

**General Electric Advanced Technology Manual**

**Chapter 3.1**

**Technical Specifications  
Control Rod Problem**

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## 3.1 CONTROL ROD PROBLEMS

### Learning Objectives:

1. State the requirements for Technical Specifications and explain the significance of Limiting Condition for Operation as applied to control rod operability, control rod scram times, and Rod Worth Minimizer operability.
2. When given an initial set of operating conditions, the student will be able to use the format and content of the Technical Specifications to identify the applicable plant/operator response.

### 3.1.1 Introduction

Control Rods are analyzed to bring the reactor subcritical at a rate fast enough to prevent the OLMCPR from becoming less than the fuel cladding integrity MCPR Safety Limit during the limiting power transient analyzed in Accident analysis section of the FSAR. This analysis shows that the negative reactivity rates resulting from the scram, with the average response of all the drives as required by Technical Specifications, provides satisfactory core protection for the most limiting transient. In addition to APLHGR and the 1% plastic strain fuel design limit.

The standby liquid control system (SLC) provides a backup reactivity control capability to the control rods. The original design basis for the SLC system is to provide a soluble boron concentration to the reactor vessel sufficient to bring the reactor to a cold shutdown condition. In addition to the original design basis, the system must also satisfy the requirements of the ATWS Rule 10 CFR 50.62 paragraph (c) (4), which requires that the system have a control capacity equivalent to that for a system with an injection rate of 86 gpm of 13 weight percent unenriched sodium pentaborate, normalized to a 251 inch diameter reactor vessel.

The term "equivalent reactivity control capacity" refers to the rate at which the boron isotope B<sup>10</sup> is injected into the reactor core. The SLC system meets this requirement by using a sodium pentaborate solution enriched with a higher concentration of B<sup>10</sup> isotope.

### 3.1.2 Shutdown Margin

A sufficient shutdown margin ensures that:

1. the reactor can be made subcritical from all operating conditions;
2. the reactivity transients associated with postulated accident conditions are controllable within acceptable limits; and
3. the reactor will be maintained sufficiently subcritical to preclude inadvertent criticality in the shutdown condition.

### 3.1.3 Control Rods

The specifications for control rods ensure that:

1. the minimum shutdown margin is maintained;
2. the control rod insertion times are consistent with those used in the accident analysis; and
3. the potential effects of the rod drop accident are limited.

Limitations on inoperable rods are set so that the resultant effect on total rod worth and scram shape will be kept to a minimum. For a control rod to be considered inoperable, one of the following conditions must exist:

- Immovable due to excessive friction or mechanical interference, or known to be untrippable.
- Unable to meet scram times
- Scram accumulators inoperable
- Uncoupled control rod
- RPIS (rod position cannot be determined).
- Not in BPWS when required

Requirements for the various scram time measurements ensure that any indication of systematic problems with control rod drives will be investigated on a timely basis.

Control rods with inoperable accumulators are declared slow or inoperable. The specifications prevents a pattern of inoperable accumulators that would result in less reactivity insertion on a scram than has been analyzed even though control rods with inoperable accumulators may still be inserted with normal drive pressure. Operability of the accumulator is based on maintaining adequate accumulator pressure. When one control rod scram accumulator becomes inoperable and the reactor pressure is >900 psig, the control rod may be declared "slow", since the control rod will still scram at the reactor operating pressure but may not satisfy the scram times.

Control rod coupling integrity is required to ensure compliance with the analysis on the rod drop accident. Control rod position may be determined by the use of operable

indicators, by moving control rods to a position with an operable indicator, or use other appropriate methods.

To ensure that the control rod patterns can be followed and other parameters are within their limits, the control rod position information system must be operable.

### **3.1.4 Control Rod Program Controls**

Control rod withdrawal and insertion sequences are established to assure that the maximum in sequence individual control rod or control rod segments which are withdrawn at any time during the fuel cycle will not be worth enough to cause fuel enthalpy to exceed 280 cal/gm for any postulated rod drop accident.

