October 20, 1995

APPLICANT: Westinghouse Electric Corporation

FACILITY: AP600

SUBJECT: SUMMARY OF AP600 MATERIALS DESIGN REVIEW MEETING

On October 13, 1995, representatives of the U.S. Nuclear Regulatory Commission (NRC) and Westinghouse met at Westinghouse's office in Monroeville, Pennsylvania to discuss materials issues related to the design of the AP600. The discussion also included a follow-on telephone conference call on October 17, 1995. Attachment 1 is a list of attendees.

The purpose of this meeting was to discuss the resolution and status of outstanding materials-related open items identified in the staff's Draft Safety Evaluation Report for the AP600. The materials and chemical engineering issues are discussed in parts of Chapters 3, 4, 5, 6, 9, and 10 of the DSER. As a part of the review, the staff wanted to obtain assurance that Westinghouse had included in the SSAR appropriate details of the design measures to minimize the potential for erosion/corrosion-induced damage of components and an appropriate surveillance program for monitoring changes in wall thickness of piping components. The staff also discussed the material specification to be used for fabrication of Alloy X-750 springs in the control rod drive mechanism.

At the end of the meeting, the staff noted that many materials and chemical engineering issues identified in the AP600 DSER were either technically resolved or closed.

Attachment 2 is a copy of the discussion material provided by Westinghouse at the meeting. Attachment 3 is a listing of the DSER Open Items discussed and the status of the open items as a result of the meeting.

original signed by:
Ralph Architzel, Section Chief
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Office of Nuclear Reactor Regulation

Docket No. 52-003

Attachments: As stated

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W AP600/NRC MATERIAL RELATED OPEN ITEMS
OCTOBER 13, 1995
MEETING ATTENDEES

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Mel Cowgill	NRC/BNL
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Attachment 1

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base alloy equivalent to Stellite-6 or qualified low or zero cobalt substitute is used. Low or zero cobalt alloys used for hardfacing or other applications where cobalt alloys have been previously used are qualified using wear and corrosion tests. The corrosion tests qualify the corrosion resistance of the alloy in reactor coolant. Cobalt free wear resistant alloys considered for this application include those developed and qualified in industry programs.

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The springs in the control rod drive mechanism are made from nickel-chromium-iron alloy (Alloy 750), ordered to AMS 5698B (Reference 2) or AMS 5699B (Reference 3) with an additional restriction on cobalt to 0.20 weight per cent maximum and restrictions on prohibited materials. ~~MIL-S-23192 or MIL-N-24114 Class A No. 1 temper-drawn wire~~. Operating experience has shown that springs made of this material are not subject to stress-corrosion cracking in pressurized water reactor primary water environments. Alloy 750 is not used for bolting applications in the control rod drive mechanisms.

4.5.1.4 Contamination Protection and Cleaning of Austenitic Stainless Steel

The control rod drive mechanisms are cleaned prior to delivery in accordance with the guidance provided in NQA-2 (Reference 1) Part 2.2. Process specifications in packaging and shipment are discussed in subsection 5.2.3. Westinghouse personnel conduct surveillance of these operations to verify that manufacturers and installers adhere to appropriate requirements as described in subsection 5.2.3.

Tools used in abrasive work operations on austenitic stainless steel, such as grinding or wire brushing, do not contain and are not contaminated with ferritic carbon steel or other materials that could contribute to intergranular cracking or stress-corrosion cracking.

4.5.2 Reactor Internal and Core Support Materials

4.5.2.1 Materials Specifications

The major core support material for the reactor internals is SA-182,SA-479 or SA-240 Type 304LN stainless steel. For threaded structural fasteners the material used is strain hardened Type 316 stainless steel. Remaining internals parts not fabricated from Type 304LN stainless steel typically include wear surfaces such as hardfacing on the radial keys, clevis inserts, alignment pins (Stellite™ 156 or low cobalt hardfaces); dowel pins (Type 316); hold down spring (Type 403 stainless steel (modified)); and irradiation specimen springs (Type 302 Stainless Steel). Core support structure and threaded structural fastener materials are specified in the ASME Code, Section III, Appendix I as supplemented by Code Cases N-60 and N-4. The qualification of cobalt free wear resistant alloys for use in reactor coolant is addressed in subsection 4.5.1.3.

4.5.2.2 Controls on Welding

The discussions provided in subsection 5.2.3.4 are applicable to the welding of reactor internals and core support components.

4.5.2.3 Nondestructive Examination of Tubular Products and Fittings

The nondestructive examination of wrought seamless tubular products and fittings is in accordance with ASME Code, Section III, Article NG-2500. The acceptance standards are in accordance with the requirements of ASME Code, Section III, Article NG-5300.

4.5.2.4 Fabrication and Processing of Austenitic Stainless Steel Components

The discussions provided in subsection 5.2.3.4 and Section 1.9 describes the conformance of reactor internals and core support structures with Regulatory Guides 1.31 and 1.44.

The discussion provided in Section 1.9 describes the conformance of reactor internals with Regulatory Guide 1.34 and 1.71.

4.5.2.5 Contamination Protection and Cleaning of Austenitic Stainless Steel

The discussions provided in subsection 5.2.3 and Section 1.9 are applicable to the reactor internals and core support structures describe the conformance of the process specifications with Regulatory Guide 1.37. The process specifications follow the guidance of NQA-2 (Reference 1).

4.5.3 Combined License Information

This section has no requirement for additional information to be provided in support of the Combined License application.

4.5.4 References

1. ASME NQA-2-1989 edition, "Quality Assurance Requirements for Nuclear Facility Applications."
2. AMS5698B, Alloy Wire, Corrosion and Heat Resistant, Nickel base - 15.5Cr - 7Fe - 2.3Ti - 1(Cb+Ta) - 0.7Al, No. 1 Temper.
3. AMS5699B, Alloy Wire, Corrosion and Heat Resistant, Nickel base - 15.5Cr - 7Fe - 2.3Ti - 1(Cb+Ta) - 0.7Al, Spring Temper.

Table 6.2.4-5

POST-ACCIDENT CONTAINMENT TEMPERATURE AND ASSOCIATED CORROSION RATES FOR ALUMINUM AND ZINC

Interval (sec)	Temperature (°F)	Al Corrosion (lb/ft^2-hr)	Zn Corrosion (lb/ft^2-hr)
~~0 - 20~~	~~287~~	~~0.045~~	~~0.00041~~
~~20 - 388~~	~~412~~	~~1.1~~	~~0.0021~~
~~388 - 1000~~	~~328~~	~~0.14~~	~~0.00074~~
~~1000 - 10,000~~	~~271~~	~~0.027~~	~~0.00032~~
~~10,000 - 100,000~~	~~240~~	~~0.0099~~	~~0.00019~~
~~100,000 - 259,000~~	~~215~~	~~0.0041~~	~~0.00012~~
~~>259,000~~	~~260~~	~~0.019~~	~~0.00027~~
0 - 25	300	0.066	0.00050
25 - 60	270	0.027	0.00031
60 - 150	250	0.014	0.00022
150 - 4000	270	0.027	0.00031
4000 - 9000	250	0.014	0.00022
9000 - 20,000	200	0.0023	0.000090
20,000 - 40,000	175	0.00084	0.000054
>40,000	153	0.00033	0.000033

trip system which continuously monitors critical turbine parameters on a multi-channel basis. Each of the channels is independently testable under load with overspeed protection during testing provided by the channels not being tested. If turbine speed exceeds 110- to 111 percent of rated speed, the emergency trip system causes steam valves to close, tripping the unit. This system is described in subsection 10.2.2.5.

Turbine Missile Protection

Turbine disk integrity minimizes the probability of generating turbine missiles and is discussed in subsection 10.2.3. Turbine missiles are addressed in subsection 3.5.1.3. The favorable orientation of the turbine-generator directs potential missiles away from safety-related equipment and structures.

Radioactivity Protection

Under normal operating conditions, there are no significant radioactive contaminants present in the steam and power conversion system. However, it is possible for the system to become contaminated through steam generator tube leakage. In this event, radiological monitoring of the main condenser air removal system, the steam generator blowdown system, and the main steam lines will detect contamination and alarm high radioactivity concentrations. A discussion of the radiological aspects of primary-to-secondary system leakage and limiting conditions for operation is contained in Chapter 11. The steam generator blowdown system described in subsection 10.4.8 and the condensate polishing system described in subsection 10.4.6 serve to limit the radioactivity level in the secondary cycle.

Erosion-Corrosion Protection

Erosion and corrosion resistant materials are used in steam and power conversion systems for components exposed to single phase or two-phase flow where significant erosion can occur. Factor considered in the evaluation of erosion/corrosion, flow-accelerated corrosion, and erosion include system piping and component configuration and geometry, water chemistry, piping and component material fluid temperature, and fluid velocity. The degree of corrosion/erosion resistance of the material is consistent with the temperature, moisture content, and velocity of the fluid to which the component is exposed. Carbon steel with no deliberate alloying additions outside carbon and manganese is not used for the applications subject to significant erosion.

In addition to material selection, layout of systems containing water or two-phase flow is designed to minimize the potential for erosion in these systems. Where carbon steel pipe is used, the size of pipe diameter results in a velocity of the fluid low enough to minimize the potential for erosion. The secondary side water chemistry, see subsection 10.3.5, includes use of a volatile pH adjustment chemical that is used to maintain a noncorrosive environment. The systems are designed to facilitate inspection and erosion/corrosion monitoring programs.

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10.1.3 Combined License Information

The Combined License holder will prepare an erosion/corrosion monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam. This monitoring program will be consistent with industry guidelines and address the requirements included in Generic Letter 89-08. ~~This section has no requirement for additional information to be provided in support of the Combined License application.~~

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10.3.5.4 Chemical Addition

AP600 employs an all-volatile treatment (AVT) method to minimize general corrosion in the feedwater system, steam generators, and main steam piping. ~~Morpholine or an alternative~~ A pH adjustment chemical and an oxygen scavenger are the two chemicals to be injected into the condensate pump discharge header, downstream of the condensate polishers.

