RAI Volume 2, Chapter 2.1.1.4, Fifth Set, Number 1:

Explain how DOE quantified the potential tipover of a Shielded Transfer Cask containing a TAD canister (i.e., WHF-ESD-24-TAD) while lifting the STC/TAD from the pool ledge to the TAD Canister Closure area. Examples of areas needing clarification follow:

a) Explain if catching the edge of the pool was included in initiating event WHF-1505.

   i. DOE identifies "Cask tip over after being placed in TAD closure station" in Figure F-24 of BSC, 2008bo.

   ii. DOE identifies in Table E6.8-1 of BSC, 2008bq that the most likely cause for the tip over is the operator catches the edge of the pool (i.e., basic event, "050-OPTIPOVER002-HFI-NOD").

b) Clarify the terminology, "pool ledge" versus "pool shelf" versus "staging-shelf." Explain if DOE is referring to the same location in the pool.

   i. For human failure event 050-OPTIPOVER002-HFI-NOD, DOE indicates in Table E6.8-1 of BSC, 2008bq on page E-213, "In this step, the DPC/STC and SNF/TC are moved to the pool ledge from the DPC cutting station or SNF preparation platform, and the TAD canister/STC is moved from the pool ledge to the TAD canister closure station outside the pool. During this movement, the cask can be tipped over if it catches the ledge of the pool as the cask is moved onto the pool shelf."

   ii. On page 1.2.5-54 of the SAR, DOE indicates, "The cask handling crane moves the shielded transfer cask with the TAD canister to the staging-shelf of the pool where the shielded transfer cask lid bolts are installed."

1. RESPONSE

Catching the edge of the pool was included in initiating event WHF-1505. By way of clarification, the pool location terms "pool ledge," "pool shelf," and "staging-shelf" are synonymous as identified as "staging shelf" on SAR Figure 1.2.5-13.

Tracing the development of event tree WHF-ESD-24-TAD through the figures and tables in *Wet Handling Facility Event Sequence Development Analysis* (BSC 2009a) and *Wet Handling Facility Reliability and Event Sequence Categorization Analysis* (BSC 2009b) defines the events included in initiating event WHF-1505. Event sequence diagram WHF-ESD-24 (BSC 2009a, Figure F-24) was developed for activities associated with the transfer of a shielded transfer cask (STC) containing a transportation, aging, and disposal (TAD) canister from the pool ledge to the

TAD canister closure station. That diagram includes the small bubble initiating event WHF-1505. The description in the WHF-1505 small bubble in Figure F-24 of the event sequence development analysis (BSC 2009a) was intended to describe that the initiating event includes STC/TAD tipover due to a catch on the edge of the pool. A more accurate description of the event is "STC/TAD tips during transfer." Table G-1 of the event sequence development analysis (BSC 2009a) associates the event tree WHF-ESD24-TAD with event sequence diagram WHF-ESD24. Event tree WHF-ESD24-TAD (BSC 2009a, Figure G-39) identifies its initiating events and includes both "Tip over of STC/TAD – Pool" and "Tip over of STC/TAD – Floor," which are consistent with the more accurate description of "STC/TAD tips during transfer."

The initiating event assignments for SAPHIRE to quantify event tree WHF-ESD24-TAD are provided in the event sequence categorization analysis (BSC 2009b, Table A4.24-2). Table A4.24-2, *Initiating Event Assignments for WHF-ESD24-TAD*, includes ESD24-POOL-TIP, "Tip over of STC/TAD – pool." This table also identifies the basic events which comprise ESD24-POOL-TIP as 050-OPTIPOVER010-HFI-NOD and TIME-OVER-POOL-TO-CLOSE (a fraction representing the fraction of time the STC/TAD spends over the pool during the movement from the pool ledge to the TAD Closure Station). Note that the basic event 050-OPTIPOVER010-HFI-NOD in Table A4.24-2 is mislabeled and is actually the basic event 050-OPTIPOVER002-HFI-NOD in Table E6.8-1 of the event sequence categorization analysis (BSC 2009b), which is specifically addressed in this RAI as identifying the most likely cause of tipover. The SAPHIRE model in the event sequence categorization analysis (BSC 2009b, Attachment H) correctly uses basic event 050-OPTIPOVER002-HFI-NOD in the ESD24-POOL-TIP fault tree.