Limitations on inoperable rods are set such that the resultant effect on total rod worth and scram shape will be kept to a minimum. No control rod, if dropped when thermal power is greater than 10%, would exceed 280 cal/gm. Therefore, requiring the RWM to be operable below 10% of rated thermal power provides adequate control.

### **3.1.5 CRD Testing**

Diagnostic testing is the selective analytical testing of specific CRD mechanisms and associated HCU's based on a prior analysis of drive performance and base test data. Tests consists of CRD scram time testing, scram valve timing, stall flow, differential pressure tests, normal drive speeds, and electrical tests. Diagnostic testing limits maintenance outage time and problems with LCO requirements in technical specifications.

Testing will:

- Minimize corrective maintenance to drives with pre-analyzed need, thus maximum utilization of maintenance time.
- Minimizes CRD operational problems in future operating cycles, maximizing plant availability and flexibility.

If a CRD fails to respond to the normal insert/withdraw command signals, notch-in or out of "00", or exhibit scram problems, a differential pressure test should be performed. An analysis of traces generated by measuring the dp changes with an oscilloscope can isolate such faults as:

- CRD mechanical malfunction
- Improper operation of HCU directional control valves (leakage, blockage)
- Improper RMCS timer operation
- Unbalanced hydraulic system (stabilizing valves, flow and pressure control)
- Scram valve leakage

- Air in hydraulic lines
- Improper electrical relay operation

When it is initially determined that an analysis is needed, the following steps should be taken:

- Install testing equipment.
- Apply notch-in signal.

Use the pressure trace for documentation purposes and as a possible trouble shooting aid.

### **Normal Notch in**

Figure 3.1-1 illustrates a notch in of a control rod drive. A surge pressure of approximately 140 psid is applied until the drive begins moving and drops to about 80 psi to maintain movement.

### **Air in System**

Anytime the control rod drive system is open for maintenance a potential for trapping air in the system exists. In addition, accumulation of air from the CRD water supply over a period of time can occur.

Air in the CRD hydraulic system can result in the following problems:

- Loss of response at directional control valve switching points during the notch out cycle when the volume of air in the supply piping to the Po side increases.
- Loss of driving pressure dp response occurs during a notch-in or notch-out cycle when the volume of air in the supply piping to the Pu side increases. With only 35 in<sup>3</sup> of air trapped in the supply piping a failure to notch can occur.
- Air in the CRD hydraulic system piping can cause breakage of internal drive seals and primary stop piston seals.
- Oxygen is also a contributing cause of intergranular cracking.

Figure 3.1-2 illustrates a control rod being notched out from position 24 with air trapped in piping to the Po side. Note the loss of dp response at directional control valve switching points and the accumulator discharge effect occurring during the settle function.

Figure 3.1-3 illustrates a control rod with insufficient differential pressure to insert the drive. Several problems could cause a low differential pressure, however, in most cases the problem is associated with the hydraulic control unit. Some of the most

obvious reasons are listed below.

- plugged filters
- failed closed insert directional control valve
- failed open withdraw directional control valve
- HCU valve line-up not correct
- severe seal damage to drive mechanism
- various electrical malfunctions that could prevent proper valve sequencing.

### **3.1.6 Exercise**

You are a resident inspector at a BWR/4 plant that has just completed a 25 day refueling outage. When you arrive at the station, the post outage plant startup is in progress. You proceed to the control room and review the shift supervisor's log. The following entries are recorded.

- Commenced a reactor startup, mode switch placed in startup/hot standby position.
- reactor critical, critical data taken
- at the point of adding heat
- Rod Worth Minimizer failure, Ops supervisor informed.
- Mode switch placed in run position.
- Plant chemist reports SLC concentration at 6.3% with a volume of 3000 gal.
- Paralleled to grid.
- Scram testing commenced.

While reading the log you hear the reactor operator inform the STA that rod 10-43 will not move.

Consult Technical Specifications, to determine control rod operability requirements, scram times requirements, and Rod Worth Minimizer requirements.

