**D.1 Marine Transport**

Figure D.1 presents the fault tree for the events at the dock (unloading and loading) and Table D.1 presents the failure data used to calculate the top event frequencies

The updated frequency and probability calculations are shown below:

| During operation, | parameter |
|---|---|
| Number of 1-tonne drums consumed per year = 148 | 148 |
| Number of 50-kg cylinders consumed per year = 0 | 0 |
| Number of barge deliveries per year = 12 | 12 |
| Average number of drums per delivery = 13 (approximately) | 13 |
| Average number of cylinders per delivery = 0 | 0 |

*Fault Tree Event B8 – Probability Of Drum Or Cylinder Passing Over 1 km Length of the Route for a Single Trip per Year with an Average Load*

| | |
|---|---|
| Average number of drums on the vessel = 13 | 13 |
| Average number of cylinders on the vessel = 0 | 0 |
| Speed of vessel = 20 km/hr | 20 |
| Length of marine transport route being considered = 1 km | 1 |

Presence probability of drums / cylinders passing over a specified route length = [(average number of drums or cylinders on a vessel) x (length of route)] / [(speed of vessel) x (8760)]

| | |
|---|---|
| Presence probability of drums passing over a 1 km route = 7.42E-05 | 7.42E-05 |
| Presence probability of cylinders passing over a 1 km route = 0.00E+00 | 0.00E+00 |

**Table D.1 Source Data Used in Marine Transport Fault Tree**

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| BI 3-1 | Chlorine release from drums or cylinders while | SVC&DS | 8.10E-06 | per year | The frequency used has not been split between the sub causes of: |
| (freq) | being transported on the chlorine boat due to | SVC&DF | 8.10E-06 | | Material defect. |
| | spontaneous causes which are independent of | SLC | 7.30E-05 | | Overpressure |
| | being transported. | SLDS | 1.50E-05 | | Valve or plug fault |
| | | SLDF | 5.80E-05 | | Human error failure |
| | | MVC | 6.30E-06 | | Corrosion |
| | | MVD | 5.30E-06 | | |
| | | MLC | 5.70E-05 | | The values are developed from the following: |
| | | MLD | 4.80E-05 | | The assumption, based on judgement with the operators is that |
| | | LVD | 9.80E-07 | | small vapour leaks can be successfully stopped on 50% of occasions |
| | | LLD | 8.80E-06 | | and small liquid leaks can be successfully stopped on 20% of |
| | | RC | 6.80E-06 | | occasions. |
| | | RD | 6.80E-06 | | |
| | | RCM1 | 0 | | The assumption, based on the drums and cylinders being full, that |
| | | RDM1 | 0 | | 90% of leaks are liquid and 10% are vapour. |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | Spontaneous failures are so unlikely to result in multiple failures that |
| | | Empty | 0 | | these outcomes can be given a failure frequency of zero. |
| BI 3-2 | Chlorine release from drums or cylinders while | SVC&DS | 5.10E-05 | per year | The frequency used has not been split between the sub causes of: |
| (freq) | being transported on the chlorine boat due to | SVC&DF | 5.10E-05 | | Jolting |
| | spontaneous causes which are dependent of | SLC | 4.60E-04 | | Other |
| | being transported. | SLDS | 9.20E-05 | | |
| | | SLDF | 3.70E-04 | | The values are developed from the following: |
| | | MVC | 3.90E-05 | | The same assumptions for success in isolating leaks, vapour/liquid |
| | | MVD | 3.30E-05 | | release ratio and multiple failure as given above for fault tree event |
| | | MLC | 3.50E-04 | | B3-1 can be used. |
| | | MLD | 3.00E-04 | | |
| | | LVD | 6.20E-06 | | Spontaneous failures are so unlikely to result in multiple failures that |
| | | LLD | 5.60E-05 | | these outcomes can be given a failure frequency of zero. |
| | | RC | 4.30E-05 | | |
| | | RD | 4.30E-05 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |
| B8 | Drums or cylinders being transported over a 1 km | SVC&DS | 7.42E-05 | | The calculation of this probability is presented in this section. It is |
| (prob) | length of the route for a single trip each year. | SVC&DF | 7.42E-05 | | calculated for the cylinder and drum incidents separately, as it is |
| | | SLC | 0.00E+00 | | dependent on the number of drums and cylinders on the chlorine |
| | | SLDS | 7.42E-05 | | boat. |
| | | SLDF | 7.42E-05 | | |
| | | MVC | 0.00E+00 | | |
| | | MVD | 7.42E-05 | | |
| | | MLC | 0.00E+00 | | |
| | | MLD | 7.42E-05 | | |
| | | LVD | 7.42E-05 | | |
| | | LLD | 7.42E-05 | | |
| | | RC | 0.00E+00 | | |
| | | RD | 7.42E-05 | | |
| | | RCM1 | 0.00E+00 | | |
| | | RDM1 | 7.42E-05 | | |
| | | RCM2 | 0.00E+00 | | |
| | | RDM2 | 7.42E-05 | | |
| | | Empty | 7.42E-05 | | |
| B9 | Collision while chlorine boat is travelling over | SVC&DS | 9.74E-06 | per | The following reduction factors are extracted from DNV CE63/94 (M1 |
| (freq) | a 1 km length of the route | SVC&DF | 9.74E-06 | km year | a, d) |
| | | SLC | 9.74E-06 | | i. 20% reduction due to installation of radar on the |
| | | SLDS | 9.74E-06 | | chlorine boat |
| | | SLDF | 9.74E-06 | | ii. 5% reduction due to the use of multi-engine vessel |
| | | MVC | 9.74E-06 | | |
| | | MVD | 9.74E-06 | | Comparing marine traffic accident statistics involving river trade cargo |
| | | MLC | 9.74E-06 | | vessels in years 2012 and 1993, there is an increase in 2.5% of accident |
| | | MLD | 9.74E-06 | | rate. To adopt a conservative approach, a safety factor 1.025 is applied. |
| | | LVD | 9.74E-06 | | |
| | | LLD | 9.74E-06 | | * Modified value is showed * |
| | | RC | 9.74E-06 | | |
| | | RD | 9.74E-06 | | |
| | | RCM1 | 9.74E-06 | | |
| | | RDM1 | 9.74E-06 | | |
| | | RCM2 | 9.74E-06 | | |
| | | RDM2 | 9.74E-06 | | |
| | | Empty | 9.74E-06 | | |
| B10 | Release occurs due to impact of the drums or | SVC&DS | 0 | | The following reduction factors are extracted from DNV CE63/94 (M2 |
| (prob) | cylinders in the collision | SVC&DF | 0 | | a, b, c) |
| | | SLC | 0 | | |
| | | SLDS | 9.55E-04 | | 80% reduction due to the provision of additional means (hooks and |
| | | SLDF | 3.82E-03 | | wires) of securing the drums, bigger vessel and rubber tires are |
| | | MVC | 0 | | placed/hanged around the vessel body on the vessel nose, tail and |
| | | MVD | 0 | | sideways. |
| | | MLC | 0 | | |
| | | MLD | 3.02E-03 | | * Modified value is showed * |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 2.04E-04 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |
| B11 | Collision results in a fire (and there has | SVC&DS | 0.05 | | |
| (prob) | not been a chlorine release due to the initial | SVC&DF | 0.05 | | |

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | impact which is modelled) | SLC | 0.05 | | |
| | | SLDS | 0.05 | | |
| | | SLDF | 0.05 | | |
| | | MVC | 0.05 | | |
| | | MVD | 0.05 | | |
| | | MLC | 0.05 | | |
| | | MLD | 0.05 | | |
| | | LVD | 0.05 | | |
| | | LLD | 0.05 | | |
| | | RC | 0.05 | | |
| | | RD | 0.05 | | |
| | | RCM1 | 0.05 | | |
| | | RDM1 | 0.05 | | |
| | | RCM2 | 0.05 | | |
| | | RDM2 | 0.05 | | |
| | | Empty | 0.05 | | |
| B12 | Fire is not extinguished before drums or | SVC&DS | 1 | | |
| (prob) | cylinders fail | SVC&DF | 1 | | |
| | | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | Empty | 1 | | |
| B13 | Fire impinges on drums or cylinders such that | SVC&DS | 0 | | |
| (prob) | failure will occur if fire is not extinguished | SVC&DF | 0 | | |
| | quickly | SLC | 0 | | |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0.05 | | |
| | | Empty | 0 | | |
| B14 | Drums or cylinders fall into sea due to a | SVC&DS | 0.2 | | Assumed to be as likely as drums or cylinders being damaged (see |
| (prob) | collision (given no other chlorine releases, | SVC&DF | 0.2 | | fault tree event B10). |
| | e.g. due to impact effects). | SLC | 0.2 | | |
| | | SLDS | 0.2 | | |
| | | SLDF | 0.2 | | |
| | | MVC | 0.2 | | |
| | | MVD | 0.2 | | |
| | | MLC | 0.2 | | |
| | | MLD | 0.2 | | |
| | | LVD | 0.2 | | |
| | | LLD | 0.2 | | |
| | | RC | 0.2 | | |
| | | RD | 0.2 | | |
| | | RCM1 | 0.2 | | |
| | | RDM1 | 0.2 | | |
| | | RCM2 | 0.2 | | |
| | | RDM2 | 0.2 | | |
| | | Empty | 0.2 | | |
| B15 | Drums or cylinders which are spilt into the sea | SVC&DS | 0.25 | | |
| (prob) | due to a collision are not recovered | SVC&DF | 0.25 | | |
| | | SLC | 0.25 | | |
| | | SLDS | 0.25 | | |
| | | SLDF | 0.25 | | |
| | | MVC | 0.25 | | |
| | | MVD | 0.25 | | |
| | | MLC | 0.25 | | |
| | | MLD | 0.25 | | |
| | | LVD | 0.25 | | |
| | | LLD | 0.25 | | |
| | | RC | 0.25 | | |
| | | RD | 0.25 | | |
| | | RCM1 | 0.25 | | |
| | | RDM1 | 0.25 | | |
| | | RCM2 | 0.25 | | |
| | | RDM2 | 0.25 | | |
| | | Empty | 0.25 | | |
| B16 | Drums are left in sea (not recovered) and fail | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a |
| (prob) | due to corrosion. | SVC&DF | 0 | | drum. Hence all the probability associated with this event is |
| | | SLC | 0 | | associated with incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |

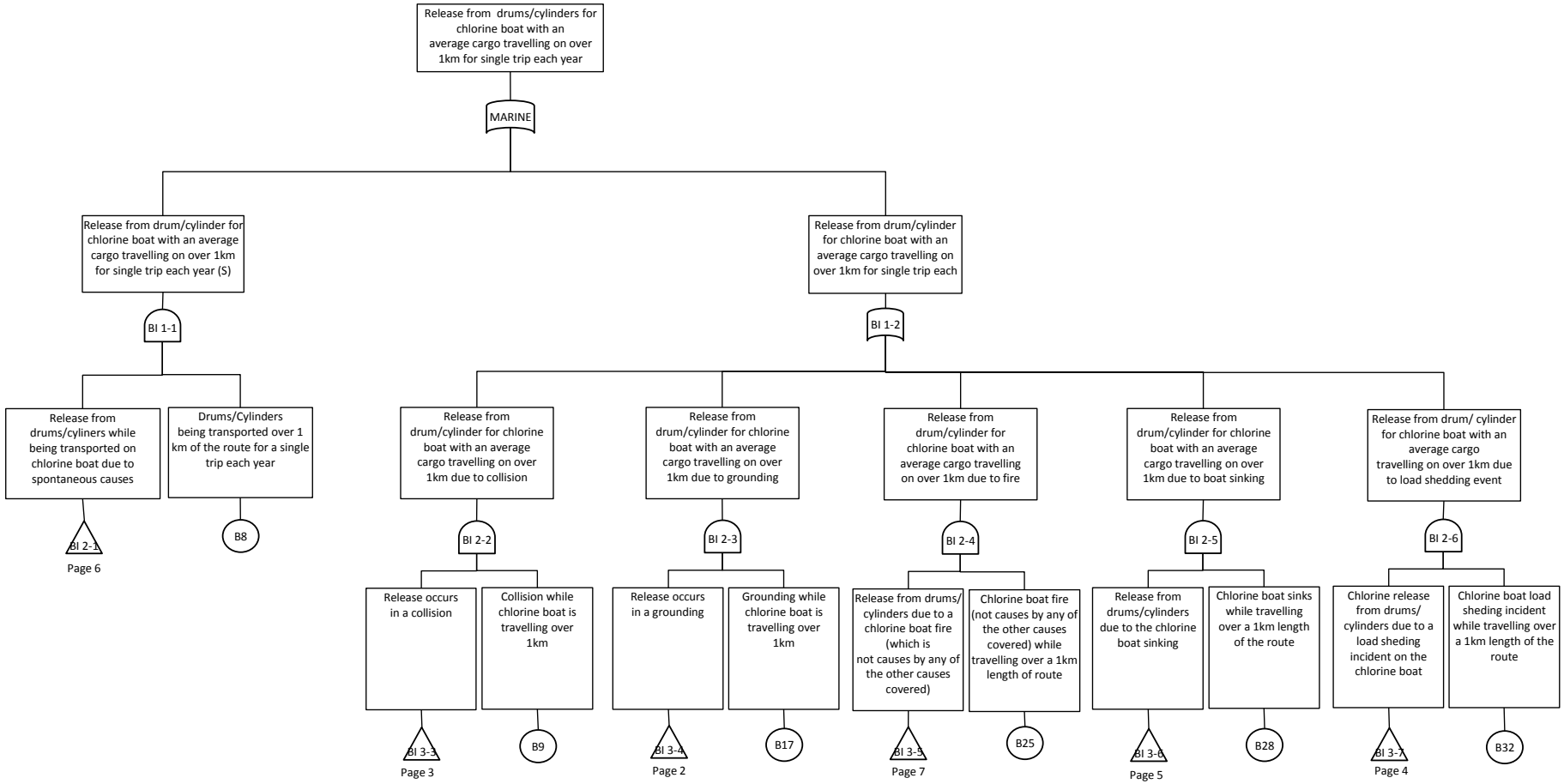
| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |
| B17 | Grounding while chlorine boat is travelling over | SVC&DS | 5.81E-07 | per | The following reduction factors are extracted from DNV CE63/94 (M1 |
| (freq) | a 1 km length of the route | SVC&DF | 5.81E-07 | km year | a, d) |
| | | SLC | 5.81E-07 | | i. 20% reduction due to installation of radar on the |
| | | SLDS | 5.81E-07 | | chlorine boat |
| | | SLDF | 5.81E-07 | | ii. 20% reduction due to the use of multi-engine vessel |
| | | MVC | 5.81E-07 | | |
| | | MVD | 5.81E-07 | | Comparing marine traffic accident statistics involving river trade cargo |
| | | MLC | 5.81E-07 | | vessels in years 2012 and 1993, there is an increase in 2.5% of accident |
| | | MLD | 5.81E-07 | | rate. To adopt a conservative approach, a safety factor 1.025 is applied. |
| | | LVD | 5.81E-07 | | |
| | | LLD | 5.81E-07 | | * Modified value is showed * |
| | | RC | 5.81E-07 | | |
| | | RD | 5.81E-07 | | |
| | | RCM1 | 5.81E-07 | | |
| | | RDM1 | 5.81E-07 | | |
| | | RCM2 | 5.81E-07 | | |
| | | RDM2 | 5.81E-07 | | |
| | | Empty | 5.81E-07 | | |
| B18 | Release occurs due to impact of the drums or | SVC&DS | 0 | | Assumed to be the same as for a collision (see fault tree event B10). |
| (prob) | cylinders during grounding | SVC&DF | 0 | | The following reduction factors are extracted from DNV CE63/94 (M2 |
| | | SLC | 0 | | a, b, c) |
| | | SLDS | 0.000955 | | 80% reduction due to the provision of additional means (hooks and |
| | | SLDF | 0.00382 | | wires) of securing the drums, bigger vessel and rubber tires are |
| | | MVC | 0 | | placed/hanged around the vessel body on the vessel nose, tail and |
| | | MVD | 0 | | sideways. |
| | | MLC | 0 | | |
| | | MLD | 0.00302 | | * Modified value is showed * |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0.0002044 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |
| B19 | Grounding results in a fire (and there has | SVC&DS | 0.05 | | Assumed to be the same as for a collision (see fault tree event B11). |
| (prob) | not been a chlorine release due to the initial | SVC&DF | 0.05 | | |
| | impact which is modelled) | SLC | 0.05 | | |
| | | SLDS | 0.05 | | |
| | | SLDF | 0.05 | | |
| | | MVC | 0.05 | | |
| | | MVD | 0.05 | | |
| | | MLC | 0.05 | | |
| | | MLD | 0.05 | | |
| | | LVD | 0.05 | | |
| | | LLD | 0.05 | | |
| | | RC | 0.05 | | |
| | | RD | 0.05 | | |
| | | RCM1 | 0.05 | | |
| | | RDM1 | 0.05 | | |
| | | RCM2 | 0.05 | | |
| | | RDM2 | 0.05 | | |
| | | Empty | 0.05 | | |
| B20 | Fire is not extinguished before drums or | SVC&DS | 1 | | |
| (prob) | cylinders fail | SVC&DF | 1 | | |
| | | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | Empty | 1 | | |
| B21 | Fire impinges on drums or cylinders such that | SVC&DS | 0 | | |
| (prob) | failure will occur if fire is not extinguished | SVC&DF | 0 | | |
| | quickly | SLC | 0 | | |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0.05 | | |
| | | Empty | 0 | | |
| B22 | Drums or cylinders fall into sea due to a | SVC&DS | 0.2 | | Assumed to be as likely as drums or cylinders being damaged (see |
| (prob) | grounding (given no other chlorine releases, | SVC&DF | 0.2 | | fault tree event B18). |
| | e.g. due to impact effects) | SLC | 0.2 | | |
| | | SLDS | 0.2 | | |
| | | SLDF | 0.2 | | |
| | | MVC | 0.2 | | |
| | | MVD | 0.2 | | |
| | | MLC | 0.2 | | |
| | | MLD | 0.2 | | |
| | | LVD | 0.2 | | |
| | | LLD | 0.2 | | |
| | | RC | 0.2 | | |
| | | RD | 0.2 | | |
| | | RCM1 | 0.2 | | |
| | | RDM1 | 0.2 | | |
| | | RCM2 | 0.2 | | |
| | | RDM2 | 0.2 | | |
| | | Empty | 0.2 | | |
| B23 | Drums or cylinders which are spilt into | SVC&DS | 0.25 | | |
| (prob) | the sea due to a grounding are not recovered. | SVC&DF | 0.25 | | |
| | | SLC | 0.25 | | |
| | | SLDS | 0.25 | | |
| | | SLDF | 0.25 | | |
| | | MVC | 0.25 | | |
| | | MVD | 0.25 | | |
| | | MLC | 0.25 | | |
| | | MLD | 0.25 | | |
| | | LVD | 0.25 | | |
| | | LLD | 0.25 | | |
| | | RC | 0.25 | | |
| | | RD | 0.25 | | |
| | | RCM1 | 0.25 | | |
| | | RDM1 | 0.25 | | |
| | | RCM2 | 0.25 | | |
| | | RDM2 | 0.25 | | |
| | | Empty | 0.25 | | |
| B24 | Drums are left in sea (not recovered) and | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a |
| (prob) | fail due to corrosion. | SVC&DF | 0 | | drum. Hence all the probability associated with this event is |
| | | SLC | 0 | | associated with incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |
| B25 | Chlorine boat fire (which is not causes by | SVC&DS | 9.50E-07 | | |
| (freq) | any of the other causes covered, e.g. collision) | SVC&DF | 9.50E-07 | | |
| | while travelling over a 1 km length of the route | SLC | 9.50E-07 | | |
| | | SLDS | 9.50E-07 | | |
| | | SLDF | 9.50E-07 | | |
| | | MVC | 9.50E-07 | | |
| | | MVD | 9.50E-07 | | |
| | | MLC | 9.50E-07 | | |
| | | MLD | 9.50E-07 | | |
| | | LVD | 9.50E-07 | | |
| | | LLD | 9.50E-07 | | |
| | | RC | 9.50E-07 | | |
| | | RD | 9.50E-07 | | |
| | | RCM1 | 9.50E-07 | | |
| | | RDM1 | 9.50E-07 | | |
| | | RCM2 | 9.50E-07 | | |
| | | RDM2 | 9.50E-07 | | |
| | | Empty | 9.50E-07 | | |
| B26 | Fire is not extinguished before drums or | SVC&DS | 1 | | |
| (prob) | cylinders fail. | SVC&DF | 1 | | |
| | | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | Empty | 1 | | |
| B27 | Fire impinges on drums or cylinders such that | SVC&DS | 0 | | |
| (prob) | failure will occur if the fire is not quickly | SVC&DF | 0 | | |
| | extinguished | SLC | 0 | | |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0.05 | | |
| | | Empty | 0 | | |
| B28 | Chlorine boat sinks while travelling over a 1 km | SVC&DS | 8.50E-07 | per | |
| (prob) | length of the route | SVC&DF | 8.50E-07 | km year | |
| | | SLC | 8.50E-07 | | |
| | | SLDS | 8.50E-07 | | |
| | | SLDF | 8.50E-07 | | |
| | | MVC | 8.50E-07 | | |
| | | MVD | 8.50E-07 | | |
| | | MLC | 8.50E-07 | | |
| | | MLD | 8.50E-07 | | |
| | | LVD | 8.50E-07 | | |
| | | LLD | 8.50E-07 | | |
| | | RC | 8.50E-07 | | |
| | | RD | 8.50E-07 | | |
| | | RCM1 | 8.50E-07 | | |
| | | RDM1 | 8.50E-07 | | |
| | | RCM2 | 8.50E-07 | | |
| | | RDM2 | 8.50E-07 | | |
| | | Empty | 8.50E-07 | | |
| B29 | Drums or cylinders in sea given chlorine | SVC&DS | 1 | | |
| (prob) | boat sinks (given no other chlorine releases, | SVC&DF | 1 | | |
| | e.g. due to impact effects) | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | Empty | 1 | | |
| B30 | Drums or cylinders which are in the sea due | SVC&DS | 0.25 | | |
| (prob) | to the chlorine boat sinking are not recovered | SVC&DF | 0.25 | | |
| | | SLC | 0.25 | | |
| | | SLDS | 0.25 | | |
| | | SLDF | 0.25 | | |
| | | MVC | 0.25 | | |
| | | MVD | 0.25 | | |
| | | MLC | 0.25 | | |
| | | MLD | 0.25 | | |
| | | LVD | 0.25 | | |
| | | LLD | 0.25 | | |
| | | RC | 0.25 | | |
| | | RD | 0.25 | | |
| | | RCM1 | 0.25 | | |
| | | RDM1 | 0.25 | | |
| | | RCM2 | 0.25 | | |
| | | RDM2 | 0.25 | | |
| | | Empty | 0.25 | | |
| B31 | Drums are left in sea (not recovered) and fail | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a |
| (prob) | due to corrosion. | SVC&DF | 0 | | drum. Hence all the probability associated with this event is |
| | | SLC | 0 | | associated with incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |

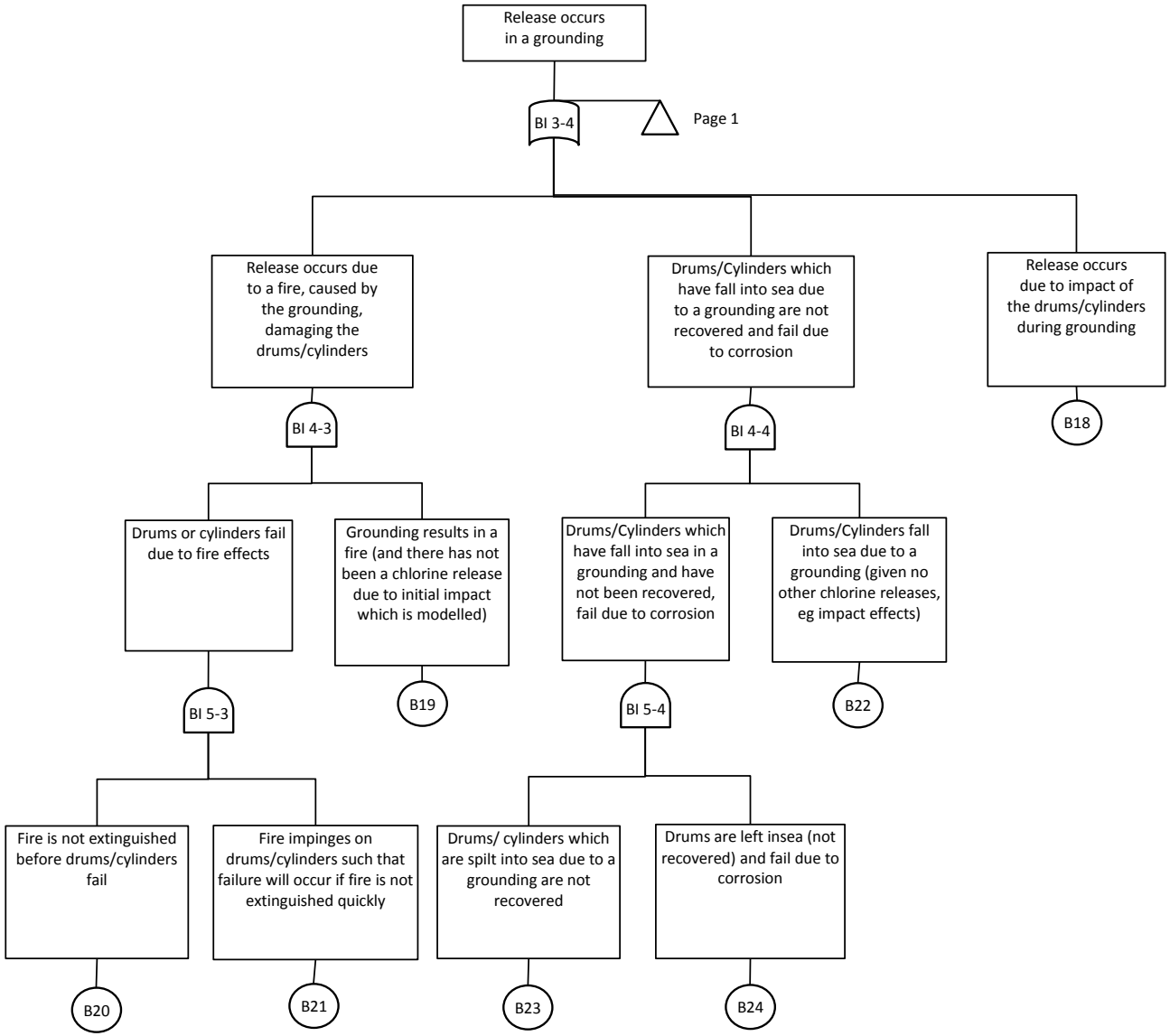
| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| B32 | Chlorine boat load shedding incident while | SVC&DS | 2.60E-06 | per | |
| (freq) | travelling over a 1 km length of the route | SVC&DF | 2.60E-06 | km year | |
| | | SLC | 2.60E-06 | | |
| | | SLDS | 2.60E-06 | | |
| | | SLDF | 2.60E-06 | | |
| | | MVC | 2.60E-06 | | |
| | | MVD | 2.60E-06 | | |
| | | MLC | 2.60E-06 | | |
| | | MLD | 2.60E-06 | | |
| | | LVD | 2.60E-06 | | |
| | | LLD | 2.60E-06 | | |
| | | RC | 2.60E-06 | | |
| | | RD | 2.60E-06 | | |
| | | RCM1 | 2.60E-06 | | |
| | | RDM1 | 2.60E-06 | | |
| | | RCM2 | 2.60E-06 | | |
| | | RDM2 | 2.60E-06 | | |
| | | Empty | 2.60E-06 | | |
| B33 | Drums or cylinders in sea due to a load | SVC&DS | 1 | | |
| (prob) | shedding incident on the chlorine boat | SVC&DF | 1 | | |
| | | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | Empty | 1 | | |
| B34 | Drums or cylinders which are in the sea due to | SVC&DS | 0.25 | | |
| (prob) | a load shedding incident are not recovered | SVC&DF | 0.25 | | |
| | | SLC | 0.25 | | |
| | | SLDS | 0.25 | | |
| | | SLDF | 0.25 | | |
| | | MVC | 0.25 | | |
| | | MVD | 0.25 | | |
| | | MLC | 0.25 | | |
| | | MLD | 0.25 | | |
| | | LVD | 0.25 | | |
| | | LLD | 0.25 | | |
| | | RC | 0.25 | | |
| | | RD | 0.25 | | |
| | | RCM1 | 0.25 | | |
| | | RDM1 | 0.25 | | |
| | | RCM2 | 0.25 | | |
| | | RDM2 | 0.25 | | |
| | | Empty | 0.25 | | |
| B35 | Drums are left in sea (not recovered) and fail | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a |
| (prob) | due to corrosion. | SVC&DF | 0 | | drum. Hence all the probability associated with this event is |
| | | SLC | 0 | | associated with incident case MVD. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | Empty | 0 | | |

