ARE YOU GETTING A PLC THAT MEETS YOUR NEEDS: *5 TIPS AND A CHECKLIST* TO SHAPING THE CONTROL SYSTEM SPECIFICATION THAT'S RIGHT FOR YOU

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Introduction:

As a consulting refrigeration engineer, I've seen substantial debates during project meetings on whether the engine room floor should be painted, where to mount the showpiece, stainless steel gauge board, and which compressor manufacturer to use. The tough questions on the control system requirements are often deferred to "later".

Sometimes, "later" never comes, as such no control system is specified, and the low bidder gets the job. Sometimes, "later" does come, and the control system is decided solely by one person's weighting such as:

- The finance person's decision is often weighted too heavily on lowest cost – sacrificing function, documentation, long-term durability
- The gadget lover's decision is often weighted too heavily on flash – pretty screens sometimes with little actual control
- The refrigeration technician's decision is often weighted too heavily on maximum features - monitoring, data collection, and control – but tending toward the highest cost
- But - when the decision is made by this group – I believe the result decision is the best fit for that facility (which maybe the Ford not the Cadillac)

My disclaimer – this is not a technical talk; and this paper is not a "white paper". I am not an electrical engineer, programmer, or a refrigeration technician. I don't sell, own or operate refrigeration equipment or controls. I'm a consulting refrigeration engineer who tries to listen to my clients and to encourage use of a thorough control system decision process - that is - when they ask for my opinions.

In this talk, my goal is to lead you through a decision process that you can use in-house or in conjunction with your engineer or design-build contractor to define your next control system.

The body of this talk has 5 Tips, as I promised in the title. The majority of the talk will focus on Tip #2: A Checklist for Decision Process. I'm hoping that this Checklist will serve you as a useful tool.

Perspective and Definition: Open Architecture vs. Proprietary Control Panels:

This talk centers on a PLC based control system. I tend to prefer PLC based systems because of their durability, enduring support, and open architecture. Open architecture is generally the ability to have a trained programmer modify the PLC program, make corrections, tune control functions, and add control points. A good PLC is an industrial, universal device that still has parts available after 20+ years, which is like 200 years in computer years.

For "proprietary" microprocessor panels, only the microprocessor panel manufacturer can modify the control panel programming and interfaces (graphics display, etc.). This limitation is ideal for compressor panels (such as FES, Frick, etc.), where I do believe only the manufacturer should be allowed to tweak the

compressor controls and safeties. Additionally, only the microprocessor panel manufacturer can supply parts.

At the end of the day – some facilities have great PLC based refrigeration control systems; some have awful ones; some facilities have great proprietary refrigeration control systems; some have awful ones. Truly, there are great control system suppliers in both arenas.

Tip #1: Above all…. Quality:

If there is one thought to place above all else – always buy quality.

- How is quality determined? – By durability and usefulness.
- How is durability and usefulness determined? - Through time testing.
- How do you validate time testing? - Take time to go and see a good sample of the control system. The sample system should be at least three (3) years old and ideally - you should talk both with the management and the refrigeration technician.

For your field trip – be sure you know who bought the control system. Why? – I've seen marginal control systems (and other equipment) defended and praised by the person who made the buying decision. As the saying goes "consider the source".

Tip #2: A Checklist for Decision Process:

Schedule a meeting with the key players – financial, management, operators plus any applicable outside consultants such as your engineer or design-build contractor. Choose a leader to conduct the decision process by discussing the items on Table 1: Refrigeration Control System Decision Checklist, and recording the answer to each item.

Clearly understand the difference between:

- What do you need?
- What do you want?
- What is the "icing on the cake"?

The completed checklist substantially provides a control system specification outline with "need" items serving as the Base Bid and "want" / "icing" items as the optional price adds. In reviewing the bids and optional price adds, your company should be able to arrive at the best decision with minimal iterations (i.e., rebidding) and frustration.

Tip #3: Be Aware of Common Installation Problems

Some installation suggestions:

- Separate Conduits are absolutely necessary for control, power, and communication
- Require installation of spare wiring
- Require tagging of wiring to match drawings
- Conduits should penetrate control panels at sides or bottom. (Avoid potential water damage from top entry)
- On the power side - separate conduits are necessary for individual VFD feeds to motors. Additionally, load reactors are commonly needed near evaporator motors with distant VFDs.

