The Integrated Boiler Room

- Gerry Cellucci Yorkland Controls

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Control Objectives for Hydronic systems

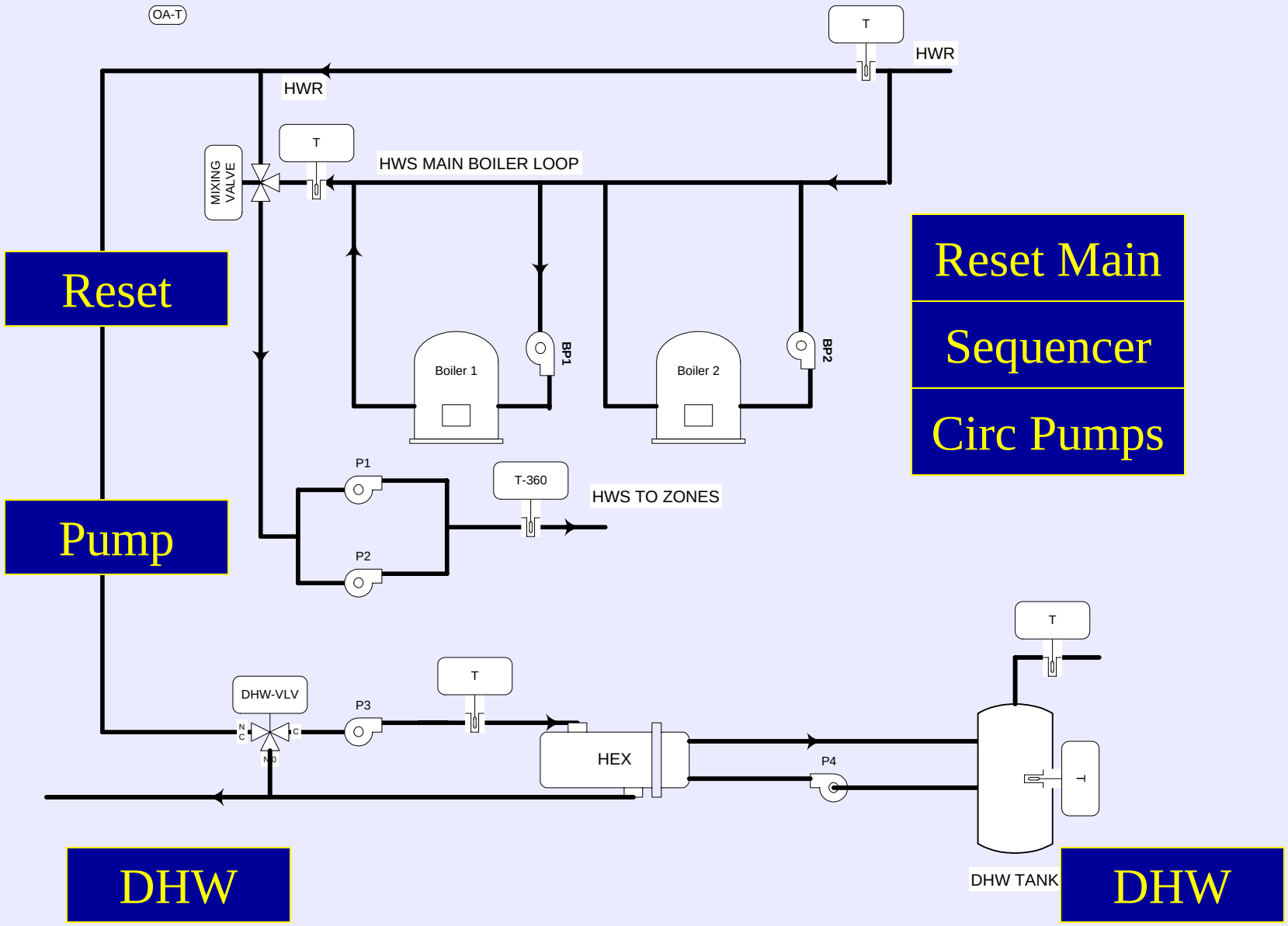
- Maximize Occupant Comfort
  - Maintain Constant Space Temperature
- Minimize Energy Consumption
  - Minimize boiler temperature
  - Minimize Boiler Cycling (on/off)
- Protection
  - Minimum Boiler Temperature Maintained
  - Boilers NOT to be Cycled on Limits

Boiler Room Control Trends

- Away from individual control of various heating loops:
  - Main Heating Loop
  - Secondary Heating Loops
  - Domestic Hot Water
  - Snow Melting
- Owners requesting operational information
  - Trends
  - Status
  - Alarms
- Reduce operating costs and increase efficiency

Typical Boiler Room Controls

- Control for Boiler sequencing
- Control(s) for “resetting” Hotwater based on outside air temperature
- Domestic Hotwater
- Air Handler Heating Coil Loops
- Radiant Heating Loops
- Differential Pressure
- Time clocks for setback


OA-T
T
HWR
HWR
T
MIXING VALVE
HWS MAIN BOILER LOOP
Reset
Reset Main
Sequencer
Circ Pumps
Boiler 1
BP1
Boiler 2
BP2
P1
T-360
HWS TO ZONES
Pump
P2
T
DHW-VLV
P3
T
HEX
P4
T
DHW TANK
DHW
DHW

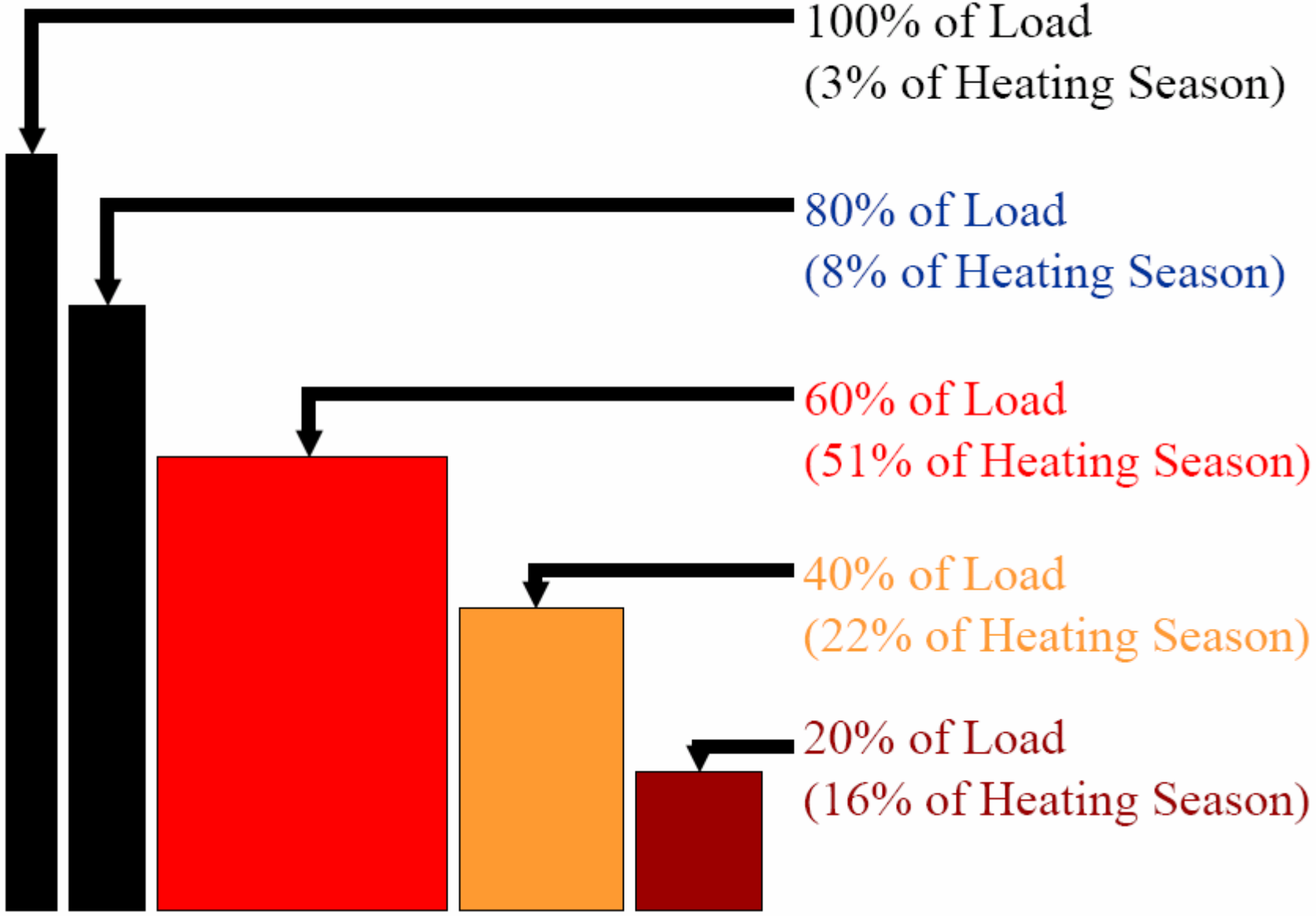
Current Control

- Different controls for the various loops
- Duplicate Sensors for the same function (Outdoor Air temp)
- Difficult to coordinate setpoints
- Limited Control Logic
- Limited Diagnostic
- Limited Alarming
- Minimal Energy Savings

Boiler Reset - What is it?

- Water temperature is varied based on outside temperature
- Heat loss from building changes continuously - not on/off
- Control matches heat loss of building to heat output of boiler (or mixing valve)

Seasonal Building Load



Boiler Reset - Benefits

- Reduced heat loss through pipes. (Standby Losses reduced)
- Increased boiler efficiency. (Boilers more efficient at lower fire)
- Elimination of uncomfortable (and expensive) overheating.
- Boiler shutoff when it's not needed.

Boiler Reset

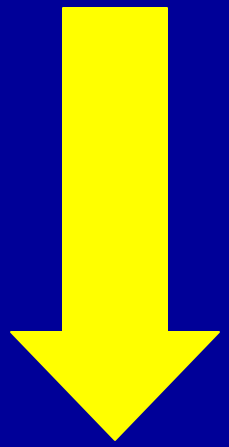
- Hotwater supply temperatures are RESET based on outside air. Goal is to reduce the seasonal average control temperature.
- Typical reset schedule
  - OA-T = 0 F HWS-T = 185
  - OA-T = 65 F HWS-T = 135
- Savings calculation are often derived from estimates
- Studies to show minimum 10% to 12 % savings

Building Reset Types

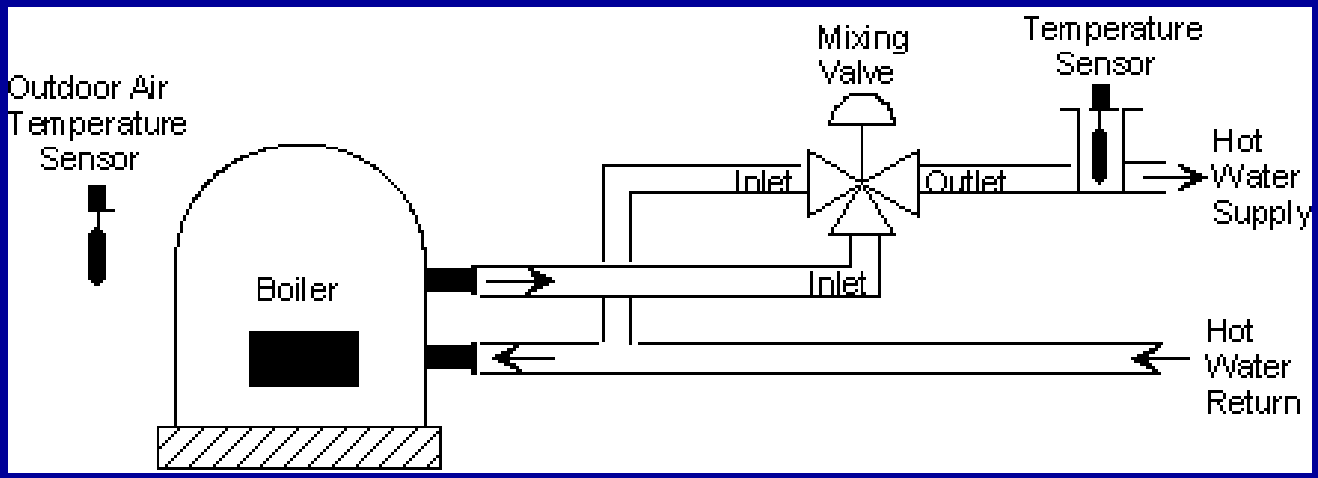
- Boiler Temperature Reset
- Mixing Reset (Building Loop)

