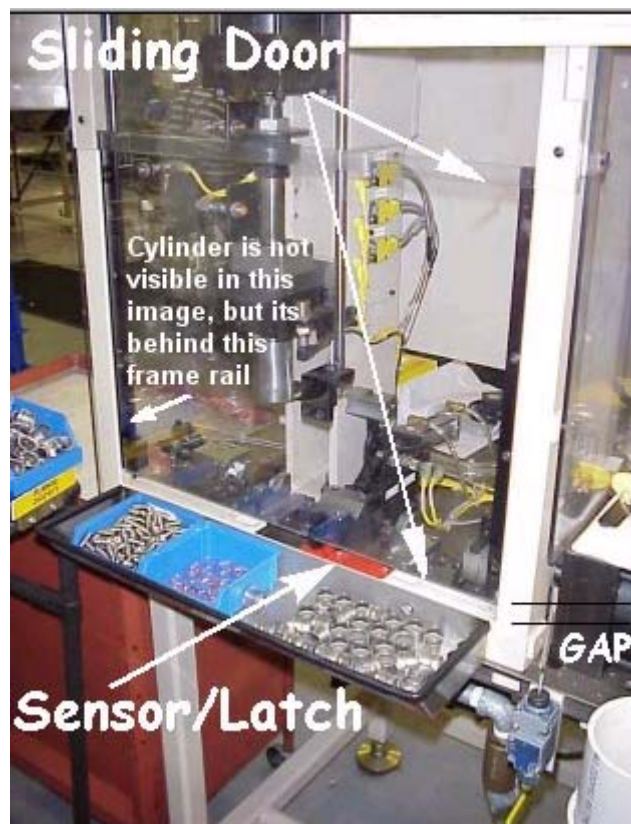


# Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit



DA-2102



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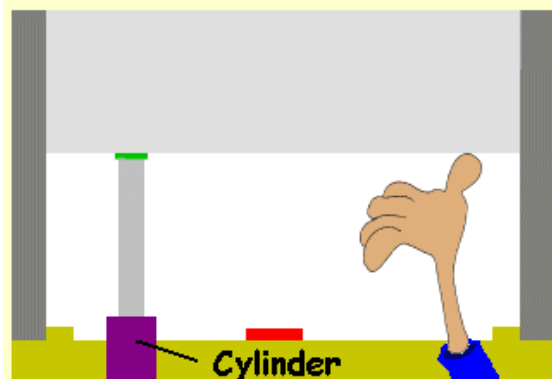
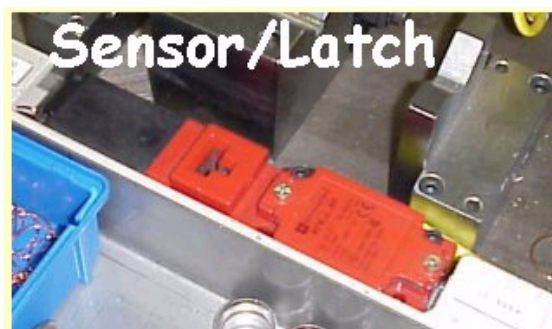
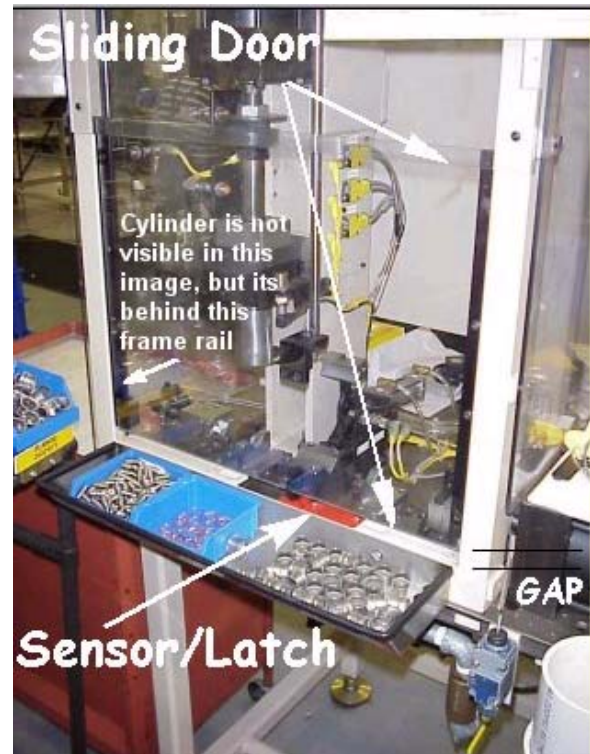
## 1. Abstract

Point-of-operation guarding on equipment is typically accomplished through the use of some sort of physical movable barrier device or through the use of a presence-sensing device such as a light curtain or safety mat.

Point-of-operation guarding has two intended functions pertaining to protecting an operator from the hazards associated with the operation of the equipment. The first function is to protect the operator from unexpected motion when the machine is in a static (e.g. non-moving) state, such as when loading or unloading the machine. This is typically accomplished by removing power from hazardous devices through hardwired circuitry. The second function is to protect the operator from the expected motions when the machine is in a dynamic (e.g. moving) state, such as operator re-entry during the hazardous portion of the machine cycle. This is typically accomplished through the use of properly designed electrical and fluid power circuits to safely control the hazardous motion when the safeguarding device has been interrupted.

When compared to a Presence Sensing type of safeguarding device, a movable barrier guard provides an additional level of protection as it provides a physical barrier between the operator and the machine's point of operation thus protecting the operator from the hazards during motion of the machine. This document looks at the use of a movable barrier guard that has a solenoid lock with the intent of simplifying the fluid power circuit since the solenoid locking barrier guard will

protect the operator from the expected motion hazards when the machine is in a dynamic state. This document looks at specifications, componentry, and circuit design considerations; summing these all up with the finalized design.



## 2. Goals

It is Delphi's goal to have safe machines while minimizing cost, doing this by consistently applying the appropriate safety circuit to the application. This document has goals for the circuit design and additional goals for the overall document and process.

### Goals for the circuit

- ✓ Meet appropriate safety specifications
- ✓ Ease to design
- ✓ Ease to adapt to different applications
- ✓ Ease to communicate / teach / and enforce
- ✓ Ease to maintain / troubleshoot

### Goals for the document

- ✓ Document intent of safety specifications
- ✓ Encourage consistent control design consideration
- ✓ Document failure mode considerations
- ✓ Document other design options which should not be used

## 3. Specifications

Delphi's *Design-In Health and Safety Specification* contains risk assessment and risk reduction sections<sup>1</sup> which detail the process to obtain the safety circuit performance level. For an operator loading to the point-of-operation (frequency is more than once per hour) where injury would be categorized as serious (OSHA recordable) even where avoidance is likely; the associated circuit performance required is Control Reliable.

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<sup>1</sup> DA-2006 section 3.3, 3.4, 3.5

**Note** that, even though the risk assessment has indicated that a control reliable circuit is required for this application, the solenoid locked barrier guard adds a level of protection that allows the fluid power circuitry to be reduced to a single channel circuit performance level.

### 3.1 Control Reliable

Delphi's *Design-In Health and Safety Specification* establishes the rules for control reliable safety circuitry<sup>2</sup>. Control reliable circuits are required to be hardware based, include checked redundancy to and including the final switching device(s), and take into account common modes of failure.

Electrical control reliable safety circuits require the use of dual-channel safety relays, two inputs with short circuit detection, and output relays with positive-guided contacts<sup>3</sup>. Contacts from any of these positive-guided relays are used in series to protect against a single failure, and "opposite state" contacts are used in circuitry which monitors the function of the safety circuits<sup>4</sup>. Positive-guided relays are sometimes added to a control reliable circuit to help monitor devices which do not have "positive-guided" indication that they are functioning properly<sup>5</sup>.

Safety interlock switches for control reliable applications require positive opening contacts (either two contacts on

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<sup>2</sup> DA-2006 item 3.5.5.4

<sup>3</sup> DA-2001 item 4.1.2

<sup>4</sup> DA-2001 section 5.4

<sup>5</sup> DA-2001 item 5.4.5.2

one switch or two switches with one contact each). Look for details in Section 4 of this document.

solenoid lock is in the fully engaged position<sup>7</sup>.

#### **4. Solenoid Locking Barrier Guard Components**

Electrical, movable barrier guard, safety componentry consists of the safety relay and a safety interlock switch w/ solenoid locking as the input device(s) to the safety relay.

Delphi's requirements<sup>6</sup> for both Single Channel w/Monitoring and Control Reliable circuits utilizing solenoid lock barrier guard safety interlock switches as the input device(s) to the safety relay are as follows:

1. Single Channel w/Monitoring circuits requires one safety interlock switch with one positive opening normally closed contact
2. Control Reliable circuits requires one safety interlock switch with two positive opening, normally closed contacts or two independent safety interlock switches w/ one positive opening, normally closed contact in each switch wired to independent channels of the safety relay.
3. The safety interlock switch shall be compliant with EN-1088 (ISO14119). The switch shall include solenoid locking and have solenoid lock monitoring capability so that the machine cannot be started until the

#### **5. Point-of-Operation Guarding**

Point-of-operation guarding, in this case a movable barrier guard w/ solenoid locking, is used to protect a person who performs an interactive task such as loading, unloading or inspecting in an area of a machine where a hazard exists. The solenoid locked movable barrier guard not only provides a guarding function while the machine is in-cycle, but also provides cycle initiation for the hazardous portion of the machine cycle upon closure of the movable barrier guard and engagement of the solenoid locking safety interlock switch.

The application of a movable barrier guard may require additional fixed hard guarding.

The function of the solenoid lock safety interlock switch is to prevent opening of the movable barrier guard during the hazardous portion of the machine cycle. The solenoid will not allow the movable barrier guard to open until all hazardous motions are verified as being in a safe state (e.g. all motions returned). An additional benefit of the solenoid locking capability of the safety interlock switch is that the operator cannot interrupt the processing of the part

**NOTE:** Some additional comments to make specific to this application are:

1. Application of the principles and circuitry listed in this white paper requires that no hazardous

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<sup>6</sup> DA-2001 item 6.3.2

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<sup>7</sup> EN-1088 item 5.5

motion occur with the barrier guard open. This includes motions in a manual mode.

2. Application of the principles and circuitry listed in this white paper require that the barrier guard safety interlock switch used for sensing closure of the barrier guard have solenoid locking capability. In other words, the barrier guard door cannot be allowed to physically be opened during the hazardous portion of the machine cycle.

## 6. Machine Overview

**Application:** This machine is a manually loaded lean assembly station, which presses three individual pieces together into a final assembly. The guard is implemented by means of a vertically sliding Lucite panel door. The lightweight door is raised and lowered by a cylinder, but the door is not attached to the cylinder rod. If a person's arm or hand interferes with the downward travel, the downward motion of the door is stopped, even though the cylinder continues its downward motion. This means that the downward motion of the door itself does not present a hazard. A Safety Interlock switch senses the "fully closed" position of the door and mechanically latches into place initiating the hazardous portion of the machine cycle. The mechanical latch prevents the door from opening during the hazardous portion of the machine cycle. When the cycle has been completed and all hazardous motions have been verified that they are in a safe state (e.g. retracted), then the solenoid unlocking function of the safety interlock switch is energized allowing the

door to unlock and raise as the door cylinder advances. The sliding door is designed such that a gap exists at the bottom of the door to further ensure that no pinch-point hazard exists.

Consideration should also be given to adding additional movable guard safety features such as rubber strips placed along the bottom edge of the guard.

**Description:** The operator places both a copper brazed pre-form and an end cap onto a fuel rail and then manually loads this subassembly into the machine point-of-operation fixture. The operator also manually loads a fuel rail core into the fixture and then actuates a whisker switch initiating retraction of the door cylinder allowing the door to close and actuate the safety interlock switch initiating the hazardous portion of the machine.

The machine cycle consists of three powered motions. The first motion is a toggle clamp that holds the fuel rail down. The second motion is a horizontal cylinder which moves forward to push the fuel rail up against a datum which seats the end cap and presses the copper brazed pre-form into location. The third motion is a vertical cylinder that lowers to press the pressure core to a depth within the fuel rail.

Acknowledgement that the core has been pressed to a depth allows all pressing motions to retract to their home position. Once all motions are verified that they are truly in the home position and the machine has completed its cycle, the solenoid safety interlock switch unlocks, and the door opens.

While the machine is cycling the operator is free to perform other tasks.

## 7. Risk Assessment Sample

The following risk assessment sample is for the fuel rail end cap and pressure core assembly machine depicted in the picture on the cover of this document and described in Section 6 above.

