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Westinghouse AP1000 Advanced Passive Plant

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Abstract – *The AP1000 is a two-loop, 1000 MWe pressurized water reactor (PWR) with passive safety features and extensive plant simplifications that enhance the construction, operation, maintenance and safety. The AP1000 design is derived directly from the AP600, a two-loop, 600 MWe PWR. The AP600 uses proven technology, which builds on the more than 30 years of operating PWR experience. The Westinghouse AP1000 Program is aimed at implementing the AP1000 plant to provide a further major improvement in plant economics while maintaining the passive safety advantages established by the AP600. An objective is to retain to the maximum extent possible the plant design of the AP600 so as to retain the licensing basis, cost estimate, construction schedule, modularization scheme, and the detailed design from the AP600 First Of a Kind Engineering program.*

Westinghouse and the US Nuclear Regulatory Commission staff have embarked on a program to complete Design Certification for the AP1000 by 2004. A pre-certification review phase was completed in March 2002 and was successful in establishing the applicability of the AP600 test program and AP600 safety analysis codes to the AP1000 Design Certification. On March 28, 2002, Westinghouse submitted to US NRC the AP1000 Design Control Document and Probabilistic Risk Assessment, thereby initiating the formal design certification review process. The results presented in these documents verify the safety performance of the AP1000 and conformance with US NRC licensing requirements.

Plans are being developed for implementation of a series of AP1000 plants in the US. Key factors in this planning are the economics of AP1000 in the de-regulated US electricity market, and the associated business model for licensing, constructing and operating these new plants.

I. INTRODUCTION

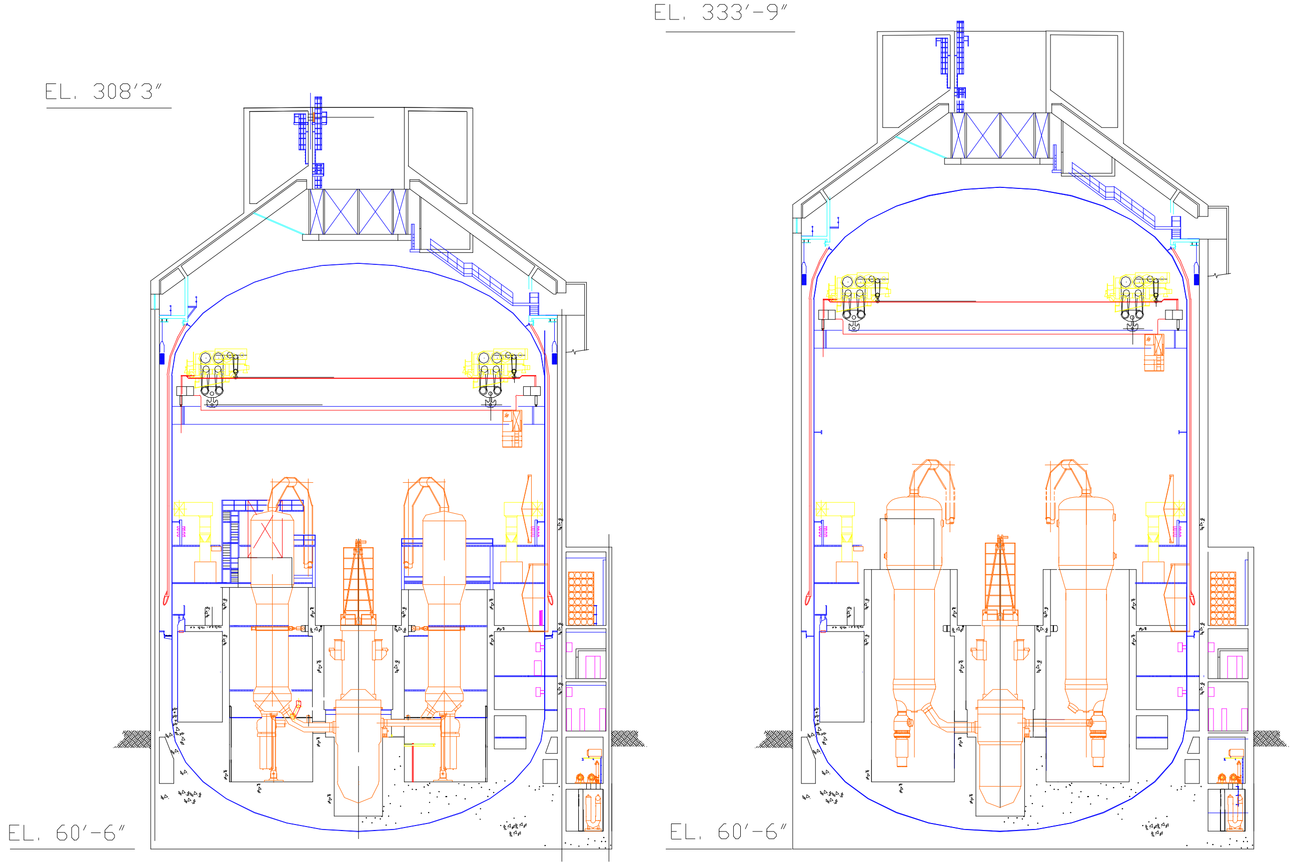
In December 1999, the Nuclear Regulatory Commission granted Design Certification to the AP600. It is the only nuclear reactor design using passive safety technology licensed in the West or in Asia.

