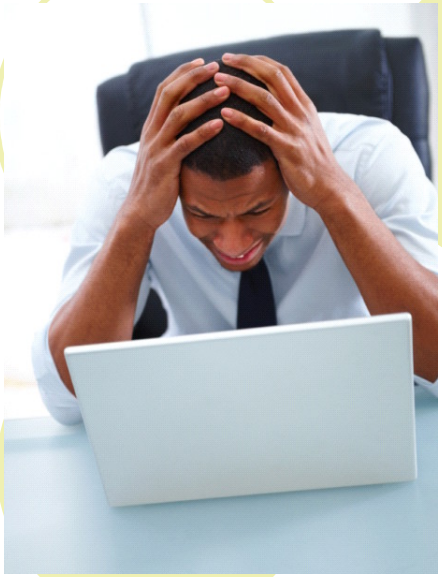
SPECIFYING BAS's



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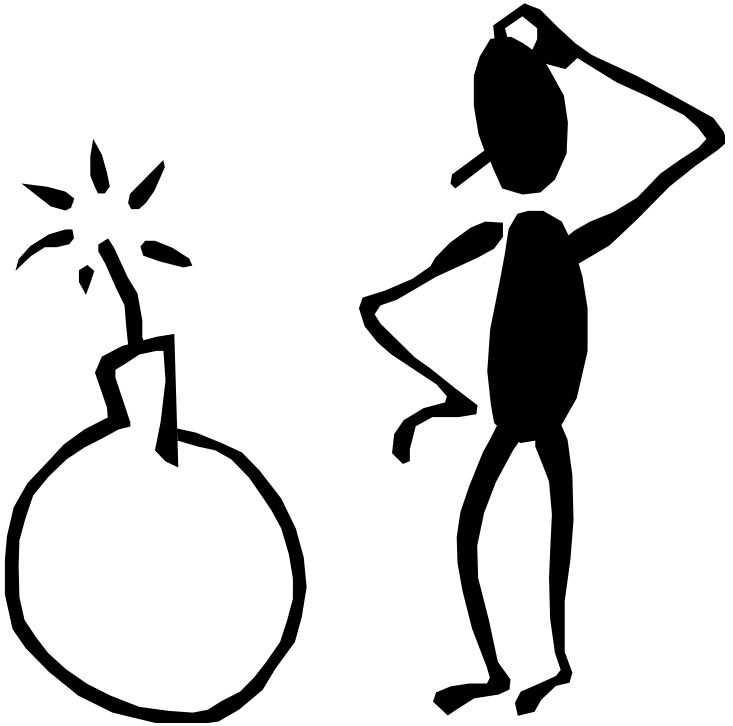
Why Is This Subject Important?

"Controls problems are the #1 reason why net-zero energy building projects are only achieving about 60% of their energy efficiency goals."

Quote made at the April, 7 2010
Rocky Mountain ASHRAE Meeting
By Drury Crawley, PhD
Team Leader of the Building Technologies Program
U.S. Department of Energy

My Experience and Perspective

- I've seen the TC industry evolve from conventional controls (pneumatics/electric) to DDC to open-protocol & web-enabled BAS's.
  - But most of the basic principles and challenges remain the same!
- Most engineers do not treat BAS design with the same rigor as that for mechanical systems.
- Most engineers do not understand what BAS design elements are important vs. moot.



Terminology & Definitions

- TC (temperature controls) = HVAC Controls
- BAS's can provide control/integration beyond HVAC, but that is not the scope of this seminar
- BAS's perform TC via DDC using a series of BAS panels/controllers linked by LAN's
- Points = physical connections between the controllers; and the sensors (AI), switches (DI/BI), actuators (AO) and relays (DO/BO)

Are BAS's Design/Build or provided per "Plan and Spec"?

What BAS Design Aspects Deserve the most Attention?

