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Supplemental Analysis to Support Postulated Events in the Process Hazards Analysis for the HEAF

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DISCLAIMER

This work was performed under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under Contract No. W-7405-Eng-48.

1.0 Purpose of the Report

The purpose of this report is to conduct a limit scope risk assessment by generating event trees for the accident scenarios described in table 4-2 of the HEAF SAR, ref 1. Table 4-2 lists the postulated event/scenario descriptions for non-industrial hazards for HEAF. The event tree analysis decomposes accident scenarios into basic causes that appear as branches on the event tree. Bold downward branches indicate paths leading to the accident. The basic causes include conditions, failure of administrative controls (procedural or human error events) or failure of engineered controls (hardware, software or equipment failure) that singly or in combination can cause an accident to occur. Event tree analysis is useful since it can display the minimum number of events to cause an accident. Event trees can address statistical dependency of events such as a sequence of human error events conducted by the same operator. In this case, dependent probabilities are used. Probabilities/frequencies are assigned to each branch. Another example of dependency would be when the same software is used to conduct separate actions such as activating a hard and soft crow bar for grounding detonator circuits. Generally, the first event considered in the event tree describes the annual frequency at which a specific operation is conducted and probabilities are assigned to the remaining branches. An exception may be when the first event represents a condition, then a probability is used to indicate the percentage of time the condition exists. The annual probability (frequency) of the end state leading to the accident scenario in the event tree is obtained by multiplying the branch probabilities together.

2.0 Conduct of the study

To conduct the study, it was important to know the hazards associated with explosives operations that include handing, processing, synthesis, transporting, storage and testing. Firing tank operations were examined in detail. A block diagram of the firing circuit (see figure 1) was generated to facilitate the understanding of how the major system components work in the shot sequence for the firing tanks. A similar scheme is used at site 300.

2.1 HEAF tours

Numerous tours of HEAF were taken. The following important components were observed in the control rooms for the firing tanks:

1. System key
2. HE key
3. Green button for start
4. Red button for fire
5. Red button for stop
6. White button for reset
7. Computer displays

The following components were examined for the run/safe system:

1. Access Entry Box
2. Run/Safe box
3. Micro Switch Door
4. Beacon
5. Door Exit box
6. Sweep box

The following components were examined for the firing tanks:

1. Tank ports
2. Ventilation system
3. Tank door and switches
4. Hydraulic system to open/close door
5. Soft crow bar (bleeder resistor)
6. Hard crow bar
7. Detonator grounding panel

and the tank diagnostic equipment that included:

1. High Speed Cameras
2. Flash Lamps
3. Laser Doppler Interferometer
4. Laser illumination and imaging
5. Heating of explosives
6. e-gun
7. X-ray heads

Numerous chemical laboratories were examined and the following were observed:

1. Fume hood ventilation system
2. Room ventilation
3. Acid Waste collection system
4. Posted weight limits and inventory
5. Storage repositories

The walls, blast doors, mazes and loading dock to HEAF were observed.
Containers used for movement of HE were observed --

1. ammunition cans
2. ice cream cartons
3. push carts

Small scale testing components were observed

1. Drop hammer machine
2. Spark test machine
3. Friction test machine

and ODTX components that include:

1. heaters
2. holding fixtures
3. test instrumentation circuitry
4. two remote cells with shielded windows
5. shock absorbing material.

The drawers, cubicles and DOT containers were observed in magazine storage. The personal duress system was examined; specific components include

1. Transmitters
2. Receivers
3. Alarm Strobes
4. Directional Alarm Strobes
5. Alarm Horns (entrance to each room)
6. Map Display Panel
7. Annunciator Panel
8. Control Chassis & Power Distribution.

2.2 HEAF Personnel Discussions

Discussions with the following individuals occurred:

William Gilliam (Facility Manager)
Roanne Lee (Lead Mechanical Engineer)
Greg Mack (Lead Electriconics Engineer)
Jim Dotts (Explosives Safety Engineer)
Denise Grimsley (1 Kg Tank Operator)
Gary Steinhour (Electronics Technician)
Ernie Urquidez (Gun Tank Operator)
Don Burns (Electronics Technican)
David Hill (Explosives Safety Engineer)
Mike Tandy (Materials Management)
Jon Maienshein (Energetic Materials Section Leader)

2.3 Documents Reviewed

The following documents were reviewed:

1. The ES&H manual ref. 2

2. The HEAF facility safety plan (FSP), ref. 3

3. Numerous HEAF control documents regarding explosives storage, operations, hazards analysis

Of particular importance to the risk assessment were two sections of the FSP -- chapter 5 (entitled Hazards Analysis and Controls) and appendix C (entitled Safety Plans for Specific Operations) and the operational procedures that were referenced for these two sections.

3.0 Risk Assessment

Simple event trees were constructed for each hazard scenario in the HEAF SAR to help in the qualitative assessment of event occurrence probabilities. Appendix A contains these event trees. Each event in an event tree was classified into one of the probability categories shown in Table 1.

Table 1 Probability rating levels

Category	Description	Estimated occurrence rate per year (nominal or best estimate)
Less than credible	Events are expected not to occur during the life cycle of the facility.	10^{-6}
Extremely unlikely	Events will probably not occur during the life cycle of the facility.	10^{-4}
Unlikely	Events may occur once during the life cycle of the facility.	10^{-2}
Medium	Event may occur during the facility or operation lifetime	10^{-1}
Likely	Events may occur several times during the life cycle of the facility.	1
Very likely	Events may often occur.	100

The frequency at which operations are conducted was obtained from ref. 4. The probability of each event tree branch was estimated by examining pairs of events and estimating the probability of event pairs as shown in Table 2. Where more than two events make up an event tree branch the branch probability was estimated by examining pairs of events, treating a pair as a single event and re-entering Table 2.

The probability of a hazard scenario was taken as the probability of the most likely branch in the associated event tree. No attempt was made to sum probabilities over all branches as the trees contain relatively few branches. Summing over branches in a quantitative probability estimation scheme would affect the probability estimates by a factor of 3 to 5. Such changes are below the resolution of the qualitative scheme adopted here.

The probability estimates of this analysis are used in the HEAF SAR summary hazard tables and together with the estimated consequences form the basis for deciding risk acceptability.

Table 2 -- Joint Probability Table (combining the probability of two events)

Annual Frequency Or Probability	→	1.0×10^{-6}	1.0×10^{-4}	1.0×10^{-2}	0.1	1	100
↓	Relative Probability Description	Less than credible	Extremely Unlikely	Unlikely	Medium	Likely	Very Unlikely
1.0×10^{-6}	Less than credible	Less than credible	Less than credible	Less than credible	Less than credible	Less than credible	Extremely Unlikely
1.0×10^{-4}	Extremely Unlikely	Less than credible	Less than credible	Less than credible	Extremely Unlikely	Extremely Unlikely	Unlikely
1.0×10^{-2}	Unlikely	Less than credible	Less than credible	Extremely Unlikely	Unlikely	Unlikely	Likely
0.1	Medium	Less than credible	Extremely Unlikely	Unlikely	Unlikely	Medium	Very Likely
1	Likely	Less than credible	Extremely Unlikely	Unlikely	Medium	Likely	Very Likely
100	Very likely	Extremely Unlikely	Unlikely	Likely	Very likely	Very likely	Not applicable

4.0 References

1. High Explosives Applications Facility (HEAF), Building 191, Revised July 2001, Safety Analysis Report, Lawrence Livermore National Laboratory.