To reduce the general corrosion rate of ferrous alloys, a pH adjustment chemical **(such as ammonia or mopholine)** is injected to maintain a noncorrosive environment. Although the pH adjustment chemical is volatile and will not concentrate in the steam generator, it will reach an equilibrium level which will help establish noncorrosive conditions.

An oxygen scavenger **(typically hydrazine or hydrazide)** is added to maintain the dissolved oxygen content in the feedwater within specified limits for each mode of operation. The oxygen scavenger also promotes the formation of a protective magnetite layer on ferrous surfaces and keeps this layer in a reduced state, further inhibiting general corrosion.

10.3.5.5 Action Levels for Abnormal Conditions

Appropriate responses to abnormal chemistry conditions provide for the long-term integrity of secondary cycle components. As such, three action levels have been defined for taking remedial action when monitored parameters are observed and confirmed to be outside the normal operating values. Normal operating value, as it is used here, refers to the value of a parameter which is consistent with long-term system reliability.

Action taken when chemistry parameters are outside normal operating ranges will, in general, be consistent with action levels described in Reference 1.

Action level 1 is implemented whenever an out-of-normal value is detected. Maintaining parameter values within the normal range will provide a high degree of assurance that corrosive conditions will be avoided. Action level 2 is initiated when conditions exist which will result in some degree of steam generator corrosion during extended full-power operation. Action level 3 is implemented when conditions exist which will result in rapid steam generator corrosion, and continued operation is not advisable.

Action Level 1

Objective: To promptly identify and correct the cause of an out-of-normal value without power reduction.

Actions

- Return parameter to within normal value range within one week following confirmation of excursion.

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Table 10.3.5-1 (Sheet 1 of 3)

GUIDELINES FOR CONDENSATE DURING POWER OPERATION

Parameters	Normal Value	Action Levels 1	Action Levels 2	Action Levels 3
Control				
Cation conductivity due to strong acid anions at 25°C, μS/cm	≤ 0.15	> 0.15	> 0.3	> 0.5
Total cation conductivity at 25°C, μS/cm	≤ 0.3	> 0.3	> 0.5	> 1.0
Dissolved oxygen, ppb[(a)]	≤ 10	> 10	> 30	
Diagnostic				
Total organic carbon, ppb	≤ 100			
Sodium, ppb	< 1			
pH at 25°C	> 9.0			
Specific conductivity at 25°C, μS/cm	2 - 6			
Volatile pH adjustment chemical, ~~Morpholine,~~ ppb	(b) (c)			

Note:
(a) Air leakage should be reduced until total air ejected flow rate is less than 6 SCFM.
(b) pH, **volatile pH adjustment chemical**, ~~morpholine,~~ and specific conductivity should correlate.
(c) Alternative volatile pH adjustment chemical may be used.

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Table 10.3.5-1 (Sheet 2 of 3)

GUIDELINES FOR FEEDWATER DURING POWER OPERATION

Parameters	Normal Value	Action Levels 1	2	3
Control				
pH at 25°C[(a)]	> 9.5	< 9.3[(b)]		
Hydrazine, ppb[(c)]	≥ 100	< 50		
Total iron, ppb	≤ 20	> 20		
Diagnostic				
Dissolved oxygen, ppb	≤ 2	> 5		
Cation conductivity due to strong acid anions at 25°C, μS/cm	≤ 0.2			
Specific conductivity at 25°C, μS/cm	4.0 - 12.0			
Volatile pH adjustment chemical, ~~Morpholine,~~ ppb	(a) (d)			

Note:
(a) pH, volatile pH adjustment chemical, ~~morpholine,~~ and specific conductivity should correlate.
(b) When operating with condensate polishers, the pH of an all-ferrous system can be controlled to a lower value of 9.2, with action required when pH < 9.2.
(c) Values apply if hydrazine is used for oxygen scavenging.
(d) Alternative volatile pH adjustment chemical may be used.

Table 10.3.5-1 (Sheet 3 of 3) DRAFT

GUIDELINES FOR STEAM GENERATOR BLOWDOWN DURING POWER OPERATION

Parameters	Normal Value	Action Levels 1	2	3
Control				
pH at 25°C[a]	9.0 - 9.5[b]	< 9.0[b]		
Total cation conductivity	≤ 0.8[c]	> 0.8[c]	> 2	> 7
Sodium, ppb	≤ 20	> 20	> 100	> 500
Chloride, ppb	≤ 20	> 20	> 100	
Sulfate, ppb	≤ 20	> 20	> 100	
Silica, ppb	≤ 300	> 300		
Diagnostic				
Cation conductivity due to strong acid anions at 25°C, µS/cm	≤ 0.5			
Suspended solids, ppb	< 1000			
Specific conductivity at 25°C, µS/cm	< 3.0			
Volatile pH adjustment chemical, ~~Morpholine,~~ ppb	(a) (d)			

Note:
(a) pH, volatile pH adjustment chemical, ~~morpholine~~ and specific conductivity should correlate.
(b) When operating with condensate polishers, the pH of an all-ferrous system can be controlled to a value of > 8.8.
(c) Based on concentrations of total anionic species present, any inconsistencies between theoretical and measured values should be investigated.
(d) Alternative volatile pH adjustment chemical may be used.

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Table 10.3.5-2

GUIDELINES FOR STEAM GENERATOR WATER DURING COLD SHUTDOWN/WET LAYUP

Parameters	Normal Value	Initiate Action	Prior to Heatup (≤ 200°F)
Control			
pH at 25°C	9.8 - 10.5	< 9.8	≥ 9.3[(a)]
Hydrazine, ppm[(b)]	75 - 200	< 75	
Sodium, ppb	≤ 1000	> 1000	≤ 100
Chloride, ppb	≤ 1000	> 1000	≤ 100
Sulfate, ppb	≤ 1000	> 1000	≤ 100
Diagnostic			
Volatile pH adjustment chemical, ~~Morpholine~~[~~(c)~~] - as required to achieve pH range			
Total organic carbon, ppb	≤ 100	> 100	

Note:
(a) Conformance with pH guideline may be waived prior to achieving no load temperature and passing steam forward to turbine.
(b) Values apply if hydrazine is used for oxygen scavenging.
~~(c) Alternative volatile pH adjustment chemical may be used.~~

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Table 10.3.5-3

GUIDELINES FOR STEAM GENERATOR BLOWDOWN DURING HEATUP (> 200°F TO < 5% POWER)

Parameters	Normal Value	Initiate Action	Value Prior to Power Escalation Above 5%	Value Power Escalation Prior to Above 30%[b]
Control				
pH at 25°C[a]	≥ 9.0	< 9.0	--	≥ 9.0
Total cation conductivity at 25°C, μS/cm	≤ 2.0	> 2.0	≤ 2.0	≤ 0.8
Dissolved oxygen, ppb	≤ 5	> 5	≤ 5	≤ 5
Sodium, ppb	≤ 100	> 100	≤ 100	≤ 20
Chloride, ppb	≤ 100	> 100	≤ 100	≤ 20
Sulfate, ppb	≤ 100	> 100	≤ 100	≤ 20
Silica, ppb	--	--	--	≤ 300
Diagnostic				
Specific conductivity at 25°C, μS/cm[a]	≥ 10			
Volatile pH adjustment chemical, ~~Morpholine~~[a]	(a) ~~(c)~~			
Silica, ppb	≤ 1000			

Note:
(a) pH, volatile pH adjustment chemical, ~~morpholine~~ and specific conductivity should correlate.
(b) This column is presented here for startup chemistry continuity with Table 10.3.5-1 since > 5% power denotes power operation. If escalation > 5% power is accomplished prior to meeting the values in this column, Action Level 1 requirements take effect.
~~(c) Alternative volatile pH adjustment chemical may be used.~~

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of the condenser every refueling outage and component inspection for air leaks during plant operation.

10.3.5.10 Corrective Actions for Out-of-Specification Condition

Cases may exist, at various action levels, where prompt action by on-shift personnel can rapidly correct an out-of-specification condition. Shift personnel receive problem-solving assistance from site technical support personnel (chemists, plant engineers, maintenance personnel, etc.) and/or offsite personnel (vendors, consultants, and/or corporate personnel) as appropriate to diagnose the root cause of out-of-specification occurrences and to apply corrective actions.

Corrective actions taken depend on the specifics of the problem. Typical corrective actions are listed below.

- Increase blowdown levels to lower chemical concentration in the steam generator water.
- Increase/decrease treatment chemicals addition to bring parameters back into specification.
- Locate and stop contaminant ingress; special samples and/or increased sampling frequency may be used to assist this effort.
- Decrease power or shutdown to limit potential damage while corrective action is being applied.
- Increase flow to condensate polishing.

10.3.5.11 Conformance to Branch Technical Position MTEB 5-3

AP600 conformance to Branch Technical Position MTEB 5-3 is discussed in Section 1.9.

10.3.6 Steam and Feedwater System Materials

10.3.6.1 Fracture Toughness

Compliance with fracture toughness requirements of ASME Code, Section III, Articles NC-2300 and ND-2300, is described in Section 6.1.

10.3.6.2 Material Selection and Fabrication

Pipe, flanges, fittings, valves, and other piping material conform to the referenced ASME, ASTM, ANSI, or Manufacturer Standardization Society-Standard Practice code.

No copper or copper-bearing materials are used in the steam and feedwater systems.

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The following ~~code~~ requirements apply to the nonsafety-related portion of the main steam system. ÷

Component	Alloy/Carbon Steel
Pipe	ASME/ANSI B36.10
Fittings	ASME/ANSI B16.9, B16.11
Flanges	ASME/ANSI B16.5

Material selection and fabrication requirements for ASME Code, Section III, Class 2 and 3 components in the safety-related portions of the main steam and feedwater systems are consistent with the requirements for ASME Class 2 and 3 systems and components outlined ~~addressed~~ in subsections 6.1.1.1 and 6.1.1.2. The material specifications for the main steam and feedwater systems are listed in Table 10.3.2-3

Conformance with the applicable regulatory guides is described in subsection 1.9.1.

