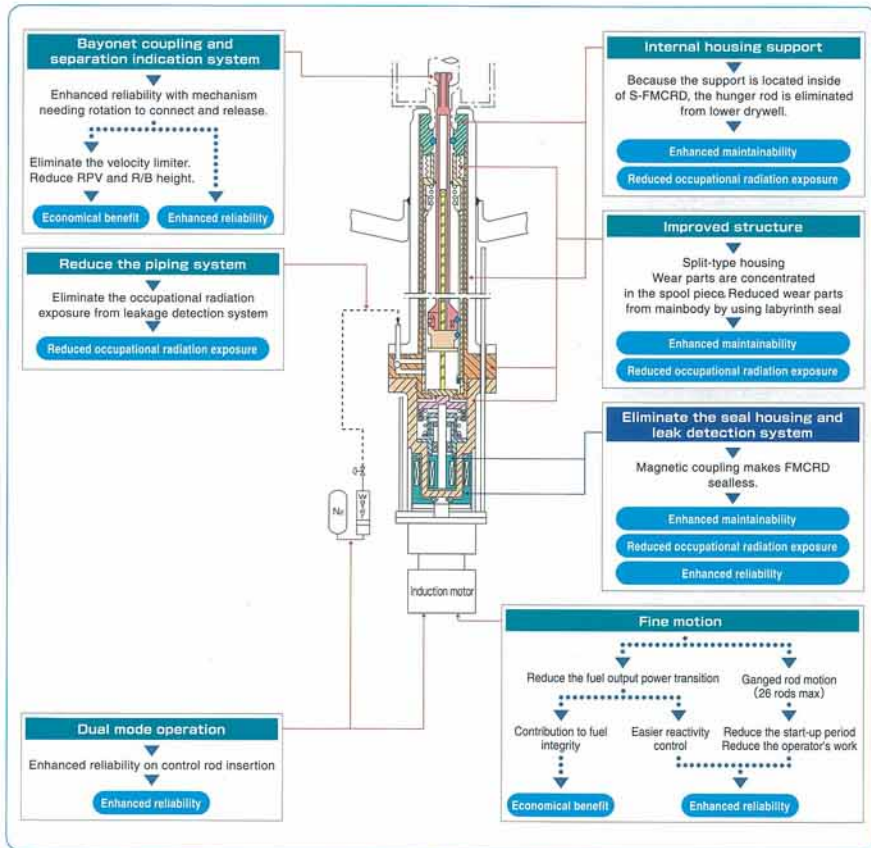


S-FMCRD supplies enhanced reliability and enhanced maintainability

There always exists requirements in reliability and maintainability with the increase of the commercial plants and the increase of electrical power per one unit. Control rod drive, which is connected with the control rod, controls the reactivity, and that is the one of the important device in consideration of plant safety. The Sealless Fine Motion Control Rod Drive (S-FMCRD) provides fine rod motion by the electric motor for the normal operation and hydraulic pressure for scram insertion, and this redundancy of power supply is the same feature of conventional FMCRD. Additionally, S-FMCRD has the excellent performance with the magnetic coupling. S-FMCRD supplies enhanced reliability, maintainability and economical benefit.



■ The common features of S-FMCRD and conventional FMCRD ■ The features of S-FMCRD

Sealless Type Sealless Type Sealless Type

Features and benefits

1. Enhanced reliability

- S-FMCRD equips high reliability in control rod insertion with using hydraulic pressure for scram insertion and electric fine rod motion by the electric motor for the normal operation and scram follow-up.
- To connect or to release the control rod, the bayonet coupling needs S-FMCRD to be rotated after removing mounting bolts for installation S-FMCRD to CRD housing.
- Enhanced reliability and enhanced maintainability are accomplished by eliminating the seal shaft penetration.

