

CONTROL SYSTEM PRODUCT LINE

Our control system product line is different from all of our competitors in that it is scalable from equipment control, such as a screw or reciprocating compressor, to full plant control. One common scalable hardware and software solution does it all.

The M&M Refrigeration control system product line is comprised of three main product groups to meet the needs and budgets of any customer.

- Compressor Control Systems (CCS)
- "Off The Shelf" Control Systems (OTS)
- Engineered Control Systems (ECS)

HARDWARE OVERVIEW

Our microprocessor based scalable hardware platform is common across the entire M&M product line and provides the following standard features:

- Bright and easy-to-read displays
- A high degree of consistency in the user interface
- Stand-alone design which does not require a PC to operate
- Interchangeable parts from compressor to the plant control system panels
- Designed to support future expansion
- Designed-in backward compatibility

COMMON HARDWARE FEATURES OF CONTROL SYSTEM PRODUCT LINE

- NEMA 4 or 4X panel
- Full numerical keypad
- Multiple sized backlit displays with graphics capability
- Support for up to 64 analog inputs
- Support for up to 16 analog outputs
- Support for up to 224 digital I/O
- Support for up to 4 communication ports
- High efficiency universal power supplies
- Battery back up memory
- Optional high speed modem
- Support for open communication protocols (Allen Bradley DF1, Modbus RTU and BACnet)



At M&M we not only design our mechanical equipment to last decades, we expect the same high standard from our controls.

SOFTWARE OVERVIEW

Our control system software is built around a core infrastructure providing the basis for everything we do. The way data is displayed, the navigation of screens, alarm processing and logging of data are all standard features in every microprocessor product we produce. Every refrigeration control software function is designed to be easily adaptable to meet our customer's needs. The list of software functions continues to grow with an ever-expanding set of standard features and options. This approach allows us to deliver products with a common look and feel, software that is fully tested, the ability to support all levels of facility complexities and provide a system to meet any budget size. Some of our software's key features include:

- Standard infrastructure (displays, logs, alarm processing)
- Standard software packages
 - Screw compressor controllers to retrofit all major manufacturer's units
 - Reciprocating compressor controllers to retrofit all major manufacturer's units
 - "Off The Shelf" controllers such as evaporator panels, condenser panels, pump package panels and ice rink skid panels
 - Stand alone controllers for ice machines, spirals, chillers, engine control, etc.
- Many options available in each module
- What a user friendly interface should look like:
 - Meaningful, readable displays with information organized by function, making the system easier to use
 - Transfer of training — consistent user interface across all product lines including PC software; you only need to learn one system
 - "At a Glance Technology" — data formatted and highlighted for quick reference by the operator
- Logs — extensive logging capability provides a very useful diagnostic tool for isolating system problems
- Alarms and failures — extensive alarms with names in user-friendly text

COMPRESSOR CONTROL SYSTEMS (CCS)

Our CCS products provide control for all manufacturer's compressors, both screw and reciprocating.

- Screw Compressors:
 - Uses our common scalable hardware and software platform
 - Real-time graphics display
 - The same high quality unit that is utilized on our screw compressor product line can be retrofitted on all major manufacturer's compressor products
 - Can easily be customized and expanded if required to perform additional functions resulting in a cost-effective small system solution
- Reciprocating Compressors:
 - Smaller enclosure, display and keypad
 - Same functionality as the screw compressor controller

