

Auxiliary Feedwater Reliability Study

1 AFW SYSTEM FAULT TREE MODELS

The fault tree models for the eleven design classes shown in [Figure 1](#) to [Figure 11](#) illustrate the logic used for generating the plant-specific AFW unreliability models. Plant-specific models were developed to identify differences in the feed control/injection path redundancy within a design class. The models were constructed to reflect the failure modes identified in the unplanned demand data and the levels of redundancy and diversity of the AFW piping segments.

1.1 AFW System Modeling Assumptions

In most cases, the models used the success criteria stated in the PRA/IPEs. However, the success criterion for several plants was modified to eliminate the non-safety class pump trains modeled in some PRA/IPEs. Since LERs are not required to be submitted for these types of pump trains, estimates for these types of non-safety components were not calculated.

- Failure to Start—Turbine-driven pump steam supply valves and associated piping (FTS-ST)
- Failure to Start—Pump, driver, valves and associated piping (FTS)
- Failure to Run—Pump, driver, valves and associated piping (FTR)
- Maintenance-out-of-service—Pump, driver, valves, and associated piping (MOOS)
- Failure to Operate—Feed control/injection header valves (AFW feed control/isolation, etc.) and associated piping faults (FTO-INJ).

The following conditions were assumed for the purposes of quantifying the operational mission fault tree:

- A demand to provide auxiliary feedwater to a steam generator is received by the AFW system.
- The FTR contribution to the unreliability is estimated on a per mission demand.
- The condensate storage tank is assumed to meet all needs for auxiliary feedwater. Alternate suction sources are not modeled.

The component failure modes were grouped according to the following breakdown:

Suction path segment (SUC)

FTO—Failure of the suction path valves and associated piping from the preferred water source (e.g., condensate storage tank) to deliver the flow to the pump trains necessary for AFW success.

Turbine steam supply (ST)

FTS—Failure to operate of the steam supply valves and associated piping upstream of the turbine steam stop valve.

Pump train segment (M or T or D)

FTS—AFW pump train failure to start, failure of the actuation circuit, and valve failures in the pump train suction and discharge piping.

FTR—Failure to run of the AFW pump train.

MOOS—Unavailability of the AFW pump train due to maintenance.

Feed control/injection header segment (INJ)

FTO—Failure of the steam generator injection paths/flow control valves and associated valves and piping to deliver the flow necessary for AFW success.

1.2 AFW Fault Tree Models

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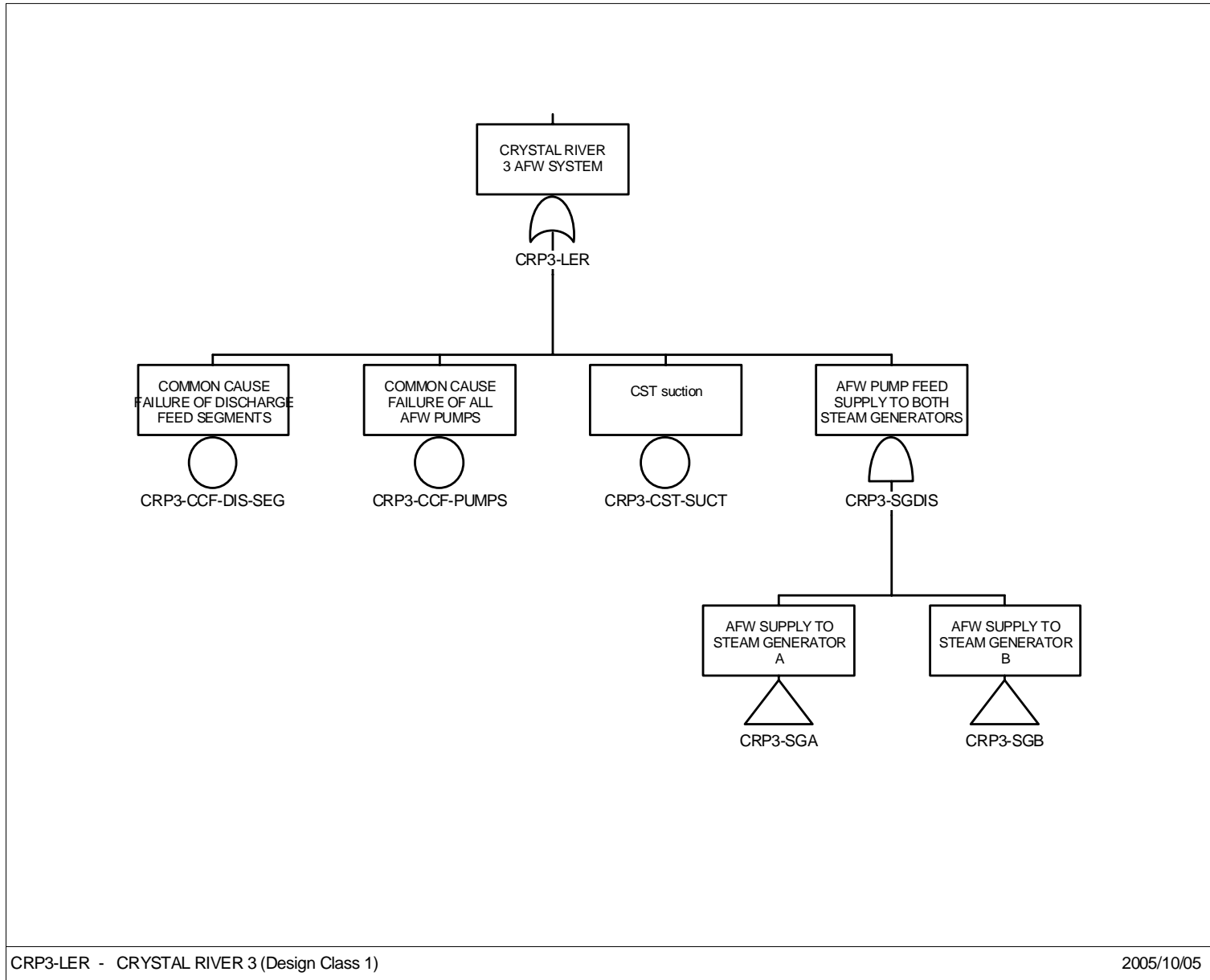


Figure 1. Design Class 1.

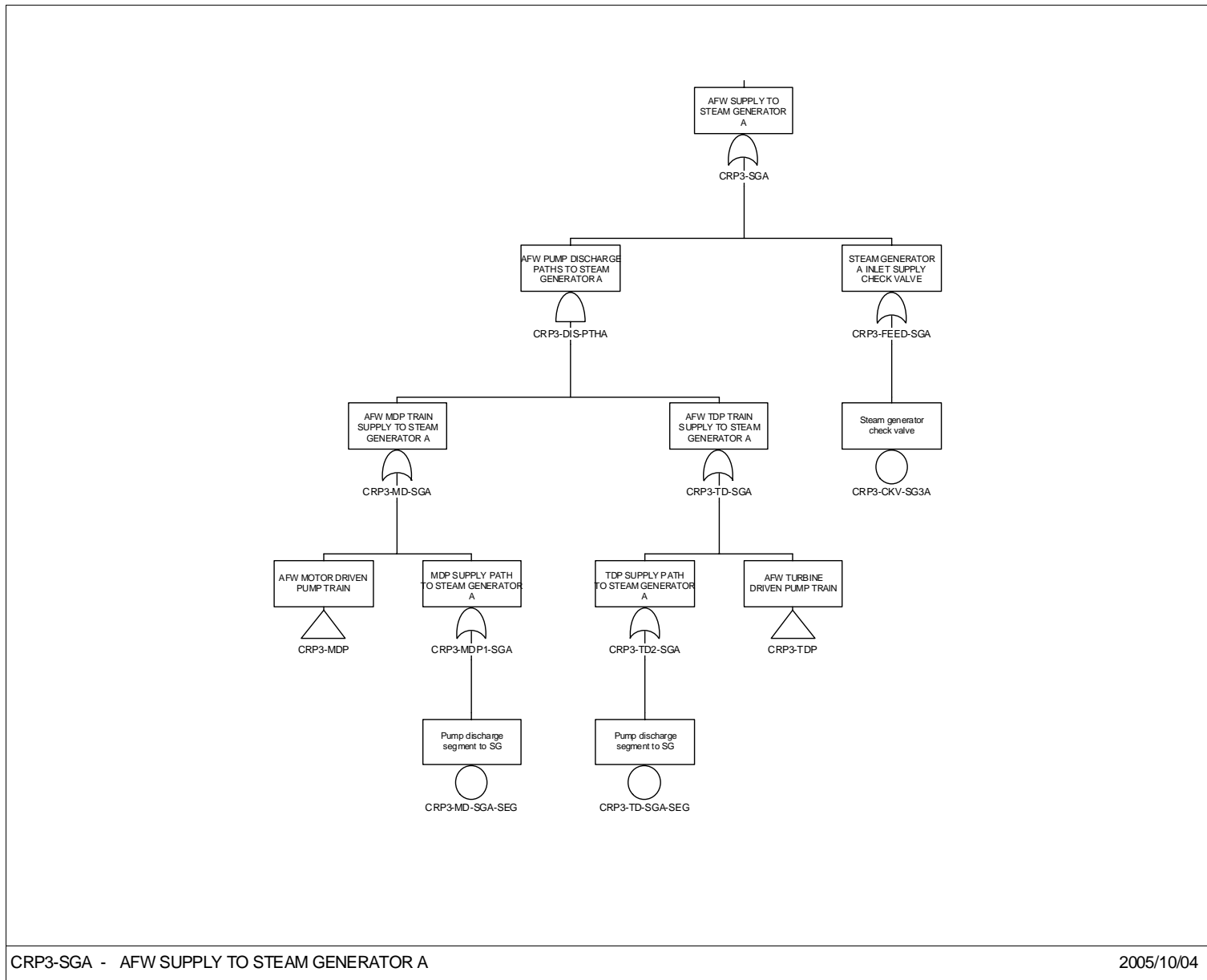


Figure 1. Design Class 1. (continued)

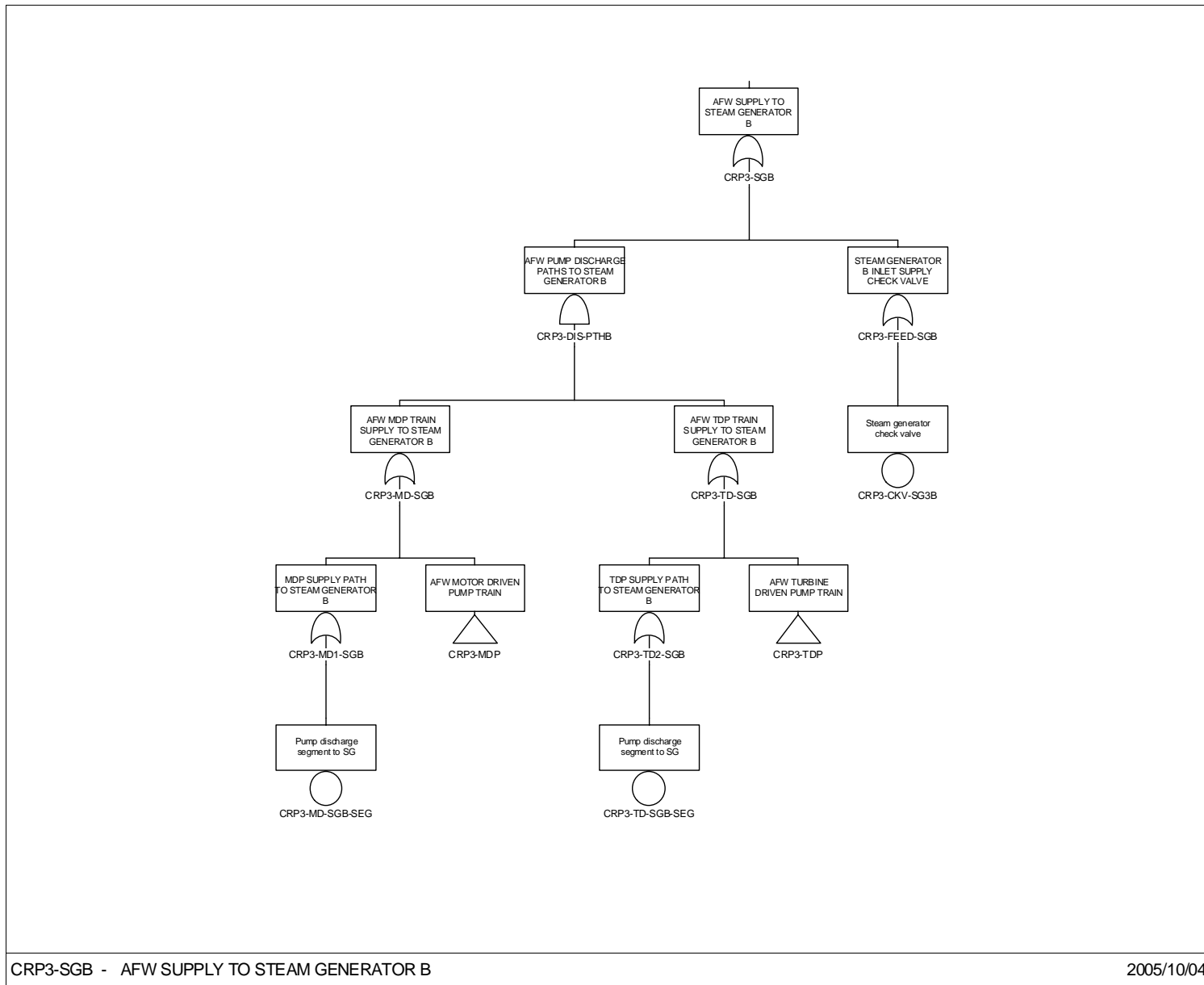


Figure 1. Design Class 1. (continued)

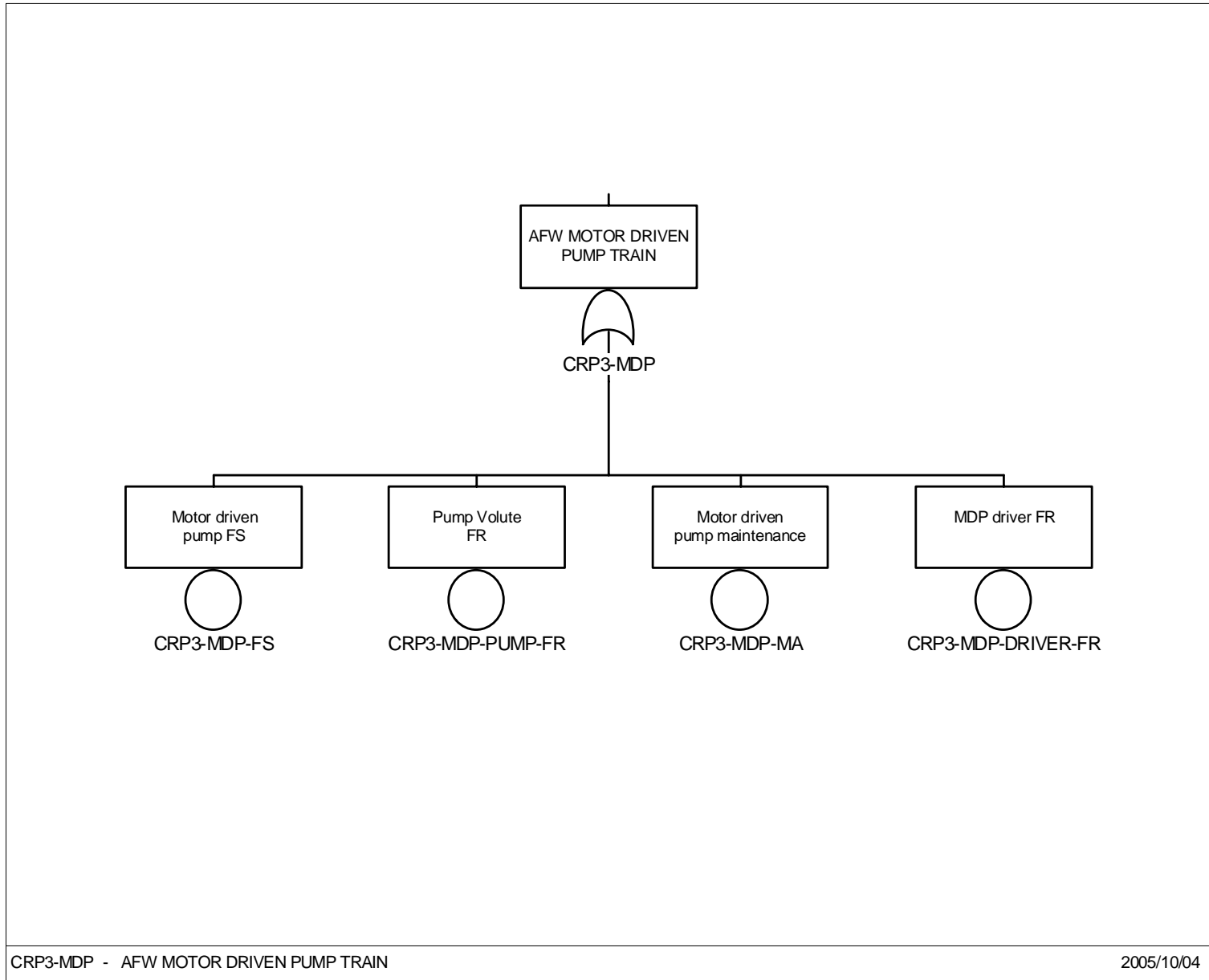


Figure 1. Design Class 1. (continued)

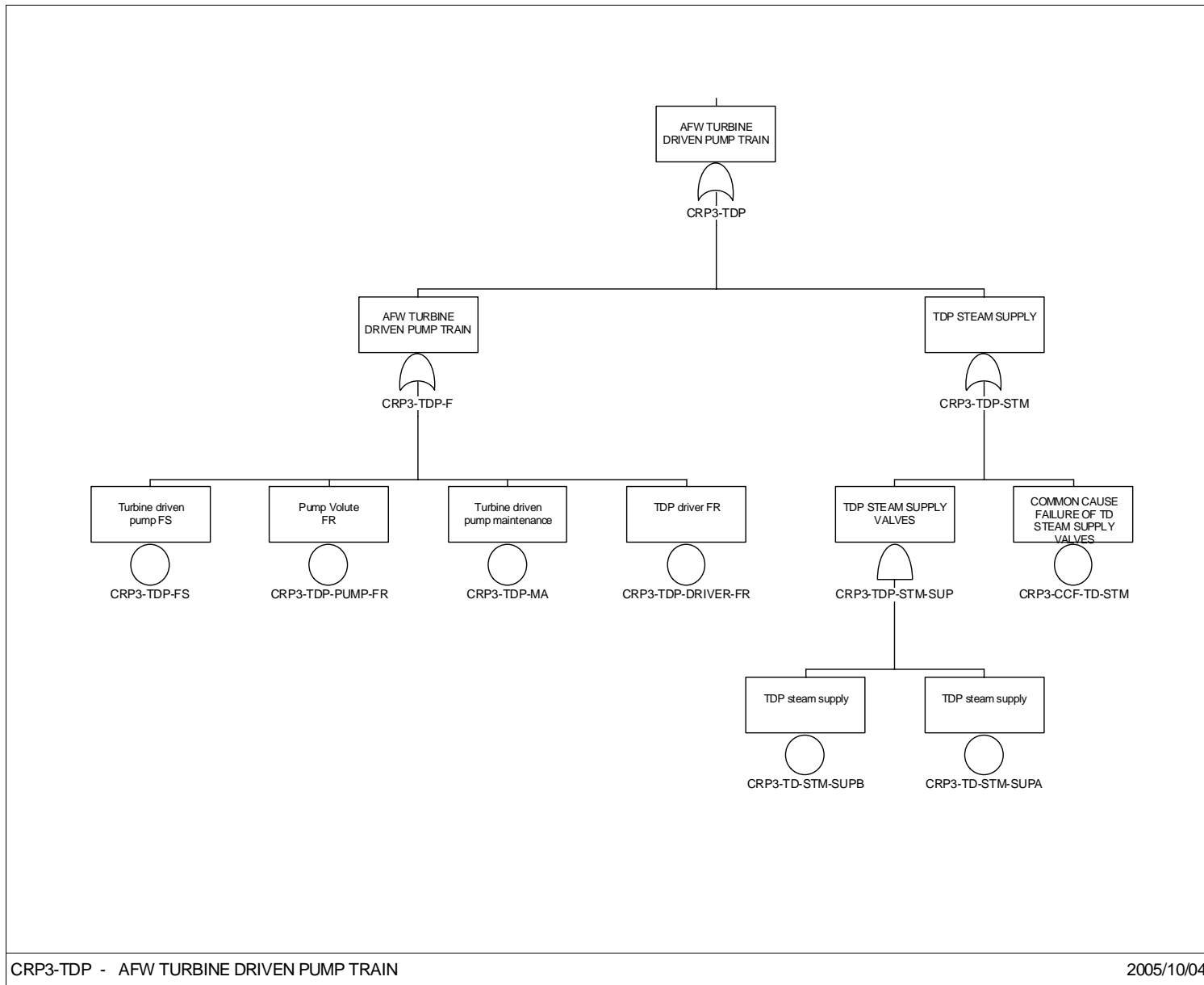


Figure 1. Design Class 1. (continued)

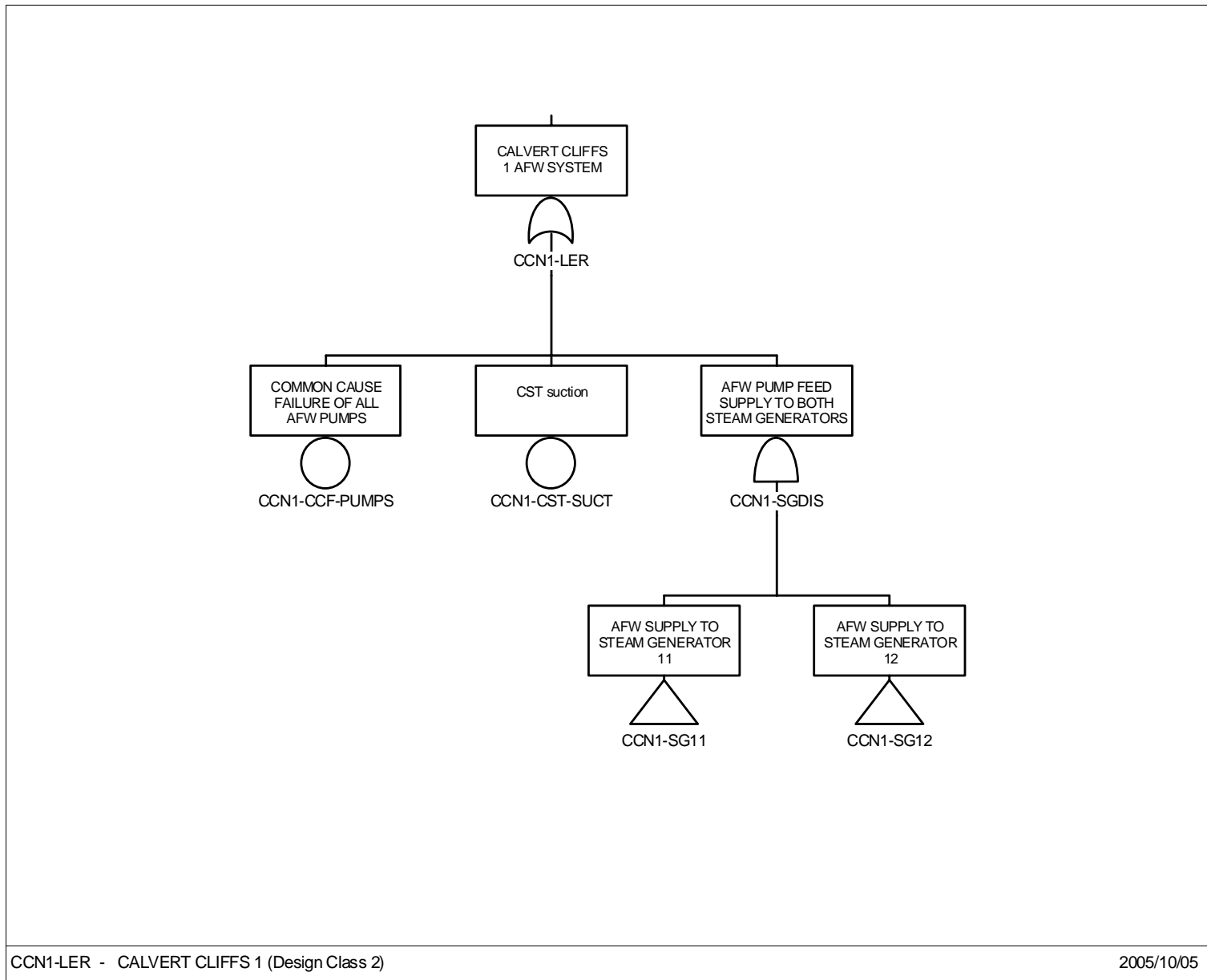


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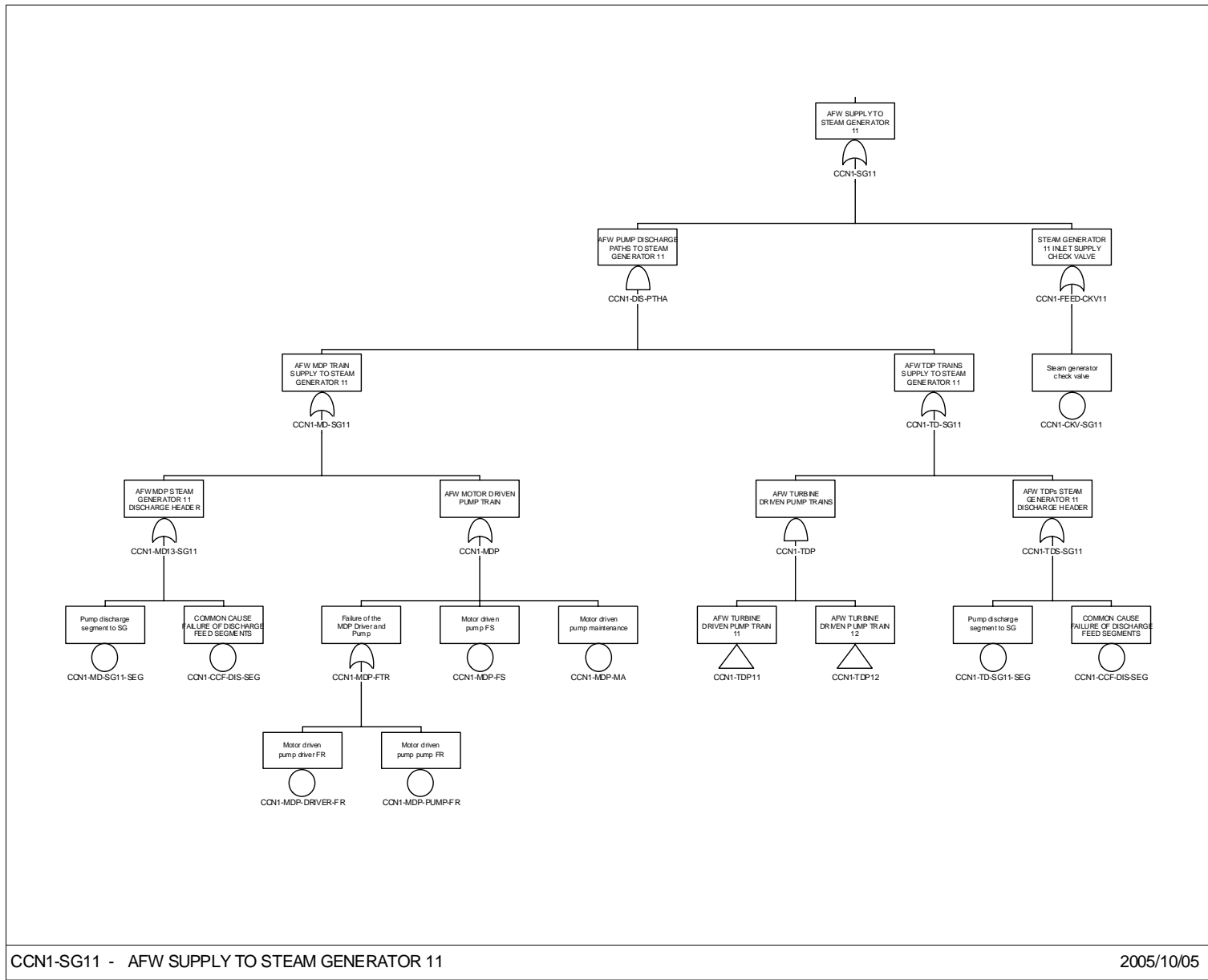


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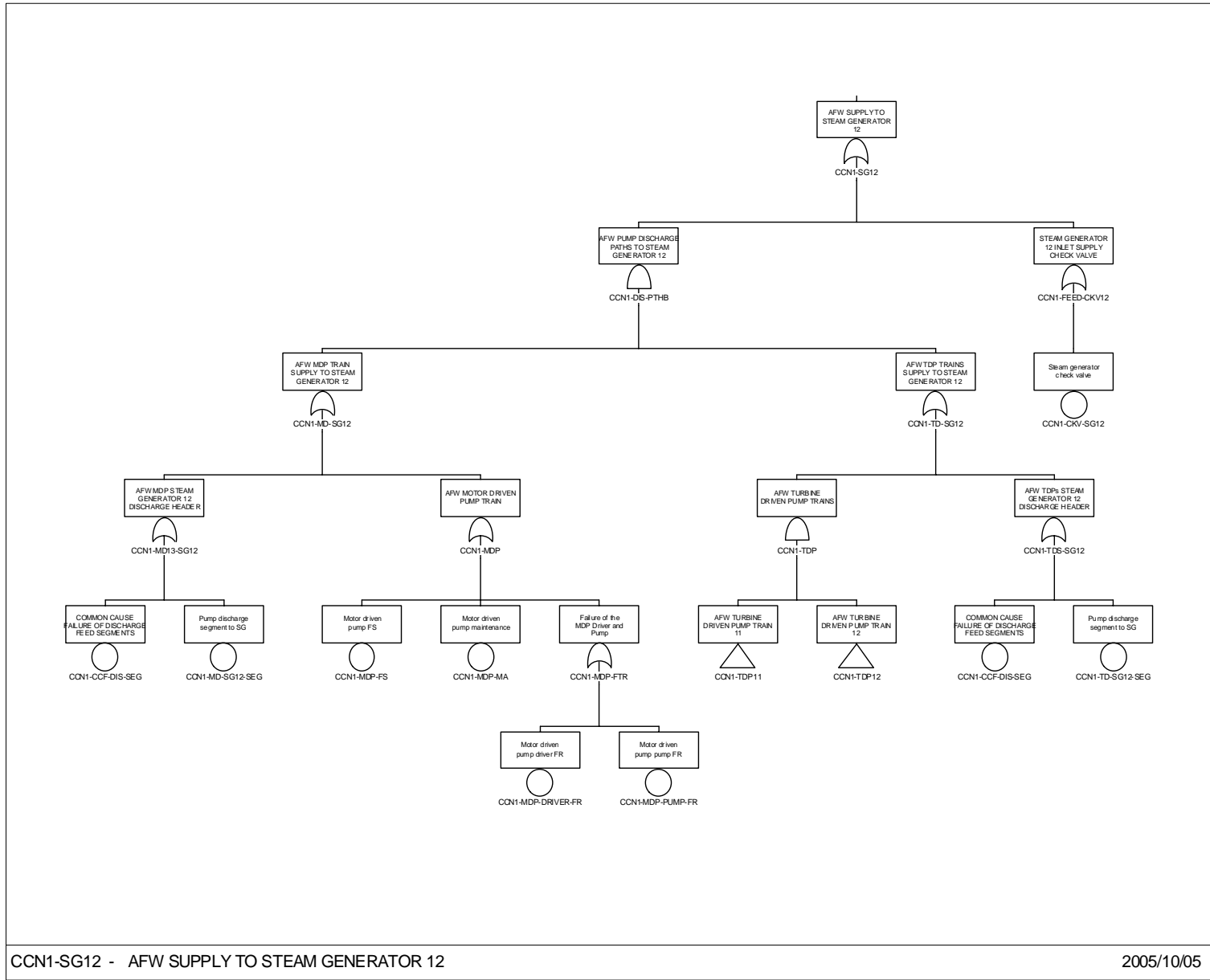