<p><b>Application:</b> Fuel Rail End Cap and Pressure Core Assembly Machine</p> <p><b>Compan</b> Delphi E&amp;C (Rochester Operations)</p> <p><b>Descripton:</b> The operator places both a copper brazed pre-form and an end cap onto a fuel rail and then manually loads this subassembly into the machine point-of-operation fixture. The operator also manually loads a fuel rail core into the fixture and then actuates a whisker switch allowing door to close. Once the door is closed and locked, the machine cycle begins consisting of three powered motions. The first motion is a toggle clamp that holds the fuel rail down. The second motion is a horizontal cylinder which moves forward to push the fuel rail up against a datum which seats the end cap and presses the copper brazed pre-form into location. The third motion is a vertical cylinder which lowers to press the pressure core to a depth within the fuel rail. Acknowledgement that the core has been pressed to a depth allows all pressing motions to retract to their home position. Once all motions are verified that they are truly in the home position and the machine has completed its cycle, the solenoid safety interlock switch unlocks, and the door opens.</p>	<p><b>Analyst Name(s):</b> Jim Welch</p>
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User	Task	Hazard / Failure Mode	S	E	A	Category	Solution	Risk Reduction Methods
Operator	Manually place end cap & pre-form onto fuel rail	Drop parts	S1	E1	A1	R1	Other Safety Measure	None Required
Operator	Manually place subassembly into fixture	Pinch Point between toggle clamp & part (unexpected motion)	S1	E2	A1	R2B	Engr Ctrls	Stroke kept to minimum to eliminate pinch point
Operator	Manually place subassembly into fixture	Pinch Point between horizontal press & part (unexpected motion)	S2	E2	A1	R3C	Engr Ctrls	Implement movable guard door & direct acting solenoid valves mounted in horizontal plane
Operator	Manually place subassembly into fixture	Pinch Point between vertical press & part (unexpected motion)	S2	E2	A1	R3C	Engr Ctrls	Implement movable guard door & direct acting solenoid valves mounted in horizontal plane
Operator	Cycle machine	Pinch Point between toggle clamp & part (expected motion)	S1	E2	A1	R2B	Engr Ctrls	Stroke kept to minimum to eliminate pinch point
Operator	Cycle machine	Pinch Point between horizontal press & part (expected motion)	S2	E2	A1	R3C	Engr Ctrls	Implement interlocked movable guard door with solenoid locking capability
Operator	Cycle machine	Pinch Point between vertical press & part (expected motion)	S2	E2	A1	R3C	Engr Ctrls	Implement interlocked movable guard door with solenoid locking capability
Operator	Unload machine	Pinch Point between toggle clamp return stop (expected motion)	S1	E2	A1	R2B	Engr Ctrls	Design to eliminate pinch point on return stroke
Operator	Unload machine	Pinch Point between horizontal press & return stop (expected motion)	S1	E2	A1	R2B	Engr Ctrls	Design to eliminate pinch point on return stroke
Operator	Unload machine	Pinch Point between vertical press & return stop (expected motion)	S1	E1	A1	R1	Engr Ctrls	Design to eliminate pinch point on return stroke
Operator	Clean machine	Pinch points for all motions (unexpected motion)	S2	E1	A1	R3B	Engr Ctrls	Implement movable guard door & direct acting solenoid valves mounted in horizontal plane

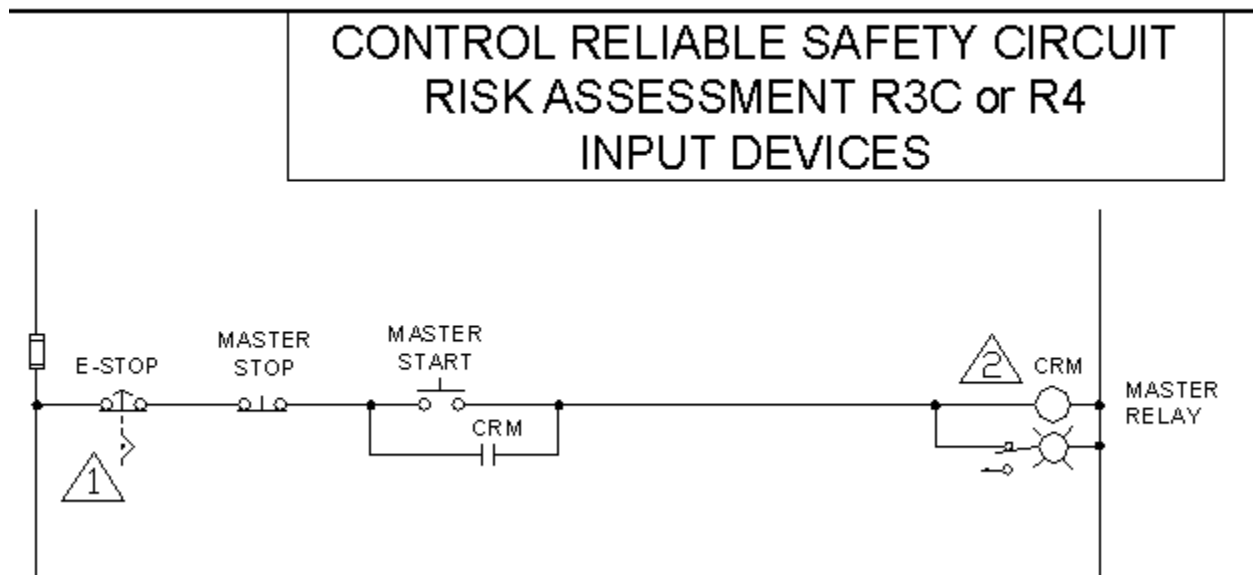
The risk assessment has indicated that the worst-case hazard for the machine is a R3C category. This dictates guarding be implemented in a Control Reliable manner and that the guard should be interlocked if it is a movable guard.



## 8. Hardwire Control Circuit Design

The hardwire control circuit design is for a control reliable implementation and has been broken down into individual circuit steps for clarity purposes. Full drawings are available in Appendix A.

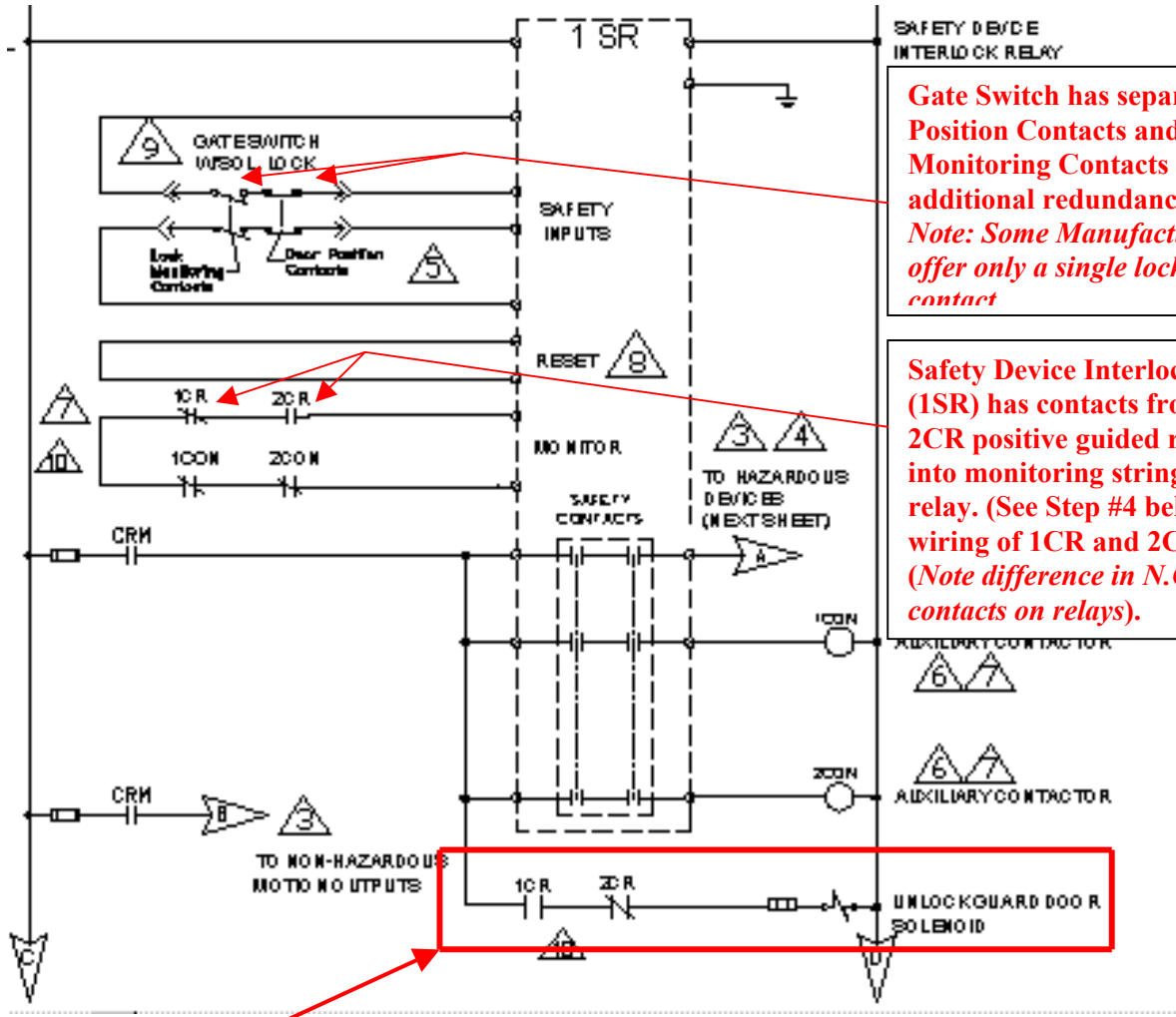
### Step #1: E-stop circuit design



**The risk assessment has determined that the safety devices connected to the safety device interlock relay (ISR) (see step #2 below) have addressed all hazards, therefore the e-stop circuit need only be a single channel circuit performance level.**

8. Hardwire Control Circuit Design (Cont'd):

Step #2: Safety Device Interlock Relay:



Gate Switch has separate Door Position Contacts and Lock Monitoring Contacts that serve as additional redundancy per EN-1088. Note: Some Manufacturer's Switches offer only a single lock monitoring contact

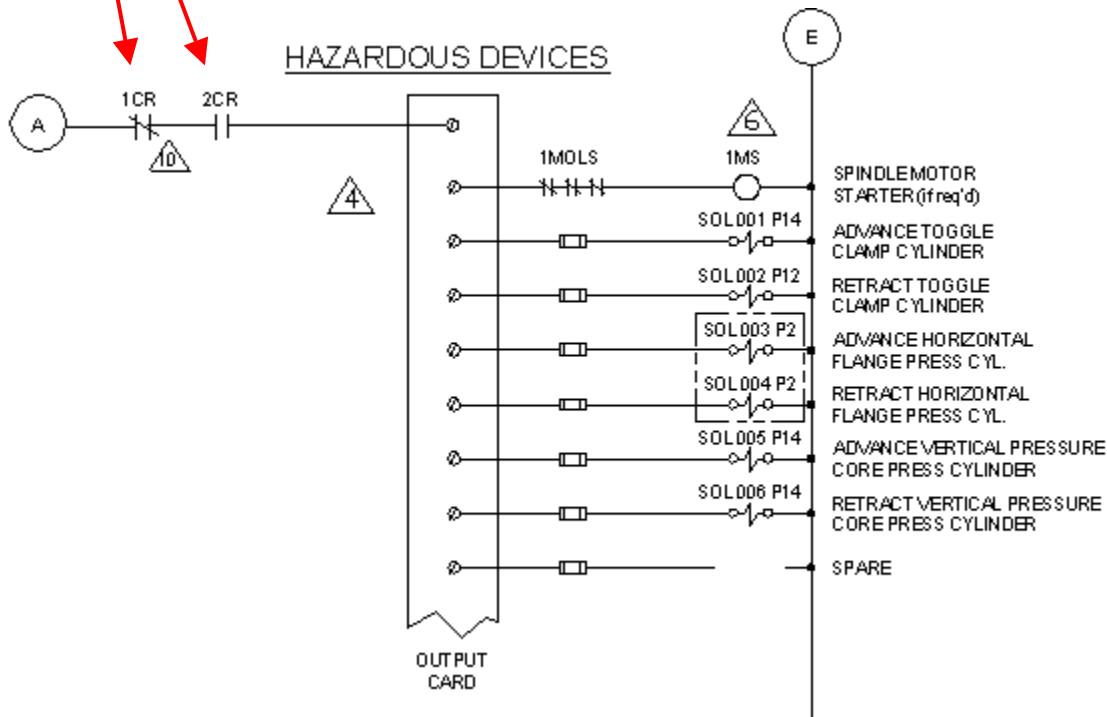
Safety Device Interlock Relay (ISR) has contacts from 1CR and 2CR positive guided relays wired into monitoring string of safety relay. (See Step #4 below for wiring of 1CR and 2CR) relays) (Note difference in N.C. and N.O contacts on relays).