- Making sure the HVAC design is controllable for the expected loads and owner's use
- Selecting the right manufacturer(s)/contractor(s)
- System architecture - communications technologies, operator interface(s), and interoperability with controls provided in mechanical equipment
- The capabilities and design of each controller type
- The sensors, actuators, valves, wiring, etc.
- Installation methods (e.g., where to use conduit)
- The sequence of operation
- The points list (the physical inputs/outputs)
- Controls "schematic" diagrams

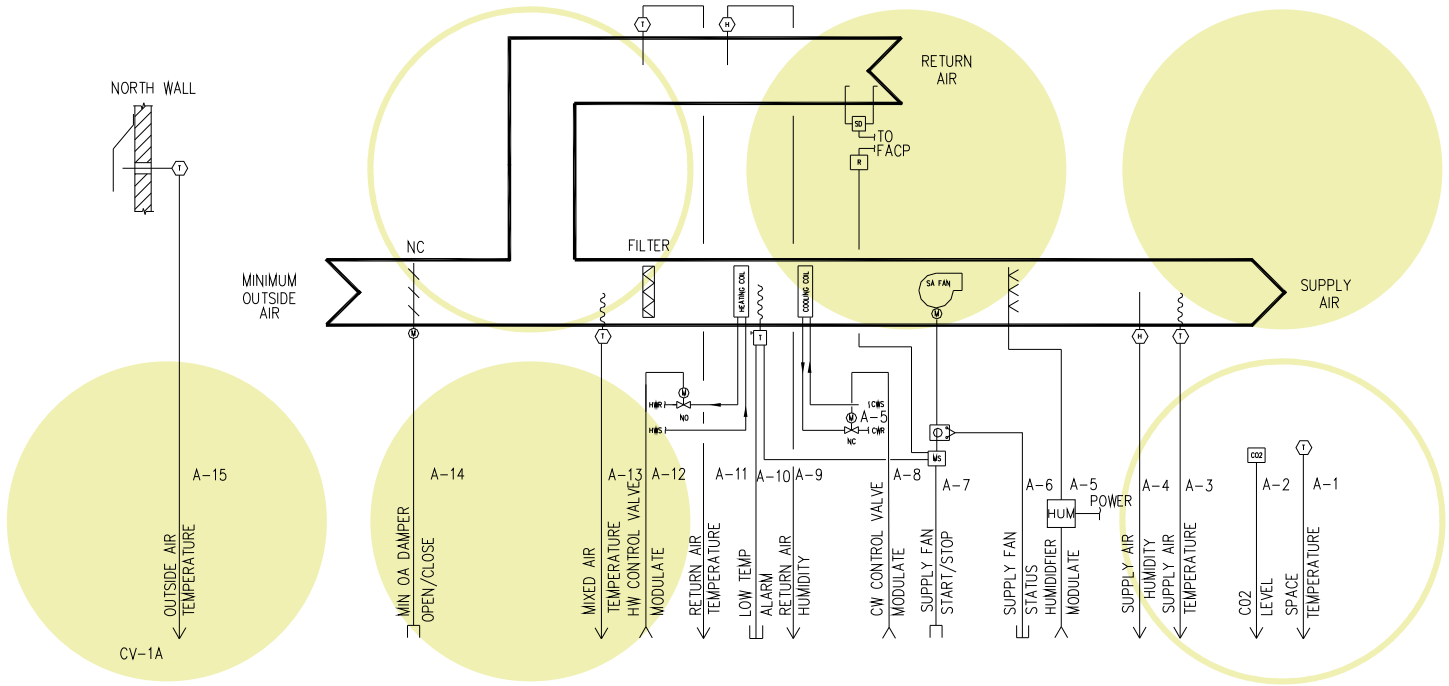
BAS's are more than design/build and deserve a targeted design effort, So…

- Don't specify details you cannot control (if you buy a Chevy then you don't get what comes in a Ford)
  - If you spec BAS manufacturer X, Y & Z, then the controllers and operator interface can only be what they make (list the preferred controllers and operator interfaces for each manufacturer – don't go into any further detail; e.g., a controller's chip speed, etc.)
- Only get detailed about architecture and communications technology if there are IT dept. or challenging interoperability requirements (between multiple manufacturers)
- Only a few field devices and installation requirements require some prescriptive detail – flow, humidity, the choice of elec. vs. pneumatic actuators, wiring installation methods
- **CONCLUSION** – HVAC controllability, Sequences of Operation and Point Lists, (and in some cases "Interoperability") are where you should focus your efforts!