Nondestructive inspection of ASME Code, Section III, Class 2 and 3 components in the safety-related portions of the main steam and feedwater systems is addressed in subsection 6.6.5.

10.3.7 Combined License Information

This section has no requirement for information to be provided in support of the Combined License application.

10.3.8 References

1. "PWR Secondary Water Chemistry Guidelines," EPRI NP-2704, 1982.

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Table 10.3.2-3

DESCRIPTION OF MAIN STEAM AND MAIN FEEDWATER PIPING

Segment	Material Specification ~~Description~~	Dimensions (in.) Nominal OD	~~Nominal ID~~	Minimum Wall / Schedule
Main Steamline				
Steam generator outlet to containment penetration	SA-333 Gr. 6 ~~32 in.~~ seamless pipe	32~~.0~~	-	1.205
Containment penetration to MSIV	SA-333 Gr. 6 ~~32 in.~~ seamless pipe	32~~.0~~	-	1.205
MSIV to auxiliary/turbine building wall	SA-333 Gr. 6 ~~32 in.~~ seamless pipe	32~~.0~~	-	1.205
Auxiliary/turbine building wall to equalization header	ASTM A-106 Gr. B ~~32 in. seamless pipe~~	32~~.0~~	-	1.205
Branch lines to turbine stop valves	ASTM A-106 Gr. B ~~24 in. seamless pipe~~	24~~.0~~	~~21.562~~	S-80 ~~1.056~~
Main Feedwater Line				
Feedwater pump outlet to individual steam generator feedwater lines	ASTM A-106 Gr. B	20 & 24		S-120
Feedwater heater bypass line	ASTM A-106 Gr. B	24		S-120
Start of indiviual steam generator feedwater lines to auxiliary/turbine building wall	ASTM A335 Gr. P-11	16		S-120
Auxiliary/turbine building wall to MFIV	SA-335 Gr. P-11	16		S-120
MFIV to containment penetration	SA-335 Gr. P-11	16		S-120
Containment penetration to steam generator nozzle	SA-335 Gr. P-11	16		S-120

not considered to be a potential source of missiles when struck by a falling object. Safety-related structures, systems, or components are protected from nonseismically designed structures, systems, or components or the interaction is evaluated. See Subsection 3.7.3.13 for additional discussion on the interaction of other systems with Seismic Category I systems. There are no high-pressure gas storage cylinders inside the containment shield building. For the reasons noted above, secondary missiles are not considered credible missiles.

3.5.1.3 Turbine Missiles

The turbine generator is located north of the nuclear island with its shaft oriented north-south. In this orientation, the potential for damage from turbine missiles is negligible. Safety-related structures, systems and components are located outside the high-velocity, low-trajectory missile strike zone, as defined by Regulatory Guide 1.115. Thus, postulated low-trajectory missiles cannot directly strike safety-related areas. ~~Credible high-trajectory missiles that could reach safety-related areas do not have sufficient kinetic energy to penetrate the tornado missile resistant concrete and steel structures housing safety-related equipment.~~

The turbine and rotor ~~disc~~ design is described in Section 10.2. Protection is provided by the orientation of the turbine-generator and by the use of fully integral ~~low-pressure~~ turbine rotors. In a fully integral turbine rotor the disks to which the blades are attached are forged as an integral part of the rotor. Analyses of the probability of the generation of missiles have been submitted to the NRC staff. ~~The report for rotors with shrunk-on discs was approved by the NRC staff (see Reference 2).~~ The description of methodology to determine the probability of missile generation for fully integral rotors was submitted in Reference 3. ~~Preliminary staff review (see Reference 4) agreed that the fully integral low-pressure rotors may be less susceptible to stress corrosion cracking than the shrunk-on discs. In the meeting on November 5, 1992 between the NRC staff, EPRI, and turbine vendors, it was concluded that the turbine failures were not a safety issue and that~~ The rotor design, manufacturing, and material specification and the inspections recommended for the AP600 ~~by the turbine vendors to ensure~~ provide ~~availability and reliability were more than sufficient to ensure~~ an acceptably very low probability (See subsection 10.2.2) of missile generation. Turbine rotor integrity is discussed in subsection 10.2.3. This discussion includes fatigue and fracture analysis, material selection, and the maintenance program requirements.

The potential that a high-trajectory missile could impact safety-related areas of the AP600 is less than 10^{-7}. Based on this very low probability, the potential damage from a high-trajectory missile is not evaluated. The probability of an impact in the safety related areas is the product of the probability of missile generation from the turbine, the probability, assuming a turbine failure, that a high-trajectory missile would land within a few hundred feet from the turbine (10^{-7} per square foot), and the area of the safety related area. In the AP600 the safety related area is contained within the containment shield building and the auxiliary building.

3.5.1.4 Missiles Generated by Natural Phenomena

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- For columns with slenderness ratio greater than 20, $\mu \leq 1.0$.
  Where: L = effective length of the member
  r = the least radius of gyration
- For members subjected to tension, $\mu \leq .5*(e_u/e_y)$
  Where: e_u = Ultimate strain
  e_y = Yield strain

3.5.4 Missile Protection Interface Requirements

The Combined License applicant must demonstrate that the site satisfies the interface requirements provided in Section 2.2. This requires an evaluation for those external events that produce missiles that are more energetic than the tornado missiles postulated for design of the AP600, or additional analyses of the AP600 capability to handle the specific hazard.

3.5.5 Combined License Information

This section has no requirement for additional information to be provided in support of the Combined License application.

3.5.6 References

1. WCAP-13856, AP600 Implementation of the Regulatory Treatment of Nonsafety-Related Systems Process, Summary Report, 1993.

2. Deleted ~~NRC Safety Evaluation Report, letter from B. D. Liaw to J. A. Martin, December 27, 1984~~.

3. WSTG-4-P, Proprietary and WSTG-4-NP, Nonproprietary, "Analysis of the Probability of the Generation of Missiles from Fully Integral Nuclear Low Pressure Turbines." October 1984.

4. Deleted ~~Letter from John C. Tsao, NRC to Daniel Fridsma, Westinghouse PGTD, received July 21, 1991.~~

10.2 Turbine-Generator

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The function of the turbine-generator is to convert thermal energy into electric power.

10.2.1 Design Basis

10.2.1.1 Safety Design Basis

The turbine-generator serves no safety-related function and therefore has no nuclear safety design basis.

10.2.1.2 Power Generation Design Basis

The following is a list of the principal design features:

- The turbine-generator is intended for baseload operation and also has load follow capability consistent with the capabilities of the AP600.
- The main turbine system (MTS) is designed for electric power production consistent with the capability of the AP600 reactor coolant system.
- The turbine-generator is designed to trip automatically under abnormal conditions.
- The system is designed to provide proper drainage of related piping and components to prevent water induction into the main turbine.
- The main turbine system satisfies the recommendations of Nuclear Regulatory Commission Branch Technical Position ASB 3-1 as related to breaks in high- and moderate-energy piping systems outside containment. The main turbine system is considered a high-energy system.
- The system provides extraction steam for seven stages of regenerative feedwater heating.

10.2.2 System Description

The Westinghouse turbine-generator is designated as a TC4F 47-inch last-stage blade unit consisting of turbines, a generator, external moisture separator reheater, exciter, controls, and auxiliary subsystems. (See Figure 10.2-1.) Figure 10.2-2 is an equipment outline drawing of the main turbine system. The major design parameters of the turbine-generator and auxiliaries are presented in Table 10.2-1. The piping and instrumentation diagram containing the stop, governing control, intercept, and reheat valves is shown in Figure 10.3.2-2.

The turbine-generator and associated piping, valves, and controls are located completely within the turbine building. There are no safety-related systems or components located within the turbine building. The probability of destructive overspeed condition and missile generation, assuming the recommended inspection and test frequencies, ~~y,~~ is less than 1×10^{-5} per year. In addition, orientation of the turbine-generator is such that high-energy missiles would be directed away at right angles to safety-related structures, systems, or components. Failure of turbine-generator equipment does not preclude safe shutdown of the reactor. The turbine-generator components and instrumentation associated with turbine-generator overspeed protection are accessible under operating conditions.

10.2.2.1 Turbine-Generator Description

The turbine is a 1800-rpm, tandem-compound, four-flow, reheat unit with 47-inch last-stage blades (TC4F 47-inch LRB). The high-pressure turbine element includes one double-flow, high-pressure turbine. The low-pressure turbine elements include two double-flow, low-pressure turbines and one external moisture separator/reheater (MSR) with one stage of reheating. The single direct-driven generator is gas cooled and rated at 880 MVA at 22 kV, 0.90 PF. Other related system components include a complete turbine-generator bearing lubrication oil system, a digital electrohydraulic (DEH) control system with supervisory instrumentation, a turbine steam sealing system (refer to subsection 10.4.3), overspeed protective devices, turning gear, a generator hydrogen and seal oil system, a generator CO_2 system, an exciter cooler, a rectifier seetion, an exciter, and a voltage regulator.

The turbine-generator foundation is a spring-mounted support system. A spring-mounted turbine-generator provides a low-tuned, turbine-pedestal foundation. The springs dynamically isolate the turbine-generator deck from the remainder of the structure in the range of ~~for~~ operating frequencies, thus allowing for an integrated structure below the turbine deck. The condenser is supported on springs and attached rigidly to the low-pressure turbine exhaust.

