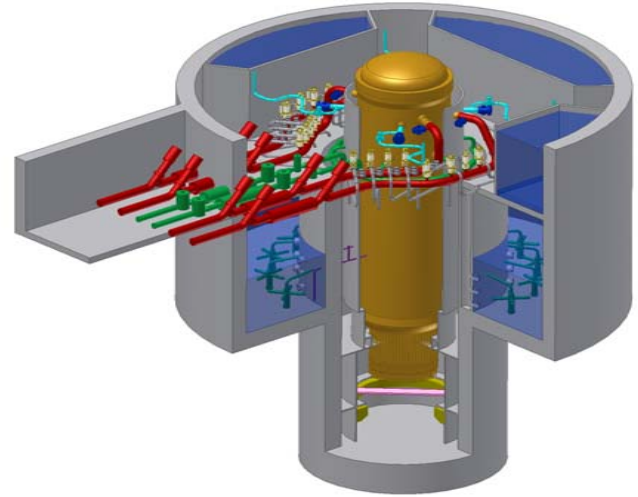


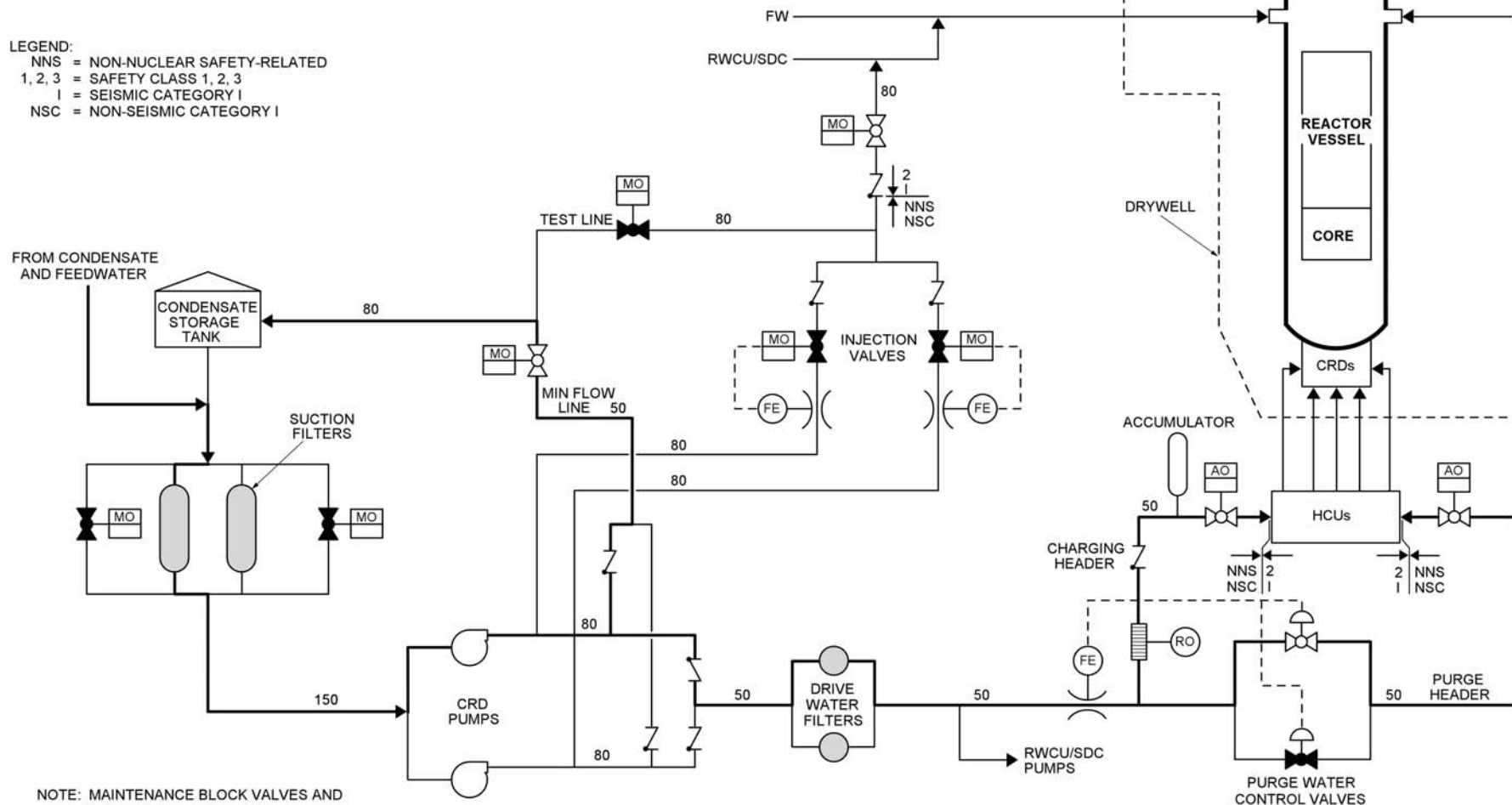
Presentation to
Nuclear Regulatory Commission

