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Beach Rental Elevator Child Entrapment Safety Analysis

Dennis B. Brickman[1], Thomas J. Bajzek[1], Erick H. Knox[1], Charles A. Fox[2], Jay K. Lueck[2], and John M. Petersen[2]

[1]Engineering Systems Inc., 4215 Campus Drive, Aurora, Illinois 60504

[2]Engineering Systems Inc., 2321 North Loop Drive Ames, Iowa 50010

Corresponding author's Email: dbbrickman@engsys.com

Abstract: A human factors accident reconstruction was conducted to analyze the circumstances surrounding a beach rental elevator ten-year-old child entrapment accident in South Carolina. The elevator control circuit allowed the elevator car to move with the accordion door open, posing a crushing hazard. This accident would have been prevented had the elevator been equipped with an adequate light curtain safety feature offered by the elevator manufacturer on its other elevator models. Following this accident, a petition for recall to repair/retrofit and rulemaking was submitted to the U.S. Consumer Product Safety Commission (CPSC) to promulgate a mandatory standard for residential elevators and to commence a recall requiring all manufacturers to retrofit existing elevators to prevent children and small adults from becoming entrapped.

Keywords: Beach Rental Elevator, Child Entrapment, Safety Analysis

1. Residential Elevator Child Entrapment Accident History

According to U.S. Consumer Product Safety Commission (CPSC) National Electronic Injury Surveillance System (NEISS) incident data, there were an estimated 1,600 injuries associated with residential elevators in a two-year period from 2011 through 2012 (Schaefer-Wilson, 2015). Additionally, at least 55 child deaths have occurred since 1967; the most recent known death occurred in 2009 (U.S. CPSC, 2014). Previous studies by the lead author analyzed the child entrapment of a three-year-old boy between the hoistway door and the elevator car accordion door in his Georgia home on December 24, 2010 (Brickman, 2013 and Brickman, 2014). In 2012, a teenager sustained a fractured ankle in a rental home in South Carolina when the elevator ran with the accordion door open. On December 23, 2014, a five-year-old girl suffered crush injuries while using a residential home elevator in a vacation property in Hermosa, California when she became trapped between the accordion door on the elevator car and the hoistway door (U.S. CPSC, August 2015). On June 26, 2015, a five-year-old girl became trapped between the hoistway door and elevator accordion door in a vacation home's residential elevator in Destin, Florida. When the elevator descended to another floor, the girl was left trapped while standing on the sill (U.S. CPSC, October 2015).

2. South Carolina Beach Rental Elevator Accident Description

During Thanksgiving of 2013, a ten-year-old boy's family rented a vacation home in Murrells Inlet, South Carolina. The home did not have internal stairs, but did have an elevator as shown in Figure 1. The holiday turned tragic early in the vacation, when family members heard noises from the elevator and found the ten-year-old boy's body trapped inside and underneath the elevator positioned on the third floor on November 26, 2013. The boy suffered devastating traumatic brain and spinal cord injuries as a result of becoming entrapped by the elevator (U.S. CPSC, September 2014). As a result of this accident, the U.S. CPSC issued a recall notice citing that the elevator can operate while the gate door is open, posing a crushing hazard (U.S. CPSC, March 2015). The elevator seller has received three reports of incidents with the elevators, including the injured ten-year-old boy. The South Carolina Department of Labor, Licensing & Regulation found that the beach rental home contains two completely separate dwelling units and the elevator does not meet code (South Carolina Department of Labor, Licensing & Regulation, 2014).

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Figure 1. Beach Rental Vacation Home Elevator.

3. South Carolina Beach Rental Elevator Accident Reconstruction

This was an unwitnessed accident. Determining the accident sequence was accomplished using established scientific methods (Knox, 2015). The available data concerning the accident, including the elevator geometry and behavior, the child's injuries, and the post-accident position of the child, were analyzed to determine how the child became entrapped.

In responding to the noises they heard from the elevator, witnesses described seeing the boy trapped in and underneath the elevator on the 3rd floor. The boy was found in the elevator limp and lying perpendicular to the doorway with his head, neck, and upper right chest below the level of the floor (Figure 2E). From below, the boy's head and right arm were seen below the level of the floor, and there was damage to the interior wall of the elevator shaft just above the 2nd floor door opening and directly in line with the path of the boy's head (Figure 2F). After a lengthy extraction, the boy was diagnosed with a traumatic brain injury consistent with an extended period of anoxia. The boy also received the following injuries: displaced fractures of the mandibular condyles bilaterally, multiple facial fractures, right clavicle fracture, multiple fractures to the right scapula, bilateral fractures to the first rib, large scalp hematoma on the posterior vertex, deep laceration of the chin, large lacerations of the left corner of the mouth and left ear, and bruising to the chest and shoulders.

Figure 2 demonstrates an animated sequence of the accident reconstruction and elevator movement associated with the ten-year-old boy's entrapment accident. The boy was in the elevator on the 2nd floor and shortly after pressing the 3rd floor button, he was on his hands and knees with his hands at the edge of the elevator floor, and positioned face down with most of his head beyond the plane of the elevator with his head at or close to the floor (Figure 2A). This would allow the boy to look down below the edge of the elevator floor. The elevator rose to a point where the top rear portion of the boy's head contacted the upper horizontal portion of the 2nd floor door opening. The chin is overlapped with, and quickly contacts the floor of elevator. This creates a compressive crushing action between the top rear of the head and the chin that fractures the mandibular condyles, and creates the lacerations at the chin and mouth (Figure 2B). The space between the elevator floor and wall was not large enough to fit the boy's head so it acted as a restraint that pulled the neck and right shoulder area down as the floor continued to rise. The head stayed below the top of the door opening and pivots as the shoulders (more on the right than left) were crushed between the wall and the edge of the floor. As the elevator progressed above the 2nd floor doorway, the boy's body (likely the head) pressed against the inner wall of the elevator and fractured the drywall, creating a depression (Figure 2C). The head stayed below the bottom edge of the flange of the elevator floor trim, while the neck and shoulders (upper chest) were crushed between the elevator floor edge and the wall, creating the crushing fractures and injuries to the boy's scapula, ribs, and chest (Figure 2D). The head likely turned slightly to the left, exposing the left side of the head and face to the wall, where the laceration to the ear occurred. Throughout this process, the left hand stayed at the edge of the elevator floor, and the body became limp and the slumped to the floor.

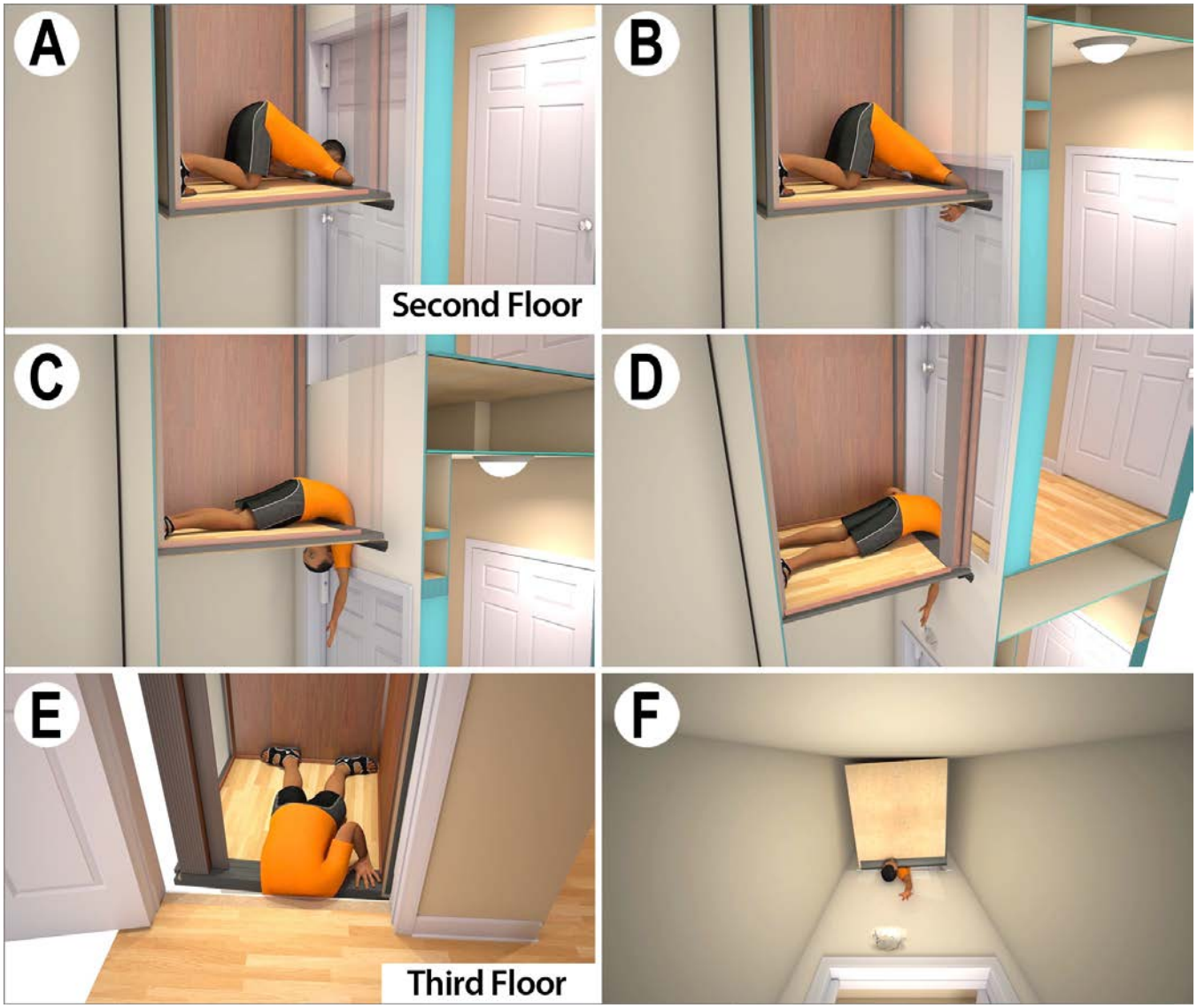

Figure 2. Elevator Accident Animated Sequence (Car Moving Up from Second Floor to Third Floor).

4. Control Circuitry

Regarding the control circuit, the primary issue in this case was the ability to operate the elevator with the gate door open. Analysis of the elevator control circuit schematics revealed a feature allowing the elevator to move in response to a call from another floor, even with the gate door open as depicted in Figure 3. This feature was only disabled for a period of 5 seconds each time the gate door opened (and elevator users presumably exited after arriving on a desired floor). After that 5 second delay, in case the users did not close the gate door after exiting the elevator, the controls would allow the elevator to travel in response to a call button pressed on another floor. Further investigation, however, including interviews of all witnesses present in the vacation home on the date of the accident, found that no call button had been pressed to cause motion of elevator at the time of the accident.

Witnesses interviewed during this investigation indicated they had observed the elevator moving between floors with the gate door open. They reported this behavior of the elevator had occurred during normal operation, not just in response to a call button on another floor. Further investigation therefore required a detailed inspection of the controls for the incident elevator. Inspection of those controls revealed a jumper wire that had been installed in a manner bypassing the safety features and allowing the elevator to be operated with the gate door open.

Figure 3. Elevator Video Sequence with Open Accordion Door (Car Moving Up from Second Floor to Third Floor).

5. Light Curtain

Additional research into alternate designs provided by the same elevator manufacturer found there were available models which included light curtains. This led to the question of whether or not the jumper wire found in the incident elevator controls would have disabled such a light curtain. It was determined that, based on analysis of circuit schematics for the various available models, the light curtain circuit, as configured in certain other models, would not have been disabled by the jumper wire. In summary, analysis of the control circuits led to the conclusion that it was feasible to include a light curtain in the incident elevator with only minor modifications to the existing circuits. Had a light curtain been installed in the subject vacation home elevator as illustrated in Figure 4, the ten-year-old boy's body would have been detected by the light curtain and the crushing injury would have been prevented.

Figure 4. Elevator Light Curtain Accident Prevention.

6. Conclusions

Results of this accident reconstruction investigation indicate that children, including teenagers, are capable of becoming entrapped between the residential elevator car and the hoistway door when the accordion door is open. The ten-year-old boy's injuries would have been prevented had the South Carolina beach rental home elevator been equipped with a light curtain safety device as offered by the elevator manufacturer on its other models. U.S. CPSC accident statistics indicate that residential elevator child entrapment injuries have occurred before and after the studied accident at issue. Petitioners to the U.S. CPSC assert that in many home elevators a child can become entrapped in the door path when the elevator is called to another floor, and the hoistway door automatically locks (U.S. CPSC, 2014). The child's body is carried along with the elevator car until the hoistway door meets the obstruction of the sill, where the child's body, usually the head, is crushed. Several technologies exist to eliminate this child entrapment hazard such as light curtains and door baffles (or space guards).

7. References

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