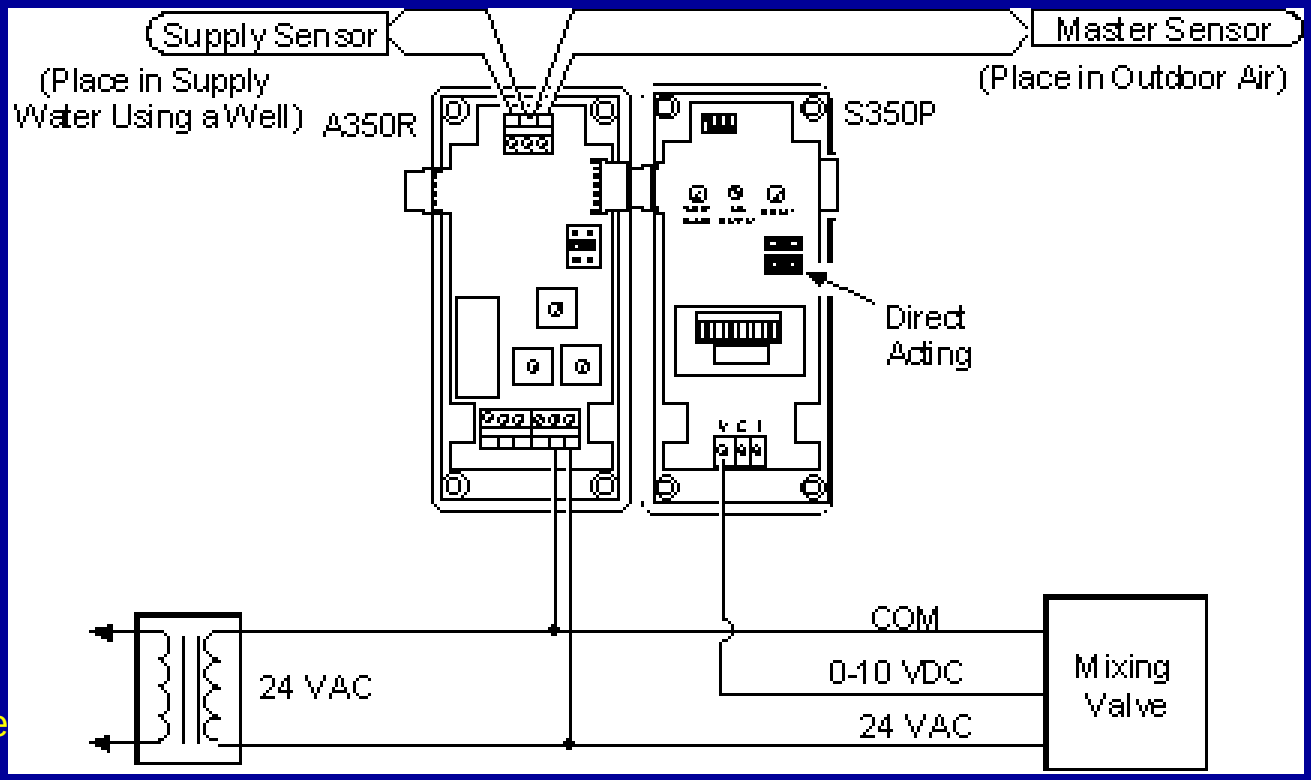
Typical Reset Products

Increasing Features



- T775 Honeywell
- A350R Johnson
- TekMar
- Dx9100


Outdoor Air
Temperature
Sensor
Boiler
Mixing
Valve
Temperature
Sensor
Inlet
Outlet
Hot
Water
Supply
Inlet
Hot
Water
Return


Supply Sensor
(Place in Supply
Water Using a Well)
A350R
Master Sensor
(Place in Outdoor Air)
S350P
Direct
Acting
COM
0-10 VDC
24 VAC
24 VAC
Mixing
Valve

Typical Reset Schedules

- Main Boiler

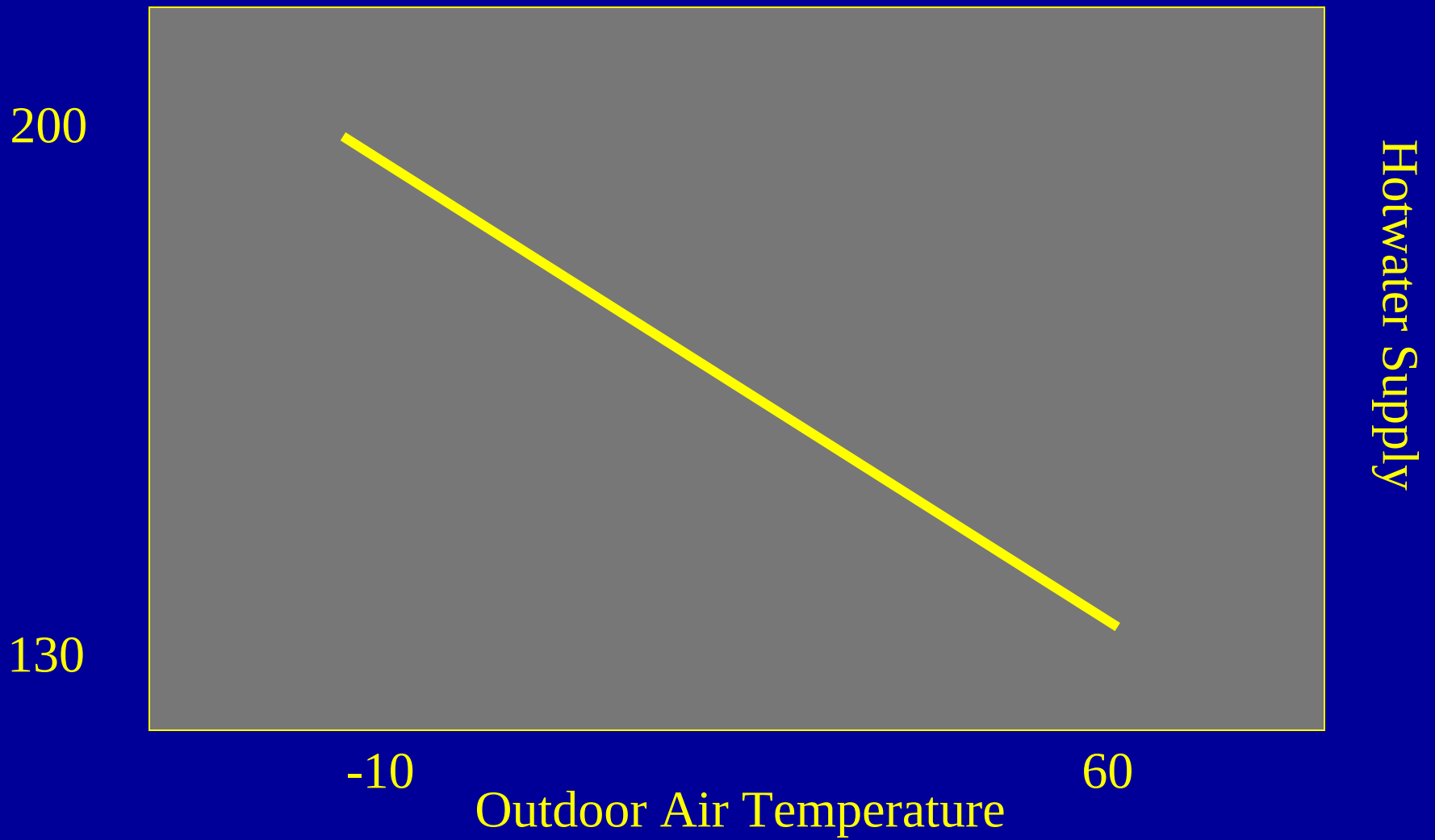
OA-T	HWS-T
-10	190
55	130

- Radiation

OA-T	HWS-T
0	180
55	100

Usually expressed as a Ratio

What is the Ratio ?



Boiler Sequencing

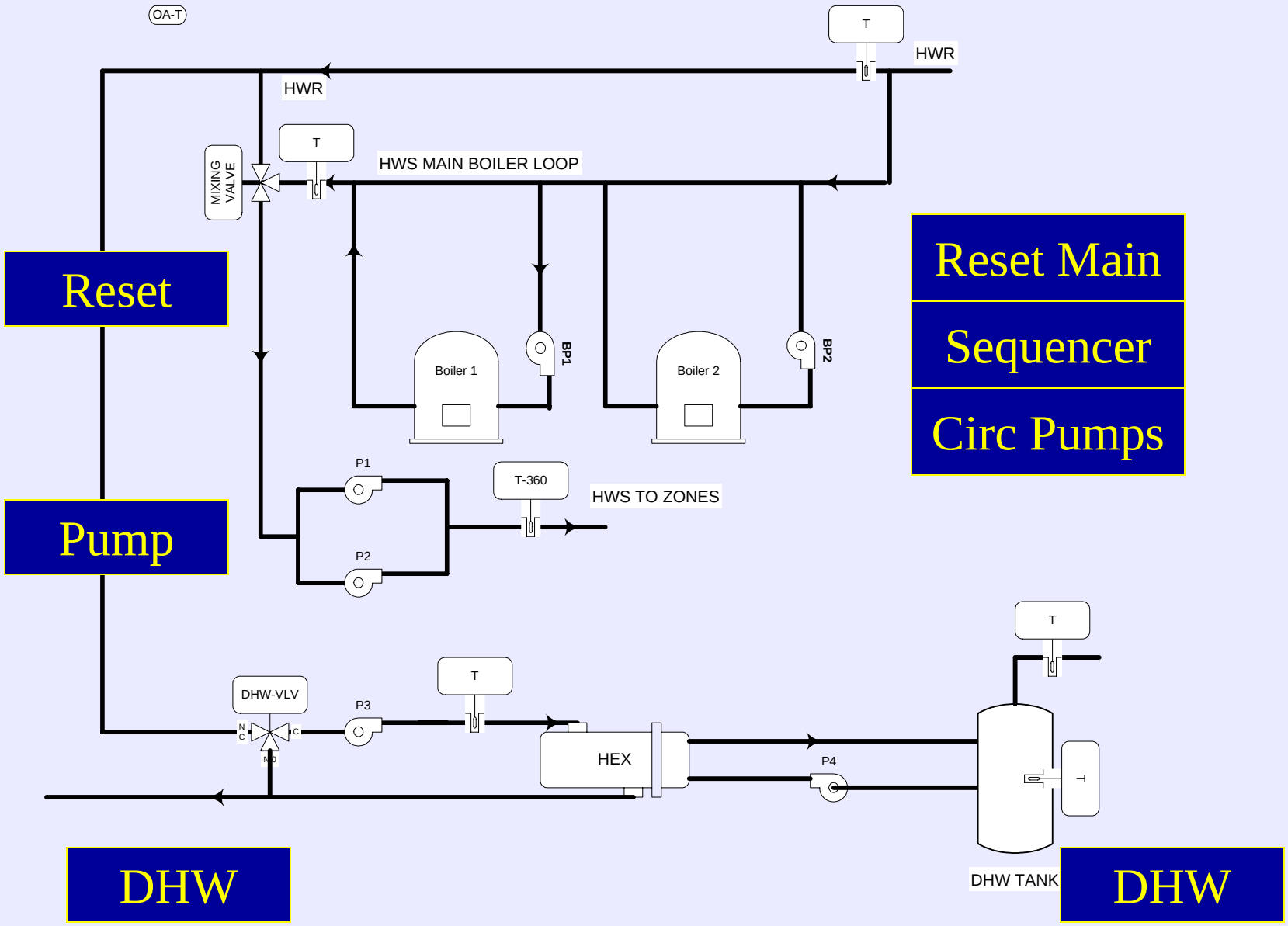
- Lead-Lag
  - Boilers run 1,2,3,4 then 4,3,2,1
  - Switching input
  - Usually set with a manual or time clock
- Rotational
  - Boilers run in logical order on the next firing cycle: 1,2,3,4, then 2,3,4,1 then 3,4,1,2, then 4,3,2,1
- Equal Run Time
  - Boiler with the least amount of “ON” time is first on.

Integrated Control Benefits
(all functions in one common interface)

- Multiple Boiler Sequencing:
  - Lead-Lag
  - Rotational
  - Equal Run Time
- Shared Sensors
- Multiple Control Loops (PID)
- Different Reset Ratios for various loads
- Pump Control
- Post-Purge Pump Control
- Anti – Condensation Protection
- Trending for Major Parameters
- Occupied Time schedule common for all the control loops

Benefits

- One location for the information
- Microprocessor based
- Easy to use customizable display
- Networkable
- Centralized Alarms
  - Pager
  - Mobile Phone
  - E-Mail


OA-T
T
HWR
HWR
T
MIXING VALVE
HWS MAIN BOILER LOOP
Reset
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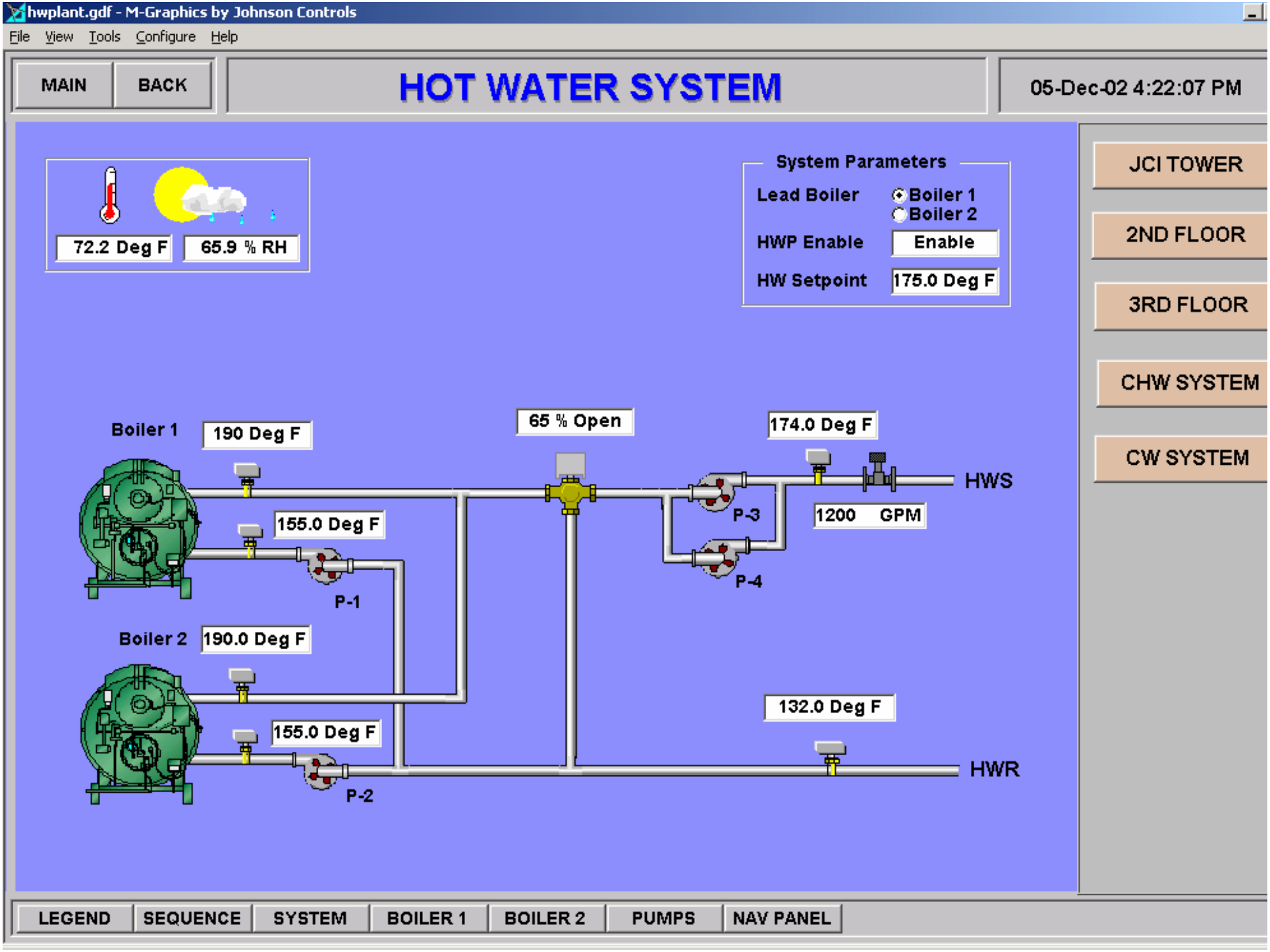
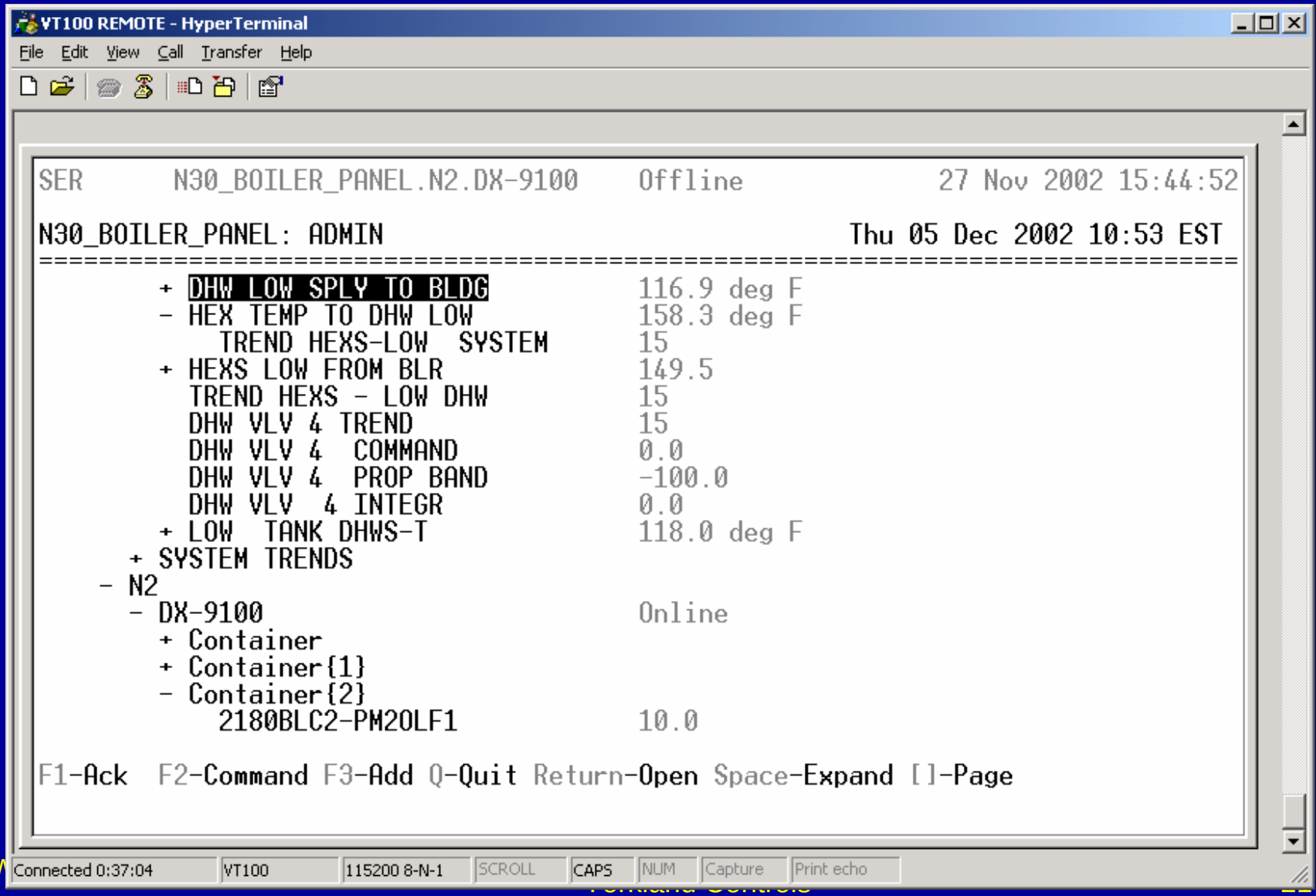
T-360
HWS TO ZONES
Pump
P2
T
DHW-VLV
P3
T
HEX
P4
T
DHW TANK
DHW
DHW


hwplant.gdf - M-Graphics by Johnson Controls
File View Tools Configure Help
MAIN
BACK
HOT WATER SYSTEM
05-Dec-02 4:22:07 PM
72.2 Deg F
65.9 % RH
System Parameters
Lead Boiler
Boiler 1
Boiler 2
HWP Enable
Enable
HW Setpoint
175.0 Deg F
JCI TOWER
2ND FLOOR
3RD FLOOR
CHW SYSTEM
CW SYSTEM
Boiler 1
190 Deg F
65 % Open
174.0 Deg F
HWS
155.0 Deg F
P-3
1200 GPM
P-4
P-1
Boiler 2
190.0 Deg F
132.0 Deg F
155.0 Deg F
HWR
P-2
LEGEND
SEQUENCE
SYSTEM
BOILER 1
BOILER 2
PUMPS
NAV PANEL


VT100 REMOTE - HyperTerminal
File Edit View Call Transfer Help
SER N30_BOILER_PANEL.N2.DX-9100 Offline 27 Nov 2002 15:44:52
N30_BOILER_PANEL: ADMIN Thu 05 Dec 2002 10:53 EST
+ DHW LOW SPLY TO BLDG 116.9 deg F
- HEX TEMP TO DHW LOW 158.3 deg F
TREND HEXS-LOW SYSTEM 15
+ HEXS LOW FROM BLR 149.5
TREND HEXS - LOW DHW 15
DHW VLV 4 TREND 15
DHW VLV 4 COMMAND 0.0
DHW VLV 4 PROP BAND -100.0
DHW VLV 4 INTEGR 0.0
+ LOW TANK DHWS-T 118.0 deg F
+ SYSTEM TRENDS
- N2
- DX-9100 Online
+ Container
+ Container{1}
- Container{2}
2180BLC2-PM20LF1 10.0
F1-Ack F2-Command F3-Add Q-Quit Return-Open Space-Expand []-Page
Connected 0:37:04
VT100
115200 8-N-1
SCROLL
CAPS
NUM
Capture
Print echo

Integration with Generic Controls

- Custom Control Loops
- Same Controller for different types of heating or cooling systems
- Easy to duplicate programs