The AP600 plant meets the U.S. utility requirements (Reference 3) including the cost goals. Westinghouse recognized that the current estimate of 4.1 to 4.6¢/kWh for the AP600 is not competitive in the U.S. market. It, therefore, embarked on the development of the AP1000, which applies economies of scale to passive safety plants to reduce the cost per kWh to about 3.0 to 3.5¢.kWh.

Simplicity was a key technical concept behind the AP600. It makes the AP600 easier and less expensive to build, operate, and maintain. Simplification helps reduce capital costs and provides a hedge against regulatory-driven operations and maintenance costs by eliminating equipment subject to regulation. There are 60 percent fewer valves, 75 percent less piping, 80 percent less control cable, 35 percent fewer pumps, and 50 percent less seismic building volume than in a conventional reactor. The AP600's greatly simplified design complies with all of the NRC regulatory and safety requirements and EPRI Advanced Light Water Reactor (ALWR) Utility Requirements Document. With the AP600 design certified by the NRC as a starting point, a minimum number of changes have been made to realize a significant increase in power in AP1000. The AP1000 plant footprint and auxiliary systems remain unchanged from AP600. Figures 1 and 2 provide section and plan view comparison of nuclear island configurations. The AP1000 design continues to use proven components, and the inherent safety and simplicity of the AP600 has been retained

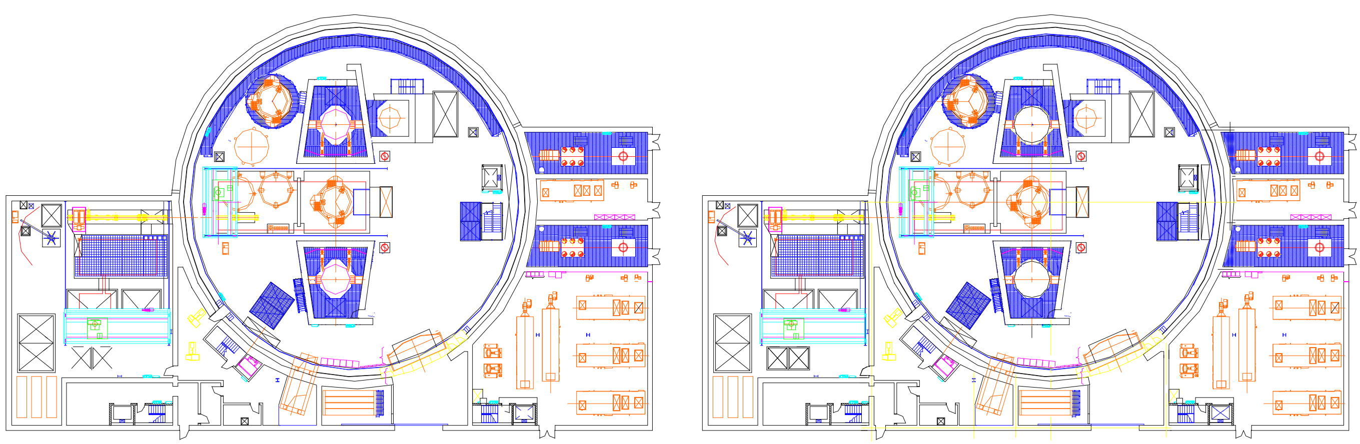
II. MAJOR EQUIPMENT DESCRIPTION

AP600 and AP1000 are based on tested and proven technology. The reactor coolant system (RCS) consists of two heat transfer circuits, with each circuit containing one



AP600 **AP1000**

Figure 1 – Westinghouse AP600 and AP1000 Plants (Section)



AP600 **AP1000**

Figure 2 – Westinghouse AP600 and AP1000 Plants (Plan)

steam generator, two reactor coolant pumps, and a single hot leg and two cold legs for circulating coolant between the reactor and the steam generators. The system also includes a pressurizer, interconnecting piping, and the valves and instrumentation necessary for operational control and the actuation of safeguards. The RCS arrangement is shown in Figure 3 and selected plant parameters are shown in Table 1.

NSSS equipment is located in the reactor containment. All safety-related equipment is located in containment or in the auxiliary building. These two buildings are on a common, seismically qualified basemat, greatly reducing the plant's seismic footprint. All major components of both AP600 and AP1000 have been proven in operating reactors under similar flow, temperature, and pressure conditions, except for the AP1000 reactor coolant pump. It is a modest extension of proven pump designs.

III.A. Reactor Design

Although different from each other, the core, reactor vessel, and internals of both the AP600 and AP1000 are essentially those of conventional Westinghouse PWRs. For both, the reactor vessel is the same as that for a standard Westinghouse three-loop plant, with nozzles adjusted to accommodate the AP600/AP1000's two loops. The internals are also standard, with minor modifications.

Several important enhancements, all based on existing technology, have been used to improve the performance characteristics of the design. For example, there are fuel performance improvements, such as Zircaloy grids, removable top nozzles, and longer burnup features. This optimized fuel is currently used in approximately 120 operating plants worldwide. Both plants use a standard 17 x 17 fuel assembly. AP600 has a 145 assembly low power density core, while AP1000 has a 157 assembly higher power density core. Compared to the AP600 12 foot long core, AP1000 has a 4.27 meter (14 foot) core. This makes the AP1000 core very similar to that in Doel 3 and Tihange 4. Both AP600 and AP1000 have more than 15 percent margin to the departure from nucleate boiling (DNB) limit for non loss-of-flow accidents.

A core shroud similar to Waterford 3 is employed. In addition, movable bottom mounted incore instrumentation has been replaced by fixed top mounted instrumentation. Inconel 600 is not used in the reactor vessel welds.

III.B. Steam Generators

Two model Delta-75 steam generators are used in AP600. Two model Delta-125 steam generators are used in AP1000. Although larger, they can still be used within the AP600 containment diameter of 39.6 meter (130 feet). Both steam generator models are based on standard Westinghouse Model-F technology. There are some 75 Model F-type units in commercial operation, with the highest level of reliability achieved by any steam generator worldwide. This reliability record is due to such enhancements as full-depth hydraulic expansion of the tubes in the tubesheets; stainless steel broached tube support plates; thermally treated, corrosion-resistant Inconel 690 (1-690) tubing; upgraded antivibration bars to reduce wear; upgraded primary and secondary moisture separators; and a triangular tube pitch. Two steam generators that are very similar to the Delta-125 model were recently installed at the Arkansas station in the US.

III.C. Reactor Coolant Pumps

Both plants use canned motor pumps to circulate primary reactor coolant throughout the reactor core, piping, and steam generators. Two pumps are mounted directly in the channel head of each steam generator.

The AP1000 reactor coolant pump motors are rated on the less dense hot water at operating temperature in lieu of the more dense ambient temperature water for the AP600. This provides the required increase in reactor coolant flow with only a small increase in the physical size of the canned motor. A variable speed controller is used in AP1000 for cold operation to compensate for the higher water density. At power the variable speed controller is disconnected and the pumps operate at constant speed, like AP600.

Elimination of the pump shaft seals greatly simplifies the auxiliary fluid systems that support a canned motor pump, reduces required maintenance and eliminates possible accidents involving seal failures. The integration of the pump suction into the bottom of the steam generator channel head eliminates the crossover leg of coolant loop piping; reduces the loop pressure drop; simplifies the foundation and support system for the steam generator, pumps, and piping; and eliminates the potential for uncovering the core during a small LOCA.

III.D. Pressurizer

The AP600 pressurizer is essentially the Westinghouse design used in approximately 70 operating plants worldwide. The AP1000 pressurizer is larger with a volume of 59.5 cubic meters (2100 cubic feet). This is accommodated by making the pressurizer taller. Without changing its diameter there is no layout effect on structures and piping around the pressurizer, thus maintaining the validity of the AP600 design in this area. Since the AP1000 reactor vessel is only slightly longer than the AP600 vessel and the primary loop piping sizes are the same; the AP1000 pressurizer gives similar margins and operating bands as the AP600 pressurizer.

