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U.S. Nuclear Regulatory Commission
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Washington, D.C. 20852-2738

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **ESBWR Design Changes Since Design Description**

In August 2003, GE provided a general description of the Economic Simplified Boiling Water Reactor (ESBWR) design (Reference 1). As design work has continued, some of the ESBWR design features described in this report have been modified. Per your request we are providing information on changes to our design configuration since submitting our reference design. Enclosure 1 summarizes the most significant changes that have been incorporated into the ESBWR design, and other changes that are currently under consideration, since the time of the Reference 1 report.

In general the changes have been made to accommodate an increase in power and to simplify design implementation of the GDCS pools. The changes to safety-related systems have generally shifted the configuration of the design closer to the configuration and system scaling that existed in the integral system tests used for TRACG qualification.

Although we feel the design is approaching the final design configuration that will be submitted for certification, it is possible that additional changes will be required to satisfy design or performance issues that might arise in the process of detailing the design. The

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draft unverified inputs contained in Enclosure 1 are provided for information only. The final design will be defined by our certification submittal next year

If you have any questions about the information provided here, please let me know.

Sincerely,

Robert E. Gamble
Manager, ESBWR

Reference:

1. MFN 03-055, Letter from Atambir S. Rao to U.S. Nuclear Regulatory Commission, *ESBWR Design Description, NEDC-33084P – Revision 1*, August 8, 2003

Enclosure:

1. MFN 04-136 – ESBWR Design Changes Since Design Description

cc: WD Beckner USNRC (w/o enclosures)
AE Cubbage USNRC (with enclosures)
MB Fields USNRC (with enclosures)
GB Stramback - GE (with enclosures)

ENCLOSURE 1

MFN 04-136

ESBWR Design Changes Since Design Description

1. Introduction

GE provided a general description of the Economic Simplified Boiling Water Reactor (ESBWR) design in Reference 1. As design work has continued, some of the ESBWR design features described in this report have been modified. This paper summarizes the most significant changes that have been incorporated into the ESBWR design, and other changes that are currently under consideration, since the time of the Reference 1 report.

In general the changes have been made to accommodate an increase in power and to simplify design implementation of the GDCS pools. The changes to safety-related systems have generally shifted the configuration of the design closer to the configuration and system scaling that existed in the integral system tests used for TRACG qualification.

Although we feel the design is approaching the final design configuration that will be submitted for certification, it is possible that additional changes will be required to satisfy design or performance issues that might arise in the process of detailing the design. Table 1 summarizes the changes that have been implemented or are currently under consideration.

2. Design Changes

2.1 Core Power and Size

The core power for ESBWR has been increased from 4000 to 4500 MWt, with a corresponding gross electrical output of about 1550 MWe. Consistent with this increase in core power, the core size was increased from 1020 to 1132 fuel bundles.

2.2 Core Lattice Type and Control Blade Pattern

The F Lattice, as described in Section 2.2 of Reference 1, contains a triangular-pitch control rod pattern that controls twelve fuel assemblies using one large control rod and controls each corner of the array by an adjacent control rod. This arrangement will be replaced by the standard BWR square-pitch control blade pattern with one control blade that controls each four-bundle cell. For ESBWR the core lattice type is now described as an N Lattice. The total number of control rod drives increases from 121 to 269 with this lattice change and the core size increase described above in Section 2.1. All reactor internal components that were modified to accommodate the F Lattice, such as the Control Rod Guide Tube, Fuel Support, Core Plate and Top Guide will revert back to the standard BWR designs. The new core and control blade configuration is illustrated in Figure 1.

2.3 Gravity-Driven Cooling System (GDCS) Pool Airspace

The GDCS pool airspace connections have been moved from the wetwell back to the drywell. Along with this the connecting vent between the wetwell airspace and the GDCS pool airspace has been eliminated (Figure 2). This configuration is the same as the arrangement in the Simplified Boiling Water Reactor (SBWR) design, which makes the configuration the same as in the integral systems test programs – PANDA M and GIRAFFE – used for qualification of the TRACG code. Containment volumes were adjusted along with this change to ensure the resulting wetwell-to-drywell volume ratio retains most of the benefit in reduced containment pressure that was gained when this GDCS airspace volume was originally moved from the drywell to the wetwell. While the previous configuration provided additional efficiency in the containment pressure performance, it resulted in several complicating design issues. This change primarily affects Sections 1.4.2 and 4.1 of Reference 1.