The foundation design consists of a reinforced concrete deck mounted on springs and supported on a structural steel frame that forms an integral part of the turbine building structural system. The lateral bracing under the turbine-generator deck also serves to brace the building frame. This "integrated" design reduces the bracing and number of columns required in the building. Additionally, the spring-mounted design allows for dynamic uncoupling of the turbine-generator foundation from the substructure. The spring mounted support system is much less site dependent than other turbine pedestal designs, since the soil structure is decoupled from turbine dynamic effects. The turbine-generator foundation consists of a concrete table top while the substructure consists of supporting beams and columns. The structure below the springs is designed independent of vibration considerations.

10.2.2.2 Turbine-Generator Cycle Description

Steam from each of two steam generators enters the high-pressure turbine through four stop valves and four governing control valves; two stop valves and two control valves form a single assembly. Crossties are provided upstream of the turbine stop valves to provide pressure equalization with one or more stop valves closed. After expanding through the high-pressure turbine, exhaust steam flows through one external moisture separator reheater vessel. The external moisture separator reduces the moisture content of the high-pressure exhaust steam from approximately 10-20 percent to 0.17 percent moisture or less.

The reheater uses a portion of the main steam supply to reheat the steam to superheat conditions. The reheated steam flows through separate reheat stop and intercept valves in each of four reheat steam lines leading to the inlets of the two low-pressure turbines. Turbine steam extraction connections are provided for seven stages of feedwater heating. Steam from the first two extraction points of the high-pressure turbine is supplied to high-pressure feedwater heaters No. 6 and 7. The high-pressure turbine exhaust supplies steam to the deaerating feedwater heater. The low-pressure turbine third, fourth, fifth, and sixth extraction points supply steam to the low-pressure feedwater heaters No. 4, 3, 2, and 1, respectively.

Moisture is removed at a number of locations in the blade path. Drainage holes drilled through the blade rings provide moisture removal from blade rings located in high moisture zones. The effectiveness of moisture removal at these locations is enhanced by moisture nonreturn catchers which trap a large portion of the water from the blade path and direct it to the moisture removal system.

The external moisture separator reheater uses multiple vane chevron banks (shell side) for moisture removal. The moisture removed by the external moisture separator reheater drains to a moisture separator drain tank and is pumped to the deaerator.

Condensed steam in the reheater (tube side) is drained to the reheater drain tank, flows into the shell side of the No. 7 feedwater heater, and cascades through the No. 6 shell to the deaerator.

10.2.2.3 Exciter Description

The excitation system is a brushless exciter with a solid state voltage regulator. Excitation power is obtained from the rotating shaft which is directly connected to the main generator shaft. The brushless exciter consists of three parts: a permanent magnet pilot exciter, a main AC exciter, and a rectifier wheel. The exciter rectifiers are arranged in a full wave bridge configuration and protected by a series connected fuse. The turbine building closed cooling water system (TCS) provides cooling water to the exciter air to water heat exchangers.

10.2.2.4 Digital Electrohydraulic System Description

The turbine-generator is equipped with a digital electrohydraulic (DEH) system that combines the capabilities of solid-state electronics and high-pressure hydraulics to regulate steam flow through the turbine. The control system has a speed control unit, a load control unit, and an automatic turbine control (ATC) unit which may be used, either for control or for supervisory purposes, at the option of the plant operator.

The DEH system employs three electric speed inputs whose signals are processed in two separate electronic logic channels. Valve opening actuation is provided by a hydraulic system that is ~~totally~~ independent of the bearing lubrication system; valve closing actuation is provided by springs and steam forces upon the reduction or relief of fluid pressure. The system is designed so that loss of fluid pressure, for any reason, leads to valve closing and consequent turbine trip.

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Steam valves are provided in series pairs. A stop valve is tripped by the overspeed trip system; the control valve is modulated by the governing system and is actuated by the trip system.

10.2.2.4.1 Speed Control Unit

The speed control unit provides speed control, acceleration, and overspeed protection functions. The speed control unit produces a speed error signal, which is fed to the load control unit. The speed error signal is derived by comparing the desired speed with the actual speed of the turbine at steady-state conditions or by comparing the desired acceleration rate with the actual acceleration rate during startup.

Three separate error signals are derived by the speed control circuits. These are the result of individual comparisons of a speed reference signal with each of the three analog speed signals that are proportional to turbine speed. The speed controller receives these three signals, performs a two-out-of-three comparison, and transmits the signal demanding the appropriate ~~control~~ speed. A failure of one speed input generates an alarm. Failure of two or more speed inputs also generates an alarm and changes speed control to a manual mode of operation where automatic compensation for speed changes (except overspeed protection) will not occur.

The speed control unit uses two redundant channels, a primary and a backup. If the primary channel fails, the backup channel takes over automatically. If the backup channel fails, the primary channel will maintain control. In the event that both channels are lost, the turbine trips.

A trip signal is sent to a fast acting solenoid valve which feeds ~~on~~ each control valve and intercept valve. Energizing these solenoid valves releases the hydraulic fluid pressure in the valve actuators, allowing springs to close each valve.

The speed control unit is designed to slowly vary the rotor speed above and below critical frequencies. This will prevent the turbine from running at a constant speed near critical blade resonances.

10.2.2.4.2 Load Control Unit

The load control unit develops signals that are used to regulate unit load. Signal outputs are based on a proper combination of the speed error, impulse pressure, and actual load (turbine megawatt) reference signals.

Steam flow is not controlled directly but rather by a characterization of turbine megawatt and valve position. Under normal conditions, the turbine requests a certain megawatt load target. Through a coordinated mode of control, the steam generator supplies the steam flow to produce the required megawatts.

10.2.2.4.3 Valve Control

The flow of the main steam entering the high-pressure turbine is controlled by four stop valves and four governing control valves. Each stop valve is controlled by an electrohydraulic actuator, so that the stop valve is either fully open or fully closed. The function of the stop valves is to shut off the steam flow to the turbine when required. The stop valves are closed by actuation of the emergency trip system devices. These devices are independent of the electronic flow control unit.

The turbine control valves are positioned by electrohydraulic servo actuators in response to signals from their respective flow control unit. The flow control unit signal positions the control valves for wide-range speed control through the normal turbine operating range, and for load control after the turbine-generator unit is synchronized.

The reheat stop and intercept valves, located in the hot reheat lines at the inlet to the low-pressure turbines, control steam flow to the low-pressure turbines. During normal operation of the turbine, the reheat stop and intercept valves are wide open. The intercept valve flow control unit positions the valve during startup and normal operations and closes the valve rapidly on loss of turbine load. The reheat stop valves close completely on turbine overspeed and turbine trip.

10.2.2.4.4 Power/Load Unbalance

A~~ssociated with the load control unit is a~~ rate sensitive power/load unbalance circuit~~, the purpose of which is to~~ initiates control valve fast closing ~~action~~ under load rejection conditions that might lead to rapid rotor acceleration and consequent overspeed.

Valve action ~~will~~ occurs when the power exceeds the load by 30 percent or more, and when the generator current is lost in a time span of 35 milliseconds or less. Cold reheat pressure is used as a measure of power. Generator current is used as a measure of load to provide discrimination between loss of load incidents and occurrences of electric system faults.

When the detection circuitry provides a signal indicating a power/load unbalance condition, the load reference signal is grounded, and the load reference motor begins to run back toward the no-load flow point. Should the condition disappear quickly, the power/load unbalance circuitry ~~will~~ resets automatically, and the load reference signal is ~~will be~~ re-established near its value prior to the loss of load.

10.2.2.4.5 Overspeed Protection

Two separate systems have been provided to protect the turbine against overspeed. The first is the speed control unit as discussed in subsection 10.2.2.4.1. The second is the emergency trip system (ETS) which operates if the normal speed control should fail. Refer to Table 10.2-2 for a description of the sequence of events following a full-load rejection. The emergency trip system is discussed in subsection 10.2.2.5.1.

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Since redundancy is built into the overspeed protection systems, the failure of a single valve will not disable the trip functions. The following component redundancies are used to guard against overspeed:

- Main stop valves/control valves
- Reheat stop valves/intercept valves
- Primary speed control/backup speed control
- Fast acting solenoid valves/emergency trip system
- Multichannel electrical overspeed trip
- Speed control/overspeed trip

The overspeed protection system components are designed to fail in a safe position. Loss of two-out-of-three ETS speed signals initiates a trip. Loss of the hydraulic pressure in the ETS also causes a trip. Therefore, damage to the overspeed protection systems, whether at the front standard of the turbine or at the steam valves, results in the closure of the valves and the interruption of steam flow to the turbine.

Quick closure of the steam valves prevents turbine overspeed. Valve closing times are given in Table 10.2-4.

10.2.2.4.6 Automatic Turbine Control

Automatic turbine control provides safe and proper startup and loading of the turbine generator. The applicable limits and precautions are monitored by the automatic turbine control programs even if the automatic turbine control mode has not been selected by the operator. When the operator selects automatic turbine control, the programs both monitor and control the turbine. The DEH controller takes advantage of the ability of the computer to scan, calculate, make decisions and take positive action.

The automatic turbine control is capable of automatically:

- Changing speed
- Changing acceleration
- Generating speed holds
- Changing load rates
- Generating load holds

~~These actions will be generated as dictated by the operating condition of the machine.~~

The thermal stresses in the rotor are calculated by the automatic turbine controls programs based on actual turbine steam and metal temperatures as measured by thermocouples or other temperature measuring devices. Once the thermal stress (or strain) is calculated, it ~~can be~~ is compared with the allowable value, and the difference used as the index of the permissible first stage temperature variation. This permissible temperature variation is translated in the computer program as an allowable speed or load or rate of change of speed or load.

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Values of some parameters are ~~can be~~ stored for use in the prediction of their future values or rates of change, which are used to initiate corrective measures before alarm or trip points are reached.

The rotor stress (or strain) calculations used in the program, and its decision-making counterpart are the main controlling sections. They allow the unit to roll with relatively high acceleration until the anticipated value of stress predicts that limiting values are about to be reached. Then a lower acceleration value is selected and, if the condition persists, a speed hold is generated. The same philosophy is used on load control in order to maintain positive control of the loading rates.