Some planning suggestions:

- Control panel location– Do not locate the Control Panel in Refrigeration Machinery Room. If high ammonia PPM is sensed, all power is shutdown leaving no control or monitoring.
- Component location – No ammonia tubing (such as to pressure sensor or pressure switch) inside control panel. (Potential for ammonia to leak inside control panel and damage copper, etc.)
- Make air conditioning provision for indoor rooms and/or for panels located outside
- Consider whether to allow with distributed I/O for PLC or microprocessors. The potential cost savings will only be apparent when considering overall installation cost (i.e., tradeoff between higher panel cost and lower wiring costs).
- Require a UPS (uninterruptible power supply) with associated power quality protection. The UPS should be sized to power for the control panel and associated devices for at least two (2) hours.

Tip #4: Documentation

Often, hands-on people hate to write, and vice versa. I strongly believe that good control system documentation is critical, but I also know that it is frequently lacking. There is a huge range of what control system suppliers will provide if left to their choosing. Frankly, the good ones plan and budget for it – so their pricing may be higher. Once the bad ones get the final payment, you have lost all hope of getting real documentation.

As you consider control system "needs" and "wants", please mark documentation as a big "need". Then, clearly specify your documentation requirements (see Table 1: Refrigeration Control System Decision Checklist – Documentation Section) for some guidance.

At a minimum, documentation must be complete and understandable to the refrigeration operator - not just to Sparkies. For example, the PLC Ladder Diagram report does not serve as a plain English description.

I strongly recommend requiring very clear instruction (and operator training) for Power Failure Re-start and for Manual Operation in the event of a control system failure – including ammonia sensor issues and use of any back-up temperature switches. Since these are not normal occurrences, these procedures are frequently overlooked until you are in dire need. (I hope this recommendation saves a call to your chief engineer who's vacationing in Hawaii but holds the only knowledge of restoring the system after a power failure.)

Above all, **do not – do not –do not make final payment** until you have received, reviewed and been satisfied that the specified control system documentation is met.

Tip #5: Try to Plan for looming legislation

Investigate whether current or pending legislation may set requirements on how your refrigeration system is controlled. If enhanced features, such as PID loops are needed for VFD controls, consider adding the requirement for this feature in your control system specification.

For example, the State of California will be mandating aspects of new or modified refrigeration systems though the building permit process. For California companies, if you want to maximize utility incentives or don't want to comply with Title 24– submit your building permit before January 1, 2010.

While Title 24 control requirements are pretty standard on most new control systems, VFD control may be challenging for retrofit or expansions of older systems, which commonly have very simple controls (i.e., evaporator control by defrost time clock and temperature switches.) So, adding two evaporators could mandate a control system purchase.

Political comment: While the mandated Title 24 measures typically provide substantial energy savings and good paybacks, no one likes being forced into change. As an industry, we were invited to comment and participate in the 2008 Title 24 Standards process..

Though, many of us passed on this 2008 process, comment will be invited for the 2011 Title 24 process according to Doug Scott of VaCom Technologies, who did participate in the 2008 process and who will be contracted to assist in the development of 2011 Title 24 refrigeration requirements for the State of California. So, if the 2008 Title 24, is troubling – participate and voice your opinions. As President Abraham Lincoln stated in his Gettyberg address, "…that government of the people, by the people, for the people…". In this case, we are "the people" and we should hardily participate in our governance. Contact Doug Scott at dscott@vacomtech.com for more or go to the Title 24 website.

Title 24 Background Information:

> 2008 Building Energy Efficiency Standards – Title 24 (Specific to California)
>
> "The Energy Commission adopted the 2008 Standards on April 23, 2008, and the Building Standards Commission approved them for publication on September 11, 2008. "

> "The requirement for when the 2008 Standards must be followed is dependent on when the application for the building permit is submitted. If the application is submitted on or after January 1, 2010, the 2008 Standards must be met."
>
> Source: http://www.energy.ca.gov/title24/2008standards/

What does this mean? Mandatory requirements for Refrigerated Warehouse (Section 126 of Title 24 – for cold storage areas at or greater than 3,000 square feet). Briefly:

1. All Evaporator Fans and Condenser Fans shall be "continuously variable speed" with associated controls to achieve temperature or pressure setpoint.

2. For ammonia systems, only evaporative condensers are allowed (no air-cooled condensers).

3. For systems with only one compressor per suction level – a compressor from each suction level shall be variable speed (unless the compressor is 50HP or smaller, or the compressor can achieve 60% or less input power of 50% capacity – such as with reciprocating compressors).

4. Other requirements address building insulation, limitations on underslab electric resistance heat, design requirements for minimum condensing pressure, and maximum design condenser pressure (varies with wetbulb).