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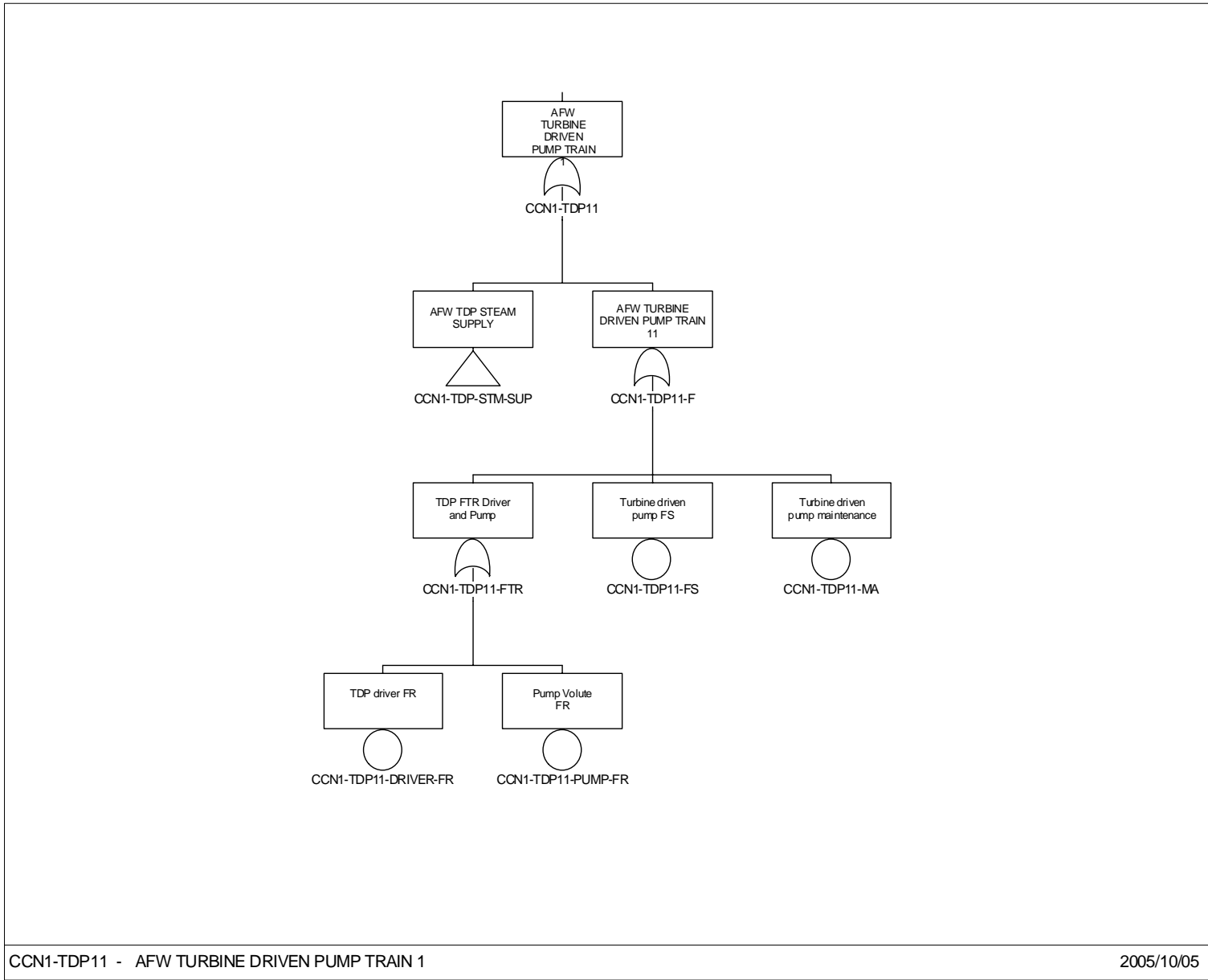


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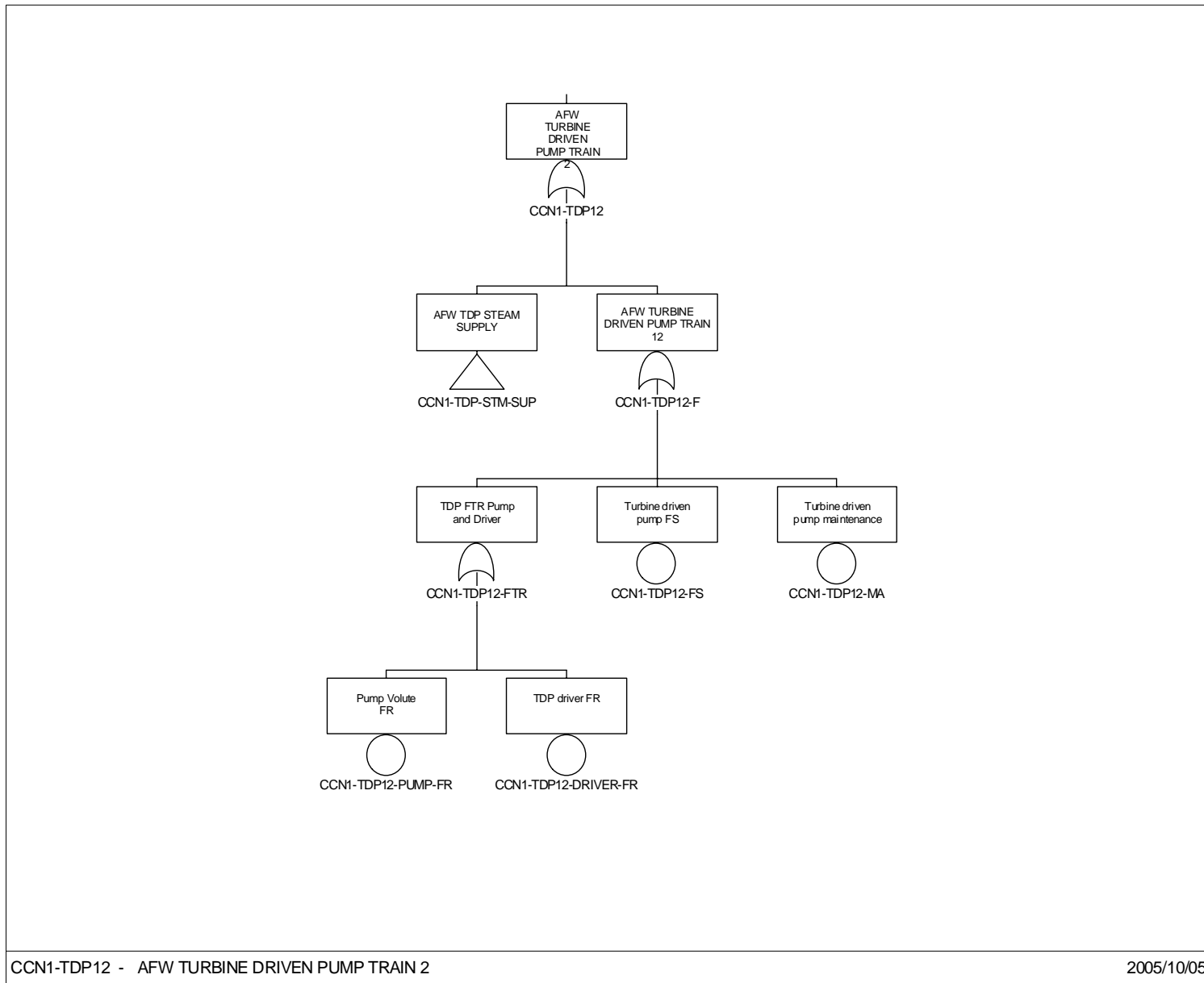


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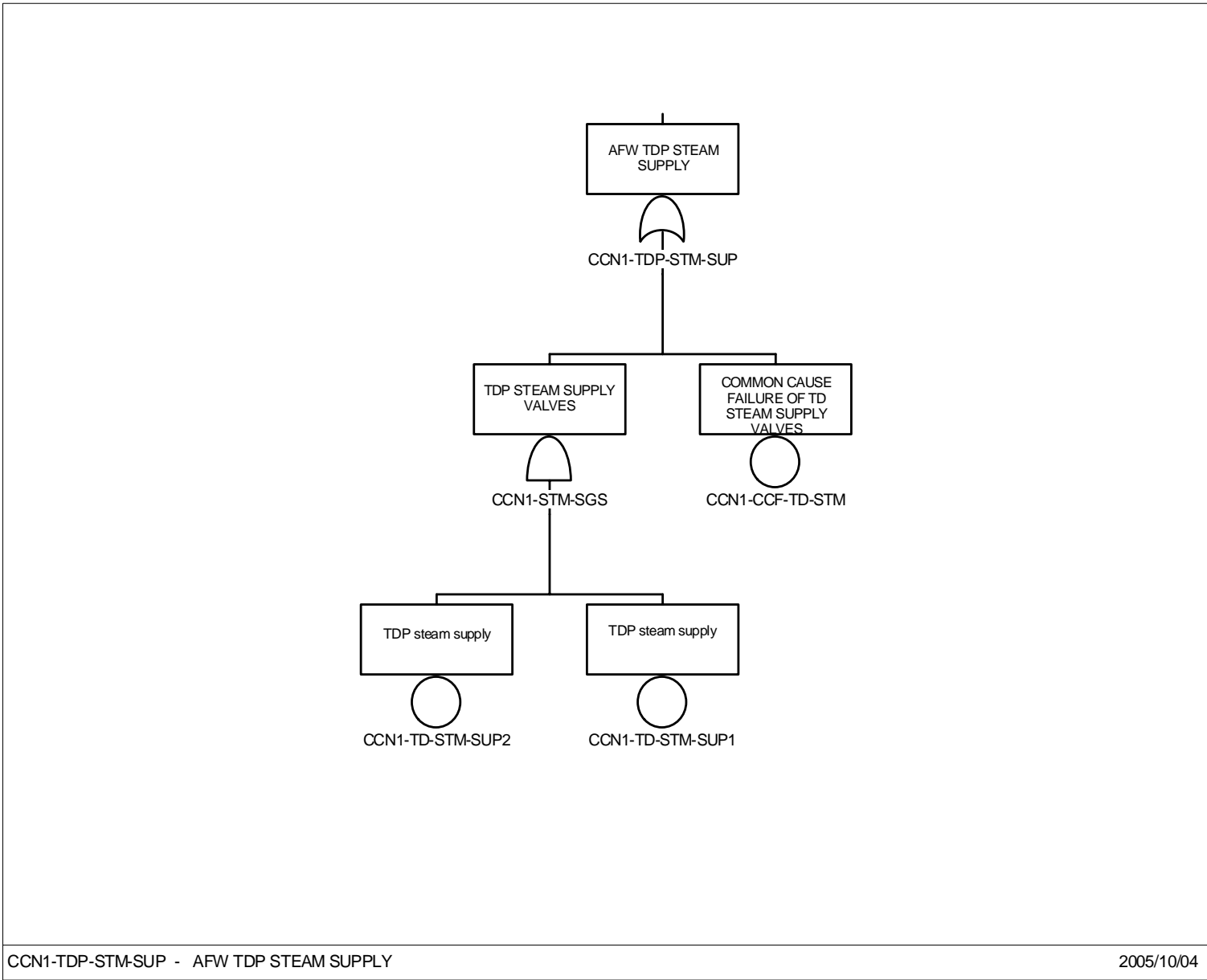


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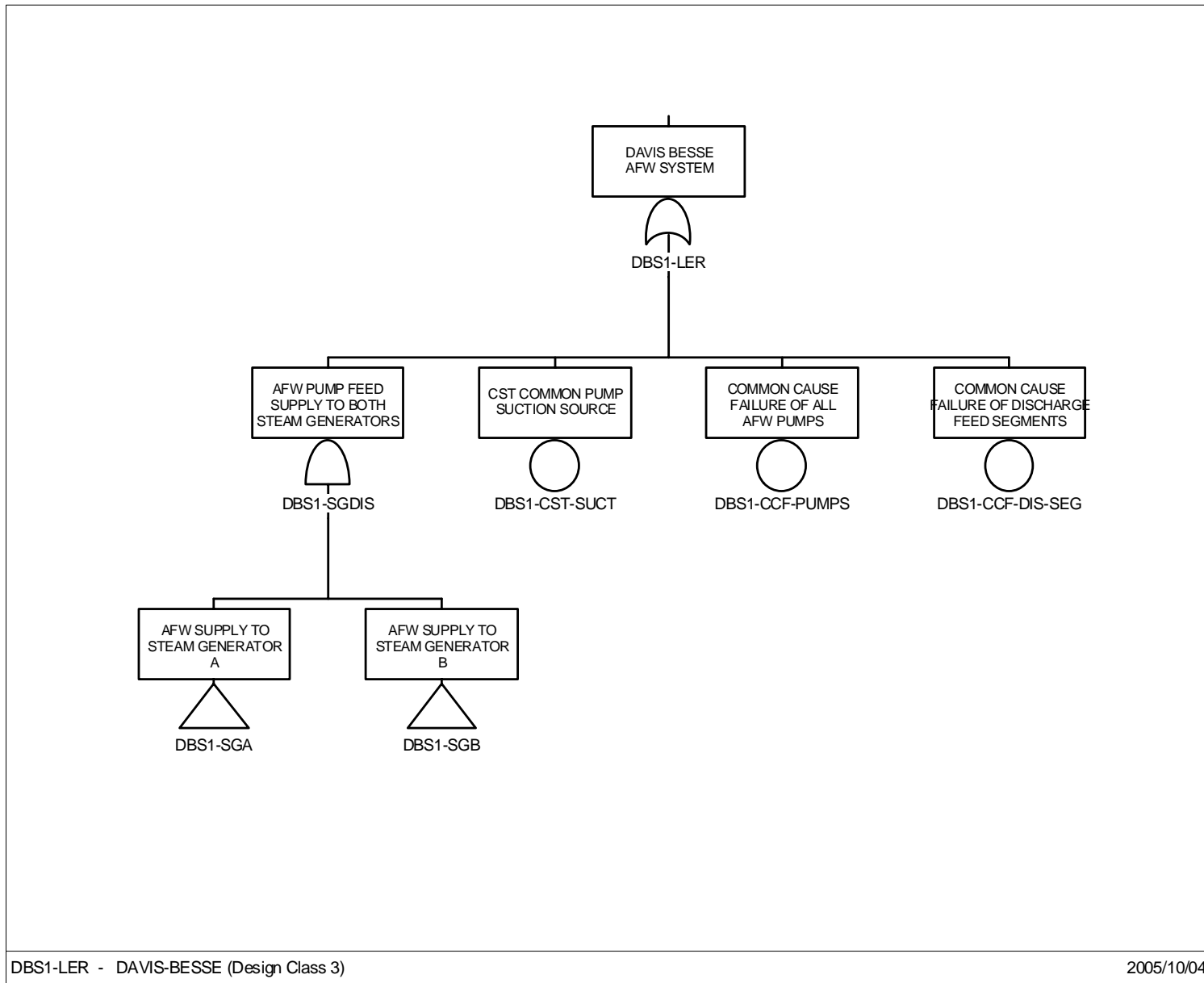


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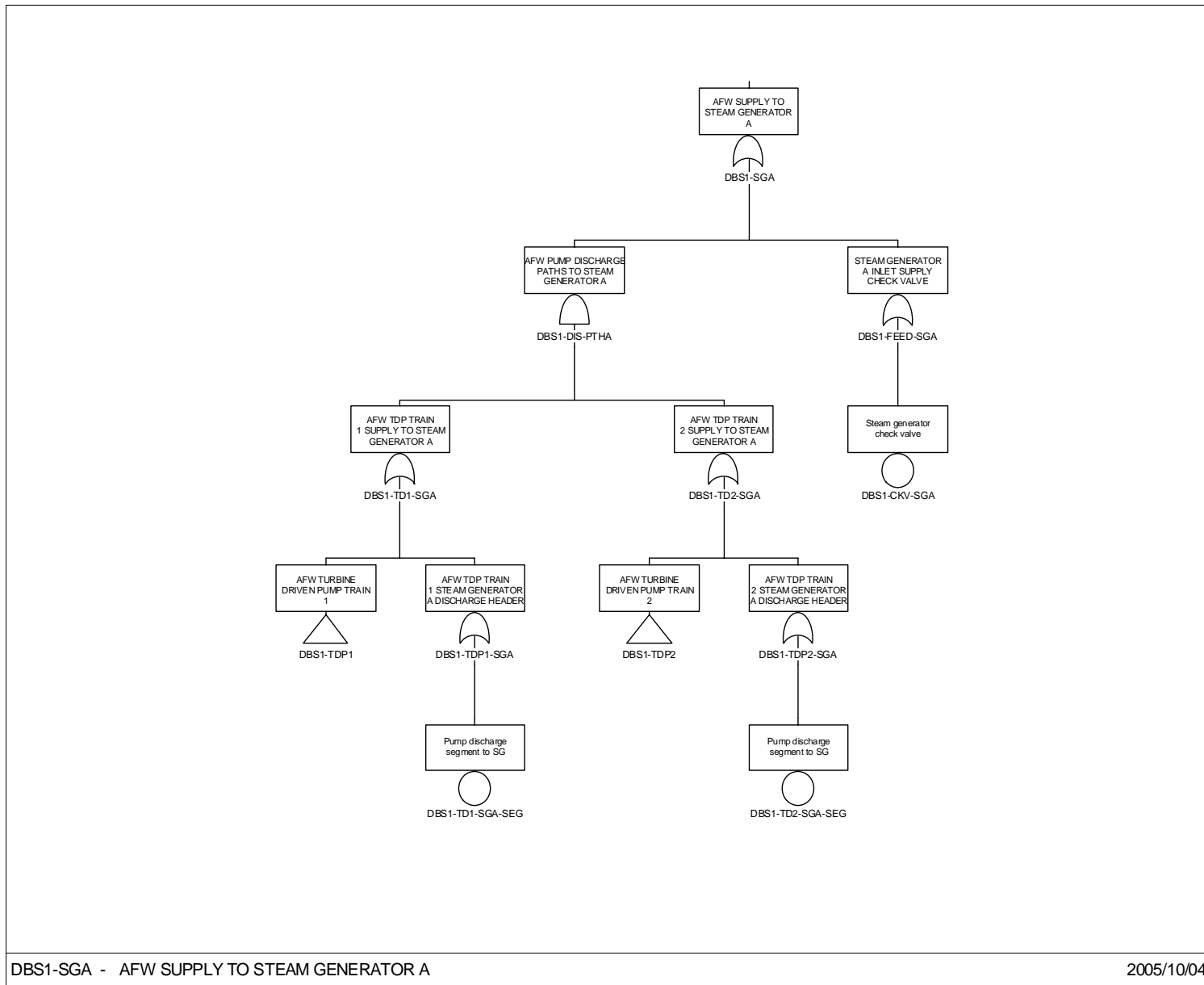


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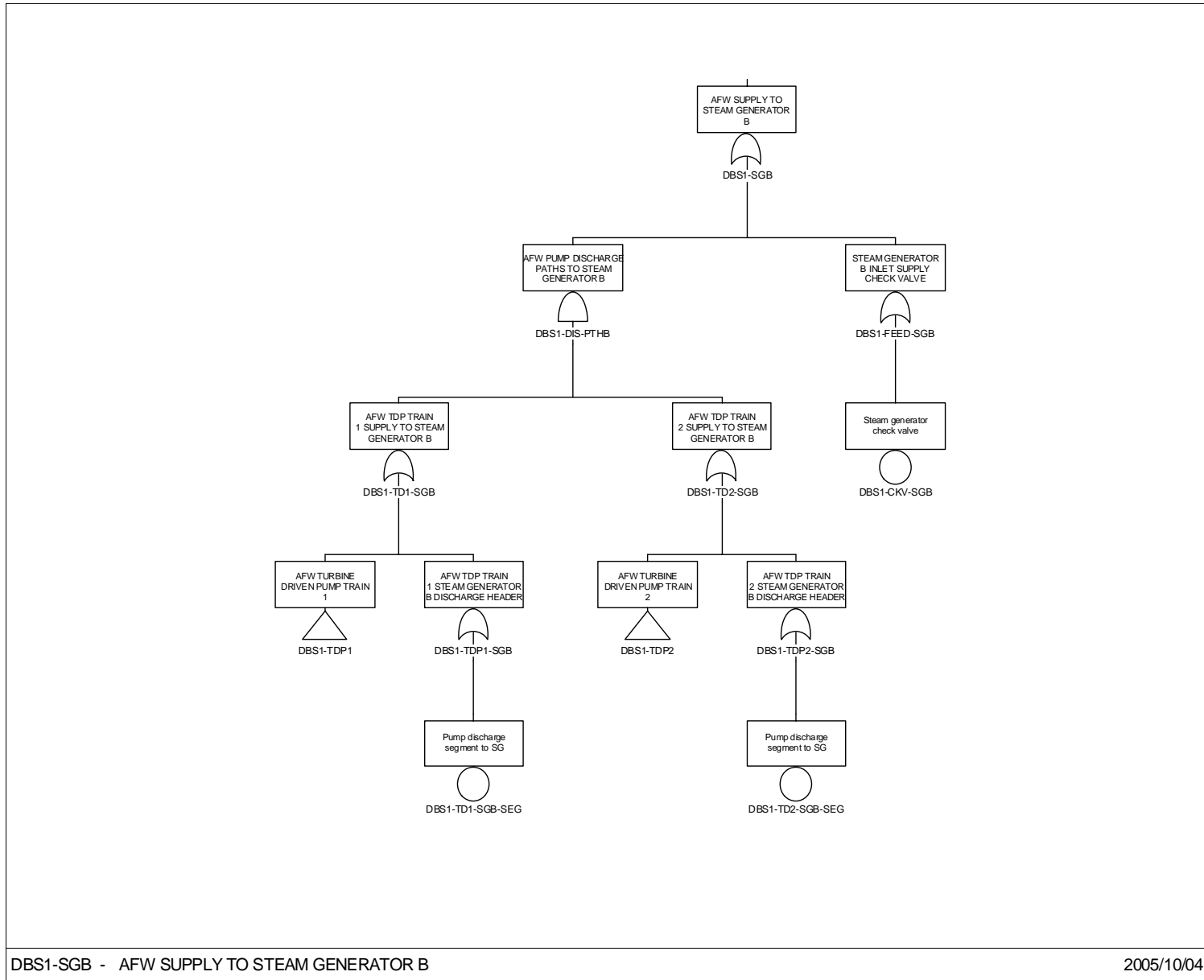


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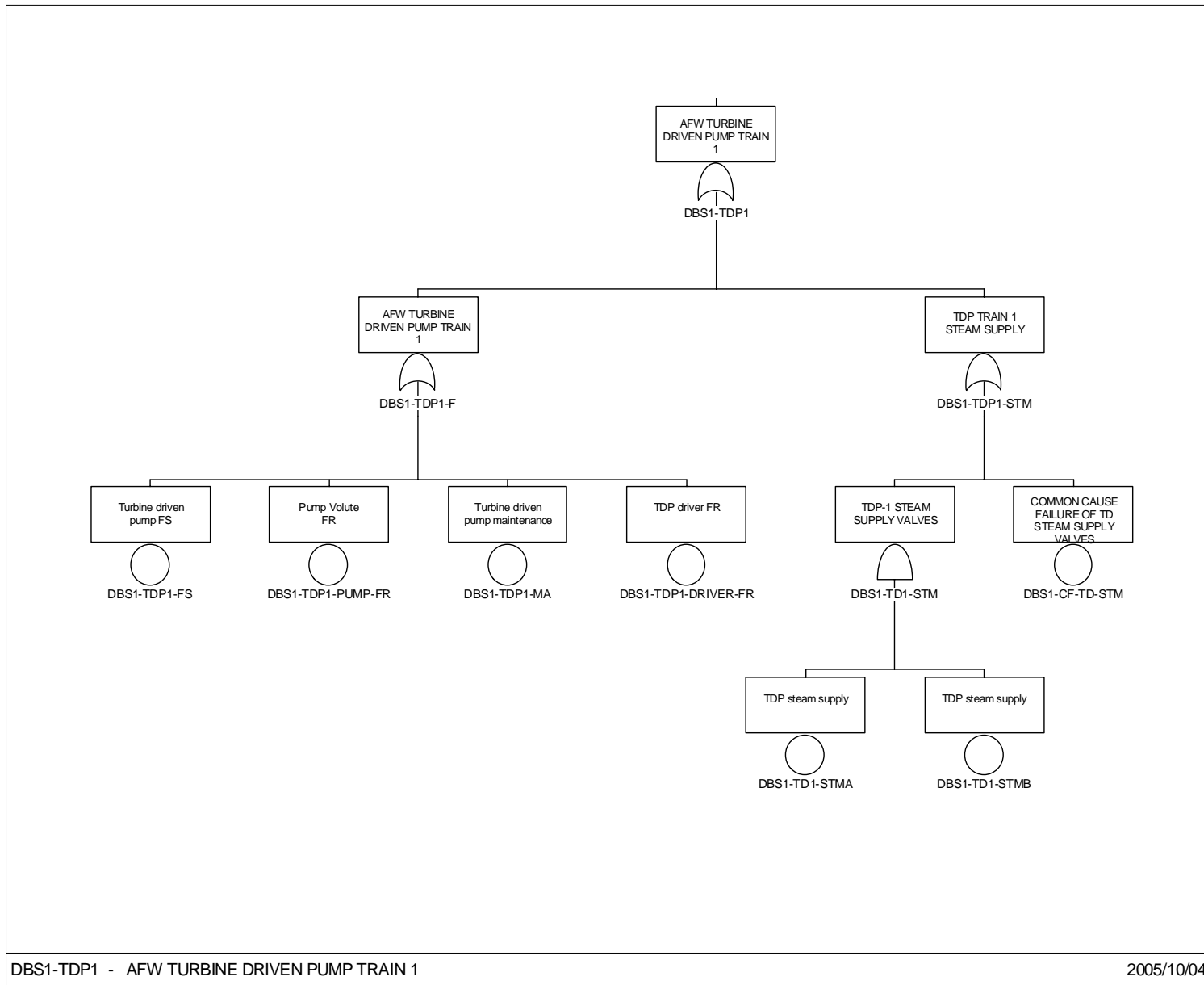


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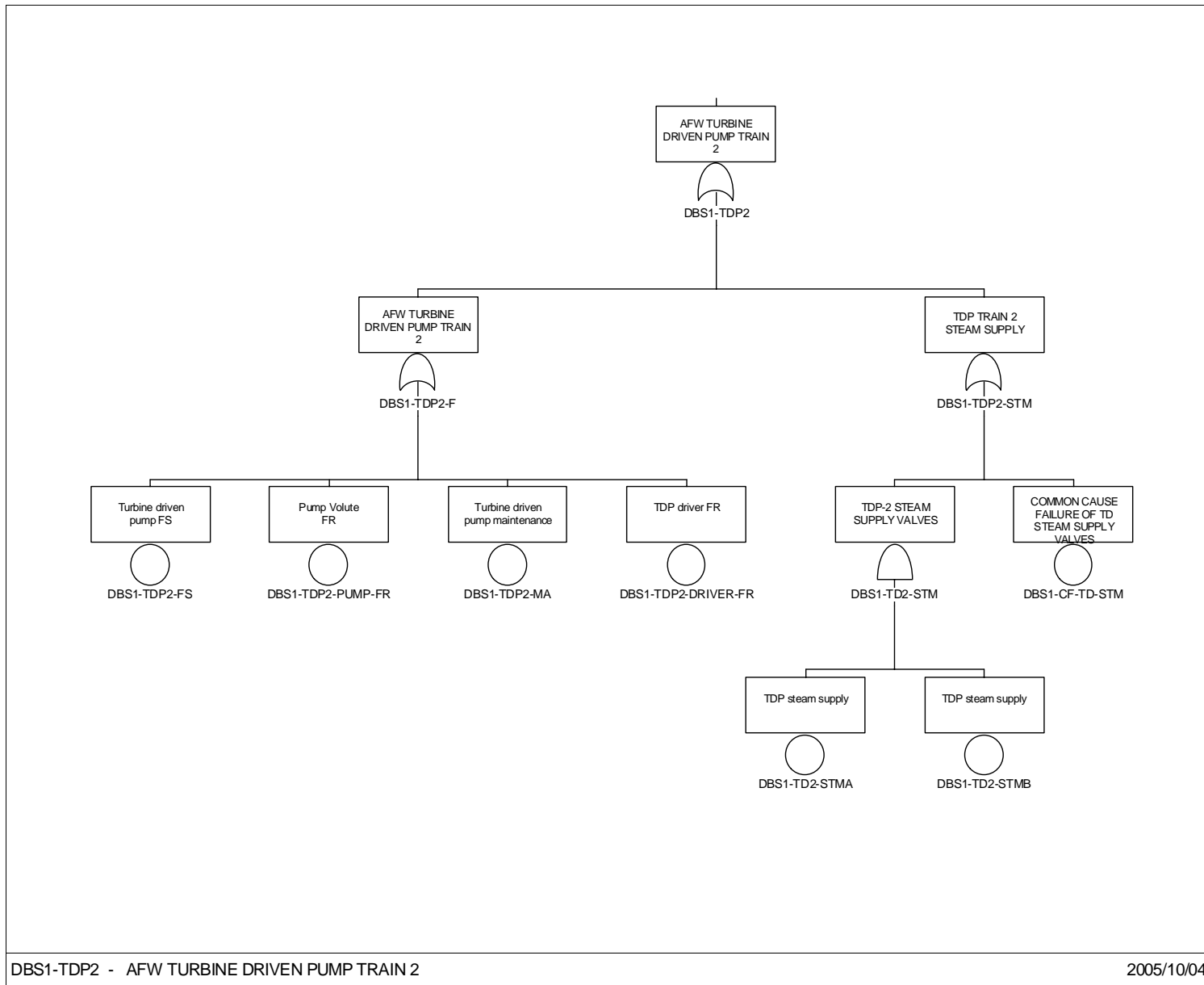


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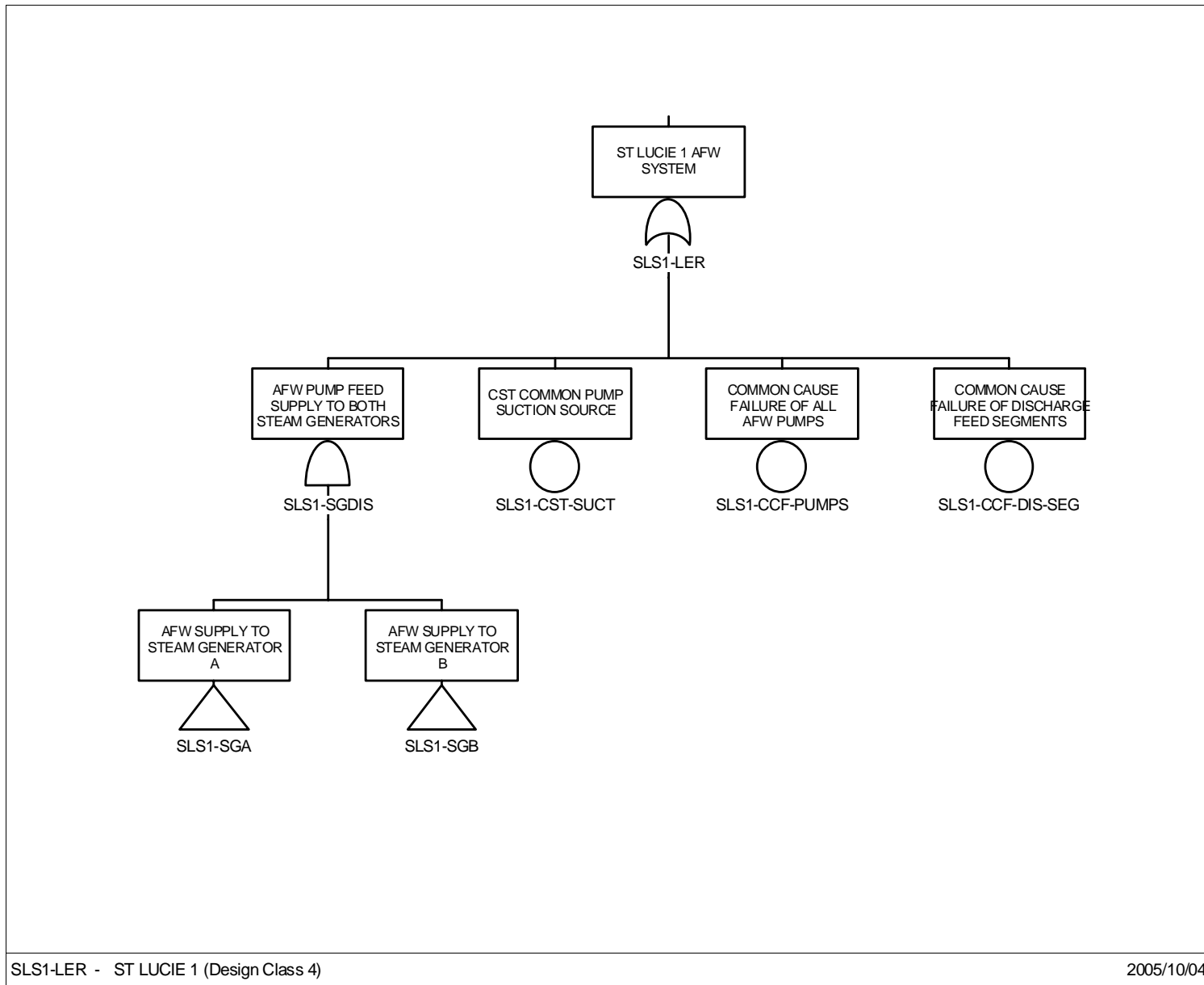


