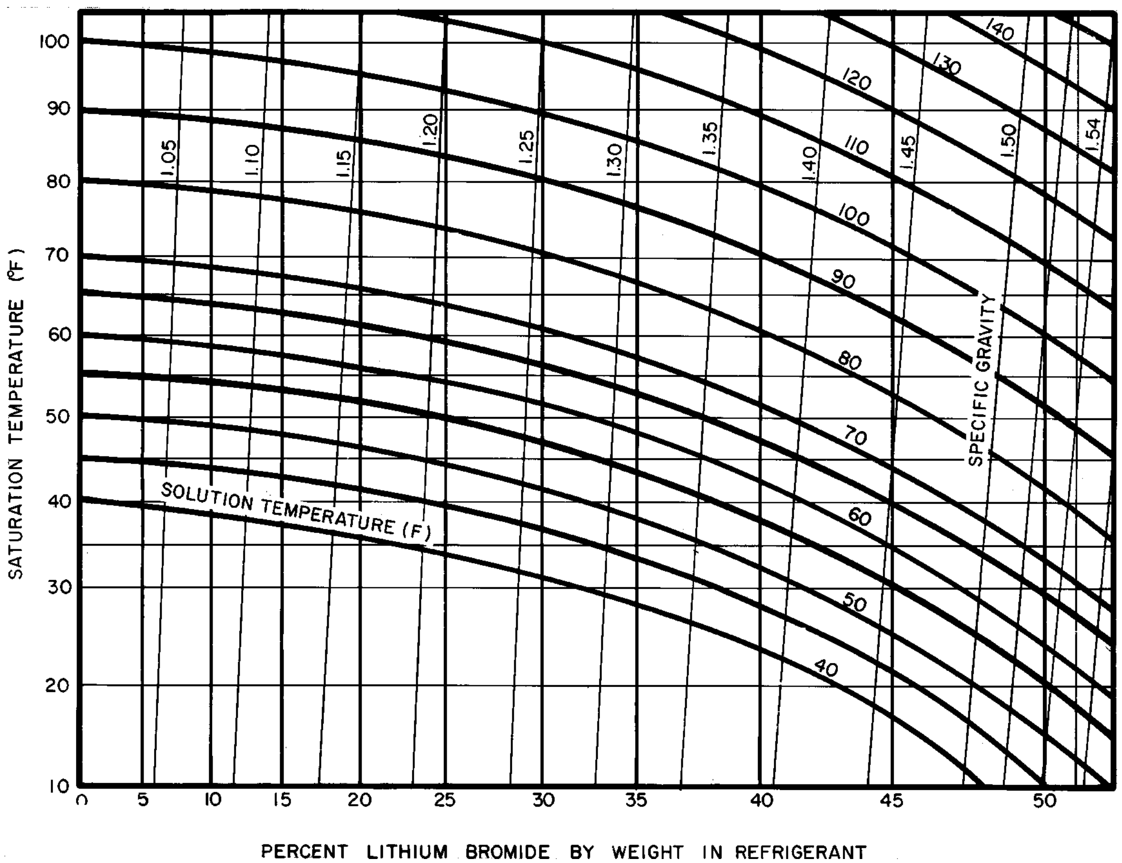


Fig. 31A — Equilibrium Diagram for Lithium Bromide in Refrigerant (°F)

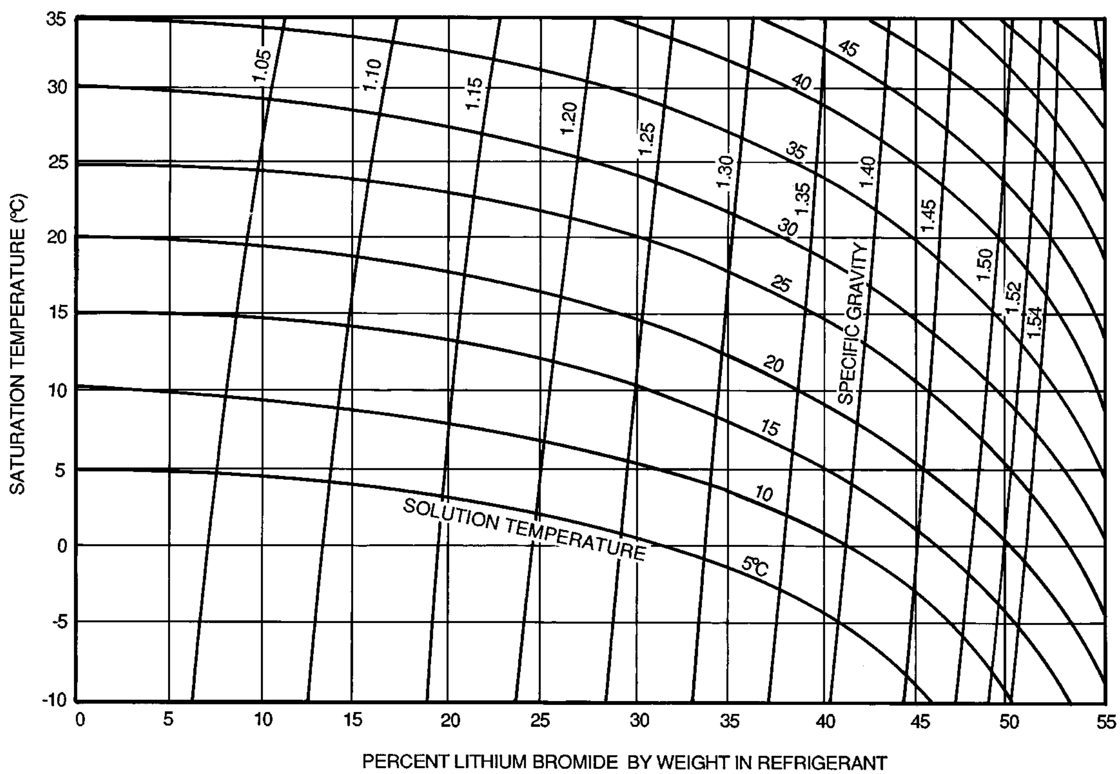


Fig. 31B — Equilibrium Diagram for Lithium Bromide in Refrigerant (°C)

Before Starting Machine — Be sure that:

1. Power is on to condensing water and chilled/hot water pump starters, cooling tower fan, and absorption machine control panel. Control panel status indicator should show ''000''.
2. Cooling tower has proper water level (cooling only).
3. Chilled/hot water circuit is full and valves are open.
4. Cooling water circuit is full and valves open for cooling operation, or drained for heating operation.
5. Fuel valves are open, fuel supply is available, and there are no leaks.
6. Air supply for burner is adequate and exhaust damper is open.
7. Controls and valves are adjusted for either cooling or heating operation.

Cooling/Heating Operation Changeover (Table 9) — Switch between cooling and heating cycles by using the following procedures. This can be done only when the chiller/heater is off. (See Machine Component Identification, Fig. 2-4, for valve locations.)

CHANGING FROM COOLING CYCLE TO HEATING CYCLE

1. Place changeover valves A and B in the FULLY OPEN position.
2. Drain all water in the cooling water piping.
3. Place the cooling/heating changeover switch (TS3) in the HEAT position.
4. Start the machine according to Start Machine section below.

CHANGING FROM HEATING CYCLE TO COOLING CYCLE

1. Place changeover valves A and B in the FULLY CLOSED position.
2. Fill the cooling water system and vent air from the piping.
3. Place cooling/heating changeover switch (TS3) in the COOL position.

IMPORTANT: Purge noncondensable gases that may have accumulated in the purge tank prior to each cooling and heating cycle operation with an auxiliary vacuum pump.

Start Machine — If machine has manual auxiliary start, first energize the auxiliaries (see Machine Controls, Start-Stop System, page 14).

Now follow one of the 2 procedures described below as it applies to your machine:

- Start-Up After Limited Shutdown — If machine has been shut down for less than 3 weeks
- Start-Up After Extended Shutdown — If machine has been shut down for 3 weeks or more

Heating Start-Up or Cooling Start-Up After Limited Shutdown — Place the manual switches in the positions indicated in Table 8 and depress the Start button. Machine should start in normal manner.

If, however, machine does not lower leaving chilled water temperature to design during cooling operation, noncondensables may be present. In this case, take an absorber loss reading (see Maintenance Procedures section, page 46).

If absorber loss is 5° F (2.8° C) or less, the chilled water temperature should drop to design within a short period as the automatic purge evacuates the machine. A completely evacuated machine normally has an absorber loss of 2° F (1° C) or less.

If absorber loss is greater than 5° F (2.8° C), follow the procedure for Cooling Start-Up After Extended Shutdown, below.

Cooling Start-Up After Extended Shutdown-(More Than 21 Days) — Start the machine in the normal manner by placing the manual switches in the positions indicated in Table 8, and then by depressing the Start button.

When refrigerant pump starts and solution is warm (strong solution approximately 100 to 130 F [38 to 55 C]), place burner control switch in LOW FIRE position.

Determine machine absorber loss (see Maintenance Procedures). If absorber loss is 5° F (2.8° C) or less, open capacity control valve by placing burner control switch in AUTO. position and allow machine to operate. The purge will evacuate the machine to the normal absorber loss of 2° F (1° C) or less.

If absorber loss is more than 5° F (2.8° C), evacuate machine to remove noncondensables that can prevent normal operation (see Maintenance Procedures section). An alternative procedure is to limit burner firing rate so that strong solution temperature remains below 140 F (60 C) while machine purge removes the noncondensables.

When absorber loss is reduced to 5° F (2.8° C) or less, place burner control switch in AUTO. position, and allow purge to establish the normal 2° F (1° C) or less absorber loss rate.

Start-Up After Below-Freezing Conditions — Refill all water circuits if previously drained. Then follow procedure for Cooling Start-Up After Extended Shutdown.

Remove solution from the refrigerant circuit by following the procedure, Removing Lithium Bromide from Refrigerant, in the Maintenance Procedures section, page 49.

Operation Check — The normal operation is shown in Fig. 32. Also note the following:

1. Check the combustion of the burner through the flame sight glass. The flame should be stable with no abnormal combustion noise.
2. There should be no safety device indications on the control panel status indictor.
3. All pumps should be operating normally. (Check for abnormal sounds.)
4. The refrigerant pump should start within 5 minutes after the chiller-heater is started. (The refrigerant pump is stopped in heating cycle.)
5. The status indicator shows ''CPF'', ''CPO'', or ''HPO''.

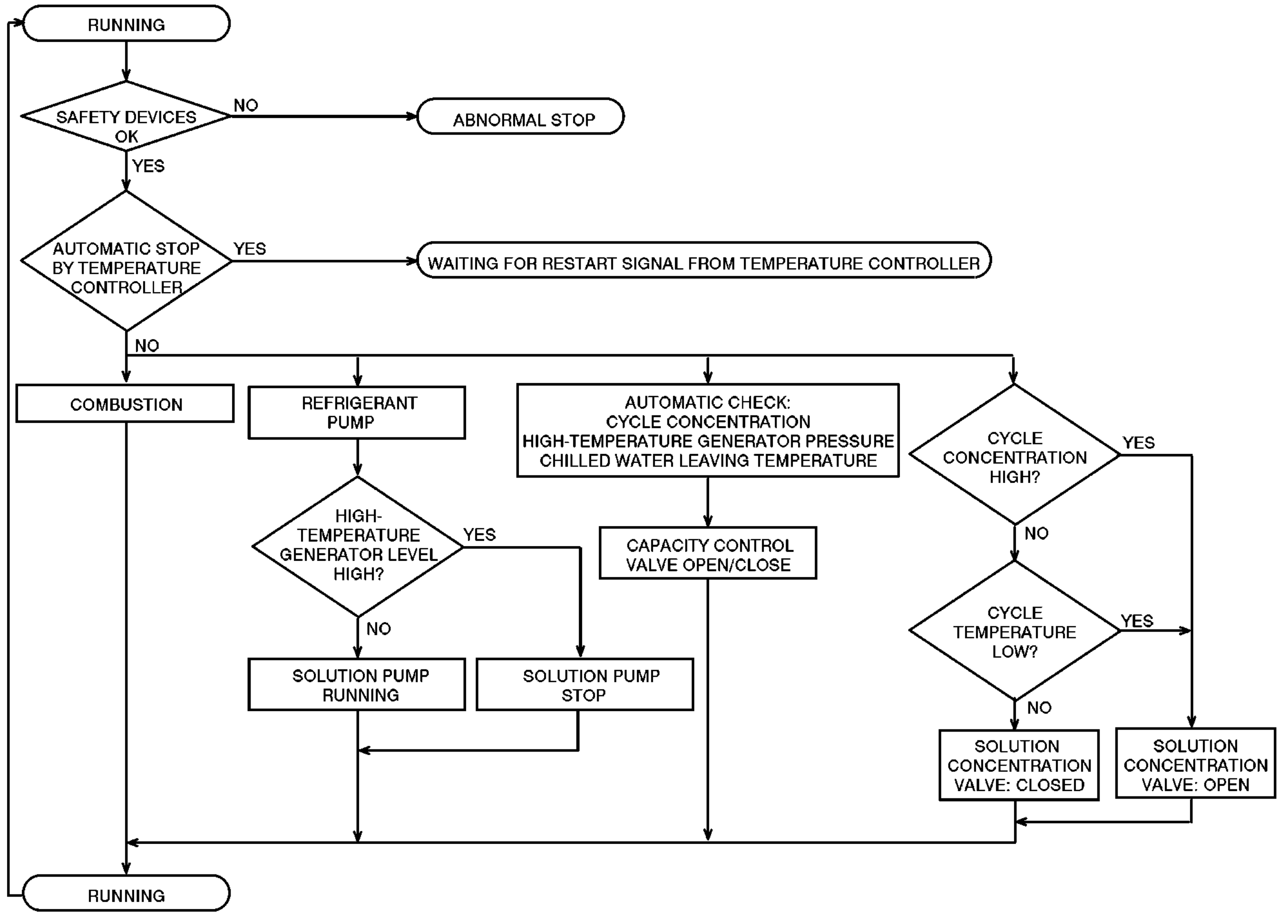


Fig. 32 — Normal Operation Flow Chart

Normal Shutdown Procedure (Fig. 25) — Depress the Stop button on the control panel. The operation status indictor will show ''dPP'' on cooling and ''dPO'' on heating during the machine shutdown cycle. The burner control will move to the LOW FIRE position and the burner combustion will then be shut off. After approximately 15 minutes of automatic dilution, the machine will shut down and the status indicator will show ''000''.

Do not stop the cooling/heating load or pumps during the dilution cycle. During this period the machine will have residual cooling or heating effect which must be dissipated by the load. Stopping the chilled water pump or cooling load during the cooling dilution cycle could cause freeze damage to the evaporator tubes.

Close the main fuel supply valve when burner combustion has stopped. Open the main circuit breaker (MCB) in the control panel when (but not until) the dilution cycle has stopped (status indicator shows ''000''). Leave the direct current power switch (TS1) ON to keep the circuit board powered. If the chilled/hot water pump, cooling water pump, and/or cooling tower fan are not interlocked with the chiller/heater controls, stop them when the first character on the status indictor shows ''0''.

NOTE: When the machine is stopped by automatic Start-Stop operation, leave the main fuel valve open, the panel main disconnect switch open, and the pumps and cooling tower in the ready-to-run state so the machine will be ready for automatic restart. The status indicator will show ''APO''.

Shutdown Below Freezing Conditions — Begin by shutting the machine down with Normal Shutdown Procedure.

Then transfer most of the refrigerant into the solution:

1. Turn the burner control switch to OFF and depress the machine Start button. Then depress the machine Stop button to start the dilution cycle.
2. Open the changeover valve ''B'' under the refrigerant tank to drain refrigerant into the absorber.
3. After about 10 minutes, close the changeover valve ''B''.
4. The machine will stop after a dilution period of about 15 minutes.

The refrigerant circuit requires special treatment to prevent freezing:

1. Fill a hose with water (to avoid letting air into the machine) and connect the hose between the solution pump and refrigerant pump service valves.
2. Push machine Start button (while burner control switch is still in the OFF position) to start the pumps.
3. Open both pump service valves for about 15 minutes. The solution pump discharge pressure is higher so solution will flow into the refrigerant circuit to provide antifreeze protection.
4. Depress machine Stop button, return the burner control switch to ON, open the control panel main circuit breaker (MCB), and remove the transfer hose.