In conclusion, catching the edge of the pool was included in initiating event WHF-1505 and carried through quantification of the initiator event tree WHF-ESD24-TAD. In addition, "pool ledge," "pool shelf," and "staging-shelf" refer to the same location in the pool.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2009a. *Wet Handling Facility Event Sequence Development Analysis.* 050-PSA-WH00-00100-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20090112.0005.

BSC 2009b. *Wet Handling Facility Reliability and Event Sequence Categorization Analysis.* 050-PSA-WH00-00200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20090112.0006.

RAI Volume 2, Chapter 2.1.1.4, Fifth Set, Number 4:

(a) Explain if DOE considered the possibility that a worker could receive a direct exposure as a result of improperly placing the lid on the TAD canister or STC in the pool or as a result of the lids being inadvertently displaced when the STC/TAD is lifted to the staging shelf of the pool.

(b) Explain if DOE considered the possibility that a worker in a subsequent operation (i.e., TAD canister closure) could receive a direct exposure when the STC lid is removed if the TAD canister inner lid had been displaced or improperly installed.

DOE identifies on page 1.2.5-54 of the SAR that after the TAD is loaded, the TAD canister inner lid, which also functions as a shield plug, is returned to the TAD canister and the lid of the shielded transfer cask is returned to the shielded transfer cask. Then, the cask handling crane moves the STC/TAD to the staging shelf of the pool where the STC lid bolts are installed.

1. RESPONSE

Event sequences initiated by the potential improper placement or inadvertent displacement of either of the two lids are screened from further consideration because they are found to be physically unrealizable or are rendered not credible by a procedural safety control.

1.1 STC SHIELD LID

Improper placement or inadvertent displacement of the STC shield lid during handling of the STC is not considered credible because of operational controls that ensure proper shield lid placement and fastening. To ensure proper placement of the shield lid, operators verify the lid alignment as part of the sequence of steps to be followed for lid placement. Operators fasten the properly placed shield lid onto the STC with bolts while the STC is still in the pool. The preclosure safety analysis identified preclosure procedural safety control PSC-6, in SAR Table 1.9-10, that requires that the STC shield lid have a minimum number of fasteners such that the stress on the fasteners is less than the yield strength whenever the STC containing a TAD canister is moved. This procedural safety control ensures that the shield lid is properly fastened so that STC shield lid displacement is not credible. On this basis, improper placement or inadvertent displacement of the STC shield lid is screened from further consideration in an event sequence.

1.2 TAD CANISTER INNER LID (SHIELD PLUG)

The shield plug is required to reduce the TAD canister axial top-surface dose rate to no more than 1 rem/hr (SAR Table 1.5.1-10, TAD Canister Performance Specification Section 3.1.4(2)), and therefore must be of substantial steel thickness. In addition, the diametrical clearance between the shield plug and the TAD canister inner surface must be minimal to reduce radiation streaming and to facilitate welding the shield plug in place. Because of the shield plug thickness

and minimal clearance, improper installation of the shield plug would result in an extreme tilting orientation in which the shield plug extends well above the top of the TAD canister. SAR Figure 1.10-29 shows a TAD canister inside a representative aging overpack and illustrates the relative size of the stainless steel shield plug and other canister components.

Because the TAD canister shield plug is installed before the STC shield lid, installation of the STC shield lid would not be possible if the shield plug were improperly installed. Therefore, the operational controls for the STC shield lid also ensure that the shield plug is properly installed. Once the shield plug is properly installed, the shield plug thickness and minimal clearance to the TAD canister prevent any displacement within the TAD canister during transfer. Thus, improper placement or inadvertent displacement of the TAD canister shield plug is screened from further consideration in an event sequence.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

RAI Volume 2, Chapter 2.1.1.4, Fifth Set, Number 6

> Explain the following statement in Table 6.3-9 of BSC, 2008bq on page 183 for basic event 050-OBJLIFT-TAD-CLOSE: "There are three crane lifts associated with the closure of the TAD canister at the TAD canister closure station. Therefore, a value of 2 is assigned to this basic event."

1. RESPONSE

For the Wet Handling Facility basic event 050-OBJLIFT-TAD-CLOSE, the number of object lifts by the jib crane during transportation, aging, and disposal (TAD) canister closure is assigned a value of two even though three lifts occur before welding the inner lid (shield plug) in place.

In the Wet Handling Facility, TAD canister closure is performed at the TAD canister closure station in the cask preparation area (SAR Section 1.2.5.1.2.4). A shielded transfer cask containing a loaded TAD canister with inner lid (shield plug) in place is transferred from the pool to the TAD canister closure station using the cask handling crane. Until the TAD canister inner lid (shield plug) is welded into place, it is considered vulnerable to displacement only from heavy object drops because the shield plug is held securely and tightly in place by its weight and the minimal clearance between the shield plug rim and the TAD canister inner surface.