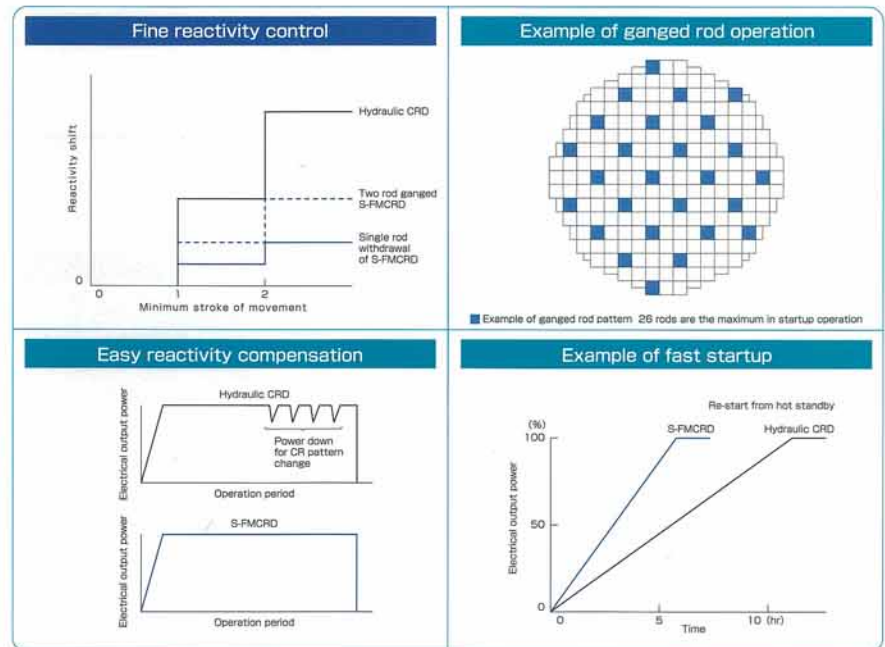
2. Enhanced operability

- Both automatic operation and ganged rod motion, 26 S-FMCRDs at maximum, shorten the startup time and reduce the operators work.
- The fine motion (36.6mm/step) by the induction motor provides fine reactivity control ability, and this ability provides enhanced operability and fine load following performance.

3. Enhanced maintainability and reduced occupational radiation exposure

- The no contact type labyrinth seal eliminates the wear parts from S-FMCRD main body of upper part. The split type housing that is designed to make maintenance parts gather in spool piece provides reduced occupational radiation exposure and easy maintenance.
- The support function is located inside of the S-FMCRD. This design eliminates the hunger rod, and provides improved maintainability in lower drywell. So it makes occupational radiation exposure be reduced.
- Both scram discharge system and leakage detection system are eliminated. These make occupational radiation exposure reduction through reduction of maintenance work.

- The features of S-FMCRD

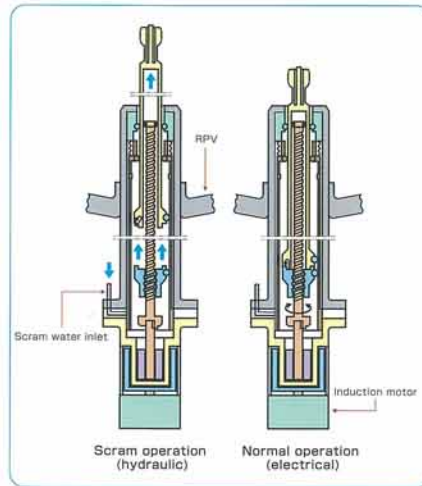


High performance and proven durability provide enhanced reliability

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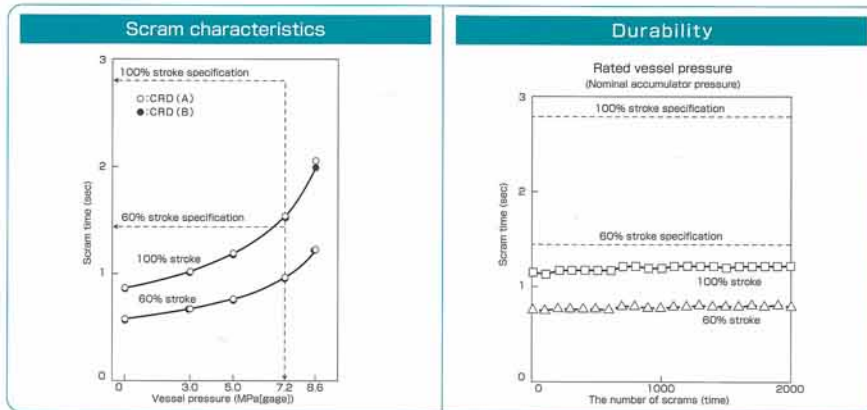
Specifications

Step moving width	36.6mm
Continuous moving speed	28±5mm/sec
Scram time	within 1.44 sec @60% stroke (rated reactor power) within 2.80 sec @100% stroke (rated reactor power)
Full stroke	3660mm
Position detection in scram operation	60% and 100% (continuous full-in detection) (by magnetic switch)
Position detection in motor operation	0-100% (sequential detection)
Type	Split type housing (magnetic coupling in spool piece)
Motor	Three-phase induction motor



Scram characteristic

The S-FMCRD system has enough capability to complete the fuel stroke scram by accumulator function only. The scram time dispersion is small during 2,000 scram cycles, which are the number more than expected to occur throughout the plant service life. And there is enough reliability, because all assemblies have retained good condition in the inspections after life cycle tests.

