4.6 FUNCTIONAL DESIGN OF REACTIVITY CONTROL SYSTEM

4.6.1 INFORMATION FOR CONTROL ELEMENT ASSEMBLY DRIVE SYSTEM

The CEADs is comprised of magnetic jack control element drive mechanisms (CEDM). Component diagrams, descriptions, and characteristics are presented in Subsection 3.9.4. Figure 4.6-1 shows the reactor vessel closure head plan view detailing the CEDM layout.

4.6.2 EVALUATION OF THE CEADS

The safety function of the CEADS is to insert control element assemblies (CEA) into the reactor core when electrical power is removed from the coils of the CEDMs by the Reactor Protection System (RPS). A failure modes and effects analysis is presented in Section 7.2 which demonstrates compliance with IEEE standard 279-1971 and shows that no single failure can prevent electrical power from being removed from the CDE coils, the armature springs automatically cause the driving and holding latches to be withdrawn from the CEDM coils, the armature springs automatically cause the driving and holding latches to be withdrawn from the CEDM drive shaft, allowing insertion of CEAs by gravity. Actuation of trip breaker is independent of any existing control signals.

For the trip function, all CEDMs are independent of one another. That is, the failure of one CEDM to trip would have no effect on the operability of other CEDMs. Sufficient shutdown margin is always provided to assure that the CEADs safety function can be performed assuming a failure of any CEDM.

→ (DRN 00-644)

The CEADS includes the CEDMs and extends to the coupling interface with the reactivity CEAs. Since there is no nonessential portion of the CEADS, no isolation is required between essential an nonessential portions of the CEADS.

The CEDMs are located where they are protected from common mode failure due to missiles and failure of moderate and high energy pipes. Sections 3.5 and 3.6 discuss protection of essential systems against missiles and pipe breaks. A potential source of common mode failure is loss of air cooling to the CEDM coils. Worse case analysis indicated that there would be adequate mechanical clearances to permit it to trip at temperatures well above normal operating of the reactor[(1)]. Testing was performed to determine the maximum CEDM temperature under conditions that simulated loss of air cooling. With the upper gripper coil energized, which is the normal operating mode, and with a reactor coolant loop temperature of 600°F, the maximum CEDM temperature was 535°F. An analysis of worst case tolerance stack-up within the CEDM indicated adequate clearances to assure scram at 650°F.

← (DRN 00-644)

For any single malfunction of the reactivity control systems, such as accidental withdrawal (not ejection or dropout) of CEAs, specified acceptable fuel design limits are not exceeded. Analyses of possible control malfunctions are discussed in Section 15.4.

4.6.3 TESTING AND VERIFICATION OF THE CEADS

→(DRN 00-644)

The functional testing program for the CEADS is described in Subsections 3.9.4.4 (CEDMs) and 4.2.4.4 (CEAs).The preoperational and startup test program for the CEADS is presented in Section 14.2.

←(DRN 00-644)

As discussed in Subsection 4.6.2, upon reactor trip all CEDMs are independent of one another. Thus the worse single failure is one that prevents one CEDM from tripping. This failure mode was considered and included in the accident analysis presented in Chapter 15.

Under large break LOCA conditions where severe loads may be applied to CEAs, no credit is taken for CEDM functioning. Testing was performed on a prototype CEDM to verify insertion time, assuming worse case plant operating conditions. Insertion time was verified by dropping the minimum effective (dry) weight of 86 pounds. This weight was calculated to be the minimum effective dry weight, assuming maximum delta-P across the core due to crudding and high reactor coolant density due to operating at a loop temperature of 475° F.

4.6.4 INFORMATION FOR COMBINED PERFORMANCE OF REACTIVITY SYSTEMS

Figures 1.2-11 through 1.2-23, Drawing G134, Drawing G135 and Drawing G136, provide plant and elevation layout drawings. These figures and drawings show that the CEADS, SIS, and CVCS are located in the Reactor Building, and the Reactor Auxiliary Building. The physical arrangement insures that no single occurrence can affect two or more reactivity control systems concurrently.

Table 4.6-1 lists the postulated accidents evaluated in Chapter 15 that take credit for two or more reactivity control systems for preventing or mitigating each accident. The related reactivity systems are also tabulated.

The maximum rate of reactivity addition that may be produced by the CVCS is too low to induce any significant pressure forces that might rupture the reactor coolant pressure boundary or disturb the reactor vessel internals.

Inadvertent startup of the safety injection system during normal plant operation would have no effect since RCS pressure is higher than the shutoff head of the HPSI pumps.

4.6.5 EVALUATIONS OF COMBINED PERFORMANCE

→(DRN 00-644; 06-871, R15)

Since the CEADS and the CVCS/SIS are separate and totally diverse in design and operation, with no common link, and since the CEADS is protected from the effects of failure of high and moderate energy piping, there are no credible potential common mode failures that could cause the CEADS to fail in combination with CVCS or SIS. This is demonstrated by the evaluations provided in Sections 3.5, 3.6, and Subsection 9.5.1.

←(DRN 00-644; 06-871, R15)

SECTION 4.6: REFERENCES

1. "Review of Reactor Shutdown Systems (PPS Design) for Common Mode Failure Susceptibility," Combustion Engineering Topical Report, CENPD-148, November 1974.

TABLE 4.6-1 Revision 14 (12/05)

POSTULATED EVENTS REQUIRING OPERATING
OF TWO OR MORE REACTIVITY CONTROL SYSTEMS

Subsection	Title	CEADS	CVCS	SIS
15.1.3.1	Steam System Piping Failures	X		X
→(DRN 03-2058, R14) ←(DRN 03-2058, R14)	Deleted			
15.4.1.5	CVCS Malfunction (Boron Dilution)	X	X	
15.6.3.1	Letdown Line Break Outside Containment	X		X
15.6.3.2	Steam Generator Tube Rupture	X		X
15.6.3.3	Small Break LOCA	X		X