Figure D.1 (1/7) Fault Tree for Marine Transport



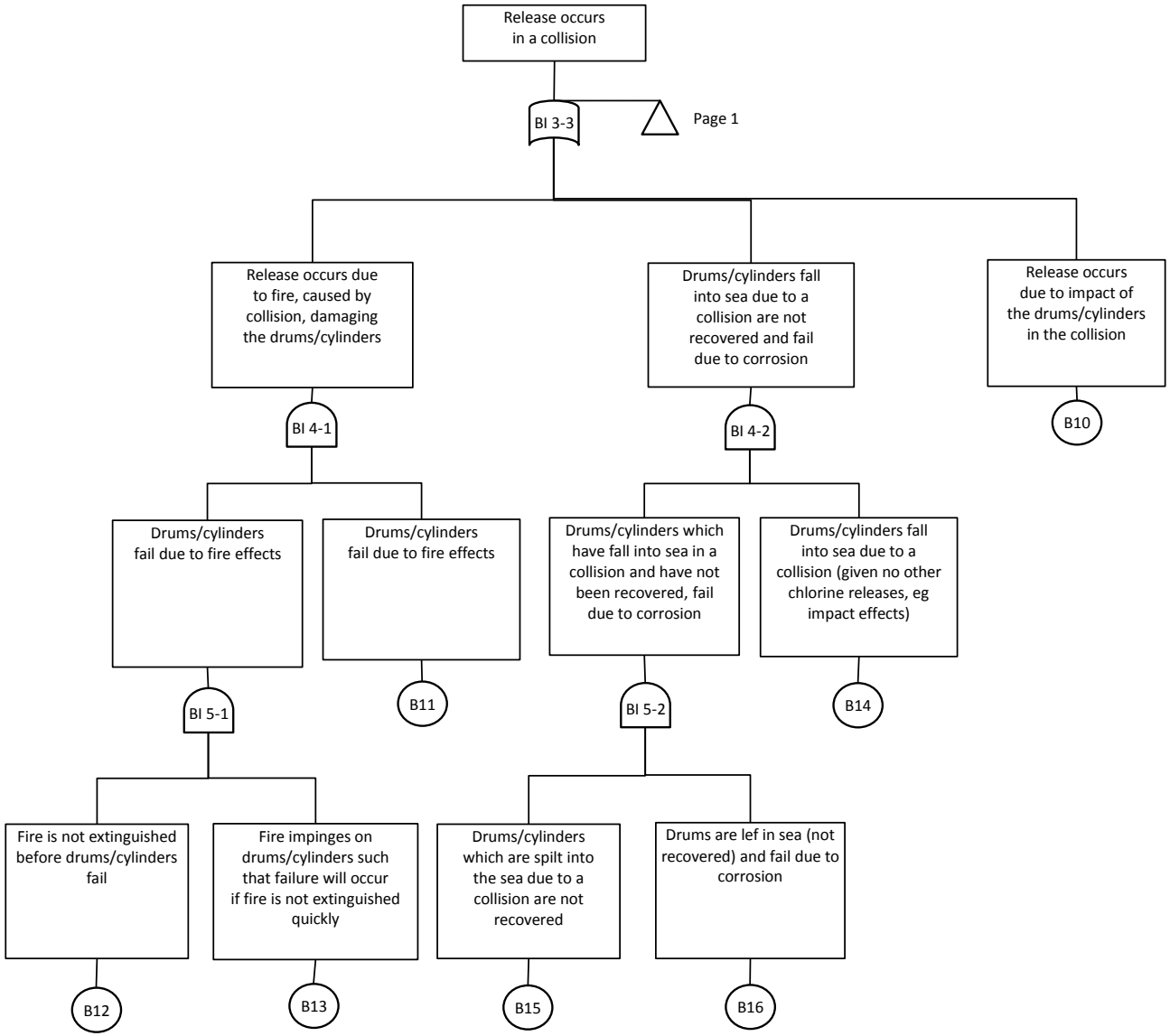

Remark:
Fault tree for Marine Transport Event (page 1of 7)
(S) – Events due to spontaneous causes
(NS) – Events due to non-spontaneous causes

Figure D.1 (2/7) Fault Tree for Marine Transport



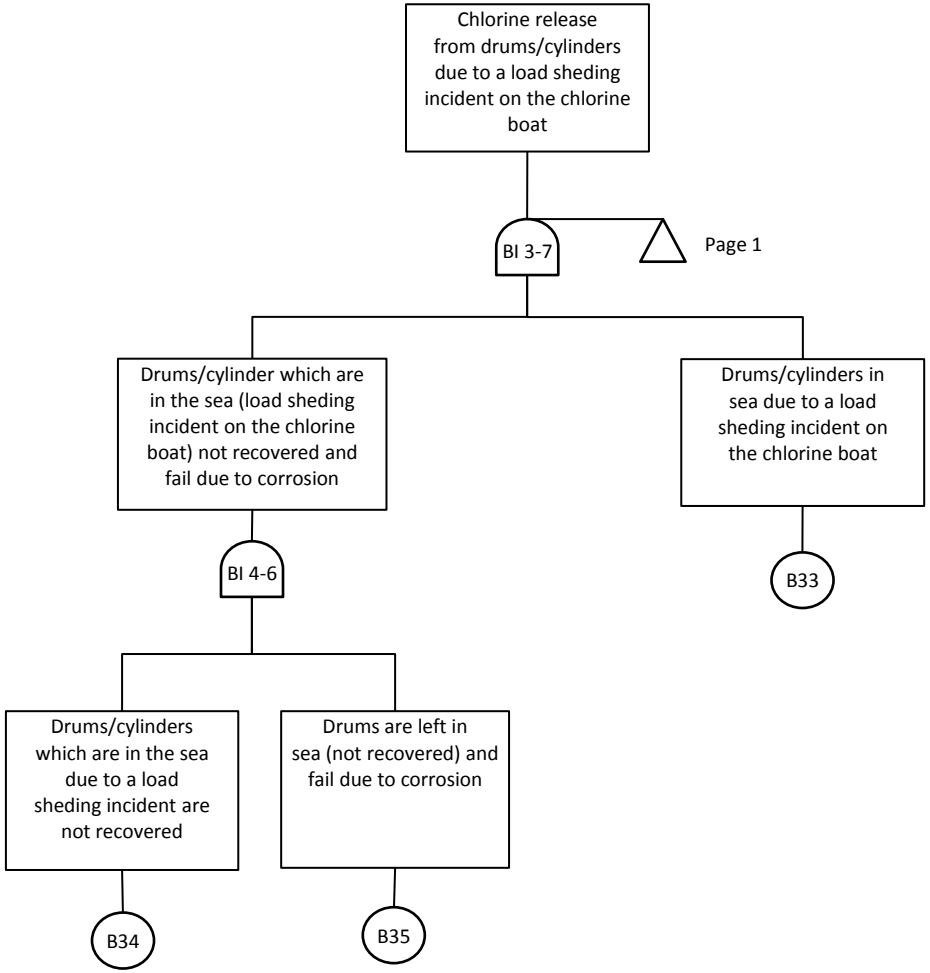

Remark:
Fault tree for Marine Transport Event (page 2 of 7)

Figure D.1 (3/7) Fault Tree for Marine Transport



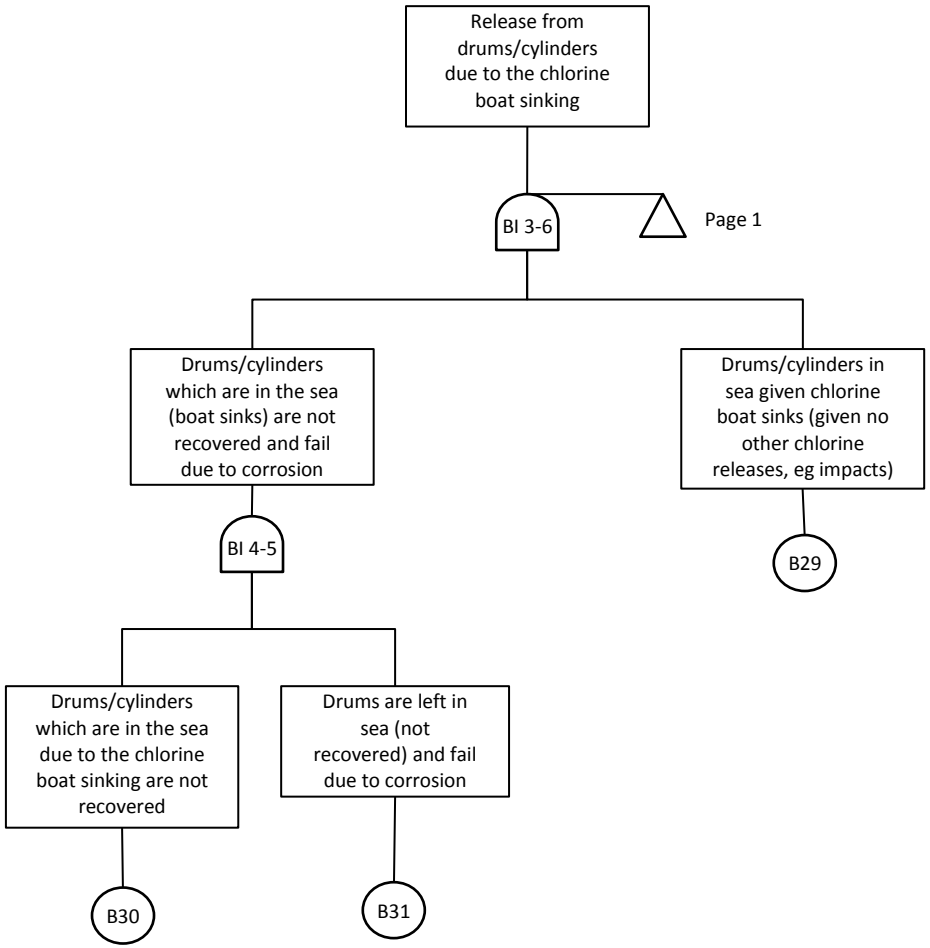

Remark:
Fault tree for Marine Transport Event (page 3 of 7)