Completely drain all water tube bundles and flush all tubes with an antifreeze chemical such as glycol.

Actions After Abnormal Shutdown (Fig. 26) — Abnormal stop occurs automatically when any of the safety devices sense a condition exceeding their normal safe operating limit. When this happens, the fuel valve is closed, the alarm buzzer sounds, and the machine shuts down. The cause of the safety shutdown will be displayed in code by the status indicator on the front of the control panel. These codes are listed in Table 16. In case of a burner or combustion failure, an alarm light on the burner control panel also illuminates.

Some safety conditions will close the fuel valve immediately, and others will first modulate the burner to the minimum firing position for a normal low fire shutdown. Also, most safety conditions will allow the normal shutdown dilution period but some will stop the machine immediately without dilution. The latter conditions should be corrected as quickly as possible to allow a restart or manual dilution before solution crystallization can occur. See Abnormal Shutdown in the Machine Controls section, page 29 for limit settings and shutdown action for each safety type.

Take the following actions after an abnormal shutdown:

1. Identify the problem from the control panel status indicator, and also from the burner control panel if it is a burner problem.
2. Depress the machine Stop button to silence the buzzer and to reset the control circuit for a restart *after* noting the failure code.
3. Correct the cause of the problem and restart the machine to be sure it operates normally. See Troubleshooting Guide, pages 54 - 56 for remedies. If shutdown occurred without adequate dilution, this should be done as soon as possible.

Table 16 — Safety Devices Status Indication Summary

INDICATION	CAUSE	SAFETY DEVICE
E01	Chilled water low temperature	Chilled water low temperature cutout
E02	Chilled/hot water low flow	Flow switch Chilled/hot water pump interlock
E03	Cooling water low flow	Optional Flow Switch Cooling water pump interlock
E04	Hermetic pumps overload	Solution pump thermal relay Solution pump coil thermostat Refrigerant pump thermal relay
E05	Generator high temperature or high pressure	High temperature generator pressure switch High temperature generator solution temperature sensor
E06	Exhaust gas high temperature	Exhaust gas high temperature thermostat Fire tube high temperature thermostat
E07	Absorber high temperature	Absorber solution temperature sensor
E08	Burner — no ignition	Burner flame detector and combustion controller
E09	Burner — misfire	Burner flame detector and combustion controller
E10	External limit device	External emergency stop switch Main power failure
E12	Chilled/hot water flow check	Flow switch, pump interlock
E13	High-temperature generator, solution high level	High-temperature generator solution level sensor
E17	Leaving chilled/hot water temperature	Chilled/hot water outlet temperature sensor
E18	Absorber solution temperature	Absorber solution temperature sensor
E19	High-evaporator generator, refrigerant temperature	High-temperature generator, refrigerant temperature sensor
E20	Entering chilled/ hot water temperature	Chilled/hot water inlet temperature sensor
E24	High-temperature generator, solution temperature	High-temperature generator, solution temperature sensor
E90	Insufficient dilution	Control circuit power failure

Actions After Power Interruption — If the control power is interrupted during operation, the chiller stops immediately without the normal shutdown sequence and dilution.

Solution crystallization can occur if the concentration is high (chiller was operating with a relatively large load). If so, depress the Start button to restart the machine as soon as possible after the power is restored. The machine will not restart automatically when power is recovered. If the chiller cannot be operated because of crystallization, follow the Solution Decrystallization instructions in the Maintenance Procedures section, page 53.

PERIODIC SCHEDULED MAINTENANCE

Normal preventive maintenance for 16DF absorption chiller/heaters requires periodic, scheduled inspection and service. Major items in the list below are detailed in the next section, Maintenance Procedures.

Every Day of Operation

1. Log machine and system readings.
2. Observe burner flame for changes.
3. Check for fuel and water leakage, vibration, abnormal temperatures, and unusual noise.

Every Month of Operation

1. Determine absorber loss (cooling only).
2. Check heating/cooling capacity control adjustment.
3. Check burner controls and linkage.
4. Check flame current and flue gas measurements.

Every 2 Months of Operation

1. Check low temperature cutout (cooling only).
2. Check dilution valve operation.
3. Check other limit and safety devices.
4. Clean flame detector and viewing windows as necessary.

Every 6 Months of Operation or Cooling/Heating Changeover

1. Check refrigerant charge (cooling only).
2. Check octyl alcohol (cooling only).
3. Exhaust purge.
4. Burner ignition test.
5. Have solution sample analyzed.

Every Year (At Changeover of Cooling/Heating Cycle or Shutdown)

1. Check tubes for scale and fouling.
2. Check/adjust temperature sensors.
3. Perform flame failure and pilot turndown tests.

Every 2 Years

1. Replace valve diaphragms.
2. Replace high-temperature generator level electrodes.
3. Check/replace palladium heater.
4. Check/replace flame detector.
5. Check thermostats and pressure switches; replace as necessary.

Every 5 Years or 20,000 Hours (Whichever Is Shorter)

1. Inspect hermetic pumps.
2. Filter or regenerate the solution
3. Check control motors, and replace as necessary.
4. Check burner controls, fan, valves, operators, and replace as necessary.
5. Check the float valve in the high-temperature generator.
6. Check and repair (as necessary) burner and fire tube return-end refractory.
7. Conduct nondestructive testing for all tubes, including fire tubes.
8. Check and clean strainers in solution piping (size 16DF028 and larger).
9. Check cooling/heating changeover valve and replace parts as necessary.

MAINTENANCE PROCEDURES

Log Sheets — Readings of machine and system pressure-temperature conditions should be recorded daily to aid the operator in recognizing both normal and abnormal machine conditions. The record also aids in planning a preventive maintenance schedule and in diagnosing machine problems. A typical log sheet is shown in Fig. 33.

Absorber Loss Determination — Take absorber loss readings when machine is operating with stable temperatures. *This is to be done only during cooling operation.*

1. Make sure that there has been no refrigerant overflow for at least 10 minutes before taking readings.
2. Fill thermometer wells on discharge lines of solution and refrigerant pumps with oil or heat conductive compound and insert thermometers.
3. Take refrigerant and solution samples (see Solution or Refrigerant Sampling, page 48), and determine the specific gravity and temperature of each sample.
4. Using Fig. 30A and B, plot the intersection point of the specific gravity and temperature of the solution sample. Extend this point horizontally to the right and read the saturation temperature.

   Repeat with refrigerant sample, using Fig. 31A and B, and reading to the left for saturation temperature. If it is known that there is no lithium bromide in the refrigerant, it is not necessary to take a refrigerant sample. In that case, the refrigerant saturation temperature is the same as the measured refrigerant pipe temperature.
5. Subtract the solution saturation temperature from the refrigerant saturation temperature. The difference is the absorber loss. Repeat the readings with a second sample to verify steady state conditions. If the absorber loss is greater than 5° F (2.8° C), machine evacuation is necessary because excessive noncondensables may interfere with normal operation before they can be removed by the purge (see Machine Evacuation section, page 48).

For probable causes and suggested remedies for high absorber loss, refer to the Troubleshooting Guide, pages 54 - 56.

Machine Leak Test — All joints welded at machine installation must be leak tested before initial start-up of machine. Joints must also be leak tested after repair. If there is any indication of air leakage, leak test the entire machine.

1. Be sure auxiliary evacuation valve, purge exhaust valve, and all service valves are closed.
2. Break machine vacuum with dry nitrogen. Pressurize machine to 4 psig (0.3 KgF/cm^2G) with tracer gas. Charge the nitrogen and refrigerant through the auxiliary evacuation valve.
3. Use dry nitrogen to raise machine pressure to 11.5 psig (0.8 KgF/cm^2G) *Do not exceed 11.5 psig (0.8 KgF/cm^2G).*
4. Leak test all joints with an electronic leak detector.
5. Correct all leaks; retest to ensure repair.
6. Release machine pressure, and perform machine evacuation.