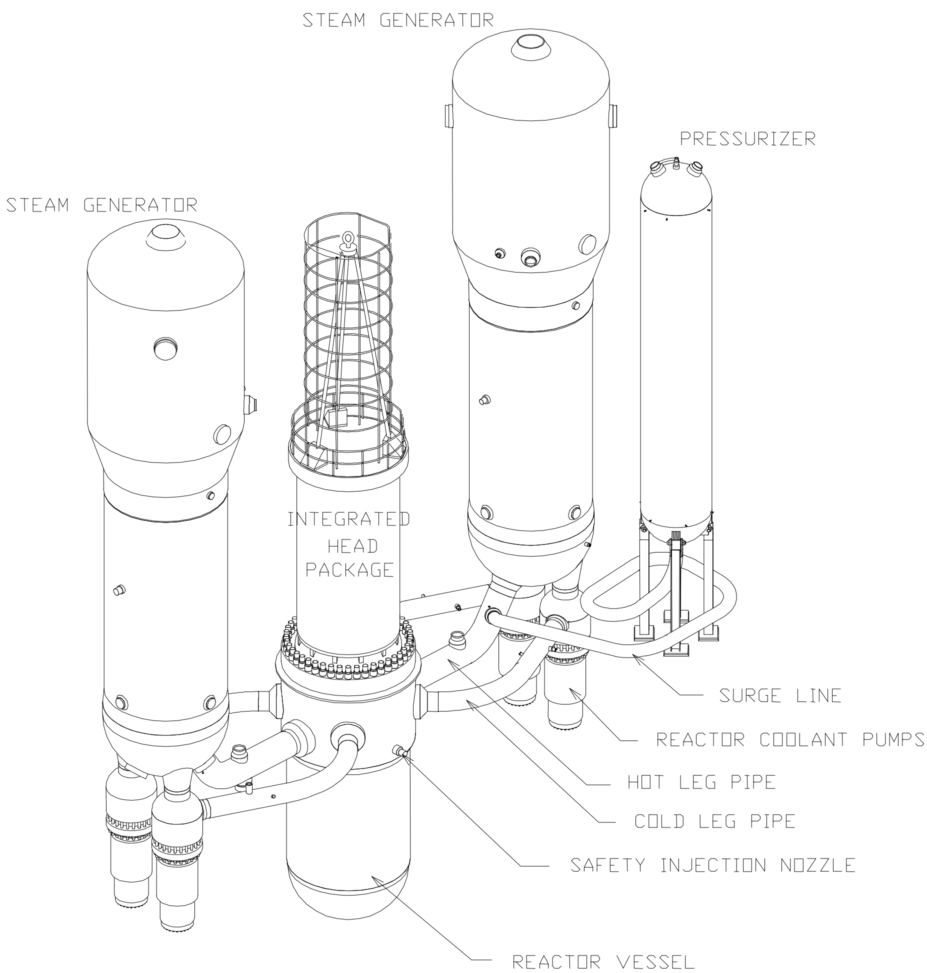


Figure 3 – AP1000 Reactor Coolant System

Parameter	Doel 4/Tihange 3	AP600	AP1000
Net Electric Output, MWe	985	610	1117
Reactor Power, MWt	2988	1933	3400
Hot Leg Temperature, ^oC (^oF)	330 (626)	316 (600)	321 (610)
Number of Fuel Assemblies	157	145	157
Type of Fuel Assembly	17x17	17x17	17x17
Active Fuel Length, m (ft)	4.3 (14)	3.7 (12)	4.3 (14)
Linear Hear Rating, kw/ft	5.02	4.1	5.71
Control Rods / Gray Rods	52 / 0	45 / 16	53 / 16
R/V I.D., cm (inch)	399 (157)	399 (157)	399 (157)
Vessel flow (Thermal) 10^3 m3/hr (10^3 gpm)	67.1 (295)	44.1 (194)	68.1 (300)
Steam Generator Surface Area, m2 (ft2)	6320 (68,000)	6970 (75,000)	11,600 (125,000)
Pressurizer Volume, m3 (ft3)	39.6 (1400)	45.3 (1600)	59.5 (2100)

Table 1 - Selected AP1000 RCS Parameters

III.E. Containment Vessel

Both plants utilize a 39.6 meter (130 feet) diameter freestanding containment vessel. AP600 utilizes three ring sections and an upper and lower head. AP1000 has an additional ring section to provide additional free volume. The AP1000 containment design pressure has been increased from 3.10 bar (45 psig) to 4.07 bar (59 psig) through the use of a slightly thicker wall thickness 4.44 cm (1 3/4 in) and a stronger steel.

The ring sections and vessel heads are constructed of steel plates pre-formed in an offsite fabrication facility and shipped to the site for assembly and installation using a large-capacity crane. The largest ring section includes the polar crane support and weighs approximately 658 metric tons (725 tons). Each of the two heads weighs approximately 500 metric tons (550 tons).

III. SAFETY THROUGH SIMPLICITY

The safety systems for both AP600 and AP1000 include passive safety injection, passive residual heat removal, and passive containment cooling. All these passive systems meet the NRC single-failure criteria and other recent criteria, including Three Mile Island lessons learned, unresolved safety issues, and generic safety issues.

Passive systems and the use of experience-based components do more than increase safety, enhance public acceptance of nuclear power, and ease licensing - they also simplify overall plant systems, equipment, and operation and maintenance. The simplification of plant systems, combined with large plant operating margins, greatly reduces the actions required by the operator in the unlikely event of an accident. Passive systems use only natural forces, such as gravity, natural circulation, and compressed gas-simple physical principles we rely on every day. There are no pumps, fans, diesels, chillers, or other rotating machinery required for the safety systems. This eliminates the need for safety-related AC power sources. A few simple valves align the passive safety systems when they are automatically actuated. In most cases, these valves are "fail safe." They require power to stay in their normal, closed position. Loss of power causes them to open into their safety alignment. In all cases, their movement is made using stored energy from springs, compressed gas or batteries.

