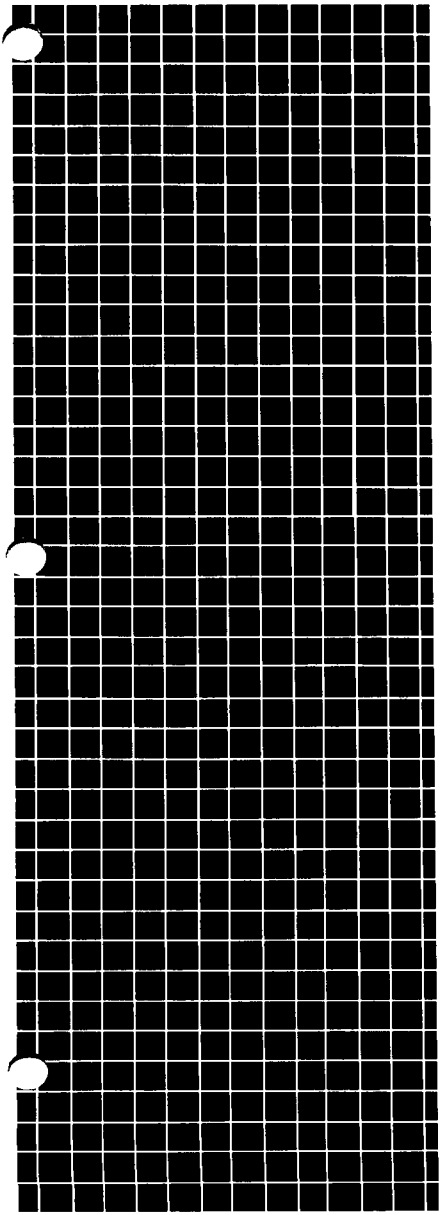

A Comprehensive Guide for the Preparation of Specifications for Distributed Microprocessor-Based Control Systems

by
Leonard A Sterle
Industrial Market Manager

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Bailey Controls
Babcock & Wilcox, a McDermott company

ABSTRACT

Preparing a distributed microprocessor control system specification which concisely presents system requirements and permits fair evaluation of vendors' proposals is a difficult task. A methodology and format are detailed which provide a basis for a specification that is easily interpreted by vendors, covers important project requirements, and permits a fair evaluation of competitive proposals.

INTRODUCTION

Preparing a clear and concise specification for a distributed microprocessor control system is a difficult endeavor, even for an experienced specification author. This paper presents a specification methodology and format which will help ensure that a specification accomplishes the following objectives:

- To define all important project requirements in a clear and concise manner permitting prompt and accurate vendor response;
- To provide a basis for fair evaluation of vendor proposals allowing selection of the most cost effective system;
- To provide adequate information to allow each vendor to minimize risk money and thus provide his best price and delivery; and
- To eliminate the potential for misunderstandings during the bid process or afterward due to specification contradictions or omissions.

SPECIFICATION STRUCTURE

A recommended format for a distributed control system specification is presented below. The information which should be provided under each specification article is detailed. The articles are ordered in a manner which is most logical from the vendors' perspective, since the specification is after all intended for their use in preparing a proposal:

I. Table of Contents

The Table of Contents should list each article of the specification and the page number on which it begins.

II. Instructions to Bidders

The Instructions to Bidders section provides information of a communicative and clerical nature and should include the following as a minimum:

- Bid due date and number of proposal copies required.
- Bid mailing address (street address, not P.O. Box) and individual to receive proposals.
- Names, phone numbers, and telecopy numbers of individuals to contact for technical and commercial questions.
- A statement that it is not the intent of the specification to amend or modify vendors' standard offerings, but that any deviations to the specification must be noted in the proposal.

III. Information Required With Proposal

This section itemizes information required in each Vendor's proposal to permit full comprehension and fair evaluation of the proposal. The following is suggested for a typical project.