Figure D.1 (4/7) Fault Tree for Marine Transport



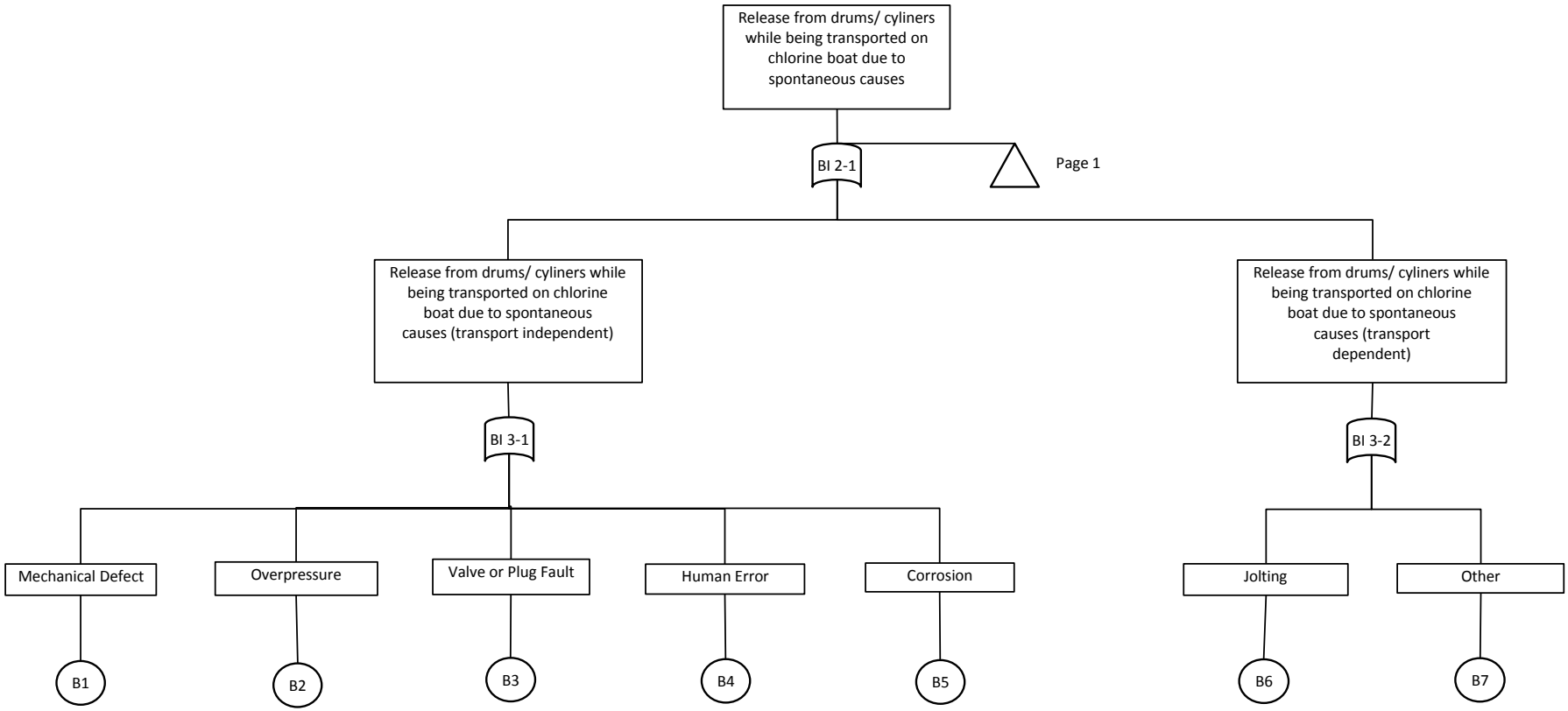

Remark:
Fault tree for Marine Transport Event (page 4 of 7)

Figure D.1 (5/7) Fault Tree for Marine Transport



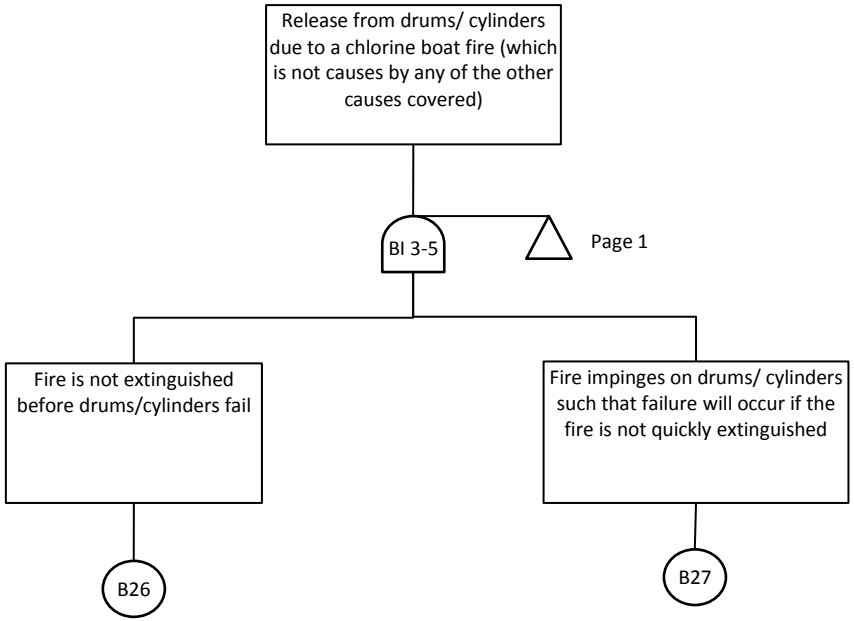

Remark:
Fault tree for Marine Transport Event (page 5 of 7)

Figure D.1 (6/7) Fault Tree for Marine Transport




Remark:
Fault tree for Marine Transport Event (page 6 of 7)

Figure D.1 (7/7) Fault Tree for Marine Transport




Remark:
Fault tree for Marine Transport Event (page 7 of 7)

**D.2 Dock (Unloading and Loading)**

Figure D.2 presents the fault tree for the events at the dock (unloading and loading) and Table D.2 presents the failure data used to calculate the top event frequencies

The updated frequency and probability calculations are shown below:

| | parameter |
|---|---|
| During operation, | |
| Number of 1-tonne drums consumed per year = 148 | 148 |
| Number of 50-kg cylinders consumed per year = 0 | 0 |
| Number of barge deliveries per year = 12 | 12 |
| Average number of drums per delivery = 13 (approximately) | 13 |
| Average number of cylinders per delivery = 0 | 0 |
| | |
| *Fault Tree Event D8 – Probability Of Drum Or Cylinder Are At The Dock (a single delivery by an average vessel load in a year)* | |
| Average number of drums on the vessel = 13 | 13 |
| Average number of cylinders on the vessel = 0 | 0 |
| Average time at the dock = 3.2 hours | 3.2 |
| (referring to the 2006 Study, average time at dock = 16 hours for handling of 66 drums and 70 cylinders. For 66 drums, the average time is estimated as 16 x (13/66) hours) | |
| | |
| Probability of a drum at the dock = 3.2 / (24 x 365) = 0.00037 | 0.00037 |
| Probability of all drums at the dock = 0.00037 x 13 = 0.005 | 0.005 |
| Probability of a cylinder at the dock = 3.2 / (24 x 365) = 0.00037 | 0.00037 |
| Probability of all cylinders at the dock = 0.00037 x 0 = 0 | 0 |
| | |
| *Fault Tree Event DI 5-1 – Frequency Of Drum Or Cylinder Dropped During The Unloading And Loading Operation* | |
| Number of lifts in a period of 1989 to 1994 = 1.54E+05 (from the previous study CE63/94) | 1.54E+05 |
| Assuming 50% confidence limits for a normal distribution, failure rate up to the end of 1994 = 4.50E-06 (from the previous study CE63/94) | 4.50E-06 |
| Number of lifts in a period of 1995 to 2002 = 1.06E+05 | 1.06E+05 |
| Number of lifts in the last 38 years (from 1989 to 2002) = 1.54E+05 + 1.06E+05 = 2.60E+05 | 2.60E+05 |
| T (number of lifts) = 2.60E+05 in the last 38 years | 2.60E+05 |
| Chi-square value for 50% confidence limit = 1.39 | 1.39E+00 |
| Chi-square value = 2T x (failure rate) | |
| Failure rate = 2.67E-06 | 2.67E-06 |
| Combined leak frequency = (failure rate) x 0.2 = 5.34E-07 | 5.34E-07 |
| Based on the accident records, there were no known leaks due to dropping containers during transfer in the last 38 years, hence the failure rate up to the end of 2002 = 5.34E-07 | 5.34E-07 |
| | |
| *Fault Tree Event D37 – Drum Or Cylinder Lifts* | |
| The frequency of drum lifts per delivery = The number of drums delivered = 13 | 13 |
| Cylinders are lifts in cages. Each each has 5 cylinders | 5 |
| The average number of cylinders per delivery = 0 | 0 |
| The number of cylinder lifts per delivery = 0 / 5 = 0 | 0 |