The automatic turbine controls programs are stored and executed in two ~~separate~~ redundant distributed processing units, one of which contains the rotor stress programs and the other a majority of the automatic turbine controls logic programs. These units communicate with each other and the base system via a data highway. Once the turbine is latched, the automatic turbine controls programs are capable of rolling the turbine from turning gear to synchronous speed with supervision from a single operator ~~action~~.

Once the turbine-generator reaches synchronous speed, the startup or speed control phase of automatic turbine control is completed and no further action is taken by the programs. Upon closing the main generator breaker, the DEH automatically picks up approximately five percent of rated load ~~in order~~ to prevent motoring of the generator. At this time, the DEH is in load control.

The DEH unit is equipped with a remote control interface which consists of three contact closure inputs to the DEH and a selection area titled REMOTE on the DEH controls. One of the three contact closure inputs is a permissive from the remote system, indicating that the DEH is permitted to enter the remote control mode. If the permissive contact input is closed and if the operator selects REMOTE mode, the remote control system ~~will now have~~ controls of the DEH load SETPOINT and load TARGET through the other two contact closure inputs. Selection of the remote mode provides for control of the turbine-generator from an operator console. One of the contact closure inputs ~~will~~ causes the DEH to increase load and the other ~~will~~ causes the DEH to reduce load. In this remote mode of control, the rate of load change is ~~implicitly~~ controlled by the amount of load change associated with each contact closure and by the number of contact closures that occur in a given period of time.

It is possible to select a combined mode of both remote control and automatic turbine control at the same time. In the combined mode of control, the automatic turbine control allows the remote control system ~~complete~~ control of load changes via the two contact closure inputs until an alarm condition occurs. If ~~any of~~ the operating parameters which are being monitored (including rotor stress) exceed their associated alarm limit, load hold is generated in conjunction with the appropriate alarm message. The DEH generates the load hold by ignoring any further load increase or decrease by the remote contact closure inputs until the alarm condition is cleared or until the operator overrides the alarm condition. At the same time that the DEH generates the load hold based on the automatic turbine control alarm condition, the DEH also informs the remote control system of its action by closing a contact

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~~closure output~~. In the ~~this~~ combined mode of control, both the load reference and the load rate are implicitly controlled by the remote control system while the automatic turbine control supervises the load changes with overriding control capability.

The operator may remove the turbine-generator from automatic turbine control. This action places the automatic turbine control in a supervisory capacity ~~only~~.

10.2.2.5 Turbine Protective Trips

Turbine protective trips are independent of the electronic control system and, when initiated, cause tripping of the turbine stop, ~~and~~ control, **interceptor, and reheat stop** valves. The protective trips are:

- Low bearing oil pressure
- Low electrohydraulic fluid pressure
- High condenser **backpressure**
- Remote trip that accepts external trips
- Thrust bearing wear
- Turbine overspeed

10.2.2.5.1 Emergency Trip System

The purpose of the emergency trip system is to detect undesirable operating conditions of the turbine-generator, take appropriate trip actions, and provide information to the operator about the detected conditions and the corrective actions. In addition, means are provided for testing emergency trip equipment and circuits.

The system utilizes a two-channel configuration which permits online testing with continuous protection afforded during the test sequence. The system controller is microprocessor based and is powered by redundant dc power supplies.

The system consists of an emergency trip control block with trip solenoid valves and status pressure sensors ~~switches~~, three test trip blocks with pressure switches and test solenoid valves, rotor position pickups, a speed pickup, a cabinet containing electrical and electronic hardware, and a remotely mounted status and test panel.

The sensing devices at the turbine transmit electrical signals to the trip cabinet where microprocessor logic determines when to trip the auto stop emergency trip header. Either of two channels is capable of tripping the turbine with the other out of service.

10.2.2.5.2 Emergency Trip Control Block

The autostop emergency trip header pressure is established when the autostop trip solenoid valves are energized closed. The valves are arranged in two channels for testing purposes—the odd numbered pair correspond to channel 1, and the even numbered pair correspond to channel 2. This convention is carried throughout the emergency trip system in

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designating devices; e.g., channel 1 devices are odd-numbered, and channel 2 devices are even-numbered. Both valves in a channel will open to trip that channel. Both channels must trip before the autostop trip header pressure collapses to close the turbine steam inlet valves. Online testing can be accomplished by "tripping" one channel at a time. Isolation between channels provides protection against spurious trips during testing.

The solenoid valves are externally piloted, two-stage valves. Electrohydraulic fluid pressure is applied to the pilot piston to close the main solenoid valve. The header pressure between channels 1 and 2 is monitored by pressure sensors ~~switches~~. The pressure sensor ~~switch~~ is used to determine the tripped or latched status of each channel and as an interlock to prevent testing one channel when the other channel is being tested.

10.2.2.5.3 Test Blocks

Low bearing oil pressure, low electrohydraulic fluid pressure, and high condenser backpressure are each sensed by separate test block instrumentation. Each test block assembly consists of a steel test block, two pressure transmitters, two shutoff valves, two solenoid valves, and three needle valves. Each assembly is arranged into two channels. The assemblies, mounted on the governor pedestal, are connected to pressure switches mounted in a nearby terminal box. The assemblies have an orifice on the system supply side and are connected to a drain or vent on the other side. An orifice is provided in each channel so that the measured parameter is not affected during testing. An isolation valve on the supply side allows the test block assembly to be serviced.

If the medium (pressure or vacuum) reaches a trip setpoint, then the pressure sensors ~~switches would function and~~ cause the autostop emergency trip header mechanism to operate. When functionally testing an individual trip device, the medium is reduced to the trip setpoint in one channel either locally through the hand test valves or remotely from the trip test panel via the test solenoid valves.

10.2.2.5.4 Thrust Bearing Trip Device

Two position pickups, which are part of the turbine supervisory instrument package, monitor movement of a disc mounted on the rotor near the thrust bearing collar. Axial movement of this collar is reflected in movement of the disc. Excessive movement of the disc is an indication of thrust bearing wear. Should excessive movement occur, relay contacts from the supervisory instrument modules close to initiate a turbine trip.

The thrust bearing trip function can be checked by a test device which simulates movement of the rotor to activate the trip outputs from the modules. ~~on which the pickups are mounted. A trip condition is simulated by moving the pickups toward or away from the disc or the rotor.~~

10.2.2.5.5 Electrical Overspeed Trip

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Three channels of turbine overspeed sensing are provided, each with its own magnetic speed pickup and tachometer. The emergency trip system controller uses two out of three logic for overspeed tripping. As a result, a malfunction in any of these channels does ~~will~~ not cause an invalid trip or prevent a valid trip. Logic is also provided in the controller to detect and identify a malfunction in the speed pickups or tachometers.

Each tripping function can be individually tested from the operator/test panel without tripping the turbine by separately testing each channel of the appropriate trip function. Tests are selected, activated, and reset on the operator/test panel. Isolation between channels provides protection against spurious trips during testing.

10.2.2.6 Other Protective Systems

Additional protective features of the turbine and steam system are:

- Moisture separator reheater safety relief valves
- Rupture diaphragms located on each of the low-pressure turbine cylinder covers
- Turbine water induction protection (TWIP) systems on the extraction steam lines

10.2.2.7 Plant Loading and Load Following

The AP600 turbine-generator control system and control strategy has the same loading and load following characteristics as the control system described in Section 7.7. In addition, the turbine-generator has the following capabilities:

- Daily load change between 100 and 30 percent of rated power
- Transition between baseload and load follow operation
- Extended weekend reduced power operation
- Rapid return to up to 90 percent of rated power

For the AP600, this load following capability is maintained for more than 90 percent of cycle life.

10.2.2.8 Inspection and Testing Requirements

Major system components are readily accessible for inspection and are available for testing during normal plant operation. ~~Controls and protective devices associated with each turbine-generator component are tested on a regularly scheduled basis.~~ Turbine trip circuitry is tested prior to unit startup.

~~For the most efficient turbine operation, the last governor valve to open in sequence should be passing near its full-flow steam capability.~~ To test governor valves with minimal disturbance, the load is reduced to that capable of being carried with one governor valve closed.

10.2.3 Turbine Rotor Integrity

Turbine rotor integrity is provided by the integrated combination of material selection, rotor design, fracture toughness requirements, tests, and inspections. This combination results in a very low probability of a condition that could result in a rotor failure.

10.2.3.1 Materials Selection

Fully integral turbine rotors are made from ladle refined, vacuum deoxidized, Ni-Cr-Mo-V alloy steel by processes which maximize steel cleanliness and provide high toughness. Residual elements are controlled to the lowest practical concentrations consistent with melting practices. The chemical property limits of ASTM A470, Class 5, 6, and 7 are the basis for the material requirements for the turbine rotors. The specification for rotor steel used in the AP600 has lower limitations than indicated in the ASTM standard for phosphorous, sulphur, aluminum, antimony, tin, argon, and copper. This material has the lowest fracture appearance transitions temperatures (FATT) and the highest Charpy V-notch energies obtainable on a consistent basis from water-quenched Ni-Cr-Mo-V material at the sizes and strength levels used. Charpy tests and tensile tests in accordance with American Society of Testing and Materials (ASTM) specification A370 are required from the forging supplier.

The production of steel for the turbine rotors starts with the use of high quality, low residual element scrap. An oxidizing electric furnace is used to melt and dephosphorize the steel. Ladle furnace refining is then used to remove oxygen, sulphur, and hydrogen from the rotor steel. The steel is then further degassed using a process whereby steel is poured into a mold under vacuum to produce an ingot with the desired material properties. This process minimizes the degree of chemical segregation since silicon is not used to deoxidize the steel.