Simple changes in the safety-related systems from AP600 to AP1000 allow accommodation of the higher plant power without sacrificing design and safety margins. Since there are no safety-related pumps, increased flow was achieved by increasing pipe size. Additional water volumes were achieved by increasing tank sizes. These increases were made while keeping the plant footprint unchanged. This ensures that the designs of other systems are not affected by layout changes. Note that detail design of a significant portion of AP600 is complete. Enforcing a rigorous "no unnecessary change policy" makes that portion of the detail design of AP1000 also complete.

IV. PASSIVE SAFTY SYSTEMS

Passive systems provide plant safety and protect capital investment. They establish and maintain core cooling and containment integrity indefinitely, with no operator or AC power support requirements. The passive systems meet the single-failure criteria and probabilistic risk assessments (PRA) used to verify reliability. The passive safety systems are significantly simpler than typical PWR safety systems. They contain significantly fewer components, reducing required tests, inspections, and maintenance. The passive safety systems have one-third the number of remote valves as typical active safety systems, and they contain no pumps. Equally important, passive safety systems do not require a radical departure in the design of the rest of the plant, core, RCS, or containment. The passive safety systems do not require the large network of active safety support systems needed in typical nuclear plants. These include AC power, HVAC, cooling water, and the associated seismic buildings to house these components.

This simplification applies to the emergency diesel generators and their network of support systems, air start, fuel storage tanks and transfer pumps, and the air intake/exhaust system. These support systems no longer must be safety class, and they are either simplified or eliminated. For example, the essential service water system and its associated safety cooling towers are replaced with a non-safety-related service water cooling system.

Non-safety-related support systems and passive safety systems are integrated into the plant design. Licensing safety criteria are satisfied with a greatly simplified plant.

The passive safety systems have been sized to provide increased safety margins, especially for more probable events. Table 2 illustrates the improved margins. Both AP600 and AP1000 have the same passive safety-related systems and they include:

IV.A. Emergency Core Cooling System

The passive core cooling system (PXS), shown in Figure 4, protects the plant against RCS leaks and ruptures of various sizes and locations. The PXS provides core residual heat removal, safety injection, and depressurization. Safety analyses (using NRC-approved codes) demonstrate the effectiveness of the PXS in protecting the core following various RCS break events. Even for breaks as severe as the 20.0-cm (8-in) vessel injection lines, there is no core uncovery for either AP600 or AP1000. Following a double-ended rupture of a main