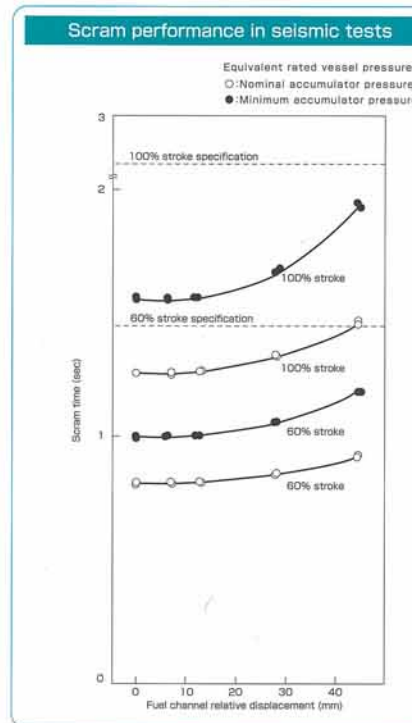


Motor driven characteristic

There are the step mode movement and the continuous movement in normal operation by the motor. The motor driven characteristic is stable and very accurate positioning throughout the life cycle test.

Scram performance in seismic tests

The influence on scram performance in design base seismic event is small enough to keep the scram well under the specification time. S-FMCRD had kept good performance during seismic tests, and all assemblies appeared good condition in the inspections after the tests.



Large multi-axial vibration test rig

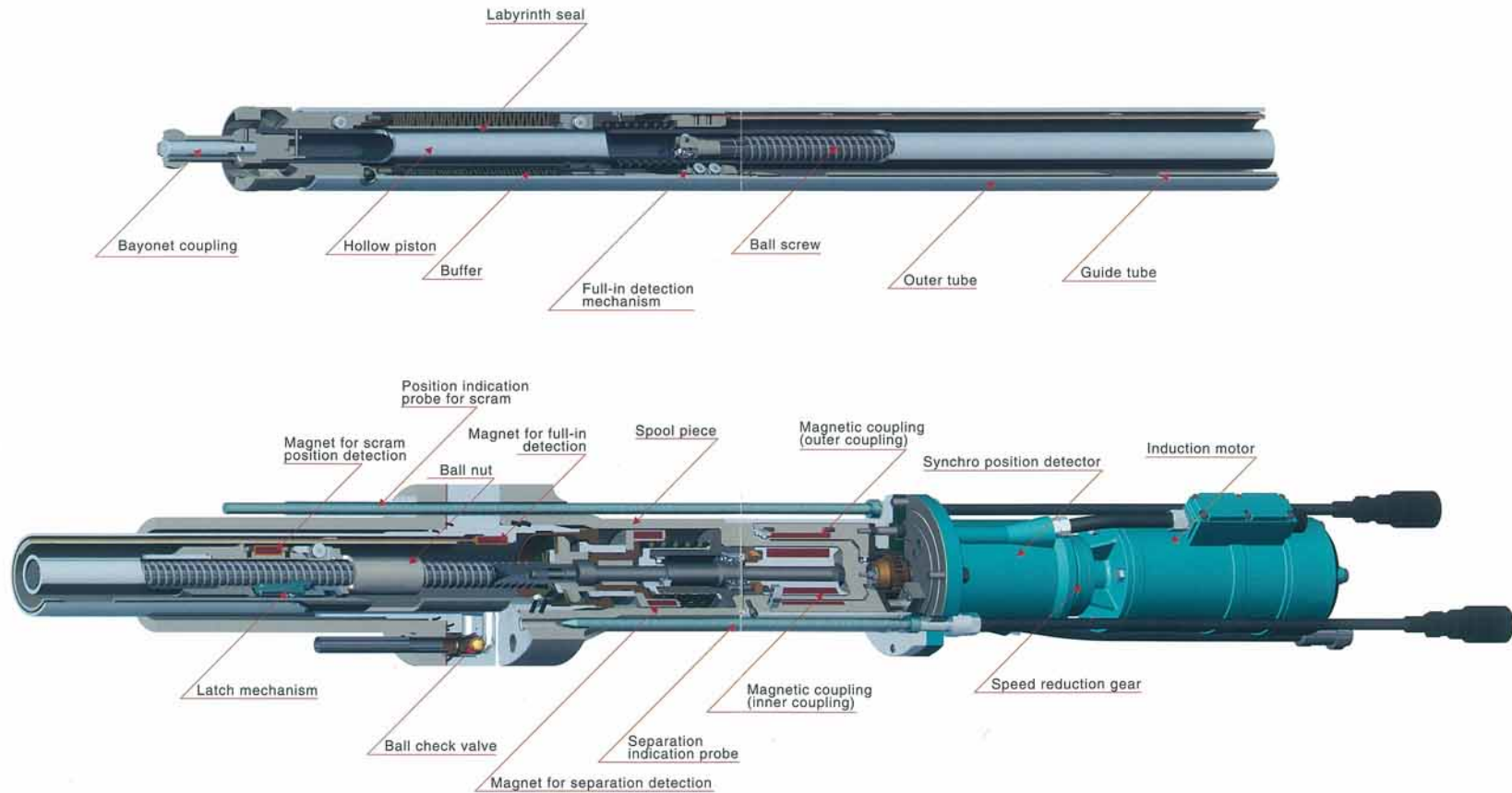


The design accomplished high reliability and easy maintenance

Sealless Type
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S-FMCRD configuration

TOSHIBA SEALLESS FINE MOTION CONTROL ROD DRIVE

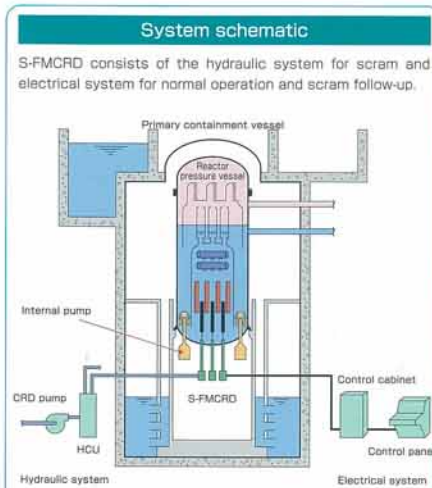


Simplified hydraulic system and the newest electrical system for reliability and operability

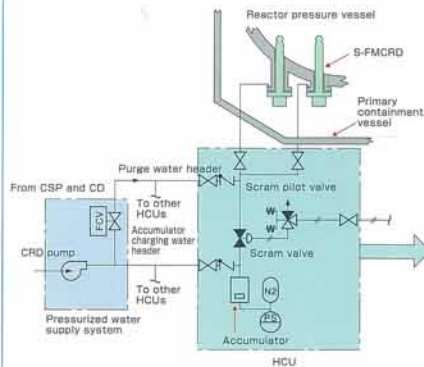
Control rod drive water system

Control rod drive water system includes high pressure pumps, valves, pipes, hydraulic control units (HCU) and so on. The water charged at high pressure in HCU rush into S-FMCRD in case of scram.

- The hydraulic system including HCU is simplified by motor driven function of FMCRD
- Because scram water is brought into reactor pressure vessel (RPV), scram discharge system is eliminated and consequently occupational radiation exposure is reduced.
- One HCU can move two S-FMCRDs together in scram.



CRD hydraulic system diagram



HCU



Scram pilot valve

- Basic configuration is similar to the proven conventional HCU for the locking piston CRD.
- Enhanced reliability is achieved by the selected materials (Teflon for diaphragm, Rulon for seat).

Scram valve

- Basic mechanism and characteristic are similar to conventional HCU for the locking piston CRD.
- Two out-ports are used to simplify HCU.

Accumulator

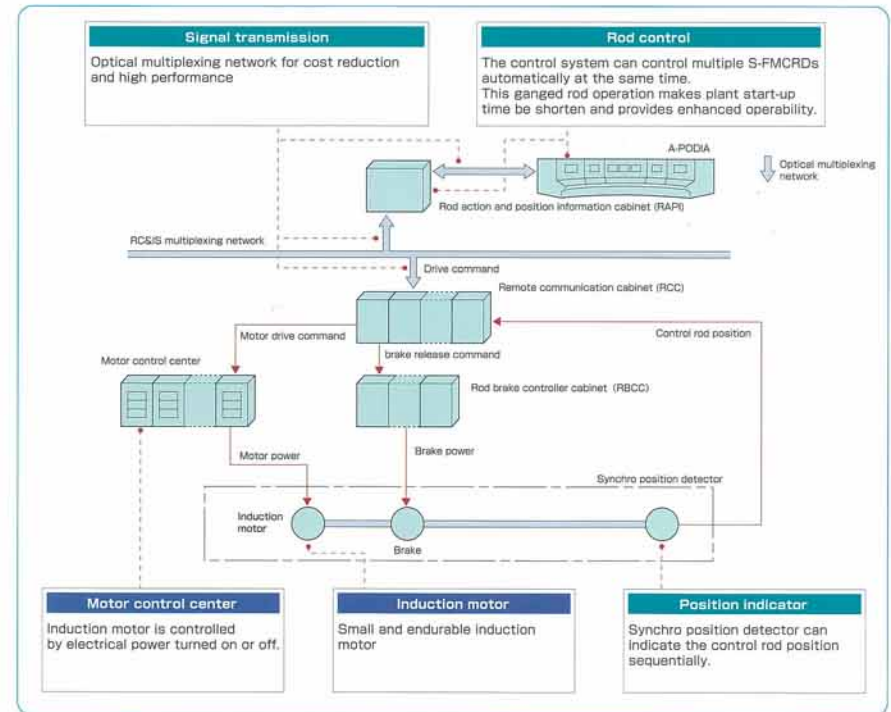
- Basic configuration is similar to conventional HCU for the locking piston CRD.

Sealless Type Sealless Type Sealless Type

Electrical system

Induction motor for normal operation and digital technology for control equipment make the control system highly reliable and economical.

Ganged rod motion, 26 S-FMCRDs at maximum, is provided. Optical multiplexing network and digital measurement/control technology provide reduction of the number of cables, and provide improved automatic operation and enhanced operation support.



Enhanced maintainability and occupational radiation exposure reduction

Maintainability

The design of S-FMCRD is considered well in maintainability. Basically, S-FMCRD upper part does not need maintenance. Because maintenance interval of spool piece and of motor unit are longer than that of locking piston CRD, the number of them in one outage is less than locking piston CRD. Additionally, automatic maintenance tools of S-FMCRD can handle them in the drywell.

Split type housing

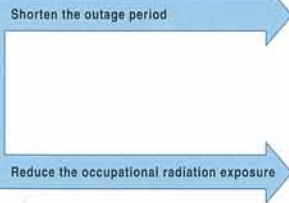
Wear parts (O-ring) are concentrated in the spool piece
—Maintenance spool piece only

S-FMCRD upper part is maintenance free
—No contact seal (labyrinth seal)
—Expansion of maintenance interval

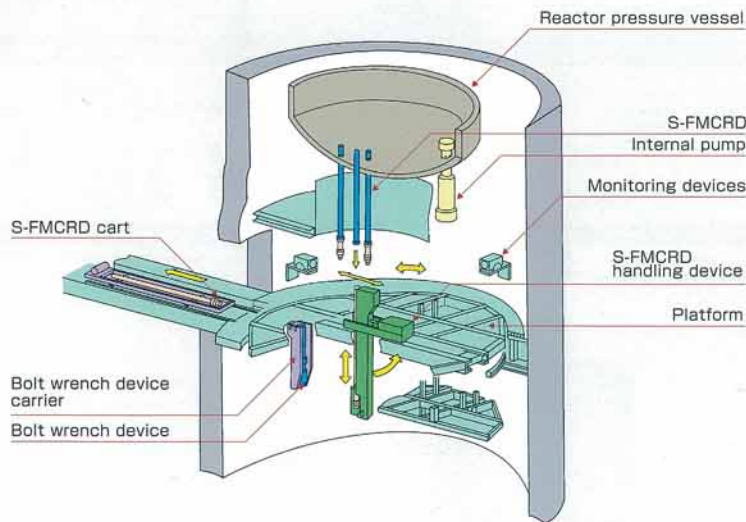
Simplify the arrangement of lower drywell

Internal housing support (eliminate the hunger rod)

Hydraulic piping and electrical cables are located in upper side



Schematic diagram of S-FMCRD handling equipment



Sealless Type

Procedure of installation and removal of S-FMCRD

(the necessary time: Toshiba measured time)

No.	1	2	3	4
S-FMCRD status				
Stage	Installed	Removal of motor unit	Removal of spool piece	Removal of upper part
The necessary time	Spool piece Motor unit	For removal : 145 min For installation : 160 min	Spool piece Motor unit Upper part	For removal : 225 min For installation : 250 min



S-FMCRD assemblies (disassembled) ▲



Magnetic coupling (inner coupling) ▲

Spool piece ▲



Installed S-FMCRD (test loop) ▲