Contacts from 1CR and 2CR are used to control the Guard Door Unlock Solenoid allowing the guard door to unlock and open for access to load and unload the machine. (Note difference in N.C. and N.O contacts on relays)

8. Hardwire Control Circuit Design (Cont'd):

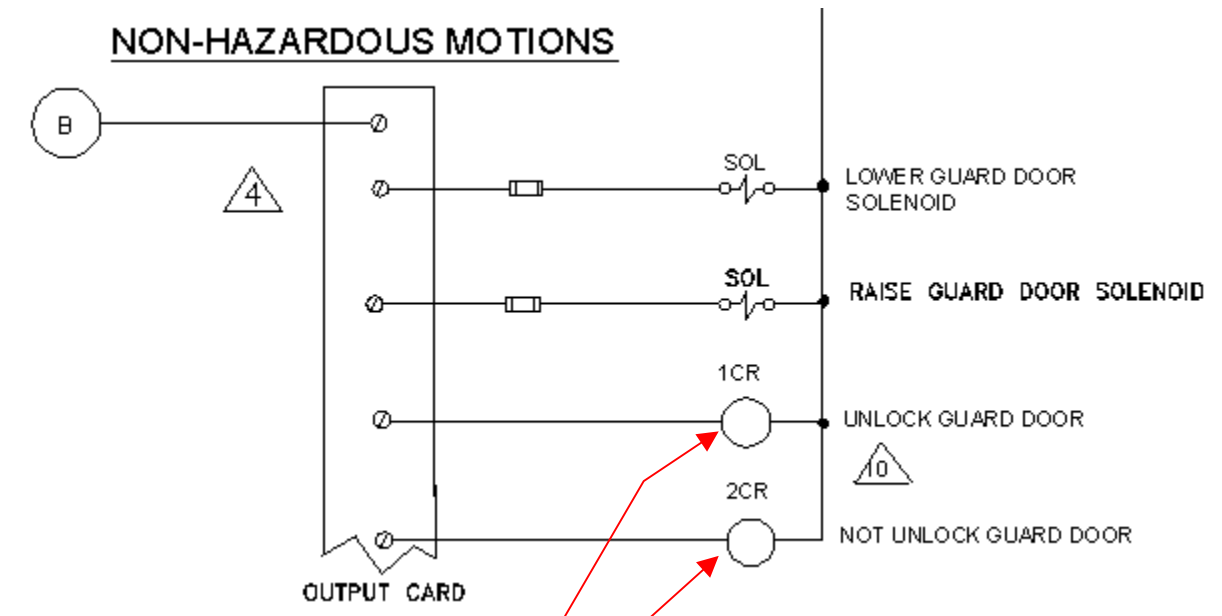
Step #3: Hazardous Devices Output Wiring:

**Contacts from 1CR and 2CR relays are wired into the input power feed wire supplying power to the output card that controls all hazardous motion producing devices. (Note difference in N.C and N.O. contacts on relays). The purpose of these contacts is to provide additional redundancy to control the hazardous motion producing outputs if the logic would allow the guard door to unlock prior to all motions hazardous motions being returned to their safe state position.**



## 8. Hardwire Control Circuit Design (Cont'd):

### Step #4: Guard Door Unlock and Guard Door Not Unlock Relays (1CR & 2CR) Wiring:



**1CR and 2CR are direct drive relays with positively guided contacts. They are wired to the PLC output card that controls non-hazardous motion producing devices. 1CR is identified as the Unlock Guard Door relay which energizes to provide power to the solenoid on the safety gate interlock switch which unlocks the guard door so that it can open and provide access for loading and unloading the machine. 2CR is the NOT state of the 1CR relay as defined in the logic program listed in section 11 of this document. The NOT state provides the redundancy required in control reliable circuits.**

## 8. Hardwire Control Circuit Design (Cont'd):

### Step #5: Notes referencing items in the hardwiring control circuit:

**FUNCTION:**

This drawing is an example that illustrates a Control Reliable safety circuit which corresponds to the risk reduction category as determined by a risk assessment for a particular machine.

Risk assessment has determined that safeguard performance meets the requirements of R3C or R4.

The state of the safety output string (contactors) are monitored by the safety device interlock relay. Redundancy is required for safety devices, the auxiliary contactors, and the blocking valves.

**NOTES:**

- 1) The risk assessment has determined that the safety devices connected to the safety device interlock relay have addressed all hazards, therefore e-stop needs only be a minimum Single Channel circuit.
- 2) The master relay (CRM) performs a safety function at a Single Channel level.
- 3) The outputs are divided into those that potentially could harm an operator (e.g. hazardous devices) and those which are assessed as being non-hazardous.
- 4) The programmable device controls the state of the outputs however supply power is disconnected based on the state of the safety devices.
- 5) An auxiliary output from the safety device(s) could be connected to the input card for state annunciation.
- 6) The contactors (1 CON & 2 CON) provide primary ("spindle") motor power (see 480v circuit) while the programmable device performs secondary control (1MS).
- 7) The state of the contactors (1 CON & 2 CON) are monitored through (normally closed) auxiliary contacts.
- 8) Manual reset is required for perimeter guards. The safety relay reset input shall require the safety device reset pushbutton signal transition in order to engage the safety contacts (i.e., anti-tie-down).
- 9) Safety devices (e.g. safety interlock switch such as a perimeter guard) are connected to 'safety device interlocking' relay.
- 10) 1 CR and 2 CR are positive guided relays with contacts in monitoring string of safety relay, in the wiring string controlling the guard door unlock solenoid, and in the incoming power feed wiring to the output card controlling hazardous motions. Gate Switch solenoid is monitored by safety relay.

**The notes section provides additional verbiage to better describe important features in the hardwiring control circuit diagrams and provide a more thorough understanding of the hardwired control circuit. Bullet 10 in the notes section discusses additional comments regarding 1CR and 2CR relays and their function in the control circuit. Bullet 10 also discusses that gate switch solenoid is monitored by the safety relay by having separate lock monitoring contacts wired into the input channels of the 1SR safety relay.**

## 9. Failure Mode Considerations of the Circuit

Control Reliable circuit applications are by definition to be implemented in hardware and not controlled by PLC's. The proposed solution discussed in this document requires interface with a PLC for portions of the control of the machine safeguarding system, yet keeps the safety portions of the circuits as hardware based componentry. This Section discusses the failure mode considerations for this circuit design and how these failure modes have been addressed by the hardwire circuit design.

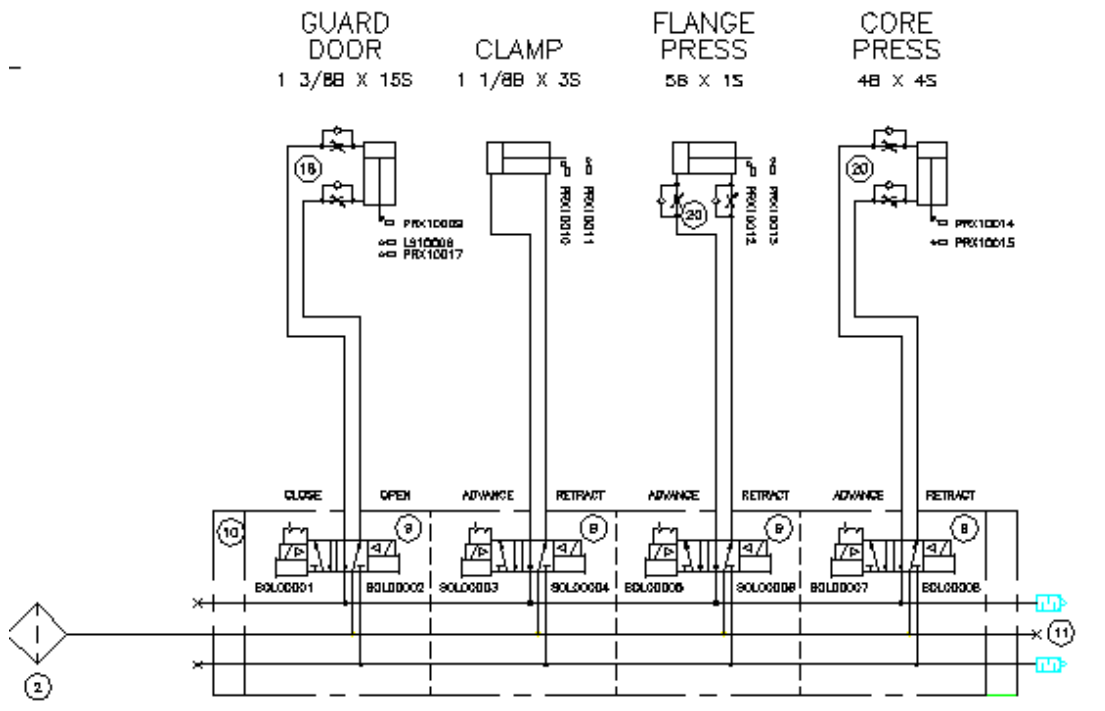
**Normal Mode of operation:** In normal operation of the machine, 1CR relay will turn on and unlock the door when a manual mode request to open the door has been initiated or when all hazardous motions have cycled and returned to their normal safe position in an automatic cycle function. These are all controlled by the PLC and enabling of 1CR and 2CR relays.

### Failure Modes:

1. If 1CR should fail in an **"Always On"** state (electronic output failure, coil seizure, contact weld, etc.), the hardwired circuit would remove power to the output card controlling hazardous motion through the N.C. 1CR contact in the incoming power feed wire string for the hazardous motion output card (refer to hardwire diagram in Step #3 of Section 8 above). In addition, the safety interlock relay will not reset since the N.C. 1CR contact in the monitoring string of the safety relay will prevent resetting of the safety relay (refer to hardwire diagram in Step #2 of Section 8 above). Not allowing reset of the safety relay will prevent closure of the safety contacts of the safety relay disabling power to the hazardous motion output card.
2. If 1CR should fail in an **"Always Off"** state, the door will not unlock since the door unlock solenoid will not energize because of the N.O. 1CR contact in the control string for the unlock solenoid (refer to hardwire diagram in Step #2 of Section 8 above). Preventing unlocking of the solenoid gate switch also prevents opening of the guard door, thus protecting the operator from hazards behind the guard door.
3. If there is a program error that allows 1CR to **"Turn On"** at the wrong time in the cycle (e.g., too early), power will be removed from the hazardous motions output card through the N.C. 1CR contact in the incoming power feed wire string for the hazardous motion output card (refer to hardwire diagram in Step #3 of Section 8 above).
4. If there is a program error that allows 1CR to **"Turn Off"** at the wrong time in the cycle, power will be lost to the unlock solenoid because of the N.O. 1CR contact in the control string for the unlock solenoid (refer to hardwire diagram in Step #2 of Section 8 above), but the door will be open and the safety input device to the safety relay will disable the output contacts of the safety relay disabling power to the hazardous motion output card (refer to hardwire diagram in Step #2 of Section 8 above).
5. Field wiring, output card failure (all outputs electronically on), and other failures, which would cause 1CR and 2CR to function "as the same relay", are addressed by use of 2CR being the logic opposite of 1CR (e.g. 2CR is the NOT state of 1CR).
6. All failure modes of 2CR are addressed by 1CR considerations (opposites mode) mentioned in item 1 through 4 above.

10. Fluid Power Circuit Design:

**Sample Circuit: Single Channel Circuit Performance**



Since the Interlocked guard door provides a level of protection for the operator during the dynamic (motion producing) state of the machine and has a solenoid unlocking feature which is only enabled, through hardwired control circuits, when the machine is in a safe state (i.e. all hazardous motions returned to a safe position), the normal control reliable fluid power control circuit controlling all hazardous motions in this example can be reduced to a single channel circuit performance level. This level of circuit performance does not require use of a control reliable blocking valve and the use of three position valves for motion control. We only need to be concerned with the static state of the machine when motions are not meant to be occurring such as when loading/unloading the machine. There are some requirements of the fluid power circuit components that must be adhered to when implementing this solution on this type of application:

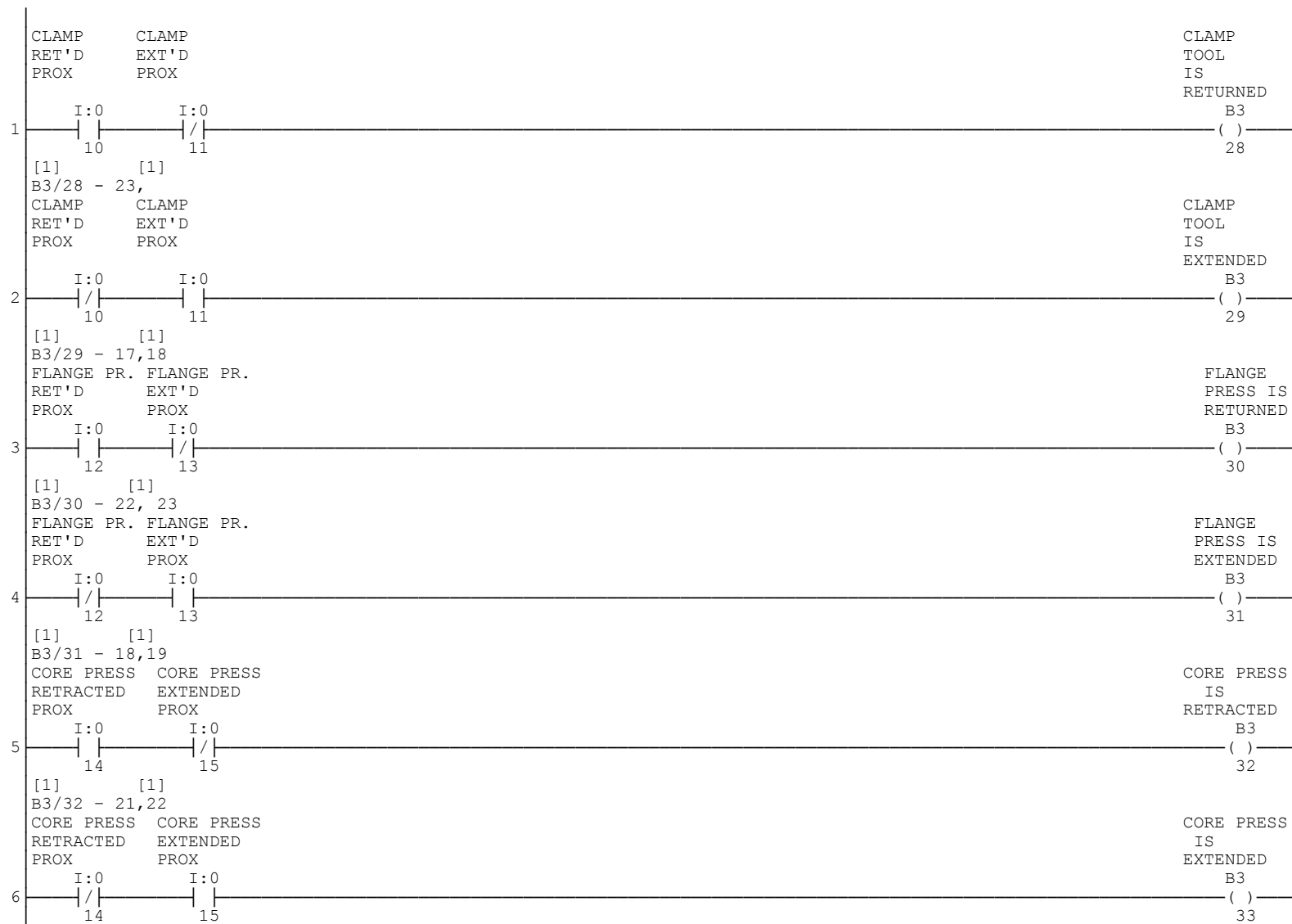
1. The valves used in the fluid power circuit **MUST** be identified as not having failure modes which would cause unintended motion (e.g. shifting of the valve spool when not under power). Direct acting (solenoid driven) valves and some manufacturers of piloted operated valves meet this requirement.
2. The valves **MUST** be mounted in a horizontal plane.
3. **Note: The fluid power circuit listed above indicates use of detented valves for all hazardous motions. Care must be given in selection of the directional valves such that in the event of a failure causing the door to open during the hazardous portion of the machine cycle that stroke lengths of the hazardous motion cylinders will not present a hazardous condition**

11. PLC Logic Design

SLC-500 Ladder Listing  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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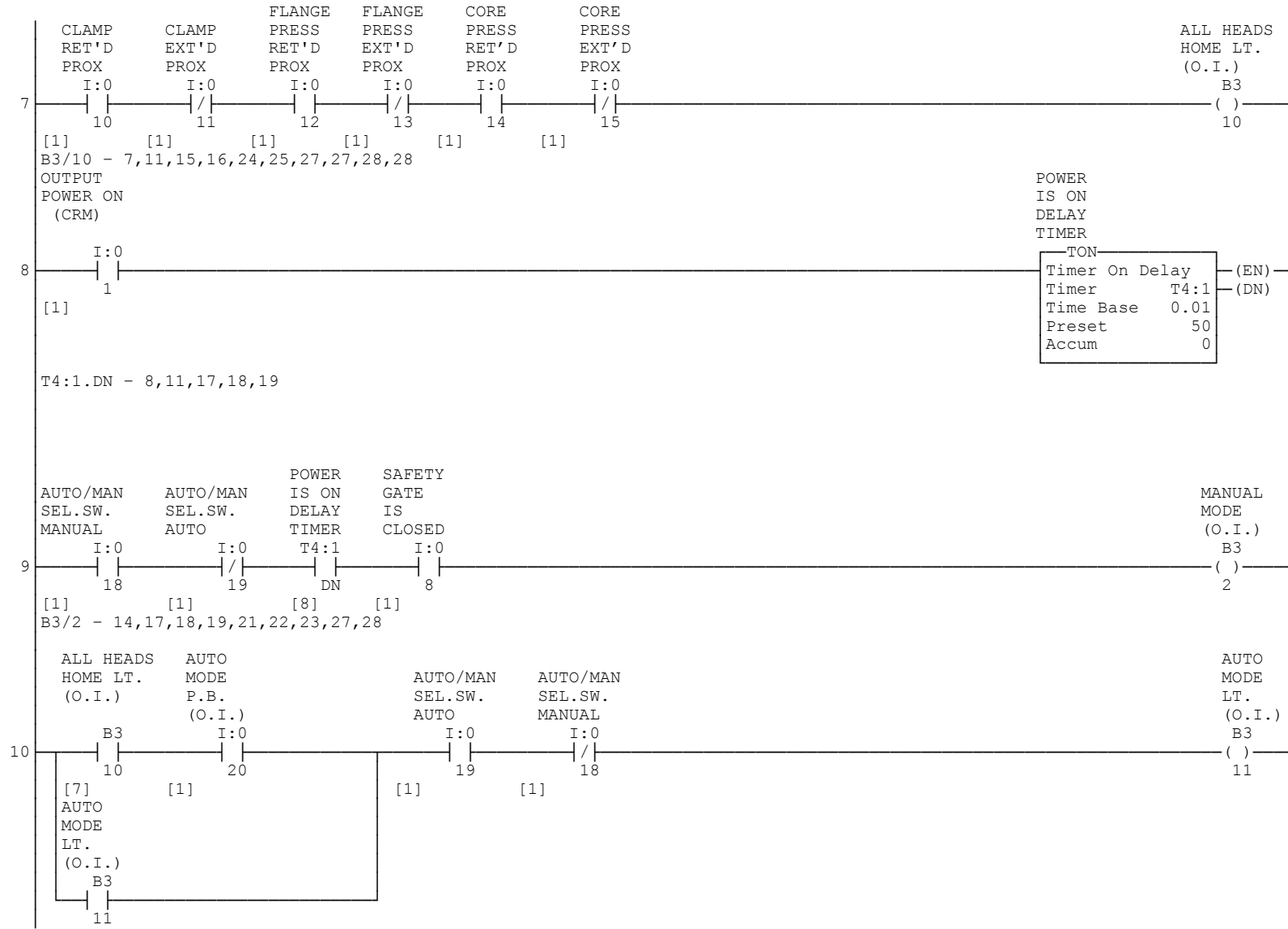




**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* OVERHEAD LOGIC / MODE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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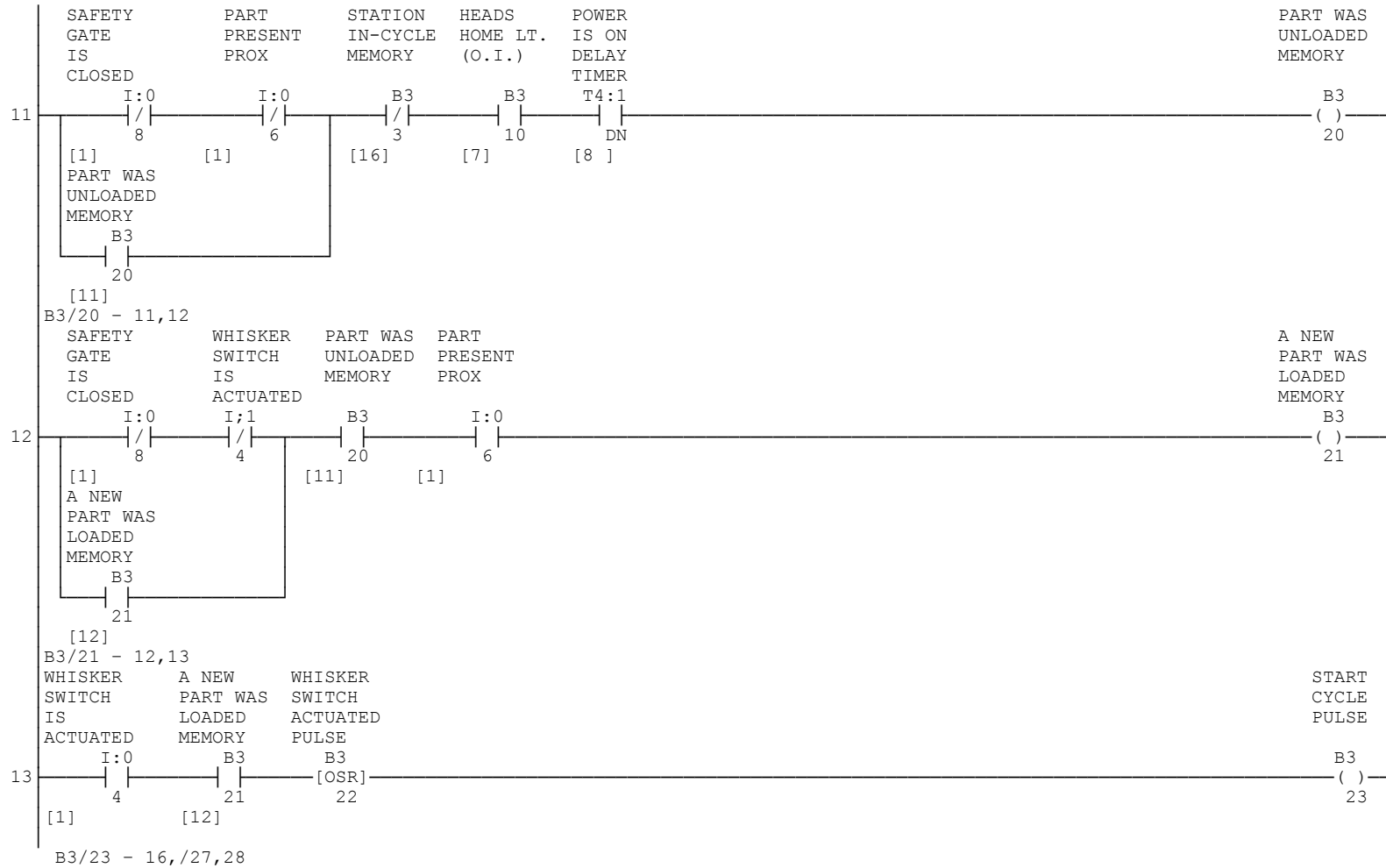
**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* OVERHEAD LOGIC / MODE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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The next 3 rungs are used for safety gate interlock closed cycle initiate. It detects that the part(s) was removed and a new part(s) loaded. It also assures that the safety gate interlock switch is functioning each cycle.



**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

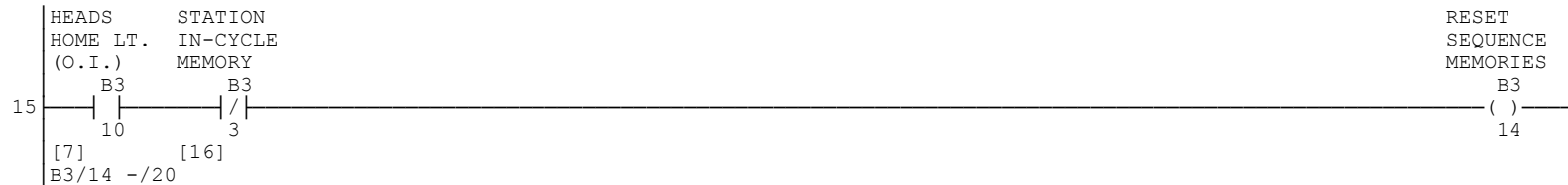
\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
 Page:00005

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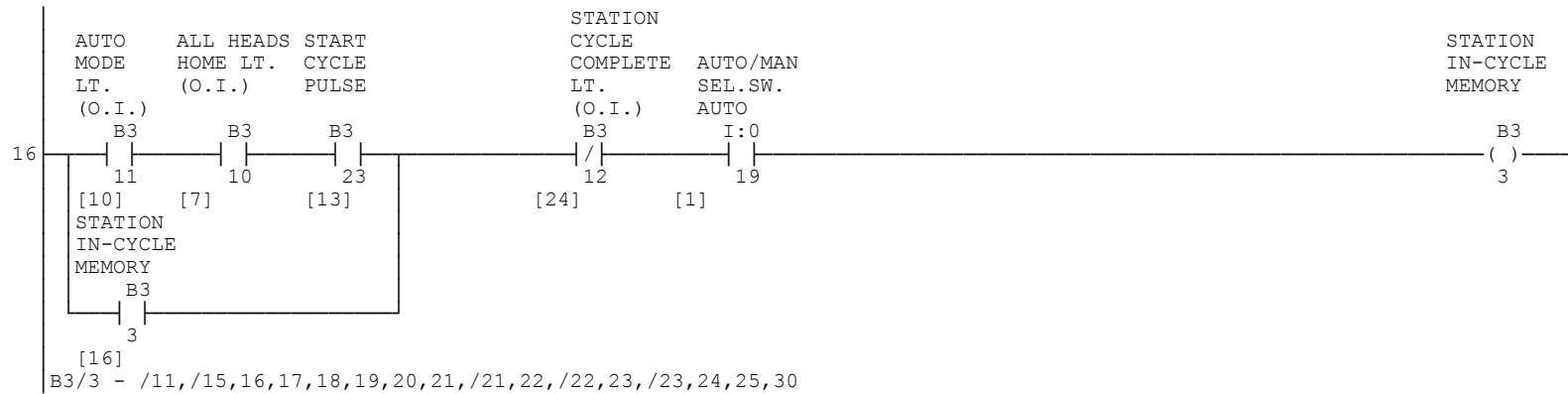
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This bit is used to turn off any memory that was used during the sequence to keep track of events. It allows us to keep sequence memories on when the cycle stalls to assist troubleshooting & makes sure they go off when the machine is returned to home.



This coil must be on for an automatic sequence motion to occur. It is normally turned off by "Cycle Complete". Simple events that run non-synchronously with the sequence logic, such as feeder escapements, can be enabled by the Auto Mode memory, and do not require their own In-Cycle Memory. Where a machine has multiple mechanical sequences that interact but are not synchronous, should have separate In-Cycle logic. Where a machine uses the same mechanical devices to serve more than one function, there should be separate In-Cycle logic for each sequence. Internal bits should be used in those sequences instead of the the output coils. At the end of the sequence logic, the internal bits should then drive the outputs coils.



***Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit***

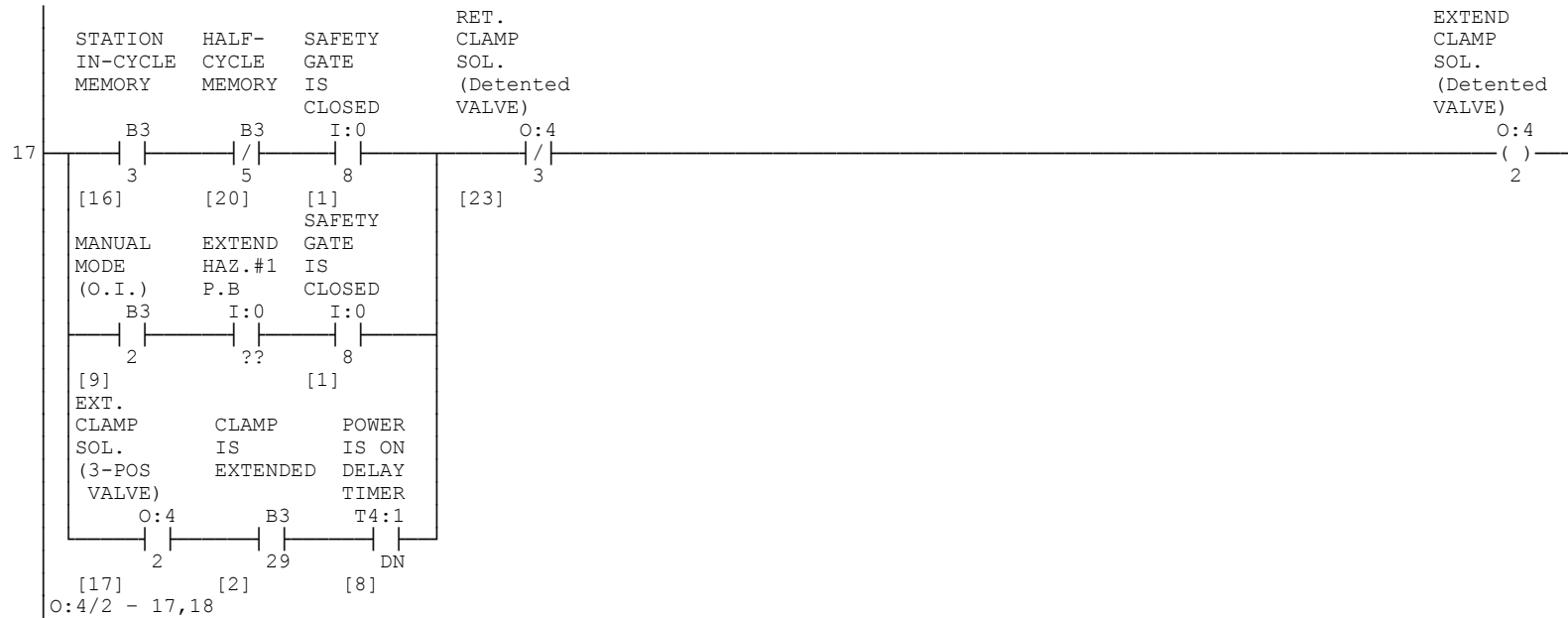
\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
 Page:00006

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In this case, a detented air valve is used to extend and retract the clamp tool

Solenoids are sealed on when the motion is complete. Seals shall only be allowed when the output is turned on and its sensors are in the correct state. It shall be broken when power is turned off.

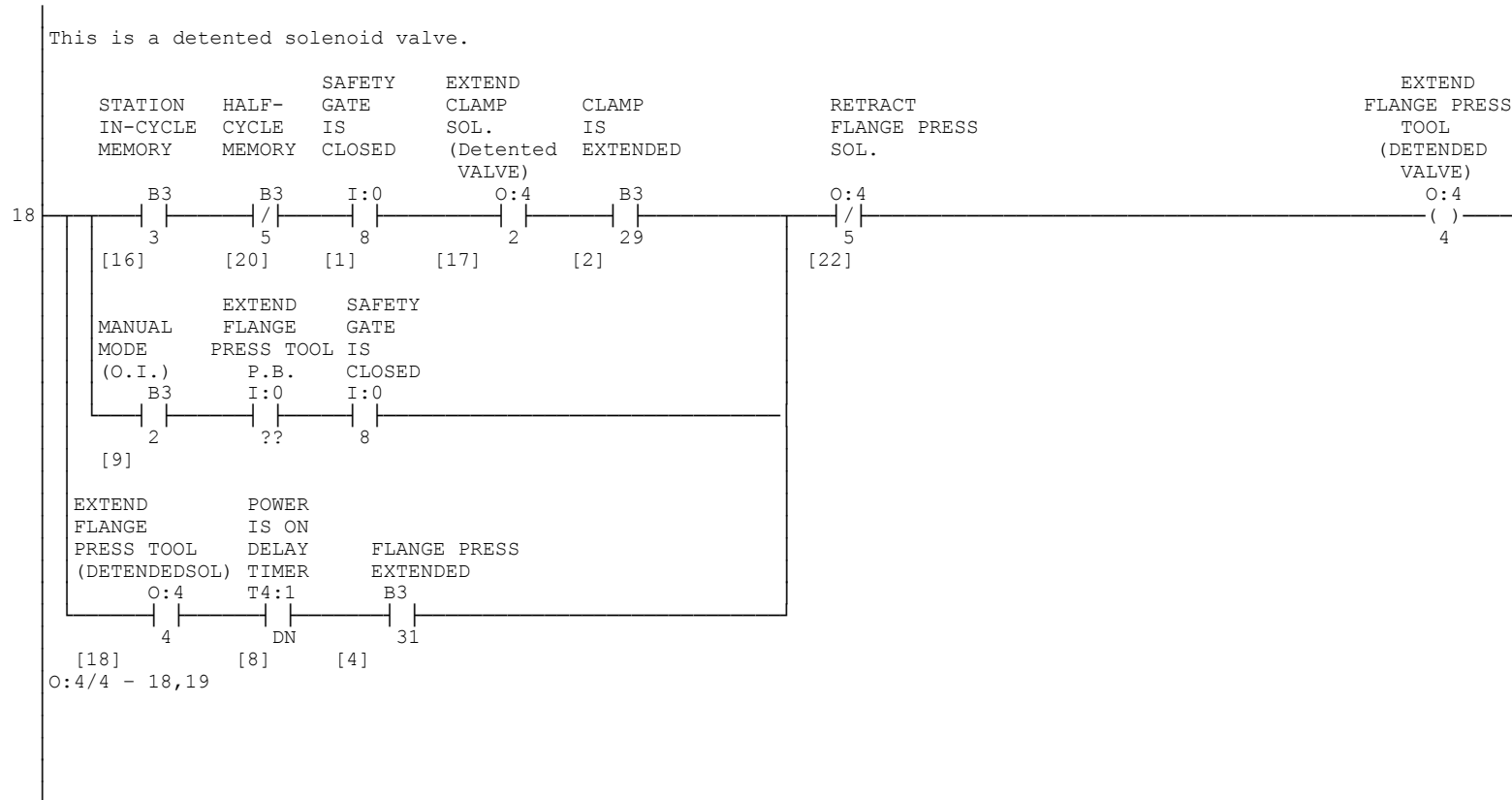


**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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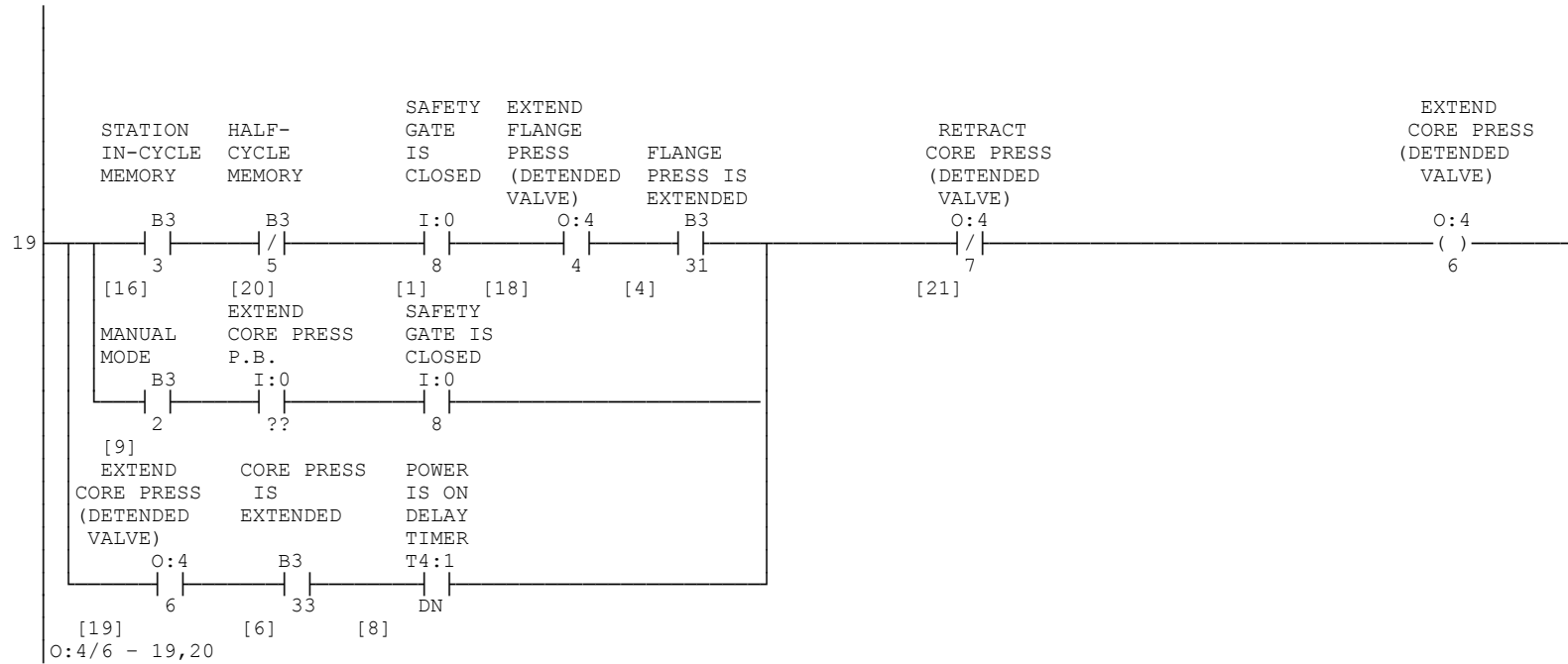