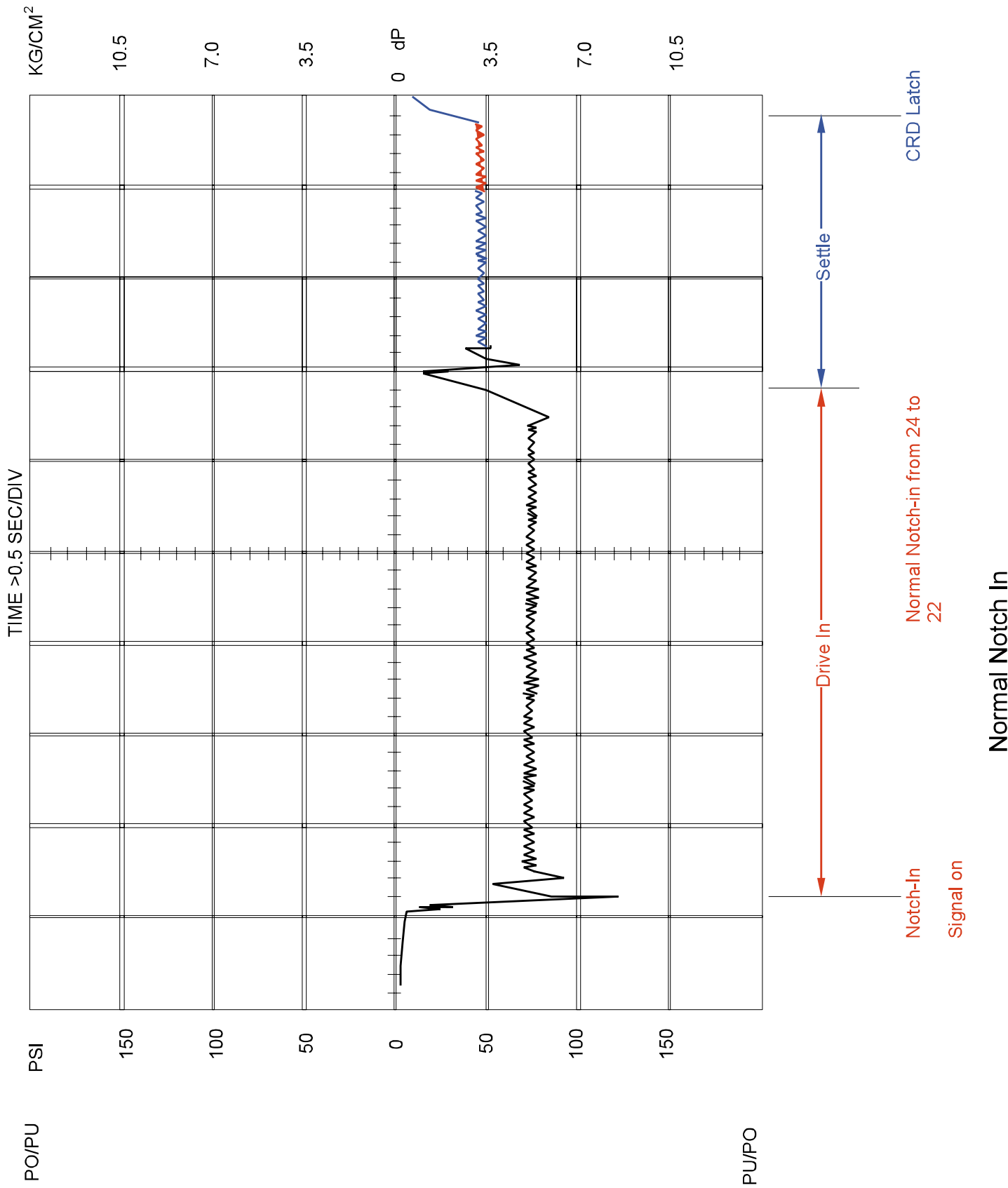
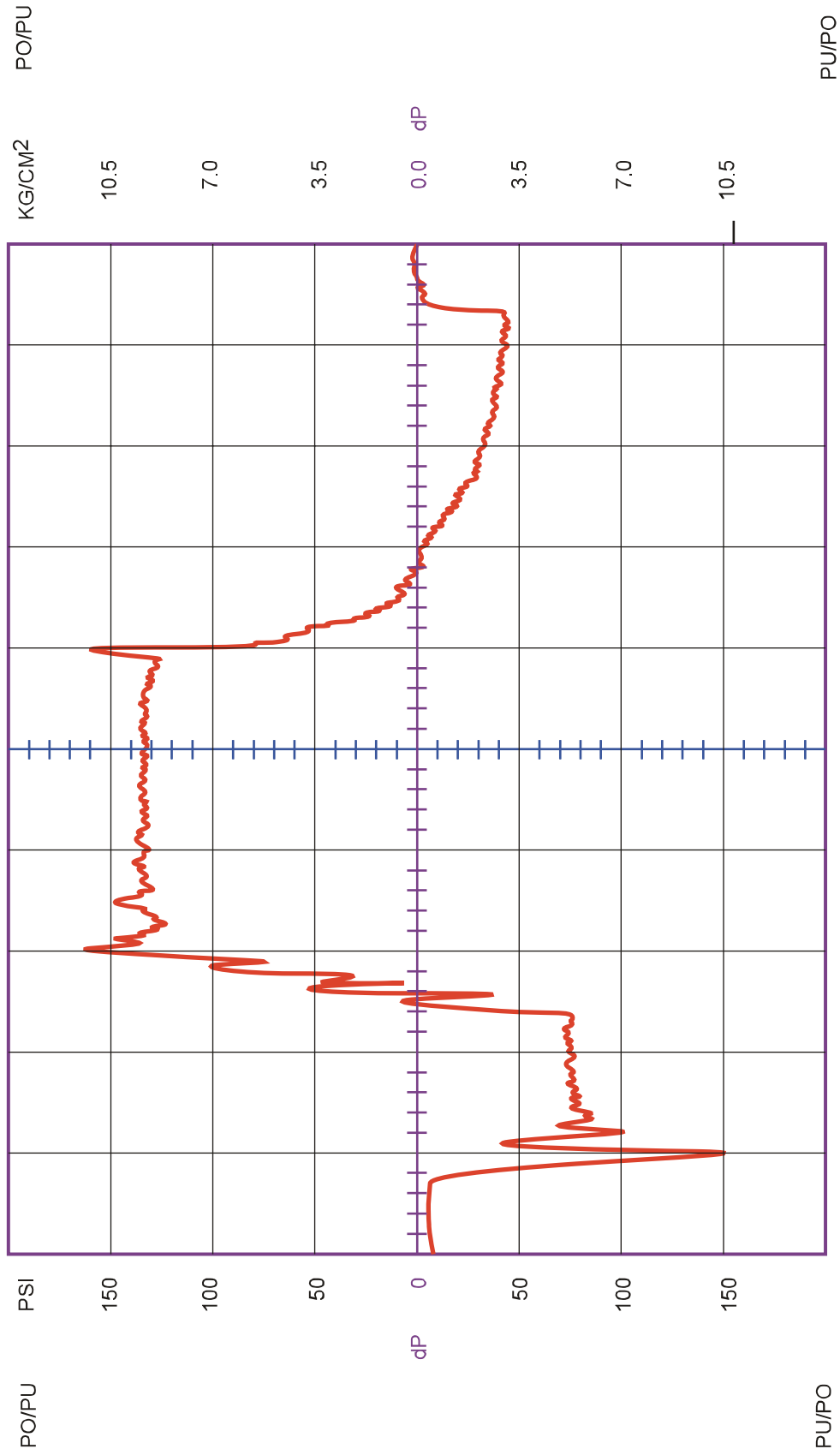


