3.5 CONTROL ROD DRIVE HOUSING SUPPORTS

3.5.1 Safety Objective

The control rod drive housing supports protect against additional damage to the nuclear system process barrier or damage to the fuel barrier by preventing any significant nuclear transient in the event a drive housing breaks or separates from the bottom of the reactor vessel.

3.5.2 Safety Design Basis

1. Control rod downward motion shall be limited, following a postulated control rod drive (CRD) housing failure, so that any resulting nuclear transient could not be sufficient to cause fuel damage or additional damage to the process barrier.

2. Clearance shall be provided between the housings and the supports to prevent vertical contact stresses due to their respective thermal expansion during plant operation.

3.5.3 Description

The control rod drive housing supports are illustrated in Figure 3.5-1. Horizontal beams are installed immediately below the bottom head of the reactor vessel between the rows of control rod housings, and are bolted to brackets welded to the steel form liner of the reactor support pedestal.

Hanger rods, about 10 feet long by 1-3/4 inches in diameter, are supported from the beams on stacks of disc springs which compress about 2 inches under the design load.

The support bars are bolted between the bottom ends of the hanger rods. The spring pivots at the top and the beveled loose-fitting ends on the support bars prevent substantial bending moment in the hanger rods if the support bars are ever loaded.

Individual grids rest on the support bars between adjacent beams. Because a single-piece grid would be difficult to handle in the limited work space and because it is necessary that control rod drive, position indicators, and in-core instrumentation components be accessible for inspection and maintenance, each grid is designed to be assembled or disassembled in place. Each grid assembly is made from two grid plates, a clamp and a bolt. The top part of the clamp acts as a guide to assure that each grid is correctly positioned directly below the respective CRD housing which it would support in the postulated accident.

When the support bars and grids are installed, a 1″ ± .25″ gap is provided between the grid and the bottom contact surface of the control rod drive flange. During system heatup this gap is reduced by a net downward expansion of the housings with respect to the supports. In the hot operating condition, a minimum gap of 7/16″ is maintained.

In the postulated CRD housing failure, the CRD housing supports are loaded when the lower contact surface of the CRD flange contacts the grid. The resulting load is then carried by two grid plates, two support bars, four hanger rods, their disc springs, and two adjacent beams.

The American Institute of Steel Construction (AISC), "Specification for the Design, Fabrication, and Erection of Structural Steel for Building," was used in the design of the CRD housing support system. However, to provide a structure that absorbs as much energy as practical without yielding, the allowable tension and bending stresses were taken as 90 percent of yield, and the shear stress as 60 percent of yield. These are 1.5 times the corresponding AISC allowable stresses of 60 percent and 40 percent of yield.

This stress criterion is considered desirable for this application and adequate for the "once in a lifetime" loading condition.

For mechanical design purposes, the postulated failure resulting in the highest forces is an instantaneous circumferential separation of the CRD housing from the reactor vessel, with an internal pressure of 1250 psig (reactor vessel design pressure) acting on the area of the separated housing. The weight of the separated housing, control rod drive, and blade, plus the force of 1250 psig pressure acting on the area of the separated housing, gives a force of approximately 35,000 pounds. This force is multiplied by a factor of 3 for impact, conservatively assuming the housing travels through a 1-inch gap before contacting the supports. The total force (10.5×10^4 pounds) is then treated as a static load in design formulas. The control rod drive housing supports are designed as Class I equipment in accordance with Appendix C, "Structural Qualification of Subsystems and Components".

All control rod drive housing support subassemblies are fabricated of ASTM-A-36 structural steel, except for the following:

Grid	ASTM-A-441
Disc springs	Schnorr Type BS-125-71-8
Hex bolts and nuts	ASTM-A-307

3.5.4 Safety Evaluation

Downward travel of a CRD housing and its control rod following the postulated housing failure is the sum of the compression of the disc springs under dynamic loading and the initial gap between the grid and the bottom contact surface of the CRD flange. If the reactor were cold and pressurized, the downward motion of the control rod would be limited to the approximate 2-inch spring compression plus the installed 1″ ± .25″ gap. If the reactor were hot and pressurized, the gap would be greater than a 7/16″ and the spring compression slightly less than in the cold condition. In either case, the control rod movement following a housing failure is limited substantially below one drive "notch" movement (6 inches). The nuclear transient from sudden withdrawal of any control rod through a distance of one drive notch at any position in the core does not result in a transient sufficient to cause damage to any radioactive material barrier. This meets the fuel damage limitation of safety design basis 1.

The control rod drive housing supports are in place any time the reactor is to be operated.

At plant operating temperature, a minimum gap of 7/16″ is maintained between the CRD housing and the supports, at lower temperatures the gap is greater. Because the supports do not come in contact with any of the CRD housings, except during the postulated accident condition, vertical contact stresses are prevented as required by safety design basis 2.

3.5.5 Inspection and Testing

The control rod drive housing supports were inspected after initial installation. When the reactor is in the shutdown mode (MODE 4 or MODE 5), the control rod drive housing supports may be removed to permit inspection and maintenance of the control rod drives. When the support structure is reinstalled, it is inspected for proper assembly, particular attention being given to assure that the correct gap between the CRD flange lower contact surface and the grid is maintained.