10.2.3.2 Fracture Toughness

Suitable material toughness is obtained through the use of materials described in Subsection 10.2.3.1 to produce a balance of material strength and toughness to provide safety while simultaneously providing high reliability, availability, and efficiency during operation. The restrictions on phosphorous, sulphur, aluminum, antimony, tin, argon, and copper in the specification for the rotor steel provides for the appropriate balance of material strength and toughness The impact energy and transition temperature requirements are more rigorous than those given in ASTM 470 Class 6 or 7.

Bore stress calculations include components due to centrifugal loads and thermal gradients where applicable. The ratio of material fracture toughness, K_{IC} (as derived from material tests on each rotor) to the maximum tangential stress for rotors at speeds from normal to design overspeed, will be at least 200 ksi x $\sqrt{in}$ (or at least 2) at minimum operating temperature. Material fracture toughness needed to maintain this ratio is verified by mechanical property tests on material taken from the rotor.

The rotor is evaluated for fracture toughness by criteria that include the design duty cycle stresses, number of cycles, ultrasonic examination capability and growth rate of potential flaws. Conservative factors of safety are included for the size uncertainty of potential or reported ultrasonic indications, rate of flaw growth (da/dN versus dK) and the duty cycle stresses and number.

A rotor forging is not accepted with a reported indication, adjusted for size uncertainty and interaction, which would grow to critical size in the applicable duty cycles of combined rotation and maximum transient thermal stress based on the brittle fracture and rotor fatigue analyses described below.

Maximum transient thermal stresses are determined from historical maximum loading rates for nuclear service rotors.

10.2.3.2.1 Brittle Fracture Analysis

A brittle fracture analysis is performed on the turbine rotor to provide confidence that small flaws in the rotor, especially near the center line, do not grow to a critical size with unstable growth resulting in a rotor burst. The brittle fracture analysis process includes determining the stresses in the rotor resulting from rotation, steady state thermal loads, and transient thermal loads from startup and load change. These stresses are combined to generate the maximum stresses and locations of maximum stress for the startup and load change transients. A fracture mechanics analysis is performed at the location(s) of maximum stress to verify that an initial flaw, equal to the minimum reportable size, will not grow to critical crack size over the life of the rotor under the cumulative effects of startup and load change transients.

A fracture mechanics analysis is done at the location(s) of maximum stress to determine the critical crack size and the initial flaw area that would just grow to the critical size when subjected to the number of startup and load change cycles determined to represent the lifetime of the rotor. This initial flaw area is divided by a factor of safety to generate an allowable initial flaw area. The minimum reportable flaw size is multiplied by a conservative factor to correct for the imperfect nature of a flaw as an ultrasonic reflector, as compared to the calibration reflector. The resulting area is the corrected flaw area. For an acceptable design the allowable initial flaw area must be greater than or equal to the corrected flaw area.

A flaw is assumed to be an internal elliptical crack on the centerline for rotors without bores. For rotor contour or for flaws near the rotor bore (for bored rotors), a surface connected elliptical crack is assumed. Analysis of the flaws is done assuming various flaw aspect ratios and the most conservative results are used. The flaw is assumed to be orientated normal to the maximum principle stress direction.

The beginning of life fracture appearance transition temperature for the high pressure and low pressure rotor is specified in the material specification for the specific material alloy selected. Both the high pressure and low pressure turbines operate at a temperature at which temperature embrittlement is insignificant. The beginning of life fracture appearance transition temperature is not expected to shift during life of the rotor due to temperature embrittlement.

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Minimum material toughness is provided in the turbine rotors by specification of maximum fracture appearance transition temperature and minimum upper shelf impact energy for the specific material alloy selected. There is not a separate material toughness (K_{IC}) requirement for AP600 rotors.

10.2.3.2.2 Rotor Fatigue Analysis

A fatigue analysis is performed for the turbine rotors to show that the cumulative usage is acceptable for expected transient conditions including normal plant start-ups, load following cycling, and other load changes. The fatigue design curves are based on mean values of fatigue test data. Margin is provided by assuming a conservatively high number of turbine start and stop cycles. The Westinghouse designed turbine rotors in operating nuclear power plants were designed using this methodology and have had no history of fatigue crack initiation due to duty cycles.

In addition to the low cycle fatigue analysis for transient events, an evaluation for high cycle fatigue is performed. This analysis considers loads due to gravity bending, bearing elevation misalignment, control stage partial arc admission bearing reactions and steady state unbalance stress. The local alternating stress is calculated at critical rotor locations considering the bending moments due to the loads described above. The maximum alternating stress is less than the smooth bar endurance strength modified by a size factor.

The AP600 turbine generator is mounted on a spring mounted support system to isolate the dynamic behavior of the turbine generator equipment from the foundation structure. The support system includes a reinforced concrete deck on which the turbine generator is mounted. The deck is sized to maintain the gravity load and misalignment load bending stresses within allowable limits. The evaluation of the loads includes a dynamic analysis of the combined turbine-generator and foundation structure.

10.2.3.3 High Temperature Properties

The operating temperatures of the high-pressure rotors are below the creep rupture range. Creep rupture is, therefore, not considered to be a significant factor in providing rotor integrity over the lifetime of the turbine. Basic data are obtained from laboratory creep rupture tests.

10.2.3.4 Turbine Rotor Design

The turbine assembly is designed to withstand normal conditions and anticipated transients, including those resulting in turbine trip, without loss of structural integrity. The design of the turbine assembly meets the more restrictive of the following criteria:

- The maximum tangential stress resulting for centrifugal forces does not exceed 65 percent of the 0.2 percent offset yield strength at design temperature and speed; or,

- The tangential stresses will not cause a flaw that is twice the corrected ultrasonic examination reportable size to grow to critical size in the design life of the rotor.

The high pressure turbine has fully integral rotors forged from a single ingot of low alloy steel. This design is inherently less likely to have a failure resulting in a turbine missile than previous designs with shrunk on disks. A major advantage of the fully integral rotor is the elimination of disc bores and keyways. In the fully integral rotor design the location of peak stresses are in the lower stress blade fastening areas. This difference results in a substantial reduction of the rotor peak stresses. The reduction of peak stresses results in a reduction of the potential of crack initiation. The reduction in peak stress also permits selection of a material with improved ductility, toughness, and resistance to stress corrosion cracking.

The non-bored design of the high-pressure turbine element provides the necessary design margin by virtue of its inherently lower centerline stress. Metallurgical processes permit fabrication of the rotors without a center borehole. The use of solid rotor forgings was qualified by evaluation of the material removed from center bored rotors for fossil power plants. This evaluation demonstrated that the material at the center of the rotors satisfied the rotor material specification requirements. Supply of forgings for no-bore rotors is by suppliers that have been qualified based on bore material performance.

The low-pressure turbine element is a fully integral rotor fabricated from a single forging with a central bore. There are no keyways, which can be potential locations for stress risers ~~ing~~ and corrosive contaminate concentration, ~~keyways~~ exposed to a steam environment. The integral disc profiles are carefully designed to limit the surface stress in areas vulnerable to stress corrosion if a less than ideal steam environment exists to 50 percent of the yield strength to reduce the chances of stress corrosion as far as practicable.

10.2.3.5 Preservice Tests and Inspections

Preservice inspections for turbine rotors include the following:

- Rotor forgings are rough machined with a minimum stock allowance prior to heat treatment.

- Each rotor forging is subjected to a 100-percent volumetric (ultrasonic) examination. Each finish-machined rotor is subjected to a surface magnetic particle and visual examination. Results of the above examination are evaluated by use of criteria that are more restrictive than those specified for Class 1 components in ASME Code, Section III and V. These criteria include the requirement that subsurface sonic indications are either removed or evaluated to verify that they do not grow to a size which compromises the integrity of the unit during the service life of the unit.

- Finish-machined surfaces are subjected to a magnetic particle examination. No magnetic particle flaw indications are permissible in bores (if present) or other highly stressed regions.

- Each fully bladed turbine rotor assembly is spin tested at 20 percent overspeed, the maximum speed following a load rejection from full load.

Rotor areas which require threaded holes are not subjected to a magnetic particle examination. The number of threaded holes are minimized and are not located in high stress areas.

10.2.3.6 Maintenance Program and Inservice Inspection

~~Recommendations of the turbine vendor for t~~The maintenance and inspection program plan for ~~of~~ the turbine assembly and valves provided by the Combined License holder is based on turbine missile probability calculations, operating experience and inspection results. The methodology for analysis of the probability of generation of missiles for fully integral rotors was submitted in WSTG-4-P (Reference 1). The methodology used for analysis of the missile generation probability calculations related to turbine valve test frequency is described in WCAP-11525 (Reference 2). The recommendations include the ~~following:~~ activities outlined below.

- Disassembly of the turbine is conducted during plant shutdown. Inspection of parts that are normally inaccessible when the turbine is assembled for operation (couplings, coupling bolts, turbine rotors, and low-pressure turbine blades) is conducted.

  This inspection consists of visual, surface, and volumetric examinations as indicated below:

  - ~~1.~~ Each rotor and stationary and rotating blade path component is inspected visually and by magnetic particle testing on accessible surfaces. Ultrasonic inspection of the side entry blade grooves is conducted. These inspections are conducted at intervals of about 10 years for low-pressure turbines and about 8 years for high-pressure turbines.

  - ~~2.~~ A 100-percent surface examination of couplings and coupling bolts is performed.

  - Fluorescent penetrant examination is conducted on nonmagnetic components.

- At least one main steam stop valve, one main steam control valve, one reheat stop valve, and one intercept valve are dismantled approximately every 4 ~~5~~ years during scheduled refueling or maintenance shutdowns. A visual and surface examination of valve internals is conducted. If unacceptable flaws or excessive corrosion are found in a valve, the other valves of its type are inspected. Valve bushings are inspected and cleaned, and bore diameters are checked for proper clearance.

- Main stop valves, control valves, reheat stop and intercept valves may be ~~are~~ tested with the turbine online. The DEH control test panel is used to stroke or partially stroke the valves ~~from full open to full closed~~.