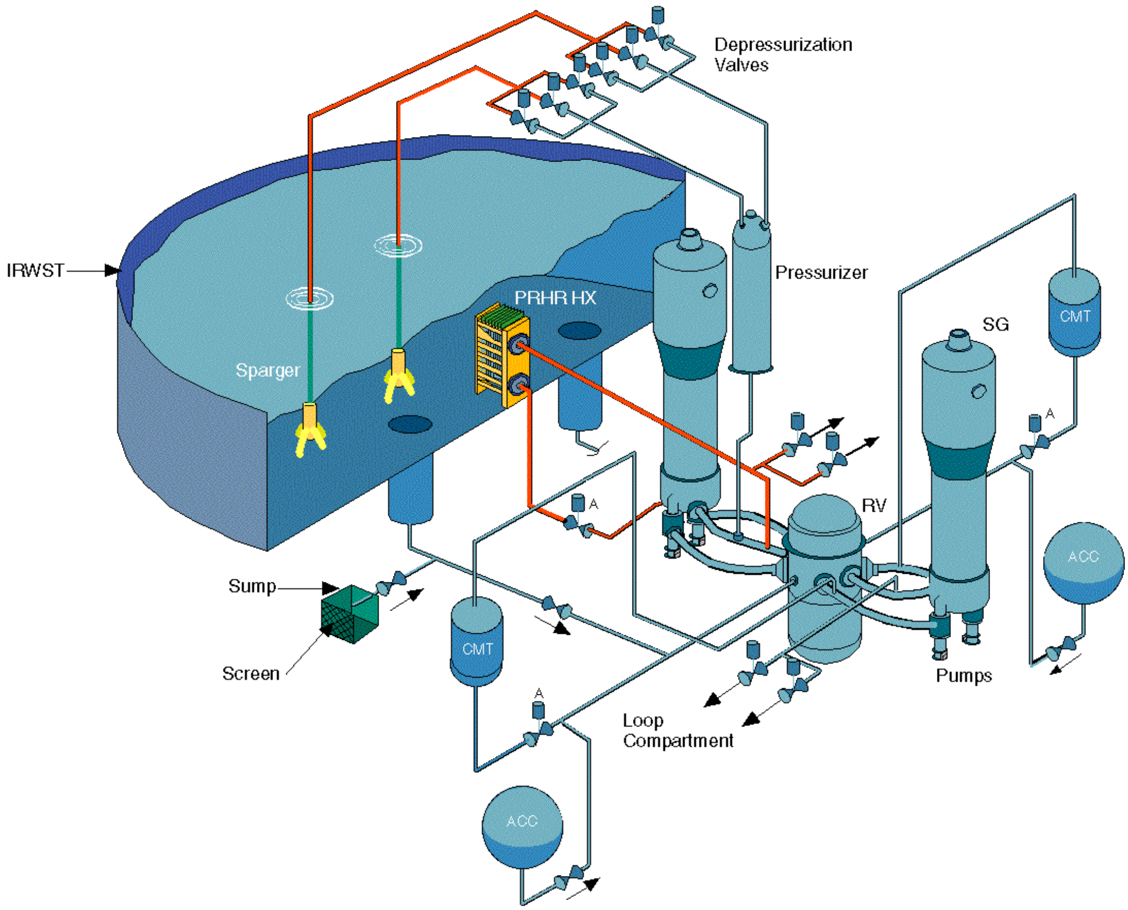


Figure 4 – AP1000 RCS and Passive Core Cooling System

	Typical Plant	AP600	AP1000
- Loss Flow Margin to DNBR Limit	~ 1 - 5%	~16%	~19%
- Feedline Break °C (°F) Subcooling Margin	>0 (>0)	~94 (~170)	~78 (~140)
- SG Tube Rupture	Operator actions required in 10 min	Operator actions **NOT** required	Operator actions **NOT** required
- Small LOCA	3" LOCA core uncovers PCT ~1500°F	< 8" LOCA **NO** core uncovery	< 8" LOCA **NO** core uncovery
- Large LOCA PCT °C (°F) with uncertainty	1093 - 1204 (2000 - 2200)	913 (1676)	1162 (2124)

Table 2 - AP1000 Safety Margins

reactor coolant pipe, the PXS cools the reactor with ample margin to the peak clad temperature limit.

IV.B. Safety Injection and Depressurization

The PXS uses three sources of water to maintain core cooling through safety injection. These injection sources include the core makeup tanks (CMTs), the accumulators, and the in-containment refueling water storage tank (IRWST). These injection sources are directly connected to two nozzles on the reactor vessel so that no injection flow can be spilled in case of larger breaks.

Long-term injection water is provided by gravity from the IRWST, which is located in the containment just above the RCS loops. Normally, the IRWST is isolated from the RCS by squib valves and check valves. This tank is designed for atmospheric pressure. The RCS must be depressurized before injection can occur. The RCS is automatically controlled to reduce pressure to about 0.83 bar (12 psig), at which point the head of water in the IRWST overcomes the low RCS pressure and the pressure loss in the injection lines. The PXS provides depressurization using the four stages of the automatic depressurization system (ADS) to permit a relatively slow, controlled RCS pressure reduction.

To maintain similar margins for accidents requiring safety injection, a few lines in the PXS were made larger for AP1000. In addition, the CMTs were enlarged to provide adequate margin without requiring redesign of adjacent piping and structure.

IV.C. Passive Residual Heat Removal

The PXS includes one passive residual heat removal heat exchanger (PRHR HX). The PRHR HX is connected through inlet ad outlet lines to RCS loop 1. The PRHR HX protects the plant against transients that upset the normal steam generator feedwater and steam systems. It satisfies the safety criteria for loss of feedwater, feedwater line breaks, and steam line breaks.

For AP1000, the PRHR HX horizontal tube portions were made slightly longer and a few tubes were added to the existing AP600 PRHR HX tube sheet. PRHR piping was made larger. These modifications resulted in a 100 percent capacity system without affecting surrounding piping and layout design.

The IRWST provides the heat sink for the PRHR HX. The IRWST water absorbs decay heat for more than one hour before the water begins to boil. Once boiling starts, steam passes to the containment. The steam condenses on the steel containment vessel and, after collection, drains by gravity back into the IRWST. The PRHR HX and the passive containment cooling system provide indefinite decay heat removal capability with no operator action required. For AP1000 the normal water level in the IRWST was raised to provide adequate water inventory without changing the structure.

IV.D. Passive Containment Cooling System

The passive containment cooling system (PCS), provides the safety-related ultimate heat sink for the plant. The PCS cools the containment following an accident so that design pressure is not exceeded and pressure is rapidly reduced. The steel containment vessel provides the heat transfer surface that removes heat from inside the containment and transfers it to the atmosphere. Heat is removed from the containment vessel by the continuous, natural circulation of air. During an accident, air cooling is supplemented by water evaporation. The water drains by gravity from a tank located on top of the containment shield building.

The containment for AP1000 has the same diameter as that for AP600. The height has been increased to provide additional free volume. This additional free volume, with a change of material for the vessel shell, provides increased margin to vessel design pressure from accident pressures over AP600.