2.4 Passive Containment Cooling System (PCCS) Design

The design of the PCCS has been changed to include six units at approximately 11 MW each instead of four units at approximately 15 MW each. This PCCS heat exchanger sizing is closer in configuration to the units that were tested for SBWR in the PANTHERS tests used for qualification of TRACG. This change primarily affects Section 4.2 of Reference 1.

2.5 Feedwater Line Size

The diameters of the main feedwater lines and their riser pipes have been increased to match the size of those lines in the Advanced Boiling Water Reactor (ABWR) plant. This was done because the flow velocities in these lines were larger than desired after the core thermal power was increased. The larger lines reduce the flow velocity and thereby reduce the potential for piping failures due to erosion-corrosion.

2.6 Design of Pressure Relief System

The total number of valves performing a safety function for overpressure protection has been increased from twelve (12) to eighteen (18). Of these eighteen valves, only ten will be part of the Automatic Depressurization System (ADS) function of the Nuclear Boiler System, whereas previously all twelve valves were part of the ADS function. The remaining eight valves will function only as safety valves for overpressure protection. This change primarily affects Sections 3.1.4 and 3.1.5 of Reference 1.

These eight safety valves will be divided into two groups of four, with each group being combined into a common header that has only one discharge line to the suppression pool. The ten ADS valves will all still have their own individual discharge lines to the suppression pool. This arrangement ensures that any leakage flow, or discharge from an inadvertently opened valve, will be directed to the suppression pool. In the event that more than one safety valve connected to the common header should open (which is only anticipated to occur during an ATWS event), a rupture disc will burst and the excess steam will be directed into the drywell. This steam then enters the suppression pool through the horizontal containment vents just as it would during a steamline break event or for a DPV actuation.

2.7 Containment Vents

The number of containment vent modules has been increased from ten (10) to twelve (12) sets of three horizontal vents. This change primarily affects Section 5.1.11 of Reference 1.

2.8 Isolation Condenser Capacity

The capacity of the four Isolation Condenser (IC) units is being increased to ensure that safety valves will not lift during anticipated operational occurrences (AOOs). The final capacity has not yet been established, but it is anticipated that the capacity of each unit will need to be increased by between 10 and 25%. The number of tubes in the final design of the IC units will be higher than the tested design by the same percentage. This is a smaller extrapolation than was done for the PCCS heat exchangers in the reference design used for TRACG qualification.

2.9 Feedwater and Condensate System

The feedwater and condensate pumps are the main loads that establish the size of the electrical power buses for normal operation. The feedwater runout flow capacity is being optimized to minimize electrical load requirements for the pumps. Studies are still underway to find an optimum runout flow capacity that meets design requirements for scram avoidance on the trip of one feedwater pump. It is anticipated that the optimized requirement for maximum feedwater runout flow will be similar to the value of 135% that is currently shown in Section 9.2 of Reference 1 (i.e., three pumps with each at 45% of rated). However, it also appears that a time delay of about 30 sec will also be needed on the low reactor water level L2 trip in order to provide the feedwater system with sufficient time to prevent unnecessary reactor isolations.

Separately GE is looking at further optimizations of the turbine plant cycle that would improve the generator output.

2.10 Turbine Bypass Capacity

At present the turbine bypass capacity for the ESBWR Reference Plant is specified as 33% of rated steam flow. As a minimum, GE intends to include a design option that would allow the turbine bypass capacity to be increased to 110% of rated steam flow to allow the ESBWR to avoid a scram for load rejection and turbine trip events. GE is currently considering whether or not to make 110% turbine bypass capacity the standard ESBWR design for US applications, but has not yet reached a final decision. This change would affect Section 9.1.6 of Reference 1 if implemented.

2.11 Spent Fuel Pool Size

The size of the spent fuel pool is being increased to accommodate ten years of spent fuel plus a full core offload. The size of the fuel building is being increased to make space for this additional fuel storage. This change primarily affects the arrangement drawings in Appendix B of Reference 1.

2.12 Fuel and Auxiliary Pools Cooling System (FAPCS) Design

The capacity of the FAPCS is being increased to accommodate the additional heat load from increasing the size of the spent fuel pool. Consideration is also being given to breaking the FAPCS into separate subsystems – one subsystem for servicing the pools located in the reactor building and another subsystem for servicing the pools located in the fuel buildings. These changes primarily affect Section 3.6 of Reference 1.

2.13 PCCS Drainage

The PCCS drain tanks, check valves, block valves, squib valves, instrumentation and dedicated RPV nozzles have been eliminated. These features had been added to ESBWR when the GDCS pools were connected to the wetwell airspace. Now that the GDCS pools are being connected to the drywell airspace, PCCS condensation will be drained directly to the GDCS pools and return to the RPV through the GDCS injection lines as was done for the SBWR. This makes the configuration the same as in the integral system tests that were used for qualification of the TRACG code. These changes primarily affect Section 4.2 of Reference 1.