**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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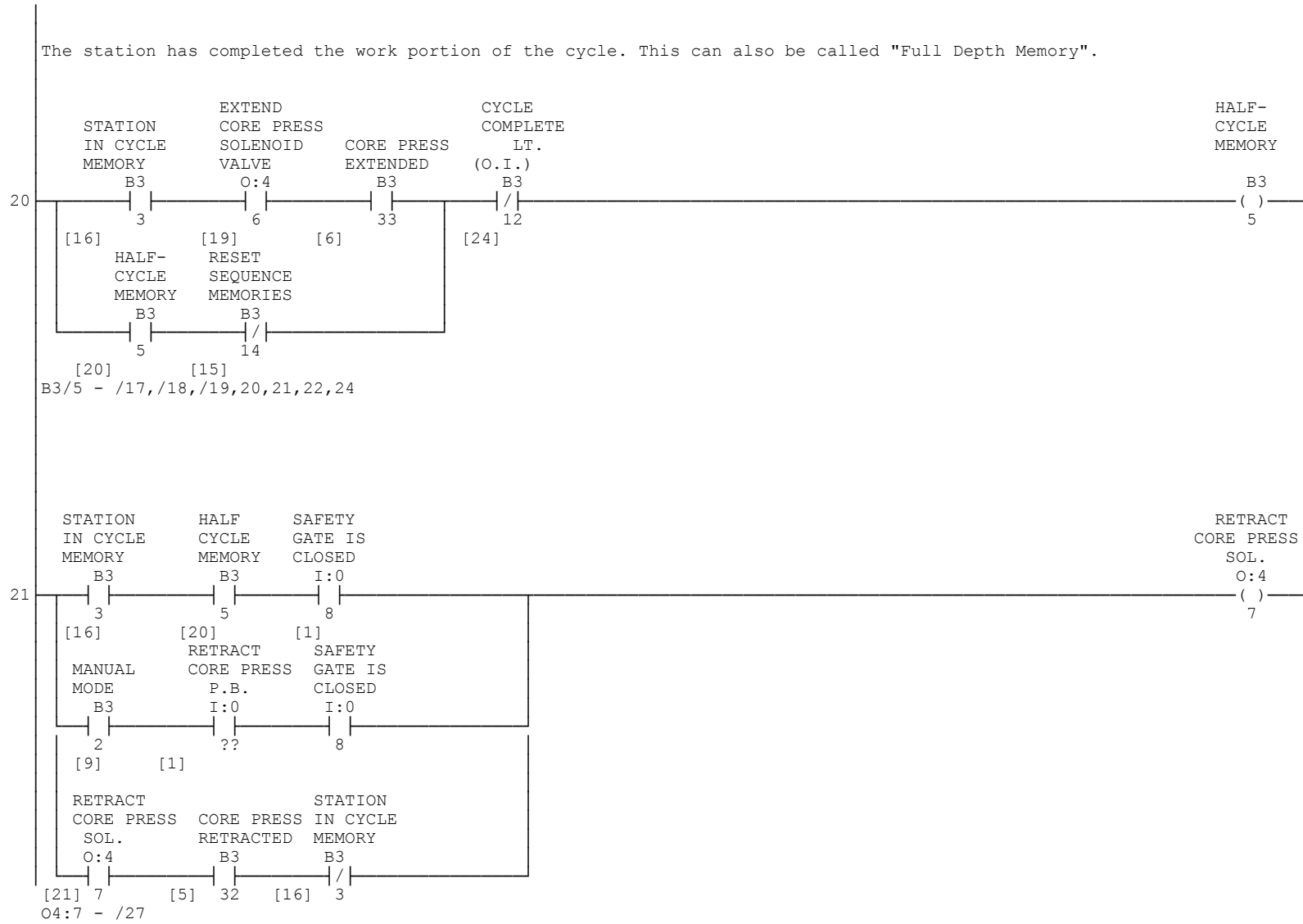


**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
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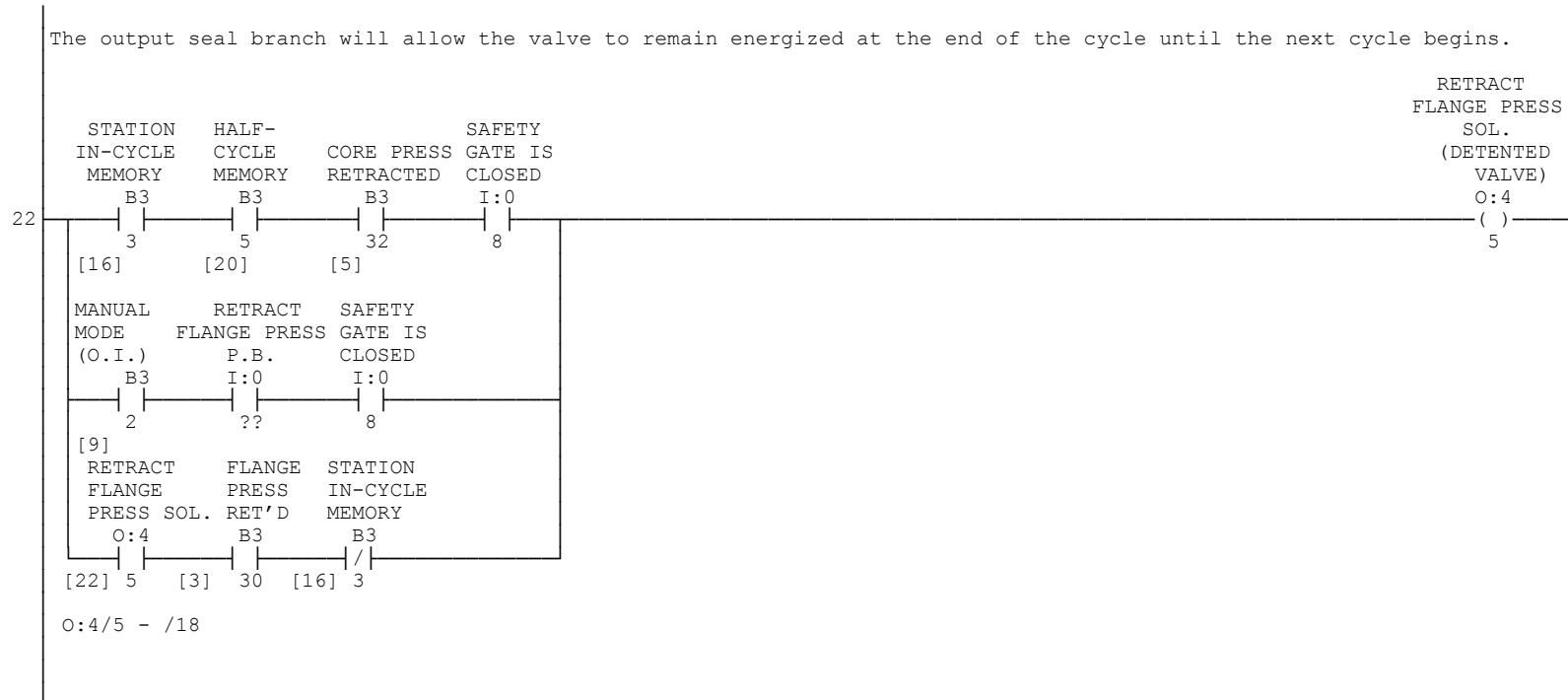


**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
 Page:00010

File #2 Proj:DCS-EX

08:30 08/24/98



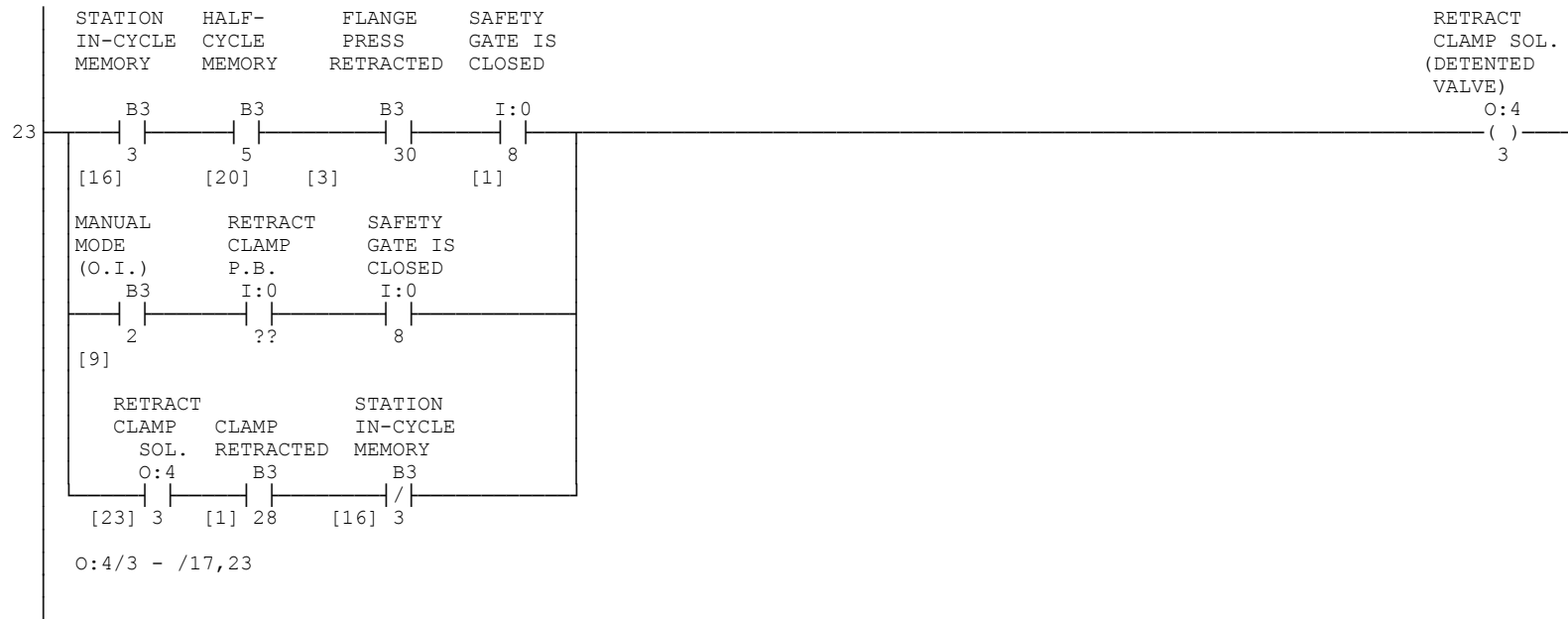


Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit

\*\*\*\* MACHINE SEQUENCE LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
 Page:00011

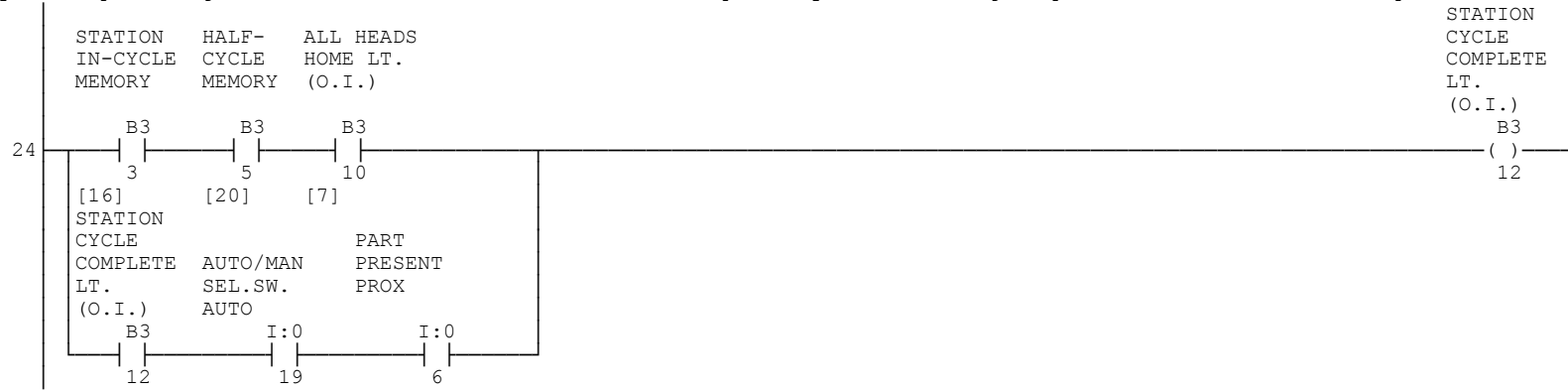
File #2 Proj:DCS-EX

08:30 08/24/98



In this approach, Cycle Complete is not allowed in Manual Mode. We want the operator to use Auto cycle to assure only good parts are produced.

The Cycle Complete light indicates the machine went thru a complete cycle & made a good part. It is reset when the part is removed.



