SAND80-2124
TTC-0156
UC-71

TRANSPORTATION ACCIDENT SCENARIOS FOR COMMERCIAL SPENT FUEL

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February 1981

ABSTRACT

A spectrum of high severity, low probability, transportation accident scenarios involving commercial spent fuel is presented together with mechanisms, pathways and quantities of material that might be released from spent fuel to the environment. These scenarios are based on conclusions from a workshop, conducted in May 1980 to discuss transportation accident scenarios, in which a group of experts reviewed and critiqued available literature relating to spent fuel behavior and cask response in accidents.

Scenarios Postulated

As can be seen in the two fault trees, many possibilities exist for potential accident scenarios. In this section five scenarios are selected as being credible: four for water-cooled casks and one for air-cooled casks. No intervention during the scenario is assumed to mitigate the consequences (e.g., no attempts to remove cask from a fire).

Scenario 1

The fault tree path describing this scenario is shown in Figures 12 and 13. The path is indicated by heavy black lines.

In this scenario, only an impact environment has been assumed during the accident. The environment is sufficient to knock crud loose and to cause a cask closure seal to fail. Valves or penetrations are assumed not to fail because the impact zone was not near them. The environment is sufficient to activate the crud release mechanism in phase 1, but since no waterlogged rods are assumed to be in the cask, no rods fail from the impact. None of the mechanisms in phase 2 occurred because the spent fuel was assumed to be more than 180-days old. It must be further noted that, even though the thresholds for the impact-rupture mechanism and for the seal-failure pathway are both assigned a value of 2a, an impact that results in seal failure does not necessarily have to result in impact rupture of the spent fuel. Conditions of impact might be such that the impact zone is in a critical location for seal failure, but in a location that results in little fuel damage.

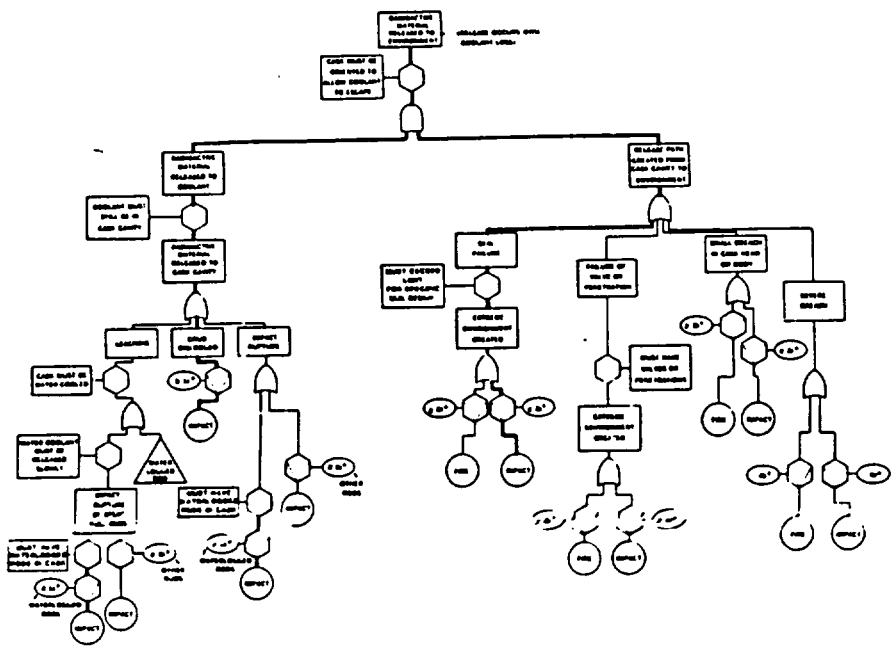

Figure 12. Fault tree for Phase 1 (Scenario 1).

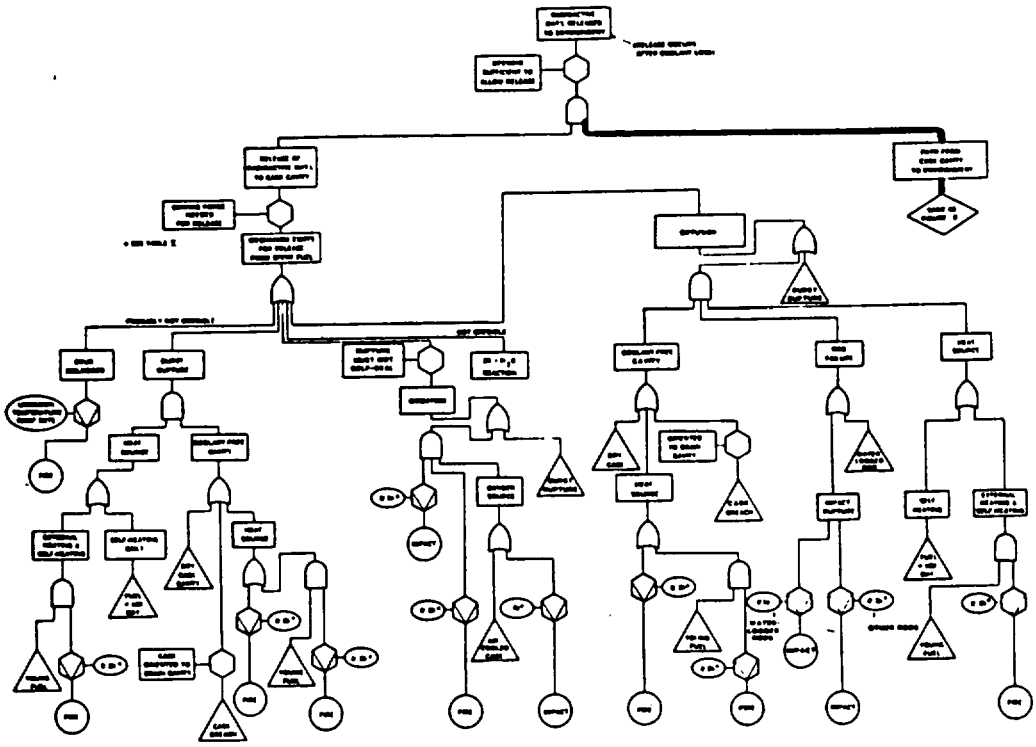

Figure 13. Fault tree for Phase 2 (Scenario 1).

Scenario 2

The fault tree paths, indicated by heavy black lines and describing this scenario, are shown in Figures 14 and 15.

In this scenario, a severe impact is assumed to occur with an accompanying fire that lasts less than one-half hour. The environments are sufficient to initiate the crud release mechanism and the leaching mechanism in phase 1 and to initiate the diffusion mechanism in phase 2. Rod failure required for leaching and diffusion is assumed to result from waterlogged rods. The cask failure pathway is through a seal. Again, valves or penetrations are assumed not to fail because the impact zone was not near them. The cask must drain its coolant

fairly rapidly so that the diffusion mechanism can be initiated. The decay heat from the spent fuel and the external fire are assumed to be sufficient to allow the diffusion mechanism to proceed.

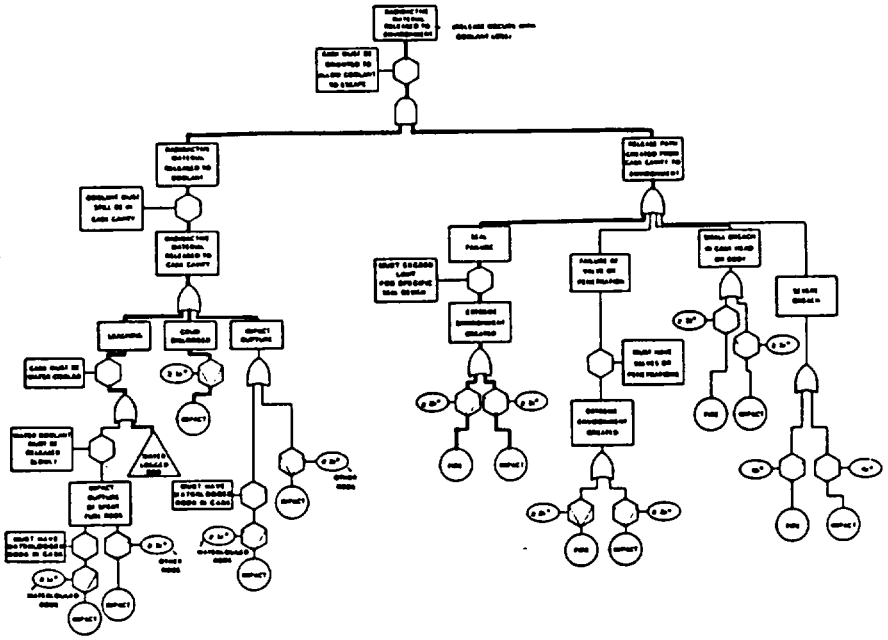

Figure 14. Fault tree for Phase 1 (Scenario 2).

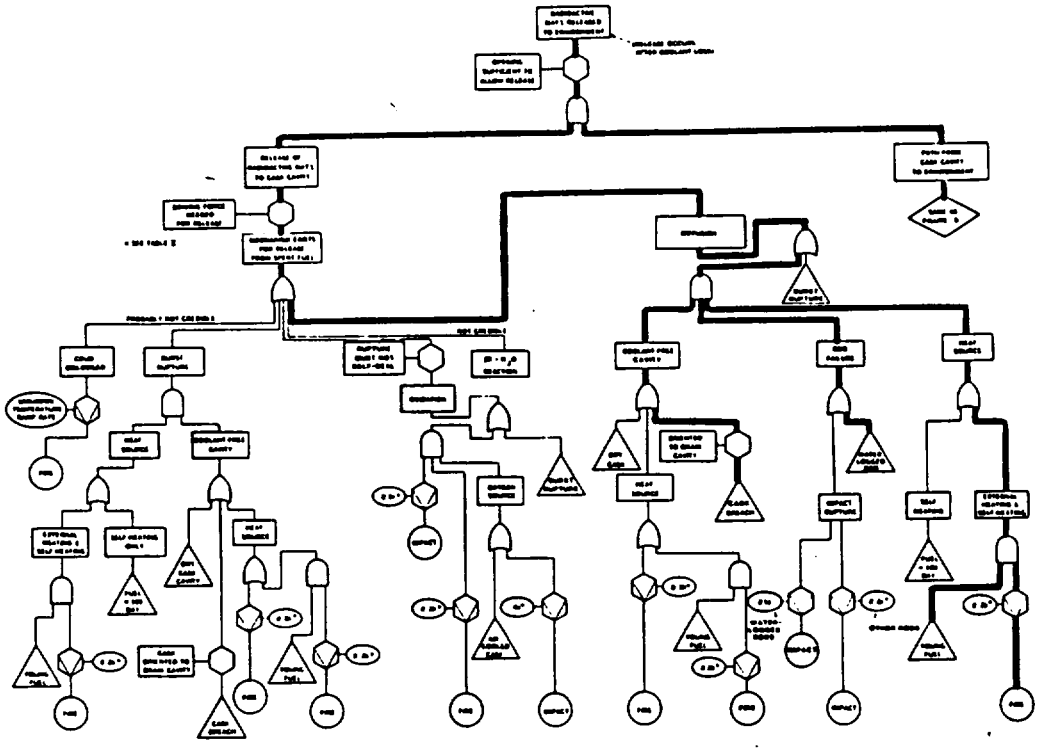

Figure 15. Fault tree for Phase 2 (Scenario 2).

Scenario 3

This scenario, as indicated in Figures 16 and 17, is different from scenario 2 in that the burst-rupture mechanism is initiated because the fire is assumed to last for a much longer time. In addition, the spent fuel is assumed to be much younger so as to have a much higher decay-heat generation rate.

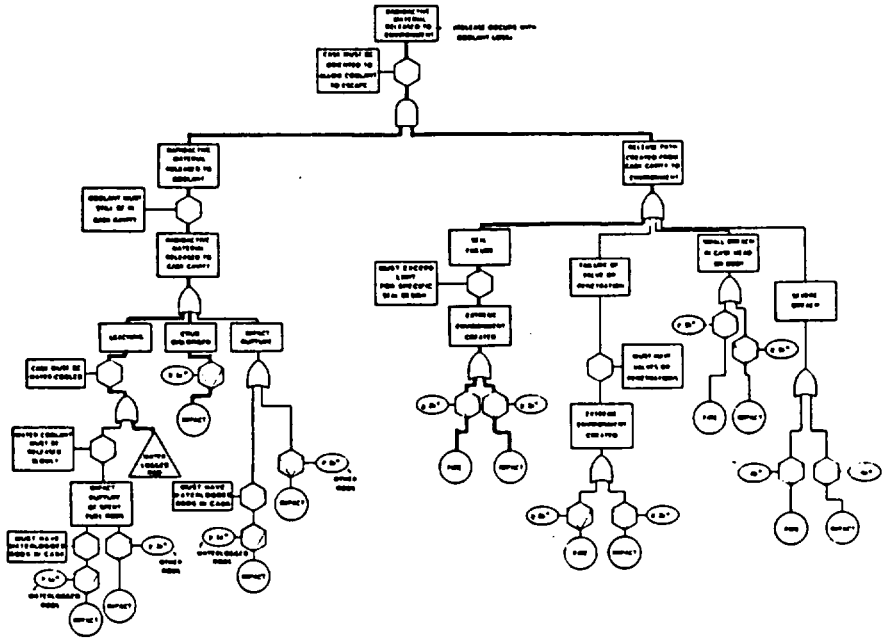

Figure 16. Fault tree for Phase 1 (Scenario 3).

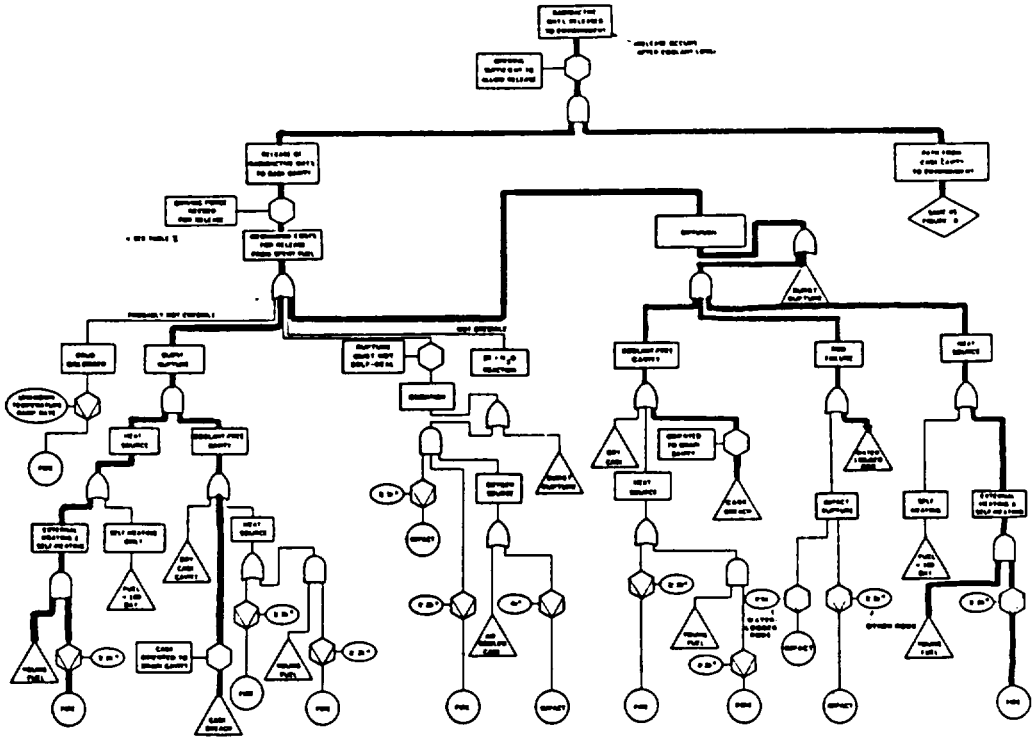

Figure 17. Fault tree for Phase 2 (Scenario 3).

Scenario 4 (A worst-case for water-cooled casks)

This scenario considers all spent fuel release mechanisms that are credible in a water-cooled cask and considers a seal failure and a small breach as the pathways for release from the cask cavity to the environment (see Figures 18 and 19). This scenario can be considered a credible worst-case scenario.

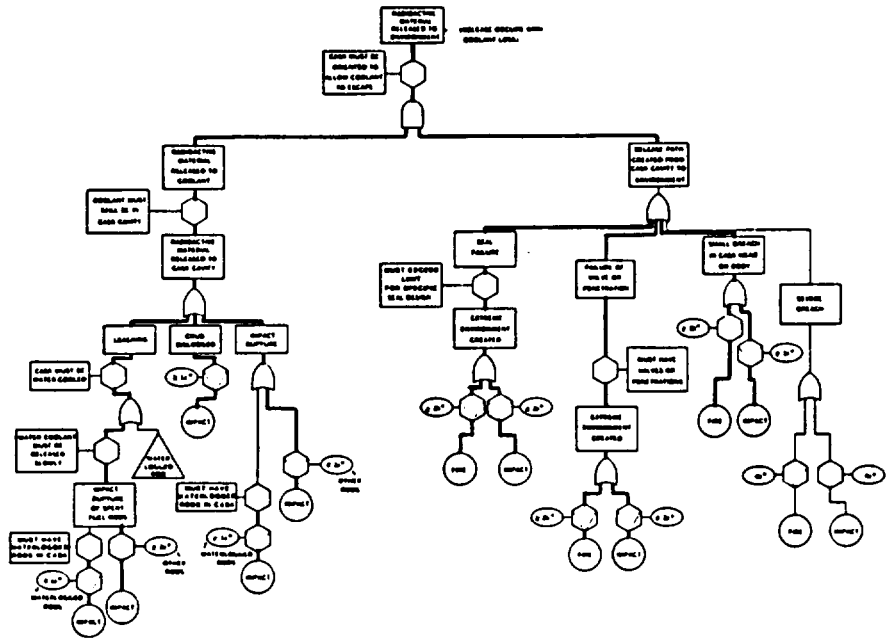

Figure 18. Fault tree for Phase 1 (Scenario 4).

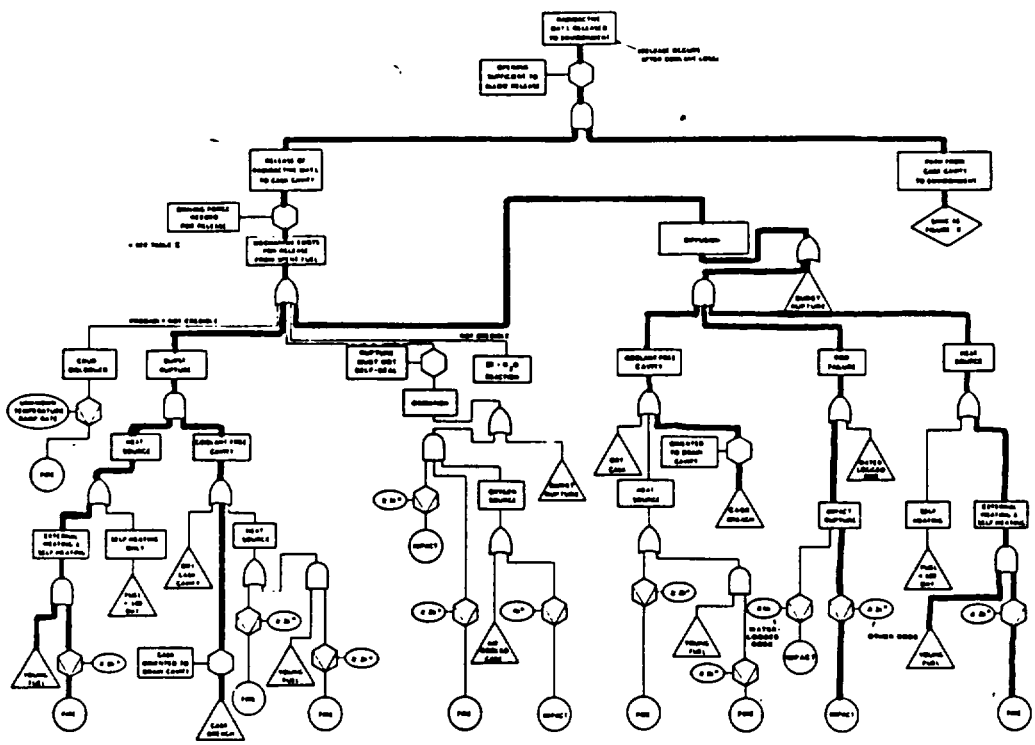

Figure 19. Fault tree for Phase 2 (Scenario 4).

Scenario 5 (A worst-case for air-cooled casks)

This scenario considers all mechanisms of release (see Figures 20 and 21) that are credible for an air-cooled cask. The oxidation mechanism is included even though severe impact must have occurred and a replenished oxygen supply must be available. If fuel that has been grossly failed in the reactor is shipped in an air-cooled cask, the oxidation mechanism could possibly take place during phase 1 (before the air coolant escapes), but for ease in presentation, this scenario considers oxidation to occur during phase 2. In either case, whether it occurs during phase 1 or phase 2 is of little significance, since the release factor is unaffected. This scenario can be considered a credible worst-case scenario for an air-cooled cask.

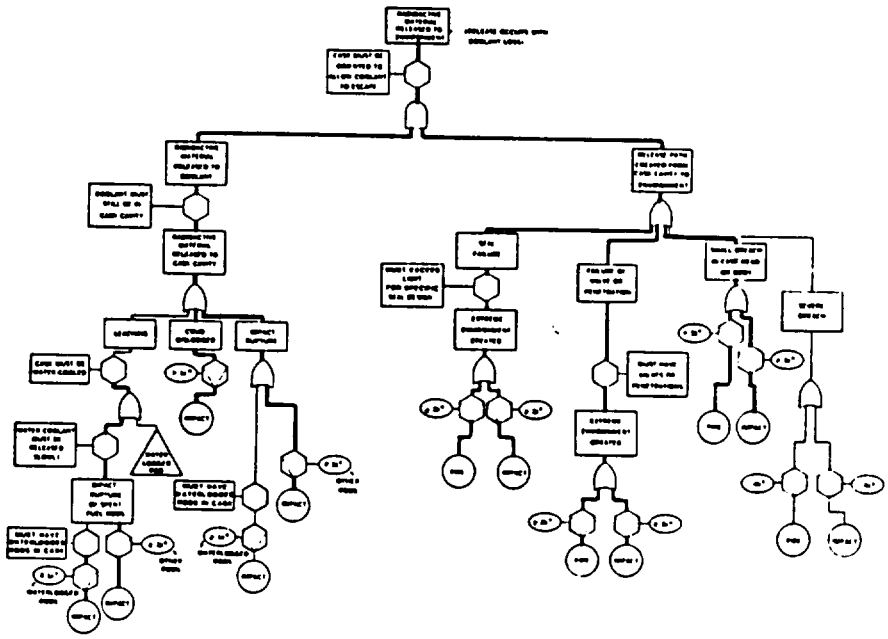

Figure 20. Fault tree for Phase 1 (Scenario 5).