**Table D.2 Source Data Used in Dock Fault Tree**

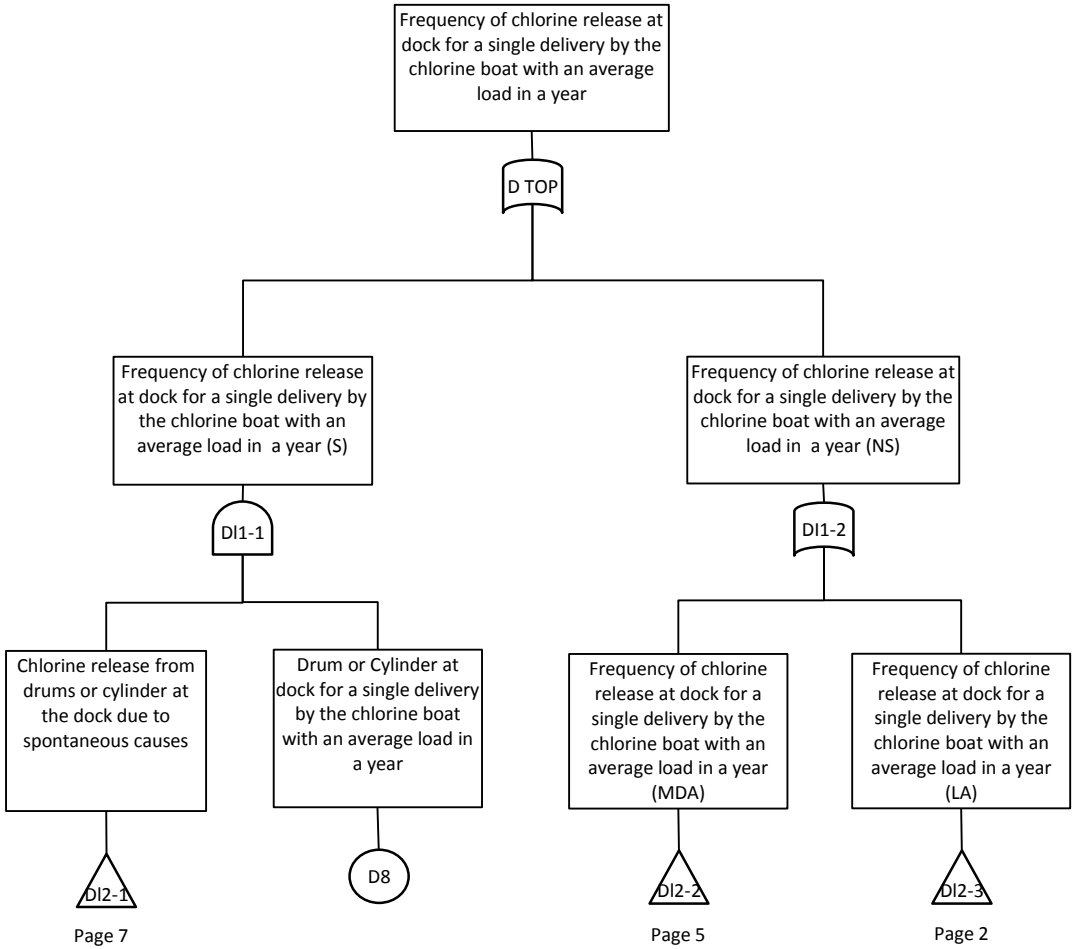
| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| DI 2-1 | Chlorine release from drums or cylinders at the | SVC&DS | 8.10E-06 | per year | The frequency used has not been split between the sub causes of: |
| (freq) | dock due to spontaneous causes | SVCD&DF | 8.10E-06 | | - Material defect. |
| | | SLC | 7.30E-05 | | - Overpressure |
| | | SLDS | 1.50E-05 | | - Valve or plug fault |
| | | SLDF | 5.80E-05 | | - Human error failure |
| | | MVC | 6.30E-06 | | - Corrosion |
| | | MVD | 5.30E-06 | | |
| | | MLC | 5.70E-05 | | The values are developed from the following: |
| | | MLD | 4.80E-05 | | The assumption, based on judgement with the operators is that small |
| | | LVD | 9.80E-07 | | vapour leaks can be successfully stopped on 50% of occasions and small |
| | | LLD | 8.80E-06 | | liquid leaks can be successfully stopped on 20% of occasions. |
| | | RC | 6.80E-06 | | |
| | | RD | 6.80E-06 | | The assumption, based on the drums and cylinders being full, that 90% |
| | | RCM1 | 0.00E+00 | | of leaks are liquid and 10% are vapour. |
| | | RDM1 | 0.00E+00 | | |
| | | RCM2 | 0.00E+00 | | Spontaneous failures are so unlikely to result in multiple failures that |
| | | RDM2 | 0.00E+00 | | these outcomes can be given a failure frequency of zero. |
| | | EMPTY | 0.00E+00 | | |
| D8 | Drum or cylinder at the dock for a single delivery | SVC&DS | 0.005 | | Based on an average load, see discussion / calculation |
| (prob) | by the chlorine boat with an average load in a | SVCD&DF | 0.005 | | in the prefix of this section. |
| | year | SLC | 0 | | |
| | | SLDS | 0.005 | | |
| | | SLDF | 0.005 | | |
| | | MVC | 0 | | |
| | | MVD | 0.005 | | |
| | | MLC | 0 | | |
| | | MLD | 0.005 | | |
| | | LVD | 0.005 | | |
| | | LLD | 0.005 | | |
| | | RC | 0 | | |
| | | RD | 0.005 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0.005 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0.005 | | |
| | | EMPTY | 0.005 | | |
| D9 | Release occurs due to impact of the drums or | SVC&DS | 0 | | |
| (freq) | cylinders in a berth impact incident | SVCD&DF | 0 | | |
| | | SLC | 0 | | |
| | | SLDS | 8.96E-08 | | |
| | | SLDF | 3.58E-07 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 2.83E-07 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 1.92E-08 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| D10 | Berth impact incident results in a fire (and there | SVC&DS | 9.61E-07 | per | The probability of a leak is taken to be the same as that for a collision |
| (freq) | has not been a chlorine release due to the initial | SVCD&DF | 9.61E-07 | km year | (i.e. 0.05, see B11 in fault trees for marine transport). |
| | impact which is modelled) | SLC | 9.61E-07 | | |
| | | SLDS | 9.61E-07 | | |
| | | SLDF | 9.61E-07 | | |
| | | MVC | 9.61E-07 | | |
| | | MVD | 9.61E-07 | | |
| | | MLC | 9.61E-07 | | |
| | | MLD | 9.61E-07 | | |
| | | LVD | 9.61E-07 | | |
| | | LLD | 9.61E-07 | | |
| | | RC | 9.61E-07 | | |
| | | RD | 9.61E-07 | | |
| | | RCM1 | 9.61E-07 | | |
| | | RDM1 | 9.61E-07 | | |
| | | RCM2 | 9.61E-07 | | |
| | | RDM2 | 9.61E-07 | | |
| | | EMPTY | 9.61E-07 | | |
| D11 | Fire is not extinguished before drums or cylinders | SVC&DS | 1 | | |
| (prob) | fail | SVCD&DF | 1 | | |
| | | SLC | 1 | | |
| | | SLDS | 1 | | |
| | | SLDF | 1 | | |
| | | MVC | 1 | | |
| | | MVD | 1 | | |
| | | MLC | 1 | | |
| | | MLD | 1 | | |
| | | LVD | 1 | | |
| | | LLD | 1 | | |
| | | RC | 1 | | |
| | | RD | 1 | | |
| | | RCM1 | 1 | | |
| | | RDM1 | 1 | | |
| | | RCM2 | 1 | | |
| | | RDM2 | 1 | | |
| | | EMPTY | 1 | | |
| D12 | Fire impinges on drums or cylinders such that | SVC&DS | 0 | | |
| (prob) | failure will occur if fire is not extinguished quickly | SVCD&DF | 0 | | |
| | | SLC | 0 | | |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0.01 | | |
| | | EMPTY | 0 | | |
| D13 | Drums or cylinders fall into sea due to a berth | SVC&DS | 3.84E-06 | | The probability of a leak is taken to be the same as that for a collision |
| (freq) | impact incident (given no other chlorine releases, | SVCD&DF | 3.84E-06 | | (i.e. 0.2, see B14 in fault trees for marine transport). |
| | e.g. due to impact effects) | SLC | 3.84E-06 | | |
| | | SLDS | 3.84E-06 | | |
| | | SLDF | 3.84E-06 | | |
| | | MVC | 3.84E-06 | | |
| | | MVD | 3.84E-06 | | |
| | | MLC | 3.84E-06 | | |
| | | MLD | 3.84E-06 | | |
| | | LVD | 3.84E-06 | | |
| | | LLD | 3.84E-06 | | |
| | | RC | 3.84E-06 | | |
| | | RD | 3.84E-06 | | |
| | | RCM1 | 3.84E-06 | | |
| | | RDM1 | 3.84E-06 | | |
| | | RCM2 | 3.84E-06 | | |
| | | RDM2 | 3.84E-06 | | |
| | | EMPTY | 3.84E-06 | | |
| D14 | | SVC&DS | 0.1 | | |
| (prob) | | SVCD&DF | 0.1 | | |
| | | SLC | 0.1 | | |
| | | SLDS | 0.1 | | |
| | | SLDF | 0.1 | | |
| | | MVC | 0.1 | | |
| | | MVD | 0.1 | | |
| | | MLC | 0.1 | | |
| | | MLD | 0.1 | | |
| | | LVD | 0.1 | | |
| | | LLD | 0.1 | | |
| | | RC | 0.1 | | |
| | | RD | 0.1 | | |
| | | RCM1 | 0.1 | | |
| | | RDM1 | 0.1 | | |
| | | RCM2 | 0.1 | | |
| | | RDM2 | 0.1 | | |
| | | EMPTY | 0.1 | | |
| D15 | Drums are left in sea (not recovered) and fail due | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a drum. |
| (prob) | to corrosion. | SVCD&DF | 0 | | Hence all the probability associated with this event is associated with |
| | | SLC | 0 | | incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| DI 5-1 | Drum or cylinder dropped during the unloading | SVC&DS | 5.34E-07 | | See discussion / calculation in the prefix of this section |
| (prob) | and loading operation. | SVCD&DF | 5.34E-07 | | |
| | | SLC | 5.34E-07 | | |
| | | SLDS | 5.34E-07 | | |
| | | SLDF | 5.34E-07 | | |
| | | MVC | 5.34E-07 | | |
| | | MVD | 5.34E-07 | | |
| | | MLC | 5.34E-07 | | |
| | | MLD | 5.34E-07 | | |
| | | LVD | 5.34E-07 | | |
| | | LLD | 5.34E-07 | | |
| | | RC | 5.34E-07 | | |
| | | RD | 5.34E-07 | | |
| | | RCM1 | 5.34E-07 | | |
| | | RDM1 | 5.34E-07 | | |
| | | RCM2 | 5.34E-07 | | |
| | | RDM2 | 5.34E-07 | | |
| | | EMPTY | 5.34E-07 | | |
| DI 6-3 | Impact failure of drums or cylinders due to a | SVC&DS | 0 | | The probability of a leak is taken as 0.2. It is assumed that 75% are |
| (prob) | lifting failure. | SVCD&DF | 0 | | small liquid leaks (SLDS, SLDF) and 25% MLD. |
| | | SLC | 0 | | |
| | | SLDS | 0.03 | | |
| | | SLDF | 0.12 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0.05 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| D24 | Drums or cylinders fall into sea due to being | SVC&DS | 0.01 | | |
| (prob) | dropped during the unloading and loading | SVCD&DF | 0.01 | | |

| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | operation | SLC | 0.01 | | |
| | | SLDS | 0.01 | | |
| | | SLDF | 0.01 | | |
| | | MVC | 0.01 | | |
| | | MVD | 0.01 | | |
| | | MLC | 0.01 | | |
| | | MLD | 0.01 | | |
| | | LVD | 0.01 | | |
| | | LLD | 0.01 | | |
| | | RC | 0.01 | | |
| | | RD | 0.01 | | |
| | | RCM1 | 0.01 | | |
| | | RDM1 | 0.01 | | |
| | | RCM2 | 0.01 | | |
| | | RDM2 | 0.01 | | |
| | | EMPTY | 0.01 | | |
| D25 | Drums or cylinders which are spilt into the sea | SVC&DS | 0.1 | | |
| (prob) | due to being dropped during the unloading and | SVCD&DF | 0.1 | | |
| | loading operation are not recovered | SLC | 0.1 | | |
| | | SLDS | 0.1 | | |
| | | SLDF | 0.1 | | |
| | | MVC | 0.1 | | |
| | | MVD | 0.1 | | |
| | | MLC | 0.1 | | |
| | | MLD | 0.1 | | |
| | | LVD | 0.1 | | |
| | | LLD | 0.1 | | |
| | | RC | 0.1 | | |
| | | RD | 0.1 | | |
| | | RCM1 | 0.1 | | |
| | | RDM1 | 0.1 | | |
| | | RCM2 | 0.1 | | |
| | | RDM2 | 0.1 | | |
| | | EMPTY | 0.1 | | |
| D26 | Drums are left in sea (not recovered) and fail due | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a drum. |
| (prob) | to corrosion. | SVCD&DF | 0 | | Hence all the probability associated with this event is associated with |
| | | SLC | 0 | | incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| DI 6-5 | The drum or cylinder which is hit by a dropped | SVC&DS | 0 | | The probability of a leak is taken as 0.2. As the failures are likely to |
| (prob) | drum or cylinder fails due to the impact | SVCD&DF | 0 | | be at the top of the containers and being conservative they are all |
| | | SLC | 0 | | modelled as incident MVD. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0.08 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| D29 | Truck overturns and spills load, due to crane | SVC&DS | 0 | | |
| (prob) | being over extended | SVCD&DF | 0 | | |
| | | SLC | 0 | | |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| DI 6-6 | Impact failure of drums or cylinders due to over | SVC&DS | 0 | | Assume to be the same as for a dropped load (DI 6-3). |
| (prob) | extending of the loading arm. | SVCD&DF | 0 | | |
| | | SLC | 0 | | |
| | | SLDS | 0.03 | | |
| | | SLDF | 0.12 | | |
| | | MVC | 0 | | |
| | | MVD | 0 | | |
| | | MLC | 0 | | |
| | | MLD | 0.05 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |

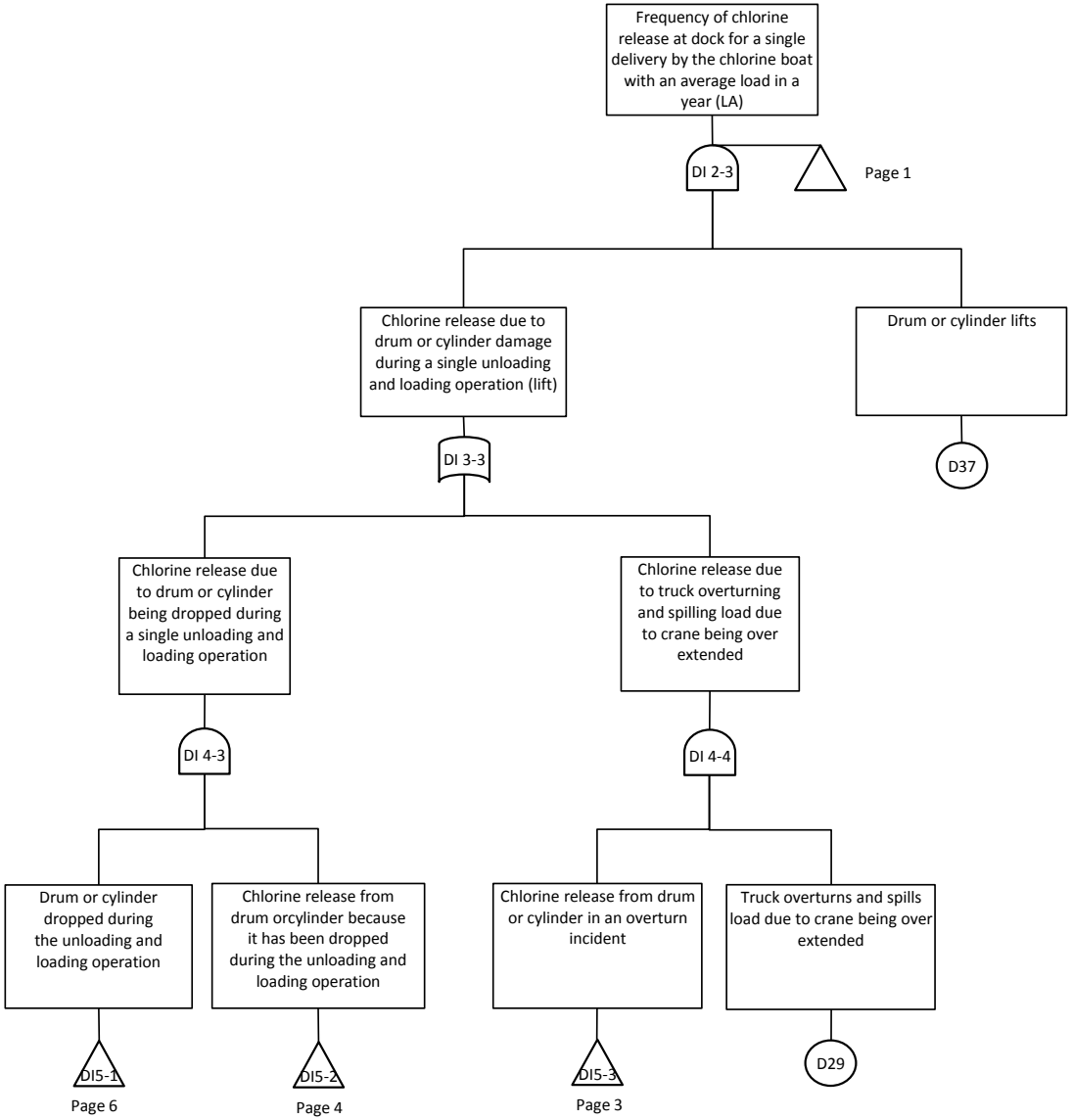
| Fault tree event no. | Fault tree event description | Failure case | Value | Unit | Remarks |
|---|---|---|---|---|---|
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| D32 | Drums or cylinders fall into sea due to being truck overturning | SVC&DS | 0.01 | | Assume to be the same as for a dropped load (D24). |
| (prob) | | SVCD&DF | 0.01 | | |
| | | SLC | 0.01 | | |
| | | SLDS | 0.01 | | |
| | | SLDF | 0.01 | | |
| | | MVC | 0.01 | | |
| | | MVD | 0.01 | | |
| | | MLC | 0.01 | | |
| | | MLD | 0.01 | | |
| | | LVD | 0.01 | | |
| | | LLD | 0.01 | | |
| | | RC | 0.01 | | |
| | | RD | 0.01 | | |
| | | RCM1 | 0.01 | | |
| | | RDM1 | 0.01 | | |
| | | RCM2 | 0.01 | | |
| | | RDM2 | 0.01 | | |
| | | EMPTY | 0.01 | | |
| D33 | Drums or cylinders which are spilt into the sea | SVC&DS | 0.1 | | |
| (prob) | due to being dropped during the unloading and | SVCD&DF | 0.1 | | |
| | loading operation are not recovered | SLC | 0.1 | | |
| | | SLDS | 0.1 | | |
| | | SLDF | 0.1 | | |
| | | MVC | 0.1 | | |
| | | MVD | 0.1 | | |
| | | MLC | 0.1 | | |
| | | MLD | 0.1 | | |
| | | LVD | 0.1 | | |
| | | LLD | 0.1 | | |
| | | RC | 0.1 | | |
| | | RD | 0.1 | | |
| | | RCM1 | 0.1 | | |
| | | RDM1 | 0.1 | | |
| | | RCM2 | 0.1 | | |
| | | RDM2 | 0.1 | | |
| | | EMPTY | 0.1 | | |
| D34 | Drums are left in sea (not recovered) and fail due | SVC&DS | 0 | | It is proposed to model this case as a medium vapour leak from a drum. |
| (prob) | to corrosion. | SVCD&DF | 0 | | Hence all the probability associated with this event is associated with |
| | | SLC | 0 | | incident case MDV. |
| | | SLDS | 0 | | |
| | | SLDF | 0 | | |
| | | MVC | 0 | | |
| | | MVD | 1 | | |
| | | MLC | 0 | | |
| | | MLD | 0 | | |
| | | LVD | 0 | | |
| | | LLD | 0 | | |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |
| D37 | Drum or cylinder lifts. | SVC&DS | 13 | per year | See discussion / calculation in the prefix of this section. |
| | | SVCD&DF | 13 | | |
| | | SLC | 0 | | |
| | | SLDS | 13 | | |
| | | SLDF | 13 | | |
| | | MVC | 0 | | |
| | | MVD | 13 | | |
| | | MLC | 0 | | |
| | | MLD | 13 | | |
| | | LVD | 13 | | |
| | | LLD | 13 | | |
| | | RC | 0 | | |
| | | RD | 13 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 13 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 13 | | |
| | | EMPTY | 13 | | |
| DI 6-8 | A drum or cylinder on the boat is hit by a truck or | SVC&DS | 0 | | The value chosen is considered relative to the equivalent dropped |
| (prob) | a dropped drum or cylinder and fails | SVCD&DF | 0 | | load event. |
| | | SLC | 0 | | The truck, drums or cylinders could fall off the dock and into the |
| | | SLDS | 0 | | chlorine boat. |
| | | SLDF | 0 | | With the current requirement for drums and cylinders to be taken only |
| | | MVC | 0 | | from the near side of the boat (the boat has to turn round to unload the |
| | | MVD | 0.08 | | far side drums and cylinders) this event is only envisaged if the truck is |
| | | MLC | 0 | | parked too far away from the dock. |
| | | MLD | 0 | | The drums and cylinders will be clamped and strapped onto the truck bed. |
| | | LVD | 0 | | The direction of fall is towards the boat. |
| | | LLD | 0 | | The probability value is chosen to be the same as for dropped loads. |
| | | RC | 0 | | |
| | | RD | 0 | | |
| | | RCM1 | 0 | | |
| | | RDM1 | 0 | | |
| | | RCM2 | 0 | | |
| | | RDM2 | 0 | | |
| | | EMPTY | 0 | | |