ENGINEER ______________________________ DATE ____________________

JOB NAME ______________________ SIZE __________ MACHINE SERIAL NO. __________

TIME OF DATA									
HOUR METER READING									
HOT OR CHILLED WATER	Heating or Cooling								
	Temperature Entering								
	Temperature Leaving								
	Pressure Entering								
	Pressure Leaving								
COOLING WATER	Temperature Entering Absorber								
	Temperature Leaving Absorber								
	Temperature Leaving Condenser								
	Pressure Entering Absorber								
	Pressure Leaving Absorber								
	Pressure Leaving Condenser								
BURNER	Selected Fuel								
	Fuel Supply Pressure								
	Fuel Valve Position								
	Air Damper Position								
	Exhaust Gas Temperature								
	Exhaust O_2 or CO_2								
REFRIG-ERANT	Pump Discharge Temperature								
	Specific Gravity								
	High-Stage Vapor Condensing Temperature								
	Low-Stage Vapor Condensing Temperature								
	Refrigerant Overflow?								
WEAK SOLUTION	Actual Temperature								
	Sample Temperature								
	Specific Gravity								
	Concentration								
	Saturation Temperature								
	Alcohol in Sample?								
	Temperature Leaving Low-Temperature Heat Exchanger								
	Temperature Leaving High-Temperature Heat Exchanger								
STRONG SOLUTION	Temperature Leaving High-Stage Generator								
	Temperature Leaving Low-Stage Generator								
	Temperature To Sprays								

Fig. 33 — Typical 16DF Maintenance Record Log Sheet

Machine Evacuation — Evacuation is required for the removal of excessive noncondensables from the machine. The machine must be evacuated after air has entered the machine during service work, when absorber loss is greater than 5° F (2.8° C) during operation, or when the machine absolute pressure is greater than 1 in. Hg (25 mm Hg) at shutdown.

1. Connect an auxiliary evacuation device to the auxiliary evacuation valve (Fig. 34). Use a line size at least equal to the connection size on the auxiliary device and keep the line as short as possible. *A check valve must be used on the suction lines. Be sure all connections are vacuum tight.*

   A vacuum pump oil trap can also serve as a cold trap if it has a center well to hold dry ice or a mixture of salt and ice. Any water vapor that can contaminate the oil in the vacuum pump is condensed and removed by the cold trap. The cold trap thus reduces the time required for evacuation and eliminates the need for frequent replacement of the pump oil charge.
2. Start evacuation device. After one minute open auxiliary evacuation valve. If the machine is not operating, reduce machine absolute pressure to the pressure equivalent of the saturation temperature of the refrigerant. If the machine is operating, evacuate until absorber loss is 5° F (2.8° C) or less.
3. Close auxiliary evacuation valve and turn off auxiliary evacuation device.
4. Machine evacuation can remove octyl alcohol. Check a solution sample for the presence of octyl alcohol and add if necessary (see Adding Octyl Alcohol, page 49).

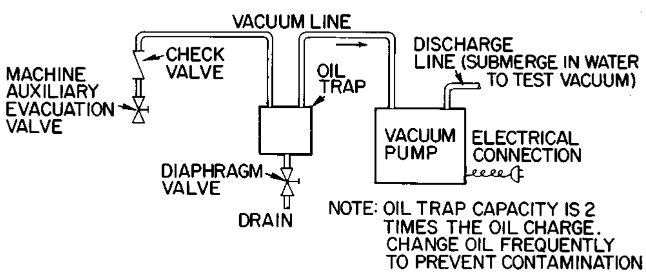


Fig. 34 — Machine Evacuation Device

Purge Exhaust Procedure — See Machine Description, pages 3 - 13, for an explanation of the purge operation, component identification, and Fig. 9 illustration.

Hydrogen gas, which is generated normally in the machine, is exhausted to the atmosphere from the purge storage tank through the heated palladium membrane cell. This is done automatically and continuously during machine operation.

Other noncondensables are stored in the purge storage tank and are removed manually with a vacuum pump (not part of the machine) through the purge exhaust valve. Typically this is done only once or twice a year, while the machine is shut down at the end of the cooling and heating seasons. However, an excessive absorber loss (see Absorber Loss Determination, page 46), may indicate the need for more frequent purging as a result of an air leak, palladium cell not functioning, or solution inhibitor depletion.

Follow the appropriate steps under Machine Evacuation, this page, to remove stored noncondensbles through the purge exhaust valve with a vacuum pump and oil trap.

Solution or Refrigerant Sampling — (See precautions pertaining to handling lithium bromide solution as described in Initial Start-Up, Solution and Refrigerant Charging, page 37).

Take solution or refrigerant samples form the pump service valve while the pump is operating.

Before taking a sample for analysis or absorber loss determination, be sure machine is operating with steady load and that there has not been any refrigerant overflow within 10 minutes prior to sampling.

Attach a hose adapter to the pump service valve. *Do not use copper or brass fittings when taking samples for analysis; copper oxide can form and contaminate samples.*

The solution pump normally discharges at above atmospheric pressure, but the refrigerant pump discharges at a vacuum, so the respective sampling procedures are different.

SOLUTION SAMPLE

1. Fill a length of flexible tubing with water and connect one end to the hose adapter. Place the free end in a container of water. Be sure end is submerged (Fig. 35).
2. Open valve slightly. When container water level rises, wait several seconds to purge the water from the tube. Then remove tube end from water and fill sample container.
3. Turn off service valve and remove hose and adapter.

REFRIGERANT SAMPLE (Fig. 36)

1. Connect a clean, empty vacuum container to the pump service valve with a length of flexible hose.
2. Connect a vacuum pump to the vacuum container with a flexible hose and isolation valve.
3. Pull a deep vacuum on the container and close the isolation valve.
4. Open the service valve slightly to drain refrigerant sample into the container.
5. Turn off service valve, remove hose and adpater, and disconnect vacuum pump.

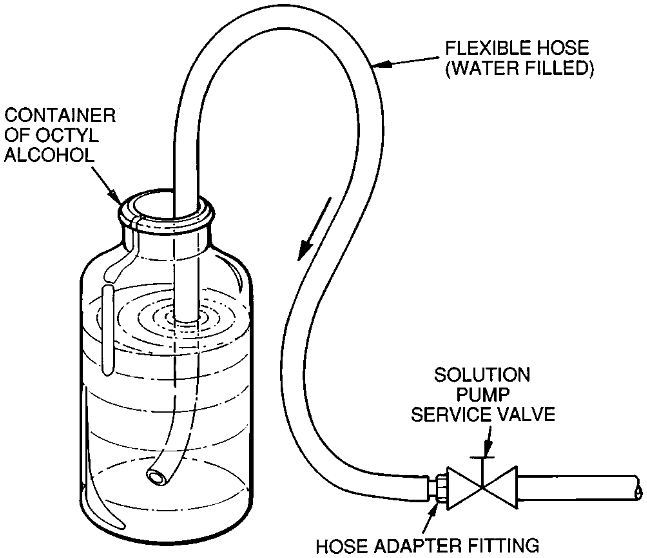


Fig. 35 — Adding or Removing Liquids

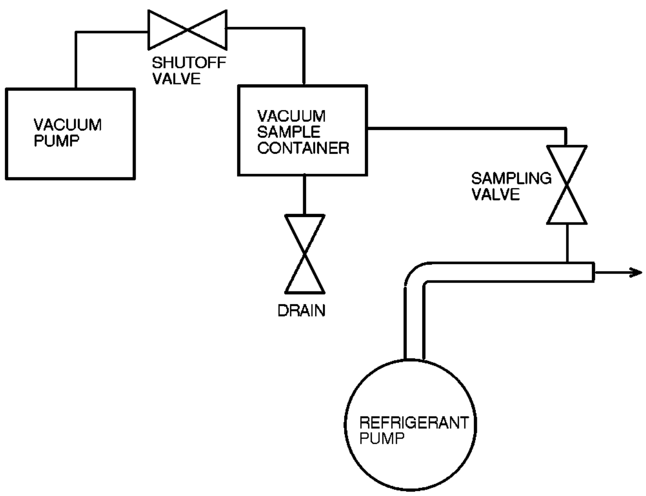


Fig. 36 — Refrigerant Sampling Technique

Solution Analysis — Laboratory analysis of a solution sample gives indication of change in solution alkalinity and depletion of inhibitor, and may indicate the degree of machine leak tightness.

Have the solution analyzed at least once a year or whenever there is an indication of a noncondensable problem. Take the sample from the solution pump service valve while the machine is running (see Solution or Refrigerant Sampling section, page 48). The sample concentration should be between 58% and 62% by weight for best results.