Analysis shows that during severe accidents the AP1000 containment is likely to remain intact and to not be bypassed. As a result, the plants have a significantly reduced frequency of release of large amounts of radioactivity following core damage in an accident. The PCS cooling capability is very reliable with its 3 way redundant (and diverse) water drain valves. In addition, even with failure of water drain, air-only cooling is capable of maintaining the containment below the predicted failure pressure. Other contributing factors include improved containment isolation and reduced potential containment bypass sequences including steam generator tube ruptures (SGTR). This enhanced containment performance supports the technical basis for simplification of offsite emergency planning.

V. PROBABILISTIC RISK ASSESSMENT

PRA has been used interactively as a part of the design process since the beginning of the AP600 program in 1985. Seven major PRA quantifications have been performed on the AP600. One major quantification has been performed on the AP1000. During each of these quantifications, the PRA results were reviewed for potential modifications. Many design and operation changes have been made based on these PRA insights, especially during the earlier AP600 quantifications.

As a result, the AP1000 PRA results show very low core melt and large release frequencies, that are significantly below those of operating plants and well below the NRC safety goals. The following shows the core melt frequency (CMF) and large release frequency (LRF) per reactor year. The AP1000 frequencies include shutdown events and external events. Shutdown events have typically not been quantified for operating plants.

	Operating	NRC	AP1000
CMF	~1 E -4	1 E -4	4.2 E -7 / yr
LRF	~1 E -5	1 E -6	3.7 E -8 / yr

A major safety advantage of passive plants versus conventional PWRs is that long-term accident mitigation is maintained without operator action and without reliance on offsite or onsite AC power sources. The passive safety systems provide long-term core cooling and decay heat removal without the need for operator actions and without reliance on active safety-related systems. For limiting design basis accidents, the core coolant inventory in the containment for recirculation cooling and boration of the core is sufficient to last for at least 30 days, even if inventory is lost at the design basis containment leak rate. There is no difference between AP600 and AP1000 in this regard. PRA sensitivity studies illustrate this improvement. The following frequencies show the CMF for at-power internal events with and without operator action:

	Operating	AP1000
CMF with operator action	~4 E -5	2.4 E -7 / yr
without operation action	~2 E -3	1.8 E -5 / yr

Severe accident phenomenon have been address with AP1000 design features. The highly redundant and diverse ADS prevents high pressure core melt sequences which can challenge the containment through direct containment heating and steam explosions. Core concrete interactions are prevented by invessel retention of core melt debris. Hydrogen ignitors and passive autocatylitic recombiners prevent hydrogen explosions.

VI. COST AND CONSTRUCTION SCHEDULE

The AP600/AP1000 plant costs and construction schedules benefit directly from the great simplifications provided by the design. In addition, modular construction techniques have been adopted. Three types of modules are employed; structural, mechanical, and piping. The approach was design the plant from the beginning to maximize the use of modules. These modules are rail shippable and would be built in factories and then shipped to the plant. At the plant these modules would be assembled into larger modules in parallel construction areas and then lifted into the plant as needed. The AP600/AP1000 plants uses over 270 modules. The use of modules provides several benefits, including:

- Reduced construction schedule
- Reduced field manpower
- Increased factory work (better quality control)
- Reduction in site congestion

Westinghouse has developed an extensive, detailed 3D computer model of the AP600 nuclear reactor plant. This model was developed over eight years, using input from a number of design participants from a variety of countries. Westinghouse also led the effort by Morrison-Knudsen (now a part of the Washington Group) to develop a construction schedule using Primavera for AP600 over the same period as the 3D-model development. MK used its construction experience and a detailed knowledge of the plant to create a detailed schedule for construction of the entire plant. This schedule was “logic” driven and included activities with industry standard durations. It is based upon a 50 hour, 5 day week and resulted in a 36 month duration from start of basemat concrete pour to the beginning of fuel load.

More recently, the 3D plant model was linked to the construction schedule so that the construction of the plant could be viewed as a function of time (4D), Reference 4. These evaluations have demonstrated the benefit of reviewing these schedules with construction specialists using the visualization capabilities of a 4D-plant model. This initial evaluation of the first portion of the AP600 construction schedule showed that the 36 month construction schedule could be reduced by at least 4 months. This study also increased the confidence of potential investors concerning the viability of the schedule and the plant’s ultimate cost.

The latest technique being utilized to improve the construction schedule is the use of immersive virtual environment techniques (Reference 6). This technique provides another step improvement in the quality of the construction visulation capabilities.

The simplifications resulting from the AP600 design is estimated to be worth 20 to 30% in capital cost as compared to current evolutionary PWRs. A detailed cost buildup was developed for the AP600 based on its detailed design information and direct quotes in 1900 commodity catagories for over 25,000 specific items including components, bulk commodity and other materials, labor, indirect and owner’s costs (Reference 5). A plant availability of 93% was used in the cost calculations; with the design simplifications, margins, and lessons learned, the AP600/AP1000 plants are expected to exceed this availability since current operating plants are exceeding this value. Staffing will be reduced for the AP600/AP1000 plants due the major simplifications incorporated into their designs.