2. ES&H Manual, Lawrence Livermore National Laboratory, Part 3.1.

3. Facility Safety Plan, High Explosives Applications Facility, Building 191, FSP-191, Effective September 30, 2000.

4. Memo from Carl Ingram to Howard Lambert, entitled "Estimated Activity Levels in HEAF, July 18, 2001.

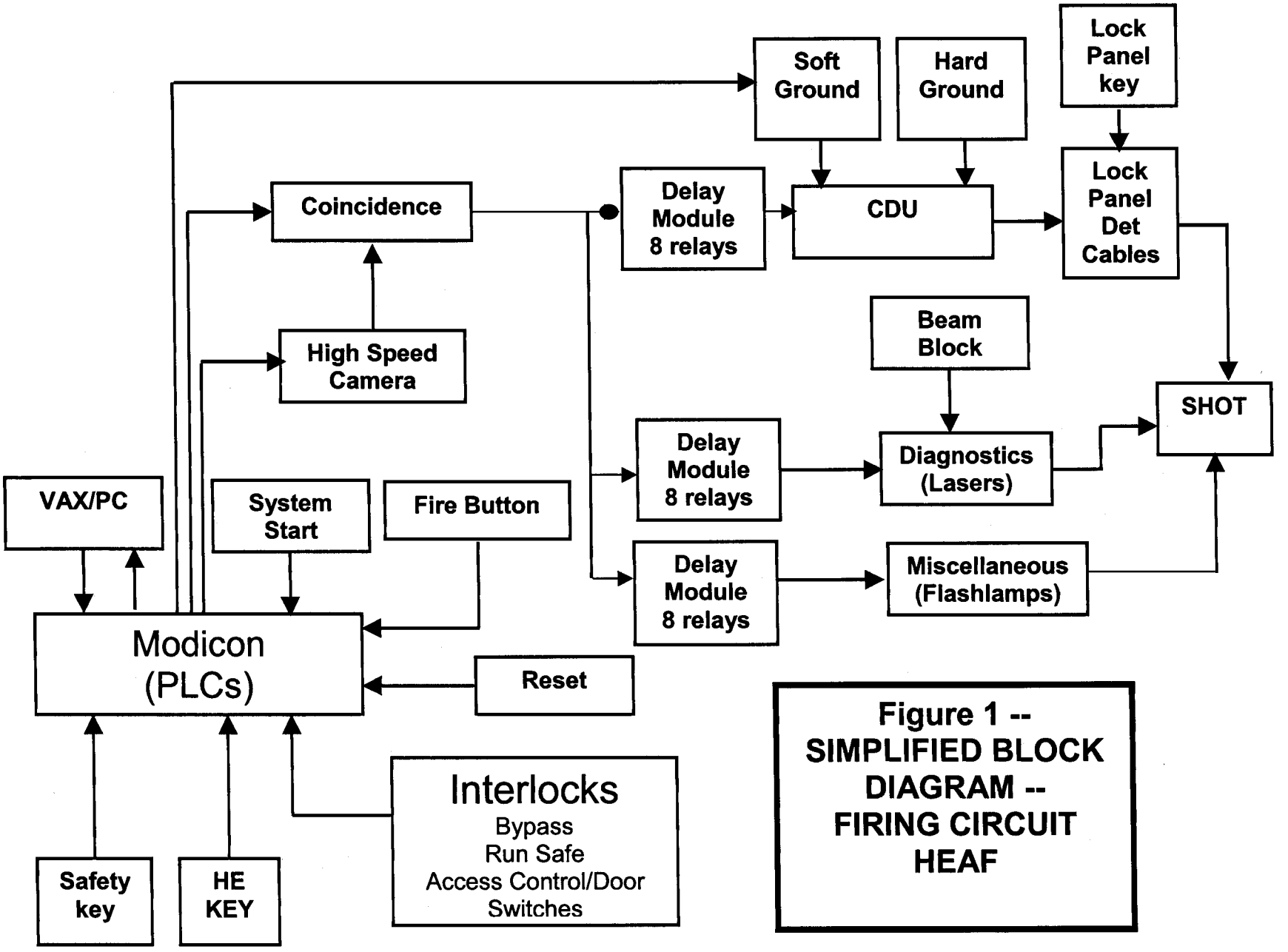


Figure 1 -- SIMPLIFIED BLOCK DIAGRAM -- FIRING CIRCUIT HEAF

APPENDIX A

EVENT TREES

Fig A -- SAR Scenario A. Accidental Detonation or Deflagration of Explosives: Explosives are dropped or struck during handling or processing (either transport or class II operations such as assembly)

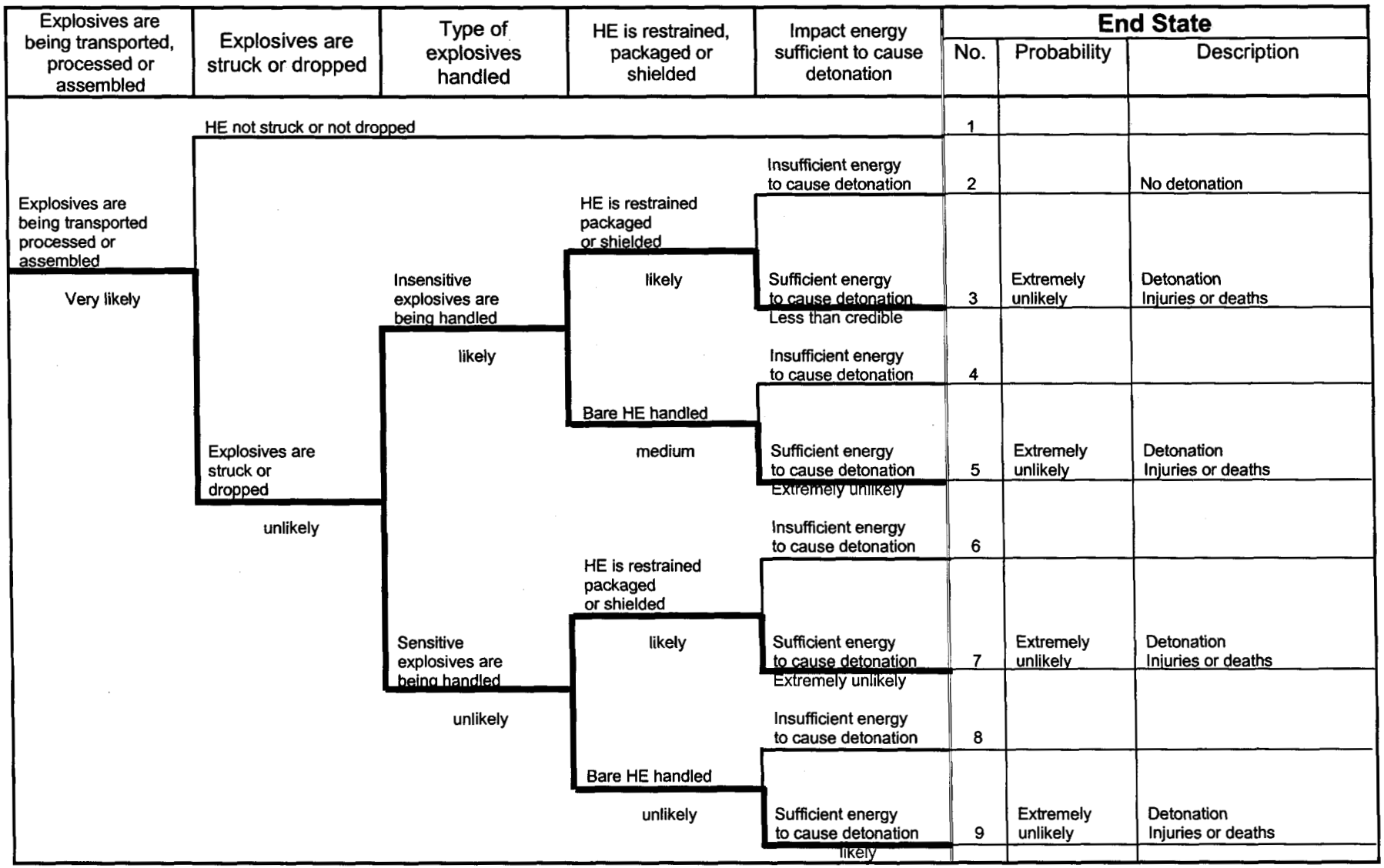


Fig B – SAR Scenario B -- Accidental Detonation or Deflagration of Explosives in storage