Solution analysis should be done by an approved laboratory. The analysis interpretation and the adjustment recommendations should be made by a trained absorption specialist.

Inhibitor — Lithium chromate inhibitor is charged into the machine with the initial charge of lithium bromide. The inhibitor is used in conjunction with alkalinity control to minimize the amount of noncondensables normally generated within the machine. Excessive noncondensable generation interferes with machine performance.

The inhibitor is gradually depleted during machine operation and occasional replenishment is necessary. Solution alkalinity also changes over a period of time and must be adjusted (see Solution Analysis, this page).

IMPORTANT: Altering the inhibitor or using solution and internal surface treatments not specified by the equipment manufacturer may result in performance deterioration and damage to the absorption machine.

Adding Octyl Alcohol — Octyl alcohol may be required when leaving chilled water temperature starts to rise above design temperature without alteration of the control set point. Since the rise in temperature can also be caused by fouled tubes or other problems, use the following procedure to determine whether a lack of octyl alcohol is the cause:

NOTE: Add octyl alcohol only during cooling operation.

1. Remove a sample of solution from the solution pump service valve (see Solution or Refrigerant Sampling section, page 48). If the solution has no odor of alcohol (very pungent), add about ½ gal. (2 L) of octyl alcohol.

   The addition of octyl alcohol also may be required after the machine has been evacuated or after an extended period of operation.

⚠ CAUTION

Use only octyl alcohol. Other types of alcohol have a detrimental effect on machine performance.

2. Fill a length of flexible tubing with water and connect one end to the high-temperature generator drain valve (see Fig. 35). Insert the other end in a container of octyl alcohol. Open the service valve to allow alcohol to be drawn into the machine. *Close valve before air can be drawn into the hose.*

Removing Lithium Bromide from Refrigerant — During normal operation, some lithium bromide may be carried over into the refrigerant. Lithium bromide in the refrigerant is automatically transferred back to the absorber by refrigerant overflow valve as needed and by the shutdown dilution valve. The refrigerant flows through the overflow pipe or dilution valve into the solution circuit and separation is made in the generator in the normal manner.

Lithium bromide can be transferred manually by placing the dilution switch at MANUAL while the machine is running and the capacity control valve is open. When the refrigerant specific gravity drops below 1.02, return the switch to AUTO. to close the dilution valve.

Refrigerant Charge Adjustment — Check the evaporator refrigerant (water) charge after every 6 months of operation. An increase in the amount of water in the machine indicates tube leakage. Furthermore, the correct refrigerant charge must be maintained for accurate refrigerant overflow to prevent solution crystallization.

For charge adjustment, refer to Refrigerant Charge Final Adjustment, page 40.

Capacity Control Adjustment — Check the leaving chilled water temperature. If design temperature is not being maintained, reset the control set point in the machine control panel, according to the Automatic Capacity Control explanation in the Machine Controls section, page 31.

If machine still fails to maintain design temperature, refer to the Troubleshooting sections entitled Problem/Symptom — Leaving Chilled/Hot Water Temperature Too High, or Too Low, page 54.

Operating and Limit Controls — Refer to the various control checkout procedures in the Before Initial Start-Up section, page 32, to verify the correct operation of the machine operating and limit controls.

Burner Checks and Adjustments — Refer to the burner manual for specific burner checkout and adjustment procedure.

Service Valve Diaphragm Replacement — To replace valve diaphragms:

1. Break machine vacuum with nitrogen. Solution and refrigerant can be transferred to opposite sumps within the machine or removed from the machine. If solution is removed from the machine, store it in clean containers for recharging.
2. Remove old valve diaphragms and replace. Torque valve bolts to approximately 3 lb ft (0.4 kg m).
3. Test all affected connections for leakage (see Machine Leak Test section, page 46).
4. Replace solution and refrigerant in machine (in a quantity equivalent to what was removed).
5. Reevacuate machine after servicing (see Machine Evacuation section, page 48).

Hermetic Pump Inspection — Figure 37 is a sectional structural schematic of a typical refrigerant or solution pump used on the 16DF machine. These centrifugal pumps are hermetic and do not require seals. The rotor assembly is enclosed in a thin stainless steel can, and some of the pump discharge liquid (refrigerant or solution) is circulated around the rotor assembly for cooling the motor and for lubricating the bearings. The following instructions are general procedures for a typical pump version. Details will vary slightly for different pump models.

⚠ CAUTION

Never run hermetic pump motor dry. Even momentary operation without machine filled with liquid will damage bearings and overheat the motor. Use only the current value specified in the control circuit diagram when setting the pump starter overloads.

DISASSEMBLY

⚠ WARNING

Disconnect all primary power to the pumps; lock and tag all disconnect switched.

1. Break vacuum with nitrogen if not already performed.
2. Remove solution and refrigerant from the machine. Store in clean containers until recharging.
3. Open the motor wiring terminal box (Item 11) and disconnect the motor power leads. Mark the leads to ensure proper reassembly.
4. Remove nuts (Item 21) holding motor adapter flange to pump casing (Item 23). With the larger motors which have a hanger support, disconnect the hanger. Place matching orientation marks on the two flanges.

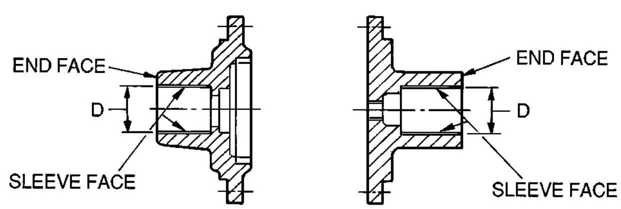
   NOTE: Use blocking to support the weight of the motor before moving it and before removing hanger support.
5. If pump has a circulation pipe (Item 1) connected to the pump discharge pipe, disconnect the circulation pipe at this time.
6. Use jackscrew to loosen motor from pump casing. Pull motor straight back from pump casing until impeller (Item 25) has cleared the housing.
7. Remove and discard casing flange gasket (Item 22).
8. Straighten locking tabs on impeller locking washer (Item 30), and remove locking screw (Item 31). Prevent impeller from rotating while removing the locking screw.
9. Remove impeller with impeller/gear puller. Remove shaft key (Item 32).
10. Remove bolts (Item 24) for motor wear ring housing (Item 33), and, using one bolt as a jack screw, carefully loosen the wear ring housing from the motor adapter flange. Place matching orientation marks on the two pieces. Pull the wear ring housing straight back from the motor while supporting the impeller shaft (Item 17), being careful to not damage the bearings or the stator and rotor cans (Items 14 and 15).
11. Remove the impeller end radial and thrust bearings (Items 34 and 35), and mark them for both location and direction (i.e., which end of the bearing faces the impeller end of the motor).
12. While continuing to support the impeller shaft, pull the rotor (Item 16) straight out of the rotor cavity, being careful to not damage the bearings or the stator and rotor cans.
13. Remove the bolts (Items 3 and 40) from the circulating pipe connecting flange(s), if not previously done, to disconnect the pipe from the end of the motor.
14. Remove and discard O-rings (Items 2 and 39).
15. Remove the bolts (Item 4) on the motor end cover (Item 5) and use one as a jacking screw to loosen the end cover from the motor end flange. Place matching orientation marks on the two pieces. Remove the cover.
16. Remove the motor end radial and thrust bearings (Items 7 and 8), and mark them for both location and direction (i.e., which end of the bearing faces the impeller end of the motor).
17. NOTE: Remove and discard motor end cover gasket (Item 6).

NOTE: Do not remove the plug (Item 18) on the top of the motor (Item 12) except when leak testing or drying the motor windings.

INSPECTION

1. Check recirculation passages in motor and recirculating pipe. Clean if necessary.
2. Inspect rotor and stator cans for scratches, rubbing, or punctures. Severe damage will require motor replacement.
3. Inspect the radial bearing cavities in the motor end cover and wearing housing. If the internal surface is rough or worn more than the maximum diameter in Table 17, replace the part.