Figure 3.1-1 Normal Notch In

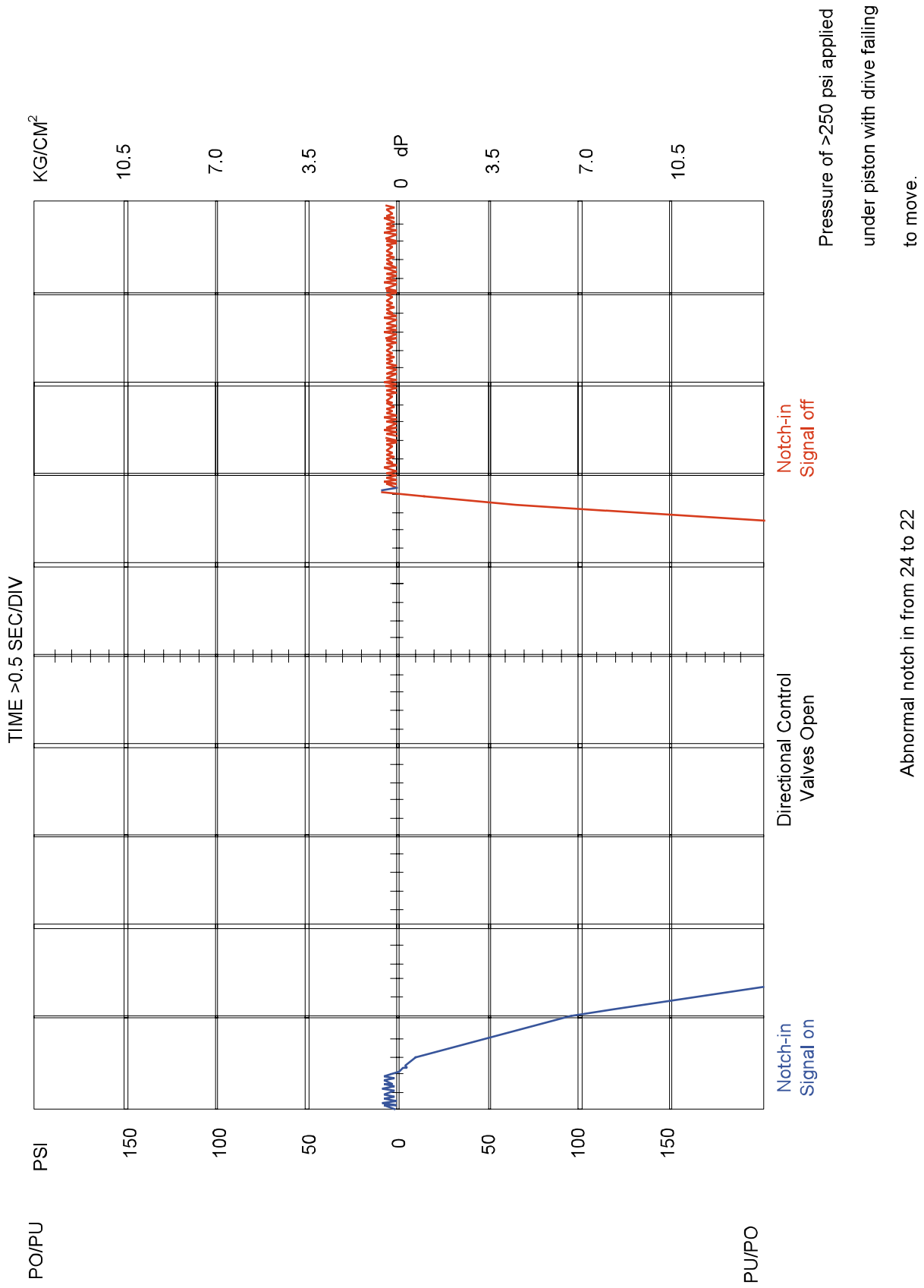




Time > 0.5 SEC/DIV

Notch-Out From Position 24 With Air Trapped In Piping To CRD Po Side

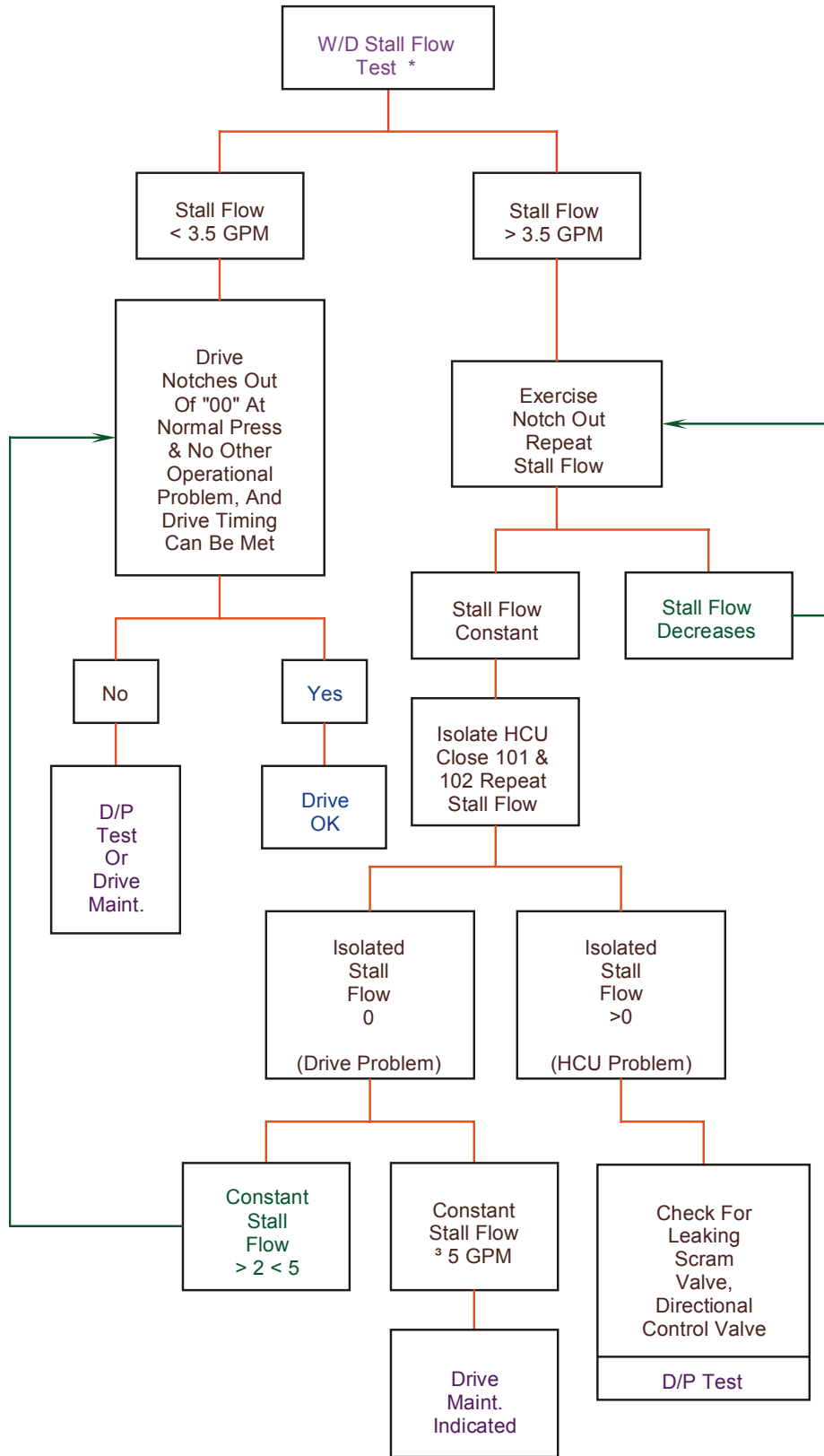
Figure 3.1-2 Notch-Out with Air Trapped in System



### High Differential Pressure

Figure 3.1-3 High Differential Pressure

This chart is intended only as a troubleshooting guide and information obtained as a result of its use should not be considered conclusive as to the condition of a drive.