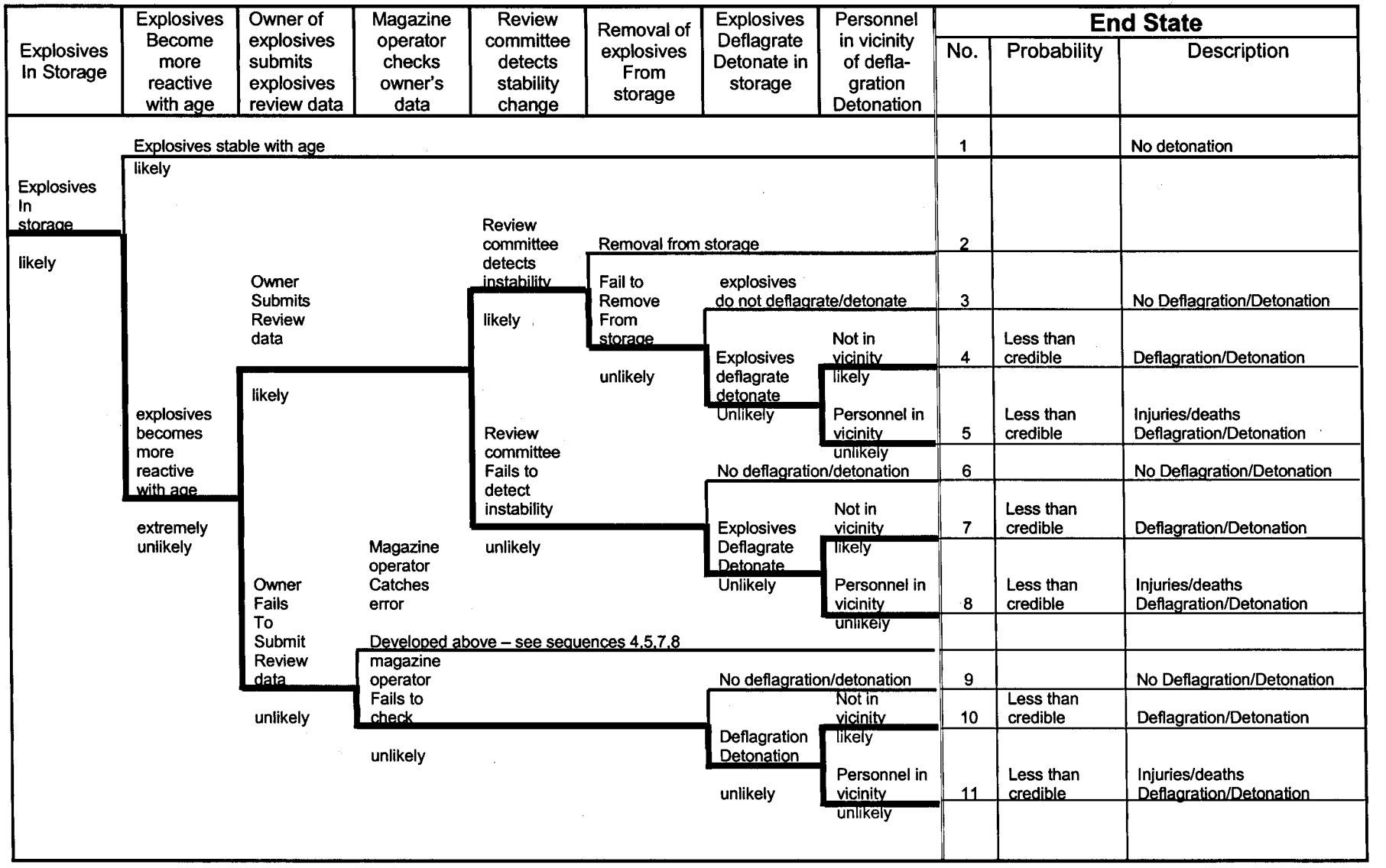
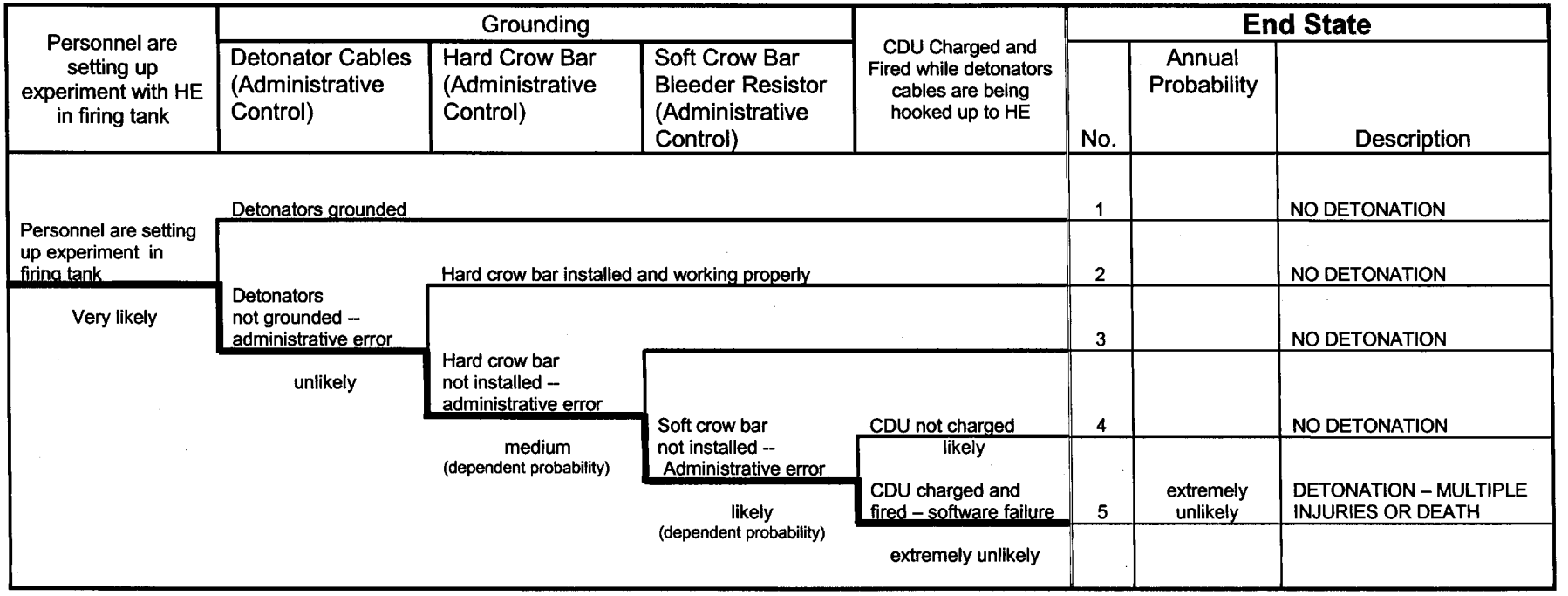
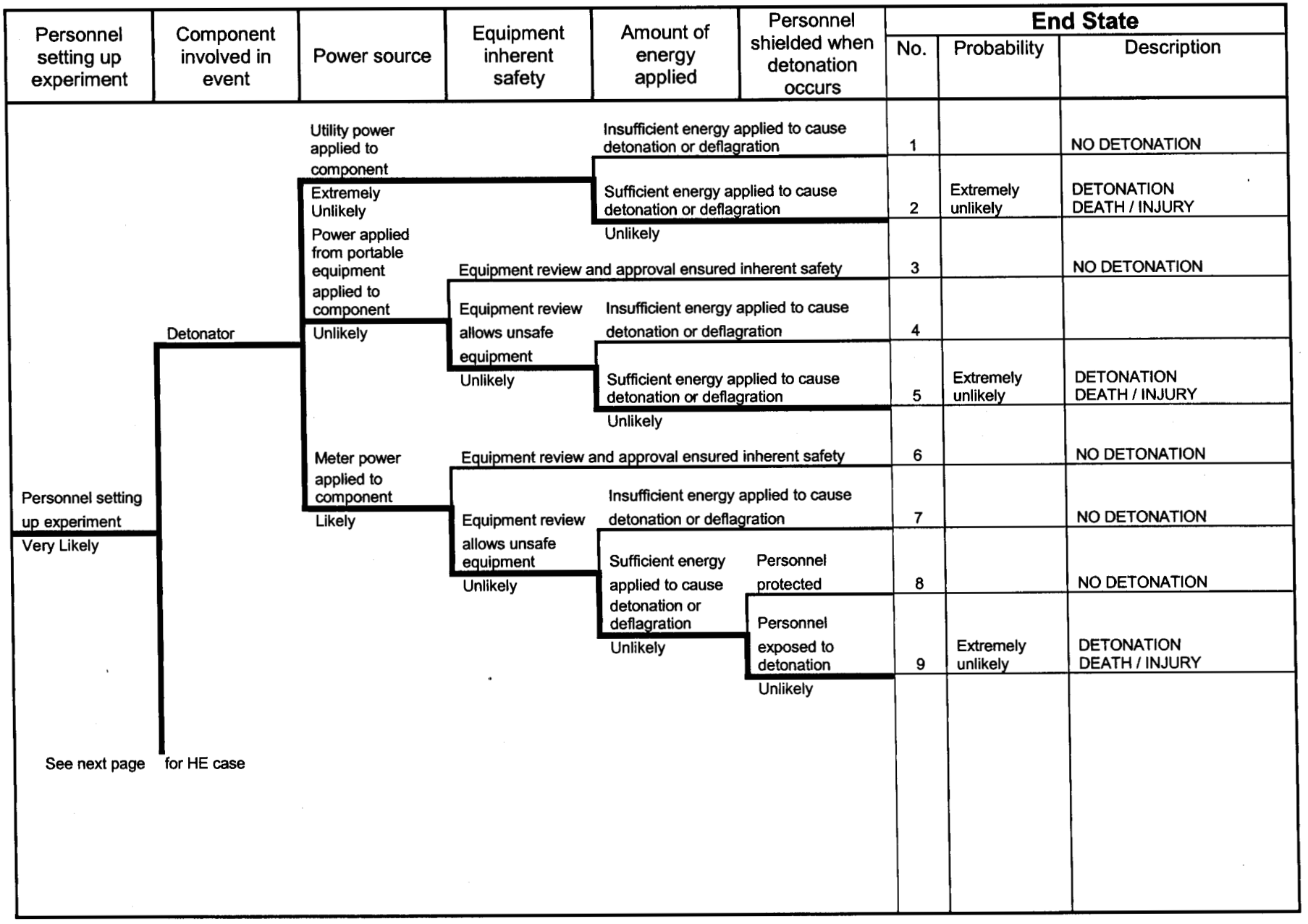


Fig C – SAR Scenario C -- Accidental Detonation Or Deflagration Of Explosives -- Intentional Detonation Experiment Prematurely Fires With Personnel In Tank Room And Tank Open



D. Accidental detonation or deflagration of explosives: explosives are initiated by electrical energy from adjacent equipment or utilities



D. Accidental detonation or deflagration of explosives: explosives are initiated by electrical energy from adjacent equipment or utilities

Personnel setting up experiment	Component involved in event	Power source	Equipment inherent safety	Amount of energy applied	Personnel shielded when detonation occurs	End State No.	End State Probability	End State Description
From previous page	High Explosive	Utility power applied to component		Insufficient energy applied to cause detonation or deflagration		10		NO DETONATION
		Extremely Unlikely		Sufficient energy applied to cause detonation or deflagration		11	Extremely unlikely	DETONATION DEATH / INJURY
				Extrmely unlikely				
		Power applied from portable equipment applied to component	Equipment review and approval ensured inherent safety			12		NO DETONATION
		Unlikely	Equipment review allows unsafe equipment	Insufficient energy applied to cause detonation or deflagration		13		NO DETONATION
			Unlikely	Sufficient energy applied to cause detonation or deflagration		14	Extremely unlikely	DETONATION DEATH / INJURY
				Unlikely				
		Meter power applied to component	Equipment review and approval ensured inherent safety			15		NO DETONATION
		Unlikely	Equipment review allows unsafe equipment	Insufficient energy applied to cause detonation or deflagration		16		NO DETONATION
			Unlikely	Sufficient energy applied to cause detonation or deflagration		17	Less than credible	DETONATION DEATH / INJURY
				Extremely Unlikely				

Fig E– SAR Scenario E Accidental Detonation or Deflagration of Explosives: Explosives are initiated by electrical energy from electronic gun

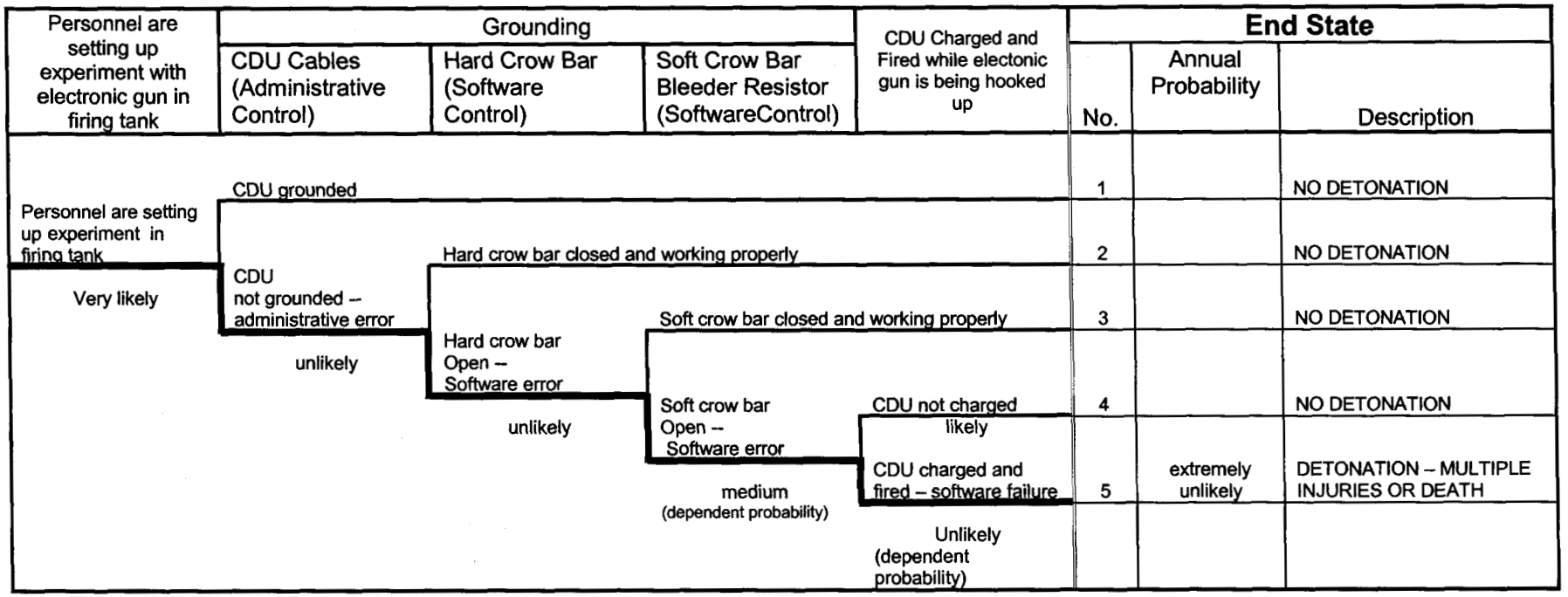


Fig F -- SAR Scenario F. Accidental Detonation or Deflagration of Explosives: Explosives are initiated by nearby fire