- List of all technical and commercial exceptions and clarifications to the specification referenced to the relevant paragraph.
- List of any features and benefits not required by the specification but included in the base bid price.
- List and description of any unsolicited options which can improve project success.
- System overview drawing denoting quantity and location of major equipment (e.g., system cabinets, operator console, engineering work station).
- Equipment list identifying quantities of major system components.

- Product specifications for major components including cabinets, power supplies, termination units, each type of control or input/output module, operator console, etc.
- Preliminary power consumption and heat dissipation data.
- Sample documentation including sample cabinet arrangement, power distribution, module configuration (application software), and external connection (terminal block) drawings.
- List of similar projects in progress or completed by the Vendor.

IV. Project Objectives

Project objectives should be summarized particularly for a retrofit project, so that Vendors' proposals can emphasize how their offerings can help meet these objectives. Higher efficiency, improved control accuracy, greater operational flexibility, and lower maintenance costs are broad examples of typical project objectives.

V. Process Overview

This section provides a brief overview of the process to be controlled including manufacturer, type, rating, and size of major plant equipment.

VI. Site Description

The major purpose of the Site Description section is to provide environmental conditions in each area where equipment will be located. Necessary information includes:

- Location of job site
- Special seismic requirements, if any
- Temperature and humidity range
- Data on airborne contaminants

VII. Scope of Work Summary

Summarize the equipment and services to be included in the bid price. Details for each of these items are provided in subsequent articles of the specification.

VIII. Work Not Included

This article should be as brief as possible and should be used to identify only those items which are not to be included in the scope of work and whose omission from the scope is not obvious.

IX. System Block Diagram and Layout

A block diagram of the envisioned control system should be provided which depicts all major components and their locations (operator consoles, control cabinets, termination cabinets, printers, etc.) with distances between equipment locations noted. Control room and cabinet room layout drawings may also be provided with dimensions, particularly if physical space is a critical consideration or if a particular console layout is desired.

X. Input/Output List Summary

The I/O list summary is probably the single most important section of the specification, particularly in terms of ensuring an accurate proposal price. A sample I/O summary is shown in Figure 1. The I/O summary must contain the following data for hardwired I/O:

- Quantity of each signal type
- Signal range for analog I/O
- Voltage level, contact rating, and contact arrangement for contact outputs
- Is the signal to be powered by the control system (i.e., contact sensing voltage or transmitter loop power)?
- Is the signal for control or monitoring use?

- Where is the signal's field wiring terminated?

For "soft" I/O obtained over RS-232 or RS-422 data links from "foreign devices" to the control system, the following information must be provided for each foreign device interface:

- Quantity of inputs and outputs to be transmitted over each data link.
- Manufacturer of the foreign device and model number
- Electrical connection type (RS-232, RS-422, etc.)
- Baud rate
- Communication protocol to be used

XI. Logic Drawings

If available, control logic drawings should be provided to indicate the level of complexity of the logic to be implemented. A few "typical" logic drawings are usually sufficient for this purpose.

XII. Process Control Units

The Process Control Units (PCUs) encompass the control system cabinets complete with all electronic modules, termination units, power supplies, mounting hardware, and cables necessary to implement the I/O and logic described in previous sections. Listed below for each major component of the PCUs is basic information required by vendors as well as some recommended system criteria which should be incorporated into the specification.

1. Systems Cabinets

- Are separate electronic module and termination unit cabinets required or can modules and terminations be mounted in the same cabinet? If separate, provide distance between module and termination cabinets.
- Cabinet rating: Specify Vendor's standard general purpose cabinet, if possible, or NEMA-12 (dust-tight) or NEMA-4 (water-tight) if site conditions necessitate.

- o Top or bottom cable entry?
- o Specify front and/or rear access only to allow butting cabinets together.
- o Specify each cabinet to have lifting eyes and door locks.
- o Indicate cabinet space limitations, if any.
- o Define space capacity to be included in system on a percentage basis for each of three levels:
  - Level 1: Spare space and power only
    Level 2: Spare space, power, cables and terminations
  - Level 3: Fully implemented spare I/O including control and I/O modules as well as power, cables, and terminations.

