APPENDIX G

CONTROL LOGIC DIAGRAMS GUIDANCE

(PROGRAMMATIC AND FACILITY)

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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	11/17/03	Initial issue.	Mel Burnett, FWO-DECS	Gurinder Grewal, FWO-DO
1	10/27/06	IMP and ISD number changes based on new Conduct of Engineering IMP 341.	Mike Clemmons, *FM&E-DES*	Kirk Christensen, *CENG*

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for upkeep, interpretation, and variance issues

Section D3060/F1050 App G	**Instrumentation & Controls POC/Committee**

1.0 PURPOSE AND SCOPE

Application of ISA-5.2-1976 (R1992), Binary Logic Diagrams for Process Operations is required for safety-related instrumentation systems (ESM Chapter 8 Section 3.4). This appendix provides additional guidance in the preparation and use of instrument loop diagrams. For examples, refer to the ISA standard.

2.0 DEFINITIONS

Control Logic Diagram – A diagram that provides easy to read graphic representation of the operation of individual system equipment controls using basic digital logic symbols. These symbols functionally relate manual and process input action to the process control and operator display output actions. The diagram does not imply the hardware to be used or describe the instrument signal levels involved. It serves as a basis for other drawings, such as electrical schematics as well as for solid-state logic systems.

3.0 DIAGRAM FORMAT AND LAYOUT

A. Refer to the LANL Drafting Manual for format and layout requirements.

B. The control logic diagram should be arranged such that it is not congested or cluttered, is easily readable, and has extra space for future revisions.

C. The overall logic flow of the drawings should be from left to right.

D. Solid right angle lines should be used to connect the logic symbols. Line connections should be indicated by dots.

E. Arrowheads should be used where the flow of logic is not in the normal direction, and where added clarity is needed.

4.0 DIAGRAM USES

A. Control Logic Diagrams have two basic purposes, functional operation and logic design.

B. The functional operation of system equipment controls should be presented within Control Logic Diagrams so that it can be easily understood. The value of Functional Operation Diagrams is lost if the basic operation is obscured by excessive detail.

1. Control Logic Diagrams should also be used to design the logic that will be converted to ladder logic or other programming language in the logic processor. To the greatest extent possible, there should be a one to one correlation between the ladder logic and the Control Logic Diagrams.
2. A control logic diagram provides an illustration of the logical design of the control system. Notes and references are also included to clarify the specific and overall system function.

C. Control Logic Diagrams are to be used in conjunction with, not in place of, Process and Instrument Diagrams, Loop Diagrams, Schematic (Elementary) Diagrams, Interconnection Diagrams, Instrument Index, Data Sheets, and Vendor Drawings.

5.0 DIAGRAM CONTENTS

A. The diagram contains graphic symbols that are interconnected to describe the logical relationships among different process equipment or calculated inputs and outputs. Symbols used in control logic diagrams are provided in ANSI/ISA-5.2-1976, Binary Logic Diagrams for Process Operations.

B. The diagram should show only one or two items of equipment per drawing. For complex interlocks between individual items of a system, a single sequence diagram should be shown with a separate sequence block for each step. Each sequence block should reference a specific detailed control logic diagram that describes that block's function.

C. Notes should be used to omit repetitive details and to clarify complex functions or operations. Two types of notes are typically provided on the specific logic diagram, general and specific. These type of notes are described as follows:

1. General notes are brief statements that explain the control system function and provide hardware detail. They include general information and assumptions that apply to each control logic diagram. The notes do not need to be included on the drawing itself, but a reference to the document in which they reside should be given. Examples of some typical general notes are:

    a. Logic symbols represent system functions only and do not normally show circuit arrangement, devices, or physical installation. They also do not define logic levels or other circuit operation states.

    b. Process equipment will remain in, or return to, the original state after a loss and restoration of power, unless otherwise noted.

    c. Inherent equipment interlocks, such as trip-free circuit breakers, are not shown.

