19.5 Aircraft Impact Assessment

19.5.1 Introduction and Background

The design of the APR1400 takes into account the potential effects of the impact of a large commercial aircraft, which the NRC has determined is a beyond design basis event. In accordance with 10 CFR 50.150(a), a design-specific assessment has been performed for the APR1400 using realistic analysis to demonstrate that, in the event an APR1400 is struck by a large commercial aircraft, design features and functional capabilities exist to ensure that the following functions are maintained:

- The reactor core remains cooled, and
- Spent fuel pool integrity is maintained.

The assessment demonstrates the inherent robustness of the APR1400 design with regard to potential large aircraft impacts.

Specific assumptions used in the APR1400 aircraft impact assessment are based on NRC requirements, and guidance provided by the NRC and the Nuclear Energy Institute (NEI). The methodology for assessing effects for aircraft impact are described in NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8 (Reference 1). These guidelines were fully followed with no exceptions taken.

This section describes the design features and functional capabilities of the APR1400 identified in the detailed assessment that assure the reactor core remains cooled and spent fuel pool integrity is maintained. These identified design features are designated as "key" design features.

19.5.2 Scope of the Assessment

The evaluation of plant damage caused by the impact of a commercial aircraft is a complex problem involving phenomena associated with structural damage resulting from the initial impact, shock-induced vibration, and the effects of an aviation fuel-fed fire. The analysis assessed the following effects of a large commercial aircraft impact on the APR1400.

- damage resulting from the impact of the aircraft fuselage and wing structure;
- shock-induced vibration on systems, structures, and components (SSC);

- penetration of hardened aircraft components, such as engine rotors and landing gear; and
- the extent of damage from fires fed by aviation fuel.

The analysis assessed the above effects of a large commercial aircraft impact at multiple locations where a large commercial aircraft could potentially strike critical APR1400 structures.

Perforation of the Spent Fuel Pool (SFP) and Reactor Containment Building (RCB) is not predicted; therefore, realistic assessments of the damage to internal SSCs within the RCB caused by 1) burning aviation fuel and 2) secondary impacts are not required. Realistic best estimate assessments of the damage to internal SSCs within the Auxiliary Building (AB) and Emergency Diesel Generator Building (EDGB) caused by 1) burning aviation fuel and 2) secondary impacts are performed.

19.5.3 Assessment Methodology

Methods described in NEI 07-13 (Reference 1) were followed to assess the effects on the structural integrity of the RCB and the SFP and to assess the physical, fire and vibration effects of the aircraft impact on SSCs in the AB and EDGB to ensure continued core cooling capability.

19.5.4 Assessment Results

The APR1400 Aircraft Impact Assessment concludes that the APR1400 can continue to provide adequate protection of the public health and safety with respect to a large commercial aircraft impact as defined by the NRC. Such an aircraft impact would not impair the APR1400's core cooling capability or spent fuel pool integrity as required by 10 CFR 50.150.

The assessment resulted in the identification of the benefits of the key design features and functional capabilities described below, changes to which are evaluated and reported in accordance with 10 CFR 50.150(c). These key design features and functional capabilities ensure that the APR1400 design fully meets the requirements of 10 CFR 50.150 by maintaining core cooling of fuel in the reactor vessel and the integrity of the spent fuel pool following the impact of a large commercial aircraft on the AB and EDGB, including the effects of burning aviation fuel and secondary impacts.

19.5.4.1 RCB and SFP

The RCB, as described in Sections 3.8.1 and 3.8.2 and shown on Figures 3.8-1 and 3.8-2 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 RCB would not result in the perforation of the containment, such as to cause direct damage or exposure to jet fuel of the systems within the containment.

The assessment also determined that key safety-related components located inside the RCB, including the reactor pressure vessel, steam generators, reactor coolant loop piping, pilot operated safety relief valves, control element drive mechanism, the safety injection and shutdown cooling system suction line motor operated valves, discharge line check valves and instrumentation and control equipment associated with core cooling are unaffected by shock-induced vibrations resulting from the impact of a large commercial aircraft.

The location and design of the control element drive mechanism described in Sections 3.9.4 and 4.6, with the control element drive mechanism located inside of the RCB on top of the reactor vessel closure head such that upon loss of internal power distribution the control rods drop into the reactor core by gravity, are key design features for ensuring that the reactor will be tripped following the impact of an aircraft.

Regarding the SFP, the assessment determined that there are no aircraft impact scenarios that result in leakage from the SFP below the required minimum water level. The pool liner is not perforated and all SFP piping attachments are configured such that they will not allow water in the SFP to drain below the minimum water level. The design and location of the SFP and its supporting structures as described in Sections 3.8A.2 and 9.1.2 are key design features for protecting the integrity of the SFP such that an impact of a large commercial aircraft would not result in leakage from the SFP below the required minimum water level.

19.5.4.2 Plant Arrangement

The APR1400 plant design and arrangement of major structures described in Section 1.2.14 and Figures 1.2-1 through 1.2-27 are key design features. Specifically, the assessment credited the arrangement of, and design of, the following building features to limit the location and effects of potential aircraft strikes on the RCB and AB in the following locations:

a. The location and design of the Auxiliary Building (AB) structure as described in Section 3.8.4 are key design features in protecting the RCB [ ] from the impact of a large commercial aircraft. Additionally, portions of the AB provide protection of the RCB on the northeast, northwest and southwest sides [ ].

b. The location and design of the EDGB as described in Section 3.8.4 are key design features in protecting portions of the east wall of the AB [ ] from the impact of a large commercial aircraft.

c. The physical separation of the east and west EDGs, as described in Section 8.3, Figure 1.2-14 and Figure 1.2-21, is a key design feature in limiting the loss of electrical power to key safety systems from the impact of a large commercial aircraft.

d. Properties of concrete and reinforcement bars, as described in Appendix 3.8A, are key design features in protecting key safety equipment in the AB.

e. The location of the AAC GTG as shown on Figure 1.2-1 relative to the EDGs is a key design feature in limiting the loss of electrical power to key safety systems from the impact of a large commercial aircraft.

19.5.4.3 Fire Barriers and Fire Protection Features

The design and location of 3-hour fire barriers, including fire doors, penetration seals and dampers that separate the safety divisions within the AB are key design features for the protection of safety-related core cooling equipment within these buildings from the impact of a large commercial aircraft. The assessment credited the design and location of fire barriers (including doors) as depicted on Figures 9.5A-1 through 9.5A-11 to limit the effects of internal fires created by the impact of a large commercial aircraft. In addition, certain fire barriers, including doors, fast-acting blast dampers and penetration seals, are credited for 5 psid. These 5 psid barriers are identified on Figures 9.5A-1 through 9.5A-9. These key design features ensure at least one complete train of secondary heat removal equipment and necessary support systems to include cooling water, electrical power supply and distribution, and instrument and control within the AB and EDGB is available to provide core cooling following the impact of a large commercial aircraft.

19.5.4.4 Core Cooling Features

The design and physical separation (by fire barriers as described in Section 9.5A) of the safety injection and shutdown cooling system (described in Sections 6.3 and 5.4.7), of the auxiliary feedwater system (described in Section 10.4.9), of the main steam safety valves and main steam atmospheric dump valves (described in Sections 10.3.2.2.3 and 10.3.2.2.4) and of the charging pumps and auxiliary charging pump (described in Section 9.3.4) are key system design features for assuring core cooling following a reactor trip in response to an aircraft impact event.

The design and physical separation of the component cooling water system (CCWS) (described in Section 9.2.2), of those portions of the essential service water system located in the ESW Building (described in Section 9.2.1), of the Class 1E electrical power supply and distribution system (described in Section 8.3), and of the safety-related instrumentation and control system (described in Chapter 7) including the physical separation between the MCR, RSR and the RCC and the ability to power the SI pumps, charging pumps, CS pumps and SC pumps from the AAC GTG are key supporting system design features for assuring core cooling following a reactor trip in response to an aircraft impact event. The action of tripping or shutting down the reactor ensures that the fuel in the reactor is kept subcritical.

Following shutdown from power operation, core cooling is maintained by the auxiliary feedwater system as described in Section 10.4.9. Primary system is maintained at operating pressure and temperature by adjusting auxiliary feedwater flow to match the decay heat rate from the reactor core. Heat is discharged to the atmosphere using the main steam safety valves or main steam atmospheric dump valves. Under these conditions, additional boration is unnecessary to maintain subcriticality.

In the event CCW RCP seal cooling is unavailable, the capability of the chemical volume and control system to provide seal-water flow to the reactor coolant pump seals described in Section 9.3.4.2.1 is a key design feature. In the event both CCW RCP seal cooling and RCP seal injection are unavailable, the capability to maintain RCS inventory with the SI system and to remove containment heat using the containment spray pumps and heat exchangers as described in Section 6.2.2 is a key design feature. The auxiliary feedwater system is available to provide decay heat removal.

For an aircraft impact during plant shutdown with the reactor vessel head removed and water level at or near the reactor vessel head flange, the reactor core is cooled by the shutdown cooling system as described in Section 5.4.7. In the event that the shutdown cooling system is unavailable, the ability to keep the fuel in the vessel covered with water using the safety injection system described in Section 6.3 or charging pumps described in Section 9.3.4 are key design features. To ensure that one train of fuel cooling or inventory makeup is available following the impact of a large commercial aircraft on the AB, administrative controls require that no trains of the safety injection and shutdown cooling system and necessary support systems are out of service when the reactor vessel head is untensioned and the reactor vessel water level is at or near the reactor vessel head flange. (COL 19.5(1))

If all Class 1E power from the EDGs is unavailable due to the loss of the ultimate heat sink or loss of all CCW, the capability of the safety injection pumps taking suction from the IRWST as described in Section 6.3, and the charging pumps and auxiliary charging pump taking suction from the VCT or BAST as described in Section 9.3.4, all powered from the AAC GTG, in order to provide make-up water for the reactor coolant system, are key design features. The AAC GTG is available to power auxiliary feedwater pumps for secondary heat removal.

19.5.5 Conclusions of Assessment

This assessment concludes that key design features and functional capabilities of the APR1400 ensure adequate protection of public health and safety in the event of an impact of a large commercial aircraft, as defined by the NRC. The postulated aircraft impacts would not impair the APR1400 core cooling capability or spent fuel pool integrity. The assessment resulted in identification of key design features and functional capabilities described in Section 19.5.4, changes to which are required to be controlled in accordance with 10 CFR 50.150(c).

19.5.6 Combined License Information

COL 19.5(1) When the reactor head is untensioned and before the refueling pool is flooded up, administrative controls will be in place to ensure that no trains of SI and shutdown cooling, including the necessary power and cooling water support systems are out of service for maintenance.

19.5.7 References

1 NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8, April 2011.