The Principles that you need to understand to Design a BAS

- A TC system's logic (the program) involves a series of schedules, control loops, various forms of "reset schedules", and interlocks – That's about It!
- A control loop must have an output (usually a controlled device – an AO or BO) with an associated input (an AI, DI some software parameter)
- A loop's output is modulated (an AO) or on/off (a BO/DO)
- Modulation requires an "infinitely" adjustable controlled device (e.g., a VFD, electronic actuator, pneu. actuator with an I/P)
- Open vs. closed loop control (what is "open loop" control?)
- On/off closed loop control requires a differential or anti short-cycle timer (and the result will "hunt") – stages of on/off will help this
- **"Make things as simple as possible but no simpler" (that's Einstein dissing the KISS principle)**

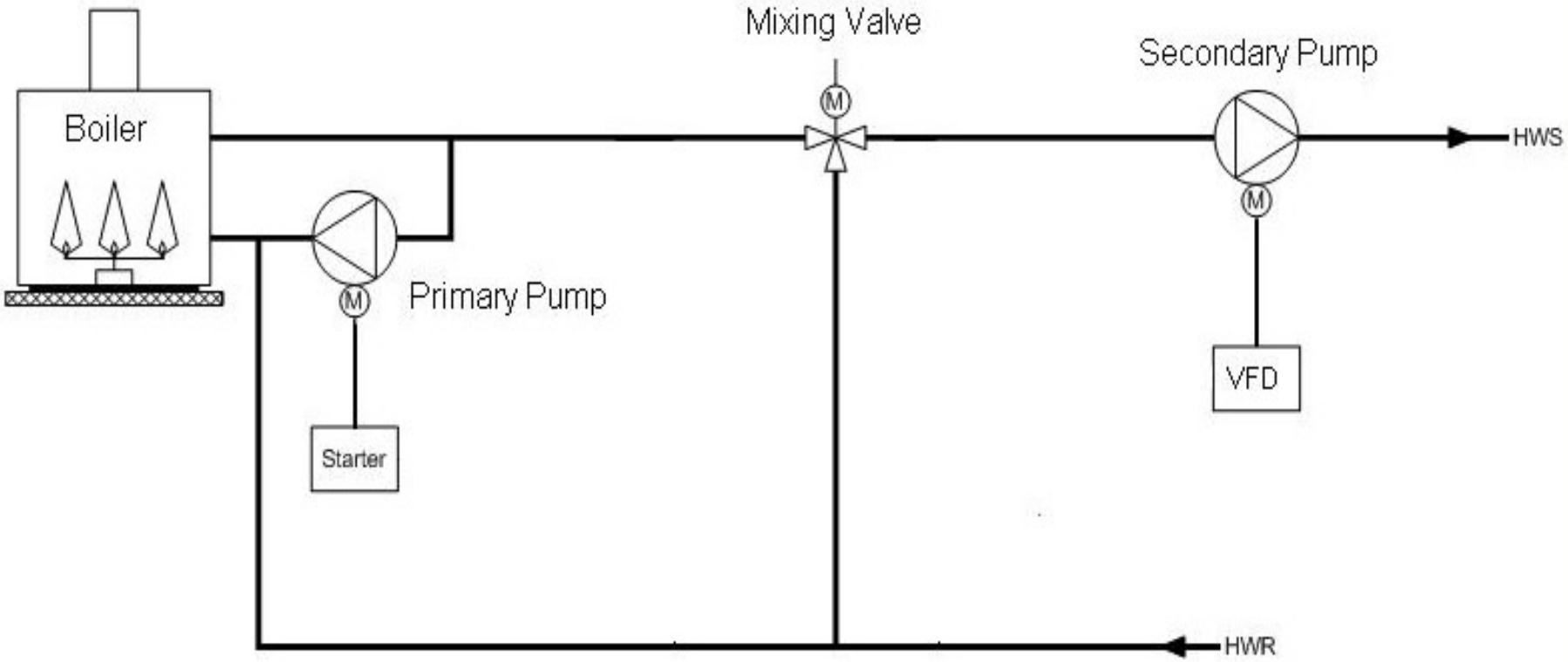
Sequences and Point Lists



Use a Process to Develop the Sequence and Points List

- Review the HVAC design for controllability and part/low load operation
- Determine what safeties/controls come with the HVAC equipment (and determine if anything should be eliminated)
- Develop the Sequences “top down” – list all unique systems, then their components
- Create a schematic diagram of each system and their components (does not need to be fancy or for the CD’s)
- Describe the system’s normal modes (e.g., occupied/unoccupied) and abnormal modes (e.g., failures, alarms) of operation
- Then add the points “identified” by the sequence to the diagram as a check
- Finally, create the point lists (can be a “list” at the end of each sequence – the simplest, on a schematic diagram - which is more work, or in separate table - which is cumbersome