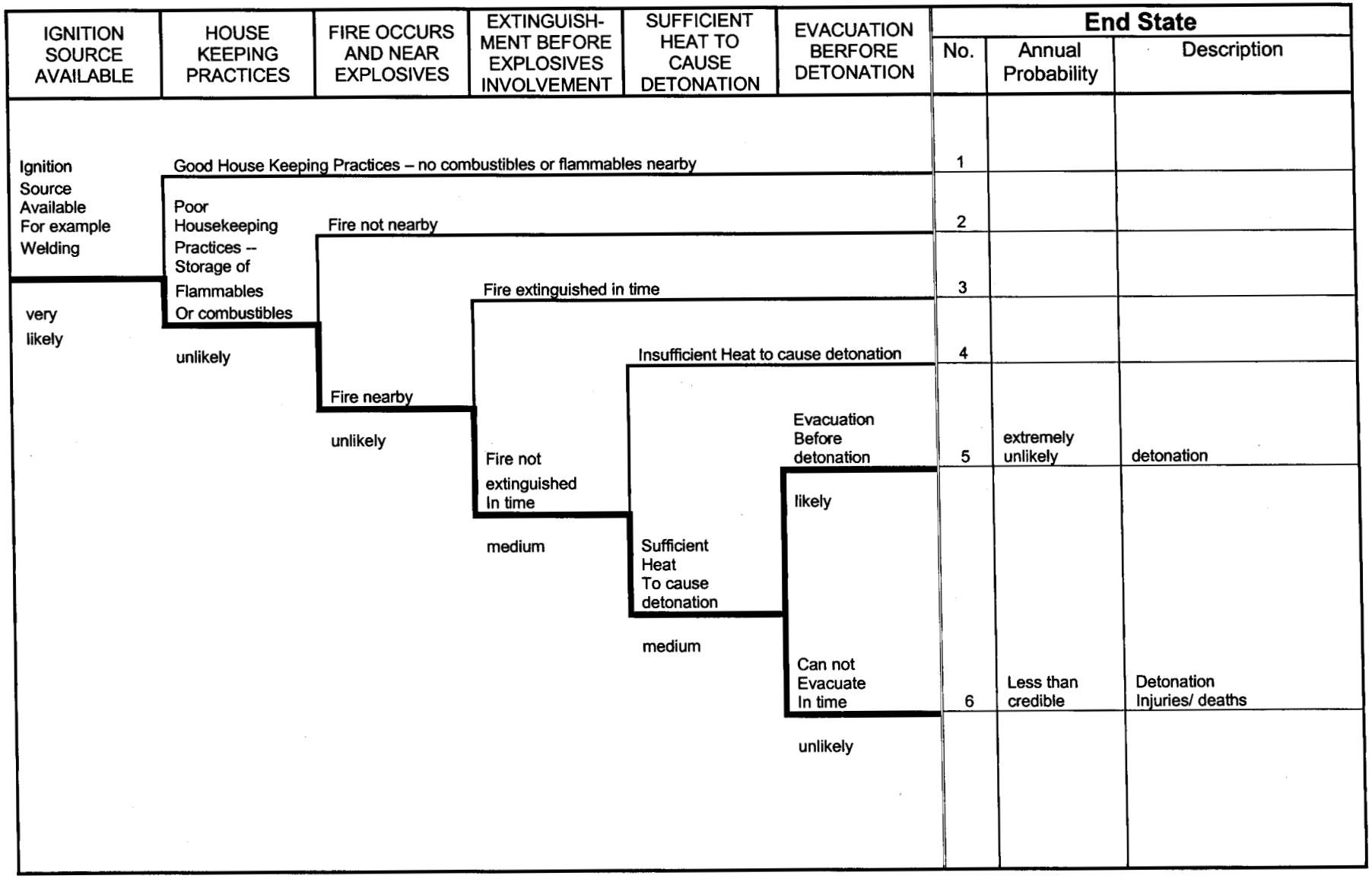


Fig G. SAR Scenario G Accidental detonation or deflagration of explosives: explosives are initiated by chemical reaction occurring nearby

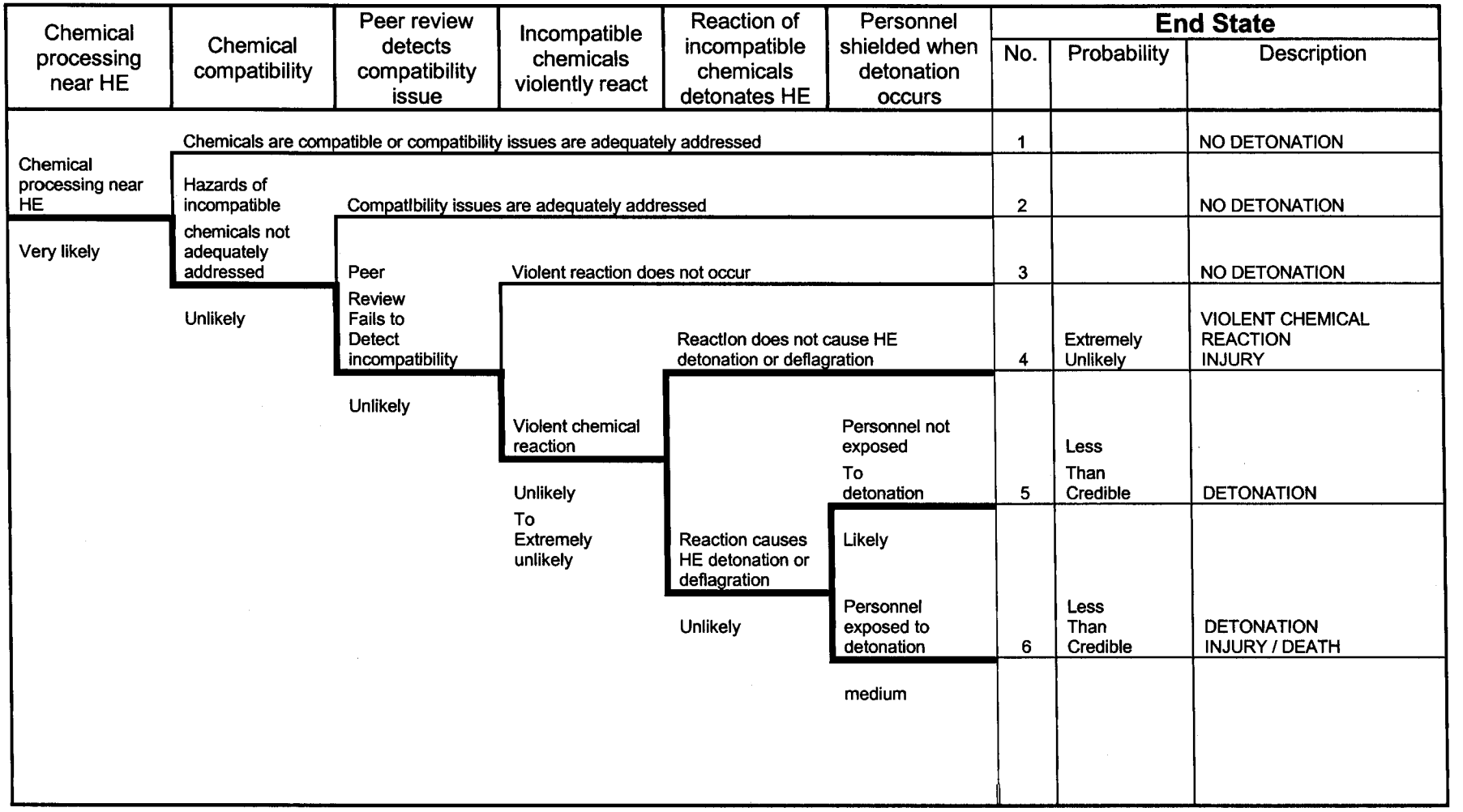


Fig. H. – SAR SCENARIO H – Accidental detonation or deflagration of explosives: explosives are initiated or sensitized and initiated by normal handling by reaction from chemical incompatibility

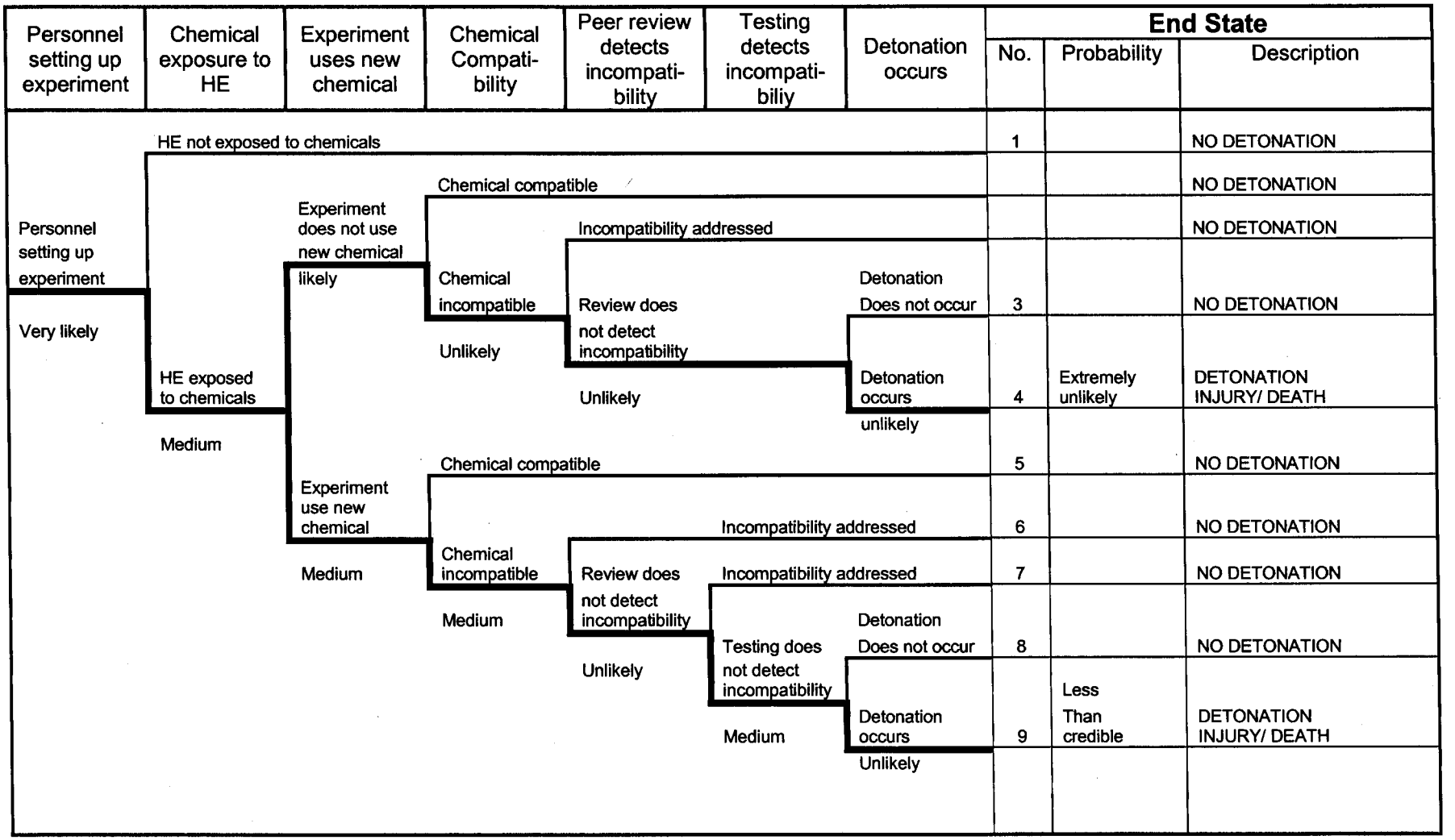


Fig I– SAR Scenario I -- Accidental Detonation or Deflagration of Explosives: Explosives are initiated by heating from laser

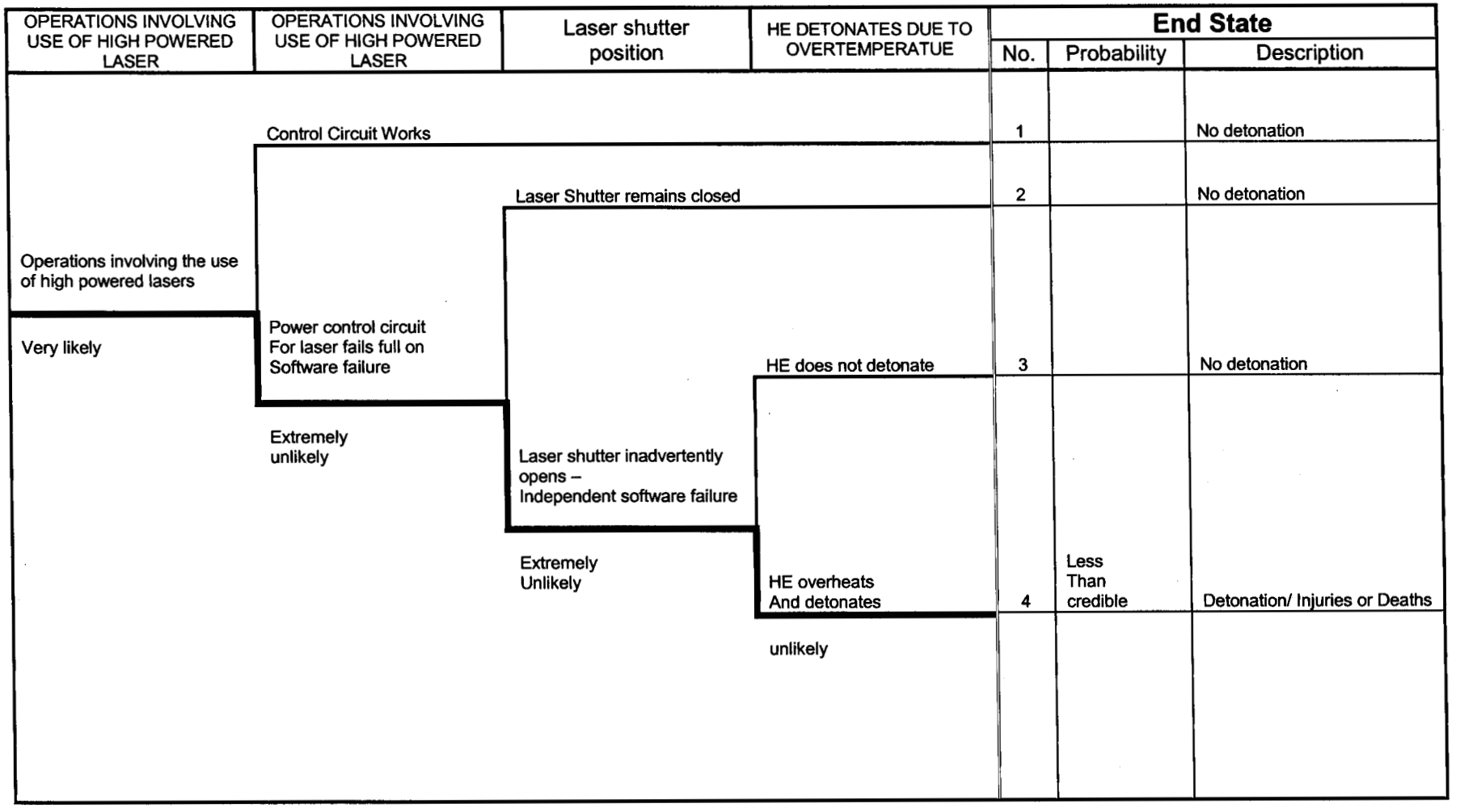


Fig J. SAR scenario J-- Accidental detonation or deflagration of explosives: Explosivers are initiated from normal stimuli after synthesis of unusually sensitive intermediate (or final) product.

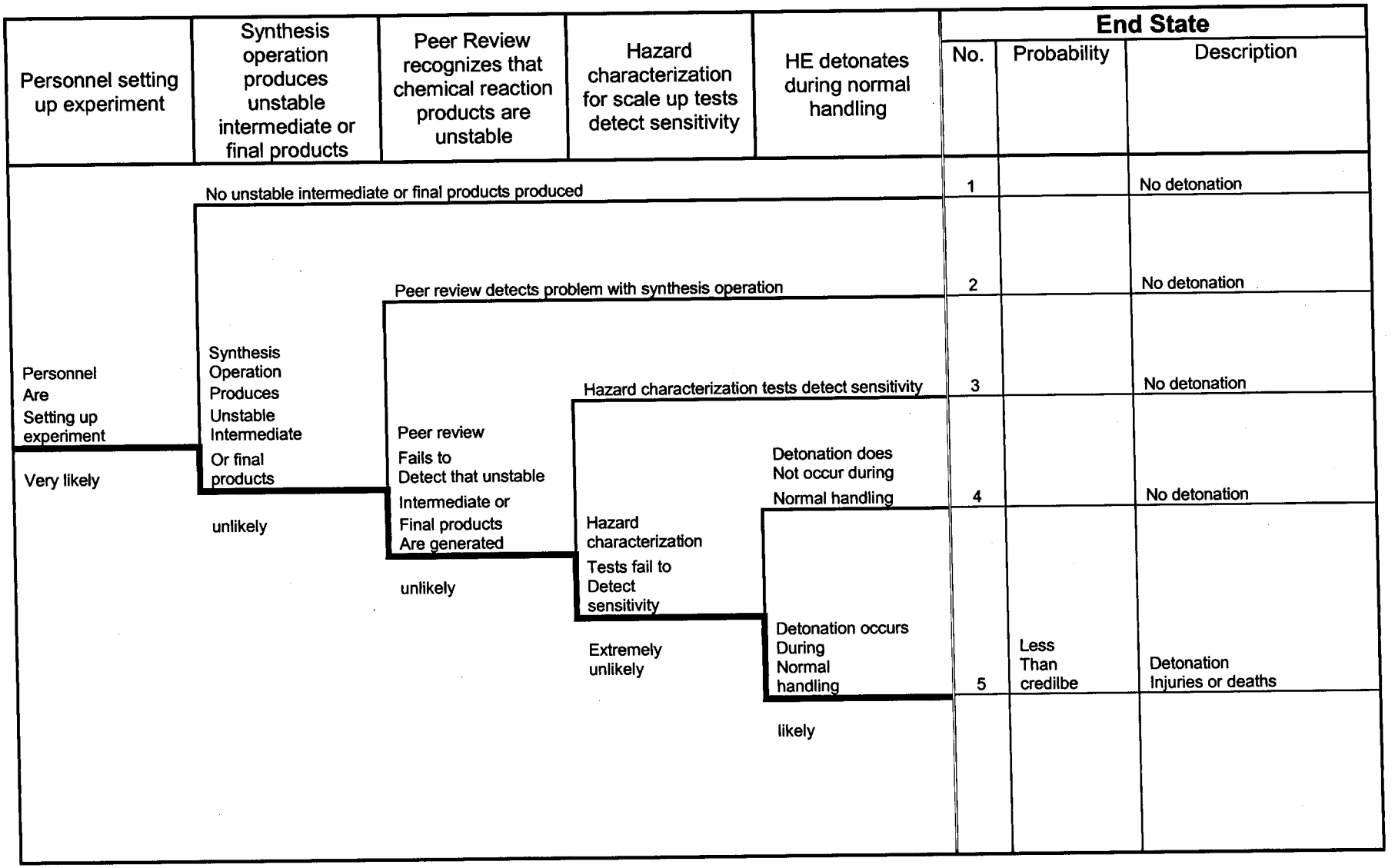


Fig K – SAR Scenario K. Accidental Detonation or Deflagration of Explosives: Explosives are initiated by unintentional heating to critical temperature.

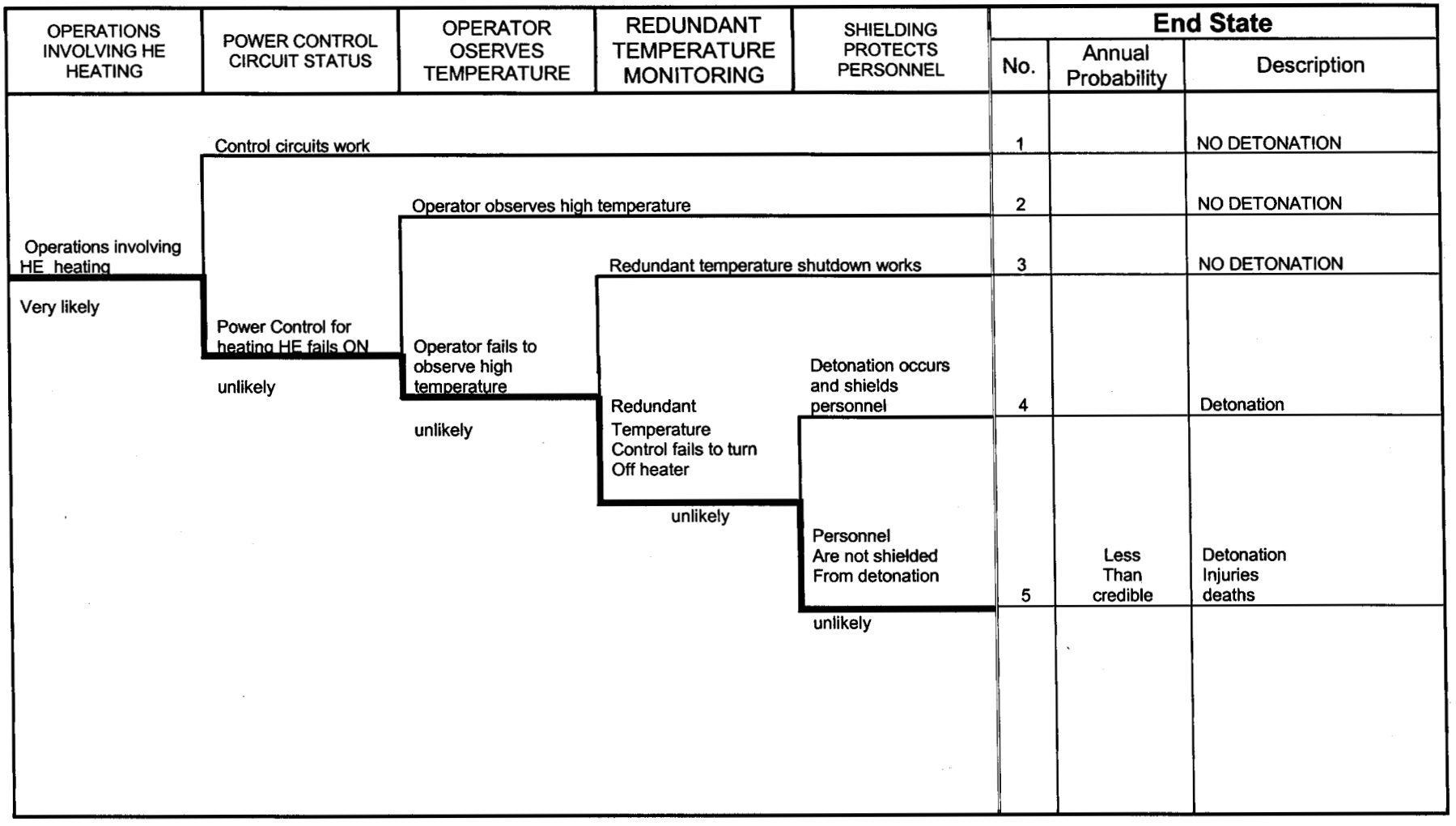


Fig L. SAR Scenario L -- Intentional detonation: Firing tank is breached or 100 mm gun breach fails

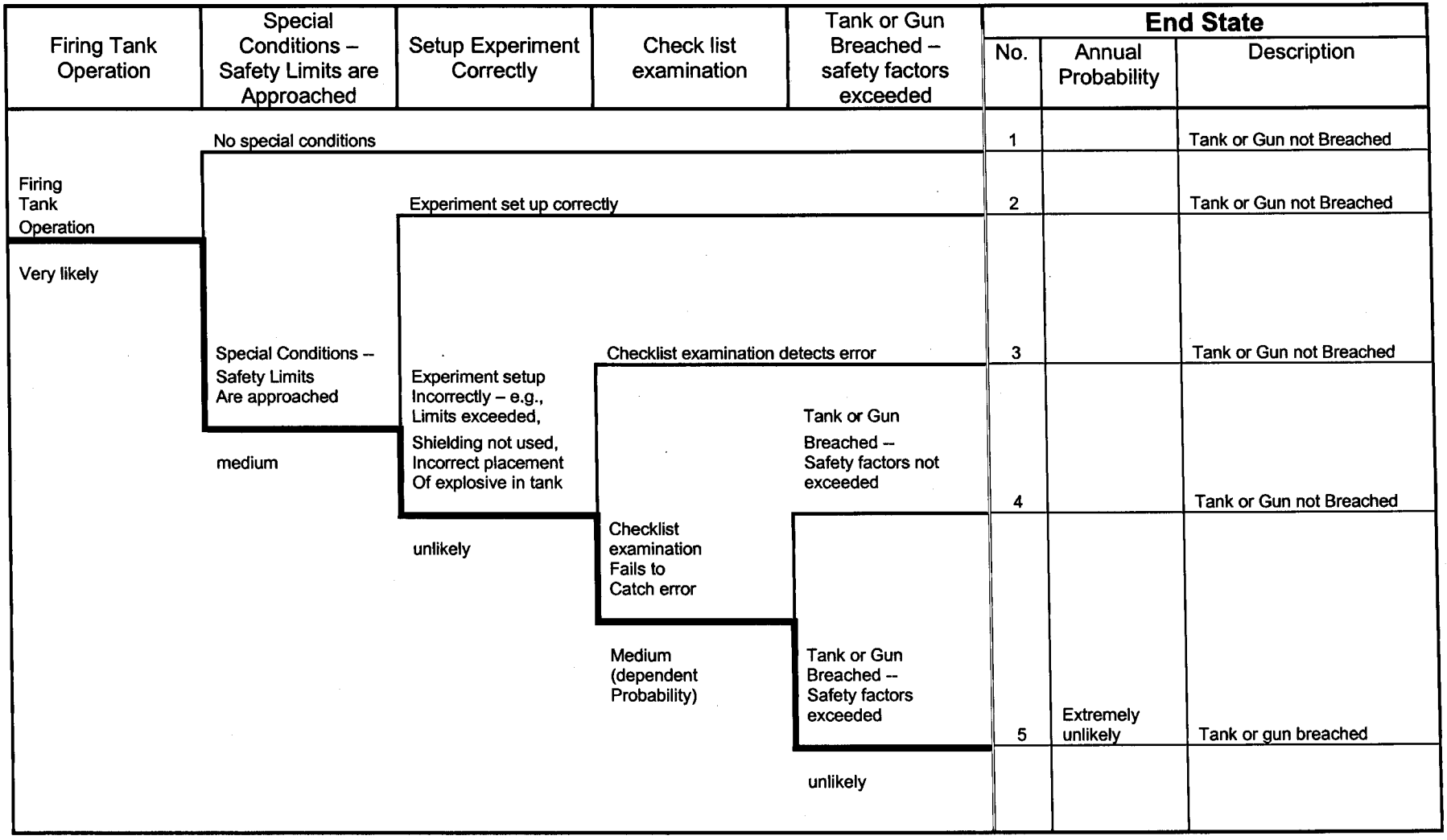


Fig. M SAR Scenario M -- Chemical dispersion/release

OPERATIONS ARE OCCURRING IN CHEMICAL LABORATIES	INIATING EVENT THAT COULD CAUSE HAZARDOUS CHEMICAL RELEASE IN CHEMICAL LABORATORIES	HOOD/VENTILATION SYSTEM MITIGATES CHEMICAL RELEASE	No.	AnnualP Probability	Description
Operations Are occurring In Chemical laboratories	Exothermic Chemical Reaction Due to human error	Hood ventilation System mitigates Chemical release	1		
	unlikely (see event tree G)	Hood ventilation System fails to mitigate Chemical release	2	Extremely unlikely	Hazardous chemical release
likely	Leak or Spill Of container	unlikely			
		Hood ventilation System mitigates Chemical release	3		
	unlikely	Hood ventilation System fails to mitigate Chemical release	4	Extremely unlikely	Hazardous chemical release
	Fire In Proximity Of chemicals	unlikely			
		Hood ventilation System mitigates Chemical release	5		
	unlikely (see scenario F)	Hood ventilation System fails to mitigate Chemical release	6	Extremely unlikely	Hazardous chemical release
	chemicals In proximity To accidental Explosives Initiation	unlikely			
		Hood ventilation System mitigates Chemical release	7		
	Extremely unlikely (see scenario A)	Hood ventilation System fails to mitigate Chemical release	8	Extremely unlikely	Hazardous chemical release
		likely			

Fig N-- SAR Scenario N. Radiological dispersion/release: Radiological materials are dispersed due to combination of spill and fire.