- Extraction nonreturn valves are tested prior to each startup.

The valve inspection frequency of four years noted above is based on evaluations performed to support this valve inspection interval at operating plants. A monitoring program is in place at operating nuclear power plants to verify the success of longer valve inspection intervals. A Combined License holder recomendation for a valve inspection frequency longer than four years may be justified when a longer interval is supported by operating and inspection program experience and supported by the missile generation probability calculations. See subsection 10.2.6.3.

Turbine valve testing is performed at quarterly intervals. The quarterly testing frequency is based on nuclear industry experience that turbine related tests are the most common cause of plant trips at power. Plant trips at power may lead to challenges of the safety-related systems. Evaluations show that the probability of turbine missile generation with a quarterly valve test is less than the evaluation criteria.

Extraction nonreturn valves are tested locally by stroking the valve full open with air, then equalizing air pressure, allowing the spring closure mechanism to close the valve. Closure of each valve is verified by direct observation of the valve arm movement.

10.2.4 Evaluation

Components of the turbine-generator are conventional and typical of those which have been extensively used in other nuclear power plants. Instruments, controls, and protective devices are provided to confirm reliable and safe operation. Redundant, fast actuating controls are installed to prevent ~~any~~ damage resulting from overspeed and/or full-load rejection. The control system initiates a turbine trip upon reactor trip. Automatic low-pressure exhaust hood water sprays are provided to prevent excessive hood temperatures. Exhaust casing rupture diaphragms are provided to prevent low-pressure cylinder overpressure in the event of loss of condenser vacuum. The diaphragms are flange mounted and designed to maintain atmospheric pressure within the condenser and turbine exhaust housing while passing full flow.

Since the steam generated in the steam generators is not normally radioactive, no radiation shielding is provided for the turbine-generator and associated components. Radiological considerations do not affect access to system components during normal conditions. In the event of a primary-to-secondary system leak due to a steam generator tube leak, it is possible for the steam to become contaminated. Discussions of the radiological aspects of primary-to-secondary leakage are presented in Chapters 11 and 12.

10.2.5 Instrumentation Applications

The turbine-generator is provided with ~~a full complement~~ of turbine supervisory instrumentation including monitors for: ~~. It is complete with sensors and/or transmitters mounted on the associated equipment which indicate the following:~~

- Speed
- Stop valve position
- Control valve position
- Reheat intercept and stop valve positions

- Temperatures as required for controlled starting, including:
  - External valve chest inner surface
  - External valve chest outer surface
  - First-stage shell lower inner surface
  - Crossover pipe downstream of reheat stop valve No. 1
  - Crossover pipe downstream of reheat stop valve No. 2
  - Crossover pipe downstream of reheat stop valve No. 3
  - Crossover pipe downstream of reheat stop valve No. 4
- Casing and shaft differential expansion
- Vibration of each bearing
- Shaft eccentricity
- Bearing metal temperatures

Alarms are provided for the following abnormal conditions:

- High vibration
- Turbine supervisory instruments common alarm

In addition to the turbine protective trips listed in subsection 10.2.2.5, the following trips are provided:

- High-exhaust hood temperature
- Low-emergency trip system pressure
- Low shaft-driven lube oil pump discharge pressure ~~trip~~
- High or low level in moisture separator drain tank

Indications of the following miscellaneous parameters are provided:

- Main steam throttle pressure
- Steam seal supply header pressure
- Steam seal condenser vacuum
- Bearing oil header pressure
- Bearing oil coolers coolant temperature
- DEH control fluid header pressure
- DEH control fluid temperature
- Crossover pressure
- Moisture separator drain tank level
- First-stage pressure
- High-pressure turbine exhaust pressure
- Extraction steam pressure, each extraction point
- Low-pressure turbine exhaust hood pressure
- Exhaust hood temperature for each exhaust

Generator supervisory instruments are provided, with sensors and/or transmitters mounted on the associated equipment. These indicate or record the following:

- Multiple generator stator winding temperatures;. the detectors are built into the generator, ~~fully~~ protected from the cooling medium, and ~~suitably~~ distributed around the circumference in positions having the highest expected temperature
- Stator coil discharge gas temperature (two detectors per phase)
- Hydrogen cooler inlet gas temperature (two detectors at each point)
- Hydrogen gas pressure
- Hydrogen gas purity
- Generator winding overtemperature
- Generator ampere, voltage, and power

Additional generator protective devices are listed in Table 10.2-3.

10.2.6 Combined License Information

The Combined License holder will prepare a turbine maintenance program. The program will address the recommendations in subsection 10.2.3.6 with specific inspection and maintenance interval commitments. The program will include supporting missile generation probability calculations. The calculation method used in WCAP-11525 (Reference 2) is an acceptable method for performing the missile generation probability calculations related to turbine valve test frequency. The maintenance program assumptions and calculations will be consistent with the results and conclusions in the turbine rotor integrity analysis. The turbine rotor integrity analysis includes consideration of brittle fracture, fatigue due to combined rotation and thermal stress, and flaw growth analysis. The combined license applicant will have available plant specific turbine rotor test data and calculated toughness curves that support the material property assumptions in the turbine rotor analysis.

10.2.7 References

1. WSTG-4-P, Proprietary and WSTG-4-NP, Nonproprietary, "Analysis of the Probability of the Generation of Missiles from Fully Integral Nuclear Low Pressure Turbines." October 1984.
2. WCAP-11525, Probabilistic Evaluation of Reduction in Turbine Valve Test Frequency, 1987

Table 10.2-1

TURBINE-GENERATOR AND AUXILIARIES DESIGN PARAMETERS

Manufacturer Westinghouse

Turbine

Type	TC4F 47-in. last row blades
No. of elements	1 high pressure; 2 low pressure
Last-stage blade length (in.)	47
Operating speed (rpm)	1800
Condensing pressure (in. HgA)	2.5
Turbine cycle heat rate (Btu/kWh)	9812

Generator

Generator rated output (kW)	792,000 (nominal)
Power factor	0.90
Generator rating (kVA)	880,000 (nominal)
Voltage (kV)	22
Hydrogen pressure (psig)	75

Moisture separator/reheater

Moisture separator	Chevron vanes
Reheater	U-tube
Number	1 shell
Stages of reheating	1

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Table 10.2-2

TURBINE OVERSPEED PROTECTION

Percent of Rated Speed (Approximate)	Event
100	Turbine is initially at valves wide open. Full load is lost. Speed begins to rise. When the breaker opens, the load drop anticipator immediately closes the control and intercept valves if the load at time of separation is greater than 30 percent.
101	Control and intercept valves begin to close.
103	The overspeed protection controller closes the control and intercept valves until the speed drops below 103 percent.
108	Peak transient speed with normally operating speed control system.
	If the power/load unbalance and speed control systems had failed prior to loss of load, then:
110-111	The electronic emergency trip system closes the control and intercept valves based on a two-out-of-three trip logic system.

Following the above sequence of events, the turbine will approach but not exceed 120 percent of rated speed.

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Table 10.2-3 (Sheet 1 of 2)
GENERATOR PROTECTIVE DEVICES FURNISHED WITH THE VOLTAGE REGULATOR PACKAGE

Device	Action	
• Generator Minimum Excitation Limiter	Limiter	- maintains generator reactive power output ~~KVA~~ above certain level (normally steady state stability limit level)
	Alarm	- when limiter is limiting
• Generator Maximum Excitation Limiter	Limiter	- maintains generator field voltage below certain voltage inverse ~~increase~~ time characteristics
	Alarm	- when limiter is timing
	Alarm	- when limiter is limiting
• Generator Overexcitation Protection	Alarm	- repositions the dc regulator adjuster to a preset position when overexcitation protection pickup level is exceeded
Inverse Timer	Alarm	- when timing commences
	ac regulator trip	- when timed out
Fixed Timer	Alarm	- when timing
	Unit trip	- when timed out
• Generator Volts/Hertz Limiter	Limiter	- maintains machine terminal volts/Hertz ratio below certain level
	Alarm	- when limiter is limiting
• Generator Dual Level Volts/Hertz Protection	Alarm	- when above either preset volts/Hertz level
	Unit trip	- if timed out at either alarm level
• Generator Automatic ~~Automated~~ Field Ground Detection	Alarm	- brush failure (alarms about 20 seconds)
	Alarm	- ground
• Regulator Firing Circuit - Loss of Thyristor Firing Pulse Protection	Alarm	- loss of one firing circuit
	Unit Trip	- loss of both firing circuits
• Thyristor Blown Fuse Detection	Alarm	- When one or more thyristor fuses in power drawers open

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Table 10.2-3 (Sheet 2 of 2)

GENERATOR PROTECTIVE DEVICES FURNISHED WITH THE VOLTAGE REGULATOR PACKAGE

Device	Action	
• Regulator Forcing Indication	Alarm	-on-line forcing
	Alarm	-off-line forcing (blocks "Raise" controls of ~~at~~ dc regulator and ac regulator adjustors)
• Regulator Loss of Power Supply (s)	Alarm	- loss of one power supply
Protection	Unit trip	- loss of both power supplies
• Regulator Loss of Sensing Protection	Alarm & AC regulator trip	when regulator voltage transformer sensing is lost
• Excitation Supply Breaker	Alarm Excitation trip	
• Alternate Excitation Removal Equipment	Alarm	- For fast de-excitation, phase back thyristor firing pulses for specified time, then trip excitation supply breaker
• Power System Stabilizer (PSS) Excessive Output Protection	Alarm Power System Stabilizer trip	- When PSS output exceeds specified level for specified time
• Power System Stabilizer Inservice Instrumentation Indication	Indicator	- lamps and contacts
• Exciter - Air Temperature Detection	Alarm	
• Exciter - Rotation Vibration Pick-up	Alarm Unit Trip	
• Exciter - Bearing Metal Detection	Alarm	
• Generator - Overvoltage Protection	Alarm	Phase back thyristor firing pulses if overvoltage condition persists for a specified time
• Exciter Diode Fuse Detection	Indicator	- Flag on Rotating Fuse raiser when fuse opens, Detected periodic checks with strobe light.