Summary
ESBWR Design Control Document, Tier 2
Chapter 4
Reactor

September 27, 2005



LEGEND:
 NNS = NON-NUCLEAR SAFETY-RELATED
 1, 2, 3 = SAFETY CLASS 1, 2, 3
 I = SEISMIC CATEGORY I
 NSC = NON-SEISMIC CATEGORY I



NOTE: MAINTENANCE BLOCK VALVES AND CERTAIN MANUAL EQUIPMENT ALIGNMENT VALVES NOT SHOWN

Control Rod Drive System

CRD Functions

Safety Related

- Provide rapid control rod insertion (scram) in response to automatic or manual signals from the RPS
- Detect separation of the control rod from the drive mechanism
- Prevent rod ejection due to drive pressure boundary or scram line failure
- Maintain reactor coolant pressure boundary integrity

CRD Functions

Non-Safety Related

- Position control rods within the core in response to signals from the RC&IS
- Supply rod status and position data to the RC&IS for rod pattern control, performance monitoring, operator display and scram time testing
- Provide automatic motor-driven insertion of control rods simultaneously with scram
- In conjunction with RC&IS, provide for selected control rod run-in (SCRRI) to mitigate the loss of feedwater heating

System Design

Description

- Major elements
 - FMCRDs
 - Hydraulic Control Units (HCUs)
 - CRD hydraulic system

System Design

System Level Performance Requirements

Scram

<u>Percent Insertion</u>	<u>Time (sec)</u>
SOM	≤ 0.20
10	≤ 0.34
40	≤ 0.80
60	≤ 1.15
100	≤ 2.23

Reactor steady-state pressure ≤ 7.48 MPaG (1085 psig) at vessel bottom

Control rod weight 83 kg maximum

CRD System Level Performance Requirements

ATWS

- Initiate on low reactor water level 2, high reactor vessel dome pressure or manual
- Start of motion of all rods ≤ 15 seconds from ARI valve energized
- All rods fully inserted within 25 seconds
- Peak reactor vessel dome pressure ≤ 10.35 MPaG (1500 psig)
- FMCRD motor-driven run-in time ≤ 130 seconds

CRD System Level Performance Requirements

Control Rod Drive Positioning

- Stroke length: 2921mm
- Step size: 36.5mm (80 steps over full stroke)
- Position accuracy: $\pm 15\text{mm}$ of target position (includes $\pm 5\text{mm}$ for position detector)
- Insert/Withdraw speed: $28 \pm 5\text{mm/sec}$