Conclusion:

My hope is that your "take-away" from this talk is agreement on the absolute importance of planning. Allow dedicated time and effort to meet with the key players – finance – management – operators – to define your refrigeration control system needs BEFORE starting the bid process. Ideally, the result of this meeting will be a refrigeration control system specification that defines your needs for the base bid and has the options you want (but don't necessarily need) listed as "optional adds".

As we are highly aware, economies change. The optional "want" price adds provide flexibility for such changes. Why rule out something, when at bid time – it may be pretty affordable. Conversely, why base bid something that is really just a want – only to have the project bid over budget.

Beyond the control system, the specification should address other installation requirements to avoid field wiring problems (such as interference) and VFD failures.

With a solid decision process and good documentation, you have a good chance arriving at quality control system (whether PLC or Microprocessor based) that will have a smooth start-up followed by many years of service

Table 1: Refrigeration Control System Decision Checklist					
Base = Required in Base Design and Price; Want = Optional Add - "Really want but can sacrifice"; Icing = Optional Add - "Icing on the Cake"					
Line.	Base.	Want.	Icing.	Further Definition Needed?	Description
("No" or Max. of (1) "Yes")				("Yes"/"No")	
1					PART 1 -Scope
2					1. Refrigeration Contractor shall furnish stand-alone system control panel(s) and all sensors.
3					2. Refrigeration Contractor shall furnish Supervisory Station Computer with Historical Data collection.
4					3. Refrigeration Contractor shall furnish Uninterrupted Power Supply (UPS).(Define scope and run time.)
5					4. Turn-key Refrigeration Contractor for control system installation
6					4.1 OR Define division of responsibility between Refrigeration Contractor and Electrical Contractor for installation
7					5. Define any allowances for future equipment (I/O - digital and analog, programming)
8					6. Define any special interfaces - (such as compressor microprocessor panel)
9					7. Is compliance with Title 24 (California) required?
10					8. Ammonia Sensing by system control panel
11					8.1 OR Ammonia Sensing by dedicated ammonia sensor panel
12					9. Alarm Panel shall be furnished by Fire Protection Contractor and shall include dry contact interface for ammonia system alarming. Define number of ammonia alarms.
13					10. Define pre-package control panels, such as screw compressor, recirculator package and make-up air handler. (Intent - prevent duplicating controls and sensors and provide for interface between control system and pre-package control panels.)
14					
15					PART 2 - Control and Monitoring Equipment (Hardware and Control Functions)
16					Control Panel Requirements - Hardware
17					1. Control panel - General
18					1.1.1 One panel may be supplied as determined by Control System Supplier to meet requirements
19					1.1.2 OR One or more panel may be supplied as determined by Control System Supplier to meet requirements
20					1.2.1 Control panel shall be PLC (open architecture) - Define acceptable manufacturers

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21					1.2.1 Control panel shall be microprocessor based (proprietary) - Define acceptable manufacturers/ control suppliers
22					1.3 Control panel shall include provision for hardwired safeties for function during control panel failure. (For example, hardwire high level shutdown to compressors.) Define.
23					2. Provide for future expansion . Define for added I/O card slots or allow communications for remote I/O panels
24					3. Panel Construction requirement: Define NEMA 12, NEMA 4 and specify indoor/outdoor panel and ambient temperature.
25					3.1 Panel shall include air conditioning (A/C).
26					3.2 OR Require control system supplier to provide A/C if needed for ambient.
27					4. U.L. Listing of control panel as an assembly
28					5. Require control system supplier to provide communication cards for communication to defined HMI, remote computer (Supervisory Station), distributed panels, etc..
29					6. Require communication for PLC direct monitoring of motor starters at MCC (i.e., if Allen Bradley - DeviceNet Scanner)
30					7. Complete labeling of all panel wiring using heat shrink wire labeling at termination per control system panel drawings and labeling of all terminals
31					8. Micro-switches (On-Auto) with labeling for each controlled component. (Note: Switches are intended to allow manual operation of components in the event of a PLC failure.)
32					9. Real time clock with date so as to provide a time stamp when alarms occur
33					10. Self check diagnostics and alarm if an internal malfunction occurs (e.g., low AC line voltage, parameter range error, analog sensor calibration error, memory error).
34					11. Define HMI interface at the Main Control Panel. (For example- HMI shall be a stand-alone, local 15" (minimum) color touch screen/ display.)
35					11.1 Define HMI interface at remote control panels
36					11.2 Control system shall support _____(Define quantity) of remote HMI screens