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Table 10.2-4

Turbine-Generator Valve Closure Times

Valve	Closing Time (Seconds)
Main stop valves	0.3
Control valves	0.3
Intercept valves	0.3
Reheat stop valves	0.3
Extraction nonreturn valves	<1.0

AP600 DSER OPEN ITEMS STATUS
CHAPTER 3 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
574	3.5.1.3-1	OI	Resolved	Need SSAR revision per 10/95 draft.
575	3.5.1.3-2	OI	Resolved	Need SSAR revision per 10/95 draft.
576	3.5.1.3-3	OI	Resolved	Need SSAR revision per 10/95 draft.
577	3.5.1.3-4	OI	Resolved	Need SSAR revision per 10/95 draft.
578	3.5.1.3-5	OI	Resolved	Need SSAR revision per 10/95 draft.
579	3.5.1.3-6	OI	Resolved	Need SSAR revision per 10/95 draft.
580	3.5.1.3-7	OI	Resolved	Need SSAR revision per 10/95 draft.
581	3.5.1.3-8	OI	Resolved	Need SSAR revision per 10/95 draft.
582	3.5.1.3-9	OI	Resolved	Need SSAR revision per 10/95 draft.
583	3.5.1.3-10	OI	Resolved	Need SSAR revision per 10/95 draft.
584	3.5.1.3-11	OI	Resolved	Need SSAR revision per 10/95 draft.
585	3.5.1.3-12	OI	Resolved	Need SSAR revision per 10/95 draft.
586	3.5.1.3-13	OI	Action W	Westinghouse to provide commitment that COL licensee will submit its turbine maintenance program to the NRC within 3 years of obtaining its license.
1878	3.5.1.3-1	COL	Resolved	Need SSAR revision per 10/95 draft.
1879	3.5.1.3-2	COL	Resolved	Need SSAR revision per 10/95 draft.
1880	3.5.1.3-3	COL	Resolved	Need SSAR revision per 10/95 draft.
1881	3.5.1.3-4	COL	Resolved	Need SSAR revision per 10/95 draft.
1882	3.5.1.3-5	COL	Resolved	Need SSAR revision per 10/95 draft.

AP600 DSER OPEN ITEMS STATUS
CHAPTER 4 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
857	4.5.1-1	OI	Resolved	
858	4.5.1-2	OI	Resolved	
859	4.5.1-3	OI	Resolved	
860	4.5.1-4	OI	Resolved	
861	4.5.1-5	OI	Resolved	
862	4.5.1-6	OI	Resolved	
863	4.5.1-7	OI	Resolved	
864	4.5.1-8	OI	Resolved	
865	4.5.1-9	OI	Resolved	
866	4.5.1-10	OI	Resolved	
867	4.5.1-11	OI	Resolved	
868	4.5.1-12	OI	Resolved	
869	4.5.1-13	OI	Action W	Revise SSAR to show latest version of AMS specifications (send copy of specs to NRC for review).
870	4.5.1-14	OI	Resolved	
871	4.5.1-15	OI	Resolved	
872	4.5.1-16	OI	Resolved	
873	4.5.1-17	OI	Resolved	
874	4.5.1-18	OI	Resolved	
875	4.5.2-1	OI	Closed	
876	4.5.2-2	OI	Closed	
877	4.5.2-3	OI	Closed	
878	4.5.2-4	OI	Closed	
879	4.5.2-5	OI	Closed	
880	4.5.2-6	OI	Closed	
881	4.5.2-7	OI	Closed	

AP600 DSER OPEN ITEMS STATUS
CHAPTER 5 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
882	5.2.1.1-1	OI	Closed	
883	5.2.1.1-2	OI	Closed	
884	5.2.1.1-3	OI	Closed	
885	5.2.1.2-1	OI	Closed	
888	5.2.3-1	OI	Resolved	
889	5.2.3-2	OI	Resolved	
890	5.2.3-3	OI	Resolved	
891	5.2.3-4	OI	Resolved	
892	5.2.3-5	OI	Resolved	
893	5.2.3-6	OI	Resolved	
894	5.2.3-7	OI	Resolved	
895	5.2.3-8	OI	Resolved	
896	5.2.3-9	OI	Resolved	
897	5.2.3-10	OI	Resolved	
898	5.2.3-11	OI	Resolved	
899	5.2.3-12	OI	Resolved	
900	5.2.4-1	OI	Closed	
901	5.2.4-2	OI	Closed	
902	5.2.4-3	OI	Closed	
903	5.2.4-4	OI	Closed	
904	5.2.4-5	OI	Closed	
905	5.2.4-6	OI	Closed	
906	5.2.4-7	OI	Closed	
907	5.2.4-8	OI	Closed	
915	5.3.2-1	OI	Closed	
916	5.3.2-2	OI	Closed	
917	5.3.2-3	OI	Closed	
918	5.3.2-4	OI	Closed	
919	5.3.2-5	OI	Closed	
920	5.3.2-6	OI	Closed	
921	5.3.2-7	OI	Closed	
922	5.3.2-8	OI	Closed	
923	5.3.3-1	OI	Closed	
924	5.3.3-2	OI	Closed	
925	5.3.5-1	OI	Closed	
931	5.4.1.4-1	OI	Closed	
932	5.4.1.4-2	OI	Closed	
933	5.4.2.1-1	OI	Closed	
934	5.4.2.1-2	OI	Confirmatory	
935	5.4.2.1-3	OI	Closed	
1894	5.2.4-1	COL	Closed	
1895	5.2.4-2	COL	Closed	
1896	5.3.2-1	COL	Closed	
1897	5.3.3-1	COL	Closed	
1898	5.3.3-2	COL	Closed	
1899	5.3.5-1	COL	Closed	

AP600 DSER OPEN ITEMS STATUS
CHAPTER 6 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
960	6.1.1-1	OI	Resolved	
961	6.1.1-2	OI	Resolved	
962	6.1.1-3	OI	Resolved	
963	6.1.1-4	OI	Resolved	
964	6.1.1-5	OI	Resolved	
965	6.1.1-6	OI	Resolved	
966	6.1.1-7	OI	Resolved	
967	6.1.1-8	OI	Resolved	
968	6.1.1-9	OI	Resolved	
969	6.1.2-1	OI	Action W	Need justification of safety classification relative to coating on outside of containment shell.
970	6.1.2-2	OI	Action W	Need discussion of 60-year life of coating on outside containment shell.
971	6.1.2-3	OI	Action W	
1026	6.6-1	OI	Resolved	
1027	6.6-2	OI	Resolved	
1028	6.6-3	OI	Resolved	
1029	6.6-4	OI	Resolved	
1030	6.6-5	OI	Resolved	
1031	6.6-6	OI	Resolved	
1032	6.6-7	OI	Resolved	
1033	6.6-8	OI	Resolved	Resolved for Class 2 and 3 components only.
1034	6.6-9	OI	Resolved	
1035	6.6-10	OI	Resolved	
1901	6.1.1-1	COL	Resolved	
1904	6.6-1	COL	Resolved	
1905	6.6-2	COL	Resolved	
1906	6.6-3	COL	Resolved	
1907	6.6-4	COL	Resolved	

AP600 DSER OPEN ITEMS STATUS
CHAPTER 9 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
1092	9.2.3-1	OI	Closed	
1095	9.3.3-1	OI	Closed	
1096	9.3.3-2	OI	Closed	
1097	9.3.3-3	OI	Closed	
1098	9.3.3-4	OI	Closed	
1100	9.3.6-1	OI	Closed	
1101	9.3.6-2	OI	Active	RTNSS-related
1102	9.3.6-3	OI	Active	RTNSS-related

AP600 DSER OPEN ITEMS STATUS
CHAPTER 10 (EMCB)

Item No.	DSER Item No.	Item Type	NRC Status	Comments
1135	10.2.9-1	OI	Resolved	
1136	10.2.9-2	OI	Resolved	Need revision to SSAR 10.2.3.1.
1137	10.2.9-3	OI	Resolved	
1138	10.2.9-4	OI	Resolved	Need SSAR revision per 10/95 draft.
1139	10.2.9-5	OI	Resolved	Need SSAR revision per 10/95 draft.
1140	10.2.9-6	OI	Action W	Westinghouse to provide commitment that COL licensee will submit its turbine maintenance program to the NRC within 3 years of obtaining its license.
1141	10.2.9-7	OI	Resolved	Need SSAR revision per 10/95 draft.
1144	10.3.1-1	OI	Resolved	Need SSAR revision per draft.
1145	10.3.1-2	OI	Resolved	Need SSAR revision per draft.
1146	10.3.1-3	OI	Resolved	Need SSAR revision per draft.
1147	10.3.1-4	OI	Resolved	Need revision to SSAR 10.1.2.
1148	10.3.1-5	OI	Action W	Need description of the program or methodology for predicting E/C.
1149	10.3.1-6	OI	Resolved	
1155	10.4.6-1	OI	Resolved	
1156	10.4.6-2	OI	Resolved	
1157	10.4.6-3	OI	Resolved	
1158	10.4.6-4	OI	Resolved	
1159	10.4.6-5	OI	Resolved	
1160	10.4.6-6	OI	Resolved	
1161	10.4.6-7	OI	Resolved	
1163	10.4.8-1	OI	Resolved	
1823	10.3.1-1	CN	Resolved	Need SSAR revision per draft.
1824	10.4.6-1	CN	Resolved	
1925	10.2.9-1	COL	Action W	Westinghouse to provide commitment that COL licensee will submit its turbine maintenance program to the NRC within 3 years of obtaining its license.
1926	10.2.9-2	COL	Resolved	Need revision to SSAR 10.2.3.2.
2030		DSER-OI50	Closed	