2. Power Supplies

Specifications of the power sources available for powering the PCUs should be provided. Redundant auctioneered module power supplies and redundant auctioneered I/O power supplies should be specified for all control applications with non-redundant power acceptable only for non-critical monitoring.

3. Data Highway

- o Data highway cables and data highway modules should be specified redundant for any system configuration involving CRT-based operator interface.

4. Controller Modules

- o Controller modules should be capable of both modulating and sequential control.
- o Controller modules should have a firmware "library" of at least 100 different "function block" control subroutines (e.g., PID, Sum, Multiply, And, Or, Not, etc.)

- Controllers should be capable of accommodating at least 2,000 function block algorithms.

- Controllers must be configured using a "function block" language using ISA or SAMA-type symbology specifically designed for process control. Services of a software or computer engineer must not be required to configure the control strategy.

- Controllers must employ on-line diagnostic routines for identification of failures or misoperations.

- Controller modules should be redundant with each primary controller having its own dedicated back-up controller. Transfer to the back-up controller upon failure of the primary must be bumpless. Replacement of the failed controller with a spare controller must be possible on-line without control interruption. The control configuration from the good controller must be downloaded automatically to the spare controller without control interruption or the use of the operator console, engineering work station, or floppy disk.

- Control loop execution speed requirements should be provided if known (e.g., 500 ms, 250 ms, etc.)

5. Input/Output Modules

   - Any critical performance requirements should be specified if applicable (e.g., accuracy, resolution, etc.).

   - All input modules must meet ANSI C37.90A or IEEE472 Surge Withstand specifications.

   - Contact inputs must be optically isolated.

   - Cold junction compensation must be provided for thermocouple inputs.

6. Field Terminations

   - Specify the maximum gauge of field wiring to be terminated.

   - Specify Vendor's standard termination units.

7. Cables

- All multi-conductor cables required to interconnect Vendor's equipment must be prefabricated with plug-in receptacles at both cable ends.
- Internal cabinet wiring should be kept to a minimum and should be limited to power wiring only.

XIII. Operator Interface

Next to the I/O List Summary, the Operator Interface section is most important in terms of ensuring an accurate proposal price. The following information must be provided:

- Operator console layout drawing showing desired console arrangement (horseshoe, straight, etc.).
- Quantity of "Master" CRT/Keyboards ("Master" CRT/Keyboard consoles contain a set of electronics typically capable of driving up to four CRTs, four keyboards, and two to four printers).
- Quantity of "Slave" CRT/Keyboards (driven by "Master" consoles). Indicate if any of the "Slave" CRTs are located remote from the control room.
- Quantity of touchscreens, trackballs, or annunciator/display select panels.
- Quantity of color and/or black & white printers and printer tables.
- Quantity of magnetic tape units or optical disk units for long-term data storage.
- Quantity of operator chairs.
- Maximum required capacity of the operator console for quantities of data base tags, faceplate displays, process graphic displays, trends, and logs (periodic, on-demand, and trip).
- Power sources available for control room equipment including voltage range, frequency range, harmonic distortion, and maximum interruption.

XIV. Engineering Work Station

The engineering work station (EWS) must provide the capability to configure, tune, and monitor the control system in ISA/SAMA diagramatical format, as well as in a text format. The engineering work station must have a hard disk drive and at least one floppy disk drive. The EWS should be capable of automatically comparing current module configuration with as-built module configurations stored on a floppy disk. The EWS should be capable of driving a printer or a plotter, with the plotter having the capability to produce documentation quality drawings.

XV. Field Mounted Equipment

It is often advantageous from a quantity discount standpoint to include field mounted equipment in the distributed control system specification, at least on an optional basis. Most full-line DCS suppliers also have field device product lines which may include pressure, differential pressure, pH, temperature, level, and conductivity transmitters; magnetic and other flowmeters; oxygen and CO analyzers; and control drives and characterizable valve positioners. Data sheets should be provided for each type of field device. A sample of the type of information which should be covered in a data sheet for bidding purposes is provided in Figure 2.