The first of the three lifts associated with closure of the TAD canister inner lid (shield plug) is the shielded transfer cask lid removal. The second lift is the shielded transfer cask shield ring installation. The third and final lift is placement of the welding machine used to weld the shield plug. Thus, there are three jib crane lifts before the shield plug is welded into place. However, because of the lighter weight of the welding machine (approximately 2000 pounds), it is not considered a heavy object. Therefore, only the first two jib crane lifts associated with shielded transfer cask lid and shield ring contribute to the lift count, and a value of two is assigned to the basic event 050-OBJLIFT-TAD-CLOSE.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

RAI Volume 2, Chapter 2.1.1.4, Sixth Set, Number 1:

> For fire related event sequences, explain how the ratio of various waste form configurations to the overall number of a particular waste form were derived for the surface facilities (e.g., TAD in an Aging Overpack vs. Overall Number of TADs in Canister Receipt and Closure Facility).
>
> These ratios are used as basic event probabilities in event sequences. For example, the total number of TADs and individual TAD configurations in ESD20-SHIELD-TAD-TCAO1 are outlined in SAR Table 1.7-5; however, it is not clear how the ratios were derived for the event sequences.

1. RESPONSE

Fire related ratios, as presented in SAR Table 1.7-5, are developed for the *Canister Receipt and Closure Facility Reliability and Event Sequence Categorization Analysis* (BSC 2009) fault trees using information from *Waste Form Throughputs for Preclosure Safety Analysis* (BSC 2007).

Fault trees that support the fire event trees are developed for each waste form (e.g., per transportation, aging, and disposal (TAD) canister). Each waste form, however, is processed through the facilities with different overpacks, such as aging overpacks and transportation casks. As shown in Figure 1, the ratios allow the fault trees to be partitioned among these overpacks. As part of the event sequence quantification, the initiating event frequencies (developed using fault trees) are multiplied by the waste form throughput count being analyzed. For example, as shown in Figure 2 (see also BSC 2009, Figure A5-84), the event sequence quantification includes multiplication by a total number of TAD canisters processed in the Canister Receipt and Closure Facility (CRCF) over the preclosure period.

Table 1 provides the CRCF throughputs as excerpted from SAR Table 1.7-5, with index numbers added for each throughput. It lists 15,121 TAD canister transfers for the CRCF over the preclosure period, but calculates only 8,143 of these TAD transfers will be to an aging overpack. Instead of developing individual event trees for each TAD canister combination (aging overpack, transportation cask, waste package), ratios for each canister combination extract the appropriate quantities from the total number of TAD canister transfers. The ratio for extracting the appropriate quantity in the example above is 0.539 ($8143 \div 15121$). As indicated in Figure 2, the event tree quantification includes multiplication by 15,121 to obtain the probability of the event sequences over the preclosure period as shown below:

$$TADquantity \times \frac{TADinAgingOverpackquantity}{TADquantity} = TADinAgingOverpackquantity$$

Table 2 provides a list of all fire related waste form throughput ratios, the fault trees which utilize them, and a description of the development of each ratio. In Figure 1, the fault tree identified in this RAI (ESD20-SHIELD-TAD-TCAO1) is annotated to illustrate the connection between the ratios in Table 2 and the fault tree basic events.

Fault trees supporting dual-purpose canisters do not use ratios because all 346 dual-purpose canisters were conservatively estimated in *Waste Form Throughputs for Preclosure Safety Analysis* (BSC 2007) to be in both a transportation cask and an aging overpack at some point within the CRCF. Ratios are not necessary for fault trees containing codisposed waste because they only exist in one form: in a waste package.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2007. *Waste Form Throughputs for Preclosure Safety Analysis*. 000-PSA-MGR0-01800-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071106.0001.

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. Throughputs per Waste Form Configuration and General Operational Area (CRCF)

General Operational Area and Relevant Waste Form Configuration	Throughput over Preclosure Period[a]		Index	
Rail-Based Transportation casks containing HLW canisters (5 canisters per cask)	1,960		C1	
Transportation casks containing DOE standardized canisters (5 to 9 canisters per cask)	385		C2	
Transportation casks containing MCOs (4 canisters per cask)	113		C3	
Transportation casks containing a DPC	346		C4	
Transportation casks containing a TAD canister	6,978		C5	
Aging overpacks containing a TAD canister	8,143		C6	
HLW canisters (transferred from a transportation cask to staging, from staging to a waste package, or from a transportation cask to a waste package)	11,760[b,c]	9,801[c]	C7	C8
DOE standardized canisters (transferred from a transportation cask to staging, from staging to a waste package, or from a transportation cask to a waste package)	6,215[b]		C9	
MCOs (transferred from a transportation cask to a waste package)	451[b]		C10	
Dual-purpose canisters	346[b]		C11	
TAD canisters (transferred from a transportation cask to an aging overpack, from an aging overpack to a waste package, or from a transportation cask to a waste package)	15,121[b,d]		C12	
Aging overpacks containing a DPC	346		C13	
Waste packages containing 1 DOE standardized canister and 4 to 5 HLW canisters	3,300		C14	
Waste packages containing 2 HLW canisters and 2 MCOs	225		C15	
Waste packages loaded with a TAD canister	8,143		C16	
Waste packages (all types produced at CRCFs)	11,668		C17	

[a] The throughput breakdown in this table embeds several bounding scenarios for waste handling facilities. Throughputs for a waste form should not be summed over several entries, because the resulting number could combine handling scenarios that are mutually exclusive and therefore may yield overly conservative numbers.

[b] Number shown is number of transfers by a canister transfer machine inside the facility considered.

[c] This number does not apply to the seismic analysis, which considers that all the HLW canisters handled in the CRCFs (i.e., 9,801 canisters) are staged before being loaded in a waste package. This conservatively increases the number of transfers to a total of 19,602.

[d] This number does not apply to the seismic analysis, which considers two separate scenarios for the transfer of TAD canisters: the transfer of 6,978 TAD canisters from a transportation cask to an aging overpack, and the transfer of 8,143 TAD canisters from an aging overpack to a waste package.

NOTE: DPC = dual-purpose canister; HLW = high-level radioactive waste; MCO = multicanister overpack.

Table 2. Fire Related Fault Tree Ratios

Ratio	Value	Fault Trees	Event Tree	Derivation[a]	
				Direct	Index
TC/DSNF to DSNF Canisters	6.2×10^{-2}	ESD20-DSNF-CSK-CPA-FIRE ESD20-DSNF-CSK-CUR-FIRE ESD20-SHIELD-DSTD-LF	CRCF-ESD20-DSTD	$\frac{385}{6215}$	$\frac{C2}{C9}$
WP/DSNF to DSNF Canisters	5.7×10^{-1}	ESD20-SHIELD-DSTD-LF	CRCF-ESD20-DSTD	$\frac{(3300+225)}{6215}$	$\frac{(C14+C15)}{C9}$
TC/HLW to HLW Canisters	2.0×10^{-1}	ESD20-HLW-CSK-CPA-FIRE ESD20-HLW-CSK-CUR-FIRE ESD20-SHIELD-HLW-LF	CRCF-ESD20-HLW	$\frac{1960}{9801}$	$\frac{C1}{C8}$[b]
WP/HLW to HLW Canisters	3.6×10^{-1}	ESD20-HLW-WP-PR-FIRE ESD20-SHIELD-HLW-LF ESD20-SHIELD-HLW-WP	CRCF-ESD20-HLW	$\frac{(3300+225)}{9801}$	$\frac{(C14+C15)}{C8}$[b]
Canister transfers to physical number of canisters	1.2×10^{-1}	ESD20-SHIELD-HLW-LF ESD20-HLW-CAN-CTM-FIRE	CRCF-ESD20-HLW	$\frac{11760}{9801}$	$\frac{C7}{C8}$[b]
TC/MCO to MCO Canisters	2.5×10^{-1}	ESD20-MCO-CSK-CPA-FIRE ESD20-MCO-CSK-CUR-FIRE ESD20-SHIELD-MCO-LF	CRCF-ESD20-MCO	$\frac{113}{451}$	$\frac{C3}{C10}$
AO/TAD to TAD Canisters	5.4×10^{-1}	ESD20-SHIELD-TAD-LF ESD20-SHIELD-TAD-TCAO1 ESD20-SHIELD-TAD-TCAO2 ESD20-TAD-CUR-FIRE-CAN	CRCF-ESD20-TAD	$\frac{8143}{15121}$	$\frac{C6}{C12}$
TC/TAD to TAD Canisters	4.6×10^{-1}	ESD20-SHIELD-TAD-LF ESD20-SHIELD-TAD-TCAO1 ESD20-SHIELD-TAD-TCAO2 ESD20-TAD-CUR-FIRE-CAN	CRCF-ESD20-TAD	$\frac{6978}{15121}$	$\frac{C5}{C12}$
WP/TAD to TAD Canisters	5.4×10^{-1}	ESD20-SHIELD-TAD-LF	CRCF-ESD20-TAD	$\frac{8143}{15121}$	$\frac{C16}{C12}$

[a] All values listed are in the CRCF section of SAR Table 1.7-5 (unless otherwise noted).