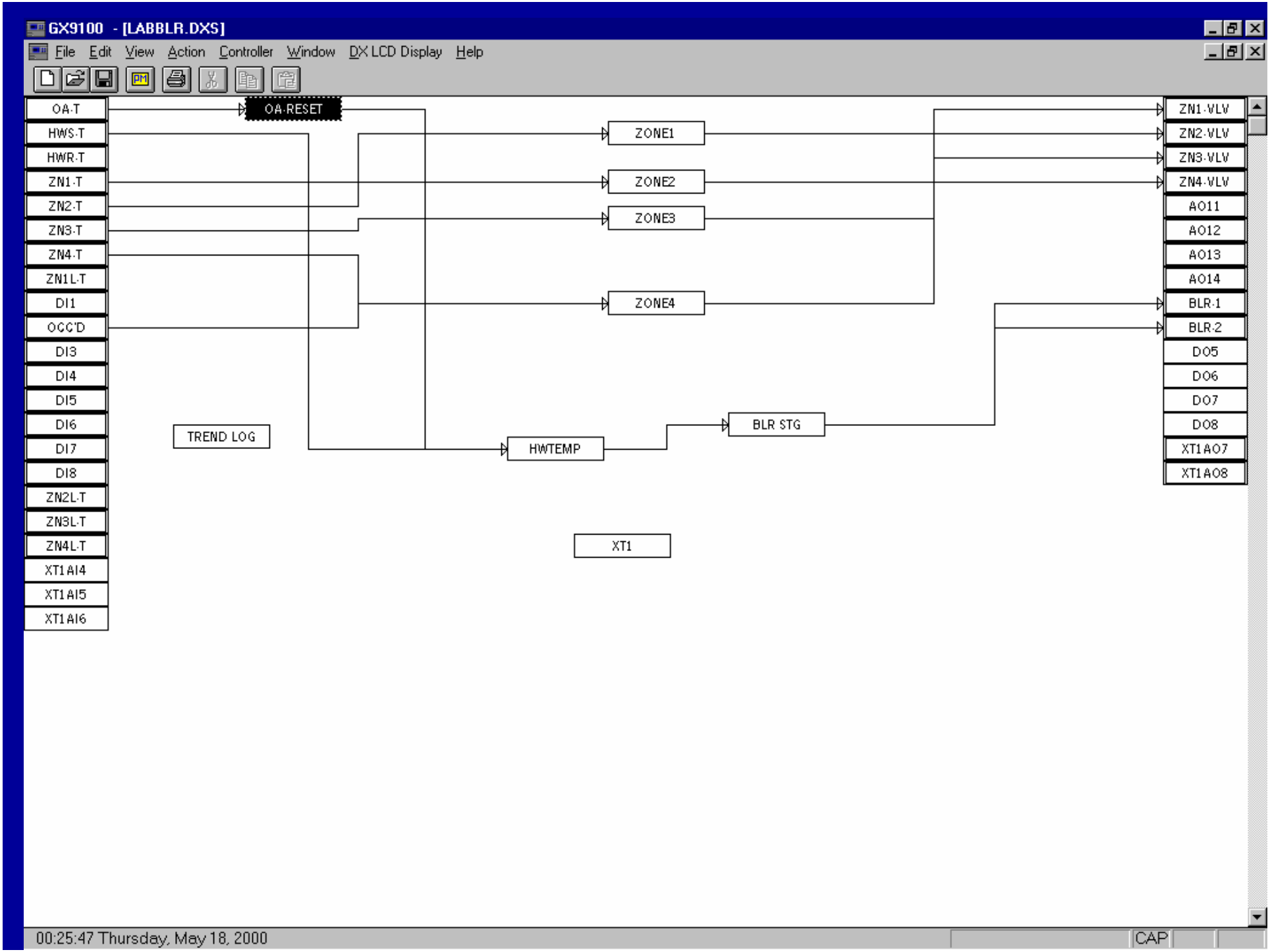
Generic Contol

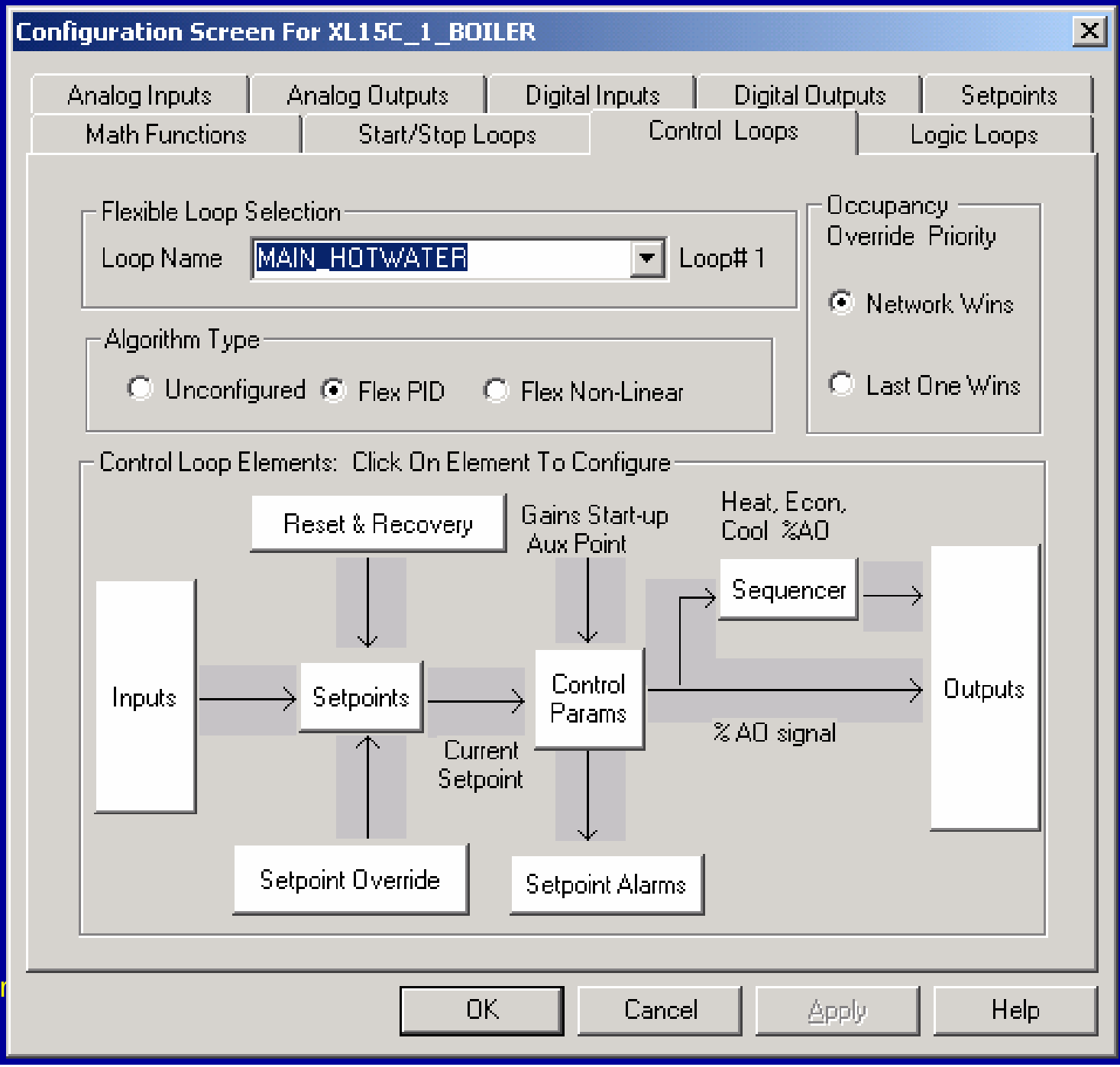
- Uses Software to set up the control loops
- Same software is used to commission

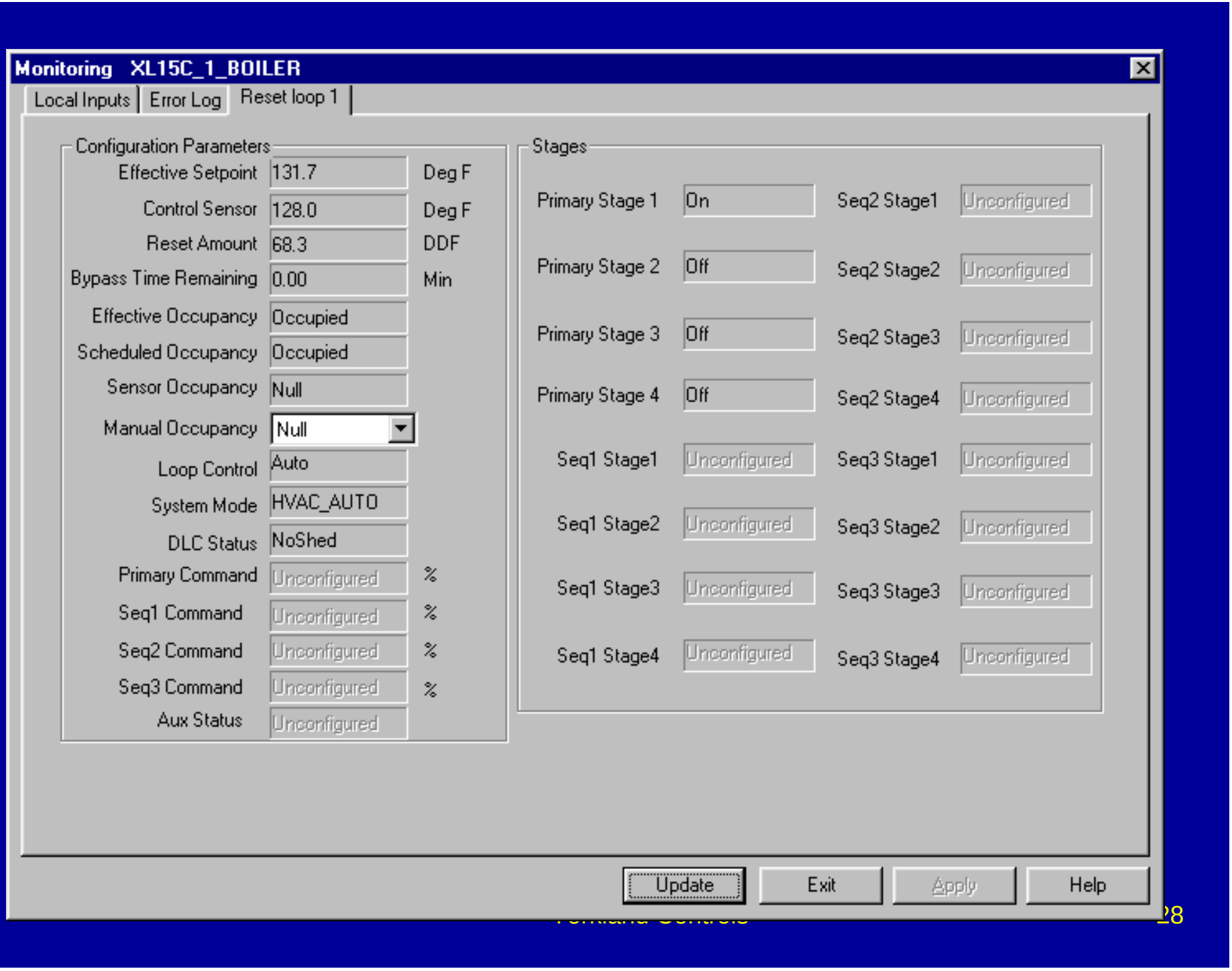
Typical Controllers

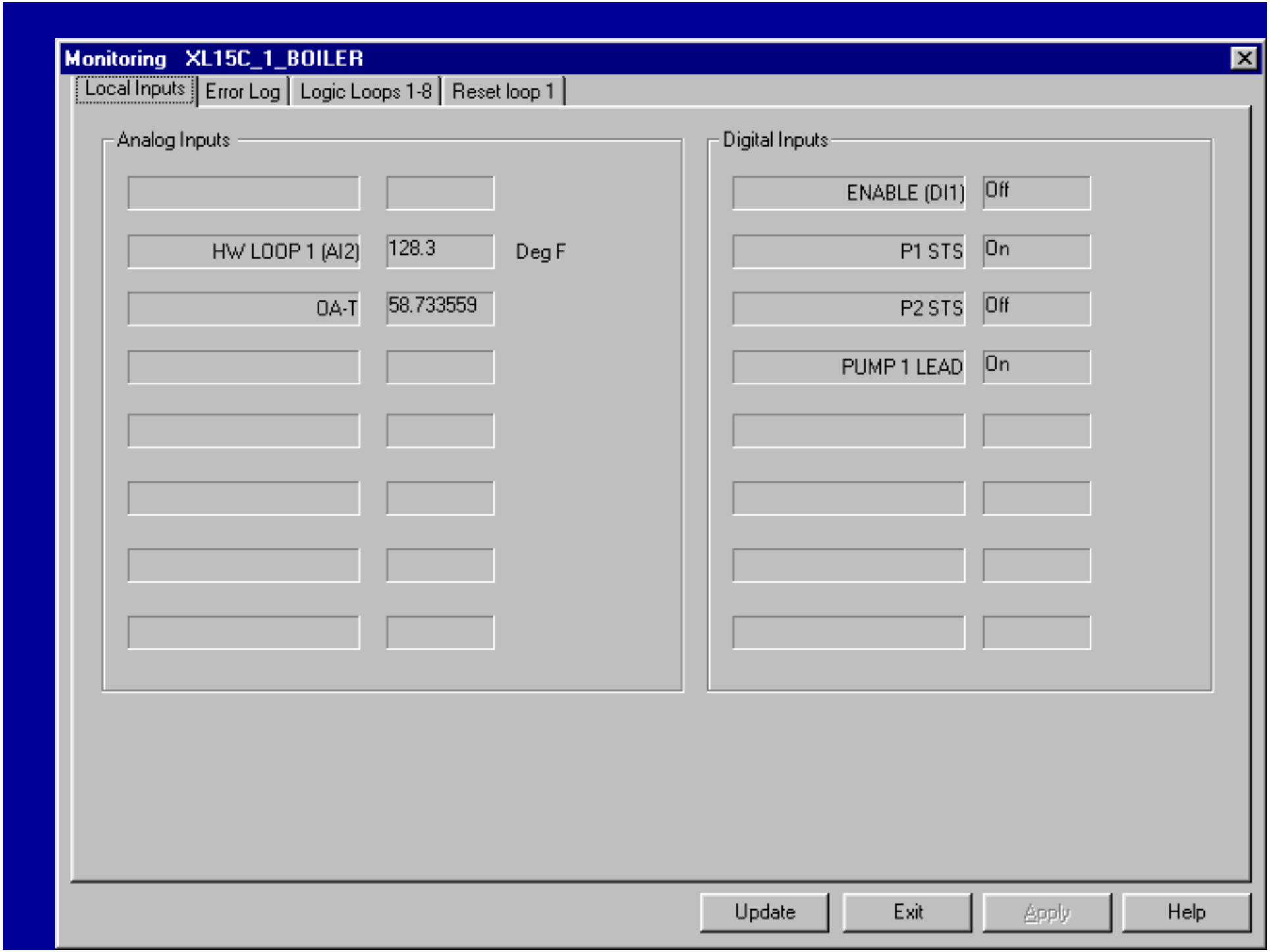
Generic Control Features

- **10 – 12 PID Control Loops with enhanced capabilities**
- **Start/Stop Loops**
- **Logic Loops**
- **Math Functions**
- **Sequencing functions**
- **Pulse inputs for flow meters**
- **8 Digital Inputs, 8 Digital Outputs**
- **8 Analog Inputs, 6 Analog Outputs**
- **Expandable I/O's**

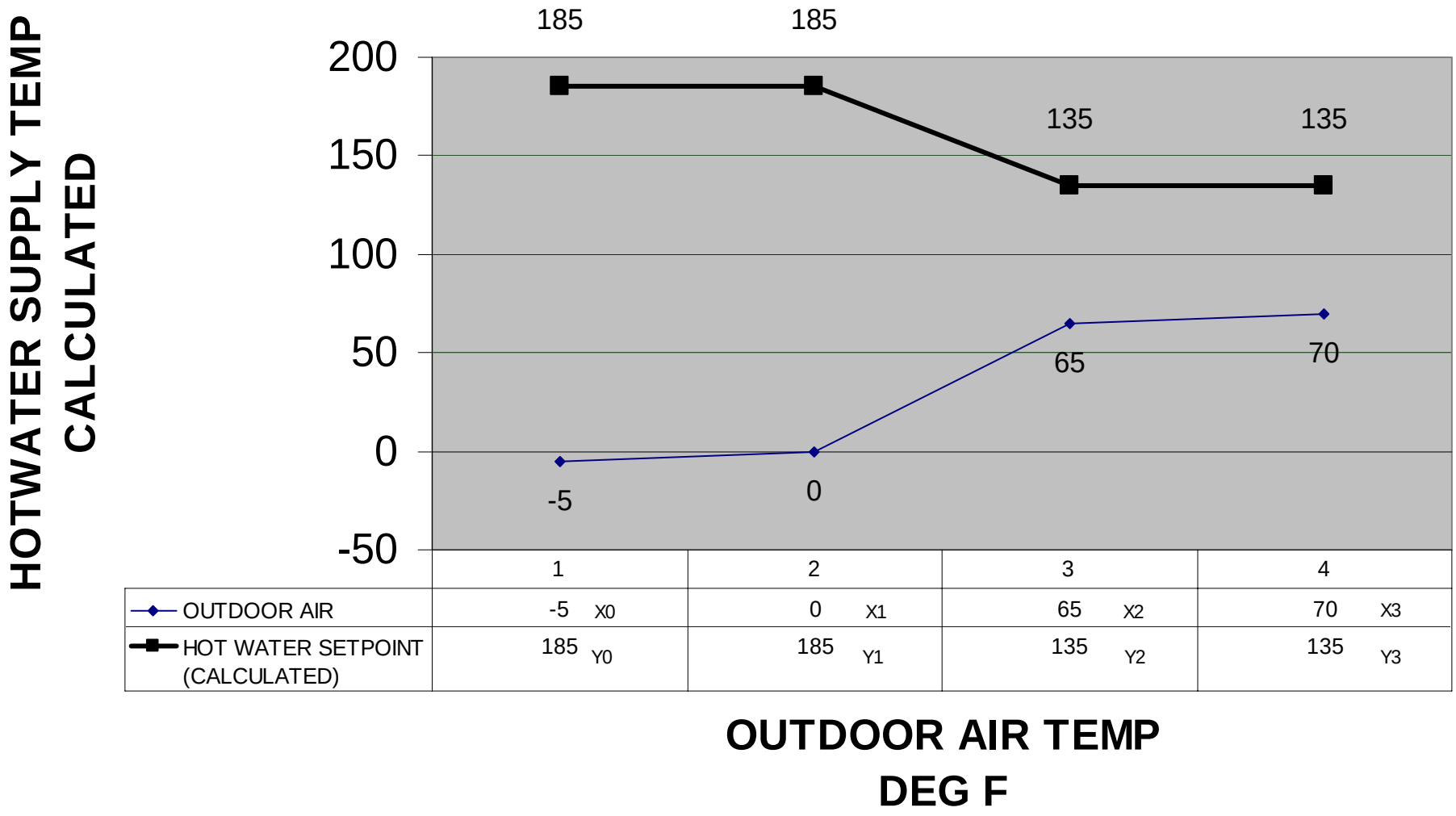

GX9100 - [LABBLR.DXS]
File Edit View Action Controller Window DX LCD Display Help
OA·T
HWS·T
HWR·T
ZN1·T
ZN2·T
ZN3·T
ZN4·T
ZN1L·T
DI1
OCC'D
DI3
DI4
DI5
DI6
DI7
DI8
ZN2L·T
ZN3L·T
ZN4L·T
XT1 AI4
XT1 AI5
XT1 AI6
OA·RESET
ZONE1
ZONE2
ZONE3
ZONE4
TREND LOG
HWTEMP
BLR STG
XT1
ZN1·VLV
ZN2·VLV
ZN3·VLV
ZN4·VLV
AO11
AO12
AO13
AO14
BLR·1
BLR·2
DO5
DO6
DO7
DO8
XT1 AO7
XT1 AO8
00:25:47 Thursday, May 18, 2000
CAP


Configuration Screen For XL15C_1_BOILER
Analog Inputs
Analog Outputs
Digital Inputs
Digital Outputs
Setpoints
Math Functions
Start/Stop Loops
Control Loops
Logic Loops
Flexible Loop Selection
Loop Name
MAIN_HOTWATER
Loop# 1
Occupancy Override Priority
Network Wins
Last One Wins
Algorithm Type
Unconfigured
Flex PID
Flex Non-Linear
Control Loop Elements: Click On Element To Configure
Reset & Recovery
Gains Start-up Aux Point
Heat, Econ, Cool %AO
Sequencer
Inputs
Setpoints
Control Params
Outputs
Current Setpoint
% AO signal
Setpoint Override
Setpoint Alarms
OK
Cancel
Apply
Help


Monitoring XL15C_1_BOILER
Local Inputs
Error Log
Reset loop 1
Configuration Parameters
Effective Setpoint 131.7 Deg F
Control Sensor 128.0 Deg F
Reset Amount 68.3 DDF
Bypass Time Remaining 0.00 Min
Effective Occupancy Occupied
Scheduled Occupancy Occupied
Sensor Occupancy Null
Manual Occupancy Null
Loop Control Auto
System Mode HVAC_AUTO
DLC Status NoShed
Primary Command Unconfigured %
Seq1 Command Unconfigured %
Seq2 Command Unconfigured %
Seq3 Command Unconfigured %
Aux Status Unconfigured
Stages
Primary Stage 1 On
Primary Stage 2 Off
Primary Stage 3 Off
Primary Stage 4 Off
Seq1 Stage1 Unconfigured
Seq1 Stage2 Unconfigured
Seq1 Stage3 Unconfigured
Seq1 Stage4 Unconfigured
Seq2 Stage1 Unconfigured
Seq2 Stage2 Unconfigured
Seq2 Stage3 Unconfigured
Seq2 Stage4 Unconfigured
Seq3 Stage1 Unconfigured
Seq3 Stage2 Unconfigured
Seq3 Stage3 Unconfigured
Seq3 Stage4 Unconfigured
Update
Exit
Apply
Help


Monitoring XL15C_1_BOILER
Local Inputs
Error Log
Logic Loops 1-8
Reset loop 1
Analog Inputs
HW LOOP 1 (AI2)
128.3
Deg F
OA-T
58.733559
Digital Inputs
ENABLE (DI1)
Off
P1 STS
On
P2 STS
Off
PUMP 1 LEAD
On
Update
Exit
Apply
Help

RESET SCHEDULE
TYPICAL



Reset Control Strategy

- Reset Schedule (ratio) calculates the Hot water temp SETPOINT
- SETPOINT is compared to ACTUAL Hot water temp
- DIFFERENCE compared to the “proportional band” (throttling band) parameter determines the amount of heating capacity required (expressed as a %)

Reset Strategy - Example

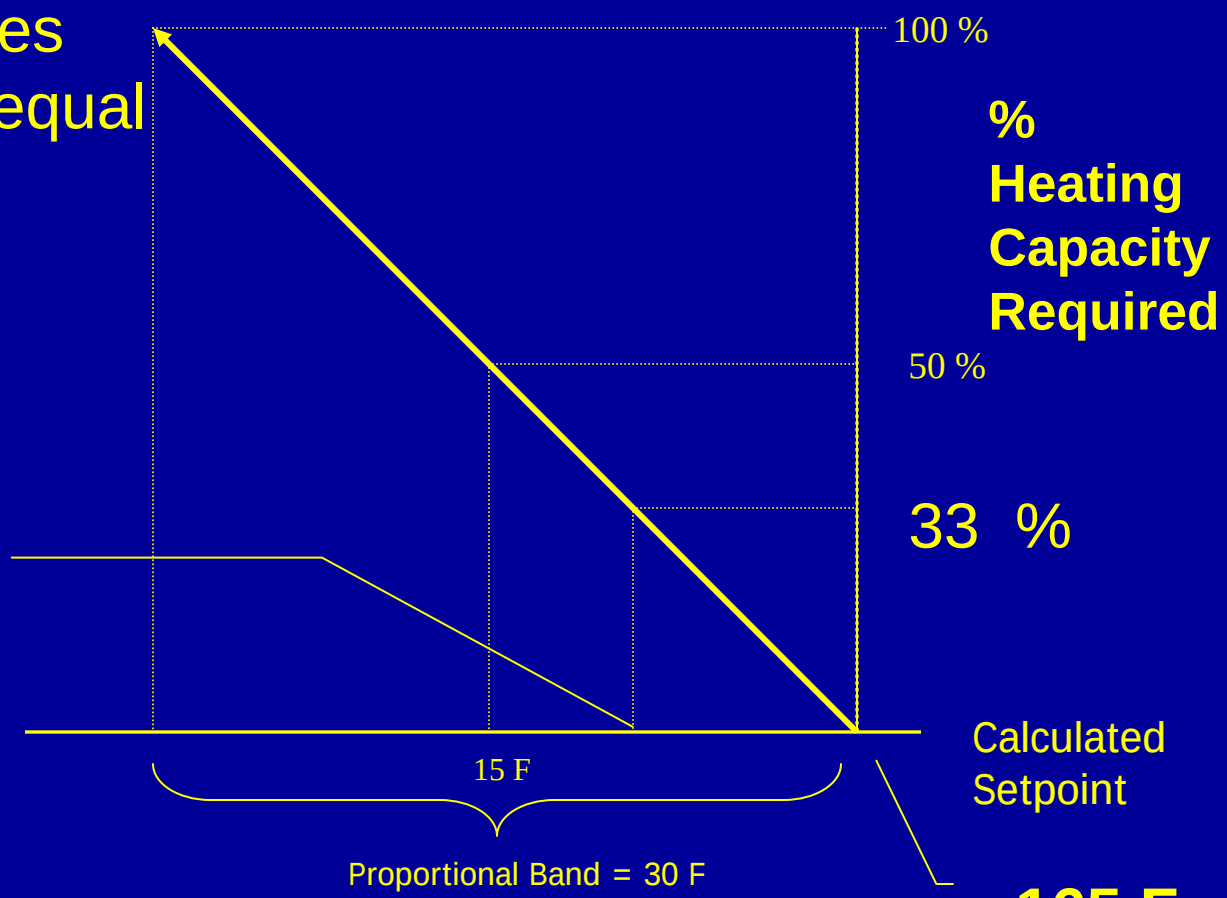
- Calculated Hotwater Setpoint = 165 F
- Actual Hotwater Temperature = 155 F
- Proportional Band Set = 30 F
- % Heating Capacity = 33%

Boiler Capacity & Proportional Band Relationship

One Boiler - 3 Stages each stage having equal capacity

One stage is ON

Actual HW Temp 155 F



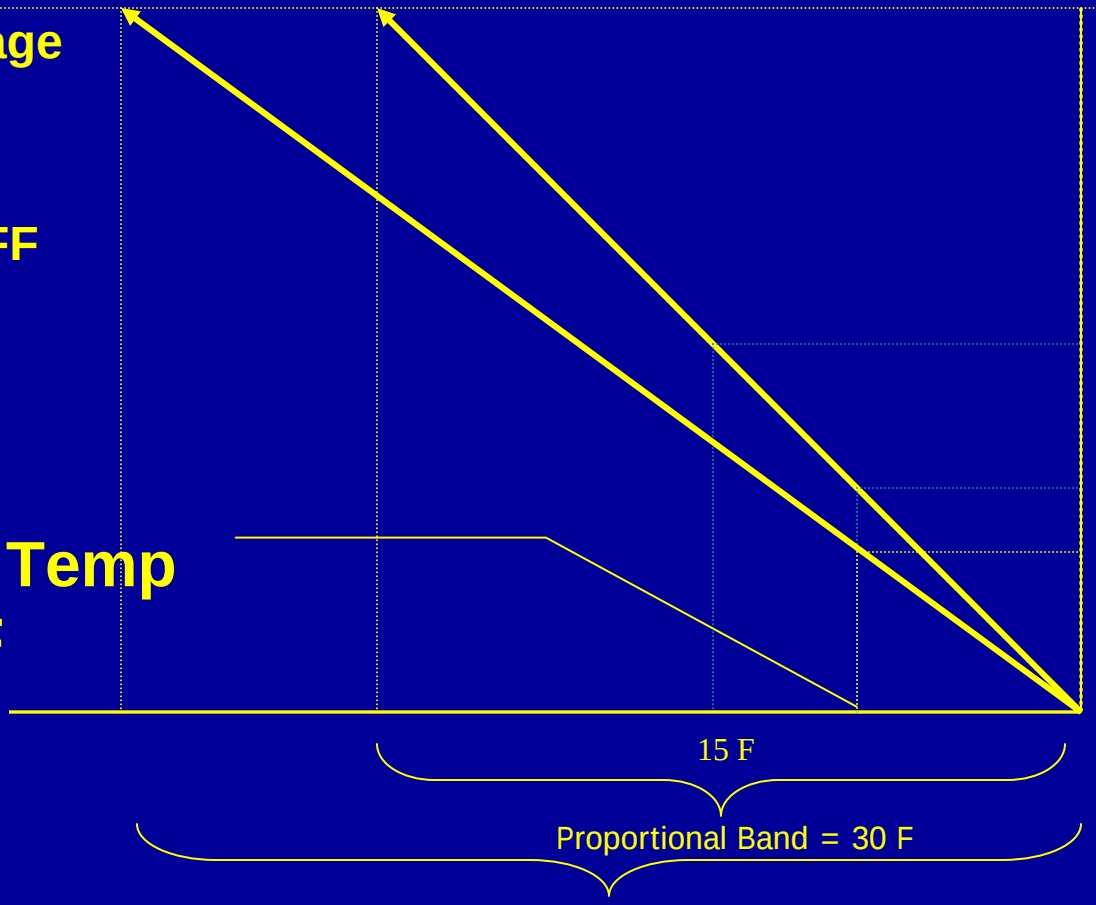
Boiler Reset – *Load Compensation*

- Direct Feedback of Buildings' Heat Load
- Boiler Capacity is adjusted by using Return Water or Space Temperature as Feedback
  - Capacity is reduced as Space temperature approaches space comfort (72F)
  - Capacity is reduced as Return Water approaches Supply Water
- New Effective Set point is used to determine Capacity

Boiler Capacity & Proportional Band Relationship

One Boiler - 3 Stages each stage having equal capacity

One stage is OFF



Simply……

- Load Compensation accounts for internal heat load by staging boilers - “OFF” SOONER & “ON” LATER…….in a smooth controlled manner. (no cycling of the boilers)

Estimated Reset Savings

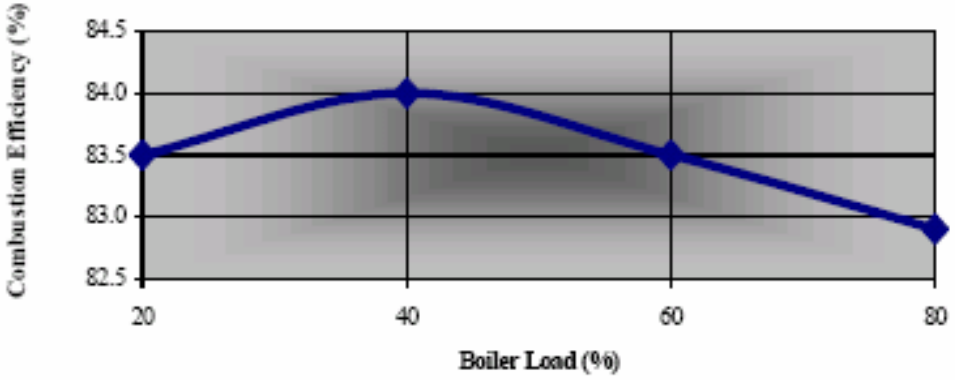
- Average reduction in boiler temp 25 F with basic reset
  - 10% to 15% Savings
- Average reduction in boiler temp 30 F with load compensation additional
  - 7% to 15%
- Utilities offering Rebates

Other Control System Features

- Variable Stage Cycling
  - Equal wear
  - Low-Med-High or Low-Low-Low Firing
- Season “Soft-Start” of Building Loop Valve
- Boiler Circulating Pump Run Time
- Characterized Reset Schedule
  - Match radiation equipment
    - Finned Tube
    - Fan Coils
    - DHW Production

Boilers Efficient at Low to Mid Load

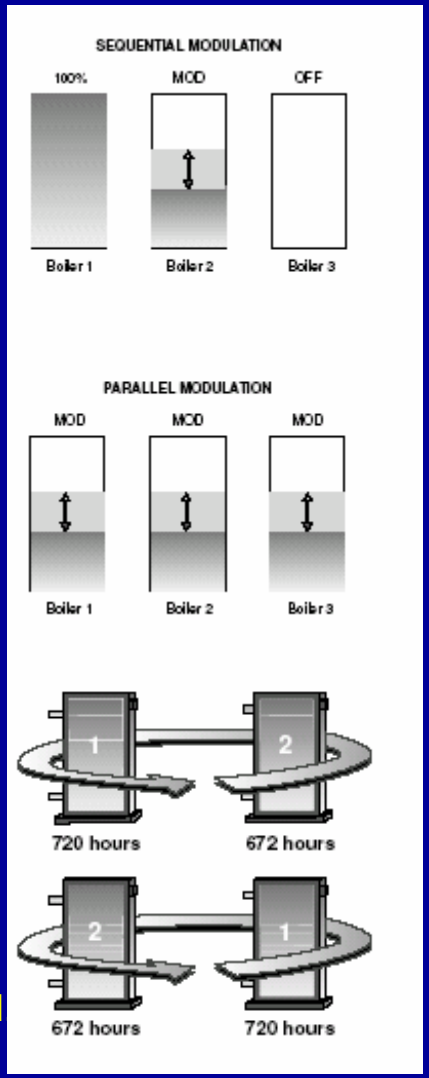
FIGURE 1: Boiler's Efficiency vs Load Graph



Boiler Loading	Boiler Efficiency	Stack Temperature	Excess Air
20%	83.5%	312^{0}F	36%
40%	84%	326^{0}F	18%
60%	83.5%	350^{0}F	15%
80%	82.9%	373^{0}F	14%

TABLE 1: Boiler's Efficiency vs. Load Data

Firing Sequence

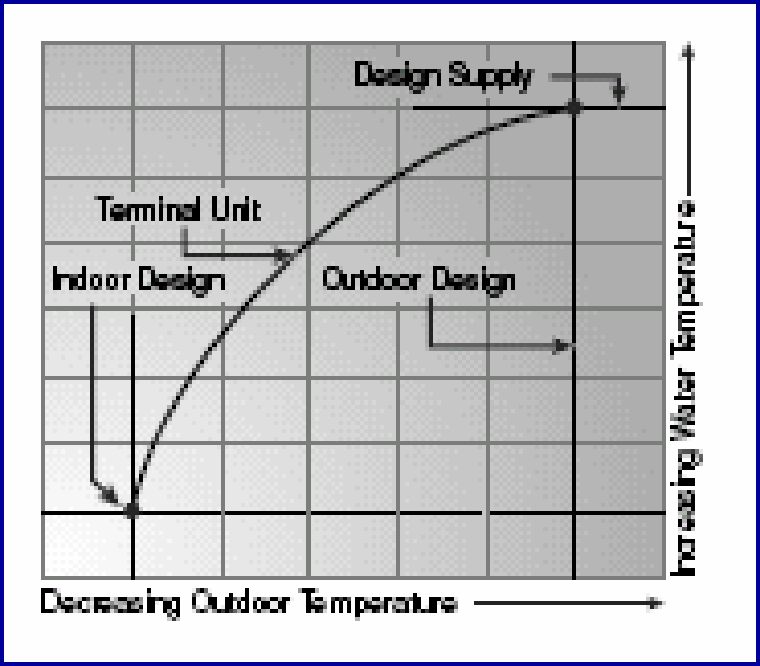


- Low - Medium - High (3 to 4 stages per boiler)

- Low – Low – Low

- Equal Run Time

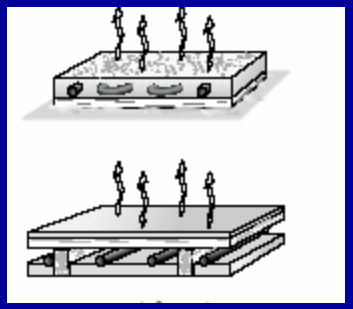
Characterized Heating Curve

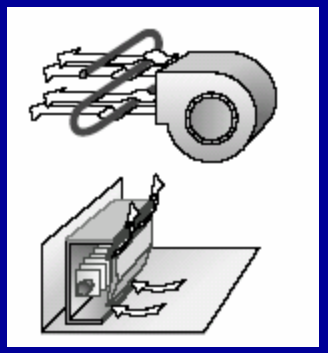


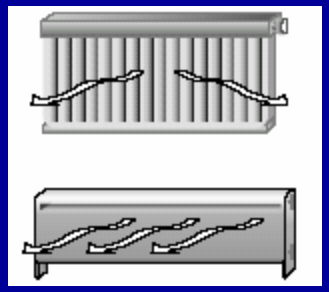
- Different types of terminal units transfer heat to the space at different proportions of radiation, and convection
- Water supply temperature is controlled by the type of terminal unit

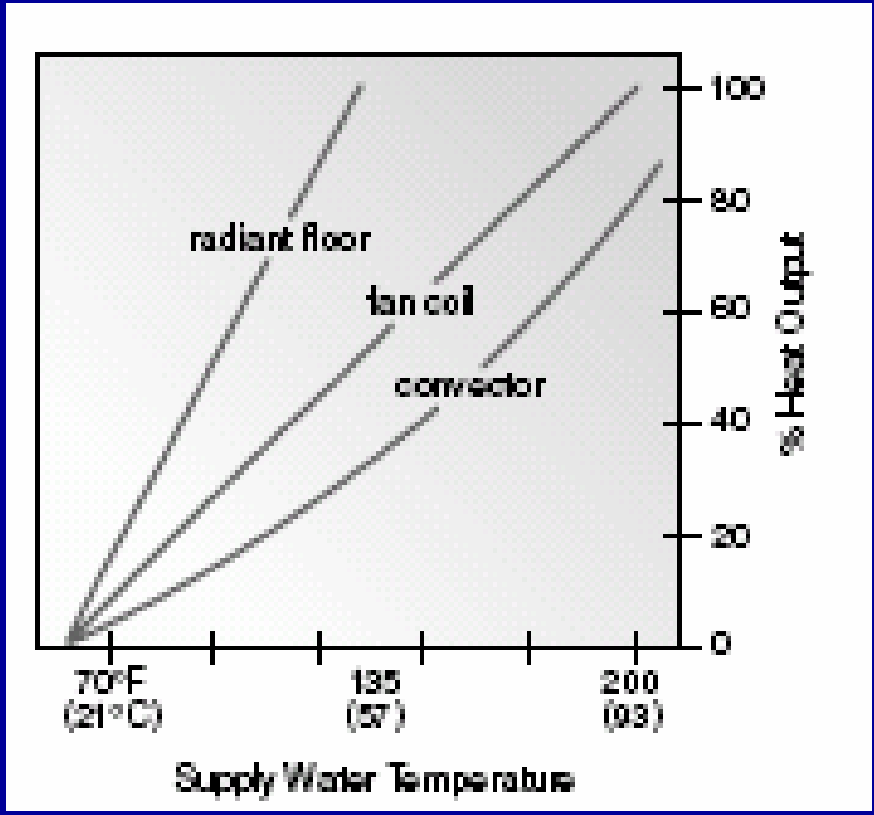
Terminal Unit Types

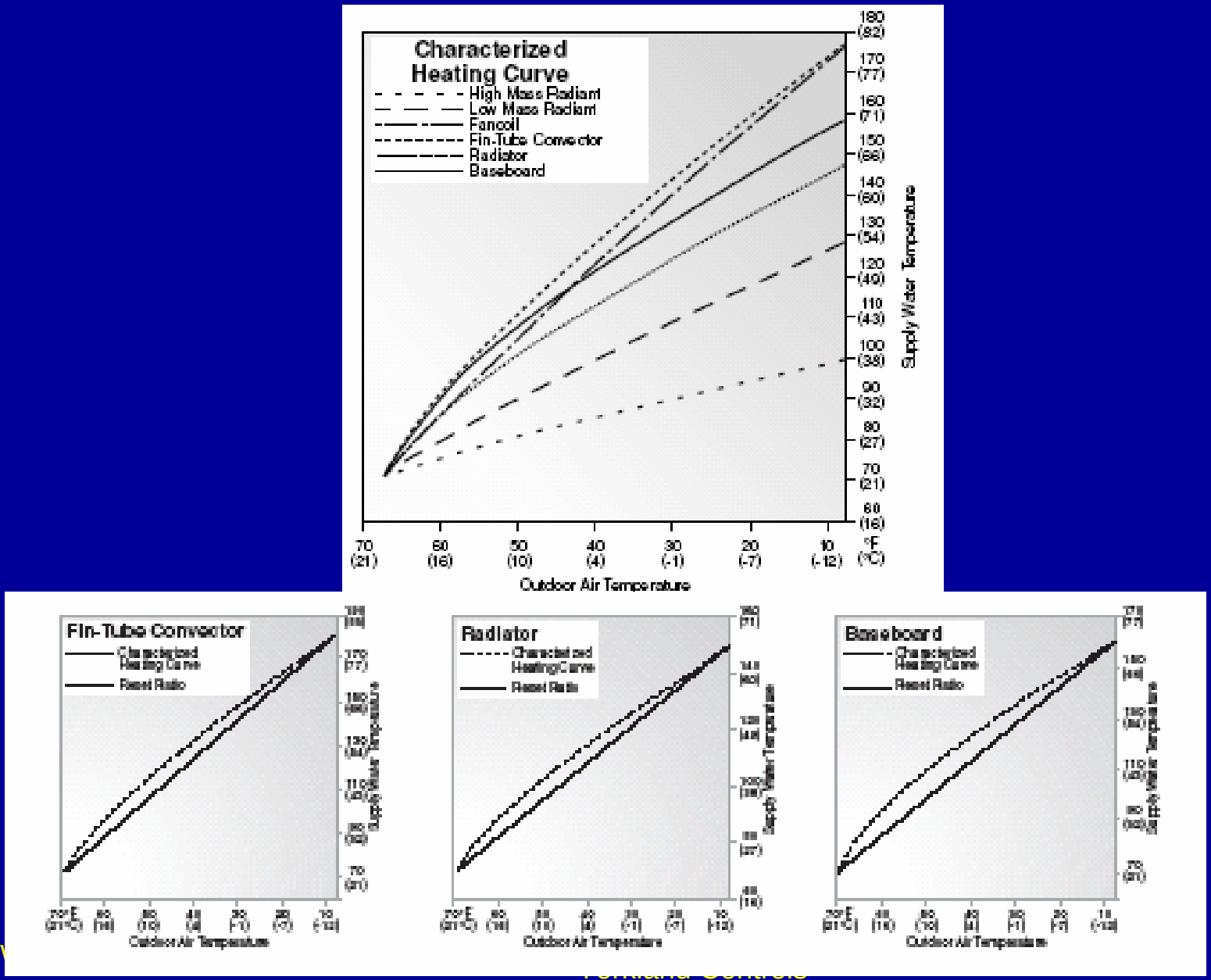
Terminal Unit	High Mass Radiant (1)	Low Mass Radiant (2)	Fancoil (3)	Fin-Tube Convector (4)	Radiator (5)	Baseboard (6)
BOIL DSGN	120°F (49°C)	140°F (60°C)	190°F (88°C)	180°F (82°C)	160°F (71°C)	150°F (66°C)
BOIL MAX	140°F (60°C)	160°F (71°C)	210°F (99°C)	200°F (93°C)	180°F (82°C)	170°F (77°C)
BOIL MIN	OFF	OFF	140°F (60°C)	140°F (60°C)	140°F (60°C)	140°F (60°C)



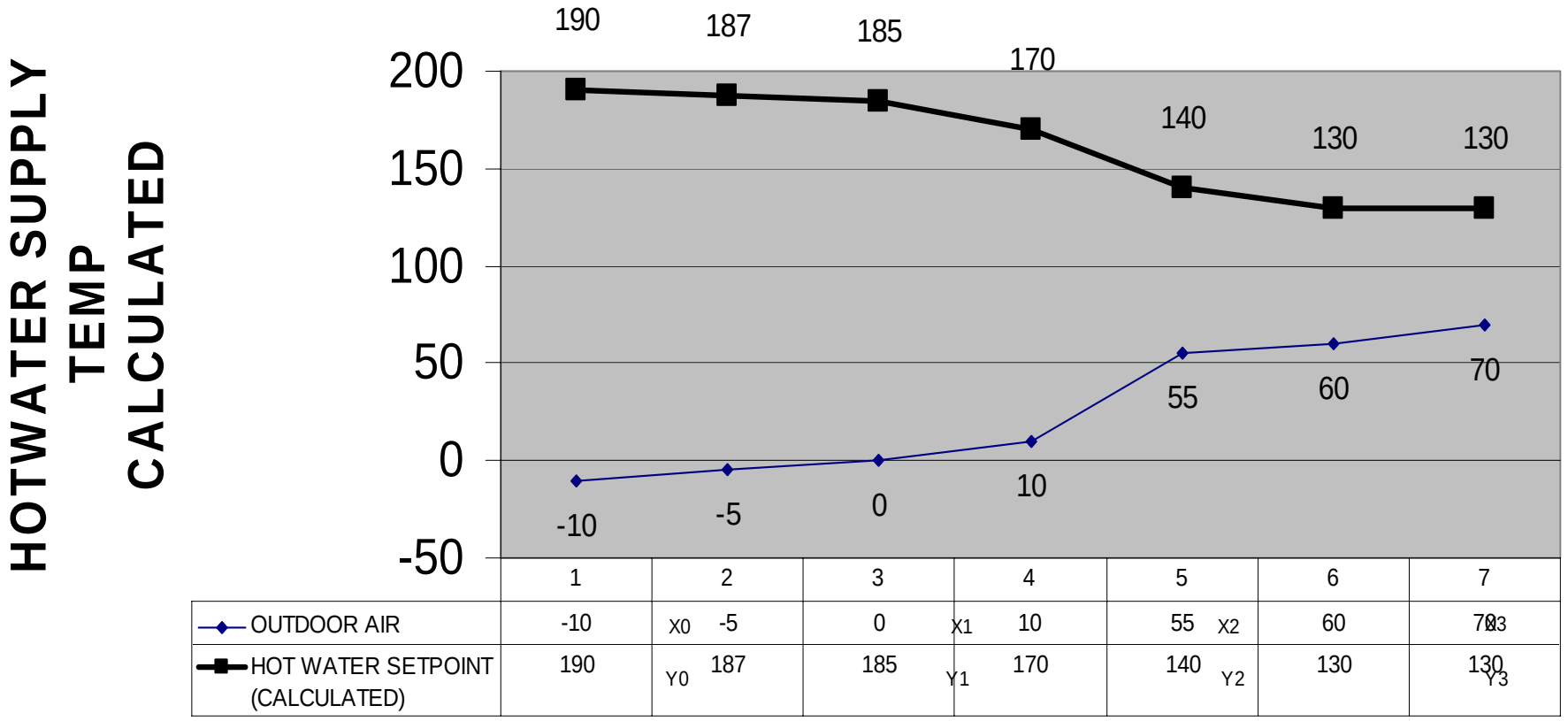





radiant floor
fan coil
convector
100
80
60
40
20
0
% Heat Output
70°F
(21°C)
135
(57°)
200
(93)
Supply Water Temperature


Characterized Heating Curve
High Mass Radiant
Low Mass Radiant
Fancoil
Fin-Tube Convector
Radiator
Baseboard
Supply Water Temperature
Outdoor Air Temperature
Fin-Tube Convector
Characterized Heating Curve
Reset Ratio
Radiator
Characterized Heating Curve
Reset Ratio
Baseboard
Characterized Heating Curve
Reset Ratio

RESET SCHEDULE
"Characterized"