XVI. Engineering Services

For the Process Control Units, one of three levels of Vendor engineering support should be specified:

A) Vendor to assemble system cabinets from Purchaser supplied cabinet arrangement drawings. Purchaser to develop module configuration drawings from Purchaser's control logic and detailed I/O list.

B) Vendor to assemble system cabinets from Vendor developed cabinet arrangement drawings. Vendor to develop module configuration drawings from Purchaser's control logic and detailed I/O list.

C) Vendor to assemble system cabinets from Vendor developed cabinet arrangement drawings. Vendor to develop module configuration drawings and control logic from Purchaser's detailed I/O list and description of desired process operation.

For the operator console, it is necessary to specify the quantity of data base tags, trends, logs, process graphics, and faceplate displays to be implemented. For each of these items, state who (Vendor or Purchaser) is responsible for design and who is responsible for configuration.

XVII. Factory Test

One of three levels of factory testing should be specified:

1) Vendor to conduct assembly verification, power, ground and a random I/O test.

2) Vendor to conduct assembly verification, power, ground, complete I/O tests, load configuration into modules, transfer to execute, and verify control performance as defined in the logic.

3) Vendor to conduct assembly verification, power, ground, complete I/O tests, load configuration into modules, transfer to execute, and perform a complete closed loop test including connection of signal sources to inputs to verify correct operation of the control scheme.

If required, the length of the customer witness test/customer familiarization to be included in the base price must be specified.

XVIII. Field Services

To provide an equal comparison of Vendors, the number of man-days of start-up service and/or installation consultation to be included in the base price must be specified. Vendor's estimates of the number of required man-days should also be solicited.

XIX. Training

Training requirements should be defined for operators, engineers, and maintenance personnel as outlined below to provide a fair basis for comparing proposals:

- Operator training - Specify number of people, duration in days, location (jobsite or Vendor's facilities), and any special requirements such as conducting two or three sessions to handle three shifts.

- Engineer training - Specify number of people, duration in days, and location.

- Maintenance/Technician training - Specify number of people, duration in days, and location.

Vendors should also be requested to state their recommendations, if different from the specification requirements.

XX. Documentation

The number of instruction book sets should be specified. Vendors' standard documentation should be accepted if possible since special documentation is generally quite expensive. However, a good set of documentation should include the following:

- Cabinet Arrangement Drawings
- Cabinet Power Distribution Drawings
- Module Configuration Drawings
- External Connection (Terminal Block Assignment) Drawings
- Complete Set of Product Instructions for each major system component including cabinets, mounting hardware, cables, power supplies, each type of controller, I/O module, or termination unit, operator console, engineering work station, etc.

XXI. Project Schedule

Critical project schedule information must be provided including the following as a minimum:

- Contract Award Date
- Notice to Proceed Date
- Customer Witness Test Date
- Delivery Date
- Start-Up Date
- Commercial Operation Date
- Turnaround Time in weeks for drawing approvals

XXII. Performance Criteria

Describe any specific performance criteria which the system must meet, if any. If performance criteria are listed, they must be easily measured and must relate only to the performance of the control system and must not be dependent on the performance of devices external to the control system.

One commonly specified criterion is system availability. As a general rule, theoretical availability calculations are of very little value in practice since they do not take into account quality control issues and are rarely based on the same method. If necessary, a thirty-day availability run could be conducted by the Purchaser after start-up; the simplest and most appropriate availability criterion is based on monitoring process down time due to the control system over the availability run in order to calculate system availability.

XXIII. Codes and Standards

Codes and standards should be referenced only to the extent which they apply specifically to the control system. A broad list of unapplicable codes and standards is meaningless and will only create confusion.

XXIV. Pricing Forms

Pricing forms should be as simple and straight forward as possible. The following pricing information is generally sufficient:

- Base bid firm lump sum price for distributed control system, field mounted equipment, engineering services, factory testing, training, field services, documentation, and freight to jobsite as defined in the specification.
- Deduct from base bid price for field-mounted equipment (for Vendors who do not have a full product line, it may be better to purchase field equipment elsewhere).
- Per diem rate for additional field services above and beyond the base price.
- Preliminary recommended spare parts list with prices.
- Add and delete multipliers off of vendor's published list prices to handle minor changes in job scope (less than 15%) after order but before factory test. This is a more effective method of handling project scope changes than a price per I/O point method since I/O can rarely be purchased on a single point basis.