**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

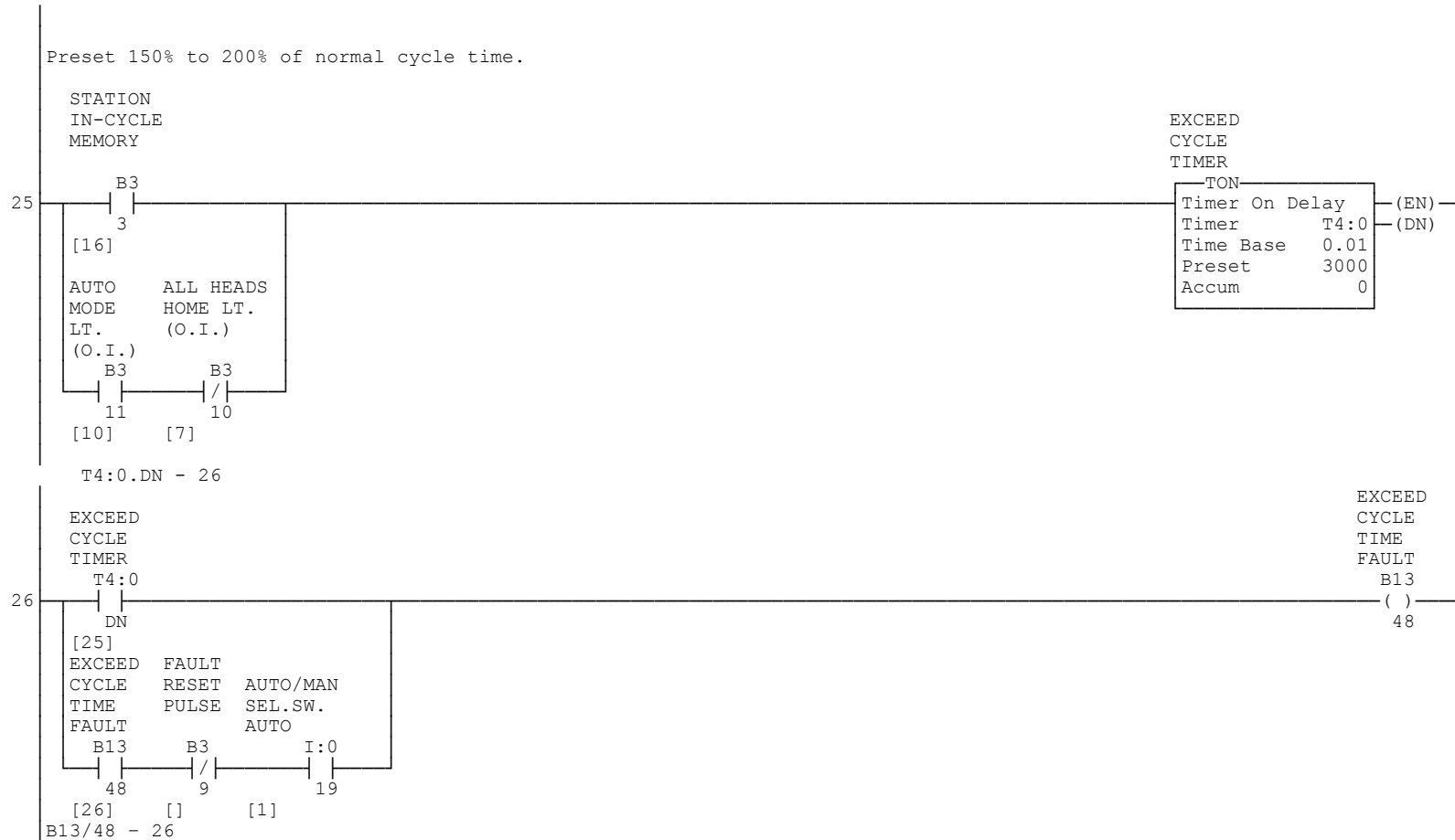
\*\*\*\* OTHER FAULT LOGIC \*\*\*\*

Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0

File #2 Proj:DCS-EX

Page:00012

08:30 08/24/98

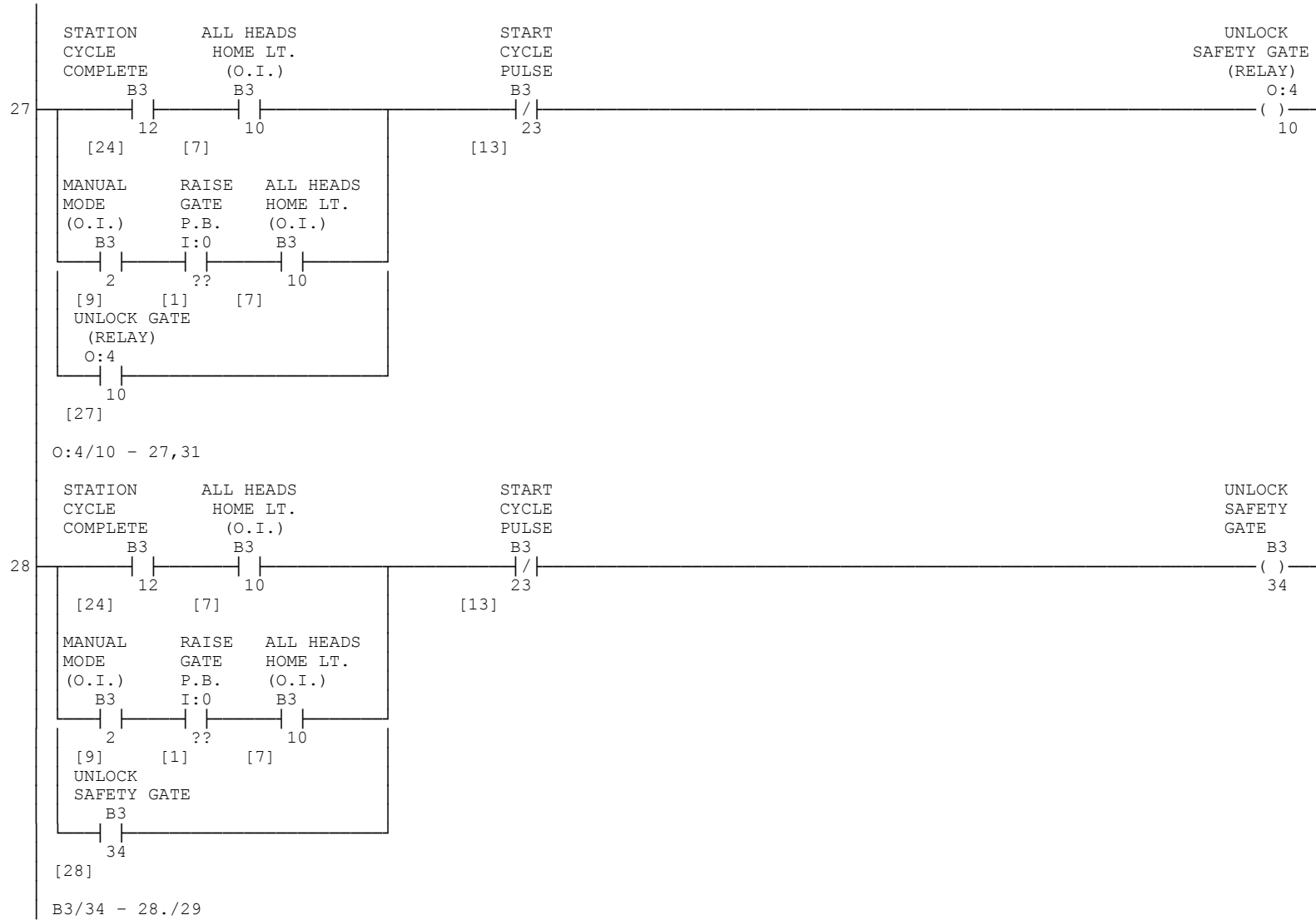


**Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit**

\*\*\*\* OTHER FAULT LOGIC \*\*\*\*  
 Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
 Page:00013

File #2 Proj:DCS-EX

08:30 08/24/98



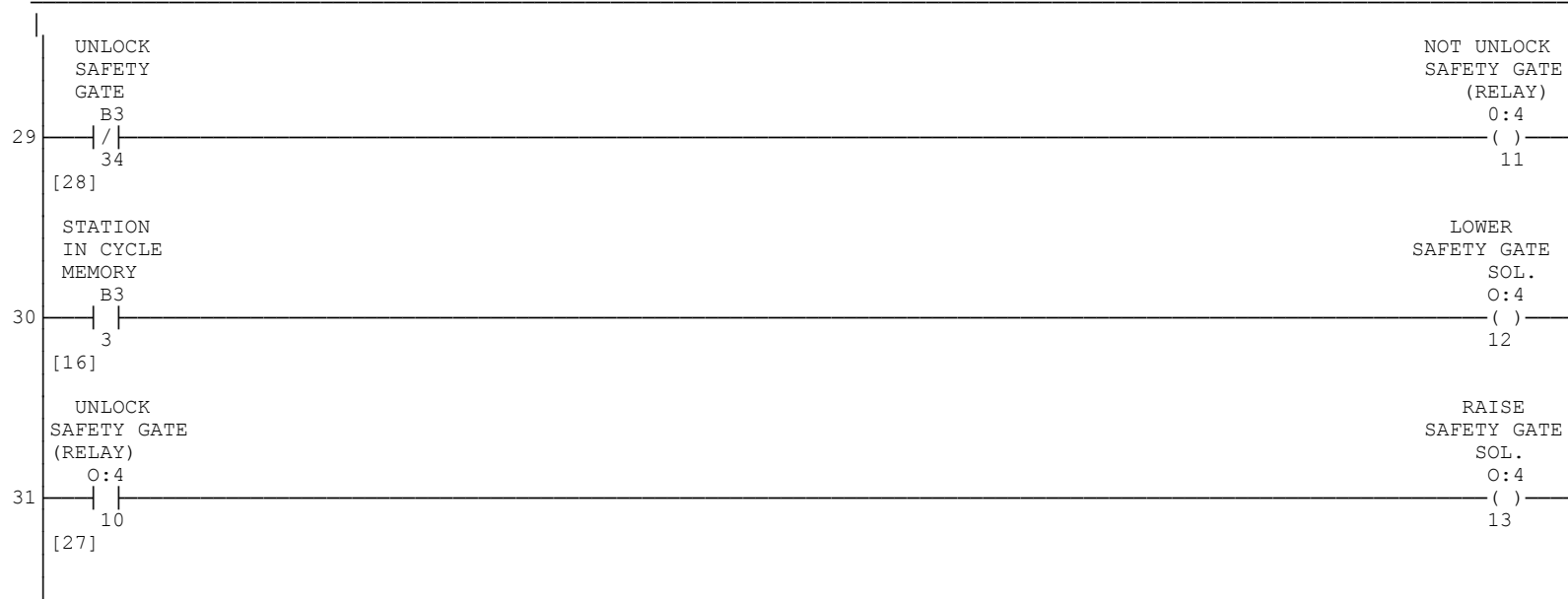
***Application Guideline for Guard Door with Solenoid Locking in a Control Reliable Circuit***

\*\*\*\* OTHER FAULT LOGIC \*\*\*\*

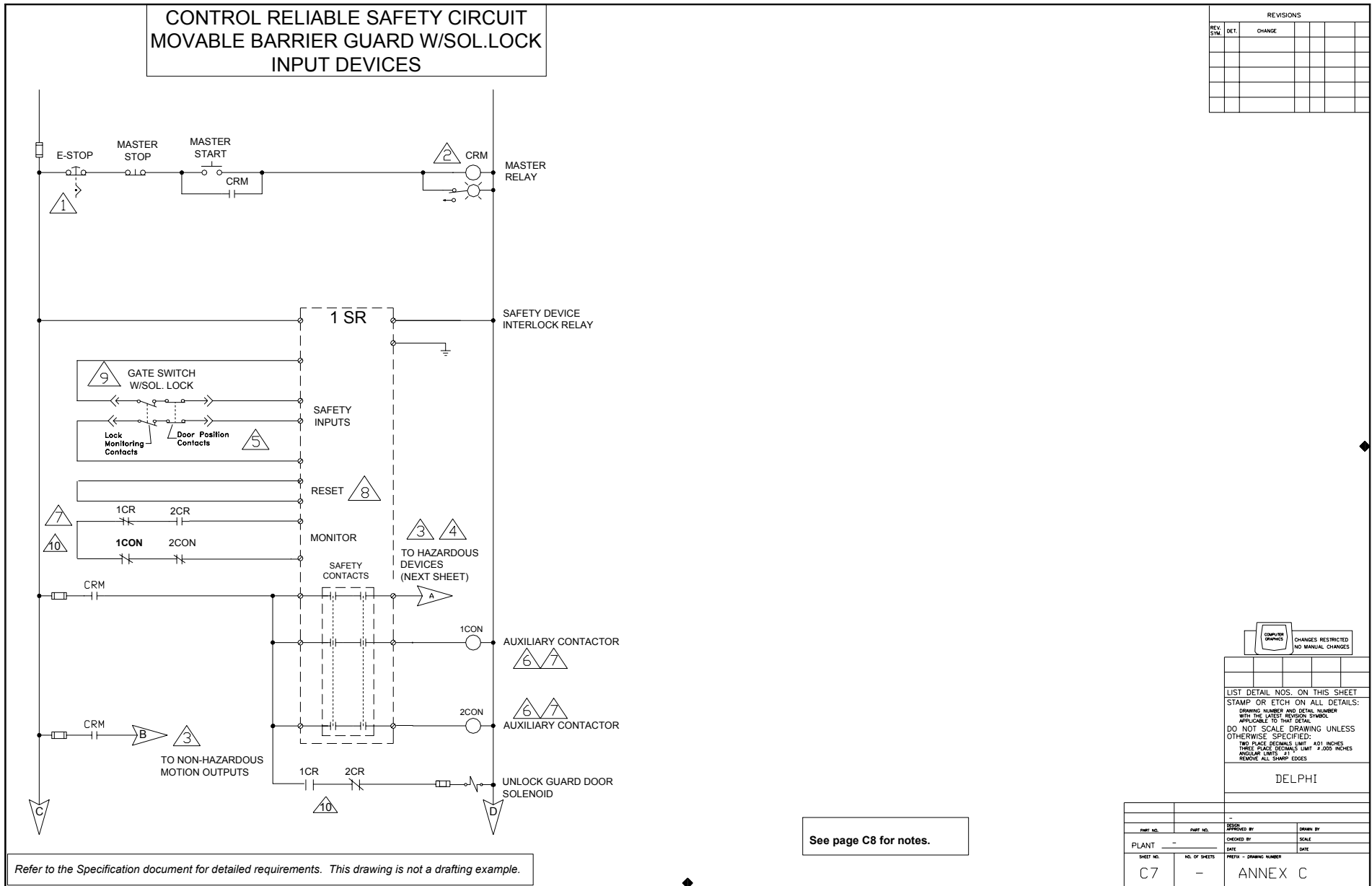
Manually Loaded Machine with Solenoid Locking Guard Door - Ver. 1.0  
Page:00013