    d. The memory, reset, and start permissive logic associated with the operation of electrical protection devices is not shown. Electrical auxiliary system breakers are reset by operation of the control room or remote switch to trip. Mechanical auxiliary system circuits are reset by operation of a switch at the switchgear or motor control center.

    e. The logic to show valve and damper position lights when the equipment is in an intermediate position is not shown.

    f. Limit and torque switches to stop valve and damper motor actuators at the end of travel are not shown in the logic. The valve type and required action will be noted on the diagram when available.

    g. Logic flow is generally from left to right. Symbols are oriented with inputs on the left and outputs on the right.

2. Specific drawing notes are included, when necessary, to clarify a particular function or to provide a more detailed description of the equipment used in the system. These notes should be referenced by number and included on the drawing. Some typical applications for specific drawing notes are:
   a. Provide a brief statement of system startup, operation, and shut down functions.
   b. Describe the purpose of a specific interlock.
   c. Describe process and control equipment failure modes.
   d. Describe process equipment response to loss and restoration of power (this could also be shown as an input to the logic).

D. The following general rules should be followed when preparing a control logic diagram.

1. Identify instruments, control switches, and equipment. The identification numbers should be identical to those shown on the Process and Instrument Diagram(s).
2. Process inputs should indicate the condition at which they will function, such as low pressure or high level. The set points should not be included, unless specifically required to understand the logic diagram. A reference to setpoint documentation may be included as a reference.
3. Each input circuit or contact should be shown as a separate logic input.
4. Manual switch operation, nameplate arrangement, and location should be shown.
5. Logic for each operating state of the equipment should be shown.
6. Output actions should be clearly defined, such as “stop main pump”, “energize solenoid valve”, etc.
7. All operator displays, such as indicating lights, annunciator inputs, and computer inputs, should be shown along with the location.
8. Complex timing functions should be combined into one timing block instead of a combination of blocks. The time setting or expected range for timing blocks should be provided on the drawings.
9. Any switching (backup power, redundant device, etc.) that occurs during faults and failures should be shown if applicable.
10. A mid-point status can be placed in the diagram if useful as a reference in a sequence.
11. If several systems contain the same equipment that operates in the same manner, one control logic drawing should be created with the device number differences noted in a table.
12. Repetitive functions are typically identified on control logic diagrams with notes used to describe the function.
13. Trip memory, reset, and start permissives that are used for mechanical device protection through physical inspection before restarting should be shown since they are non-repetitive.

14. Electrical protection circuits, memory, and start permissive interlocks are typically not shown. The specific circuits can be shown on schematic diagrams or as a detail on the control logic diagram.
15. Similar equipment and functions should be controlled and presented in a consistent manner.
16. A reference should be given for any related Process and Instrument Diagram, Schematic Drawing, or Vendor Logic Diagram.
17. The control logic diagrams can be more or less detailed depending on its intended use. For example: The logic that shows the state a device will enter when simultaneous conflicting signals occur, such as start and stop, can be described graphically or through specific notes.

E. In order to promote uniform diagramming of similar logic functions, the following terminology should be used where applicable.

1. "Start" and "Stop" should be used for manual logic inputs that are applied to mechanical equipment such as pumps or fans.
2. "On" or "Off" should be used for equipment such as heaters.
3. "Close" and "Trip" should be used for electrical system circuit breakers.
4. "Electrical Protection" should be used to describe inputs that involve any short-circuit current, over-current, torque protection, or motor high temperature protection provided for electrical equipment.
5. "Mechanical Protection" should be used to describe all process logic inputs that protect mechanical equipment, such as loss of suction pressure or high vibration.
6. Control logic diagrams should be labeled and noted properly to avoid possible misinterpretation. For example, when describing a device such as a valve that may have two distinct states, indicate that it is "open" or "closed". Stating that the valve is "not closed" or "not open" could be interpreted to mean that the valve is in an intermediate state.