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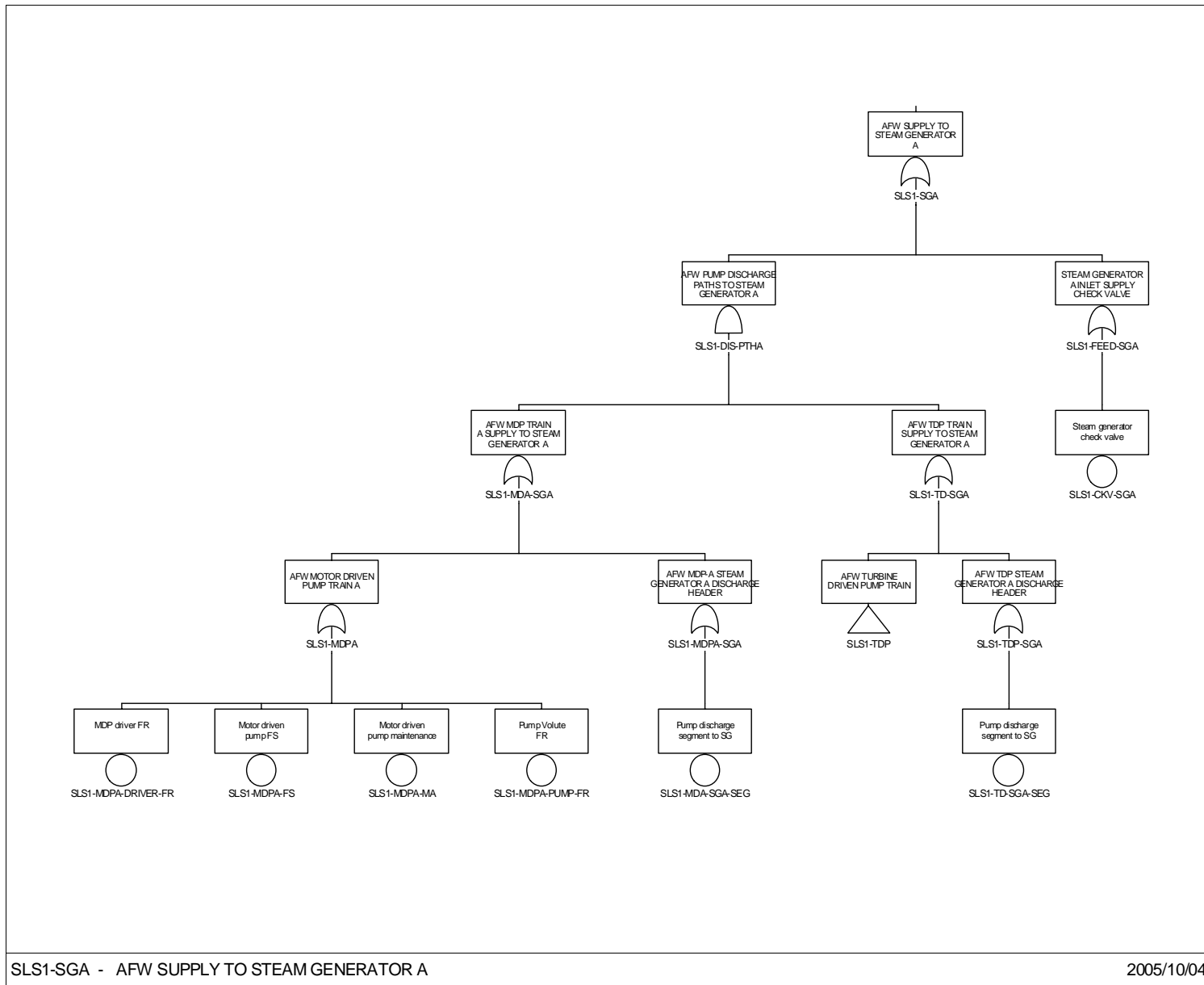


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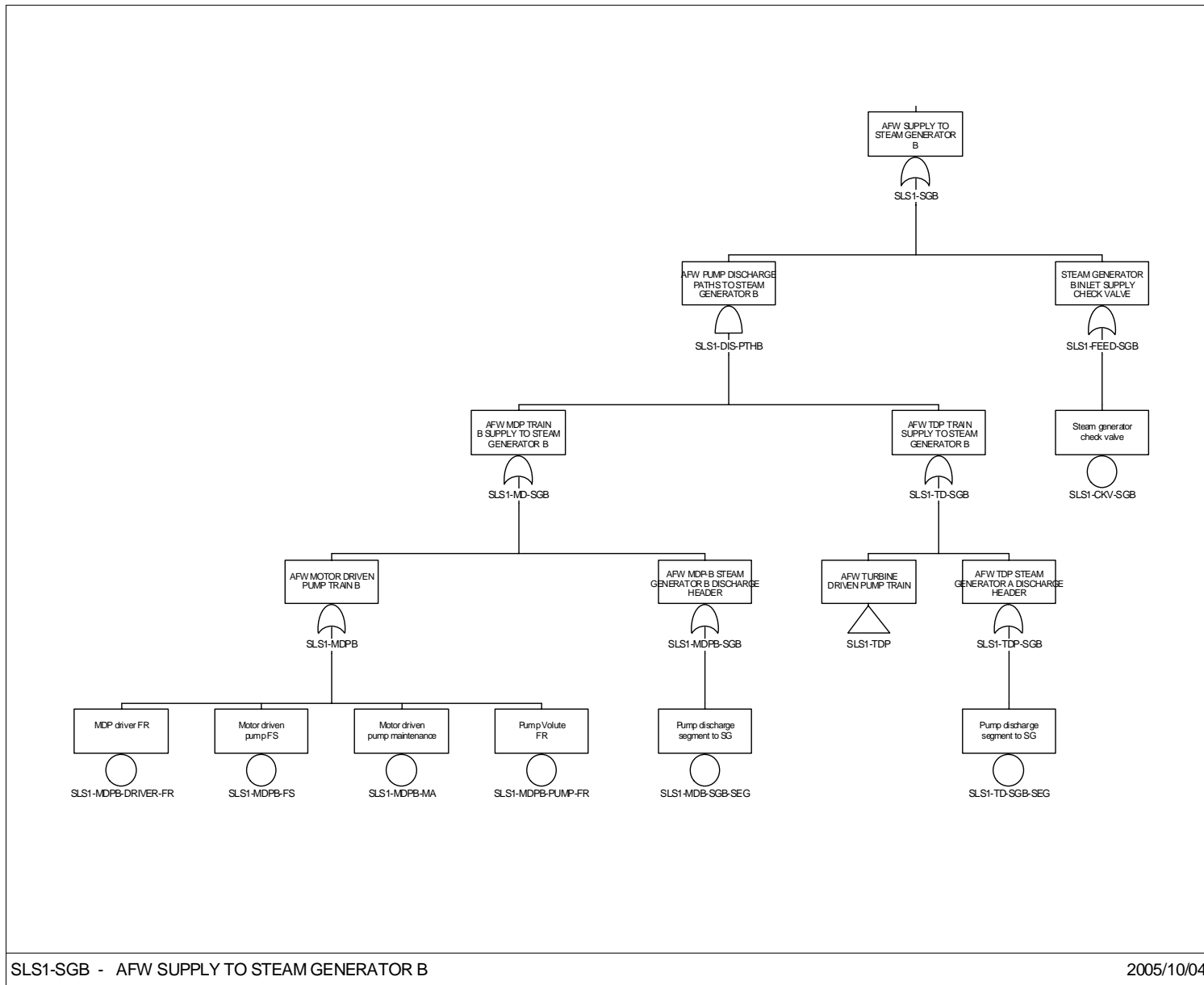


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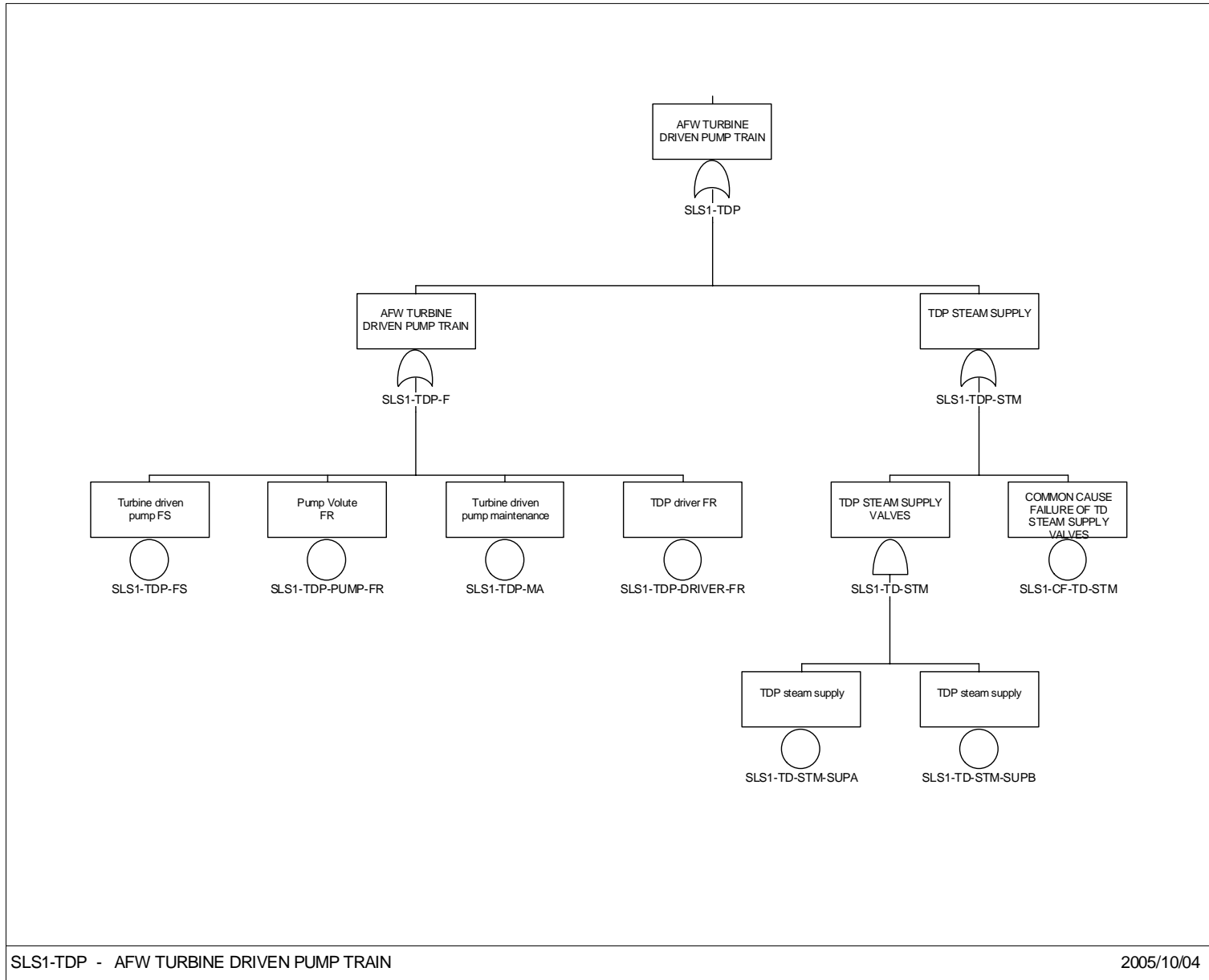


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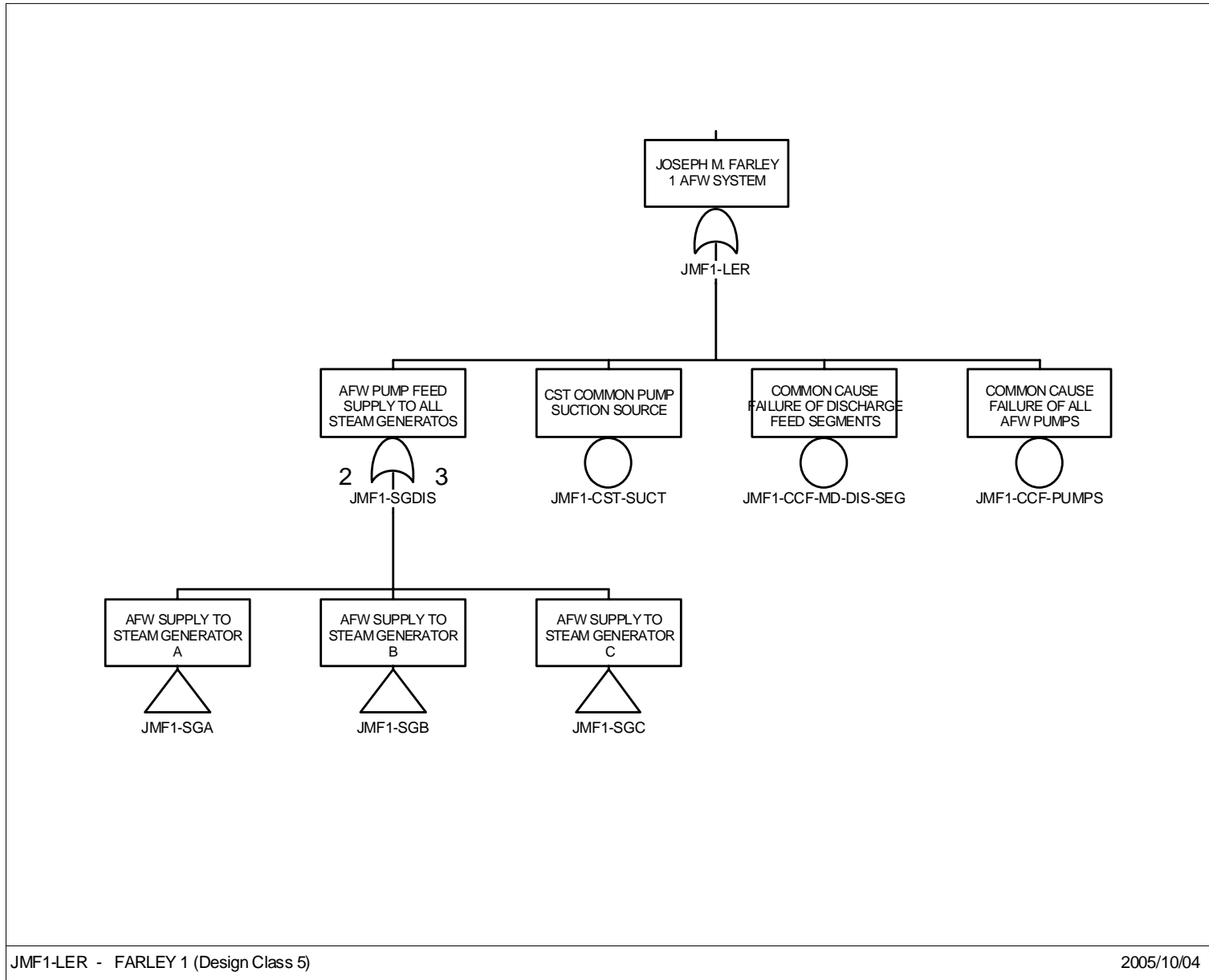


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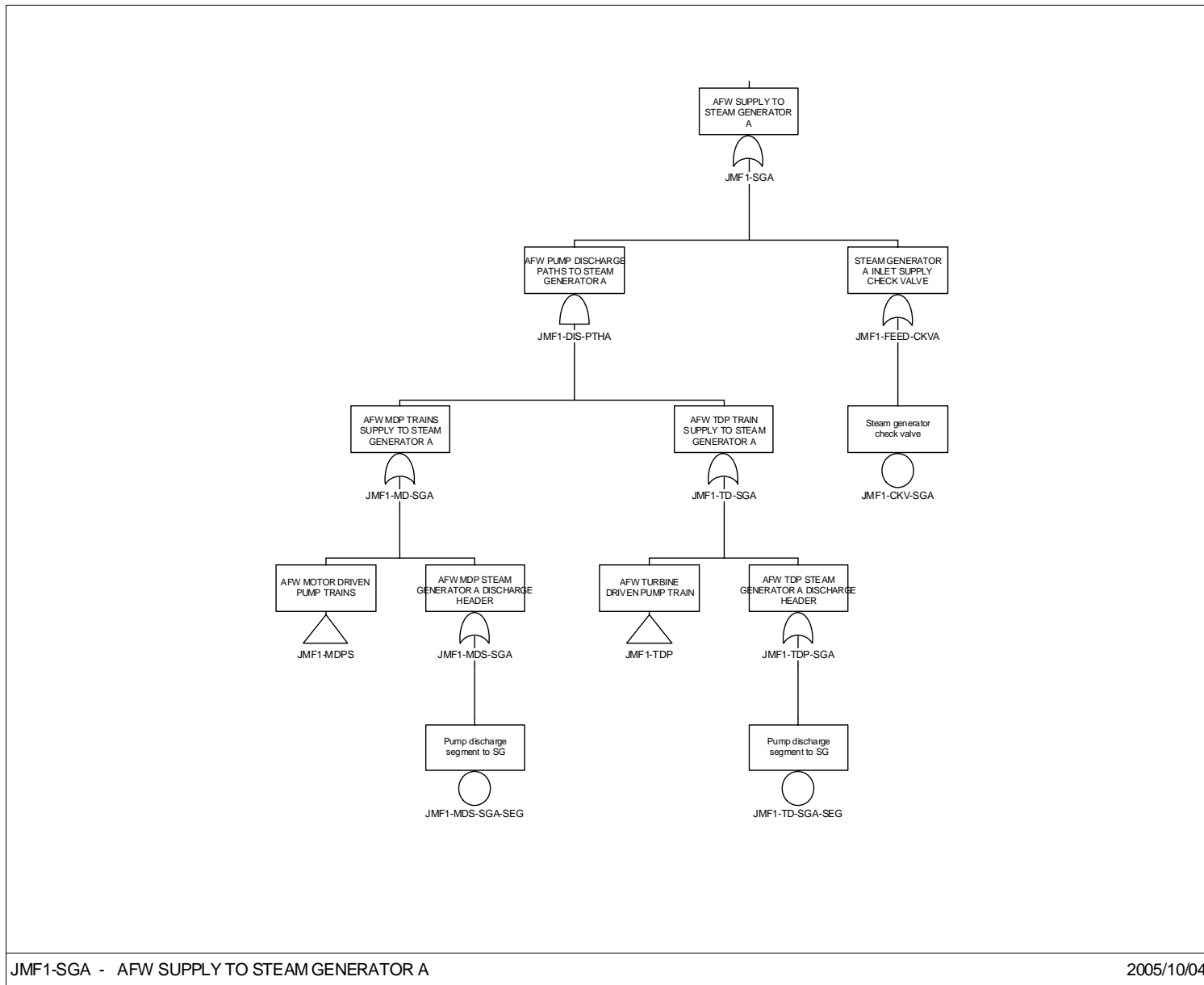


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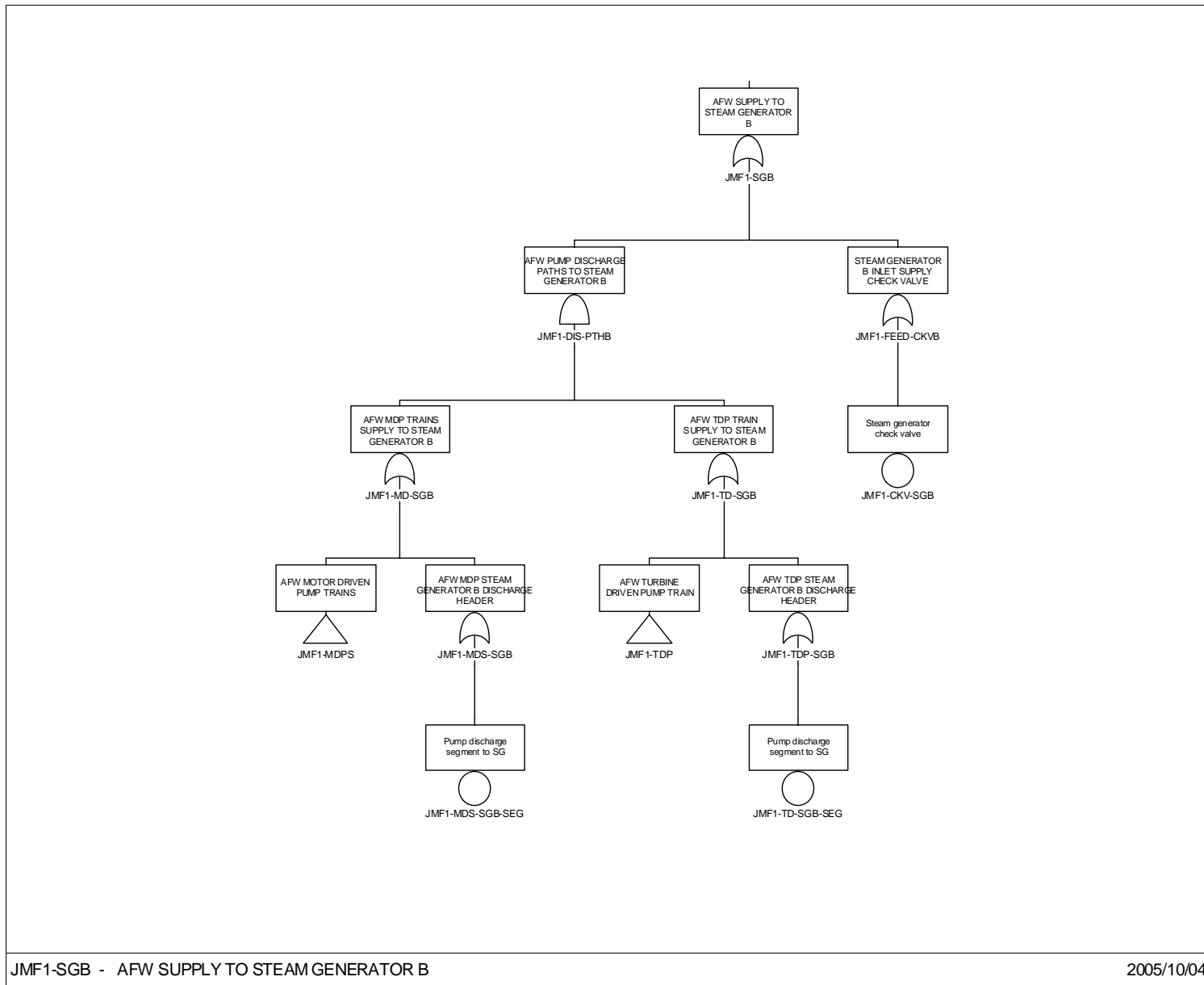


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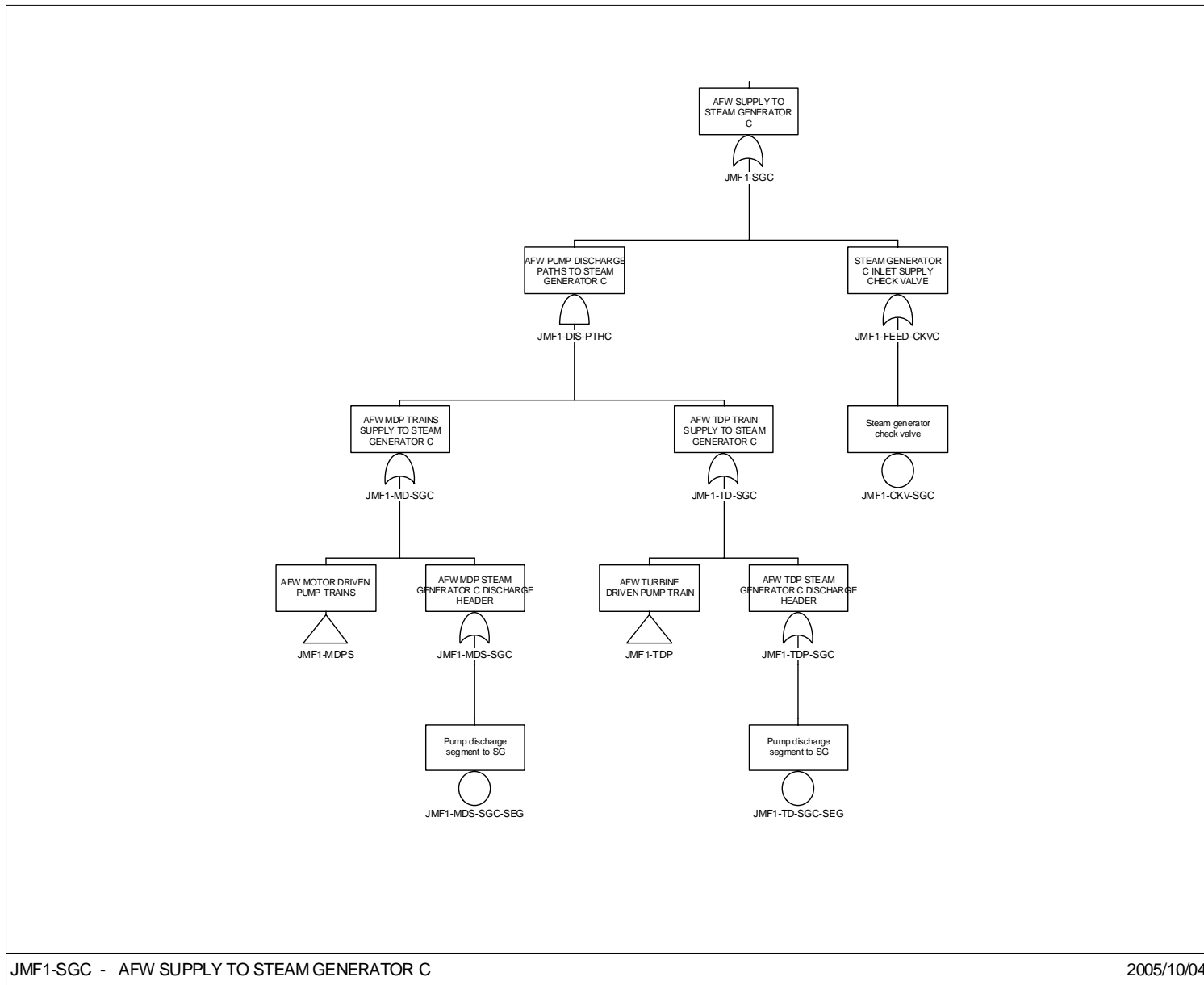


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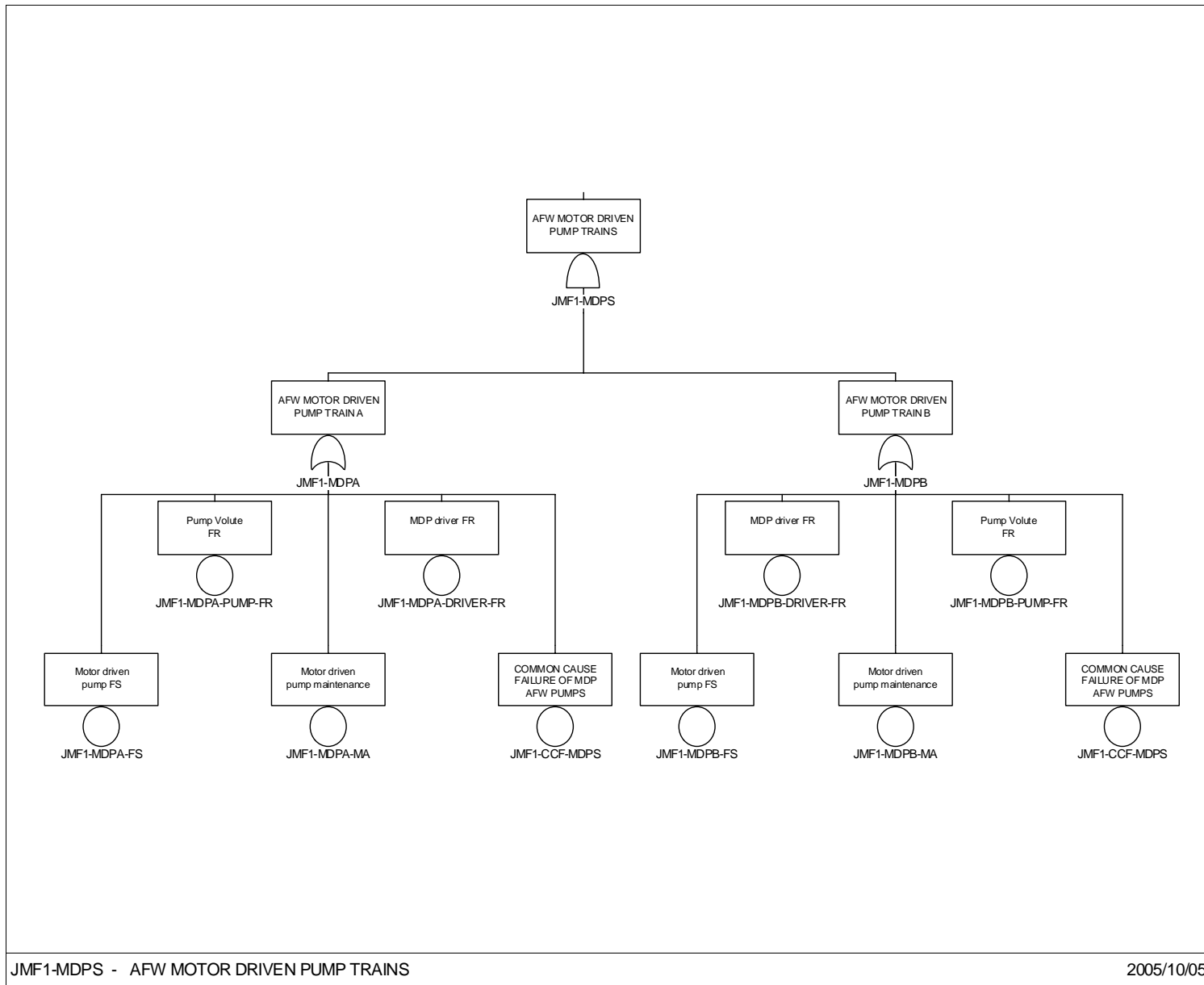


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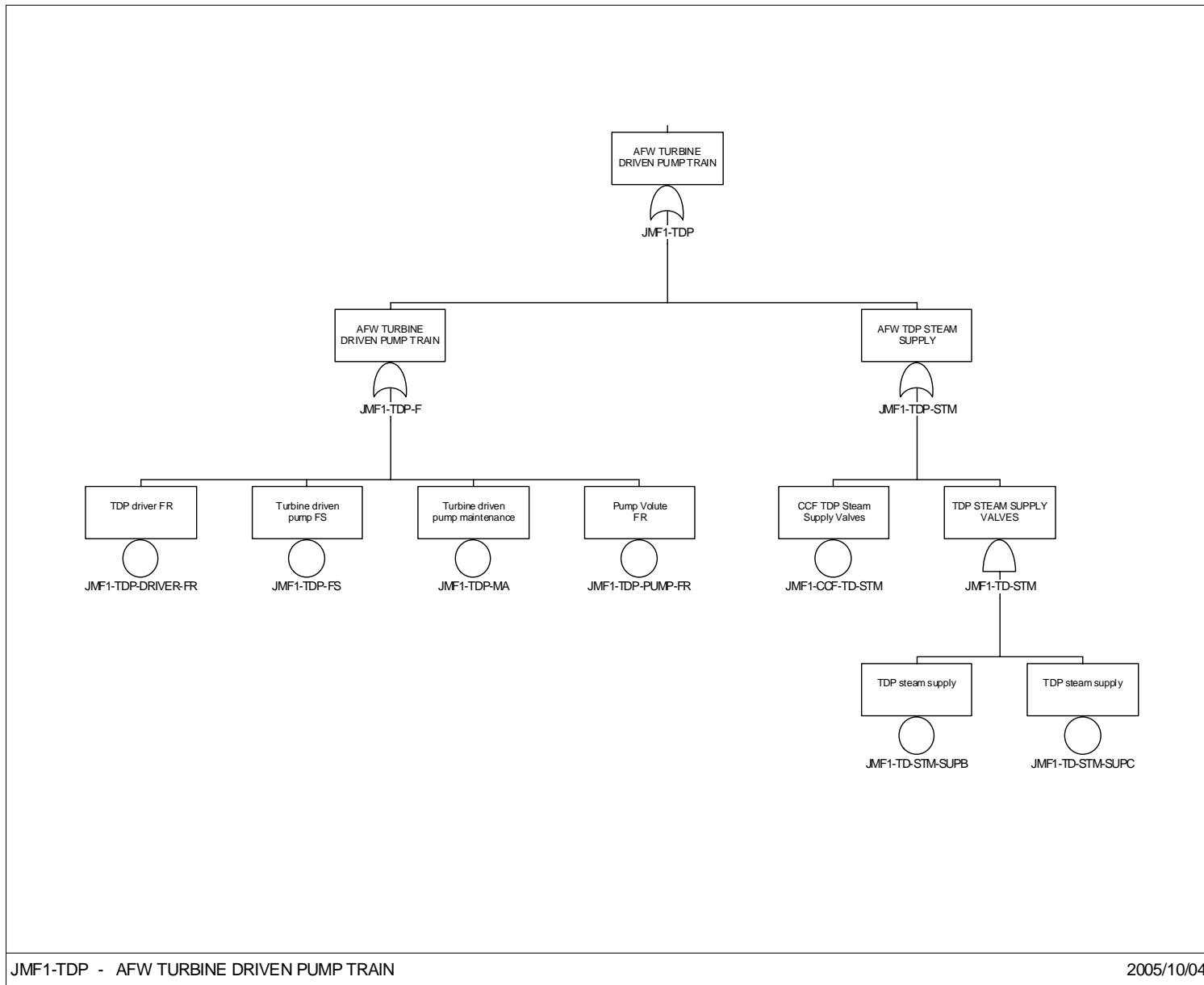


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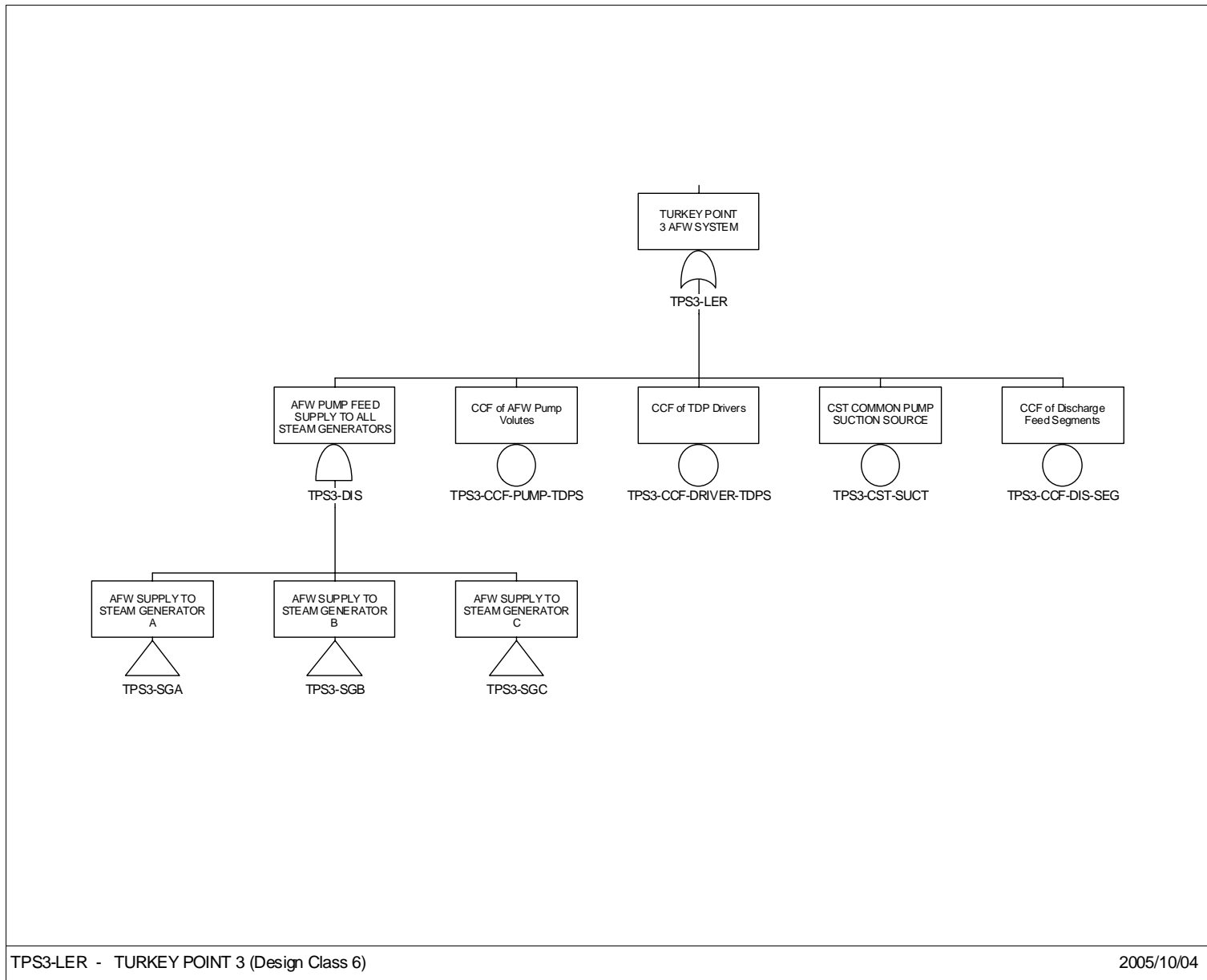


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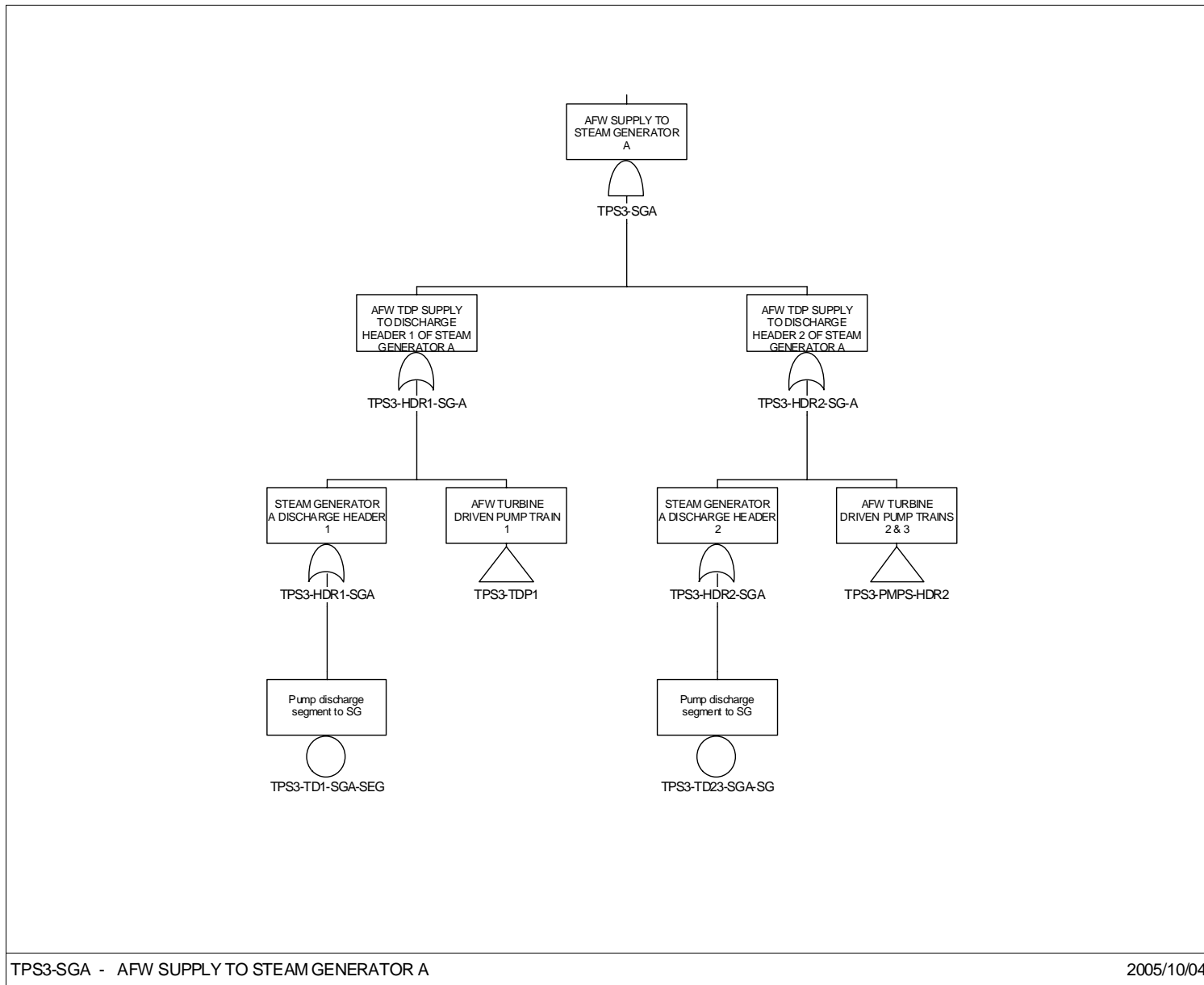


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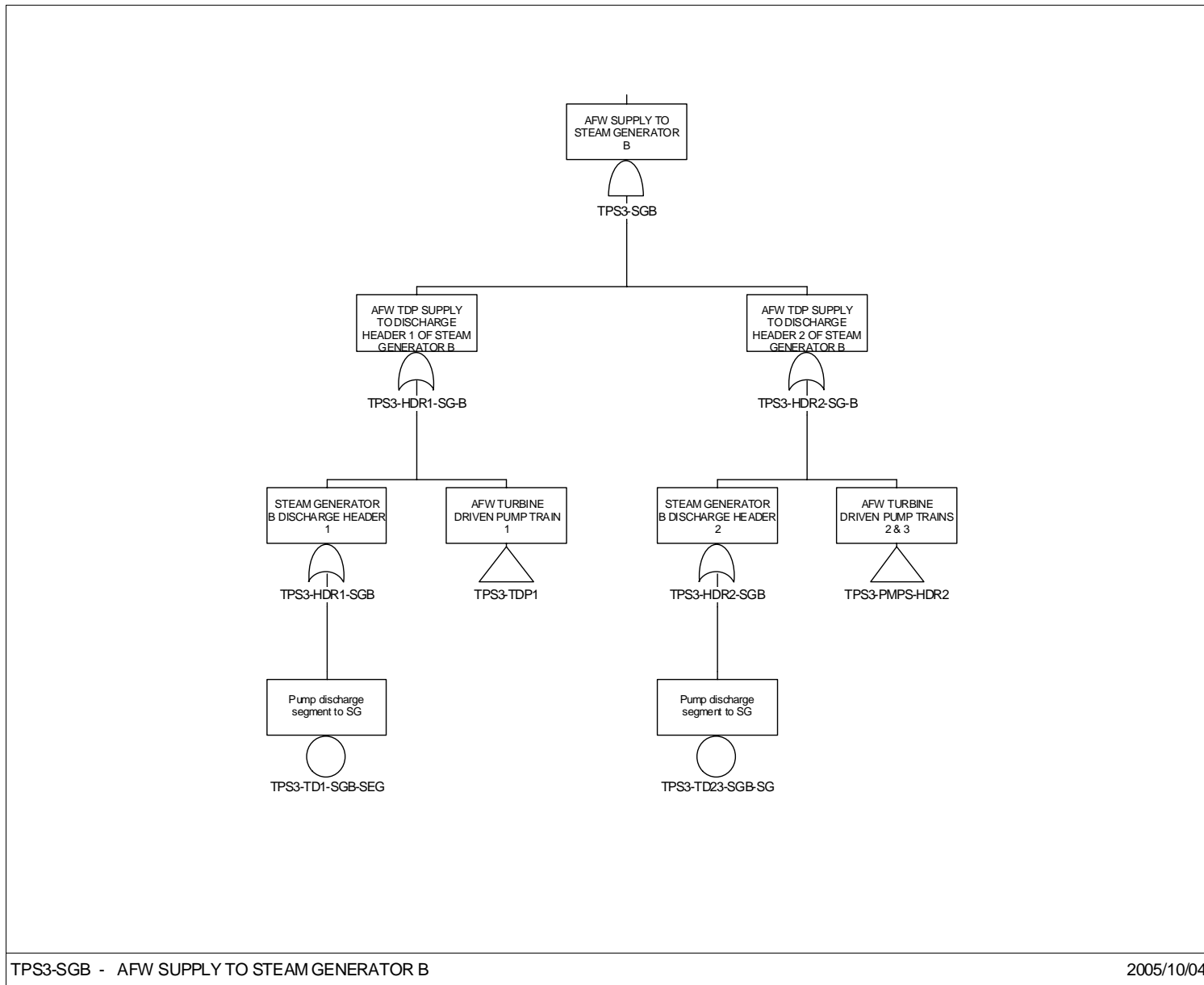


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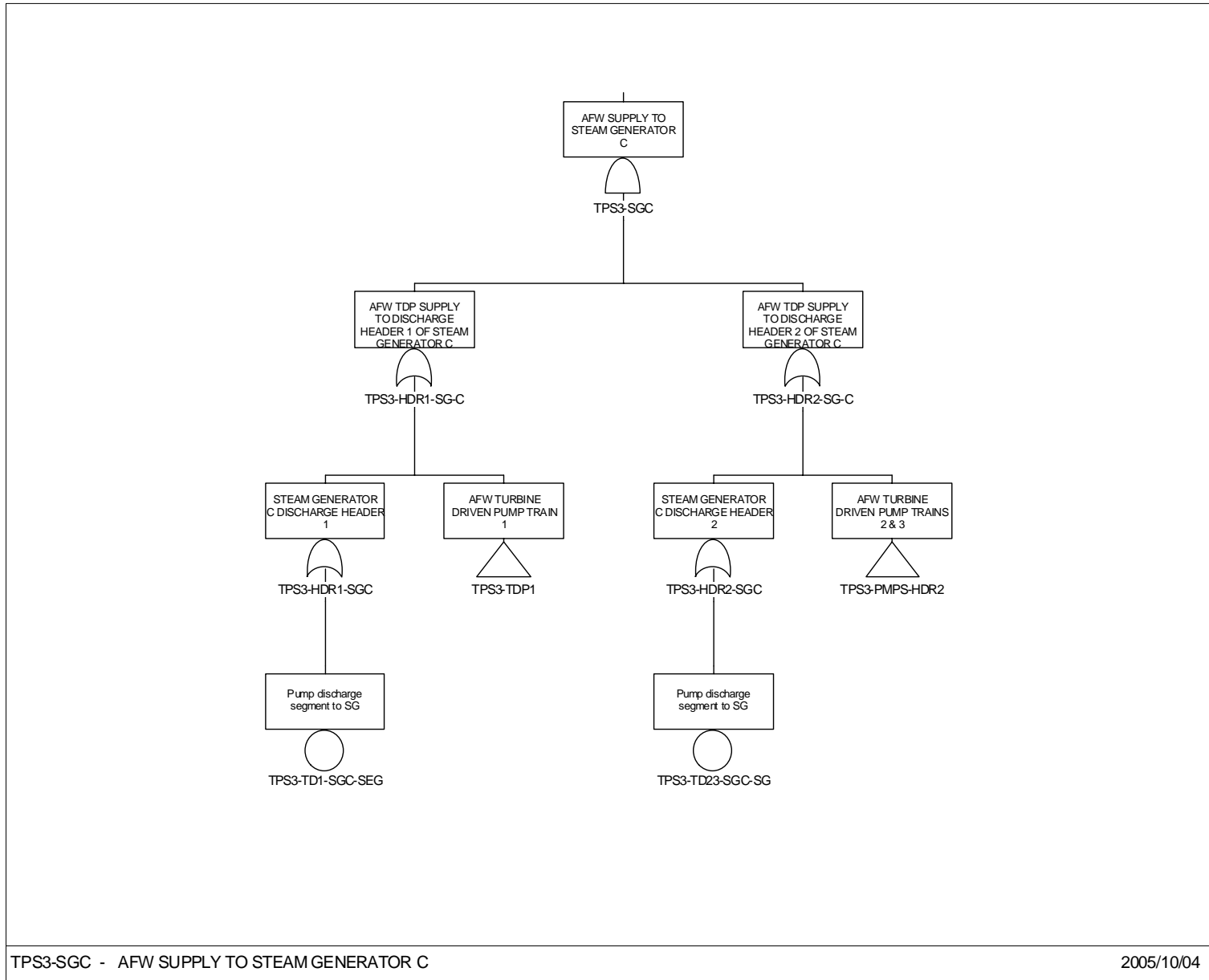


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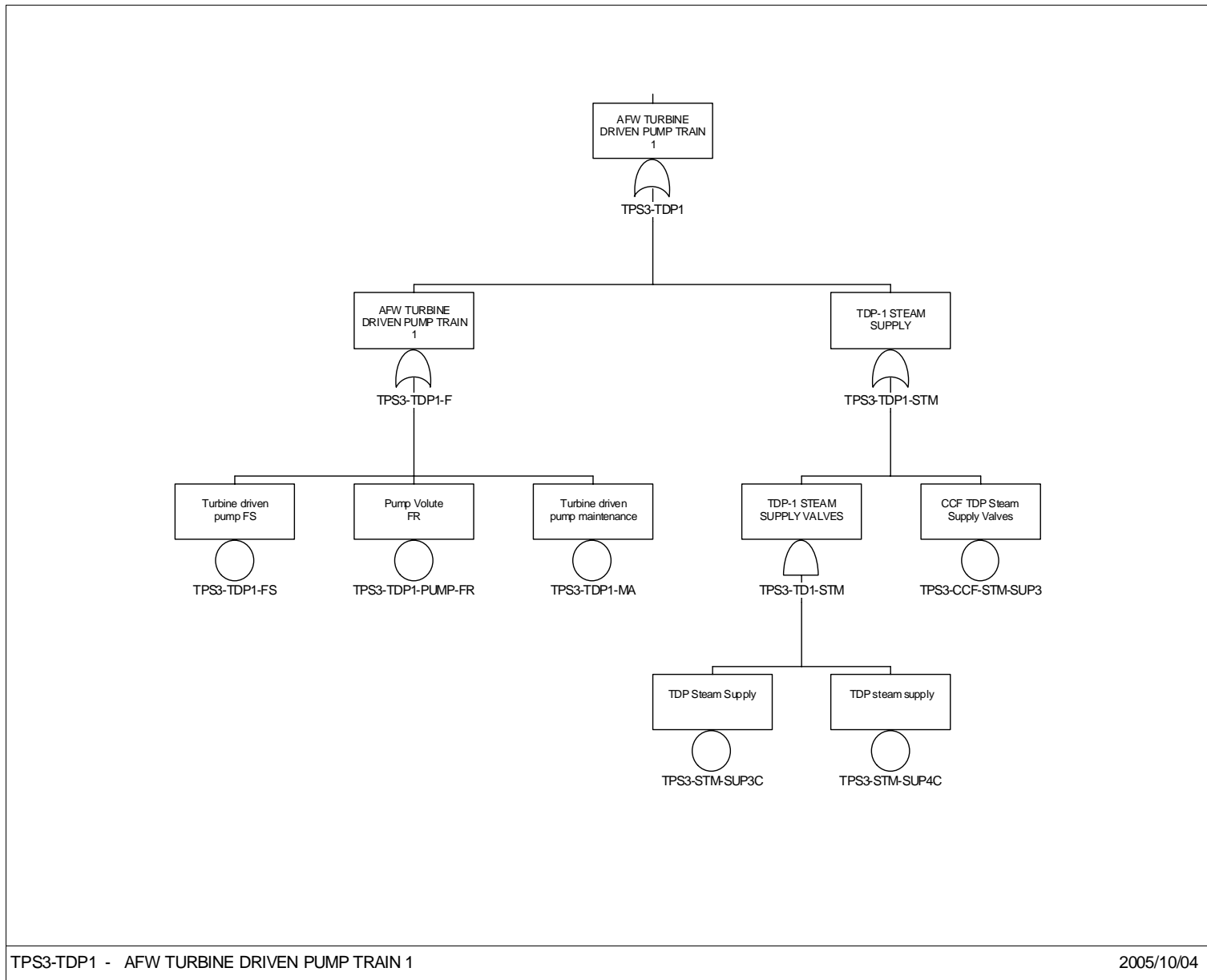


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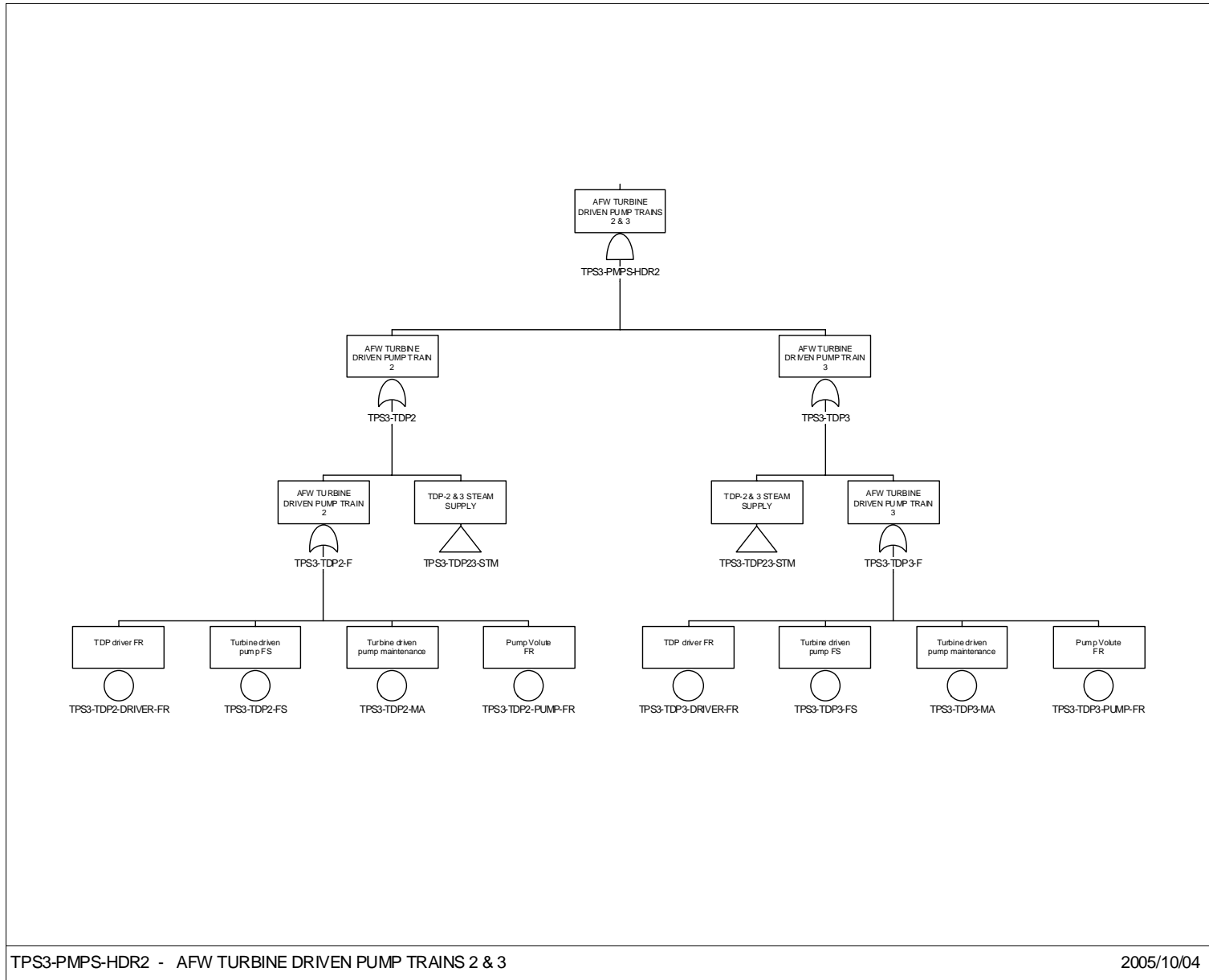


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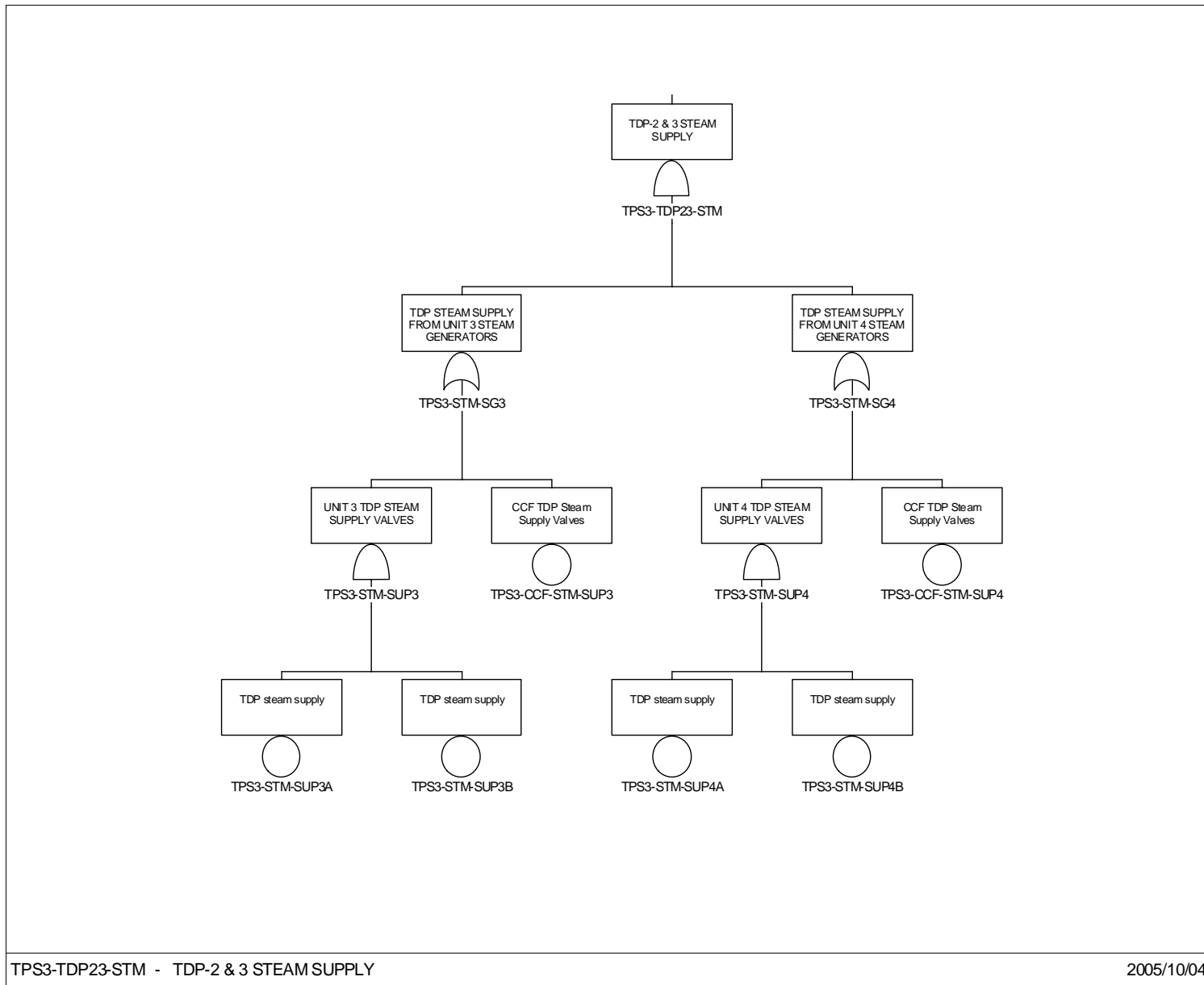


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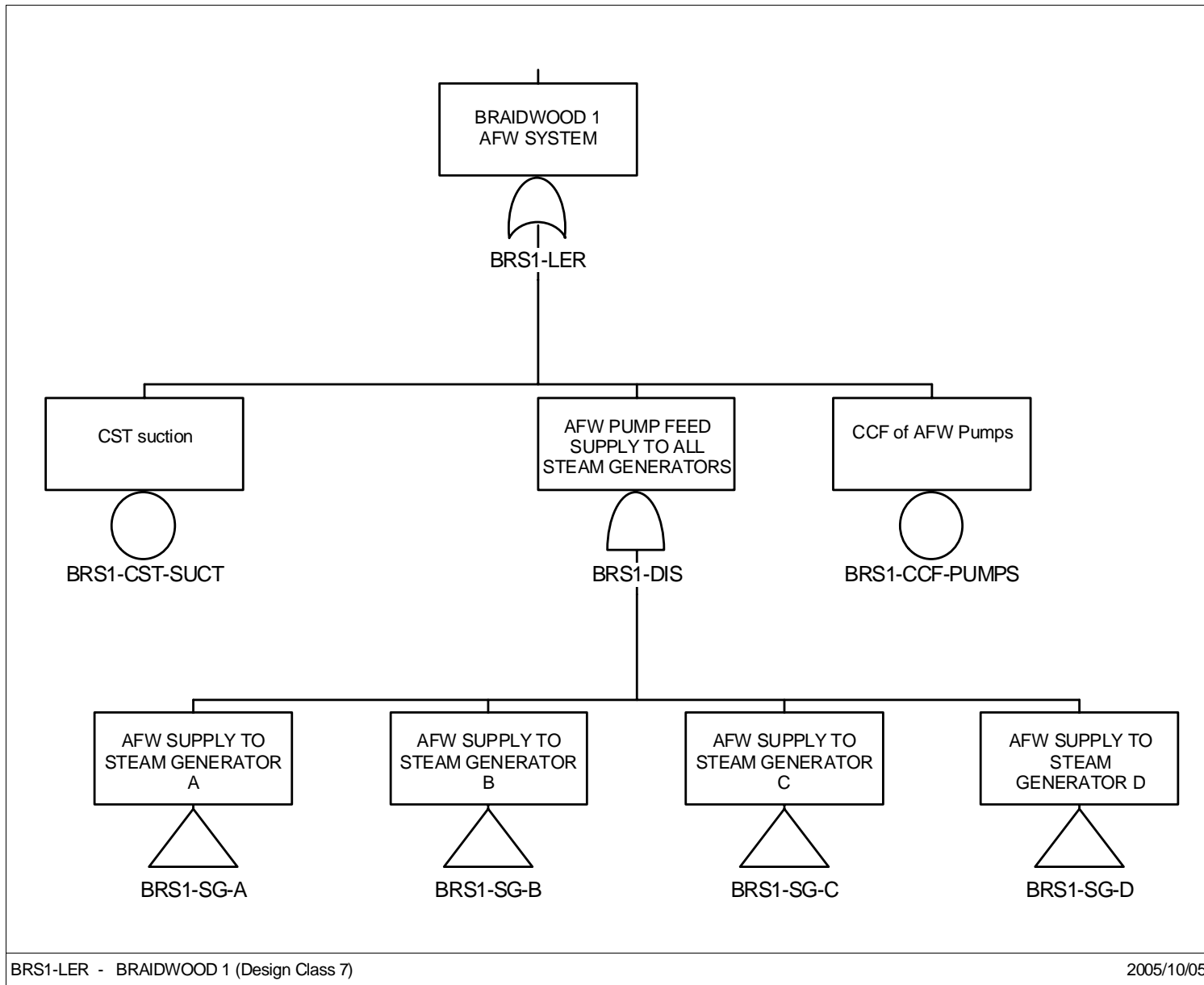


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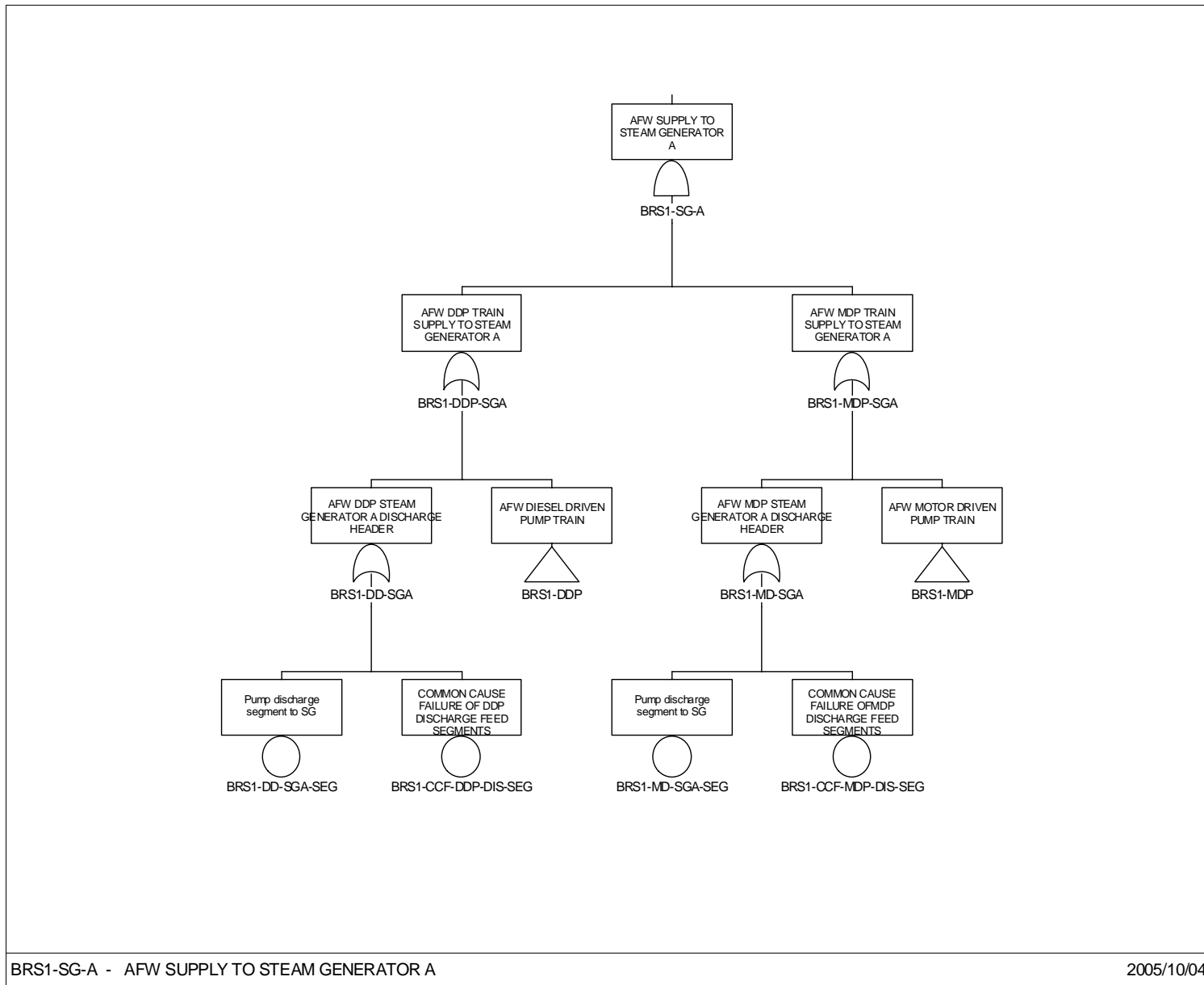


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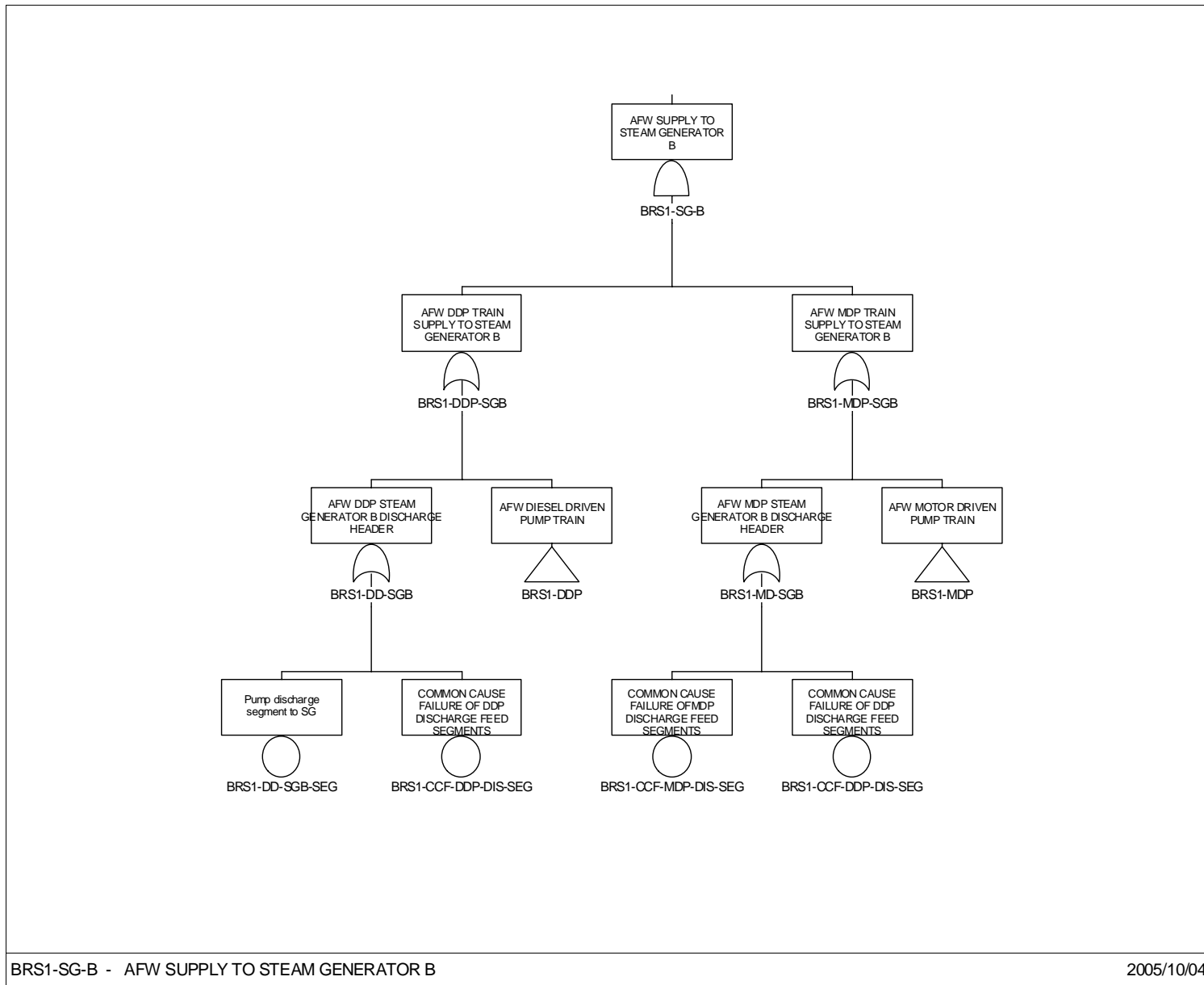


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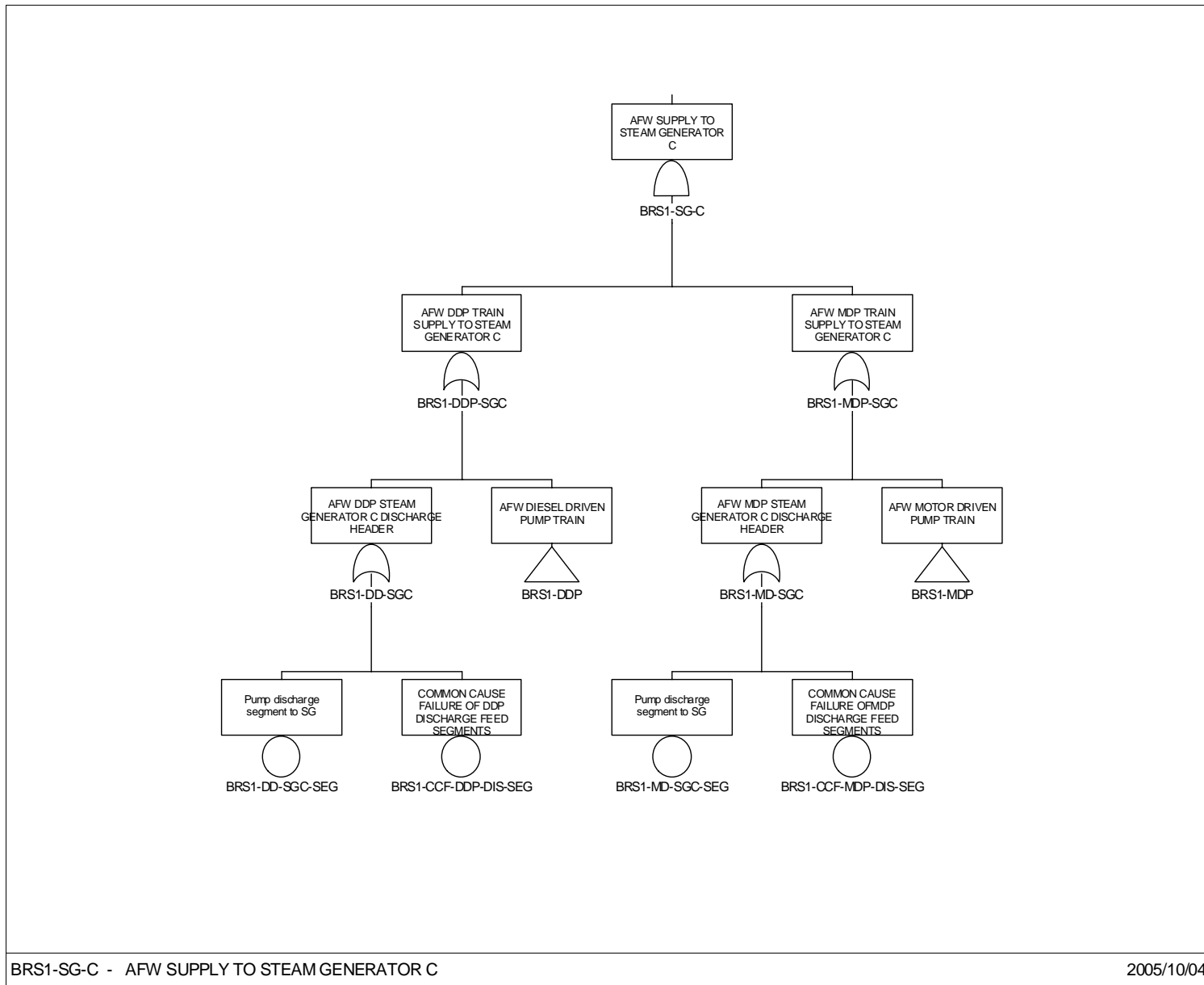
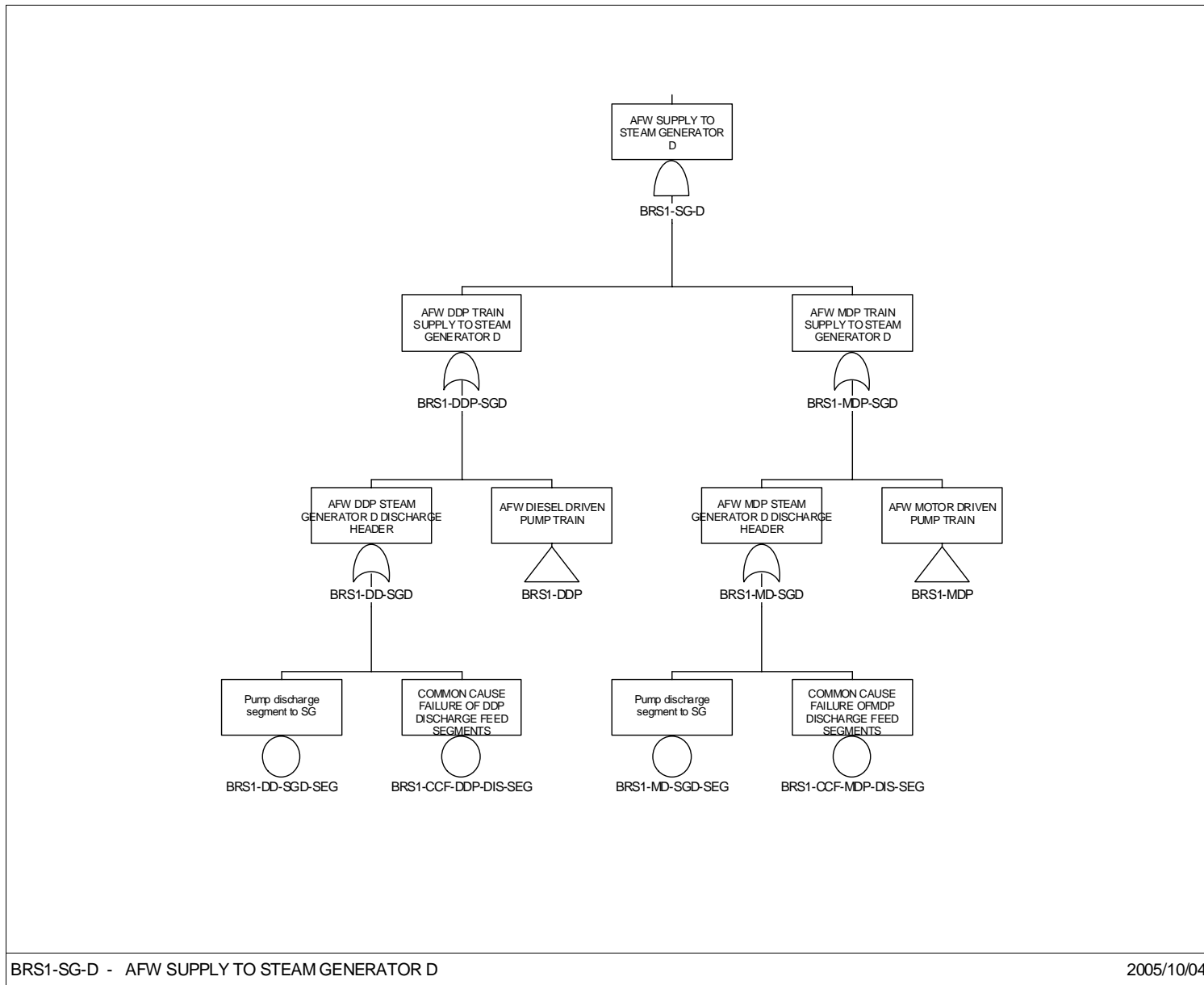


Figure 7. Design Class 7. (continued)



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Figure 7. Design Class 7. (continued)

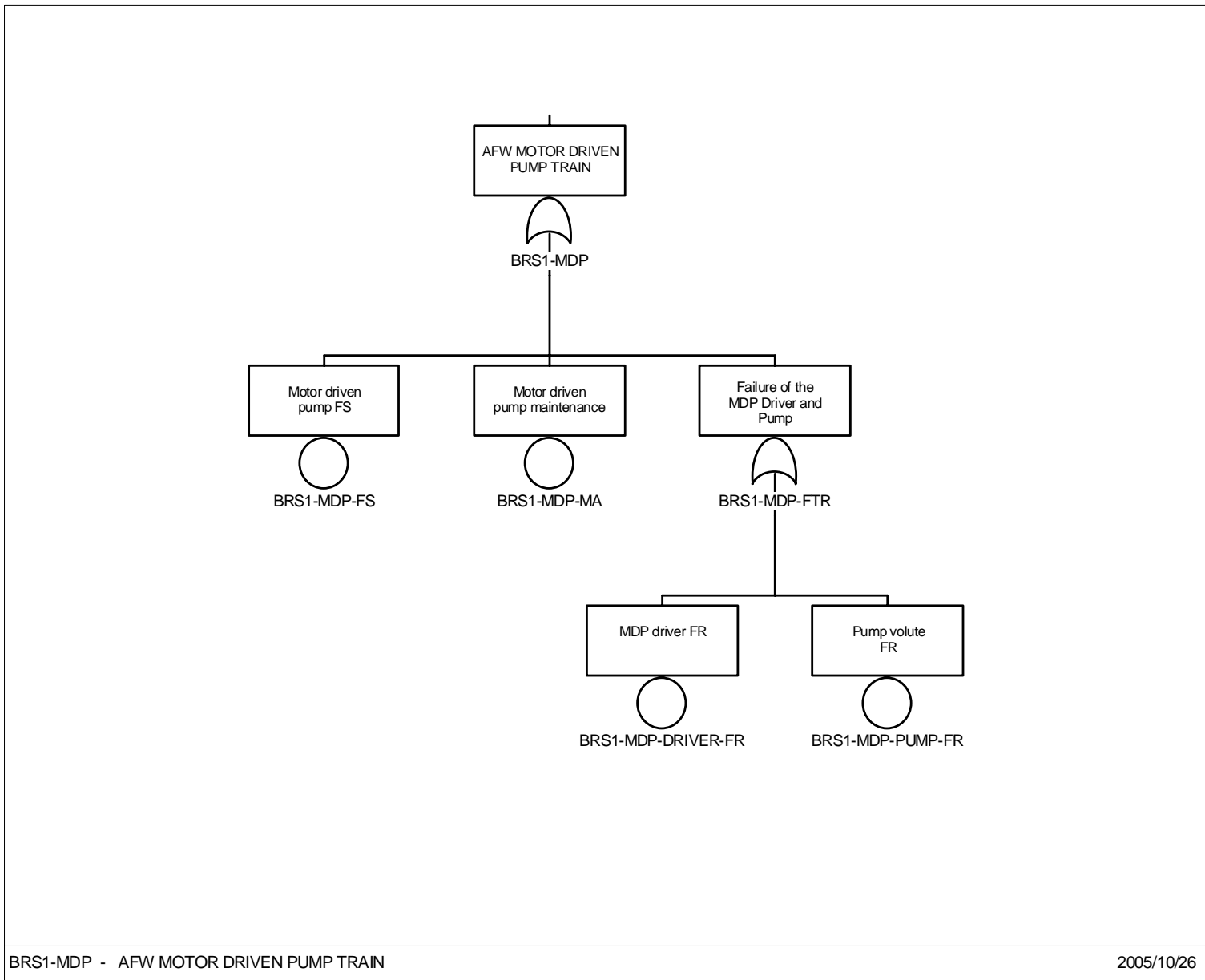


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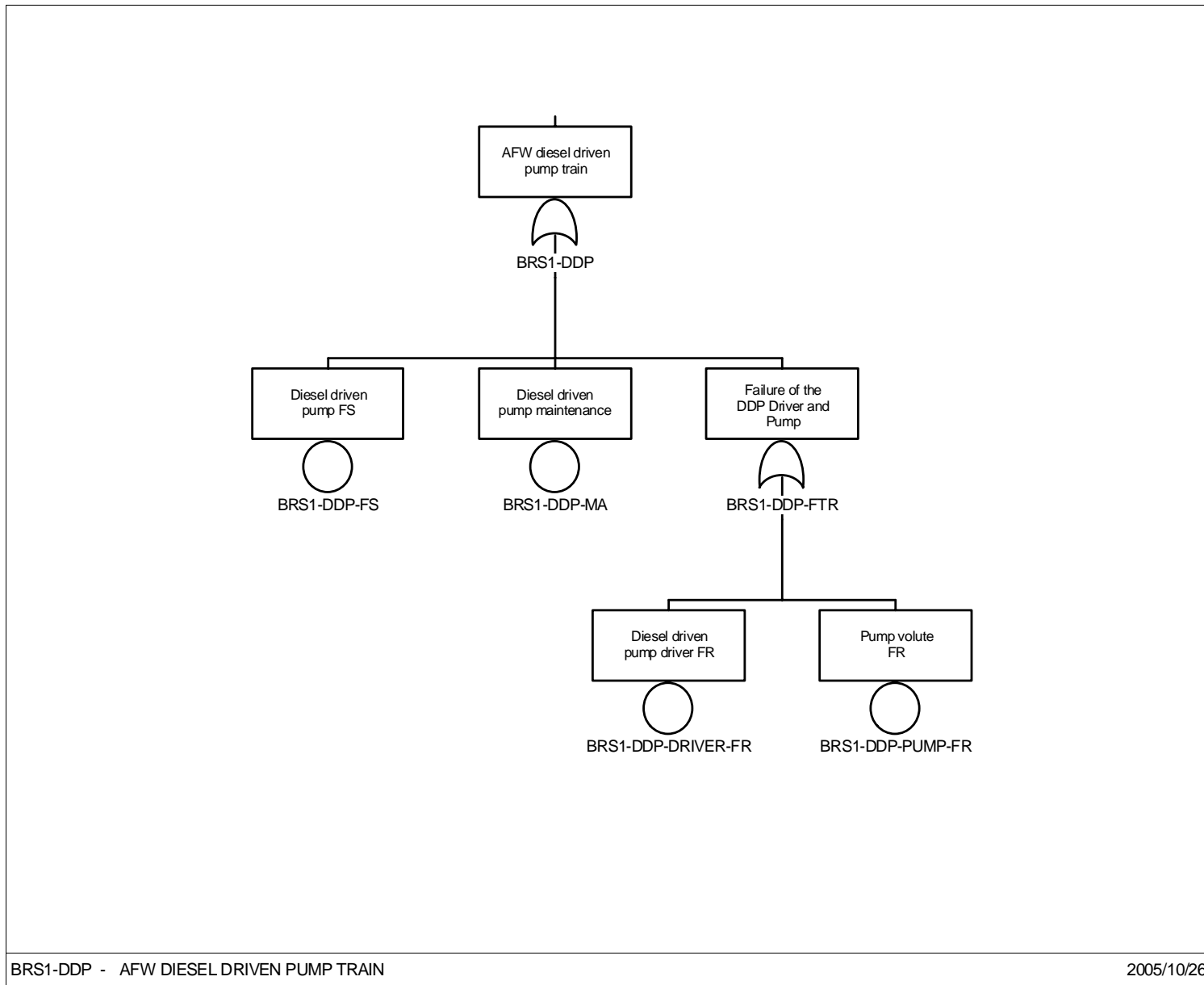


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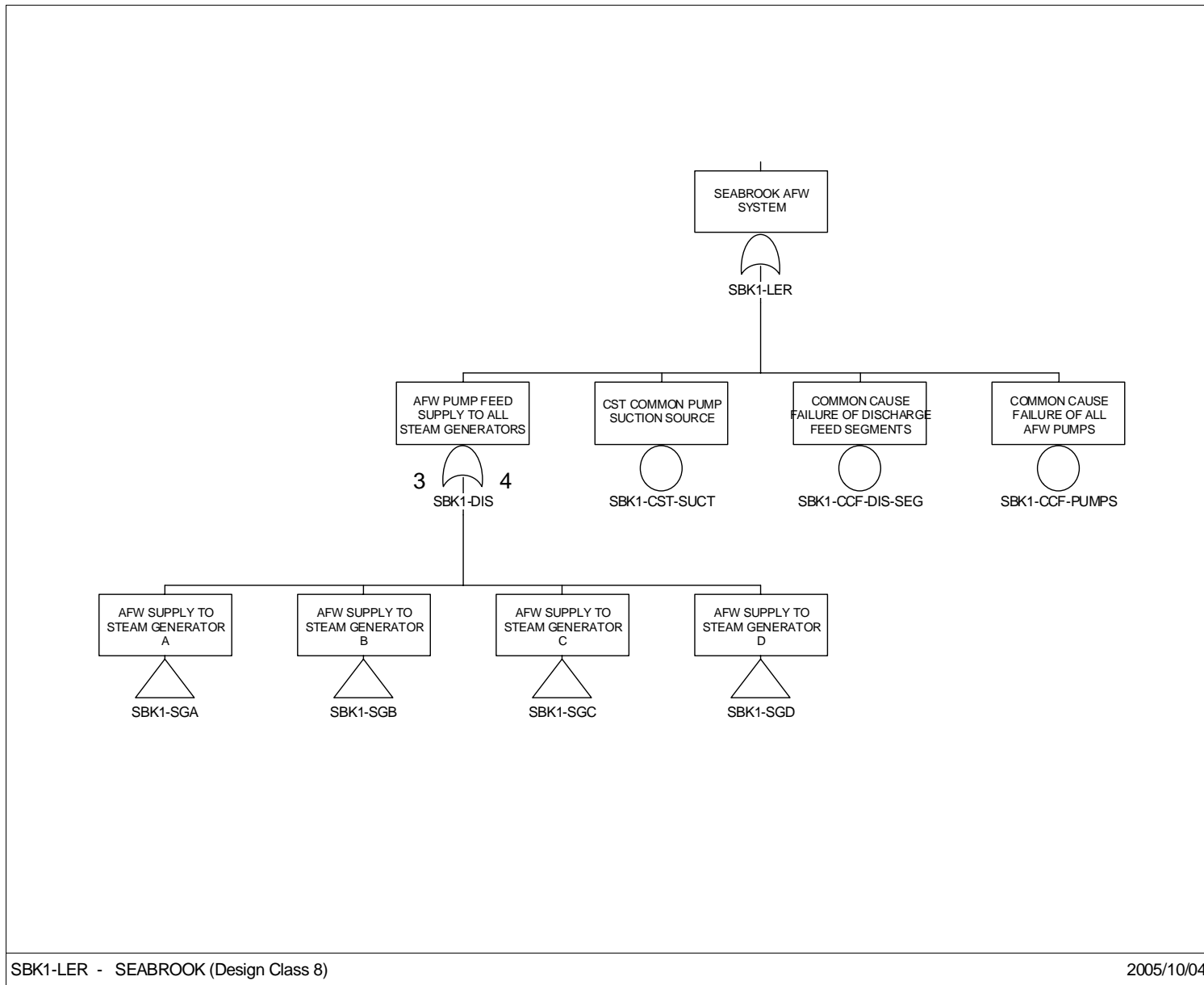


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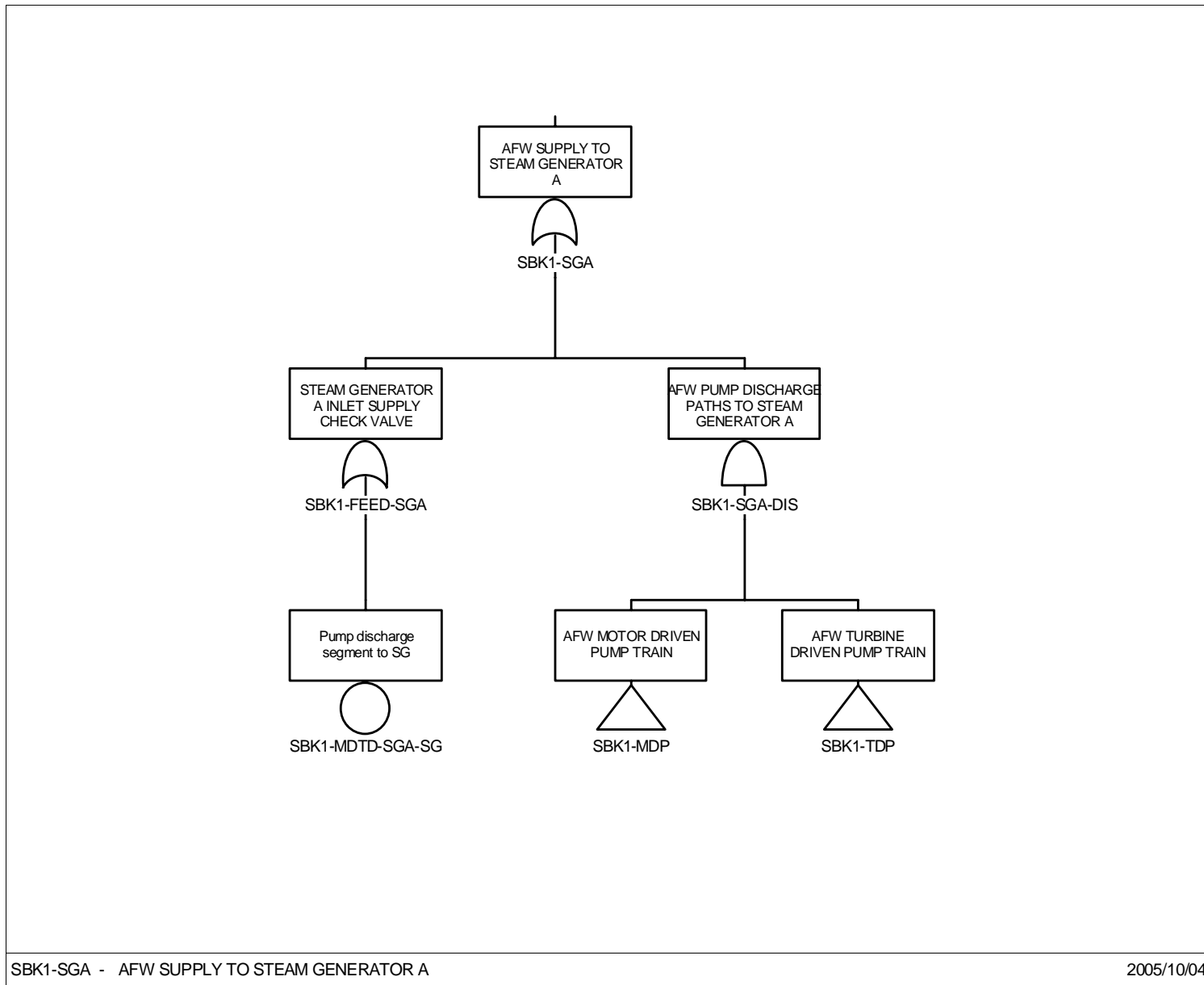


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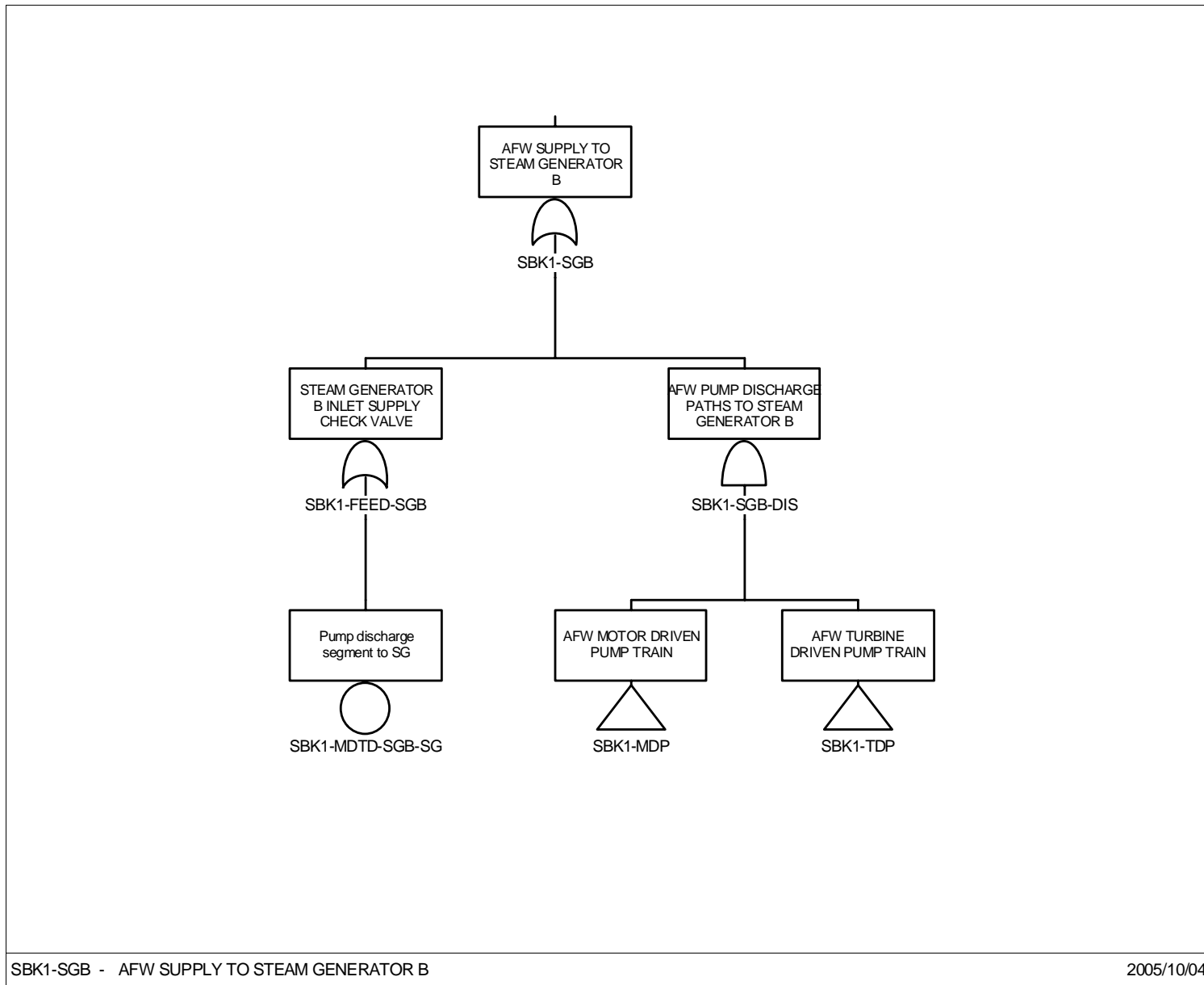


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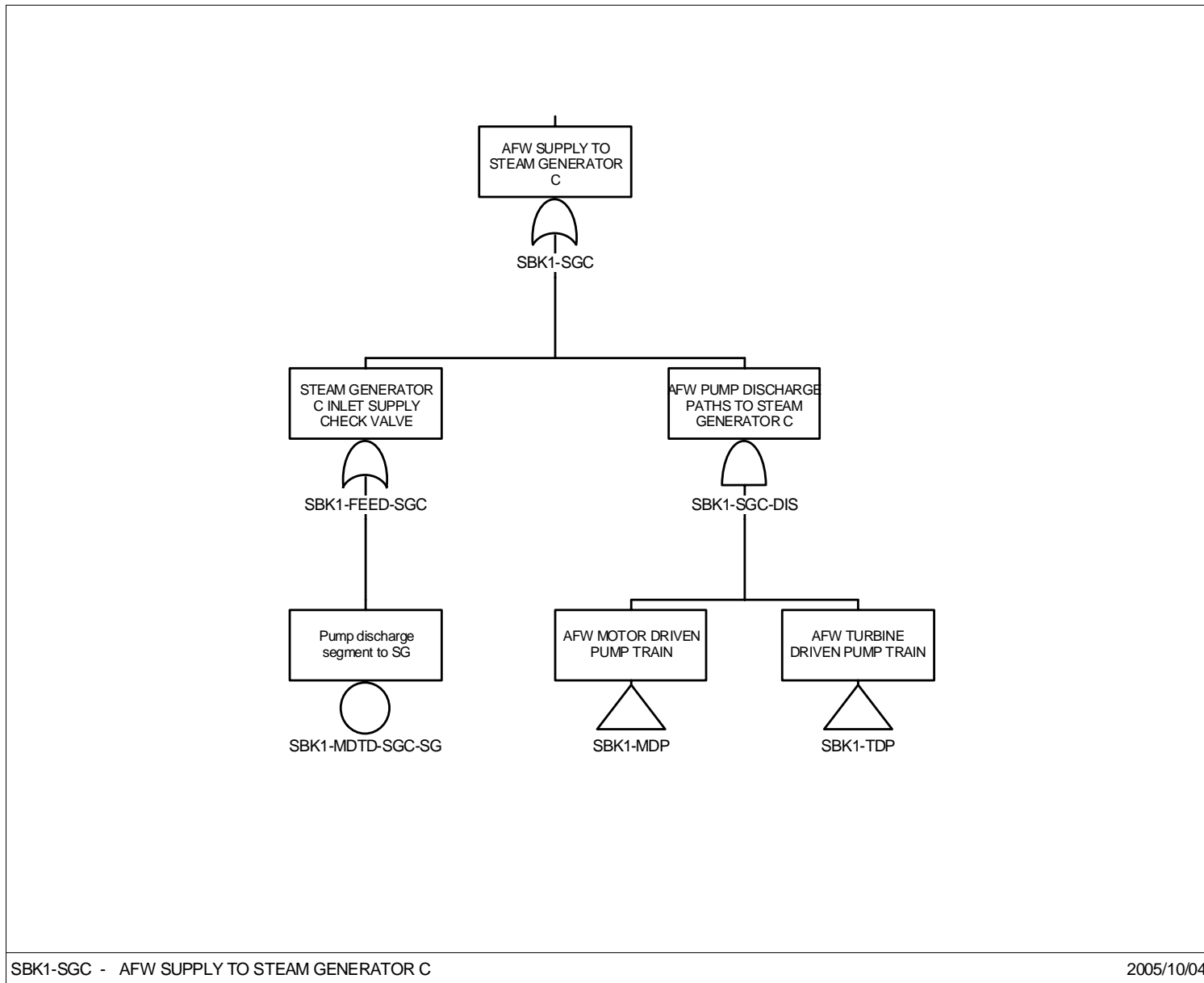


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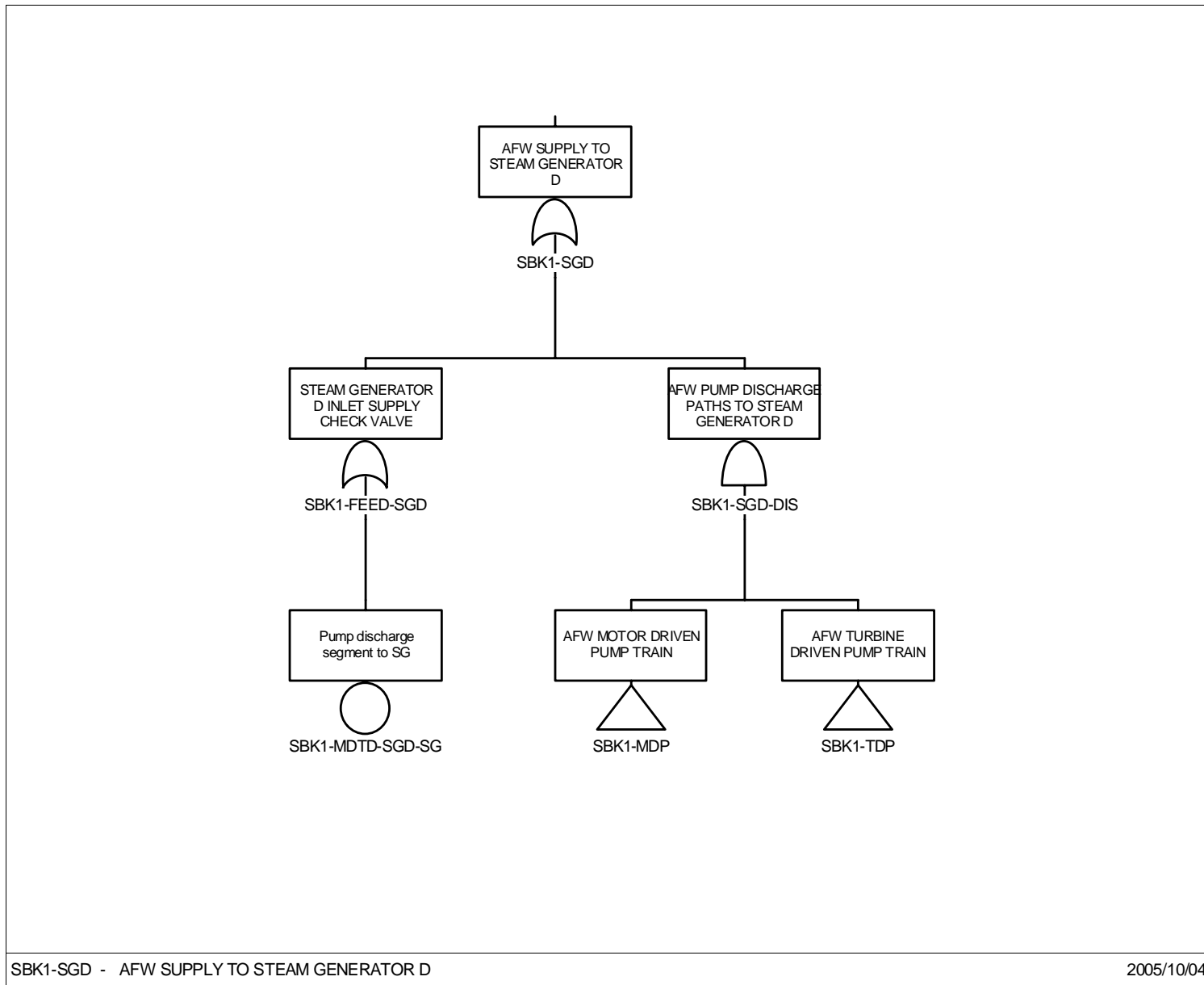


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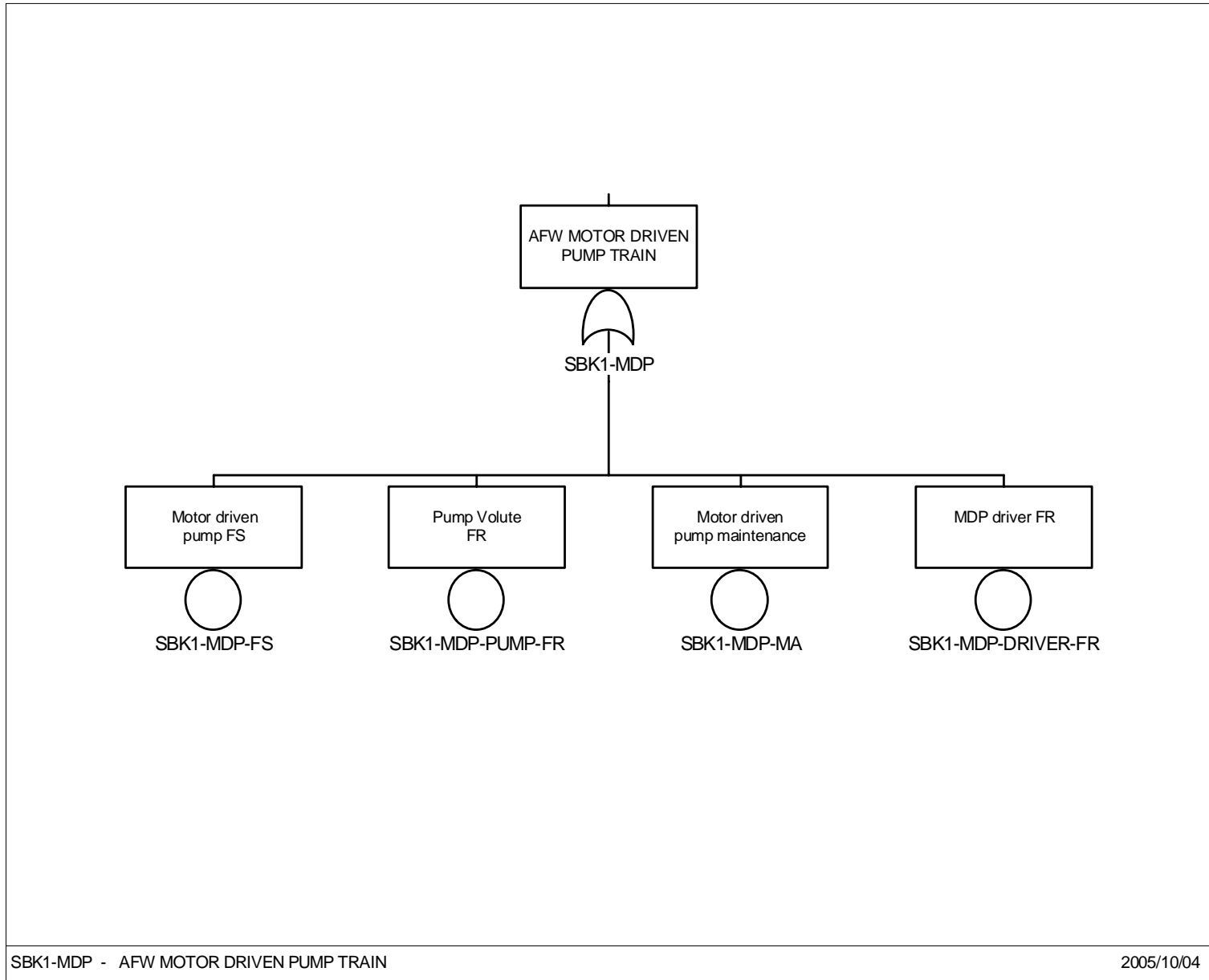


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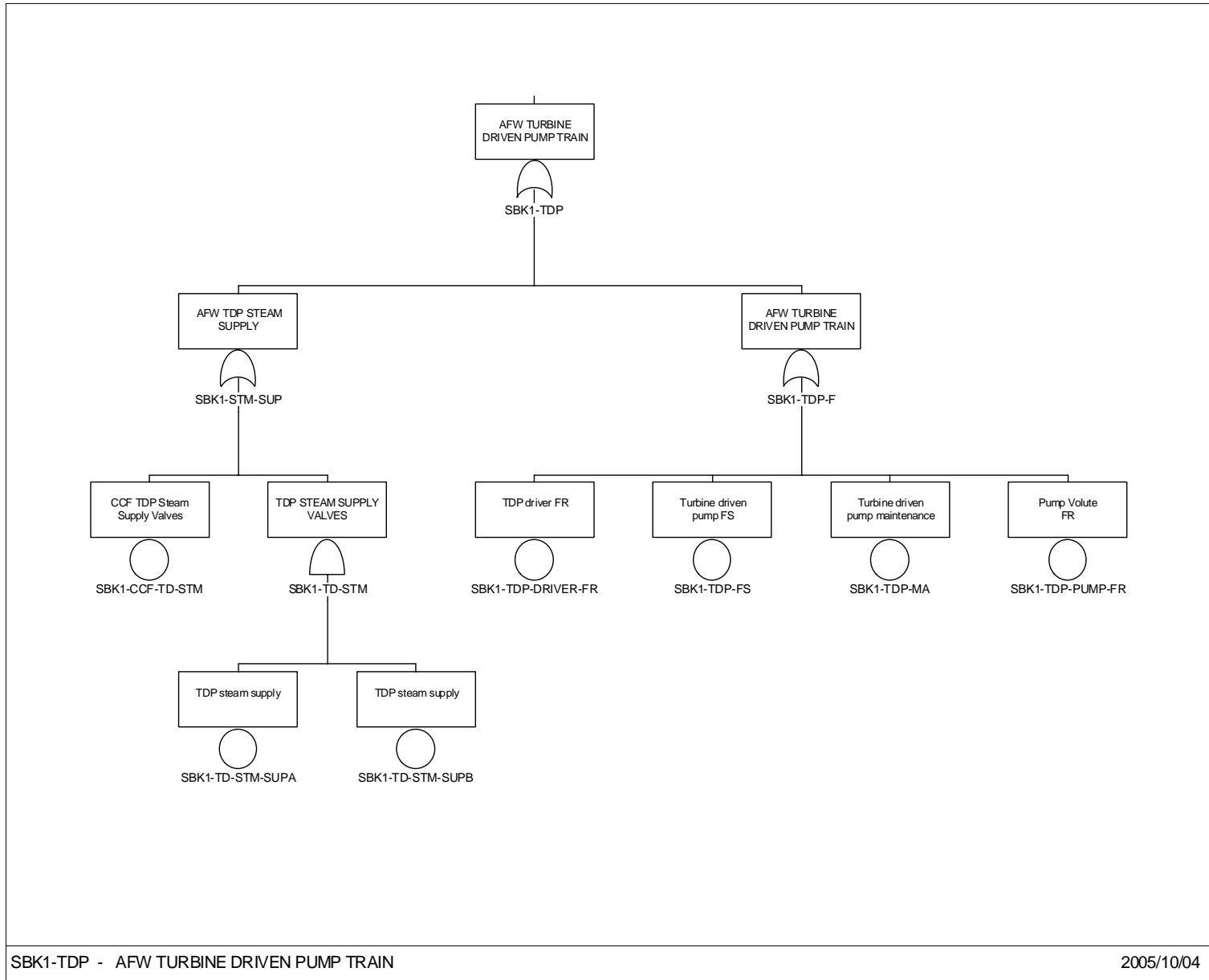


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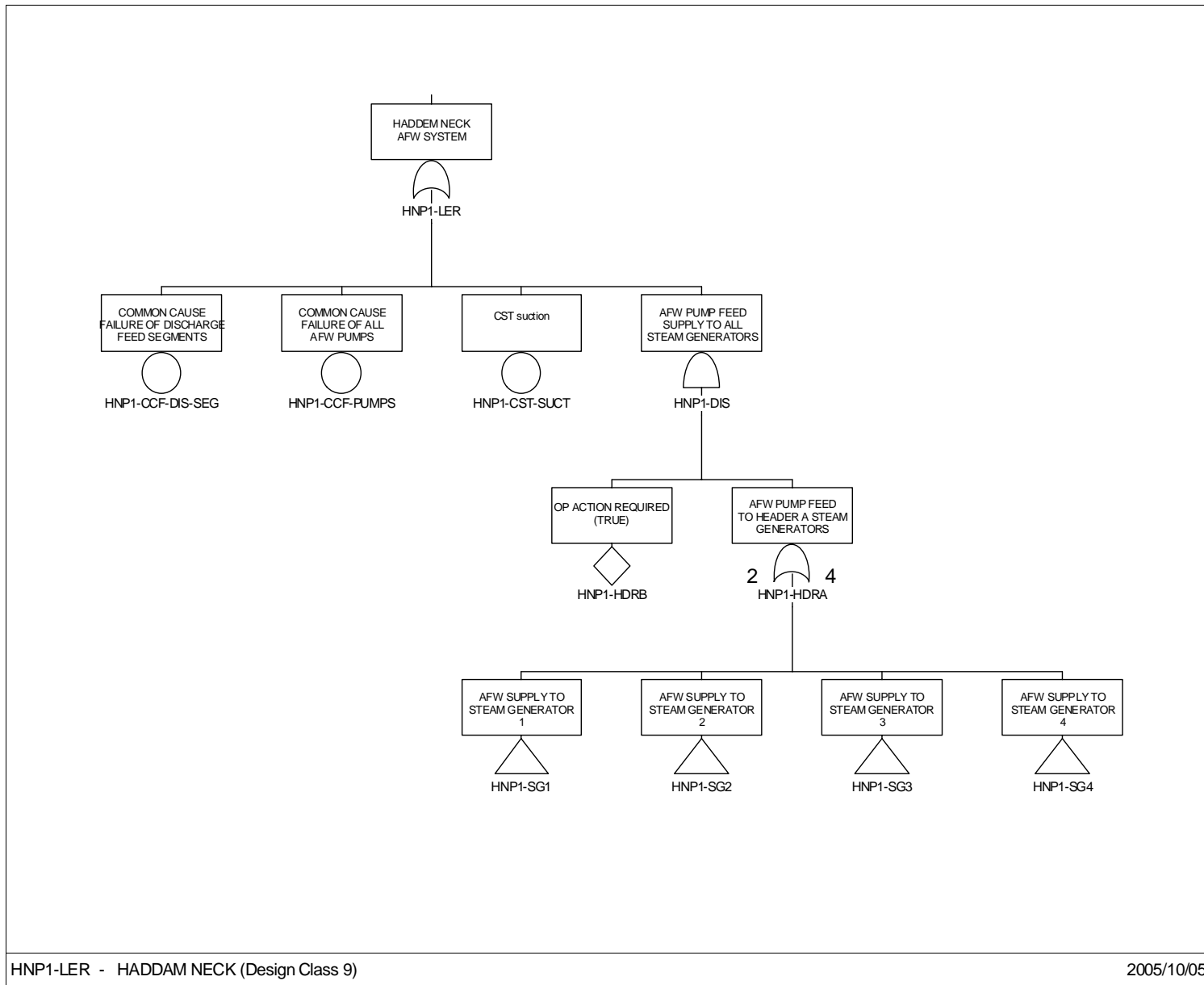


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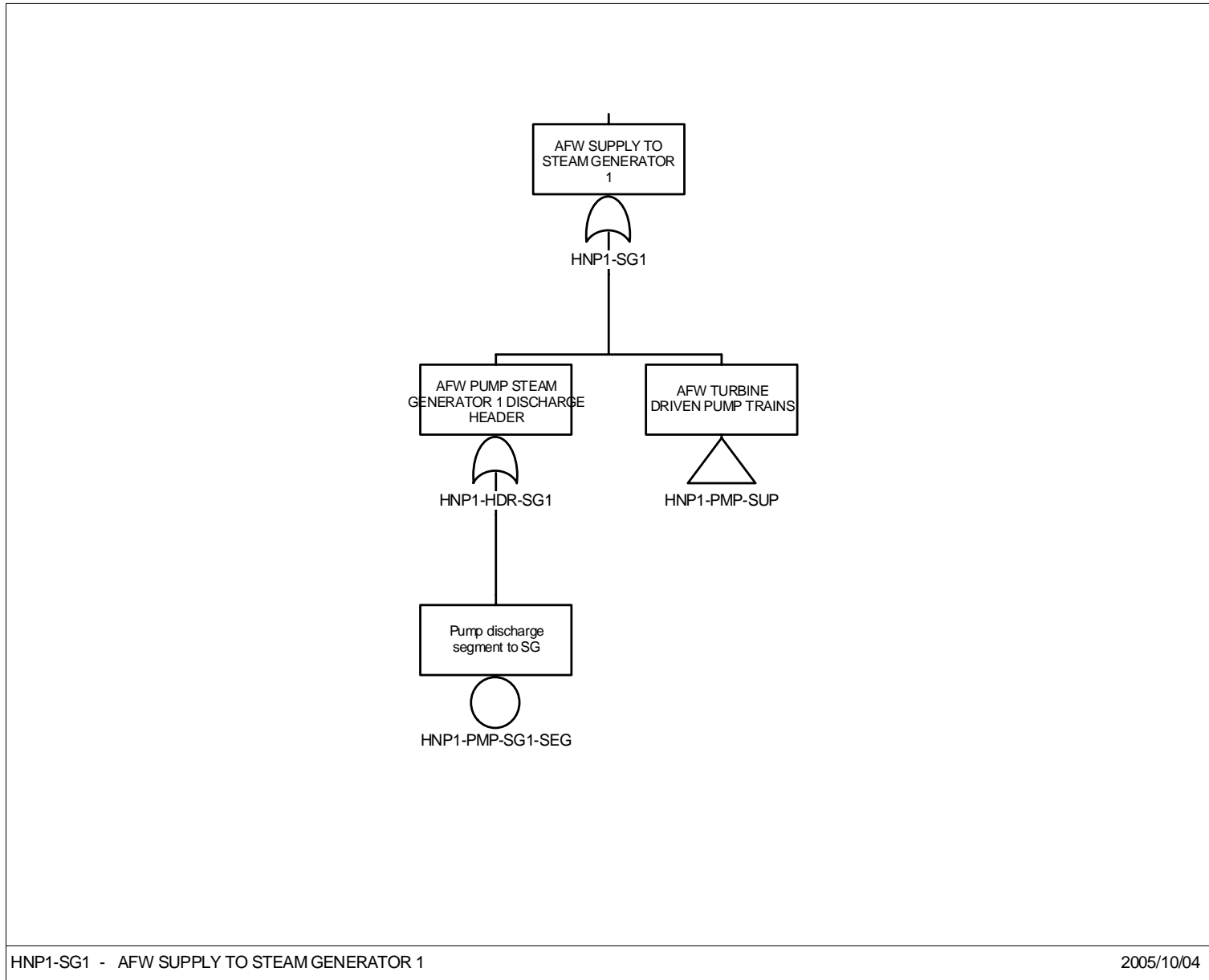


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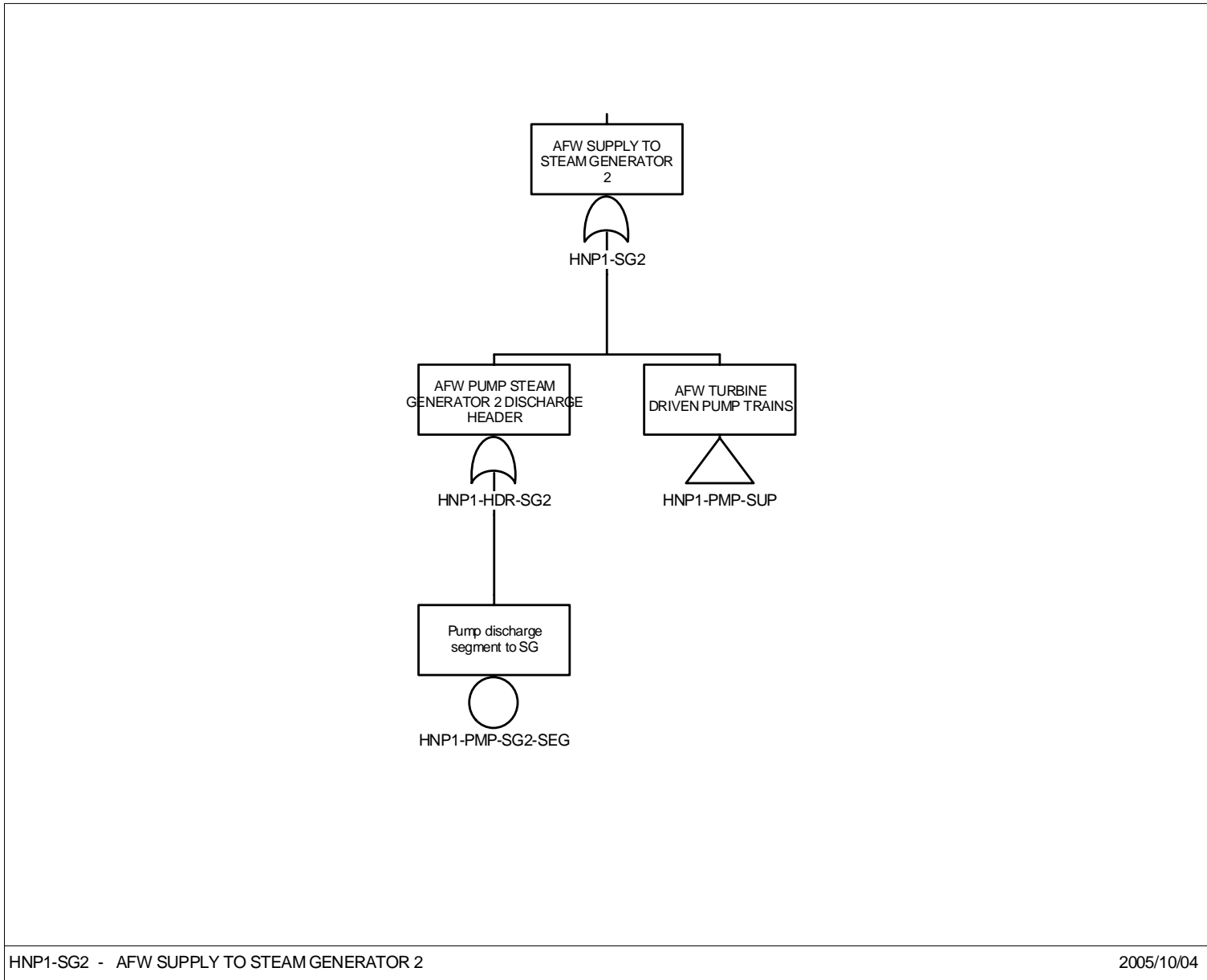


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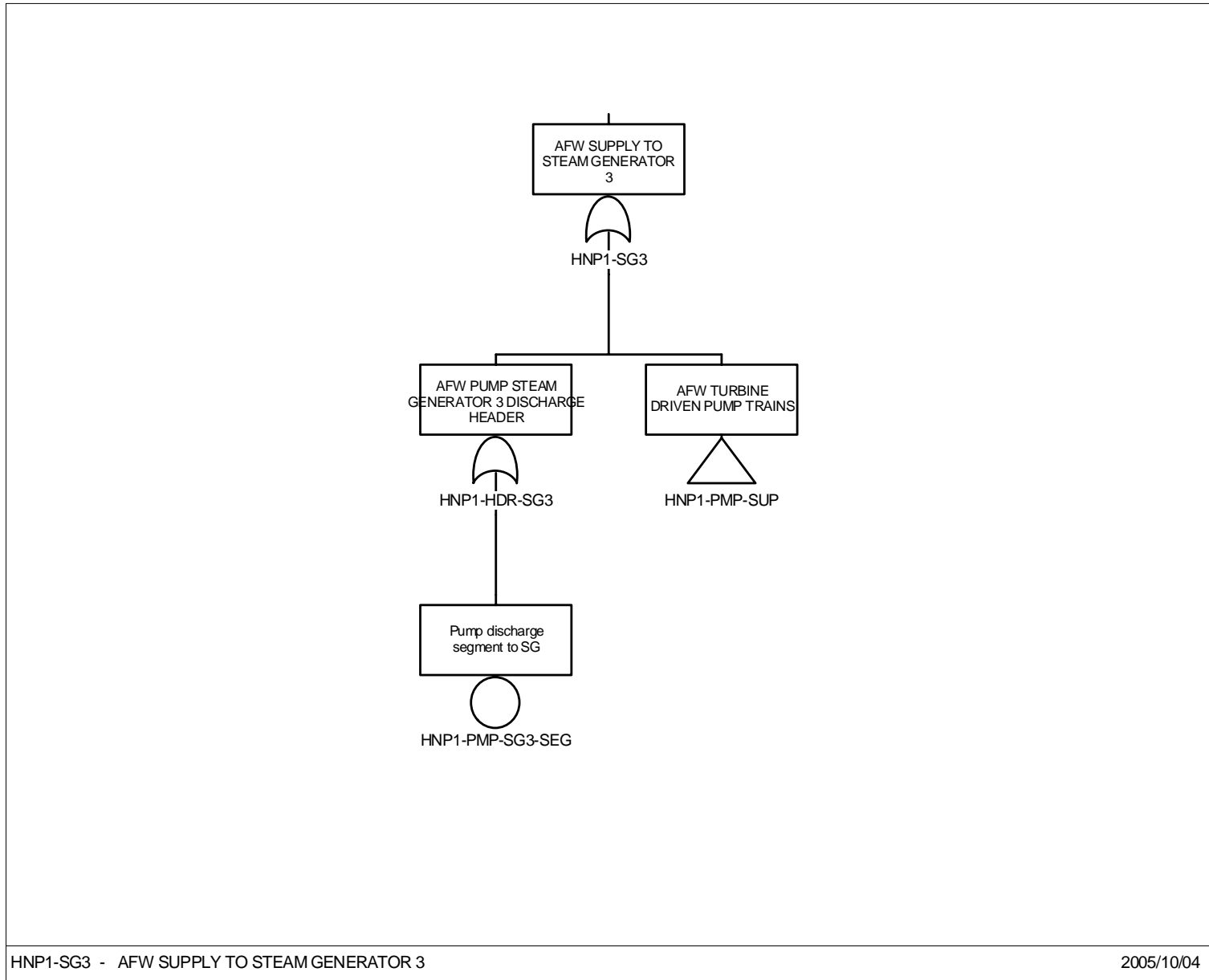


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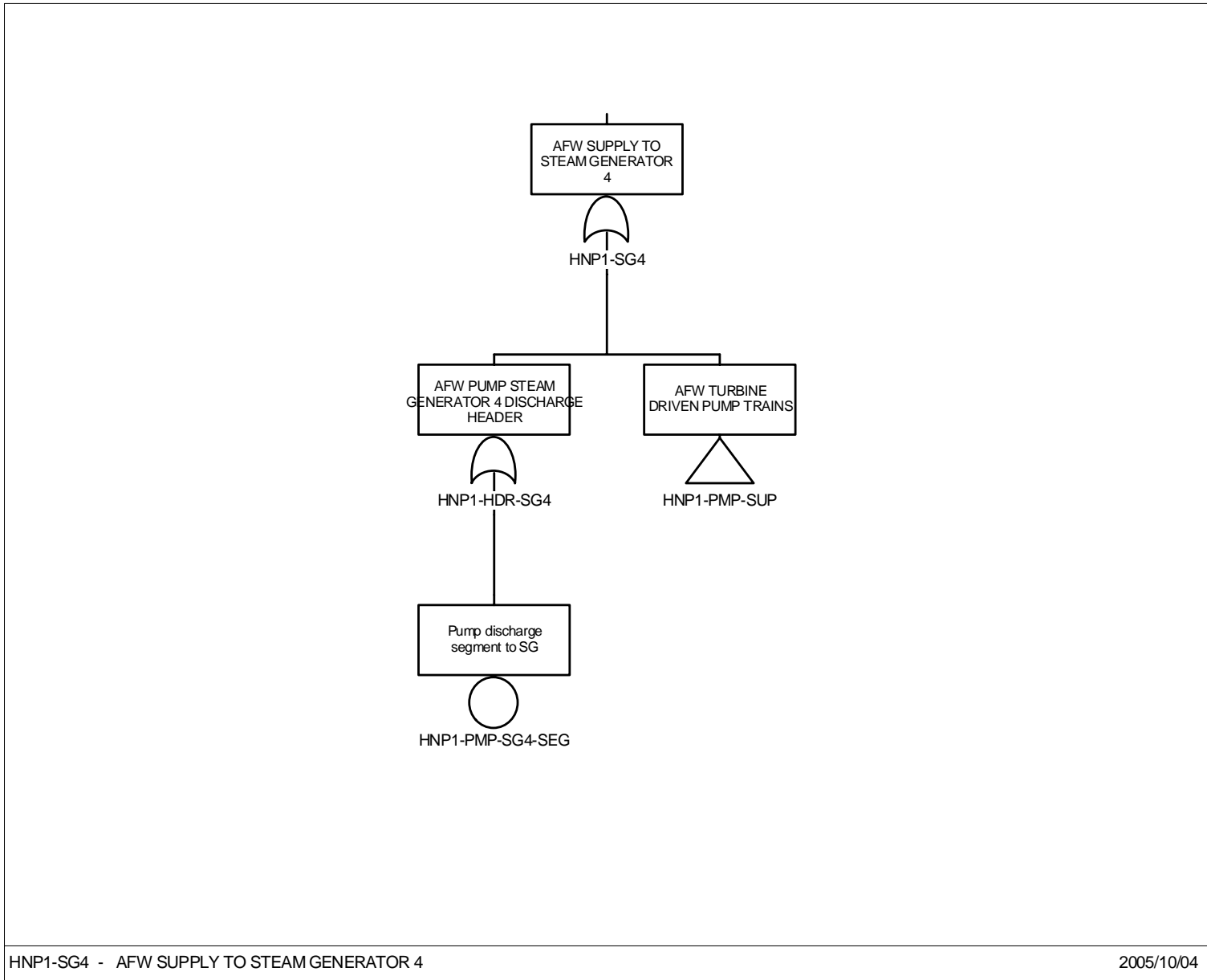


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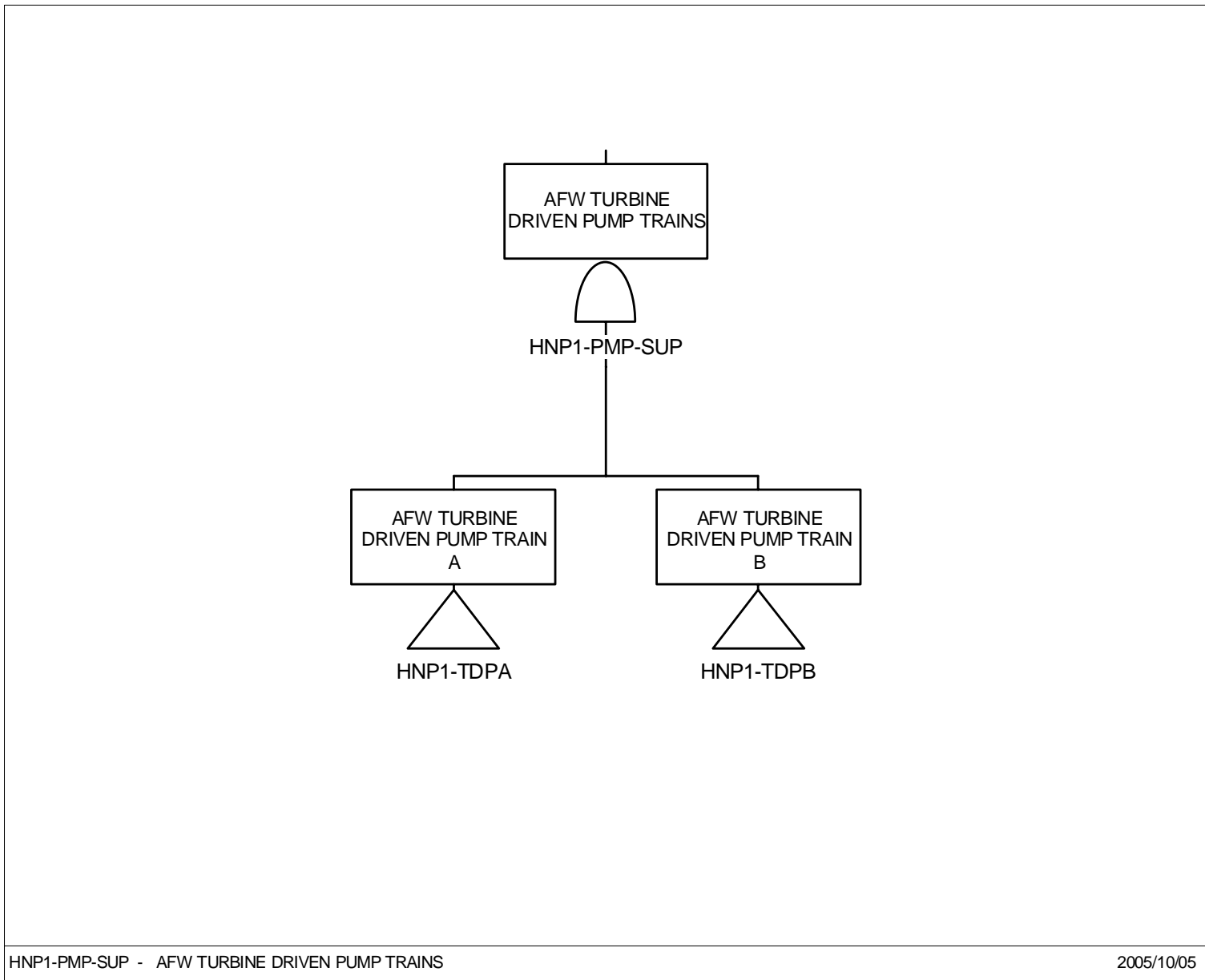


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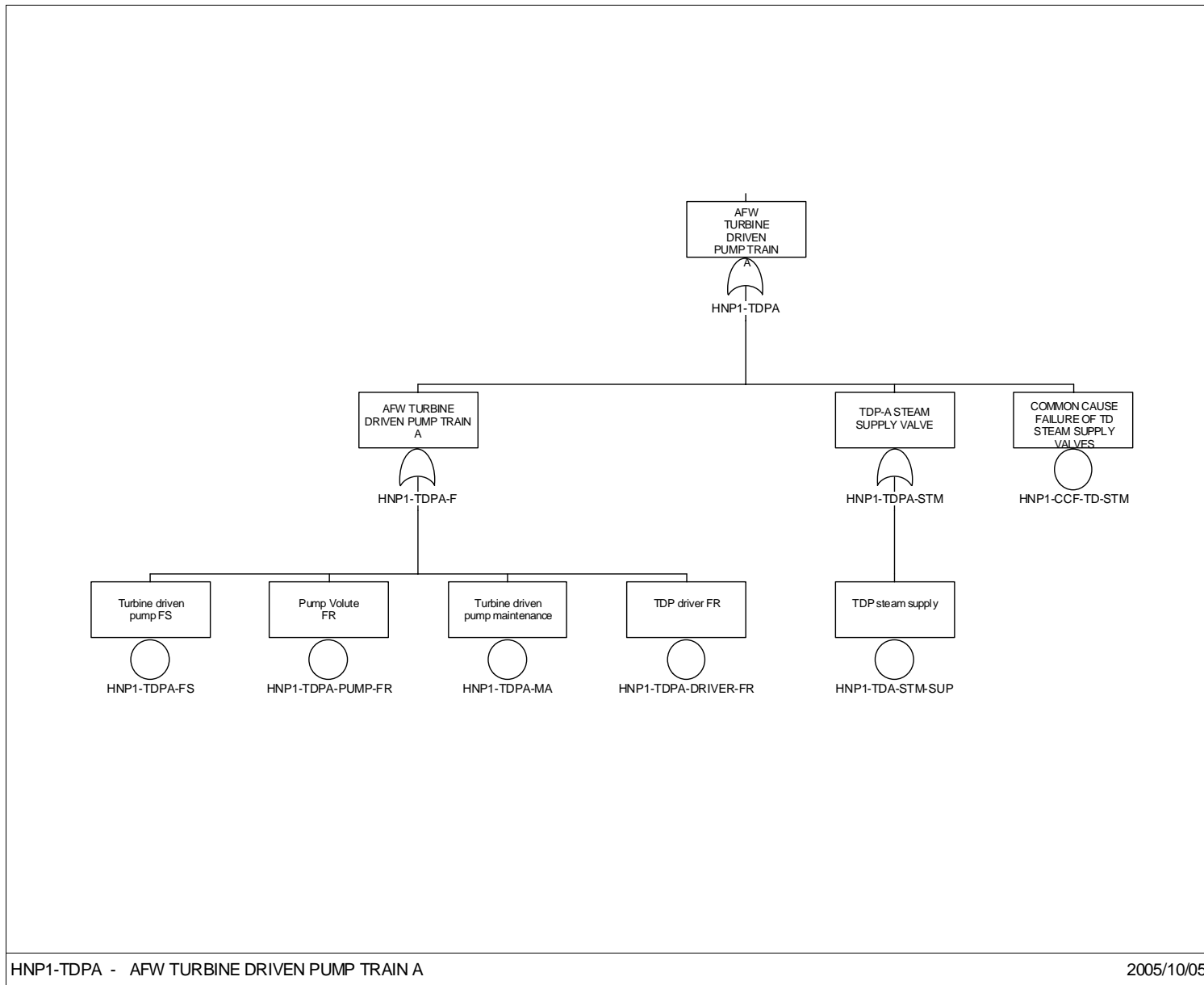


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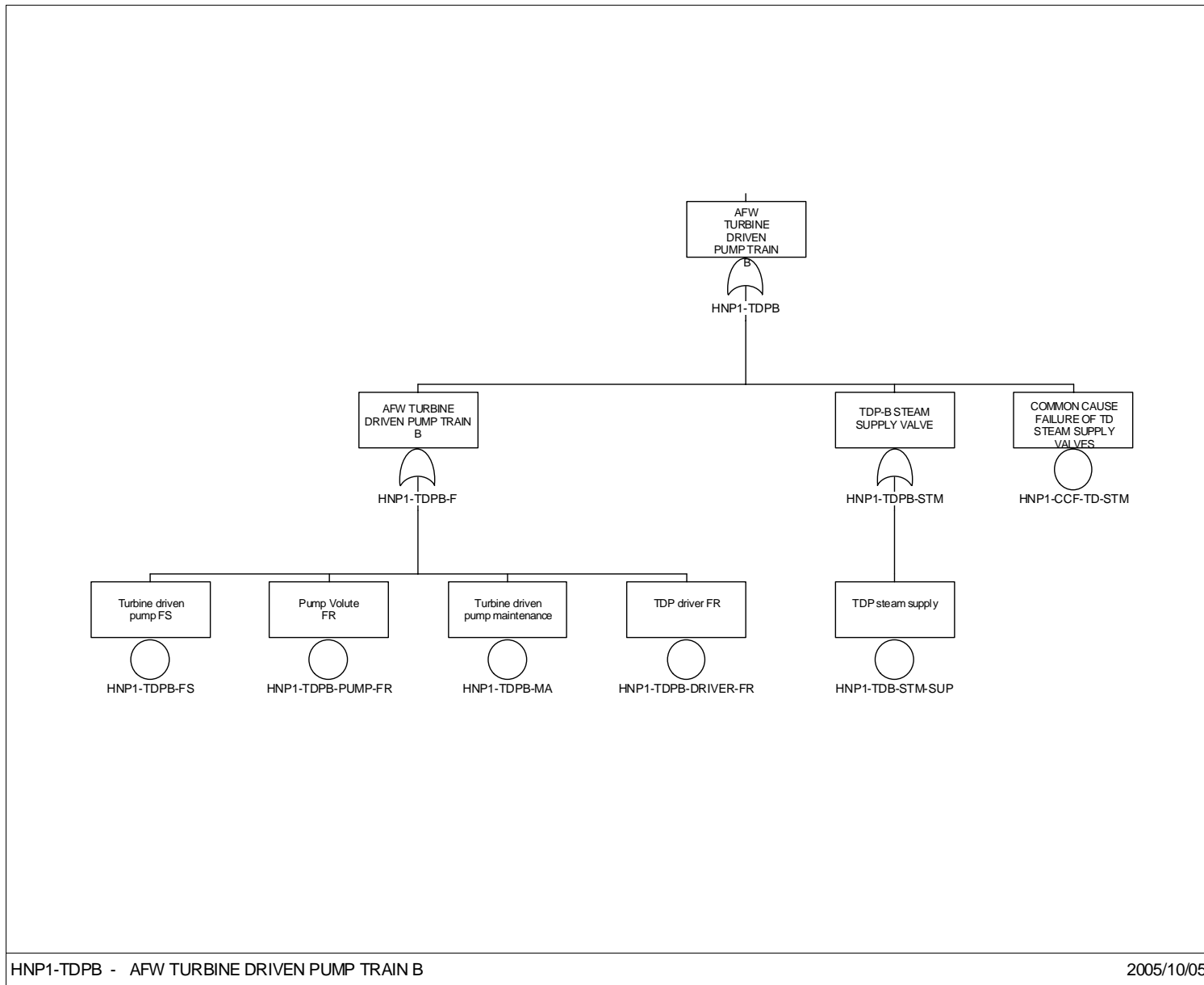


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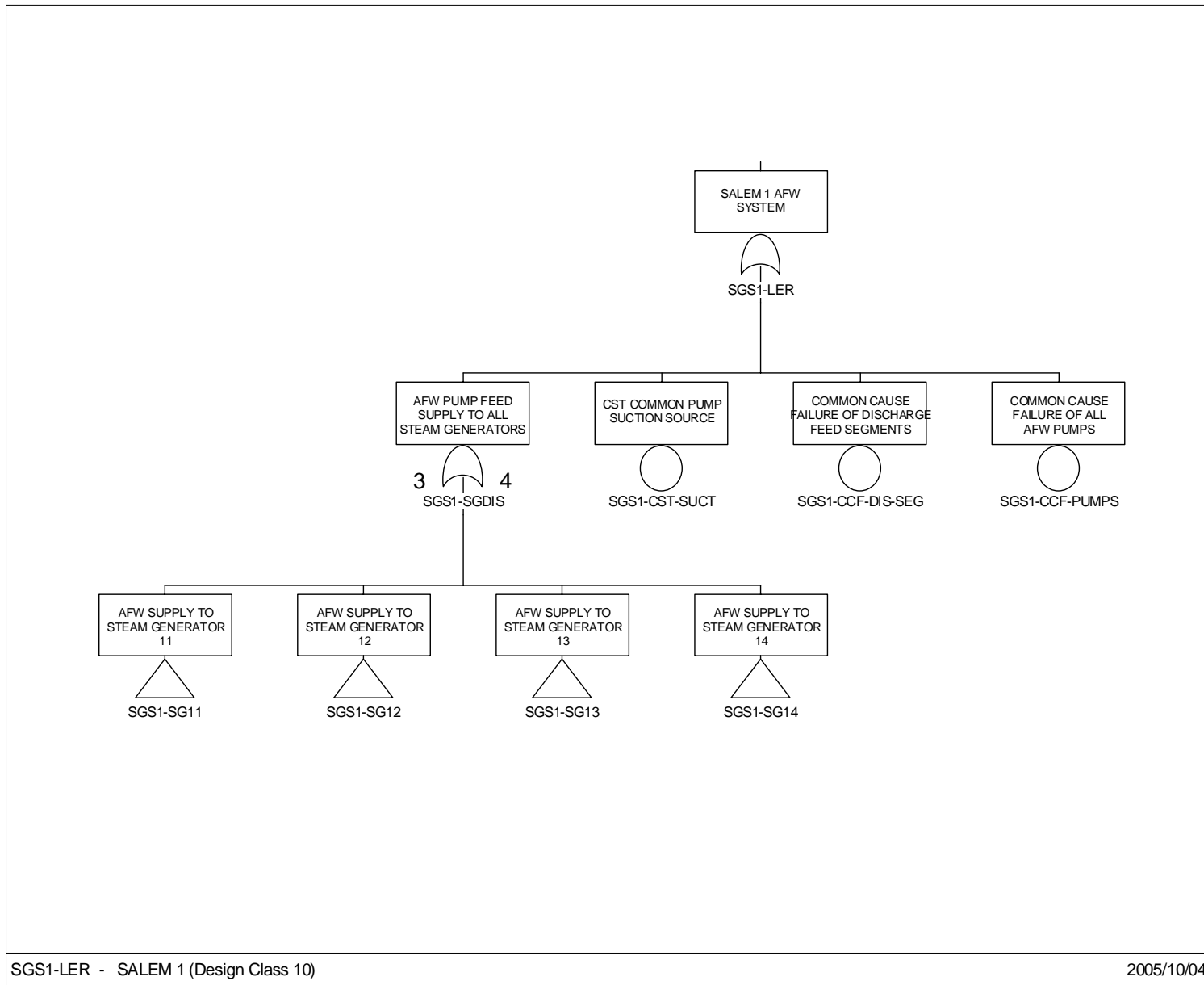


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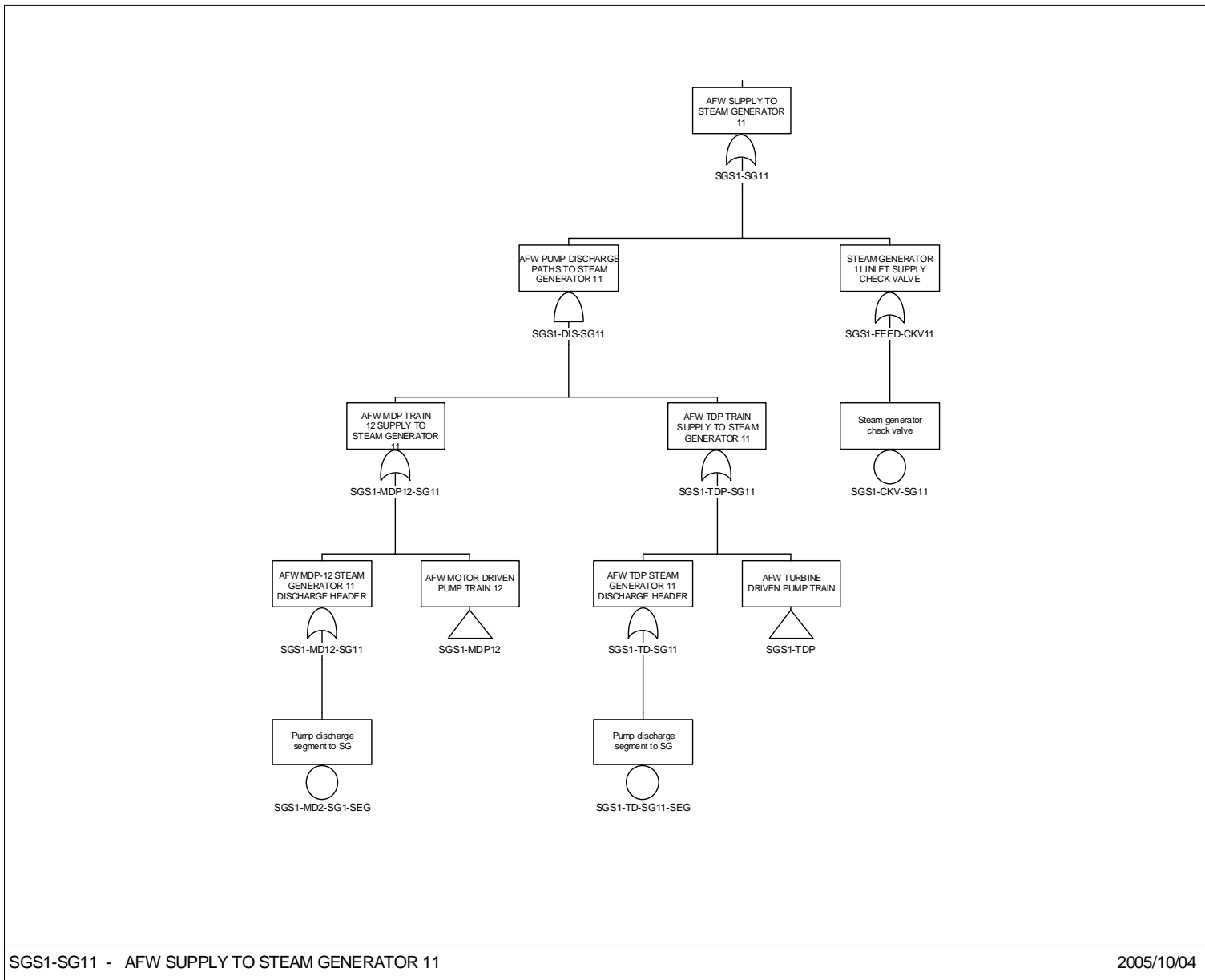


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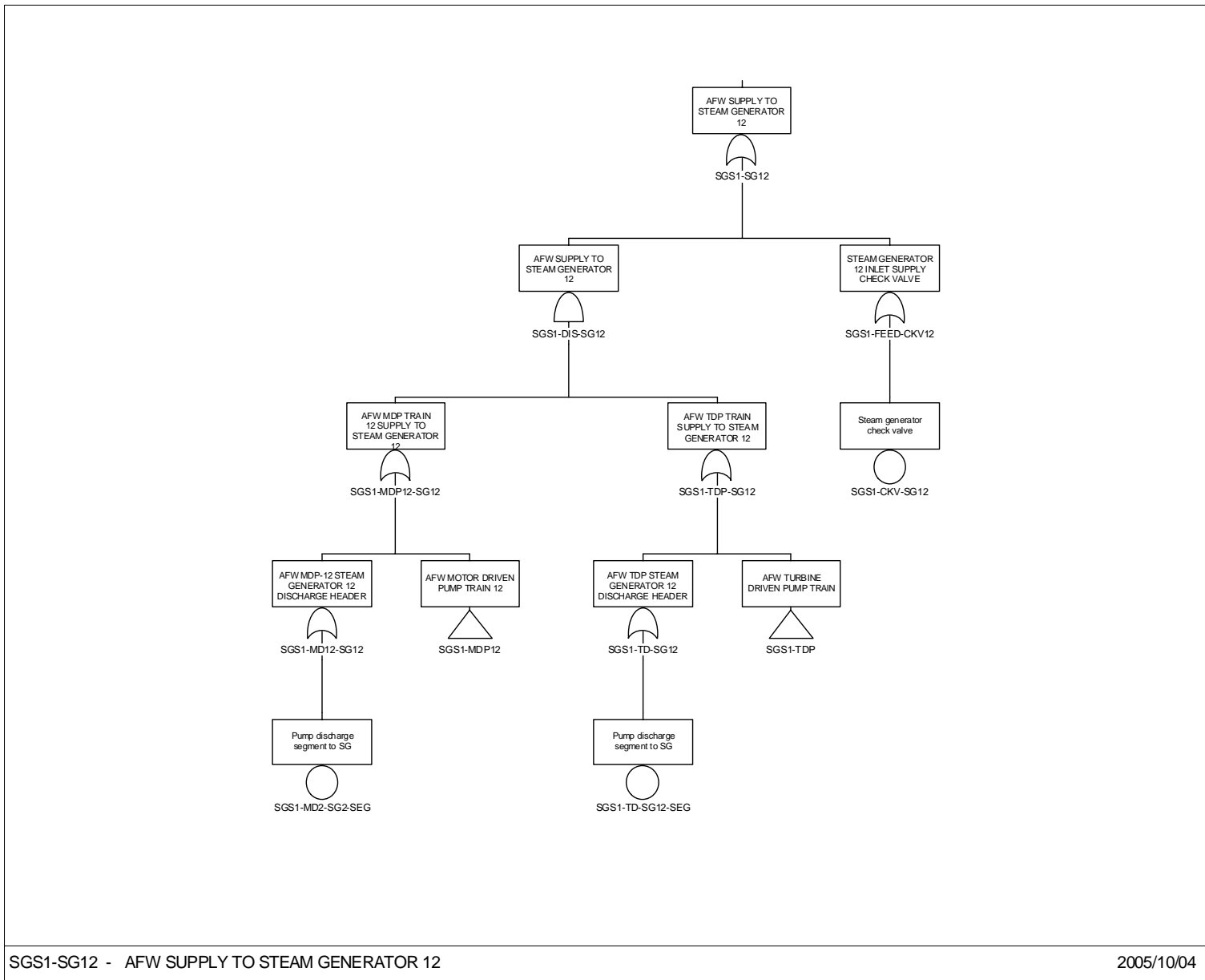


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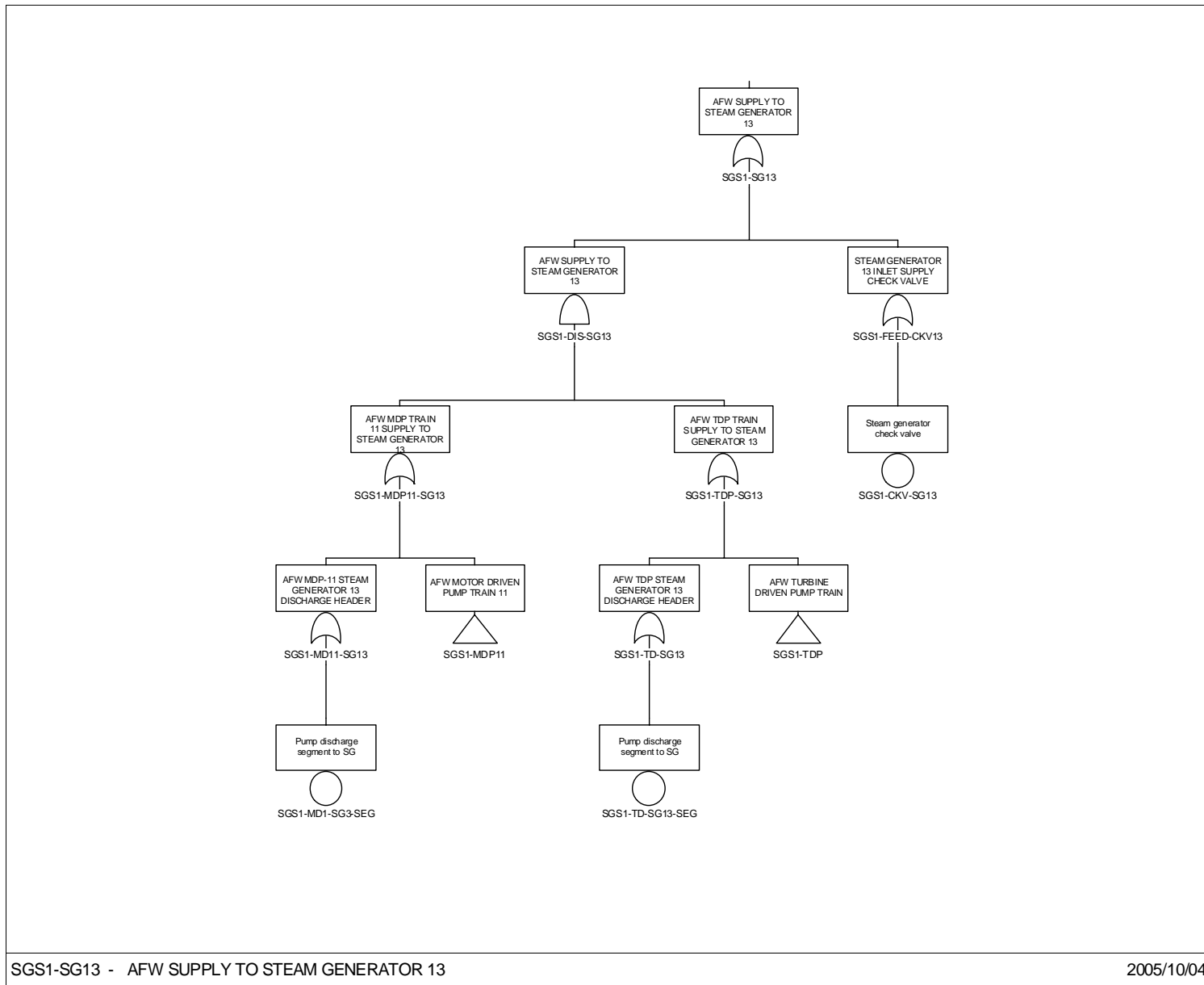


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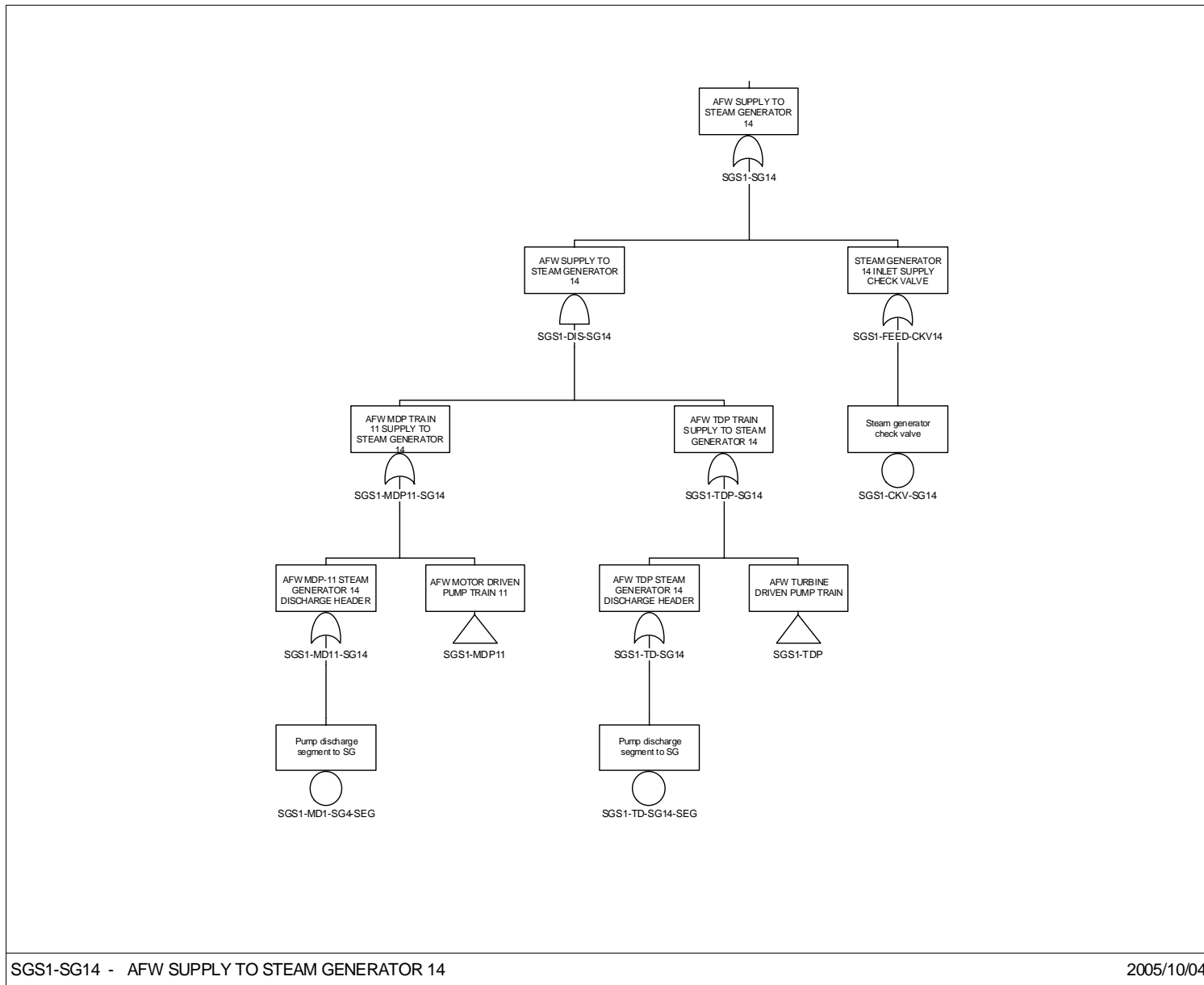


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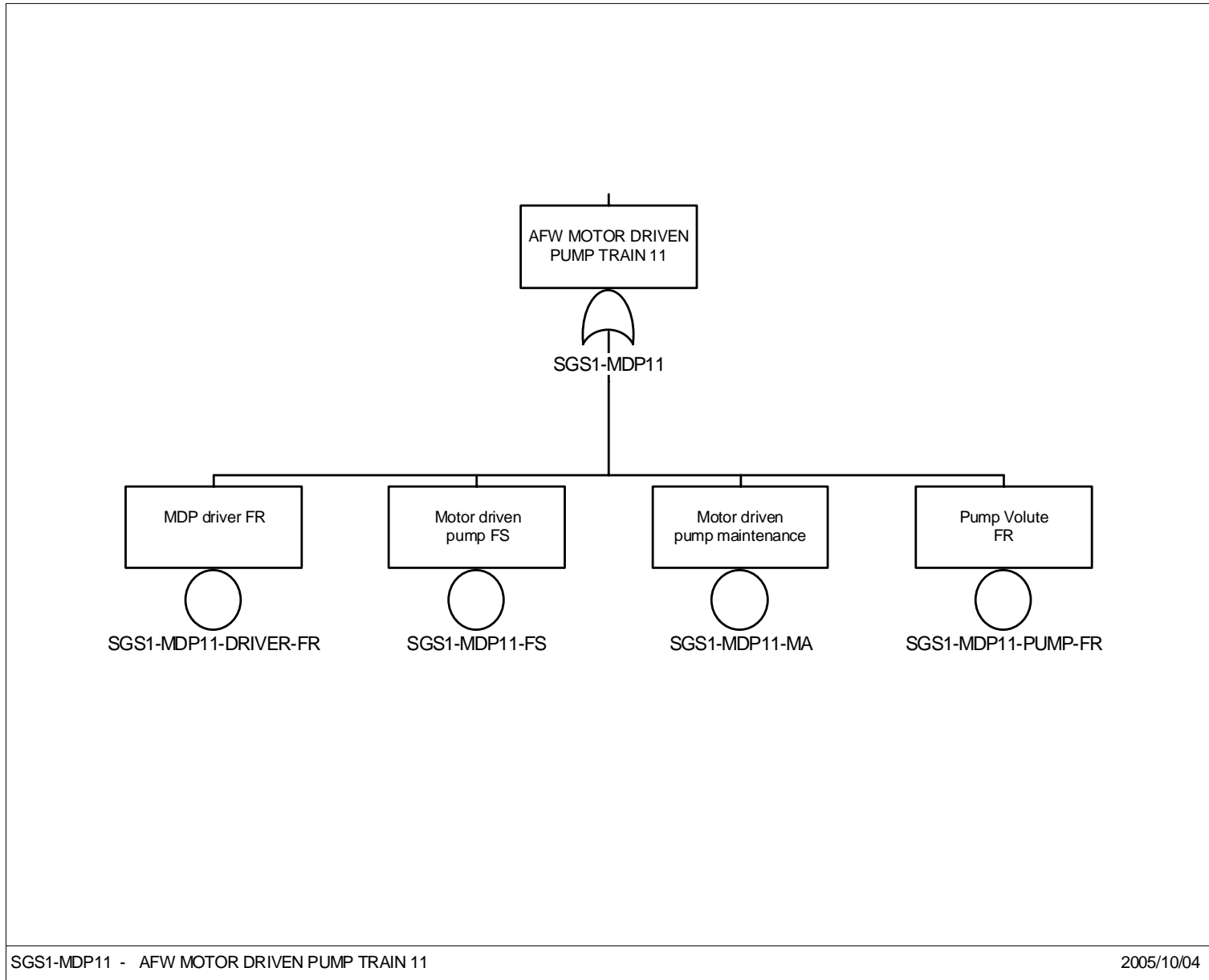


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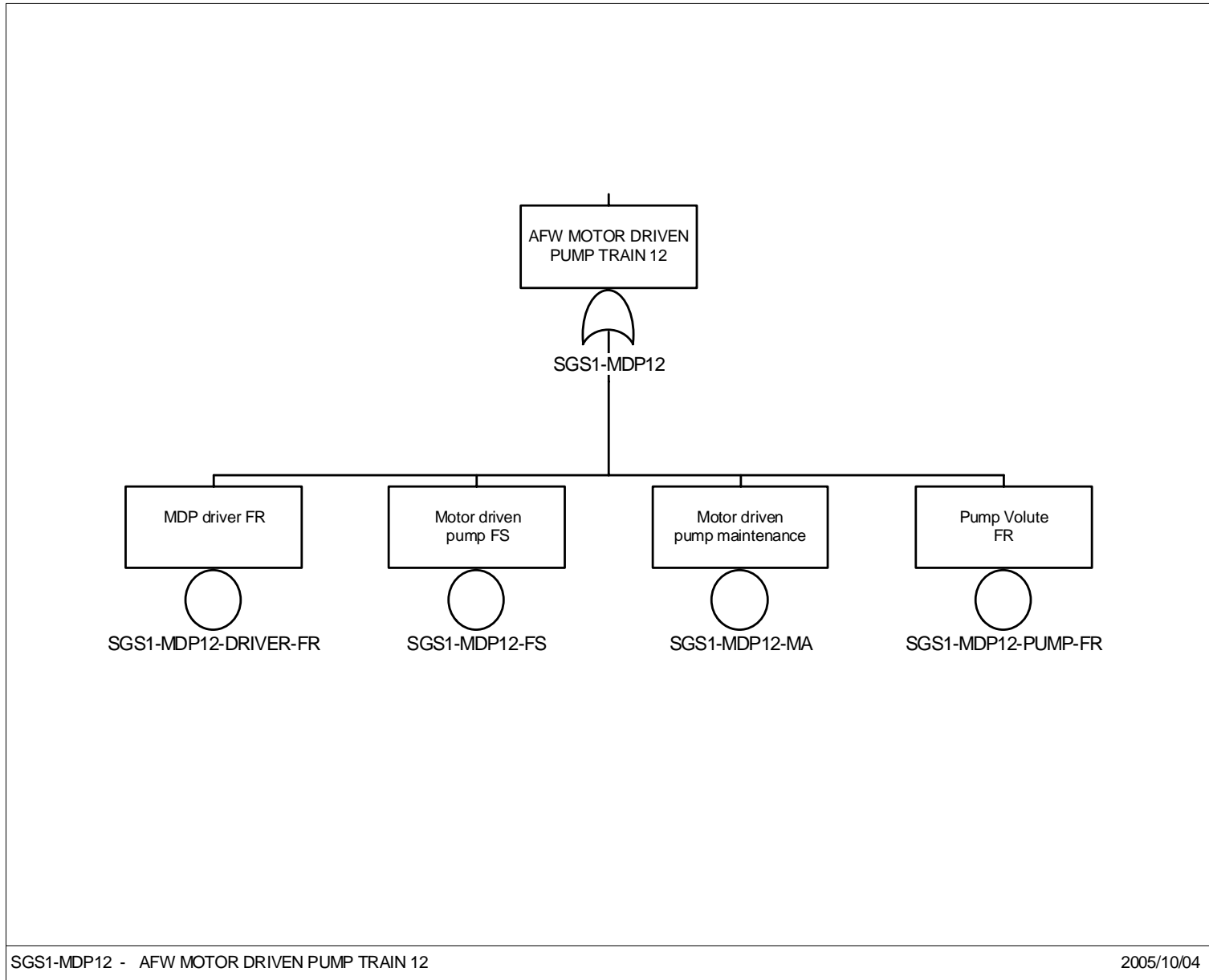


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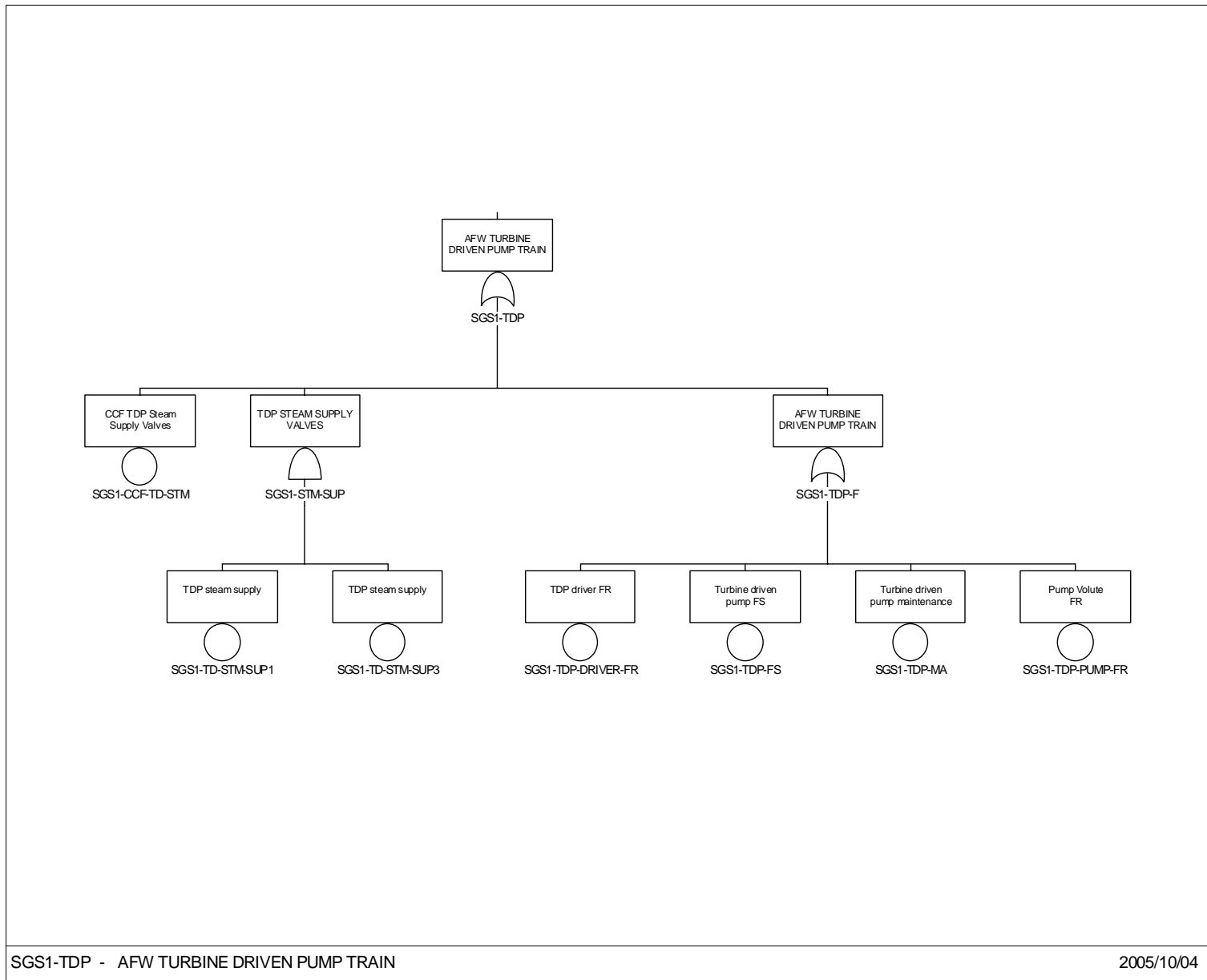


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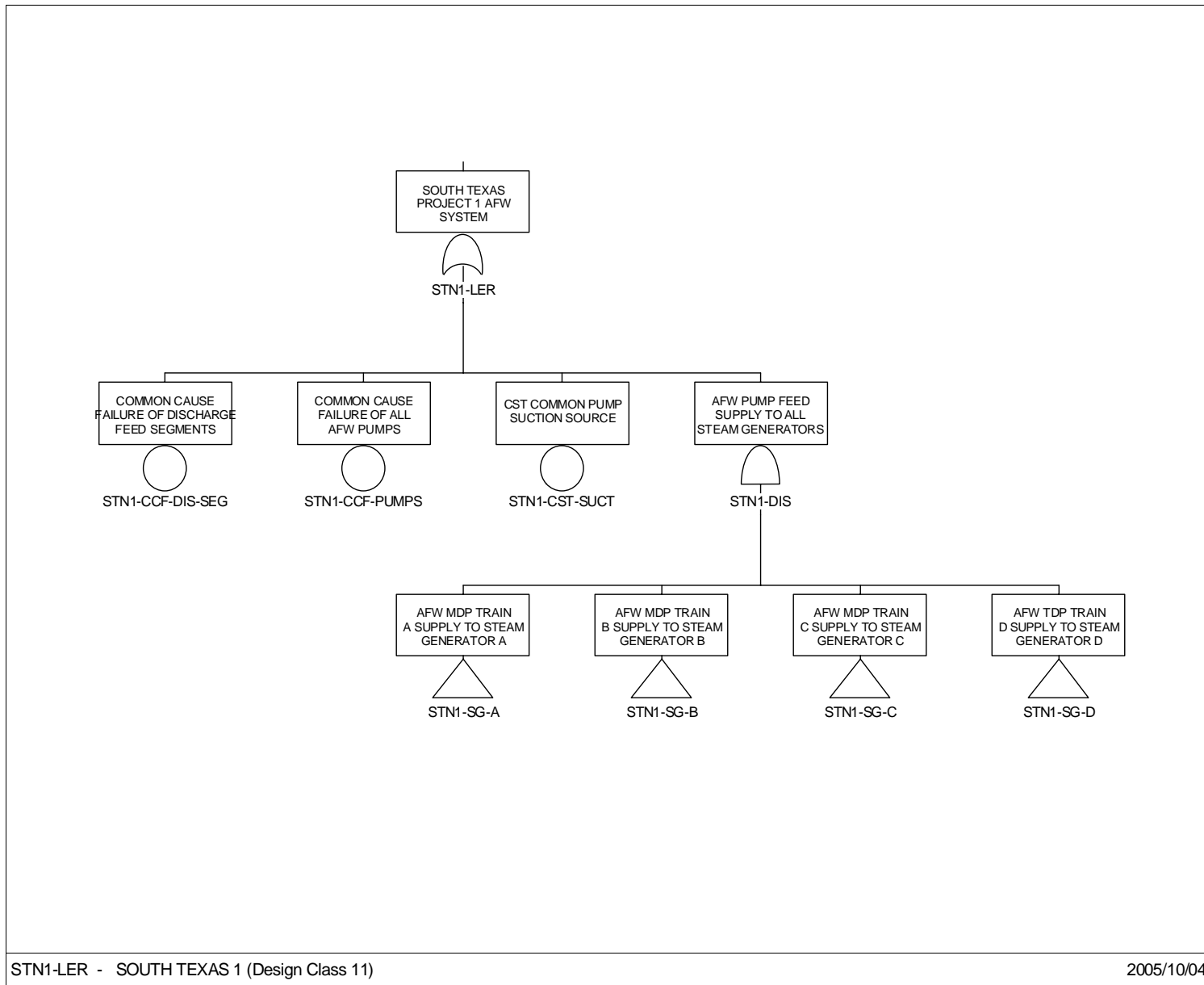


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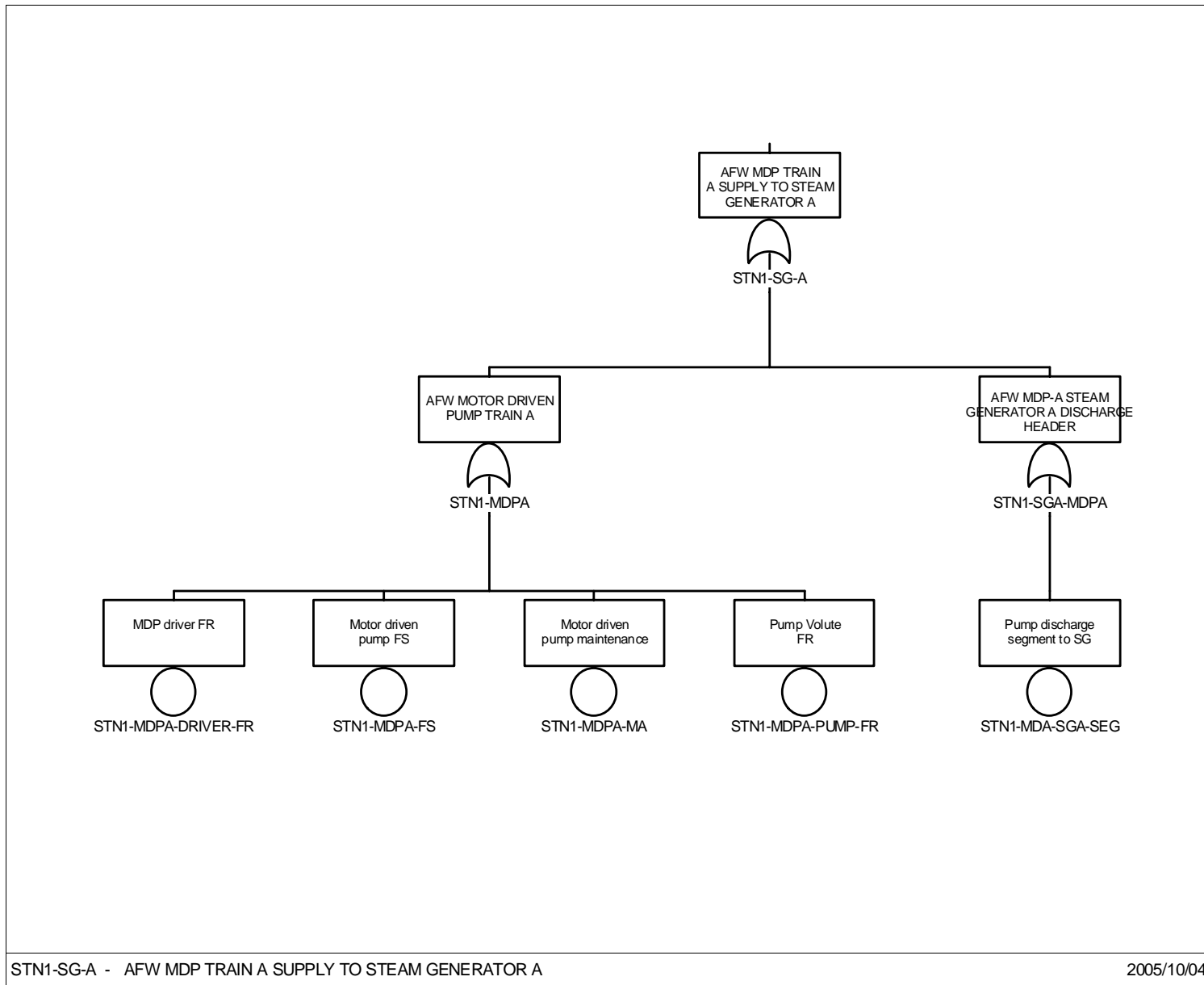


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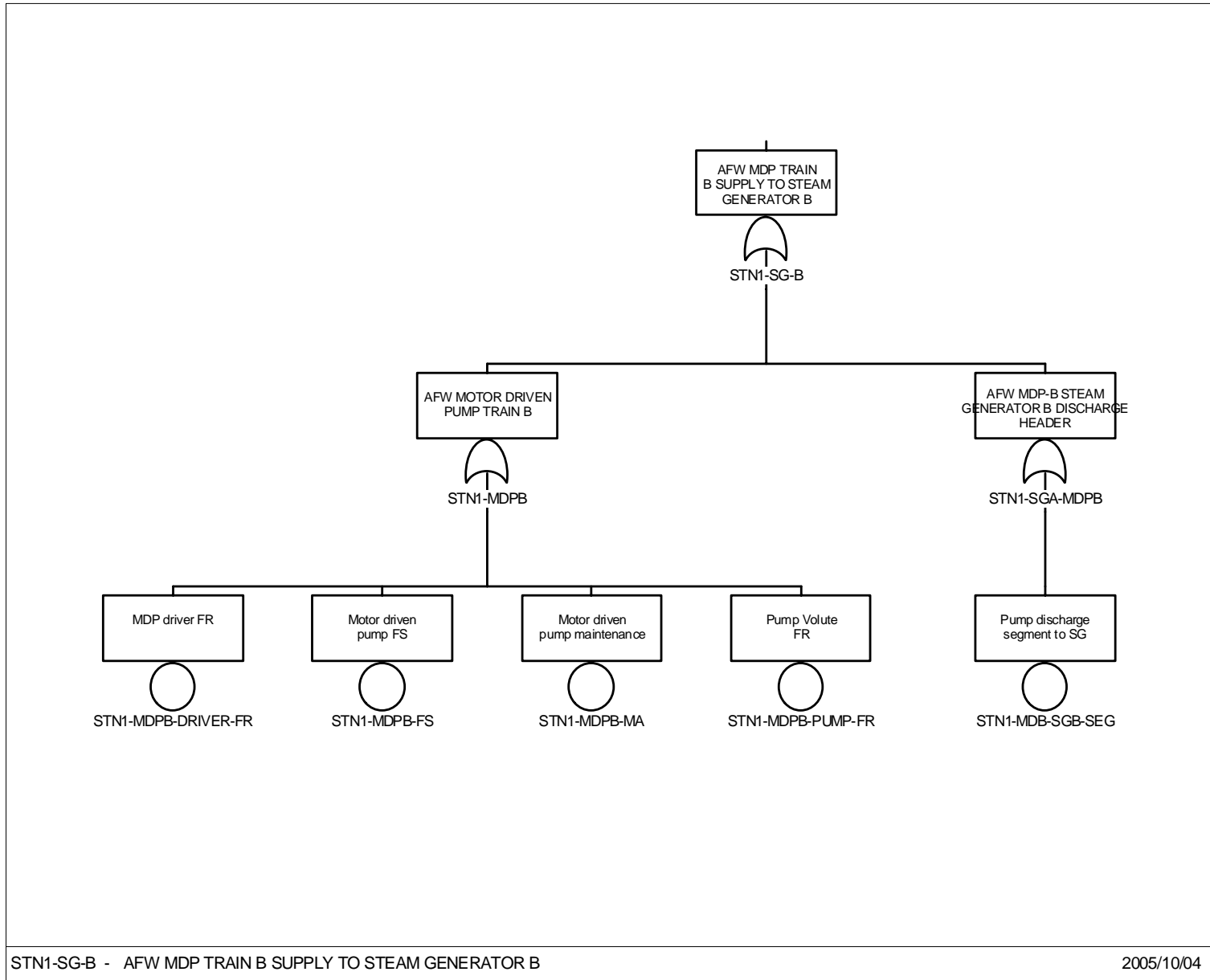


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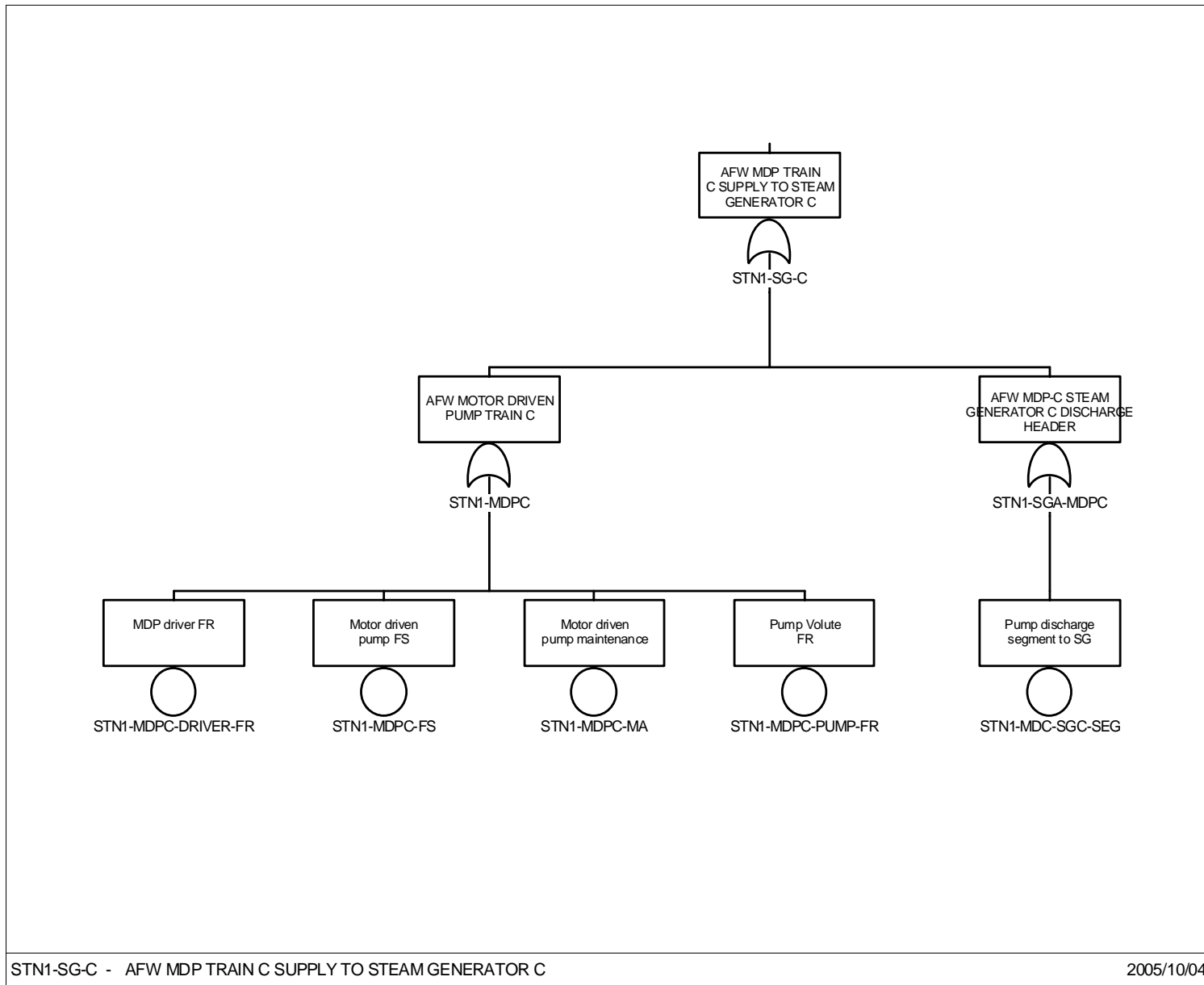


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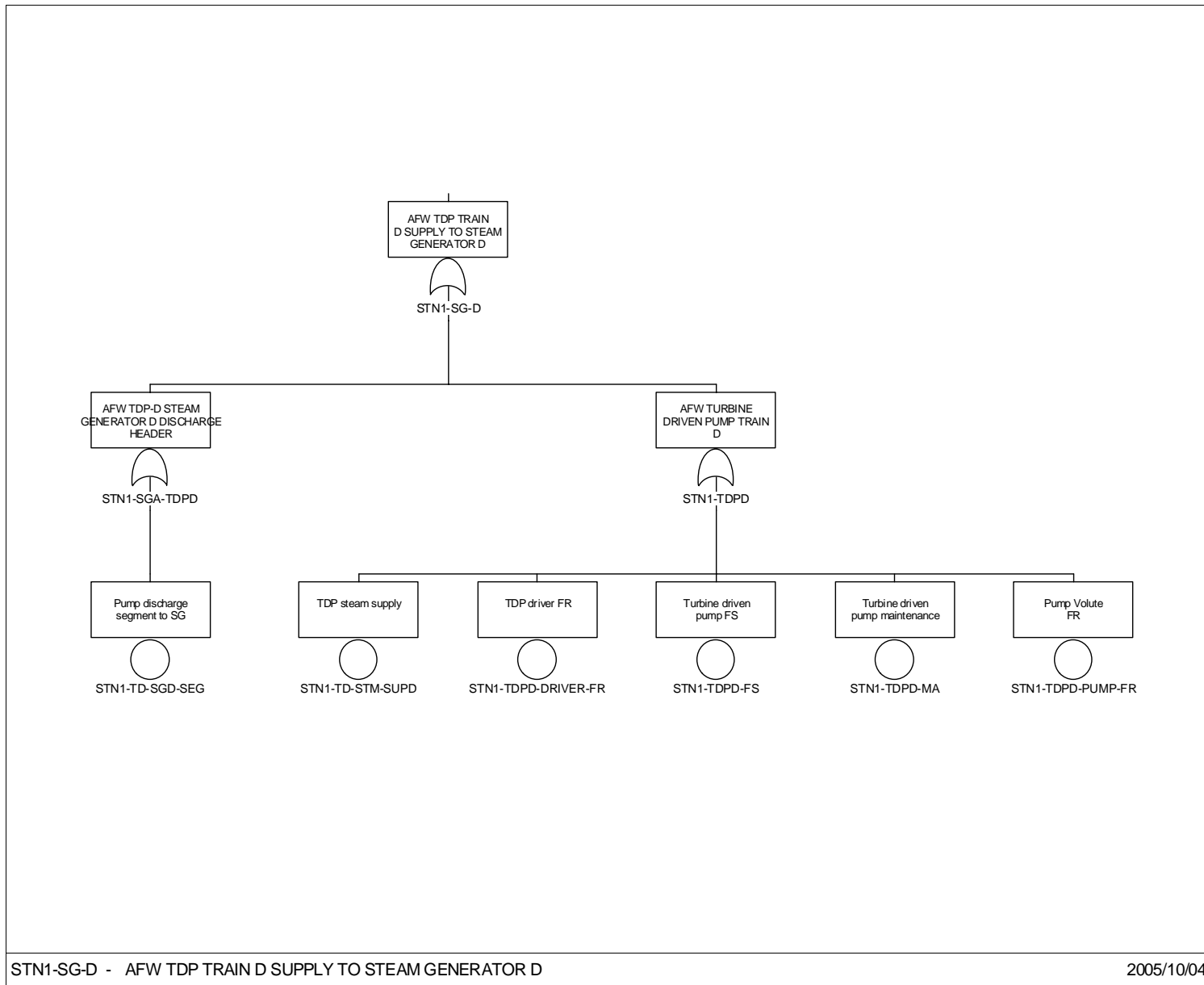


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