File #2 Proj:DCS-EX

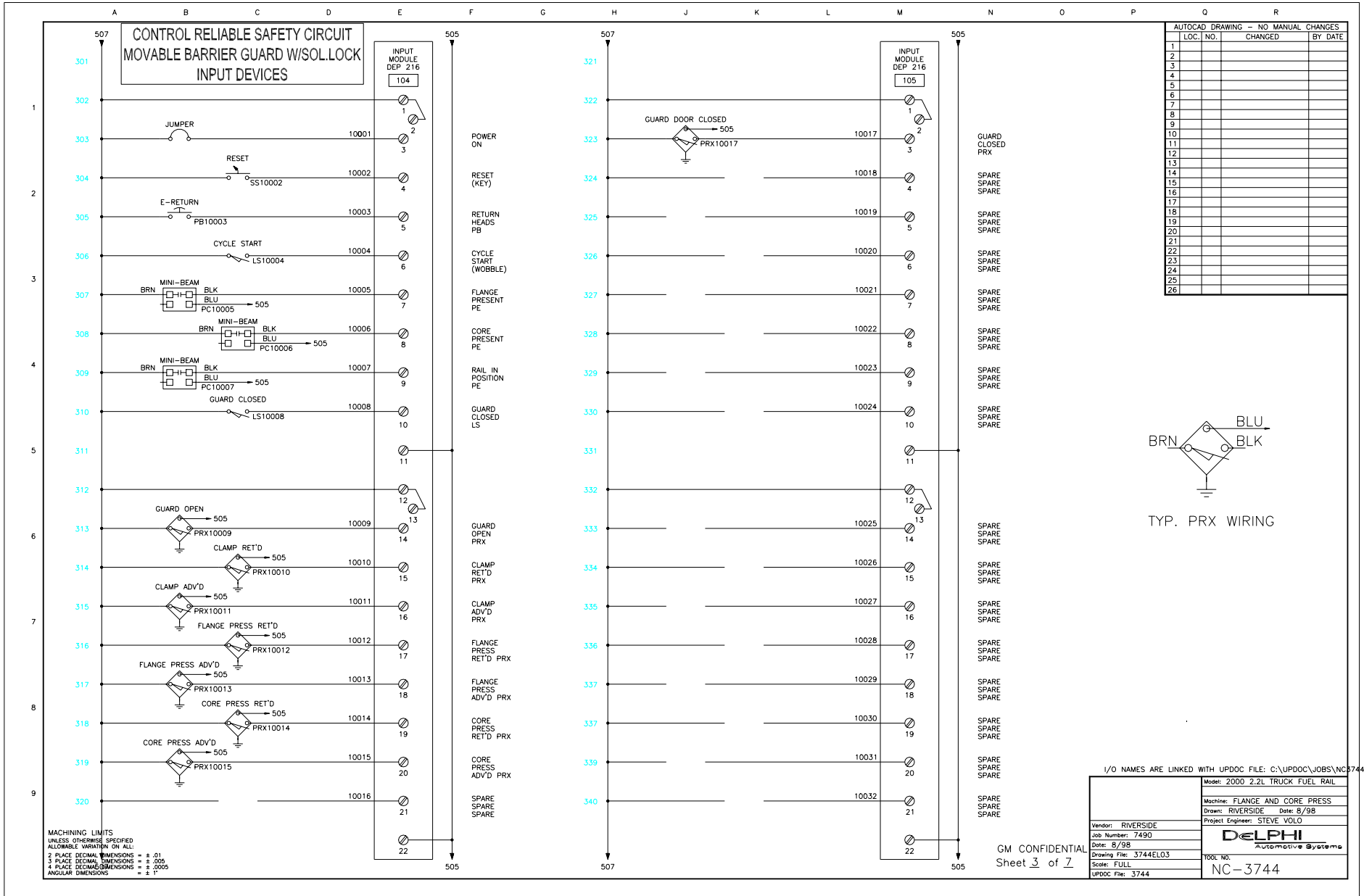
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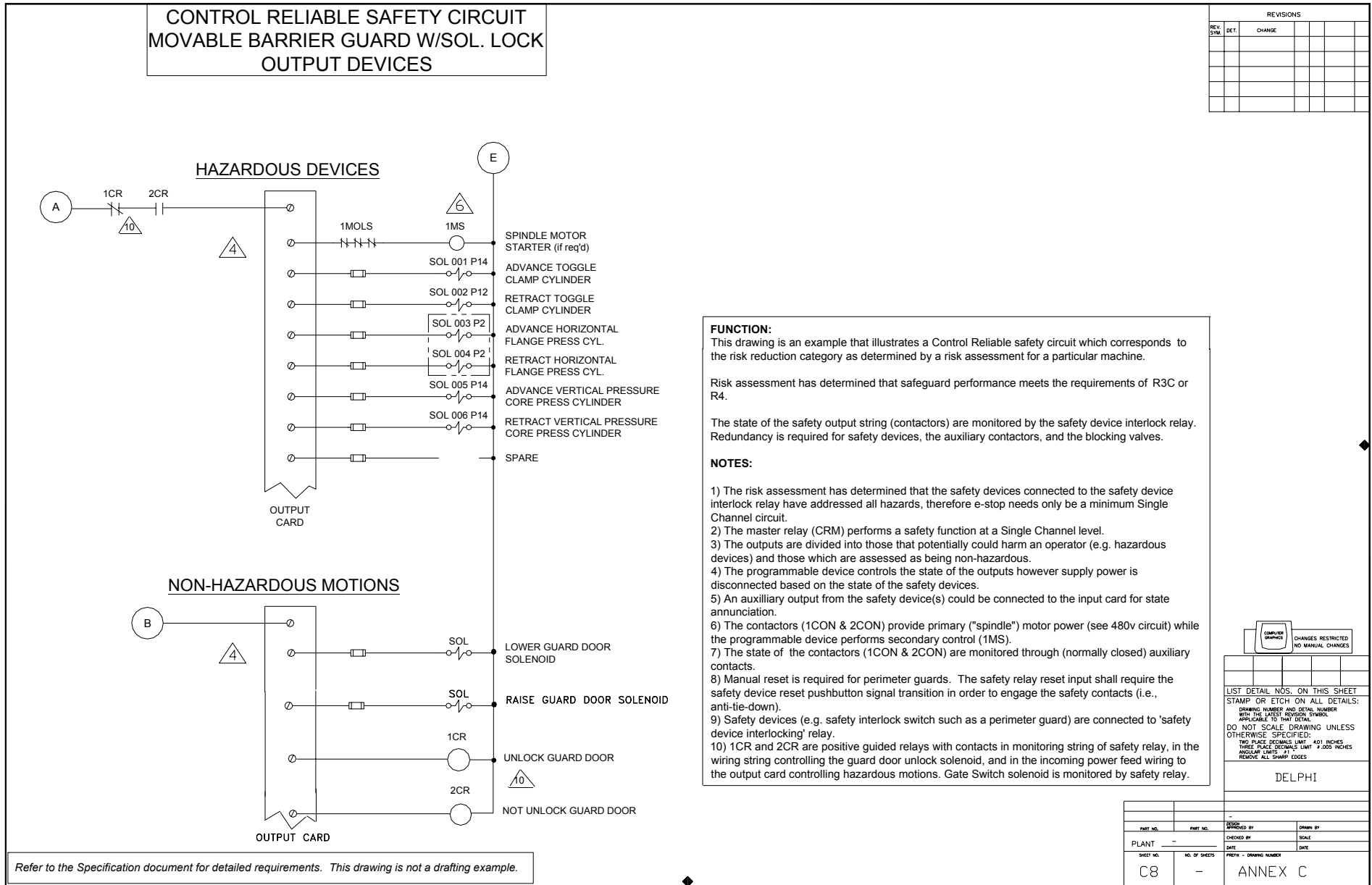
**Annex A: Autocad Drawings**



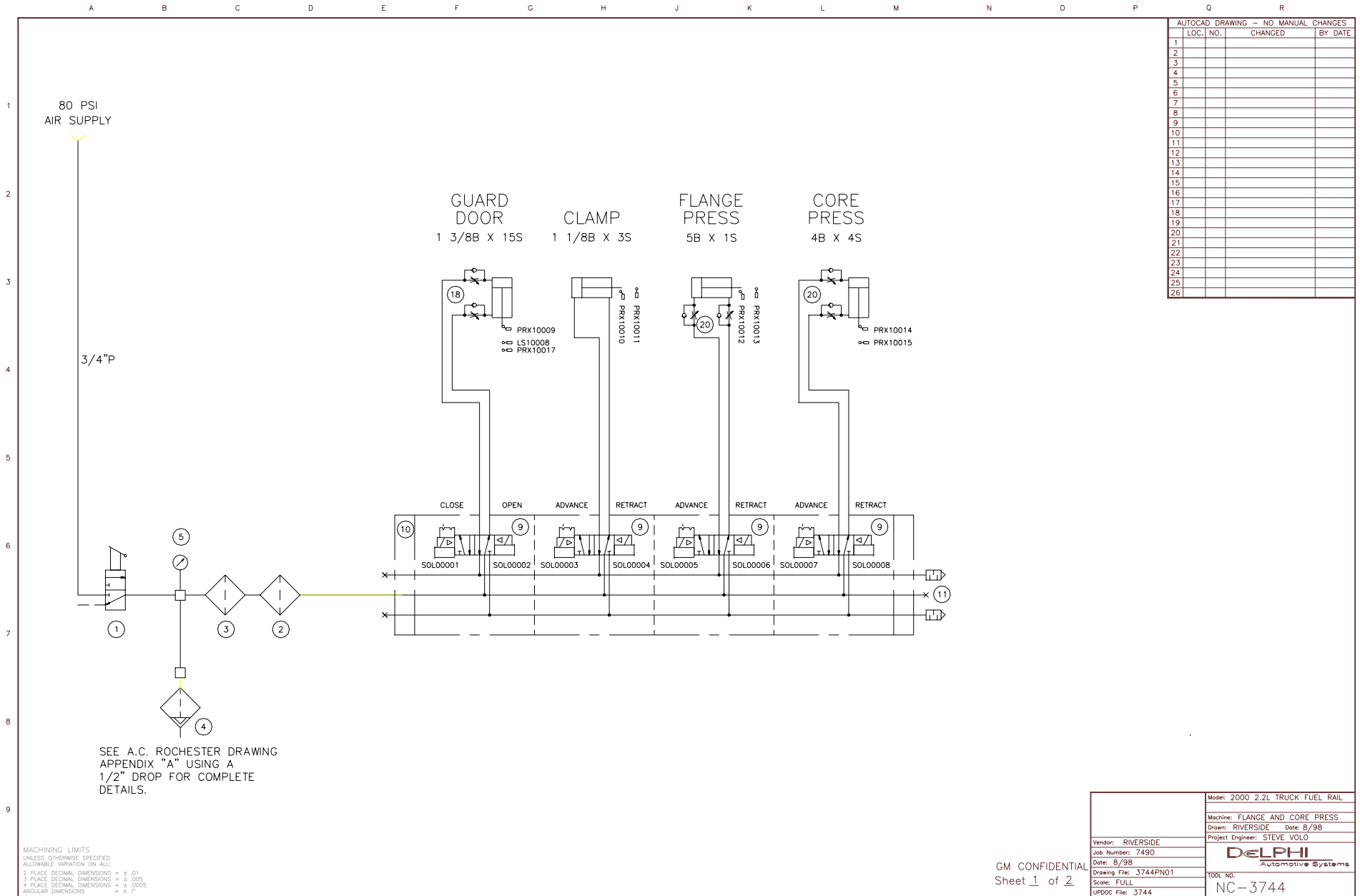
Annex A: Autocad Drawings (Cont'd)



**Annex A: Autocad Drawings (Cont'd)**



**Annex A: Autocad Drawings (Cont'd)**





**Annex B: Bibliography**

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