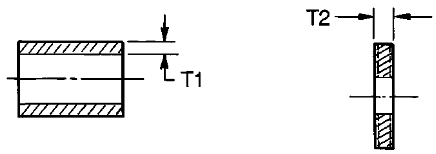
Table 17 — Maximum Radial Bearing Cavity Measurement



MOTOR SIZE	MAX. DIAMETER (D)	
kW	in.	mm
1.5	1.27	32.3
3.7	1.51	38.3
5.5	1.98	50.3
7.5	1.98	50.3

4. Inspect the radial and thrust bearings. If the surface is very rough or deeply scratched, or if worn to a thickness less than listed in Table 18, replace the bearing. The thrust bearing on the impeller end normally receives the greatest wear.

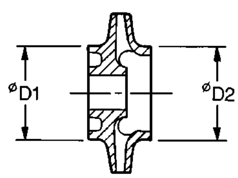
Table 18 — Minimum Bearing Thickness Measurement



MOTOR SIZE	MIN. RADIAL THICKNESS (T1)		MIN. THRUST THICKNESS (T2)	
kW	**in.**	**mm**	**in.**	**mm**
1.5	0.13	3.3	0.18	4.6
3.7	0.15	3.8	0.18	4.6
5.5	0.19	4.8	0.22	5.6
7.5	0.19	4.8	0.22	5.6

5. Check the impeller wear surfaces. If very rough or worn to outside diameters less than listed in Table 19, replace the impeller.

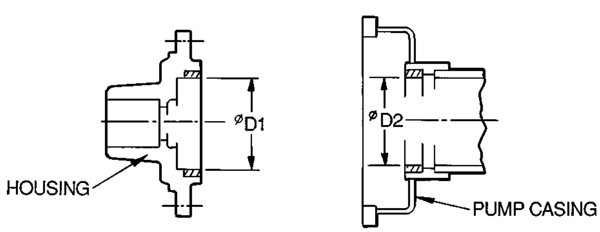
Table 19 — Minimum Impeller Wear Diameters



MOTOR SIZE	MIN. MOTOR SIDE (D1)		MIN. SUCTION SIDE (D2)	
kW	**in.**	**mm**	**in.**	**mm**
1.5	3.45	87.6	2.98	75.6
3.7	3.92	99.6	3.92	99.6
5.5	3.92	99.6	3.92	99.6
7.5	3.92	99.6	3.92	99.6

6. Check the wear rings. If the wear surfaces are very rough or deeply scratched, or are worn to inner diameters less than listed in Table 20, replace the wear ring. They are retained by setscrews (Items 26 and 27).

Table 20 — Maximum Wear Ring Inner Diameters



MOTOR SIZE	MAX. MOTOR RING (D1)		MAX. CASING RING (D2)	
kW	**in.**	**mm**	**in.**	**mm**
1.5	3.47	88.2	3.00	76.2
3.7	3.95	100.2	3.95	100.2
5.5	3.95	100.2	3.95	100.2
7.5	3.95	100.2	3.95	100.2

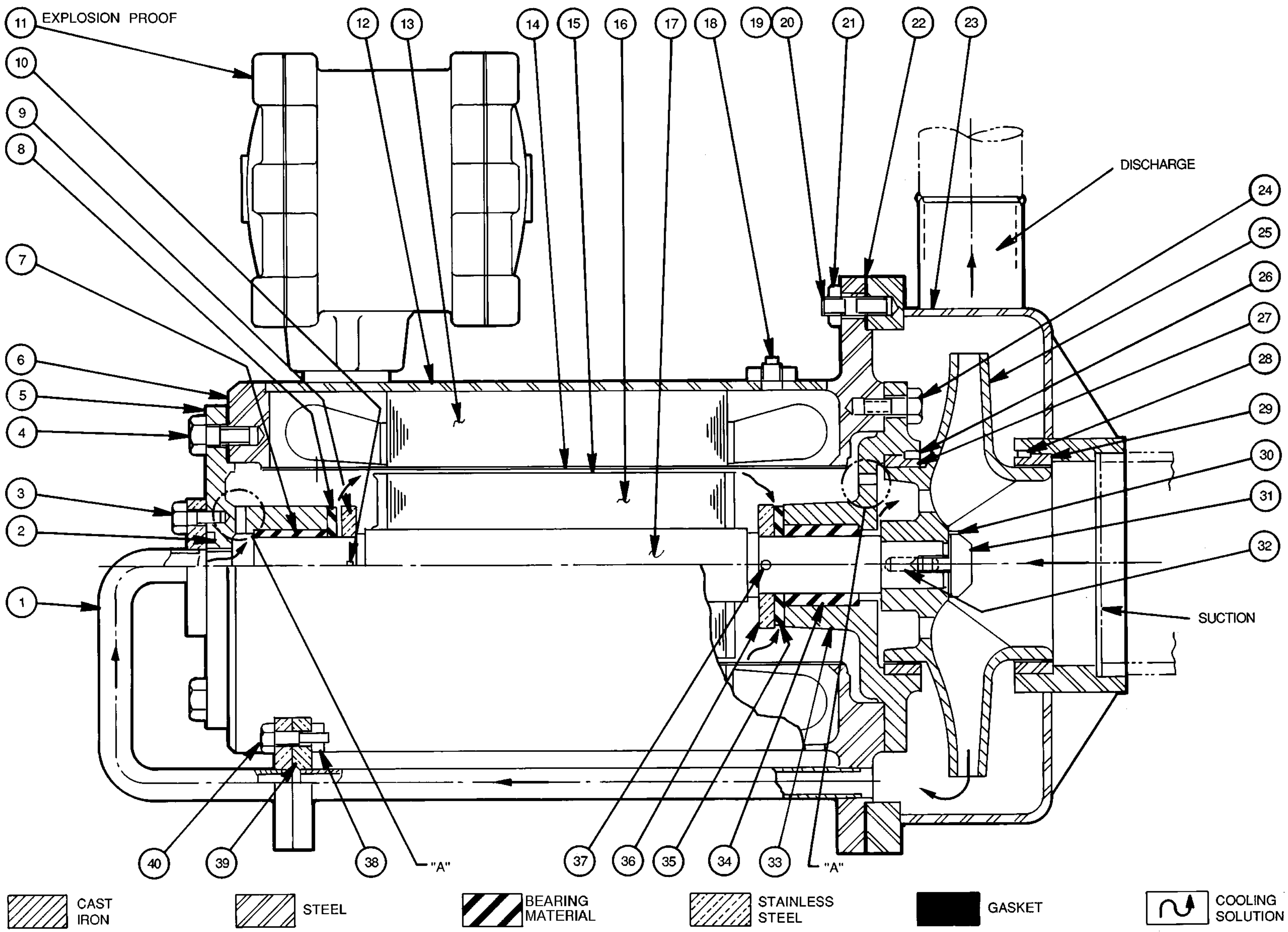
7. Check the condition of the thrust collars (Items 9 and 36) on the rotor shaft. If very rough, deeply scratched, or severely worn, they should be replaced. They are retained by pins (Items 10 and 37).
8. Check the condition of the radial bearing sleeve faces on the rotor shaft. If very rough, deeply scratched, or severely worn, they should be replaced. They are retained by pins.
9. Check the motor insulation resistance. If less than 10 milliamps, the windings must be dried.

REASSEMBLY

1. Clean all parts, gasket surfaces, and O-ring grooves. Use new gaskets (Items 6 and 22) and new O-rings (Items 2 and 39).
2. Install motor end radial bearing (Item 7) in the motor end cover (Item 5) and apply a small amount of gasket paste to both sides of the gasket (Item 6). Mount the motor end cover and gasket, aligning the match marks applied during disassembly. The internal flow passage "A" should be at the top as the pump is installed on the chiller.
3. Place thrust bearings (Items 8 and 35) against their respective thrust collars on the rotor shaft (Item 17). Carefully guide rotor (Item 16) into position within the stator (Item 13) to avoid damage to the bearings, rotor liner (Item 15), and stator can (Item 14).
4. Install radial bearing (Item 34) and motor side wear ring (Item 27) in the wear ring housing (Item 33). Mount the wear ring housing, aligning the match marks applied during disassembly. The internal flow passage "A" should be at the top as the pump is installed on the chiller.
5. Install impeller (Item 25) with impeller key (Item 32), locking washer (Item 30) and locking screw (Item 31). Bend washer tabs over flats of locking screw head.
6. Turn impeller by hand to be sure it rotates easily.
7. Install new O-rings (Items 2 and 39) in flanges for recirculation pipe (Item 1) and mount pipe in place.
8. Install pump casing wear ring (Item 29) if not already in place.
9. Apply a small amount of gasket paste to both sides of gasket (Item 22) and position on pump casing flange. Slide motor stator housing and adaptor flange assembly into pump casing, aligning the match marks applied during disassembly. Use blocking to support the motor stator until all bolts have been tightened and the motor support, if used, has been reconnected.