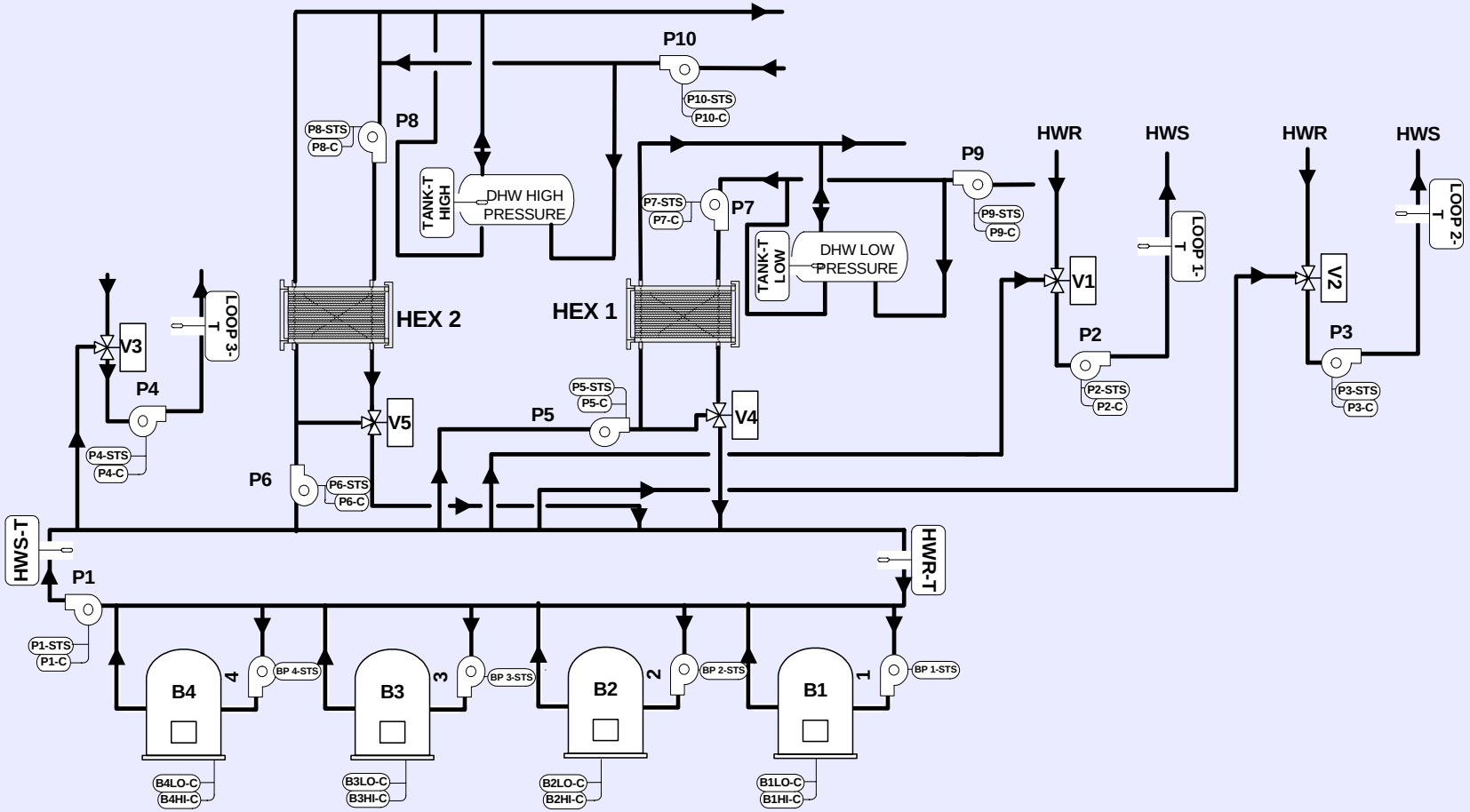


Dx9100 Generic Controller Example

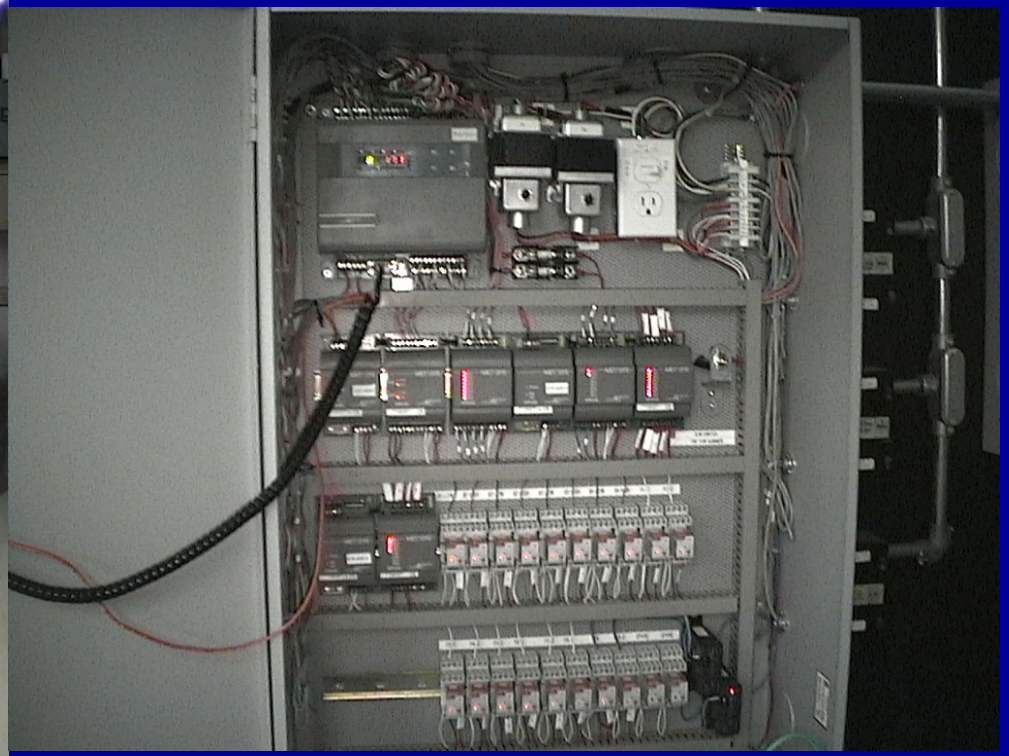
Boiler Product for Intergrated Heating Plants

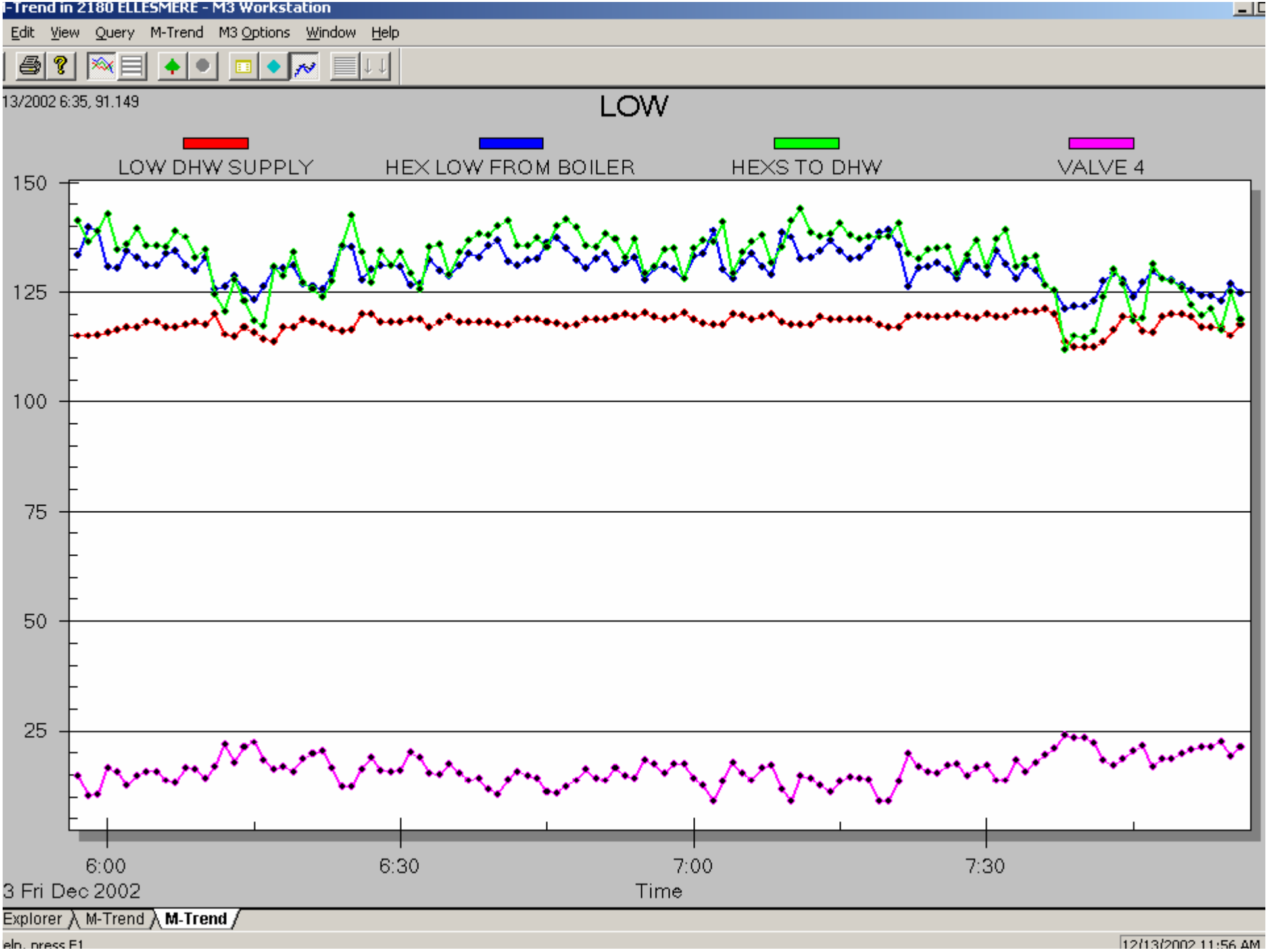
- Johnson Dx9100 Configurable Controller
- Allows for Flexibility in Control Strategy
  - Standard Reset Curve
  - Characterized curve
- Integral Boiler Control
  - Main Hot water
  - Building Loop
  - Domestic Hot water
- Allows for Load Compensation Strategy Change
  - Space sensing for small facilities
  - Return Water sensing for larger systems
- Maybe networked and monitored
- Over 90 contractor individuals trained
- Product Stocked and supported

Typical Projects MTHA



Intergrated Boiler Control Room




-Trend in 2180 ELLESMERE - M3 Workstation
Edit View Query M-Trend M3 Options Window Help
13/2002 6:35, 91.149
LOW
LOW DHW SUPPLY
HEX LOW FROM BOILER
HEXS TO DHW
VALVE 4
150
125
100
75
50
25
6:00
6:30
7:00
7:30
3 Fri Dec 2002
Time
Explorer
M-Trend
M-Trend
elp, press F1
12/13/2002 11:56 AM

Diagnostic Exercise 1

- HWS -T = 178F
- HWR -T = 172F
- What assumptions can you make?
  - Load ?

Diagnostic Exercise 2

- HWS-T = 170 (current reading)
- HWR-T = 160 (current reading)
- Setpoint = 185
- Trend showed:
  - HWS-T = 198F
  - HWR-T = 180F
- 2 out of 4 Boilers not firing
- ????

Diagnostic Exercise 3

- HWS-T = 170
- HWR-T = 175

- ???

Diagnostic Example 4

- OA-T = 0 F
- HWS-T = 185
- HWR-T = 160
- All boilers on and firing

- ????

Service Tips

- Familiarize yourself with the system
- Review diagnostic information
- Check Trending info (if available)
- Make sure equipment is functioning
- Check sensors and relays
  - Most outputs from controllers are TRIAC with Pilot Relays
- Software would be nice to have – BUT NOT necessary – use the display?

Tools of the Controls Trade ?

- Supplier Commissioning Software
  - Allows you to verify operation and get all parameters
- Laptop or Display Device
- Control Logic Experience
- Understand the control terms
  - PID
  - Dead Bands

Typical Cost - Conventional

- 8 Stage Boiler Control $ 1890
  - Lead/Lag / Pump
- Reset Control w/Pump $ 750 (250x3)
- Lead/Lag Pump Control $ 400
- Domestic w/ VLV output $ 400
- Time Clock $ 60

Total **$ 3,500.00**

Integrated Controller System

- Controller $ 1400
- Sensors $ 400
- Panel $ 250
- Programming $ 500
- **TOTAL $ 2550.00**
  - Display(optional) 750.00
  - Software 500.00
  - Hardware 100.00

Questions

Thank You