2.14 Plot Plan and Building Arrangements

The overall plot plan and arrangements of equipment within the nuclear island buildings are being optimized. The control building arrangement is being optimized for a passive plant design. We are considering several wide ranging options (e.g. square or round reactor buildings). It is not expected that these variations will impact the configuration inside the containment.

2.15 Primary Coolant Heating for RPV Hydrostatic Testing and Initial Reactor Startup

Section 3.5 of Reference 1 indicates that electric heaters in the Reactor Water Cleanup/Shutdown Cooling (RWCU/SDC) System will be used for primary coolant heating for RPV hydrostatic testing and initial reactor startup when decay heat is not available. An alternate method for performing this heatup by using the auxiliary boiler system and feedwater pump heat is being explored that could lead to elimination of the heaters in the RWCU/SDC System.

3. Reference

1. NEDC-33084P, *ESBWR Design Description*, Revision 1, August 2003.

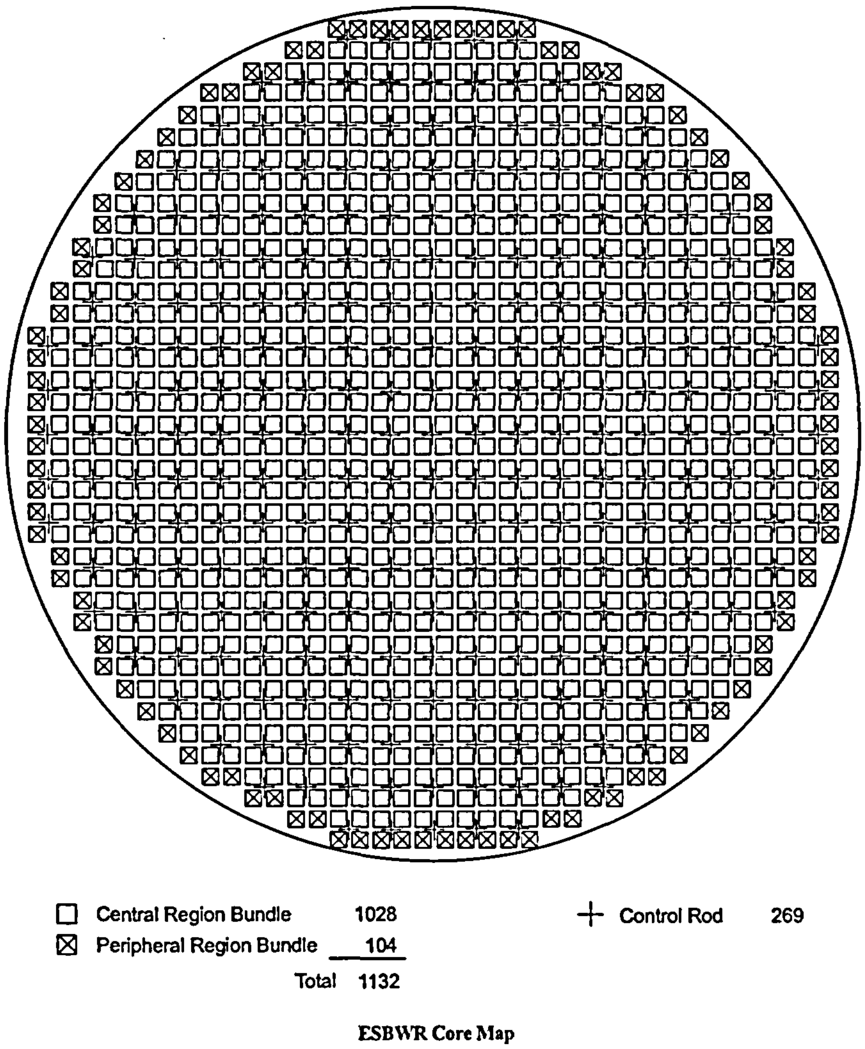

Figure 1. ESBWR Core Schematic

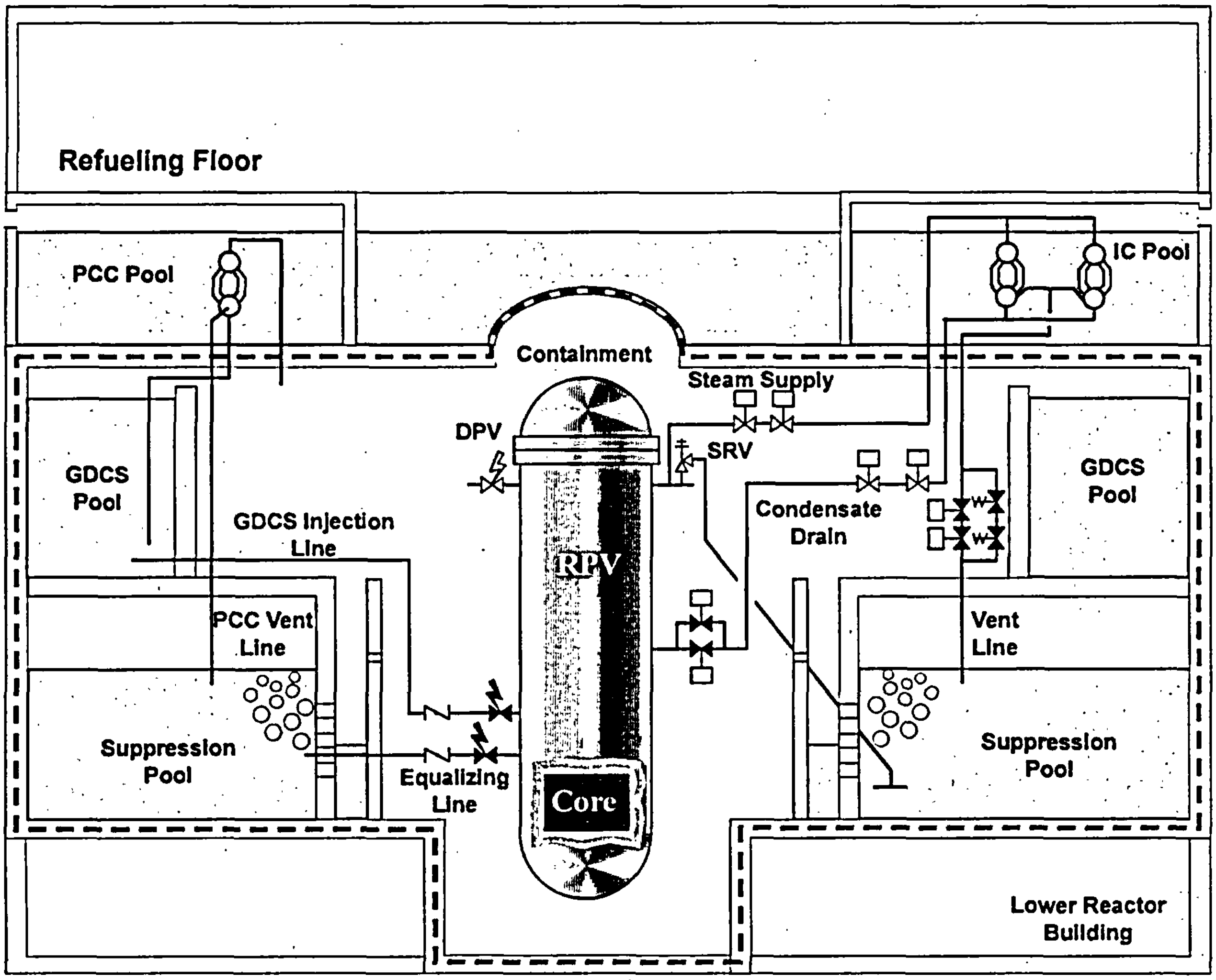

Figure 2. ESBWR Safety System Configuration (not to scale)

Table 1. Summary of ESBWR Design Changes

Item	Description of change
1	Core power increase to 4500 MWt
2	Core size increase to 1132 fuel bundles
3	Change from F Lattice to N Lattice, with corresponding changes to control blades and other core internals components
4	Connection of GDCS airspace to drywell
5	Increased number of PCCS heat exchangers
6	Feedwater line size increase
7	Pressure relief system changes
8	Increased number of containment vents
9	Increased capacity of isolation condenser units
10	Feedwater flow runout capacity
11	Time delay for low water level setpoint L2
12	Turbine plant optimizations to improve generator output are being explored
13	Increase turbine bypass capacity to 110% for reference plant
14	Increase capacity of spent fuel pool
15	Increase FAPCS cooling capacity
16	Eliminate PCCS drainage hardware by rerouting discharge flow to GDCS pools
17	Plot plan and building arrangement optimizations
18	An alternate method is being explored for primary coolant heating for RPV hydrostatic testing and initial reactor startup when decay heat is not available