- o Itemized prices for solicited options.
- o Itemized prices for any unsolicited options.

XXV. Terms and Conditions

All items of a legal or contractual nature should be addressed only in this section and should not be intermingled with the technical requirements since legal items are usually prepared and reviewed by different parties than technical items. Progress payments should be offered as payment terms, since they not only result in a lower base bid price, but also provide additional incentive for the Vendor to meet all milestone dates, increasing the likelihood that the field start-up date will be met.

CONCLUSION

A concise but thorough method of preparing a distributed control system specification has been presented. The importance of providing the specification information detailed herein cannot be overemphasized if a truly useful document is to result. It is suggested that this guide be used as a checklist for every distributed control specification to ensure that the specification is easily interpreted, covers important project requirements, and permits selection of the best system to meet these requirements.

FIGURE 1 - SAMPLE I/O LIST SUMMARY

QUANTITY	SIGNAL TYPE	RANGE	CONTROL OR MONITORING	POWERED	PHYSICAL CABINET LOCATION
10	Analog Inputs	4-20mA	M	Yes	Area A
40	Analog Inputs	4-20mA	C	Yes	Area A
15	Thermocouple Inputs	Type J	C	N/A	Area A
20	Analog Outputs	4-20mA	C	Yes	Area A
30	Contact Inputs	125VDC	C	Yes	Area A
25	Contact Outputs	120VAC, 3A Resistance, SPST	C	N/A	Area A
10	Analog Inputs	0-10VDC	M	No	Area B
20	Contact Inputs	24VDC	C	No	Area C
15	Contact Outputs	24VDC, 5A Form C	C	N/A	Area C
28	RS-232 Inputs	Analog Values	M	N/A	Area A
10	RS-232 Outputs	Digital Values	M	N/A	Area A

FIGURE 2 - TYPICAL FIELD DEVICE DATA SHEET INFORMATION

FOR BIDDING PURPOSES ONLY

Pressure Transmitters

- o "Smart" Type (Yes, No)
- o Span & Service
- o Maximum Static Pressure
- o Flange Connection Material (Hastelloy, 316S.S., Monel)
- o Fluorinated or Silicone Fill Fluid
- o Integral Digital Display (Yes, No)

Differential Pressure Transmitters

- o "Smart" Type (Yes, No)
- o Span (PSID) & Service
- o Maximum Static Pressure
- o Flange Connection Material (Hastelloy, 316S.S., Monel)
- o Fluorinated or Silicone Fill Fluid
- o Integral Digital Display (Yes, No)
- o Three, Five, or No Valve Manifold
- o Flow (Yes, No)

Level Transmitters

- o "Smart" Type (Yes, No)
- o Span (in.H_2O) & Service
- o Flange Connection Material (Hastelloy, 316S.S., Monel)
- o Fluorinated or Silicone Fill Fluid
- o Tank Flange Size
- o Integral Digital Display (Yes, No)

Control Devices

- o Service
- o Pneumatic or Electric
- o Required Torque Rating
- o Air Failure Brake (Yes, No)
- o Available Air Supply (PSI)
- o Shaft Position Transmitter and/or 4 Position Switches
- o Heater (Yes, No)
- o Linkages (Yes, No)

Characterizable Positioners (Pneumatic)

- o Service
- o Pulse or Current Type
- o Fail-in-place (Yes, No)
- o Integral Valve (Yes, No)
- o Mounting Kit (Specify Stem Size)
- o Position Transmitter (Yes, No)
- o Connecting Link (Yes, No)

Bailey Controls

Babcock & Wilcox, a McDermott company

29801 Euclid Avenue Wickliffe Ohio 44092 Phone (216) 585 3500

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