COMPLETION

1. Leak test affected joints to be sure all pump connections are tight. (See Machine Leak Test section, page 46.)
2. Evacuate machine (see Machine Evacuation section, page 48).
3. Recharge machine with same quantity of solution and refrigerant as removed.
4. Reconnect motor power leads to motor wires in same arrangement as when disconnected and replace junction box cover.
5. Restore power supply to pump and chiller controls.
6. Record inspection date and results.



LEGEND

1 — Circulation Pipe
2 — O-Ring Gasket
3 — Bolt
4 — Bolt
5 — Motor End Cover
6 — Motor End Cover Gasket
7 — Radial Bearing (B)
8 — Thrust Bearing (B)
9 — Thrust Collar (B)
10 — Pin
11 — Terminal Box
12 — Motor Frame
13 — Stator
14 — Stator Liner (Stator Can)
15 — Rotor Liner (Rotor Can)
16 — Rotor
17 — Shaft
18 — Plug
19 — Bolt
20 — Bolt (Jack Screw)
21 — Nut
22 — Casing Flange Gasket
23 — Pump Casing
24 — Bolt
25 — Impeller
26 — Set Screw
27 — Motor Side Wear Ring
28 — Set Screw
29 — Pump Casing Wear Ring
30 — Locking Washer
31 — Locking Screw
32 — Key
33 — Wear Ring Housing
34 — Radial Bearing (A)
35 — Thrust Bearing (A)
36 — Thrust Collar (A)
37 — Pin
38 — Nut
39 — O-Ring Gasket
40 — Bolt

A — Circulation Hole

Fig. 37 — 16DF Refrigerant Solution Pump Schematic (Typical)

Condensing Water Tube Scale is indicated if the temperature difference between condensing water leaving the condenser and refrigerant condensate from the condenser is greater than the normal 4 to 7° F (2 to 4° C) difference at full load (capacity control valve fully open). Scale reduces heat transfer, increases steam consumption, and limits machine capacity. Scale can also cause serious corrosion damage to the tubes.

Soft scale can be removed from tubes with cleaning brushes specially designed to avoid scraping or scratching the tube walls. The brushes are available through your Carrier representative. *Do not use wire brushes.*

⚠ CAUTION

Hard scale may require chemical treatment for its prevention or removal. Consult a water treatment specialist for proper treatment.

Water Treatment — Untreated or improperly treated water may result in corrosion, scaling, erosion, or algae. The services of a qualified water treatment specialist should be obtained to develop and monitor a treatment program.

⚠ CAUTION

Water must be within design flow limits, clean, and treated to ensure proper machine performance and reduce the potential of tubing damage due to corrosion, scaling, or erosion. Carrier assumes no responsibility for chiller damage resulting from untreated or improperly treated water.

Solution Decrystallization — Crystallization occurs when strong solution concentration and temperature cross over to the right of the crystallization line on the equilibrium diagram (Fig. 30A and B). It should not occur if machine controls are correctly adjusted and machine is properly operated. Refer to the Troubleshooting Guide, pages 54 - 56 for probable causes and remedies.

If crystallization occurs, it generally takes place in the shell side of the low-temperature heat exchanger and blocks the flow of strong solution from the low-stage generator. The strong solution then overflows into a pipe that returns it directly to the absorber sump. The solution pump then returns the hot solution through the heat exchanger tubes, automatically heating and decrystallizing the shell side.

However, if the cause of the crystallization continues, the solution crystallization can continue and may become severe. In that case, depress the chiller/heater Stop button, place the burner control at MANUAL, and depress the machine Start button for restart. Place the dilution valve on manual to dilute the solution and open the heat exchanger bypass valve ‘‘C’’ to help solution circulation. When the solution has been completely decrystallized, reset the switches to the normal positions and close valve ‘‘C’’.

If crystallization results from a long, unscheduled shutdown (such as from a power failure) without proper dilution, the solution pump(s) may become bound and fail to rotate. This will cause the overloads to trip out. In such a case, decrystallize as follows:

1. Heat the solution pump casing and adjacent lines with steam.

⚠ CAUTION

Under no circumstances apply heat directly to pump motor or controls when warming the casing. Do not apply direct heat to any flange connections; high temperature can deteriorate the gasket material.

2. Rotation of a hermetic pump cannot be viewed directly. Check the solution pump rotation by installing a compound gage on the pump service valve and reading discharge pressure. Be sure to reset the pump overloads in control panel if they are tripped.

   If the pump is rotating normally, the gage will show a reading above atmospheric pressure. If the pump casing and discharge line are completely blocked, the gage will show zero atmospheric pressure. If the pump interior is only partially blocked, a deep vacuum will indicate that the pump is not rotating.
3. Continue heating the casing until gage pressure shows above atmospheric pressure with pump overloads reset. *Do not reset pump overloads more than once in any 7-minute period.*

   If the heat exchanger is also blocked, the decrystallization process will begin as soon as the solution pump starts rotating and the adjacent weak solution lines have decrystallized. If the heat exchanger or adjacent piping does not decrystallize automatically, heat the blocked area externally with steam or a soft torch flame. Crystallization in purge piping can be broken up by applying heat in the same manner.
4. If the strong solution line from heat exchanger to absorber spray nozzles is blocked, turn off the condensing water pump and operate the machine with the burner operating on MANUAL. Turn the dilution switch to MANUAL to dilute the solution. The entire unit will pick up heat and the crystallization will dissolve. *If severe crystallization is present, it may take 4 to 6 hours to fully decrystallize, but the burner should be left on only long enough to heat the solution.*

Internal Service — To prevent corrosion from air inside the machine, break vacuum with nitrogen when opening the machine for maintenance or repair.

While the machine is open, it is good practice to minimize the amount of air entering by continuously feeding nitrogen into the machine at approximately 1 psig (0.1 KgF/cm^2G) pressure.

Perform service work promptly and efficiently and close up the machine as soon as possible. Do not rely on inhibitor for corrosion protection from exposure to air.

Leak test the machine thoroughly after the machine has been closed up.

⚠ WARNING

When flamecutting or welding on an absorption machine, some noxious fumes may be produced. Ventilate the area thoroughly to avoid breathing concentrated fumes.

Hydrogen can form an explosive mixture in air. Never cut into purge chamber unless purge has been exhausted to remove any hydrogen gas that might be present in the chamber.