Example System

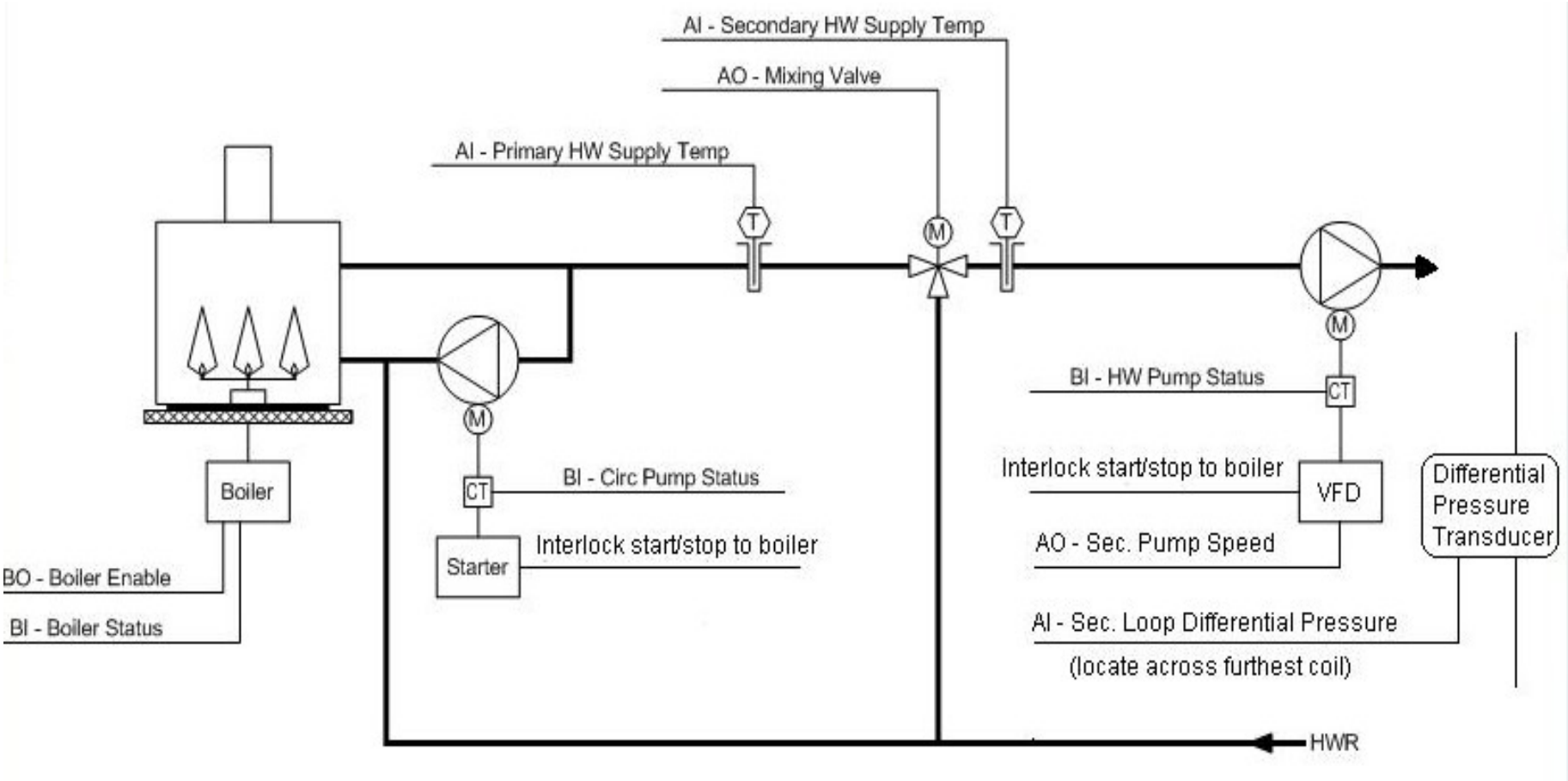


Example of the Process

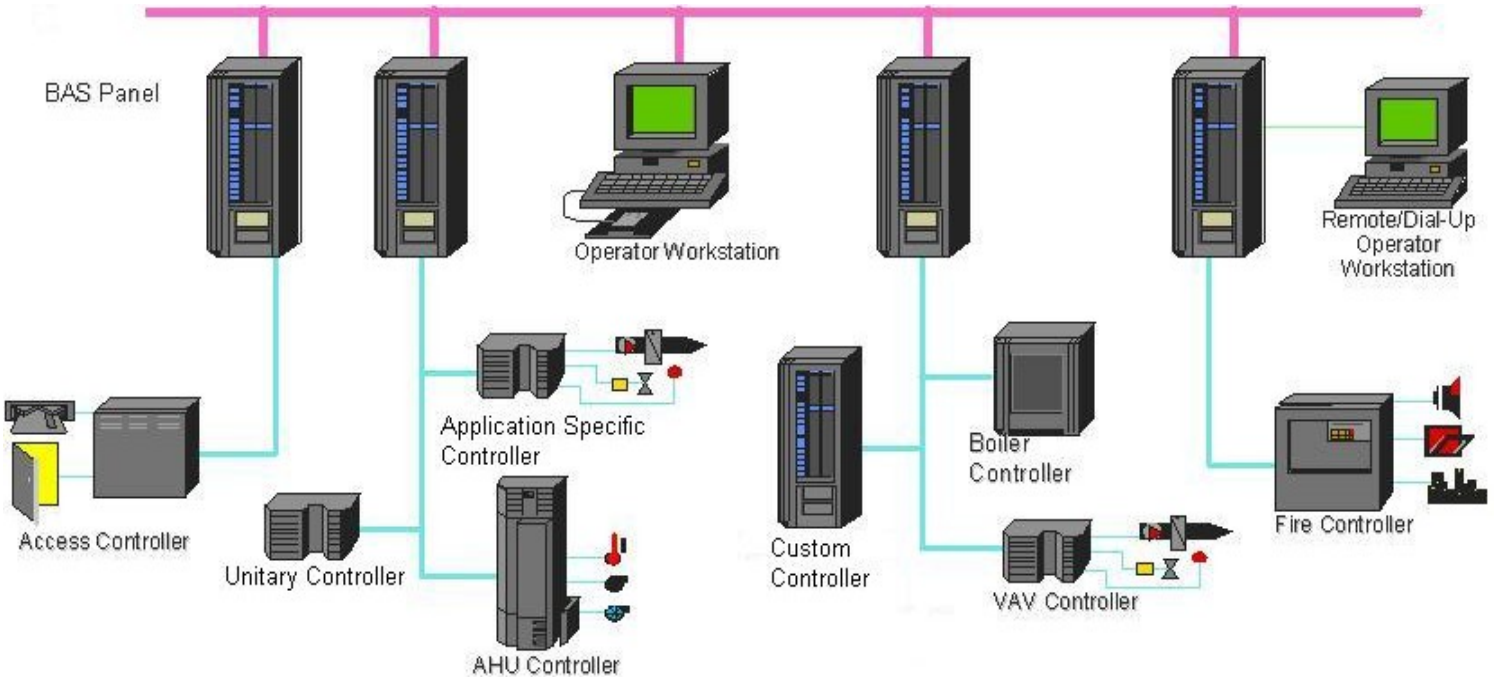
Hot Water Heating System

- Boiler
  - Occupied Mode Start/Stop
    - Start when OAT is under 65 deg. F.
  - Unoccupied Mode Start/Stop
    - Start when OAT is under 45 deg. F.
- Pumps
  - Constant Volume Primary Pump
    - Interlock to boiler
  - Variable Volume Secondary Pump
    - Interlock to boiler and modulate VFD to maintain loop diff. pressure
- Mixing Valve
  - When boiler is on modulate to maintain the HWST to the reset schedule…
- Failure Alarm – Issue alarm when boiler failure is detected
- **What are the points?**

Example System Points



BAS Architecture, Panels/Controllers and Interoperability



The Basic Rules

- Rule 1 - Determine what Protocol and Interoperability needs/goals are required.
- Rule 2 - Don't spec what doesn't exist.
- Rule 3 - Don't spec voluminous details that apply to only one BAS or all BAS's "on average" – these can't be enforced.
  - Panels/Controllers – Listing type (i.e., BTL-listed B-BC), transport protocol (MS/TP vs. IP), routing?, integral point HOA's/LED's, and not much more.
- Rule 4 - Develop a short list of BAS manufacturers, associated contractors, and the acceptable products for each.
- Rule 5 - Research the protocol technologies for some of the HVAC equipment controls involved.

Some More Useful Rules

- Avoid terms like: Native, Open, Compatible, etc, - they are unenforceable
- Do not specify protocol details unless necessary and make sure you know what they mean
  - PICS, B-BC, BIBB's, MS/TP, BACnet/IP, BBMD
- Try to use products and product combinations with which you have experience.
- Don't' say "Communicate/Share all points and data" (i.e., with the chiller) – the system will get bogged-down and what does "all" mean?
- IF YOU ARE UNCOMFORTABLE WITH THE ABOVE CONSULT WITH A BAS SPECIALIST!

A Simple Way to Specify BAS Panels/Controllers & Interoperability

1. Develop a short list of BAS manufacturers that you know to provide listed/certified BACnet or LonWorks controllers (both is possible but could be riskier).
2. Specify that all AHUs and terminal units (e.g., VAV boxes) have field-installed controls by the winning BAS bidder.
   - ✓ Make sure that the other division 15 sections for this equipment specifies that no controls be provided.
3. Allow the BAS to interface to the chiller, boiler, VFD, etc. controls by either discrete BAS I/O points, or via BACnet or LonWorks systems (not both).
   - ✓ Make sure this choice is listed in the equipment specs!

Conclusions:

- Do any specifics about the BAS Panels/Controllers including the use BACnet or LonWorks need be specified?
- Is this a realistic approach for most projects?

A Real Approach to Specifying Interoperability

- For each equipment-provided controller research and select a single “Basis of Design for BAS Integration”.
- For the BAS:
  - Specify for each above controller the type of interface (protocol and transport) required.
  - Only list the points and sequence handled by the BAS.
- In the equipment specs indicate:
  - Which product is the “Basis of design for BAS Integration”.
  - Specify the communications, data and sequence requirements that are specific to that product.
- BUT what if the Basis of Design is not chosen…?

What If The Basis of Design is not Chosen?

Include the following language:

"If the Basis of Design for BAS Integration is not chosen then:

1. The controller shall use the specified protocol and transport technology OR it is the Contractor's responsibility to provide modifications to the BAS to communicate with that provided.
2. If the controller uses a proprietary protocol incompatible with the BAS it is the Contractor's responsibility to provide the necessary gateway to the specified protocol and transport technology.
3. It is the Contractor's responsibility to ensure that the specified sequence of operation and shared data is provided OR to provide modifications to the BAS to complete the provide the sequence and data."

Example: VAV Box with Factory BACnet Controls & BAS CO_2 Reset

SECTION 15900 – TEMPERATURE CONTROL

2.01 Product Requirements

A. All panels/controllers shall be BTL-listed….

2.02 System Architecture

A. Provide one B-BC panel with Clause 6 routing and an MS/TP port for the VAV box controllers (see spec 15xxx)….

3.01 Sequences of Operation

A. VAV Box

1. Index the box's occupied/unoccupied mode according to the building's occupancy schedule.
2. Reset the minimum air flow setpoint based on the area's CO_2 sensor as follows:…

Why only specify this portion of the VAV box sequence here?

The Real Approach:
Example Specification Text (continued)

SECTION 15xxx – AIR TERMINAL DEVICES

2.01 VAV Boxes

A. Products – AirMaster (Basis of Design for BAS Integration),…

B. Controller

1. Controller shall be a BTL-listed B-ASC device with MS/TP communications.
2. Controller points and data shall be readable and/or writeable via BACnet communications as shown on the following page
3. <add “Basis of Design” disclaimer” language….>

The Real Approach:
Example Specification Text (continued)

SECTION 15xxx – Air Terminal Devices (cont.)

BACnet Point/Data Table

Point/Data Name	AI	BI	AO	BO	AV	BV
Occupied Mode						R/W
Space Temp.	R					
Damper (2 points)				R/W		
Air Flow	R					
Air Flow Setpoint					R	
Min. Airflow Setpoint					R/W	
Cooling/Heating Mode						R

The Real Approach:
Example Specification Text (continued)

15xxx – Air Terminal Devices

C. Sequence of Operation

1. Pressure Independent Control with dual heating/cooling space setpoints and deadband (box operates at minimum when in deadband)
2. The Minimum airflow setpoint shall increase to the minimum heating airflow setpoint when the reheat coil valve is operating.
3. When in the cooling mode the minimum airflow setpoint shall be reset by the BAS.

Why is the above necessary?

You can't hold the TC contractor responsible for providing whatever products and labor that might be necessary for making integration work! WHY:

- Chillers, Boilers, AHU's, etc. are:
  - Chosen by the MC based on low price.
  - Without input from the successful TC contractor
- Therefore the successful TC contractor has no way of knowing:
  - What interfaces, routers, gateways, etc. to include in their price.
  - What programming efforts to include in their price to coax the HVAC equipment into providing the specified sequence of operations or data.

THANK YOU

QUESTIONS?