APPENDIX 19F MALEVOLENT AIRCRAFT IMPACT

19F.1 Introduction and Background

A design-specific assessment of the effects on the AP1000 of the beyond design basis impact of a large commercial aircraft has been performed in accordance with 10 CFR 50.150(a) to identify design features and functional capabilities that demonstrate with reduced use of operator actions: (i) the reactor core remains cooled, the containment remains intact, and (ii) spent fuel pool integrity is maintained. The specific assumptions regarding the aircraft impact were based on guidance provided by the NRC and the Nuclear Energy Institute, including the loading function derived from the aircraft impact characteristics for use in assessments of aircraft impact effects.

This appendix describes those design features and functional capabilities identified in the assessment, and discusses how the identified design features and functional capabilities show that with reduced use of operator actions, the reactor core remains cooled and the containment remains intact, and spent fuel pool integrity is maintained. In the following discussion, the identified design features are designated as "key design features."

19F.2 Scope

The evaluation of plant damage caused by the impact of a commercial aircraft is a complex analysis problem involving phenomena associated with structural impact, shock-induced vibration, and fire effects. The assessment of the aircraft impact also considers structural damage, such as that caused by the impact/penetration of hardened components (e.g., engine rotors, landing gear).

An assessment of the effects of aircraft fuselage and wing structure is also performed.

An assessment of the effects of shock-induced vibration on systems, structures, and components is performed.

An assessment of the impact/penetration of hardened aircraft components, such as engine rotors and landing gear is performed.

Perforation of analyzed structural components, including the containment vessel and the spent fuel pool liner, is not predicted; therefore, realistic assessments of the damage to internal systems, structures, and components caused by 1) burning aviation fuel and 2) secondary impacts are not required.

19F.3 Assessment Methodology

Methods described in NEI 07-13, Revision 7 (Reference 1) were followed to assess the effects on the structural integrity of the primary containment and spent fuel pool, and to assess the physical, fire, and vibration effects of the aircraft impact on the core cooling capability of the existing and enhanced design. In accordance with the recommendation set forth in subsection 2.4.1(4) of NEI 07-13, Revision 7, an analytical evaluation and experimental verification has been performed for the first of a kind steel-concrete modular design feature subjected to the aircraft impact loading.

19F.4 Results/Conclusions

A detailed aircraft impact assessment was performed for AP1000 in accordance with the guidance in NEI 07-13 (Reference 1). The assessment concludes that an aircraft impact would not inhibit AP1000's core cooling capability, would not impact containment integrity, and would not impact spent fuel pool integrity based on best-estimate calculations.

The assessment resulted in the identification of the following design features and functional capabilities; changes to which are evaluated and reported in accordance with 10 CFR 50.150(d).

19F.4.1 Shield Building and Spent Fuel Pool

The shield building, as described in Chapter 3, is a key design feature for the protection of the safety systems located inside containment from the impact of a large commercial aircraft. The assessment concludes that a strike upon the shield building would not result in perforation of the shield building so damage to the containment vessel would not occur. Therefore, the systems and equipment within the containment vessel are not damaged from the impact or from exposure to jet fuel.

The assessment finds that safety-related components inside containment, including the reactor pressure vessel and passive core cooling system, remain intact and maintain their intended capabilities following the shock-induced vibrations resulting from the impact of a large commercial aircraft based on applying the methodology in Reference 1.

This assessment also concludes that a strike upon the auxiliary building would not result in loss of spent fuel pool liner integrity. Both the structural design of the shield building and the auxiliary building, as described in Chapter 3, are considered key design features.

19F.4.2 Site Arrangement

The assessment credits the design and arrangement of certain building features, depicted in Figures 3.7.2-12 and 3.7.2-19, to limit the effects of a potential aircraft impact on the auxiliary building. These key features are as follows:

- The design of the wall along the south end of the turbine building at column line 11.2, as described in subsection 3.7.2.8.3, is a key design feature for the protection of the auxiliary building from the impact of a large commercial aircraft.

- The design of the wall along the east side of the annex building at column line E, as depicted in Figure 3.7.2-19, is a key design feature for the protection of the auxiliary building from the impact of a large commercial aircraft.

- The design and location of the spent fuel pool in the southern portion of the auxiliary building, as depicted in Figure 3.7.2-12 and described in subsection 9.1.2.2, is a key design feature for the protection of the spent fuel from the effects of an impact of a large commercial aircraft. The spent fuel pool is located in area 6 of the auxiliary building. The spent fuel pool liner is protected from the east, south, and west by a minimum of 7 feet, 3 inches of concrete

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and from the north by the location of the shield building. Therefore, the liner is not impacted and the spent fuel pool integrity is maintained.