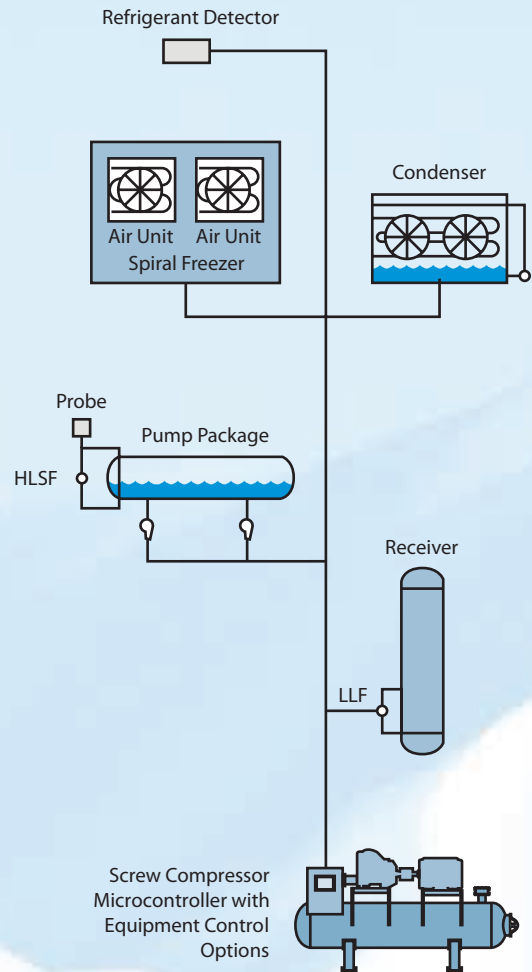
Screw Compressor Controller Features

The M&M Compressor Control System is an advanced microcontroller that has been specifically developed to provide the industry's most extensive compressor control flexibility and safety. It is easy to use with no prior computer knowledge being necessary. All information is clearly presented on three types of display screens:

- Status screens, which provide continuously updated information regarding current compressor operating conditions
- Menu selection screens, which are used to access various data entry screens
- Data entry screens, where control, alarm and failure setpoints are observed and/or entered into the computer memory

Data entry is menu-driven in a format that guides the operator to make entries or changes. Each standard screw compressor micro has a minimum of 130 different screens.

The NEMA 4 control cabinet consists of a door-mounted keypad and display, a high efficiency universal power supply, a microcontroller main processing board, a digital input/output rack and a pre-numbered field wiring terminal strip. A battery with 10-year life is also provided to ensure that no data is lost during shutdown or temporary loss of power.



Compressor Controller Options

The expandable nature of the M&M Compressor Control System readily permits expansion to control other components of a refrigeration system. The controller can support up to 16 analog inputs, 4 analog outputs and 64 discrete I/O. With this added hardware additional refrigeration control needs can be handled, such as the following:

- Condenser Control
- Pump Package Control
- Evaporator Zone Control
- Vessel Control
- Surge Drum Control
- Other multi-task functions

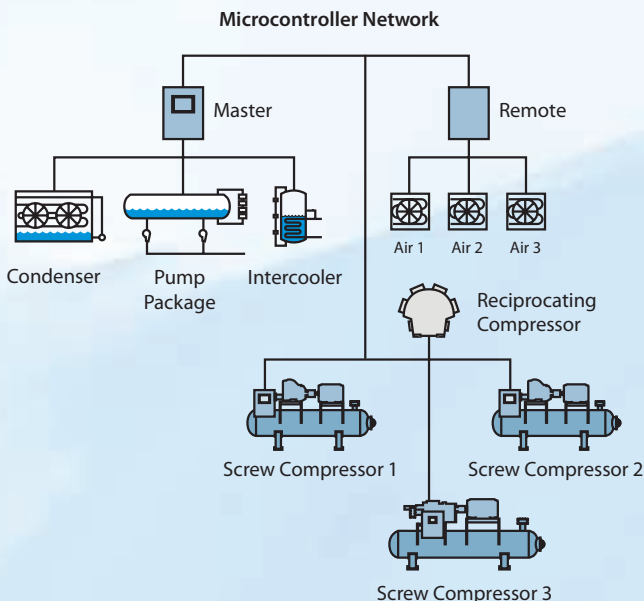
“OFF THE SHELF” (OTS) CONTROL SYSTEMS

Our OTS Control System components are designed to meet the needs of small and medium facilities. These pre-configured units allow a facility to get control of their refrigeration and energy usage with minimal capital expense by offering the following features:

- Utilizes our common scalable hardware and software platform
- Contains all features of our customized control systems
- Can be configured by the end user to match their facility
- Designed to solve specific control requirements for small to medium sized facilities

OTS Components

- Master Screw Compressor
 - With sequencing for up to 8 compressors
 - With condenser control (support for up to 4 Pumps, 8 Fans)
 - With sequencing and condenser control
- Evaporator Controller (4, 8,12,16, 20 zone configurations)
- Condenser Controller
- Pump Package Controller
- Ice Rink Controller (single and dual rink)
- Beer Distribution Warehouse Controller (10/2 and 20/4 CEW/Draft configurations)



ENGINEERED CONTROL SYSTEMS (ERS)

Our modular design is also what makes the Microcontroller the “building block” for more extensive system control. For larger sites with several screw compressors and associated equipment, multiple Microcontrollers can be networked to form a fully customized Engineered Control System (ECS.) An ECS could consist of screw compressor Microcontrollers, one Master Microcontroller with keypad and display and perhaps one or more Remote Microcontrollers (no keypad or display.) Control of various refrigeration system components such as condensers, evaporators, refrigerant pumps, etc., can be housed in a single Microcontroller (either Master or Remote), in a wide range of combinations. These various configurations allow panels to be either centralized or distributed to minimize wiring cost during installation. The ECS is also expandable; as the refrigeration system grows, only additional Microcontrollers are needed. All data entries are made on the keypad of the Master Microcontroller or a Compressor Microcontroller. No personal computer is required for system control and monitoring. The ECS network provides the flexibility and capability of microprocessor control at a cost far lower than competitive PC-based control systems.

Refrigeration Components

- Screw compressors
- Reciprocating compressors
- Rotary compressors
- Condensers
- Pump packages
- Intercoolers
- Evaporators
- Chillers
- Spiral freezers
- Purgers
- Scrape surface heat exchangers
- Ice machines
- Surge drums
- Transfer systems
- Blast freezers
- Hydro-vac coolers
- Tunnel freezers
- Double and single ice rink systems
- Leak detection systems
- kW monitoring
- kW load shedding
- Floor warming systems
- Exhaust fan control
- King solenoids
- All types of pressure, temperature, infrared, etc. sensor monitoring

CONTROLLER OVERVIEW

Main Status and Graphic Screens are automatically displayed unless keypad activity is occurring. The controller displays and continuously updates the following list of important compressor operating information as a status screen or a graphic screen.

- S1 Suction Pressure Setpoint (four available)
- SP Actual Suction Pressure
- DP Discharge Pressure
- OP Oil Pressure (above discharge pressure)
- OF Oil Filter Pressure Drop
- SV Slide Valve Position
- MA Motor Amps
- ST Suction Temperature
- DT Discharge Temperature
- OT Oil Temperature (into the compressor)
- OS Oil Separator Temperature

The Main Status Screen also displays:

Operation Mode

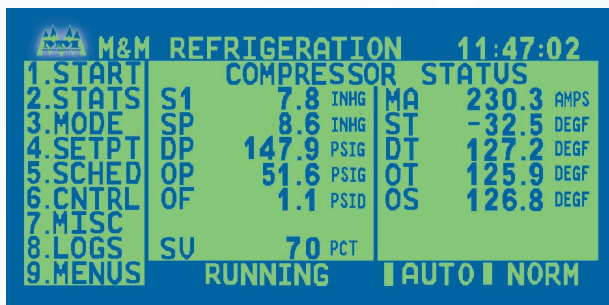
(Local, Manual, Automatic, Remote, Auto Remote, Sequenced)

Operation Status

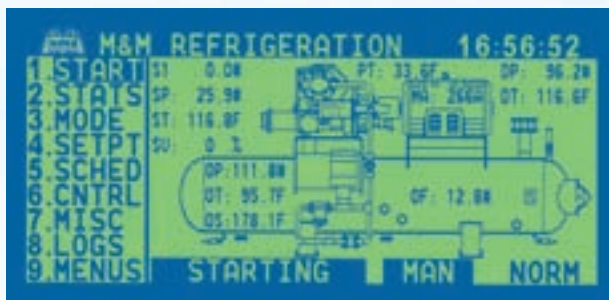
(Running, Starting, Stopped, Alarm, etc.)