TROUBLESHOOTING GUIDE

PROBLEM/SYMPTOM	PROBABLE CAUSE	REMEDY
Machine will not run when Start button is depressed	No power to control panel (no status display)	Check for building power failure. Check main circuit breaker.
	Control circuit power switches open (no status display)	Close TS1 control circuit switch and main circuit breakers in control panel.
	Control panel fuse blown (no status display)	Check circuits for ground or short. Replace fuse.
	Run interlock or safety switch open (safety code displayed)	Correct cause of problem (see Causes and Remedies under Abnormal Stop section). Depress Stop then Start buttons.
Burner misfire on pilot or main flame ignition attempt (“EO8” fault code)	Manual fuel valve closed	Open the valve.
	Abnormal supply gas pressure	Check fuel supply and pressure regulator.
	Loose linkage to air damper or fuel valve	See burner manual for adjustment instructions.
	Insufficient combustion air to equipment room	Open air supply to equipment room.
	Burner malfunction (various causes)	See burner manual for correction instructions.
Leaving chilled water temperature too high (machine running)	Set point too high	Reset on capacity control.
	Excessive cooling load (machine at capacity)	Check for cause of excessive load.
	Excessive chilled water flow (above design)	Take accurate flow check and reset flow.
	Low condensing water flow (below design)	Take accurate flow check and reset flow.
	High supply condensing water temperature (above design)	Check cooling tower operation and temperature controls.
	Fouled water tubes (poor heat transfer)	Clean tubes. Determine if water treatment is needed.
	Fouled generator tubes (poor heat transfer with high stack temperature)	Clean tubes. Check air supply. Adjust burner if necessary.
	Machine needs octyl alcohol addition	Check solution sample and add octyl alcohol if necessary (see Maintenance Procedures, Adding Octyl Alcohol section, page 49).
	Noncondensables in machine	Check absorber loss (see Absorber Loss Determination section, page 46). If above 5° F (2.8° C), see Causes and Remedies under Inadequate Purging.
	Capacity control malfunction	Check calibration and operation of capacity controls.
	Burner capacity controls not fully open	Place machine and burner Auto.-Manual switches in AUTO. position.
	Low burner firing rate	Adjust burner controls.
	Solution crystallization (solution flow blockage)	See Causes and Remedies under Solution Crystallization.
	Excessive refrigerant overflow	Check refrigerant charge (see Maintenance Procedures, Refrigerant Charge Adjustment section, page 49).
Leaving hot water temperature too low (machine running)	Set point too low	Reset on capacity control.
	Excessive heating load (machine at capacity)	Check for cause of excessive load.
	Excessive hot water flow (above design)	Take accurate flow check and reset flow.
	Fouled hot water tubes (poor heat transfer)	Clean tubes. Determine if water treatment is needed.
	Fouled generator tubes (poor heat transfer with high stack temperature)	Clean tubes. Check air supply. Adjust burner if necessary.
	Noncondensables in machine	See Causes and Remedies under Inadequate Purging.
	Capacity control malfunction	Check calibration and operation of capacity controls.
	Burner capacity controls not fully open	Place machine and burner Auto.-Manual switches in AUTO. position.
	Low burner firing rate	Adjust burner controls.
Leaving chilled water temperature too low (machine running)	Set point too low	Reset on capacity control.
	Capacity control malfunction	Check calibration and operation of capacity controls.

PROBLEM/SYMPTOM	PROBABLE CAUSE	REMEDY
Leaving hot water temperature too high (machine running)	Set point too high	Reset on capacity control.
	Capacity control malfunction	Check calibration and operation of capacity controls.
Leaving chilled water temperature fluctuates (machine running, capacity control hunting). Burner and temperature cycling at low load is normal.	Chilled water flow or load cycling	Check load stability and system controls.
	Capacity control malfunction	Check calibration and operation of capacity controls and position of sensor in well.
	Condensing water flow or temperature cycling	Check condensing water temperature control and cooling tower operation.
Leaving hot water temperature fluctuates (machine running, capacity control hunting). Burner and temperature cycling at low load is normal.	Hot water flow or load cycling	Check load stability and system controls.
	Capacity control malfunction	Check calibration and operation of capacity controls, and position of sensor in well.
Excessive refrigerant overflow to absorber during cooling cycle	Noncondensables in absorber	Check absorber loss (see Maintenance Procedures, Absorber Loss Determination section, page 46). See Causes and Remedies under Inadequate Purging.
	Fouled water tubes (poor heat transfer)	Clean tubes.
	Machine needs octyl alcohol	Check solution sample and add octyl alcohol if necessary (see Maintenance Procedures, Adding Octyl Alcohol section, page 49).
	Excessive refrigerant charge in machine	Adjust refrigerant charge (see Maintenance Procedures, Refrigerant Charge Adjustment section, page 49).
Inadequate purging (low machine capacity and high absorber loss on cooling)	Air leakage in vacuum side of machine	Leak test and repair if necessary (see Maintenance Procedures, Machine Leak Test section, page 46).
	Inhibitor depleted	Have solution analyzed. Add inhibitor and adjust alkalinity if necessary (see Maintenance Procedures, Solution Analysis and Inhibitor sections, page 49).
	Purge valves not positioned correctly	Check valve positions (see Maintenance Procedures, Machine Description, Purge section, page 13).
	Palladium cell not heated or functioning	Check line voltage power supply to cell and cell operation.
	Purge storage chamber full	Use vacuum pump to evacuate storage chamber.
	Purge solution supply lines crystallized	Heat solution supply lines (see Maintenance Procedures, Solution Decrystallization section, page 53).
Strong solution crystallization during operation (strong solution overflow pipe hot)	Refrigerant not overflowing to limit solution concentration	Check refrigerant charge (see Maintenance Procedures, Refrigerant Charge Adjustment section, page 49).
	Noncondensables in absorber	Check absorber loss (see Maintenance Procedures, Absorber Loss Determination section, page 46). See Causes and Remedies under Inadequate Purging.
	Fouled water tubes (poor heat transfer)	Clean tubes.
	Machine needs octyl alcohol	Check solution sample and add octyl alcohol if necessary (see Maintenance Procedures, Adding Octyl Alcohol section, page 49).
Solution crystallized during shutdown (solution crystallization symptoms)	Insufficient solution dilution at shutdown (either power failure or dilution cycle fault)	Verify that the dilution valve opens and solution pump continues to operate for at least a 15-minute dilution period.
Abnormal solution pump noise (some noise in the solution piping is normal)	Pump cavitation due to low solution level	Hold dilution valve Auto.-Manual switch at MANUAL for 3 minutes to raise solution level. If it continues, may be caused by crystallization or low solution charge.
Abnormal refrigerant pump noise	Pump cavitation due to low refrigerant level from cooling water temperature being too low at low load	Maintain cooling water temperature no lower than 59 F (15 C). Stop machine for about 20 minutes to recover, then restart.

TROUBLESHOOTING GUIDE (cont)

PROBLEM/SYMPTOM	PROBABLE CAUSE	REMEDY
Abnormal stop (fault code displayed with alarm buzzer)	Code “E01” (cooling only) — low chilled water temperature at or below 39 F (4 C)	Verify that chilled water low temperature cutout opens at factory setting of 39 F (4 C) (see Check Low Chilled Water Temperature Cutout section, page 35). Also verify that the capacity control low-temperature limit turns the burner off at no less than 41 F (5 C) (see Machine Controls, Automatic Capacity Control section, page 31).
	Code “E02” — Low chilled/hot water flow, or chilled/hot water pump interlock(s) are open	Verify chilled/hot water pump is running, discharge pressure is normal, valves are correct, and piping strainers are clear.
	Code “E03” (cooling only) — Condensing water pump interlock(s) are open, or low flow when flow switch is used	Verify condensing water pump is running, discharge pressure is normal, valves are correct, and piping strainers are clear.
	Code “E04” — Solution or refrigerant pump motor overloads or high motor temperature switches	Press overload relay reset button if overload has tripped. Check overload setting, motor run amps, pump discharge pressure, and motor temperature. If solution pump has tripped, check for solidification.
	Code “E05” — High-temperature generator, high solution temperature, or high pressure	Verify high-stage generator limit settings of 338 F (170 C) for strong solution temperature and –0.8 in. Hg (–20 mm Hg) for maximum pressure, and check switch operation. For cooling operation, check cooling water for high temperature or low flow. Place the dilution switch in MANUAL for about 3 minutes to dilute and cool the solution. For heating operation, verify the machine switchover valves are fully open.
	Code “E06” — High flue gas, fire tube, or refractory temperature	Verify temperature limit settings for exhaust stack and fire tube are at 572 F (300 C) and the refractory is at 302 F (150 C), then check switch operation. Check for dirty generator tubes or damage to return end cover refractory. Adjust burner controls or repair refractory if necessary.
	Code “E07” (cooling only) — High absorber weak solution temperature	Verify absorber weak solution temperature above 113 F (45 C). Check for low cooling water flow or high temperature. Also check for poor absorber heat transfer (dirty tubes).
	Code “E08” — Burner ignition failure	See Cause and Remedies under Burner Misfire on Ignition Attempt.
	Code “E09” — Burner operation failure	See burner manual for correction instructions.
	Code “E10” (optional) — External limit device	Determine what condition is being sensed and the cause of the fault.
	Code “E12” — Chilled/hot water pump interlock open but flow switch is closed, or vice versa	Check chilled/hot water pump operating status and interlock, flow switch operation, valves, and strainers.
	Codes “E13 through E34” — Sensor error, out of range	Have sensors checked and calibrated.
	Code “E90” — Insufficient shutdown dilution	Repeat dilution cycle by depressing Start then Stop buttons. Determine reason for inadequate dilution.