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37					12. Main Control Panel outside panel door shall include pre-mounted/wired: (Define)
38					12.1 Emergency Kill Button,
39					12.2 Two (2) Ventilation Fan Hand/Off/Auto switches
40					12.3 Reset switch.
41					12.4 Other (additional buttons, lights, etc.) - Define:
42					13. Control Panel (Main or Distributed, if allow) shall include power supplies for 24V devices (Hansen VariLevel, etc.). Define.
43					14. The complete control system and associated wiring/cable selections shall be suitable for the distances between components per the Refrigeration Drawings.
44					15 Control Panel Requirements – Sensors
45					15.1 Define Sensors – Scope and type (such as RTD, Thermocouple, etc.): Such as Air temperature (cold rooms, Engine Room), underfloor temperature, pressure transducers, and ambient temperature, ambient humidity.
46					15.2 Define Ammonia Sensors: Electro-chemical sensors and infrared as manufactured by _____ shall be provided. Define enclosures (standard, washdown, SS, etc.) and heaters as needed for ambient.
47					15.3 Back-up temperature switches – Define if deemed necessary
48					16. (Not used)
49					17. Control Panel Functionality- Global Requirements
50					17.1 All control panel inputs must be modifiable at the HMI and Supervisory Station by the operator:
51					17.2 Alarms for each of the panels shall be displayed locally. Digital outputs (dry contacts) for alarms shall be provided for field wiring to the Alarm System (provided by others).
52					17.3 Secured screen at HMI to prohibit unauthorized user access at HMI. Provide multiple user access levels (at least three levels suggested - Monitoring only, Setpoint change and Full Access).
53					17.4 Complete interface to the Supervisory Station is required such that anything that can be changed/viewed the HMI (touchpad/display) can also be changed or displayed at the Supervisory Station Computer.

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54					17.5 Operator calibration of analog sensors by means of entering a reference setpoint at HMI or Supervisory Station Computer.
55					18. Control Panel Functionality- Motor Monitoring: Provide monitoring of amps, motor speed, On/Off status, and total run hours (with reset). Define specific motors or all.,
56					19. Control Panel Functionality- Evaporator Control
57					19.1 Control room temperatures by controlling refrigerant valves and evaporator fans (fixed, two-speed or VFD); control coil defrosting (time scheduled or manually initiated); and continuously monitor temperature for high and low alarms.
58					19.2 Provide PID for continuous VFD fan control.
59					19.3 Additional Control features, defrost loops, temperature set-back on time, other. Define.
60					20. Control Panel Functionality - Condenser Control
61					20.1 Control discharge pressure by control speed (via 4-20 mA) of fan and cycling pumps. Continuously monitor pressures and temperature for high and low alarms. Sequence shall cycle pumps off last.
62					20.2 Provide PID for continuous VFD fan control.
63					20.3 Additional features: Wet bulb approach control option such that discharge setpoint is offset from the monitored wet bulb temperature; Non-condensable alarm, other. Define.
64					21. Control Panel Functionality -Compressor Sequencing Control
65					21.1 Control suction pressure on each of the two (2) suction levels by cycling compressors. Controls shall optimize use of the variable speed compressor motor on RC1.
66					21.2 Provide interface for compressor panel control of the compressor capacity (VFD and unloading)
67					21.3 Additional features: Separate Sequence for minimum load operation, other. Define.
68					21.4 Define interface with compressor control panel (via communication or hardwire)
69					22. Control Panel Functionality- Miscellaneous Vessels, Pumps, and Valves
70					21.1 Define as needed.
71					21.2 Define interface with miscellaneous equipment control panels (via communication or hardwire)