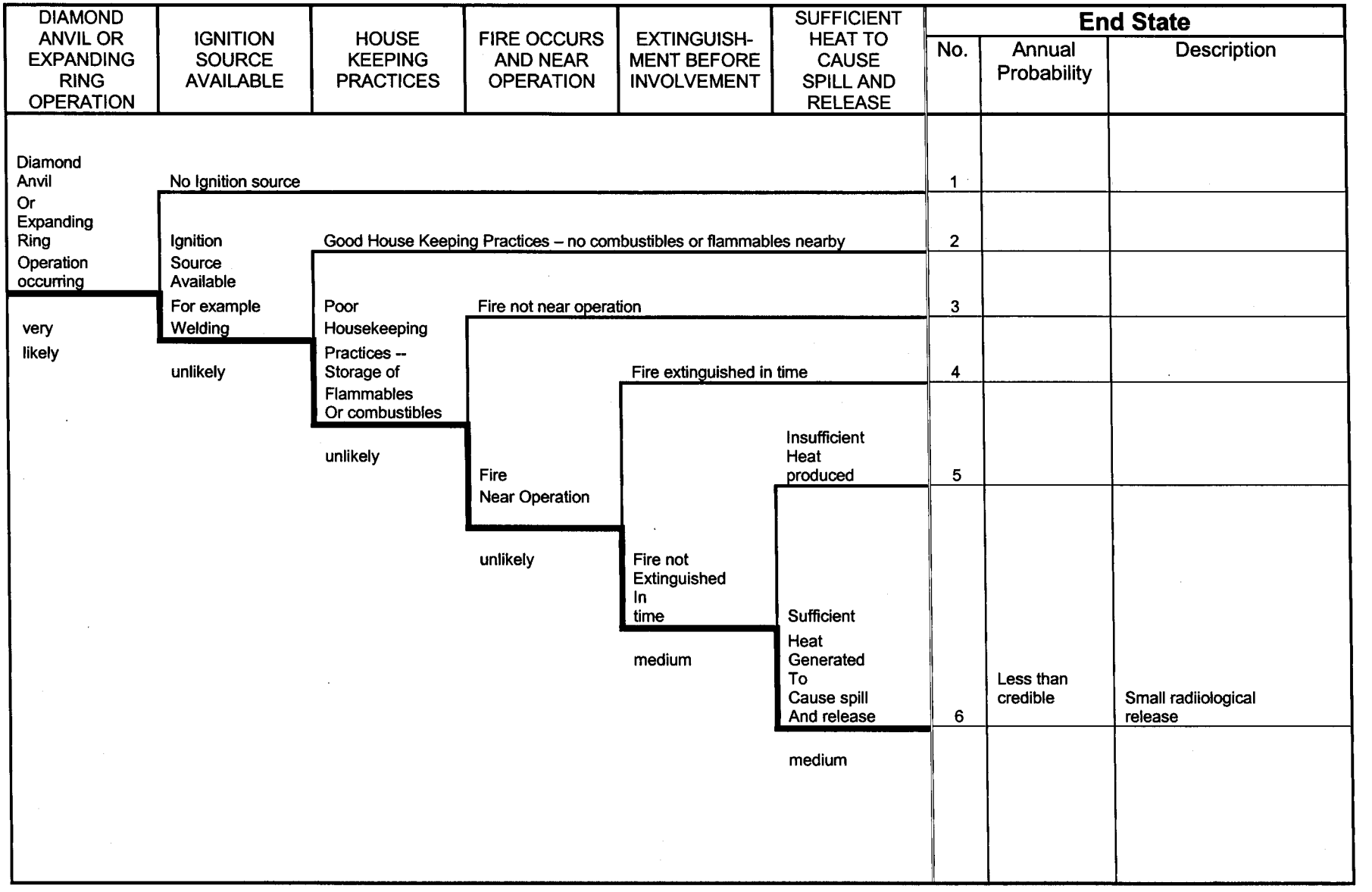


Fig O -- SAR Scenario O -- Chemical exposure: Personnel are exposed to toxic or asphyxiant gases or radiological contamination from re-entry into firing tanks after an experiment

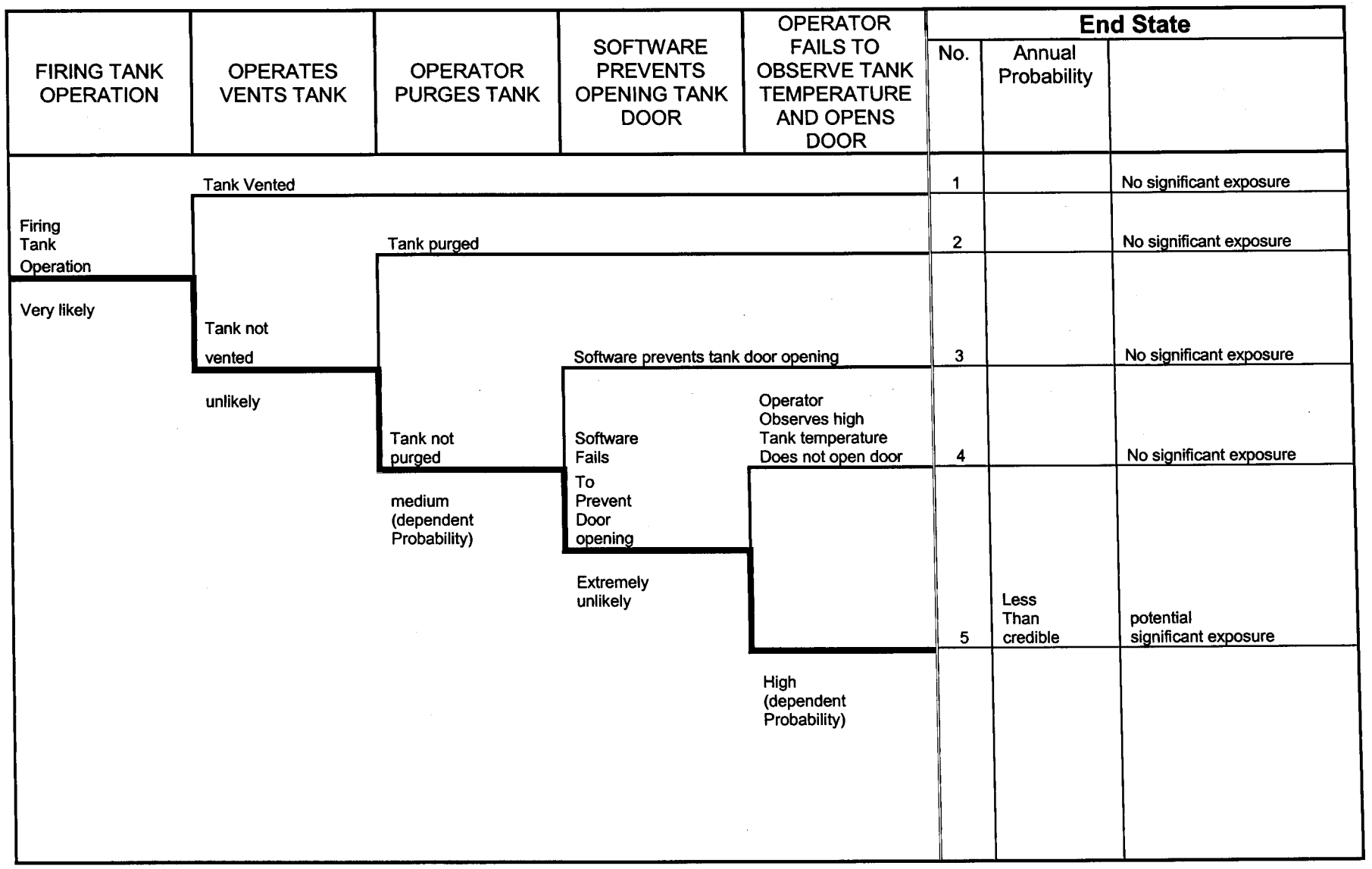


Fig P -- SAR Scenario P -- Ionizing radiation exposure: Personnel are exposed to radiation from radiation generating devices (e.g. x-ray heads)