[b] HLW ratios utilize the number of HLW canisters handled in the CRCFs (9,801) rather than the number of transfers (11,760).

NOTE: AO = aging overpack; DSNF = DOE spent nuclear fuel; HLW = high-level radioactive waste ; MCO = multicanister overpack; TC = transportation cask; WP = waste package.

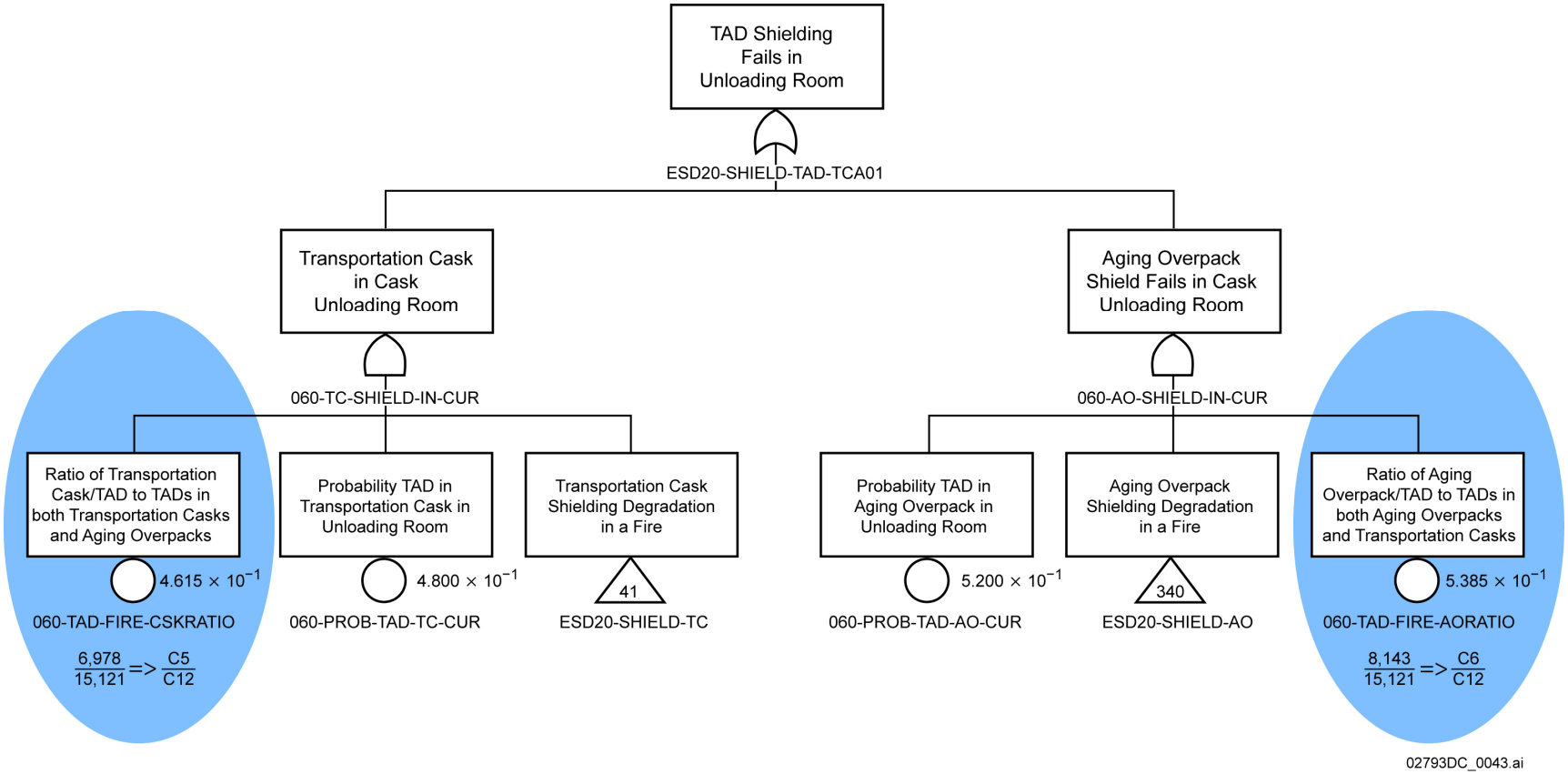

Figure 1. Fault Tree ESD20-SHIELD-TAD-TCAO1 with Ratio Equations

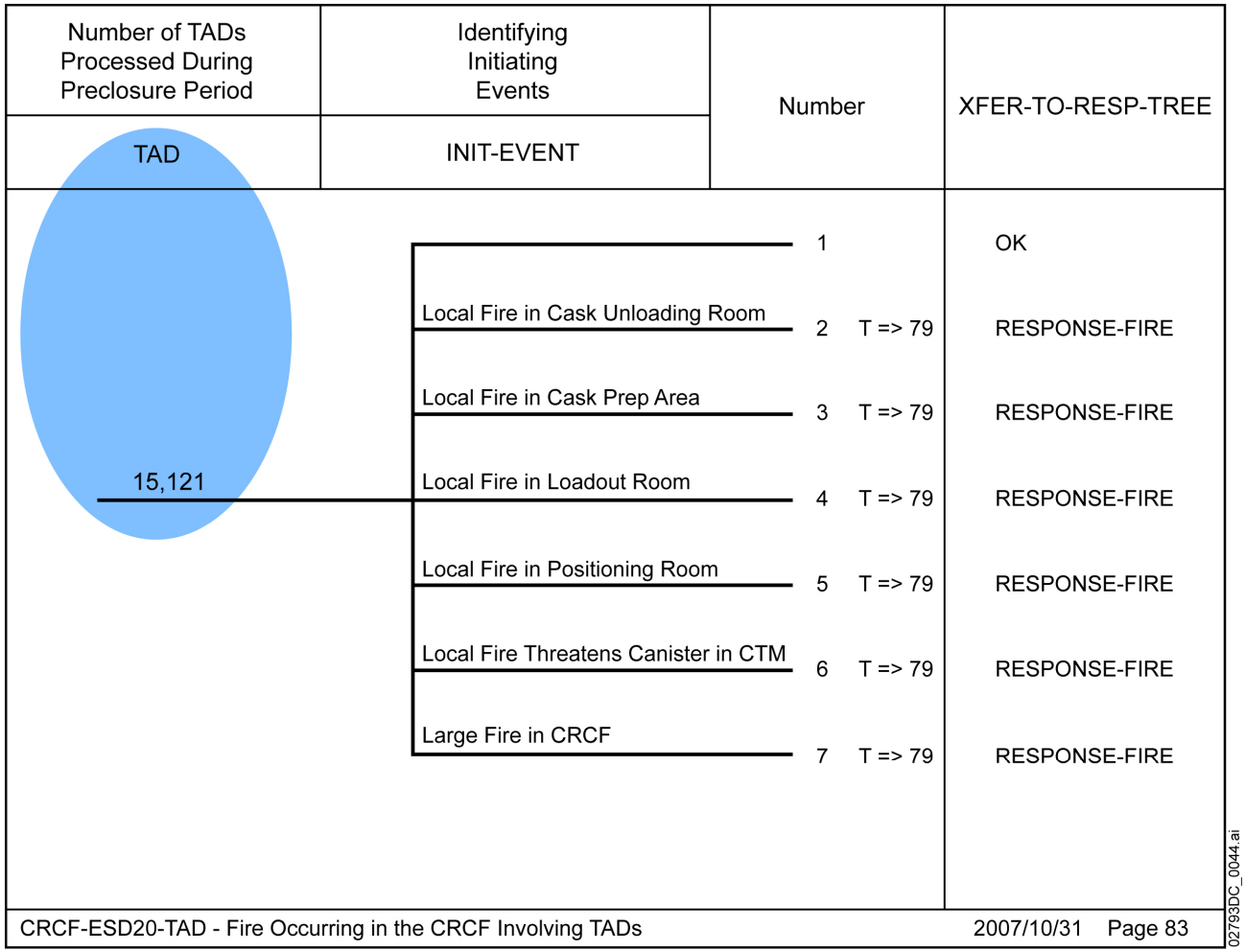

Figure 2. Event Tree CRCF-ESD20-TAD with Basic Event “TAD” Value

NOTE: CTM = canister transfer machine.