CRD System Level Performance Requirements

High Pressure Makeup

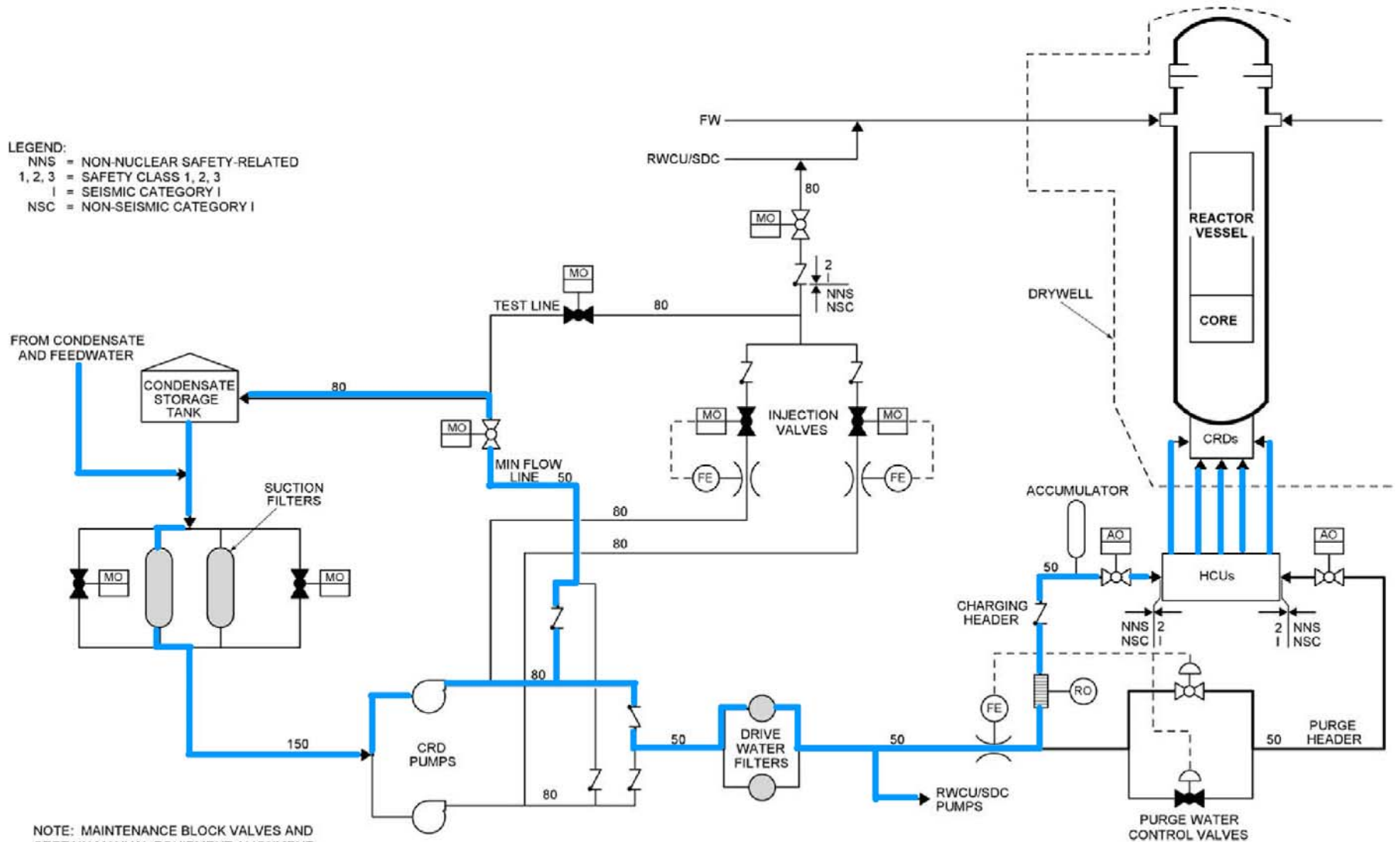
- Actuated by low reactor water level 2 signal
- Flow rate to reactor: 236 m³/hr (1046 gpm)
[118 m³/hr (523 gpm) per pump]
- 1250 psid differential pressure between reactor dome and water source
- Time delay to rated flow into RPV: 10 sec (operating pump)
25 sec (standby pump)
- Time delay for standby power: 120 sec

System Operation

Operating Modes:

- Normal Operation
 - Control Rod Insertion/Withdrawal
- Scram
- ARI
- High Pressure Makeup

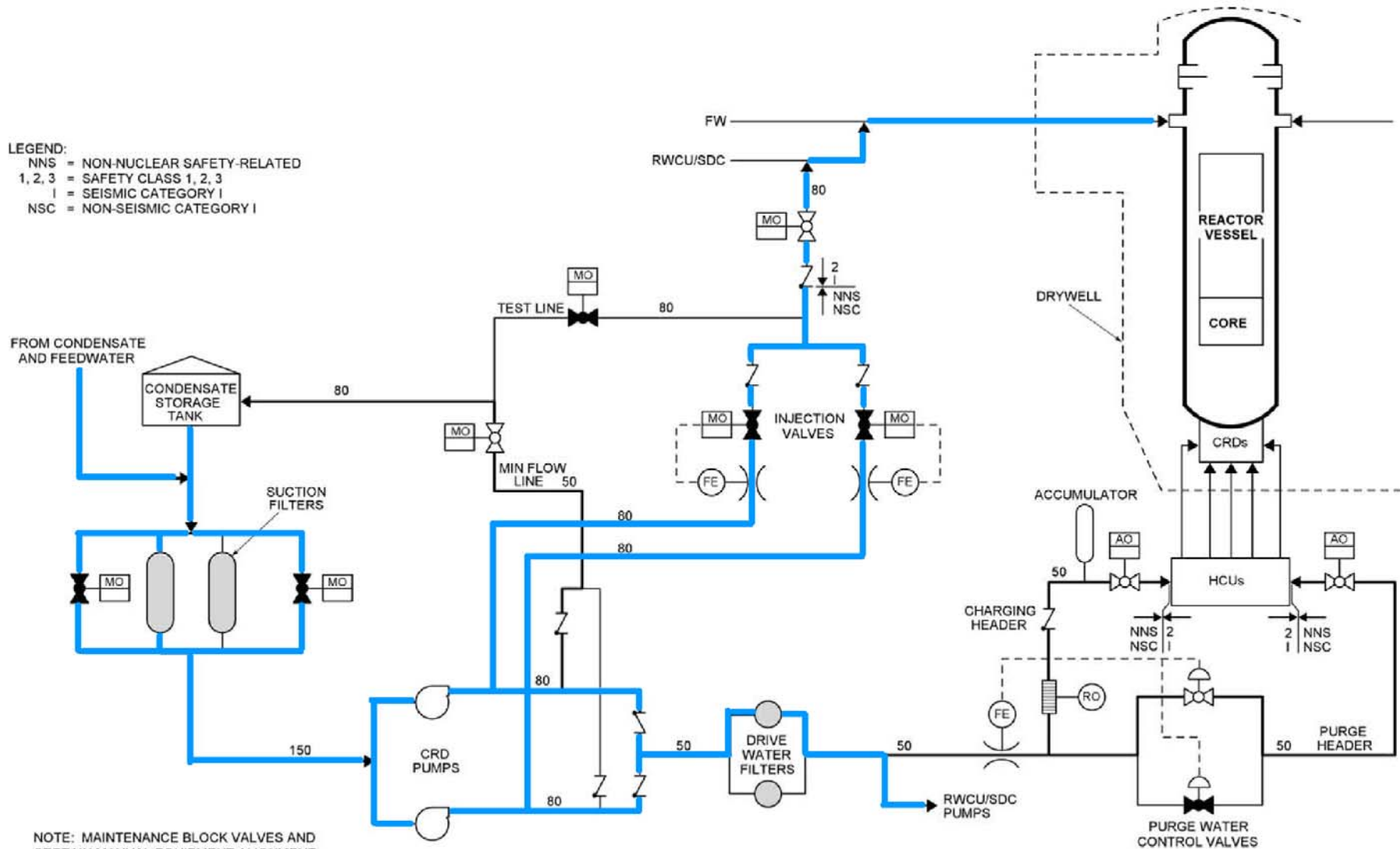
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SCRAM

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HIGH PRESSURE MAKEUP

Major Components

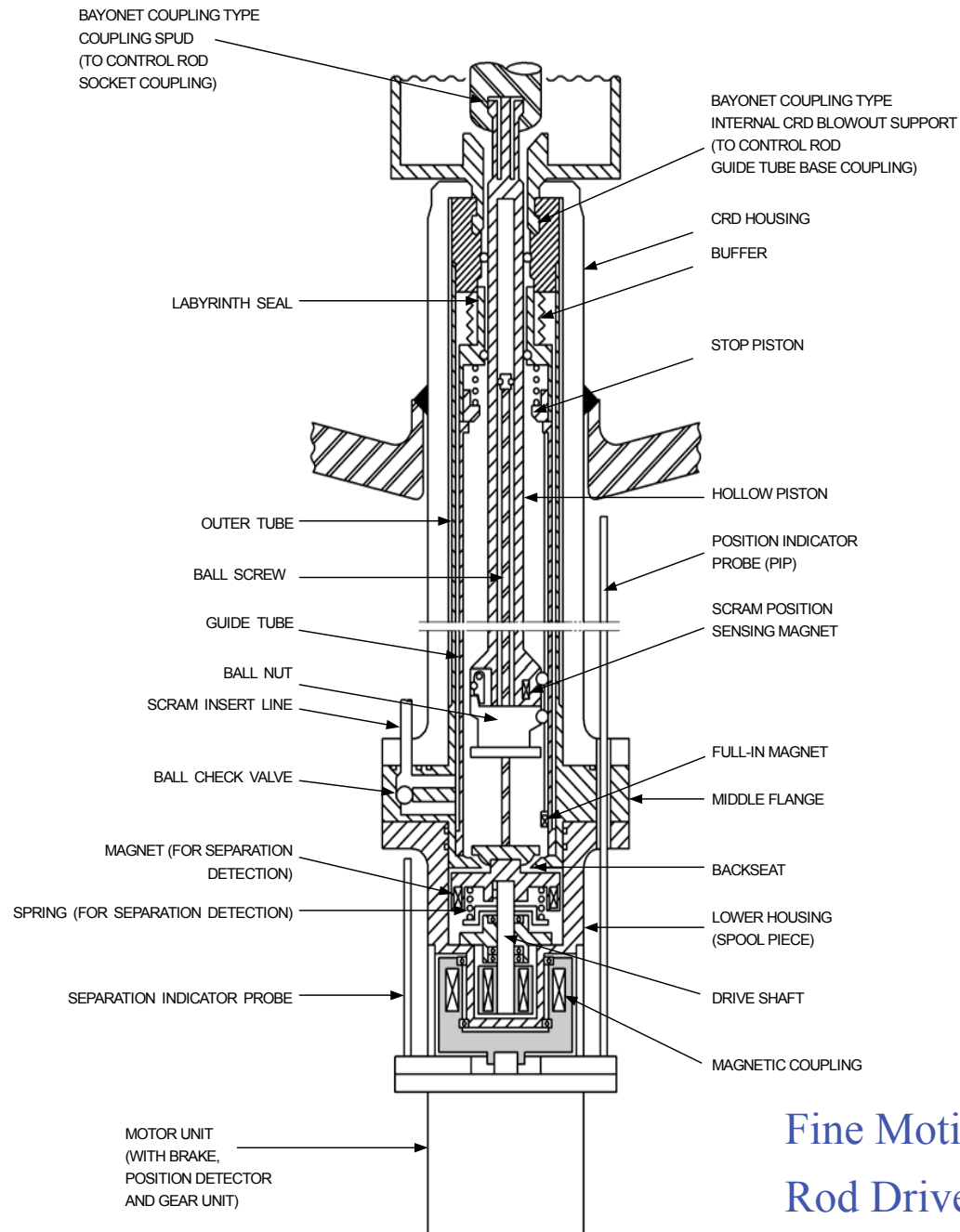
Hydraulic Control Unit (HCU)

- Same as ABWR (K-6/7 and Lungmen)
- Vertical cylindrical accumulator (66 liters)
- Vertical cylindrical nitrogen bottle (200 liters)
- Number of units: 135