The calculated operating costs for the AP600 is estimated to be 4.1 to 4.6¢/kWh. The AP1000 with its small cost increase and large power increase, results in a cost per kWh of about 3.0 to 3.5¢.kWh for a twin unit plant.

VII. LICENSING

In June 1992, AP600 safety analysis and probabilistic risk assessment reports were submitted to the NRC. The Commission documented its acceptance of the AP600 safety systems in the Final Design Approval on September 3, 1998. This milestone provides a high certainty for the licensability of the AP600 in international markets. In December 1999, the NRC issued the Design Certification for AP600 as Appendix C of 10CFR Part 52. This makes the AP600 the only licensed passive safety system nuclear power plant in the world.

Westinghouse and the US Nuclear Regulatory Commission staff have embarked on a program to complete Design Certification for the AP1000 by 2004. A pre-certification review phase was completed in March 2002 and was successful in establishing the applicability of the AP600 test program and AP600 safety analysis codes to the AP1000 Design Certification.

On March 28, 2002, Westinghouse submitted to US NRC an application for Final Design Approval and Design Certification of the AP1000 standard plant. The application includes the AP1000 Design Control Document (Standard Safety Analysis Report and Inspections, Tests, Analysis and Acceptance Criteria (ITAAC) and Probabilistic Risk Assessment (References 1 and 2). The NRC formally docketed the application on June 25, 2002 signifying its acceptance as a complete safety case. Because of the few design changes from AP600, approximately 80 percent of the AP600 Standard Safety Analysis Report remains unchanged for AP1000.

For those areas that do change - for example, the safety analysis in Chapter 15 - Westinghouse uses the same process as for the AP600 to show that the worst-case scenarios remain within limits for the AP1000. Westinghouse does not plan to open any new policy issues by using a different licensing approach for the AP1000 from that used for the AP600.

The NRC has reviewed the DCD and PRA documents. They have issued their requests for additional information by September 30, 2002. Westinghouse provided responses to the NRC requests by December 2, 2002. The NRC is now reviewing our responses. Because of the pre-certification review and the discussions with the staff during their review and request writing, Westinghouse believes that the AP1000 Design Certification will proceed in an efficient manner.

VIII. AP1000 DEPLOYMENT

The US Department of Energy is now implementing the "Nuclear Power 2010" initiative. The goal of Nuclear Power 2010 is to support industry initiatives to eliminate barriers to the deployment of a series of advanced nuclear plants in the U.S. by the year 2010. The initiative encourages investment in projects that can improve the economic competitiveness of new nuclear power plants. The DOE is supporting a program that will effectively shorten the time between plant contract and power operation.

The required lead time for an advanced nuclear plant such as AP1000 has been estimated to be approximately 5-6 years between the plant order and its commercial operation. This includes approximately 3 to 4 years for construction, with the remaining 2 years being required for the power company to order long lead items, prepare the site and perform startup operations. The Early Site Permit (ESP) and Combined Operating License (COL) are part of the U.S. licensing process established under 10 CFR Part 52 and would be completed prior to the initiation of site activities.

Three US Power companies are currently engaged with the US NRC to complete an ESP for three sites that could accommodate an advanced nuclear plant like AP1000. The ESP licensing process is a significant milestone in the realization of new nuclear build in the US. It has been projected that the US power companies will receive ESPs by 2005 thereby allowing the completion of COL and initiation of new plant construction activities.

Demonstration of the COL licensing process is an important next step in the realization of the Nuclear Power 2010 initiative. The Westinghouse AP1000 is well-positioned to be the reference plant in COL applications. Westinghouse is now working with power companies, architect engineers, and international partners, to plan the next steps in the deployment of a series of AP1000 standard plants in the US under the Nuclear Power 2010 initiative.

IX. CONCLUSIONS

The AP600 is a simple, licensed, mature design, using proven components in an innovative and elegant approach to safety. The successful evolutionary step from the AP600 to the AP1000, with minimum changes, makes the AP1000 a nuclear plant with a cost per kWh in the range of electricity prices today. The changes represent a very modest increase in the overall plant capital cost. This slight increase, when divided by the large increase in power output, gives significantly lower electricity cost in the range of 3.0 to 3.5¢/kWh. The Westinghouse AP1000 represents a nuclear power plant that is economical in the U.S. deregulated electrical power industry that is ready for deployment in the near term.

NOMENCLATURE

ADS - Automatic Depressurization System
ALWR - United States Advanced Light Water Reactor
CMF - Core melt frequency
CMT - Core Makeup Tank
I&C - Instrumentation and control
IRWST - In-Containment Refueling Water Storage Tank
LRF - Large activity release frequency
LOCA - Loss of coolant accident
PCS - Passive Containment Cooling System
PRHR HX - Passive Residual Heat Removal Heat Exchanger
PRA - Probabilistic Risk Assessment
SGTR - Steam generator tube rupture accident

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