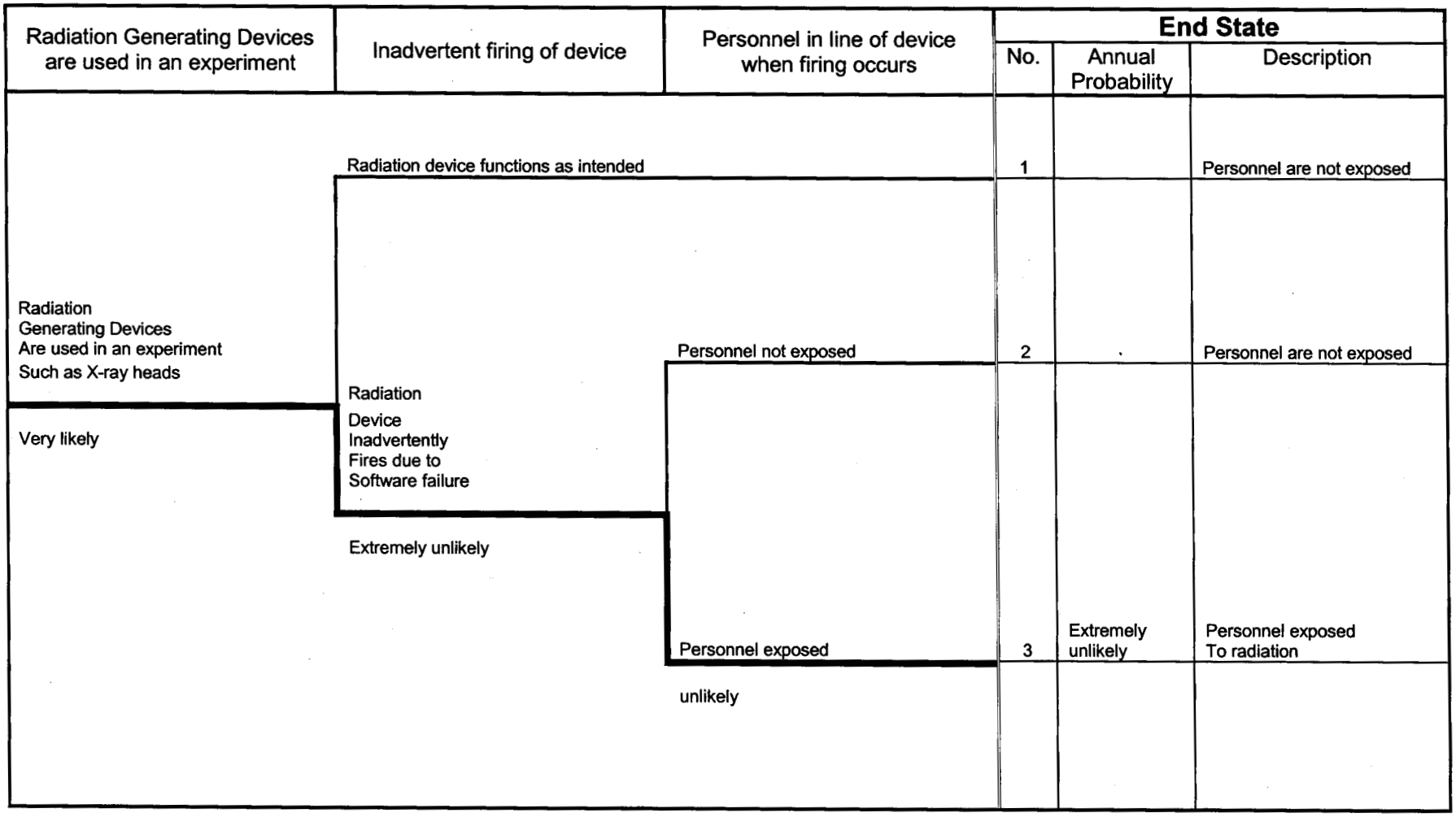


Fig Q – SAR Scenario Q -- Non-ionizing radiation exposure: Personnel are injured from exposure to laser light

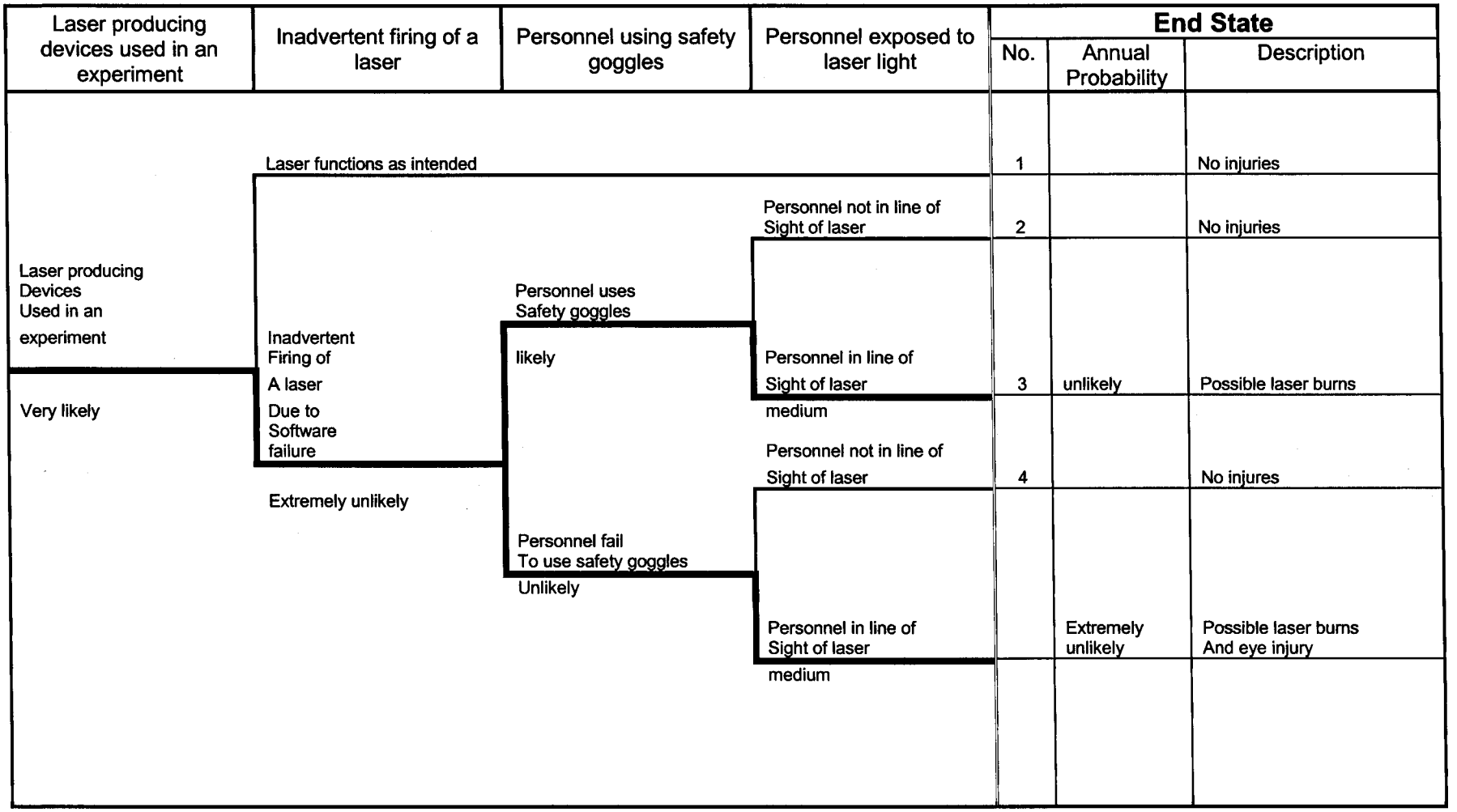
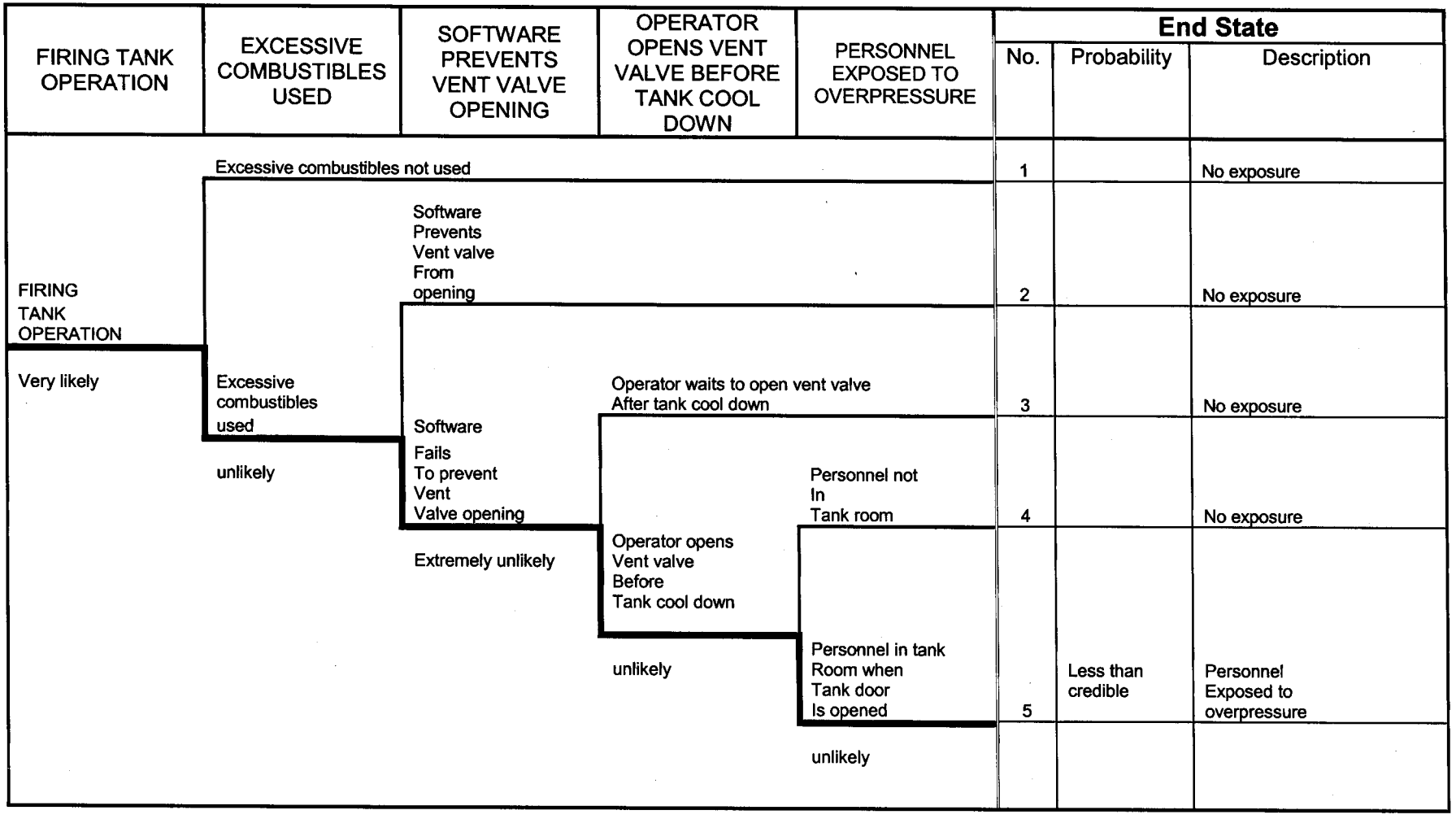


Fig. S – Scenario S -- Personnel exposed to overpressure: Secondary burnoff in firing tank ruptures exhaust ventilation ducting.



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