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72					23. Control Panel Functionality - Ammonia Detection
73					23.1 Monitor ammonia sensors and provide alarming and shutdown functions. Define.
74					23.2 Operator adjustable setpoints for trip points (Low, High, High-High)
75					23.3 Low Trip (ppm) indication and alarm for each sensor.
76					23.4 Common High Trip (ppm) indication and alarm for all sensors.
77					24. Emergency Alarms and Shutdowns
78					24.1 Alarms and Shutdowns as triggered by ammonia detection. Different shutdowns are required for the various sensor locations, high level trip and low level trips.
79					24.2 Emergency Shutdowns as triggered by any of the Emergency Kill Buttons.
80					24.3 Ventilation fan(s) operation as triggered by an ammonia detection, Emergency Kill button or Ventilation Fan switch.
81					24.4 Operator adjustable setpoint for Refrigeration Equipment Room temperature setpoint.
82					25. Define Remote Emergency Kill Buttons and Ventilation Fan HOA switches. (Refer to code requirements.)
83					
84					PART 3 -Supervisory Station and Historical Data Station
85					1. Provide complete Supervisory Station Computer as needed for requirements or Define (Harddrive, modem, etc)
86					2. Provide printer as needed for requirements or Define (type, feature - paper size, black/white or color)
87					3. Provide all software as needed or Define minimum requirements.
88					4. Company (in-house) Computers: Define quantity for interface allowance.
89					5. Supervisory Station Engineering (Minimum requirements):
90					5.1 The Supervisory Station shall be turn-key configured system to provide communications with the panels referenced above and the screw compressors. Supervisory computer displays shall contain information relevant to the user's operation.

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91					5.2 Control System Supplier in-house testing with "live" communications hook-up to control panels (CP-RCP1) before shipment to site.
92					5.3 Graphic displays shall include
93					5.3.1 System Overview of refrigeration system flow diagram
94					5.3.2 Submenus from overview allowing for status and setpoint changes
95					5.3.3 Individual equipment displays with associated submenus.
96					5.3.4 Complete interface with manufacturer panels (Define) required including the ability to view all monitored conditions, all alarms, change any setpoint. In essence, remotely do access all control functions
					5.3.5 Alarm summary display and files (same to file)
97					5.3.6 Secured screen at Supervisory Station to prohibit unauthorized user access. Provide multiple user access levels (at least three level suggested - Monitoring only, Setpoint change and Full Access Alarm summary display and files (same to file)
98					6. Historical Data displays with Data base tools for analyzing data and generating reports
99					7. Communications Diagnostics - The system will provide a function to allow the engineer to monitor the number of messages transmitted to each of the networks, and the number and type of errors encountered with each message.
100					
101					PART 4 -Control System Warranty
102					1. The control system as defined above and all associated components and sensors shall have a one-year warranty from completion of start-up.
103					
104					
105					PART 5 -Training and Start-up
106					1. Refrigeration Contractor shall provide (direct and via the control system supplier) start-up of the control system and all component plus training for Refrigeration Technician on panels. Strongly suggest - Define minimum days on-site by control system supplier technician.

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107					1.1 Start-up shall include complete testing to confirm all control aspects are completely functional, included checks to confirm alarms and shutdowns actually perform as required. For example, trigger ammonia sensor with sample to activate
108					2. Refrigeration Contractor shall provide (direct and via the control system supplier) training for Refrigeration Technician and Operations on the control system. Strongly suggest - Define minimum days on-site by control system supplier technician.
109					2.1. Training shall include recommended sensor testing procedure and schedule on all sensors, included ammonia detection sensors
110					2.2 Training shall include procedures/steps to re-start refrigeration system and control in the event of a power failure.
111					2.3 Training shall include procedures/step on the control system use and operation; and manually operation in the event of control panel failure.
112					
113					PART 6 -Control System Documentation
114					1. Control System Drawings
115					1.1 Field wiring point-to-point diagrams showing all the refrigeration control panels and components as boxes with wire/cable types, quantities, and connections to each other and to the system components such as fan starters, solenoids, high
116					1.2 Control panel enclosure drawings showing I/O rack, processor, and miscellaneous component locations within the panel. Control panel wiring drawings shall show internal wiring, I/O numbering and field wiring terminals. These drawings will
117					2. Control System Program
118					2.1 Hardcopies of all PLC programs with back-up copies on CD or DVD
119					2.2 Originals of all software installed on PLC or computers

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120					2.3 Plain English description of all control functions - understandable to Operators who do not have an electrical background.
121					3. Custom (System Specific) Operating Instruction Manual
122					3.1 Detailed the information on each panel and supervisory system. The manual shall detail functions, displays, keypad usage and the function of each mouse "click" or keystroke where applicable.
123					3.2 PDF instruction manual of components used.
124					4. Written instructions on manual operation (during PLC failure) and system restart (i.e.. following a power failure).
125					5. Define bid documents - refrigeration system details (including layout of components, Emergency Truth Table, and point-to-point drawing)
126					5.1 Note: Emergency Truth Table shows a summary of emergency control operations, alarms and automatic failures
127					6. Required as-built mark of project documents - refrigeration system details (including layout of components, Emergency Truth Table, and point-to-point drawing)

END