\* Normal W/D Stall Flow For New Drives Is Between 1 And 2 GPM

Figure 3.1-4 Trouble Shooting Guide

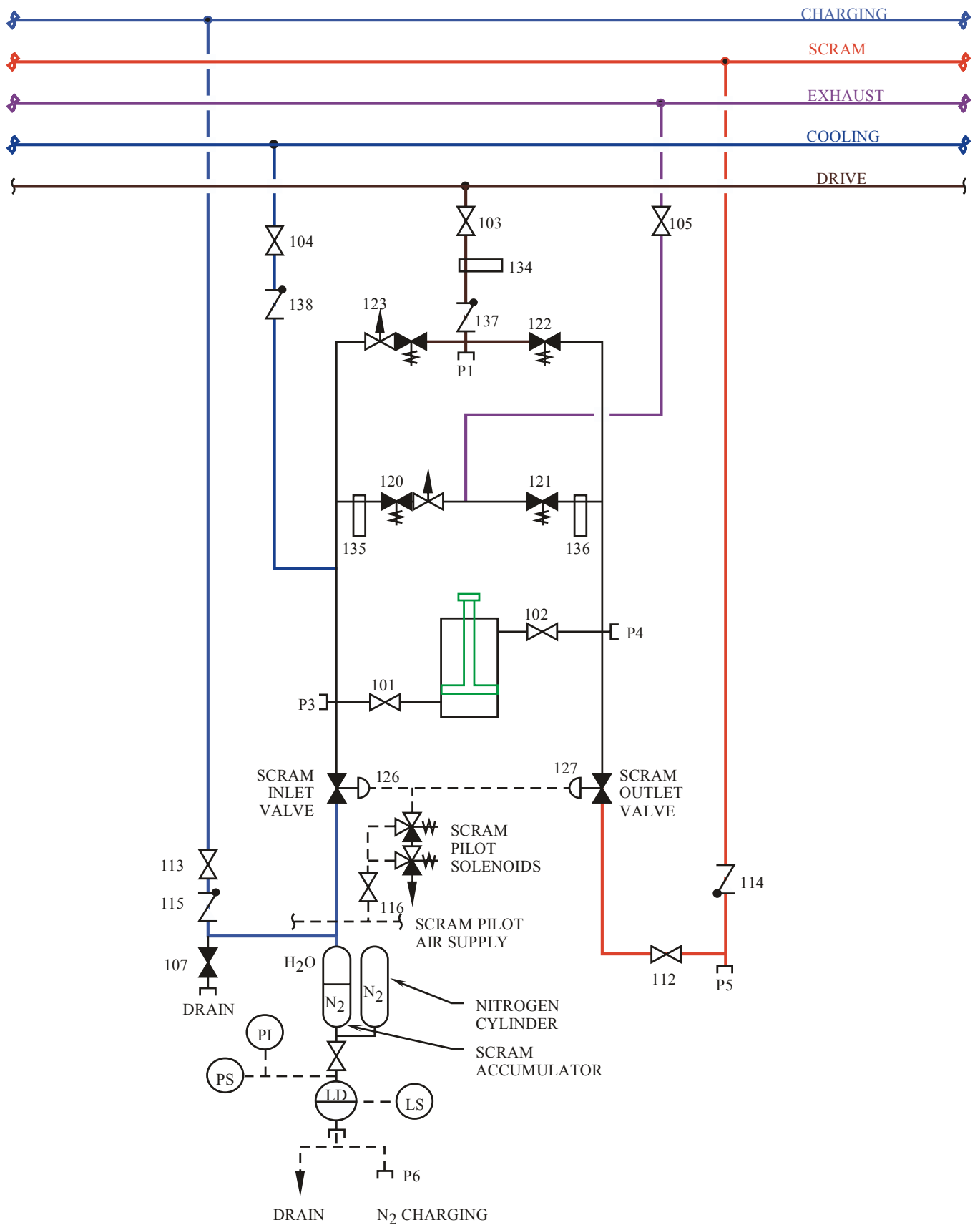


Figure 3.1-5 CRD Hydraulic Control Unit