- The locations of the main control room (MCR), remote shutdown station, and secondary diverse actuation system (DAS) panel are a key design feature for the protection against the physical and fire damage resulting from the impact of a large commercial aircraft. The detailed aircraft impact assessment shows that an aircraft impact cannot destroy all three of these locations due to the number of barriers associated with these locations. The main control room is located in room 12401, the remote shutdown station is located in room 12303, and the secondary DAS panel is located in room 12554. The assessment determined that any impact scenario would not destroy all three of these locations, and from any one of these locations, passive safety injection and recirculation for long-term core cooling can be initiated.

- The design of the five oversized doors located on the east wall of room [ ]^{SRI}, the east wall of room [ ]^{SRI}, the shield building wall on the west side of room [ ]^{SRI}, east wall of room [ ]^{SRI} and the shield building wall on the west side of room [ ]^{SRI} are key design features for the protection against the physical and fire damage resulting from the impact of a large commercial aircraft. These doors and their connections to the walls are considered key design features because they are designed with a thickness that provides impact resistance equivalent to that of the wall. The doors at the east wall of room [ ]^{SRI}, the shield building wall on the west side of room [ ]^{SRI}, east wall of room [ ]^{SRI}, and the shield building wall on the west side of room [ ]^{SRI} are normally thicker than what is required for impact resistance due to radiation shielding. The door on the east wall of room [ ]^{SRI} is calculated to have a thickness of at least 5″ steel to meet the impact resistance requirement. The walls are considered key design features for protecting containment integrity and core cooling.

19F.4.3 Core Cooling and Containment Integrity

If necessary, core cooling can be maintained by actuating the passive safety injection portion of the Passive Core Cooling System (PXS) and Reactor Coolant System (RCS) as described in DCD Section 6.3. The portions of the PXS and RCS required for safety injection are located inside containment and are key design features. Their location protects them from damage due to an aircraft impact because the containment vessel remains intact and has no structural damage. The following valves are key design features and need to actuate for passive safety injection and recirculation for long-term core cooling:

- ADS Stage 4 squib valves, RCS-V004A/B/C/D (3 of 4)

- In-containment refueling water storage tank (IRWST) injection line squib valves, PXS-V123A/B and PXS-V125A/B (1 of 4)

- Recirculation line squib valves, PXS-V118A/B and PXS-V120A/B (1 of 4)

The steel containment vessel is protected by the shield building and is a key design feature. Based on beyond design basis calculations, the steel containment vessel is not impacted as a result of an

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aircraft impact on the shield building. If necessary, containment integrity is maintained by portions of the Passive Containment Cooling System (PCS). Containment integrity is maintained via air-only cooling by the passive containment cooling system. As discussed in Section 19.40, with air-only cooling (without design basis cooling), containment failure within 24 hours is predicted to be highly unlikely.

For design basis accidents, containment cooling is provided by water cooling of containment. Water cooling is distributed onto the containment vessel by the PCS water distribution bucket located above the containment vessel. Although the water distribution bucket is predicted to be unnecessary following an aircraft impact, an assessment has been performed on the water distribution bucket and predicts the support structure to be intact.

SRI

19F.4.4 Reactor Trip

The reactor trip equipment is a key design feature. This equipment includes the sensors and manual inputs, protection and safety monitoring system cabinets, and reactor trip switchgear as described in subsection 7.2.1. In the event of an aircraft impact, it is likely that ac power will be lost. On a loss of ac power, the control rods are de-energized and fall by gravity into the reactor core. If ac power is not lost, plant shutdown will be controlled by the intact protection and safety monitoring system or initiated manually from the main control room, remote shutdown room, or reactor trip switchgear. Additionally, if PMS is not intact as a result of the impact, the reactor trip breakers will open due to undervoltage. This results in the control rods being de-energized and falling into the reactor core. If the reactor trip switchgear or rod drive motor-generator sets are not intact, the rods also are de-energized and fall by gravity into the reactor core.

19F.4.5 Supporting Power, Instrumentation, and Control Equipment

The supporting equipment for the main control room, remote shutdown station, and secondary DAS panel are key design features. These include the class 1E batteries, the supporting PMS control and instrumentation cabinets and cabling for the equipment identified in Section 19F.4.3, the transfer switch to isolate the MCR and transfer controls to the remote shutdown room, and the DAS cabling for the squib valve control cabinet. These key design features enable the actuation of safety injection through operation of the squib valves. The functional capabilities of the secondary DAS panel are described in subsection 7.7.1.11 and is referred to as the DAS squib valve control cabinet. These key design features are protected by their spatial separation as described in Section 19F.4.2.

19F.4.6 Fire Barriers

The design and location of 3-hour fire barriers within the auxiliary building are key design features for the protection of equipment needed to manually actuate the systems and equipment potentially required for core cooling following the impact of a large commercial aircraft. The assessment credited the design and location of fire barriers (including doors), as described in Appendix 9A, to limit the effects of fire damage created by the impact of a large commercial aircraft. Penetrations through specific barriers in the auxiliary building are rated to withstand a differential pressure of 5 psid based on the methodology in Reference 1. These barriers are identified in subsection 9.5.1.2.1.1.

19F.5 References

1. NEI 07-13, Revision 7, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs."