RAI Volume 2, Chapter 2.1.1.4, Eighth Set, Number 5:

> Provide technical basis for assuming zero probability of failure for degradation or loss of shielding of Waste Package Transfer Trolley (WPTT) (Tables 6.3-6, BSC 2008ac) under structural challenges (e.g., collision of WPTT with facility structures).
>
> The End State Cut Sets Detailed Report for CRCF event sequence ESD10-WP-TAD-SEQ2-DE in the SAPHIRE model (Attachment H, BSC2008ac)) shows that number of WPTT collision during the preclosure period is about 24 obtained from WP-TAD=8.1×10^{3} and 060-OPWCOLLIDE1-HF-NOD=3×10^{-3}. DOE relied on the statement "structural challenge sufficiently mild" from the impact (Table 6.3-6, BSC2008ac) for assigning zero probability of failure for the pivotal event ESD10-WP-TAD-COLLIDE-SH to prevent the event sequence.

1. RESPONSE

The waste package transfer trolley travels at an extremely slow speed of 0.1 m/s (20 ft/min) by design. An impact at this speed is equivalent to a drop from a height of less than 0.02 in (2 mm), which is not expected to result in any damage to the shielding. Nonetheless, the waste package transfer trolley loss of shielding event probability was assigned a value of zero because the shielding is not important to safety and therefore it is removed from the event sequence. The shielding is not relevant because activities associated with the loading and transfer of a waste package using the waste package transfer trolley are performed remotely, as stated in *Canister Receipt and Closure Facility Event Sequence Development Analysis* (BSC 2008, Section 4.3.4, Table 4 (description of Node 10)). The use of the zero event probability reflects the fact that personnel will not be in the waste package positioning rooms or the waste package loadout room during operations involving the waste package transfer trolley and therefore the shielding is not important to safety. From the time the operators load the waste package using the canister transfer machine until the waste package leaves the facility, all operations are performed remotely.

Should an operator be present during transfer operations, an operator exposure would take place. Procedural safety control, PSC-3 (SAR Table 1.9-10), assures evacuation of personnel prior to movement of the waste package transfer trolley with a loaded waste package. Two separate checks of the areas are performed before operations begin, one locally and one from the control room via camera. Inadvertent operator presence in the loadout room, event 060-OPDIREXPOSE3-HFI-NOD, has been modeled in event sequence ESD19-FACILITY-DR (BSC 2009, Table A4.19-2). Inadvertent operator presence directly results in a worker exposure event; no initiating event involving damage to the waste package transfer trolley shielding is required. Therefore, any direct exposure sequence involving a collision (i.e., inadvertent operator presence and loss of waste package transfer trolley shielding) would be a nonminimal cutset scenario. Assigning a value of zero to the probability of basic event 10-WPTT_SHIELDING (waste package transfer trolley shielding fails) was used to eliminate the nonminimal cutset scenarios, instead of removing them from the model.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2008. *Canister Receipt and Closure Facility Event Sequence Development Analysis*. 060-PSA-CR00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080221.0008.

BSC 2009. *Canister Receipt and Closure Facility Reliability and Event Sequence Categorization Analysis*. 060-PSA-CR00-00200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20090112.0004.

RAI Volume 2, Chapter 2.1.1.4, Eighth Set, Number 6:

> Clarify how event sequence probability is determined for each initiating event identified under a “small bubble” (e.g., Figure F-3, BSC 2008ab).
>
> DOE has grouped several initiating events under a “small bubble.” For example, event sequence diagram CRC-ESD-03 (Figure F-3, BSC 2008ab) shows that “TC [transportation cask] drop from operational height” during upending and transfer of transportation cask to the Cask Transfer Trolley operations (represented by the small bubble) can potentially occur due to six independent initiating events. However, it is not clear how DOE has determined the event sequence probability for each independent initiating event.

1. RESPONSE

1.1 EVENT SEQUENCE DIAGRAM CONSTRUCTION AND TRANSFORMATION

The initiating events identified on a master logic diagram (MLD) are grouped into event sequence diagrams according to whether they elicit a similar response of structures, systems, and components and operations personnel. The event sequence diagrams show small bubbles surrounding a larger bubble. Each small bubble initiating event is a grouping or category of contributing initiating events that not only involve the same structures, systems, and components and operations response, but also the same pivotal event conditional probabilities. Different small bubbles in the same event sequence diagram have the same pivotal events, but may have different pivotal event conditional probabilities. The big bubble initiating event is also called an aggregated initiating event. Categorization is based on each event sequence that emanates from the big bubble initiating event for each waste form (BSC 2008, Section 4.3.4.4). There is a direct correlation from the small bubbles, boxes, paths, and end states on the event sequence diagram to the initiating events, pivotal events, paths, and end states on the event trees for the same event sequence (BSC 2008, Figure 5).

Each MLD initiating event has a designator. Each small bubble is associated with one or more such designators in the event sequence diagrams. This association points out that all the MLD initiating events are included in the event sequence diagrams. A small bubble, however, represents a category or grouping of initiating events that is more comprehensive than the list from the MLD. The detailed causative contributors to a small bubble initiating event category, and their probabilities of occurrence, are developed by fault tree analysis. Fault tree analysis is a more complete and accurate way of determining the contributors to a small bubble initiating event and is a standard method for this purpose. As in the example shown in Section 1.2, each MLD initiating event listed under a small bubble can be shown to be incorporated in its associated initiating event fault tree.

As described in SAR Sections 1.7.3 and 1.7.4, when input into the appropriate event tree, the initiating events are partitioned across several different possible paths; each node where the path diverges is represented by a pivotal event. Each path on an event tree starts with the initiator tree equivalent to a small bubble, continues through the system response tree, and ends with an end state. Each path to an end state of a system response tree is quantified for each small bubble. The results of this quantification are found in Table G-2 of the reliability and event sequence categorization analyses (e.g., BSC 2009).

In summary, to quantify an event sequence, the initiating event frequency (or expected number of occurrences) of an initiator tree branch (e.g., "Drop of Cask" in Figure 1) is multiplied by the number of waste forms handled and then multiplied by the conditional probability of each subsequent pivotal event node (in the system response event tree) in an event sequence until an end state is reached. The initiator event tree CRCF-ESD03-DPC (Figure 1) coupled to the system response event tree (RESPONSE-TCASK1 in Figure 2) provides an example of how event sequences emanating from a small bubble are quantified. The first branch on the left of Figure 1 (labeled "Number of TCs Containing DPCs Processed During Preclosure Period") represents the number of transportation casks (TCs) containing a dual-purpose canister (DPC) that will be processed over the preclosure period. This number (TC-DPC) is then multiplied by each of the six probabilities associated with each initiator event branch. For example, TC-DPC is multiplied by the frequency of "Drop of Cask." "Drop of Cask" is the event tree equivalent of the small bubble "TC drop from operational height." Each of these six branches uses its initiating event fault tree to develop the causative contributors and frequencies. For example, the "Drop of Cask" branch is quantified with fault tree ESD3-DPC-DROP.

Figure 2 represents the system response event tree for each of the six initiator tree branches. The divisions in the paths refer to the pivotal events listed above the branches. Upward branches indicate success of the pivotal event while downward branches indicate a failure. For example, event sequence #6 is a path consisting of INIT-EVENT (e.g., "Drop of Cask") followed by failure of pivotal events TRANS-CASK, CANISTER, and CONFINEMENT, followed by success of MODERATOR, which leads to the end state unfiltered radionuclide release (RR-UNFILTERED). The corresponding fault trees used to develop the probabilities are (BSC 2009, Section A4.3.2):

a. ESD3-DPC-DROP-TCASK for TRANS-CASK failure

b. ESD3-DPC-DROP-CAN for CANISTER failure

c. ESD3-CONF for CONFINEMENT failure, and

d. the value of 1 for success of MODERATOR.

The event sequence frequency #6 emanating from the small bubble "TC drop from operational height" is developed from the quantification of the Boolean intersection of the fault trees ESD3-DPC-DROP, ESD3-DPC-DROP-TCASK, ESD3-DPC-DROP-CAN, ESD3-CONF, with the result multiplied by TC-DPC (for the number of transportation casks with DPCs) and 1 (for MODERATOR success).

1.2 CRC-ESD-03 SMALL BUBBLE CONTRIBUTORS

This RAI specifically addresses CRC-ESD-03 (BSC 2008, Figure F-3), small bubble "TC dropped at operational height." In the following discussion of this event sequence diagram, the DPC waste form was chosen as the example for text, figures, and tables. Figure 1 shows the SAPHIRE initiator event tree developed from the event sequence diagram with the specific initiating event ("Drop of Cask") identified in blue. This transfers into the response tree depicted in Figure 2. To quantify the initiating event fault tree ("DPC Hi Star Cask Dropped"), all events listed under the small bubble (Table 1) are considered. All of these events are contributors to initiating event fault tree ESD3-DPC-DROP. Events CRC-501, CRC-510, CRC-704, CRC-902, and CRC-1001 have been combined into a "200 ton crane drop fault tree" (060-3-DPC-CRANE-DROP), as operational crane drop data does not discriminate among various causes of a crane drop. Event CRC-901, "Cask tilting frame failure causes cask drop," has also been considered and was developed into basic event 060-TILTFRAME-CSC-FOH.

Figure 3 is the initiating event fault tree for "TC dropped at operational height" (ESD3-DPC-DROP). Figure 4 annotates Figure 3 to show the small bubble events considered in the two branches of the fault tree.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2008. *Canister Receipt and Closure Facility Event Sequence Development Analysis*. 060-PSA-CR00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080221.0008.

BSC 2009. *Canister Receipt and Closure Facility Reliability and Event Sequence Categorization Analysis*. 060-PSA-CR00-00200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20090112.0004.

Table 1. Initiating Event "TC Dropped at Operational Height" Considered Events

Identifier	General Event Description
CRC-501	Cask handling crane malfunction causes transportation cask drop
CRC-510	Cask tips and drops after placed onto cask transfer trolley
CRC-704	TC collides with object during movement by cask handling crane leads to a cask drop
CRC-901	Cask tilting frame failure causes cask drop
CRC-902	Cask handling crane malfunction leads to cask drop
CRC-1001	Cask handling crane drops cask

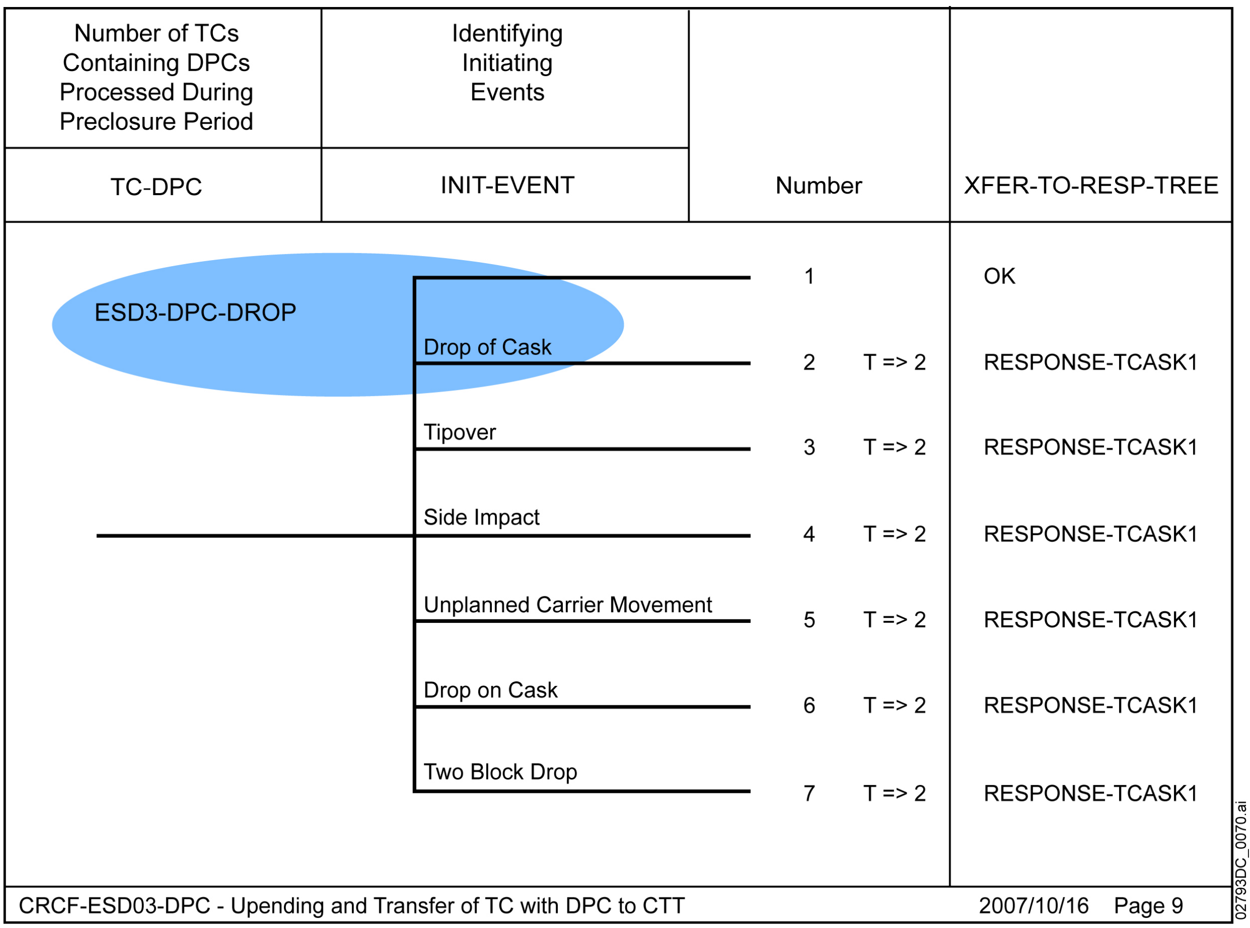

Figure 1. DPC ESD03 Event Tree

NOTE: CTT = cask transfer trolley.

Source: SAPHIRE Model, CRCF Attachment H (BSC 2009).

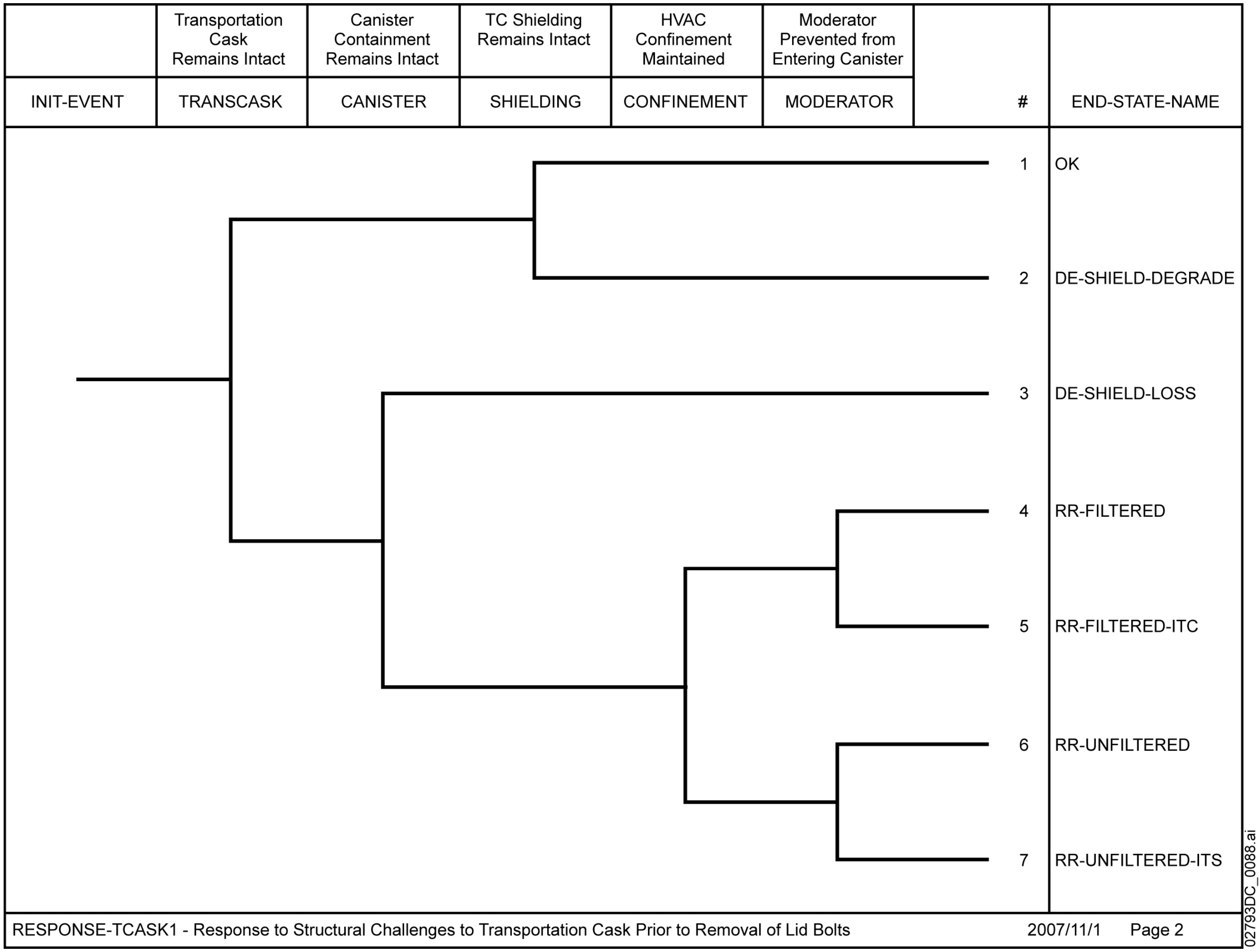

Figure 2. DPC ESD03 Response Tree

NOTE: HVAC = heating, ventilation, and air conditioning.

Source: SAPHIRE Model, CRCF Attachment H (BSC 2009).

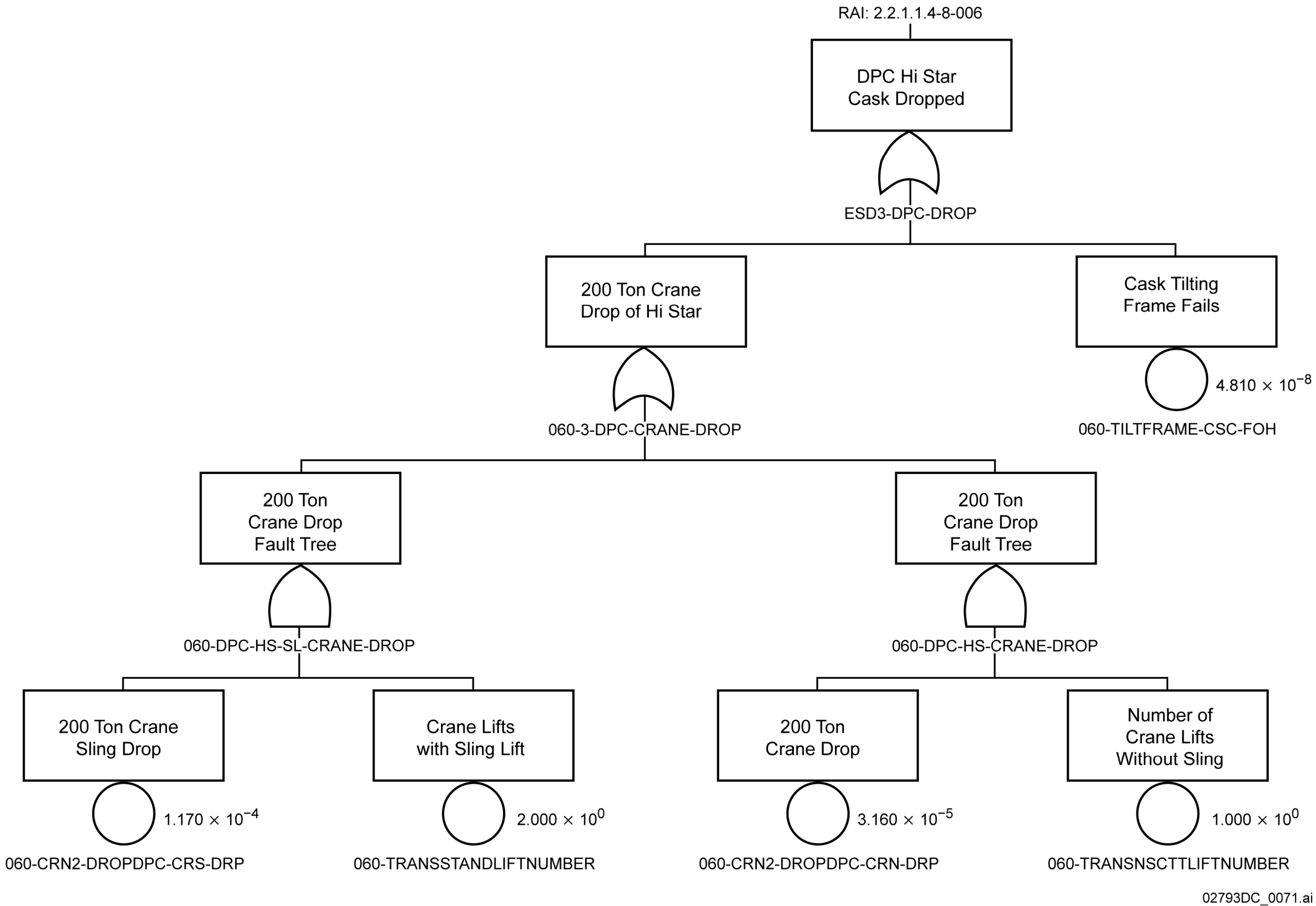

Figure 3. Initiating Event Fault Tree ESD3-DPC-DROP

Source: SAPHIRE Model, CRCF Attachment H (BSC 2009).

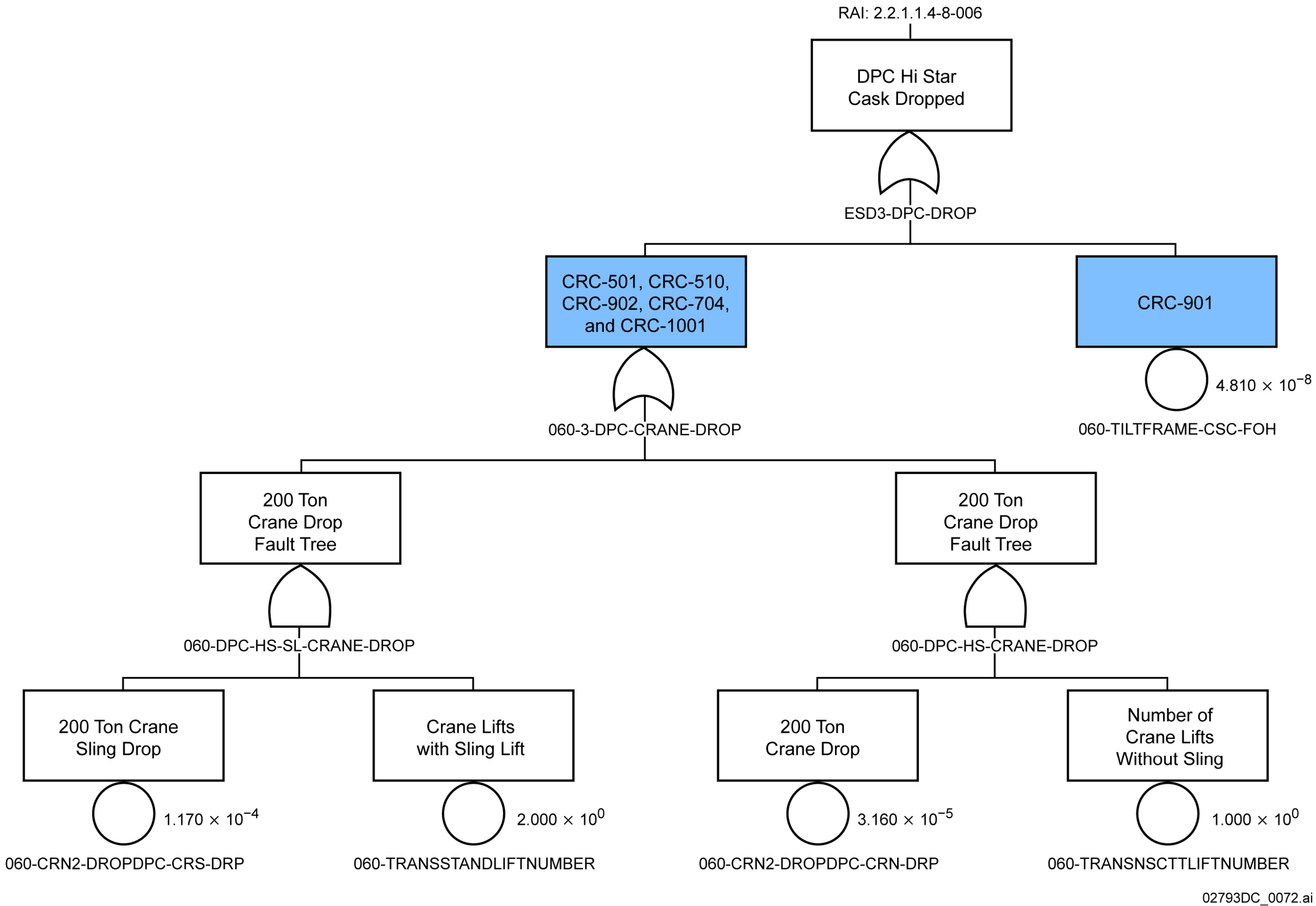

Figure 4. Initiating Event Fault Tree ESD3-DPC-DROP with Small Bubble List Items

Source: SAPHIRE Model, CRCF Attachment H (BSC 2009).