Alarm or Failure Message

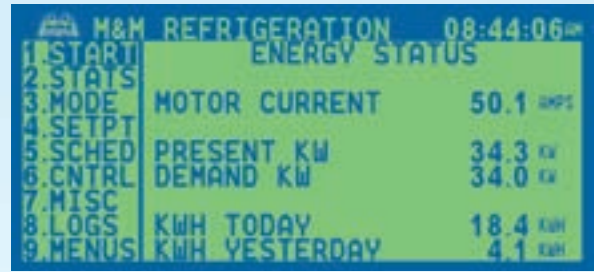
(62 possible messages)



Status Screen



Graphic Screen



Energy Status Screen displays real-time values of the following useful energy data:

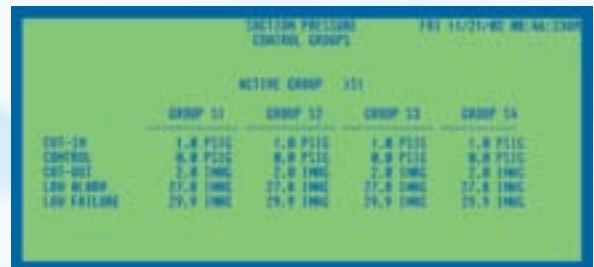
Motor Current

Present kW (instantaneous demand)

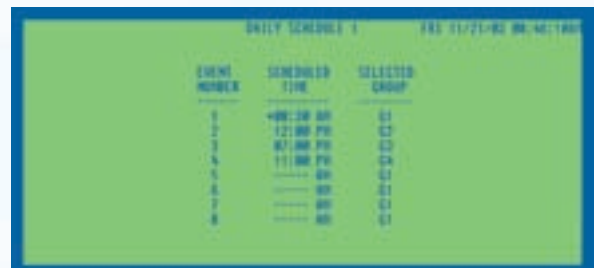
Demand kW (average demand calculated over the last 15 minutes)

Today's kWh (total energy consumed since midnight)

Yesterday's kWh (total energy consumed on the previous day)



Control Setpoints Screen permits the operator to enter up to four suction pressure control setpoints, with corresponding cut-in and cut-out pressure selections. In addition, the operator can choose to operate the compressor solely on either setpoint, or to let the compressor automatically select the setpoint from a pre-determined, selectable suction pressure setpoint schedule.



Setpoint Scheduling Screens provide tremendous flexibility of operation between the four available suction pressure setpoints. The microcontroller can be programmed for as many as eight setpoint changes per day, with up to seven different daily schedules. This valuable feature can save energy in plants operating on time-of-day electric rates, or in plants where cooling loads vary on an hourly and/or daily basis.

PARAMETER	SETPOINT	UNIT
WIDE FREQUENCY	127.8	RPM
WIDE ALARM	100.0	RPM
WIDE UNLOAD	127.8	RPM
WIDE CONTROL	100.0	RPM
WAMP UNLOAD	100.0	RPM
WAMP CONTROL	127.8	RPM
WAMP START DELAY	15.0	MIN
WAMP START ENABLE	ENABLE	

Operating, Alarm and Failure Setpoints Screens provide operator adjustable entries for key compressor parameters which when exceeded will trigger an alarm or shut down the compressor. A description of the alarm or failure will be shown on the Active Alarm and Failures Screen, and will also be stored in the Operation Log and in the Alarm or Failure History. These screens also contain selectable parameters to establish a gradual, controlled startup and loading of the screw compressor. Capacity, discharge pressure and motor amps are allowed to gradually increase during the startup period by controlling the movement of the slide valve in response to changes in these parameters. This feature eliminates possible current spikes that can create an excessive demand charge during startup.

TIME	DATE	TYPE	ENTRY DESCRIPTION	LEVEL
02:34:13	01/24/99	ALARM	Z1 FREEZER 1 TEMP	HIGH
02:30:39	01/24/99	ALARM	Z1 FREEZER 1 TEMP	LOW
02:26:44	01/24/99	ALARM	Z3 FREEZER 3 TEMP	HIGH
04:54:30	12/1/98	ALARM	Z3 FREEZER 3 TEMP	HIGH
00:09:10	12/09/98	ALARM	Z3 FREEZER 3 TEMP	LOW

Alarm, Failure and User Logs displays the last 50 messages, irrespective of time of occurrence. These messages include date and time of occurrence and a description of the alarm or failure. The user log records user number entries by date and time. These screens are of tremendous value in identifying chronic problems or for basic troubleshooting.

TIME	DATE	SETP #/F	CNTR #/F	MODE	STATE	TYPE	ENTRY DESCRIPTION
02:34:13	01/24	0.0#	1.4"	AUTO	FAILED	ALARM	Z1 FREEZER 1 TEMP
02:32:05	01/24	0.0#	1.7"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE
02:30:39	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	ALARM	Z1 FREEZER 1 TEMP
02:26:26	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE
02:27:49	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE

Operation Log records all data from the status screen for the past one hour, in 30 second intervals. In the event of an alarm or failure, an entry is recorded at the time of the malfunction, and the offending parameter is identified. Provision is also made for auxiliary input safeties, motor starter failure, bad sensor detection and faulty startup sequence check.

USER	PASSWORD	LEVEL
1	999999	99
2	885522	52
3	742533	74
4	115523	12
5	821477	33
6	442255	48
7	----	00
8	----	00
9	----	00
10	----	00

Password Menu Screen permits the operator to assign passwords for up to 10 control users. In addition, there can be as many as 99 different levels of password access, ranging from "observe only" to complete access for making data entries on all screens. Access to the password schedule screen requires the highest access level password. This extensive password system ensures complete security control and flexibility.

TIME	DATE	SETP #/F	CNTR #/F	MODE	STATE	TYPE	ENTRY DESCRIPTION
02:34:13	01/24	0.0#	1.4"	AUTO	FAILED	ALARM	Z1 FREEZER 1 TEMP
02:32:05	01/24	0.0#	1.7"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE
02:30:39	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	ALARM	Z1 FREEZER 1 TEMP
02:26:26	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE
02:27:49	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	FAIL	SLIDE VALVE
02:26:44	01/24	0.0#	1.6"	AUTO	STOP-OFFLINE	ALARM	Z3 FREEZER 3 TEMP

Trend Log provides the same information as the operation log by recording the last 200 sets of compressor operating parameters (i.e., main status screens) at a time interval selected by the operator (typically every 15 minutes).

	LOAD CONTROLS	UNLOAD CONTROLS	REFERENCE DATA
NORMAL BANDWIDTH	10.0 PSID	10.0 PSID	SETPOINT SI 0.0 PSIG
CONTROL DEADBAND	1.0 PSID	2.0 PSID	SLIDE VALVE POSN 3.2 INHG
LONG PULSE	10.0 SEC	10.0 SEC	
SHORT PULSE	1.0 SEC	1.0 SEC	SLIDE VALVE TIME 0 SEC
UPDATE TIME	15.0 SEC	15.0 SEC	SLIDE VALVE POSN 0 PCT

SCREW MODE AUTO
SCREW STATE RUNNING

Adjust Controls Screen provides a means of adjusting capacity control (slide valve movement) sensitivity. Operator selectable entries for normal bandwidth (suction pressure differential), control deadband, update time, shortest slide valve pulse, and longest slide valve pulse are provided. In addition, pertinent real-time control data is displayed to facilitate control adjustments.

M&M PC MONITOR

The entire M&M control system product line supports the addition of our Windows-based PC Monitor software package. PC Monitor facilitates remote or on-site monitoring and modification of M&M control system products. From any location, an operator can observe and modify current operating setpoints and retrieve valuable system information to a computer. The PC Monitor software can be configured to support any combination of the following features:

- On-site Direct Link, having one or more networked desktop computers with color monitor, keyboard and printer
- Remote Modem Link, providing computer communications with a control site over a telephone line connected to a modem in the Master Microcontroller

Typical main PC screen



- see Figure 1
- actual dates and times
- communications indicator
- overall system alarms & failures
- system status normal, alarm, fail
- print any screen in color or black and white
- bar appears on all PC screens

PC SOFTWARE FEATURES

All software is Microsoft Windows based comparable with Windows 98 or higher releases. Anything that the operator can do at the keypad of the microprocessor can be done from the PC. The same screens can be seen and all setpoints can be changed.

Figure 1, Tool box screen



STANDARD PC SOFTWARE FEATURES



Communications
direct connect, networked
or modem data



System Logging
automatic daily downloading of
all data to the hard disks based
on operator defined schedule



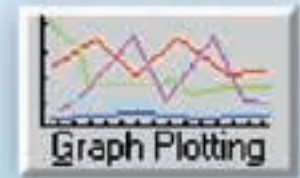
Reports
allows operator to choose
standard summary report or
design his or her own specific
report; dates, times, items,
report title, auto print on time,
and many other options



System Information
system specific software



Reports Setup
printer and screen fonts setup



Graph Plotting
allows operator to plot any
analog on any date, as a
historical graph or to select
real-time trend plotting



Save/Restore
retains all micro setpoints for
downloading and uploading



System Setup
allows operator to set prefer-
ences for general system setup
parameters which are Automatic
Scrolling, Disk Space, Clock
Mode, Colors, Sound, Automatic
Return and Communication
Error Display Menu



Equipment Runtimes
total running hours for all
controlled equipment



Directory Setup
allows operator to set
preferences for the location
of the data directory files,
data directory path and
runtime directory path



Maintenance Manager
support of any plant item
with task forecasting by date
or runtime, pending mainte-
nance task reports, work order
generation and maintenance
history logs

COLOR GRAPHIC DISPLAYS

Screens show real-time animated movement of screw and piston compressors along with all other refrigeration components. Red indicates that the piece of equipment is turned off. White indicates the piece of equipment is on. Compressors, fans, pumps, etc. are in motion when white and running. Color code is used to determine different temperature piping within the system. Digital readouts of all key sensor points are displayed on each screen (see Figure 2 & 3.)

You can select equipment such as an air unit and go directly to its status screen. You can also select a screw compressor and see the package fully animated (see Figure 4.) You can also select other screens such as a plant floor plan or specific equipment such as a spiral freezer (see Figure 5 - 7.)

All alarms or failures are shown on these screens by color (yellow-alarm, red-fail) and they will be flashing.