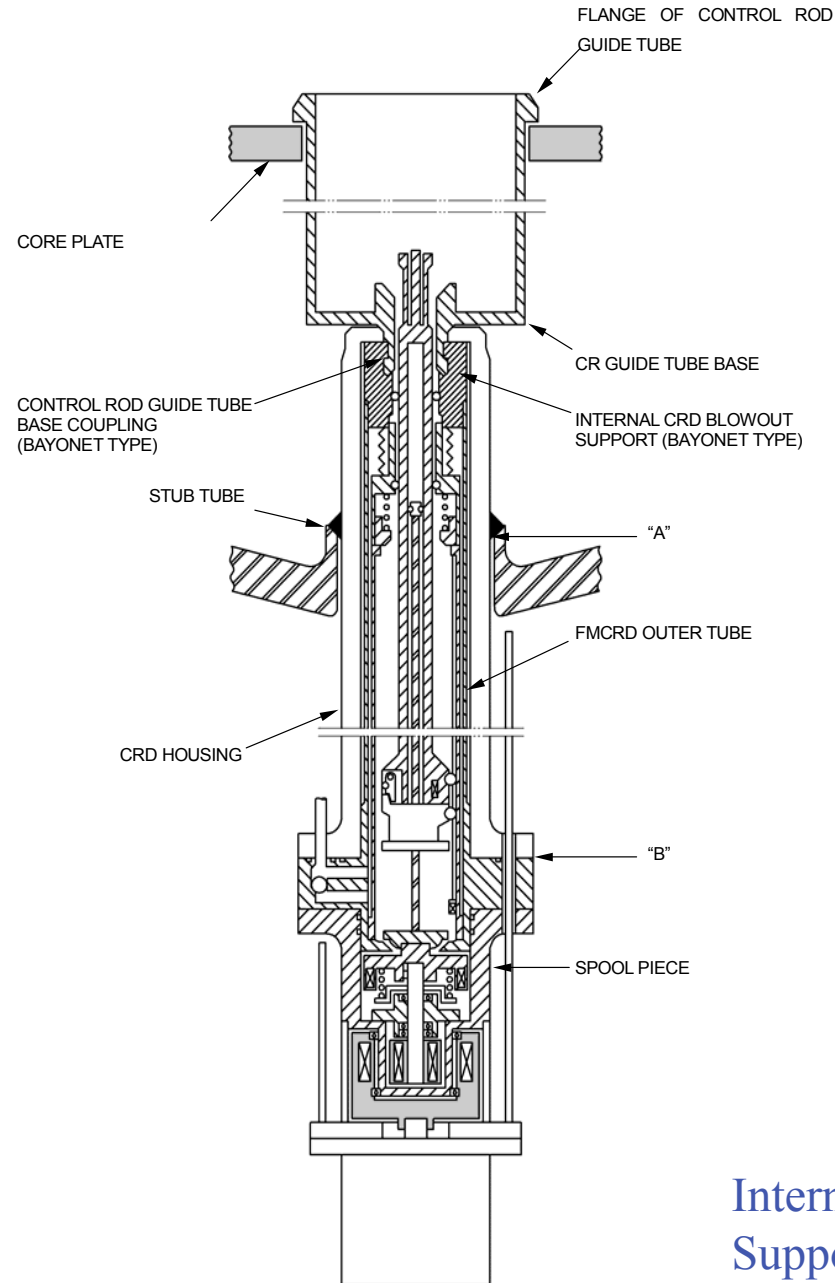
Major Components

FMCRD

- Number of Units: 269
- Electric motor-driven for normal rod positioning
- Hydraulic powered for scram
- Induction motor drive
- Sealless design
- Magnetic coupling between motor and ball screw shaft



Fine Motion Control Rod Drive Schematic



Internal CRD Blowout Support Schematic

Major Components

CRD Pump

- Normal operation flow rate: 585 l/min (155 gpm)
- High pressure makeup flow rate 1973 l/min (523 gpm)

System Design Comparison with ABWR

ESBWR

Induction motor FMCRD with
magnetic coupling (no drive shaft
seals)

Eliminated FMCRD leak detection
system

High pressure makeup (HPMU)
function

- Pump suction filter bypass lines
- Injection line to RWCU/SDC
- Full flow test return line to CST

Pump capacity based on HPMU
function (1973 l/min per pump)

ABWR

Stepping motor FMCRD (drive shaft
seal housings)

FMCRD drive shaft seal leakage
detection system provided
(network of undervessel small-
bore piping)

No high pressure makeup function

Pump capacity based on FMCRD
purge flow and HCU accumulator
sizing (507 l/min per pump)