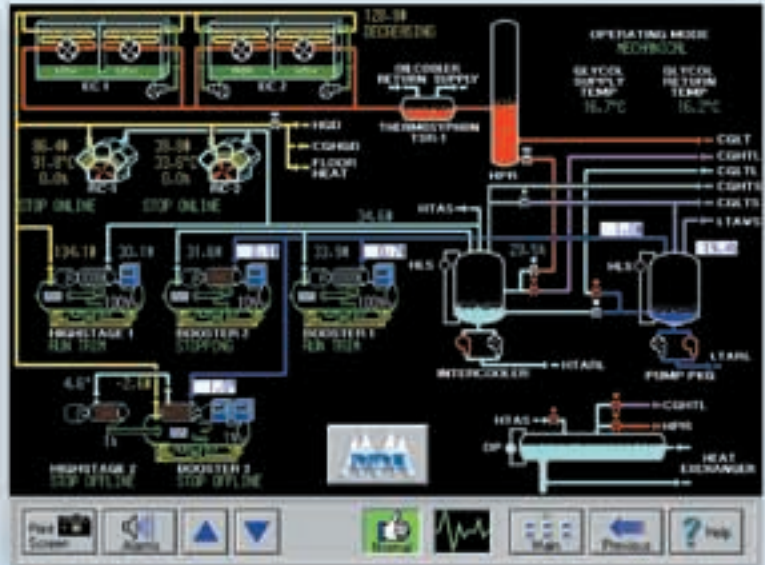


Figure 2, typical engine room

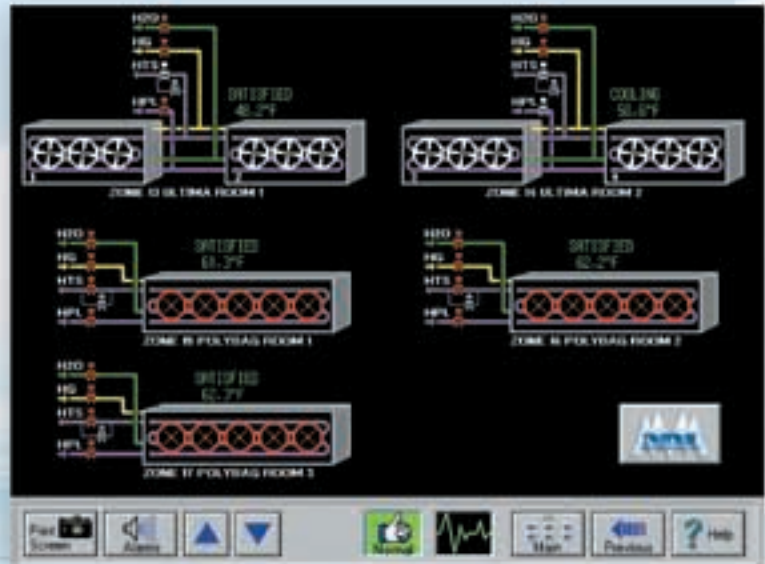


Figure 3, typical air units



Figure 4, typical screw compressor



Figure 5, typical floor plan



Figure 6, special equipment

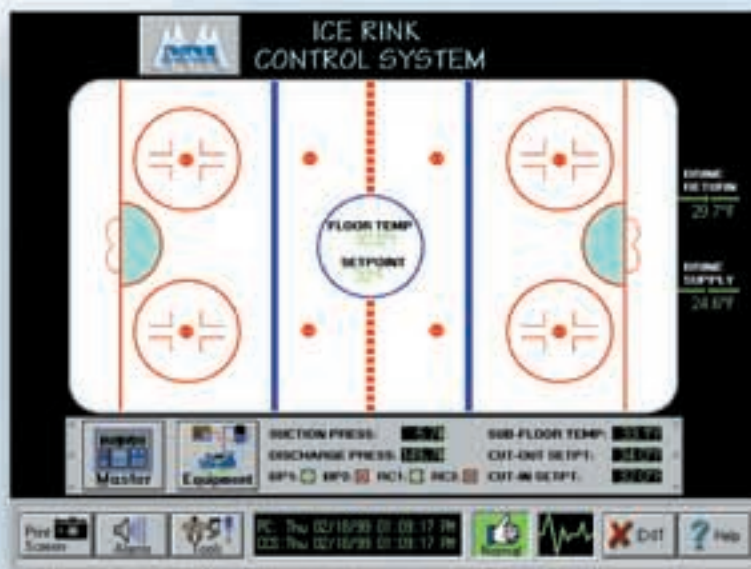


Figure 7, ice rink main status screen



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