Figure D.2 (1/7) Fault Tree for Dock (Unloading and Loading) Events



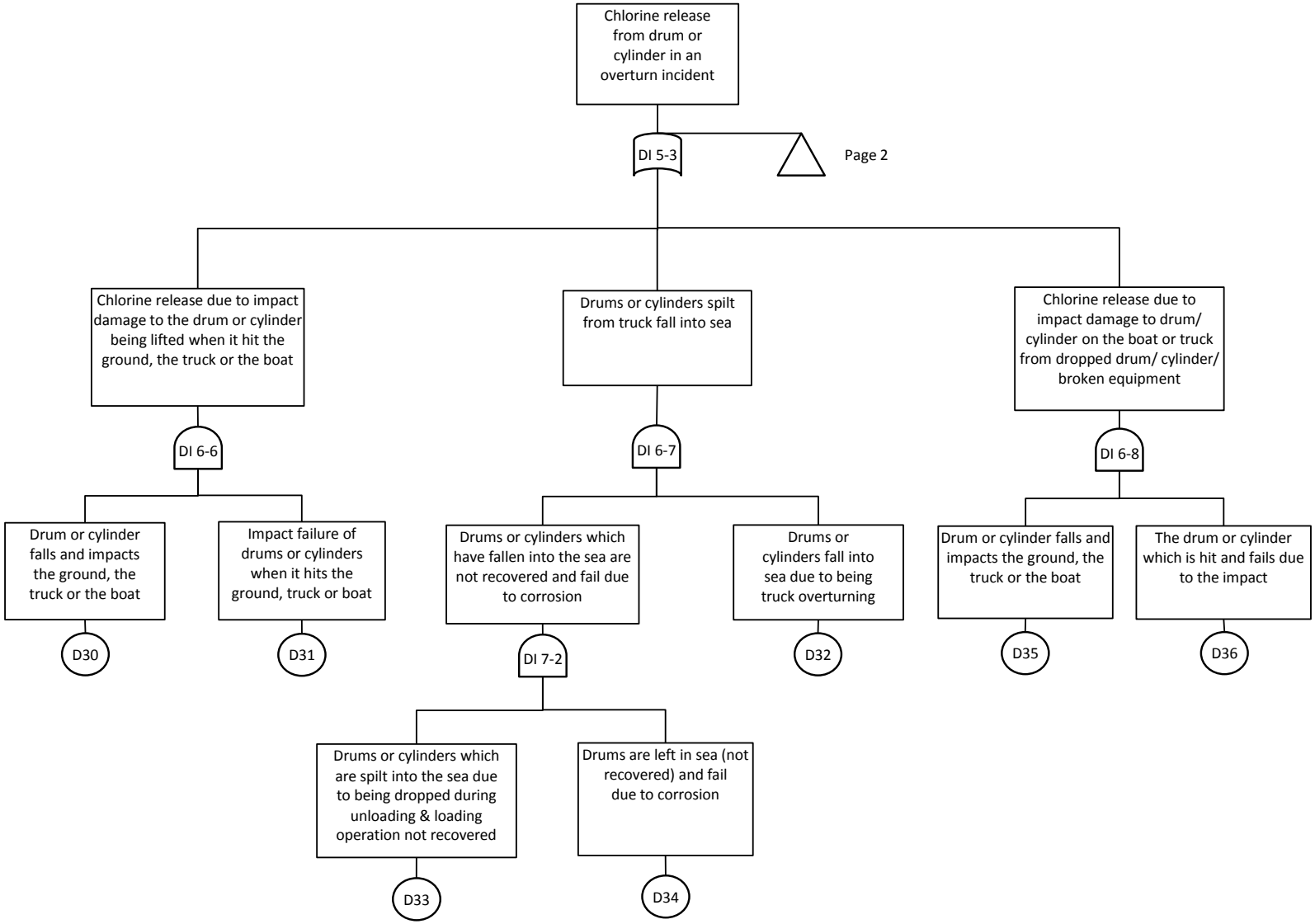

Remarks:
Fault tree for Dock Event (page 1 of 7 )
(S)-Event due to spontaneous causes
(NS)-Events for non-spontaneous causes
(MDA)-Marine docking accidents
(LA)-Unloading and loading accidents

Figure D.2 (2/7) Fault Tree for Dock (Unloading and Loading) Events




Remarks:
Fault tree for Dock Event (page 2 of 7)

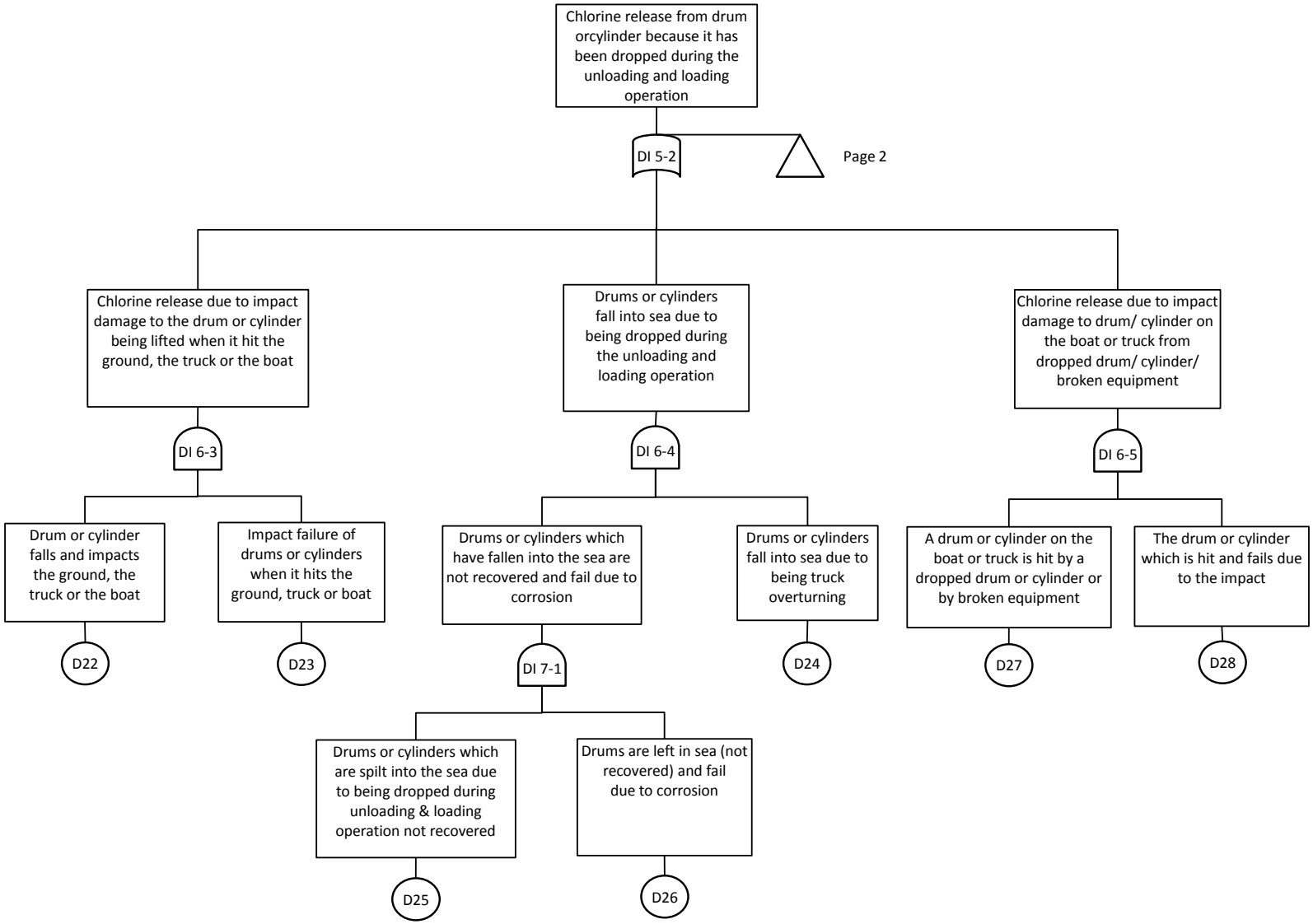
Figure D.2(3/7) Fault Tree for Dock (Unloading and Loading) Events




Remarks:

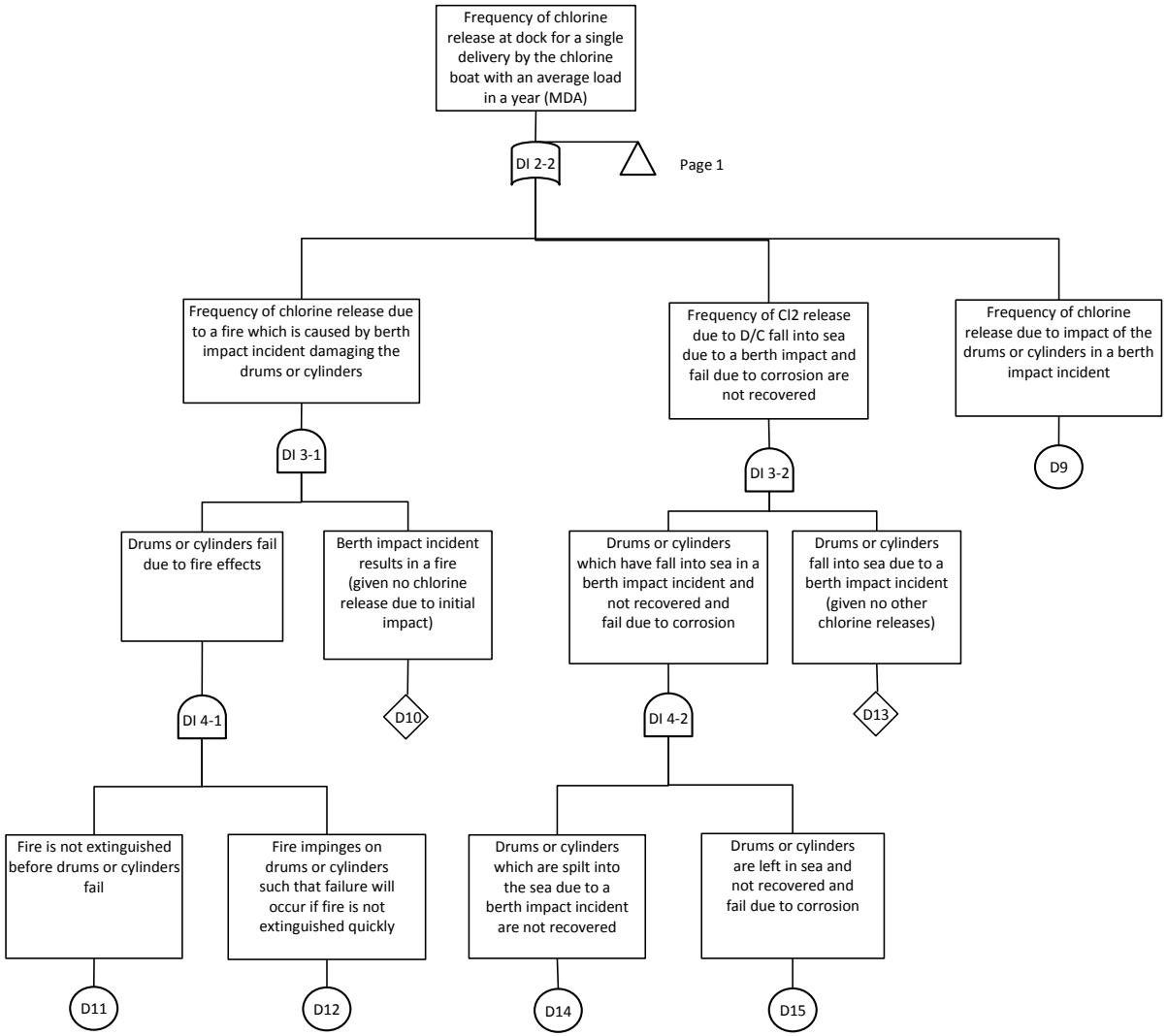
Fault tree for Dock Event (page 3 of 7)

Figure D.2 (4/7) Fault Tree for Dock (Unloading and Loading) Events



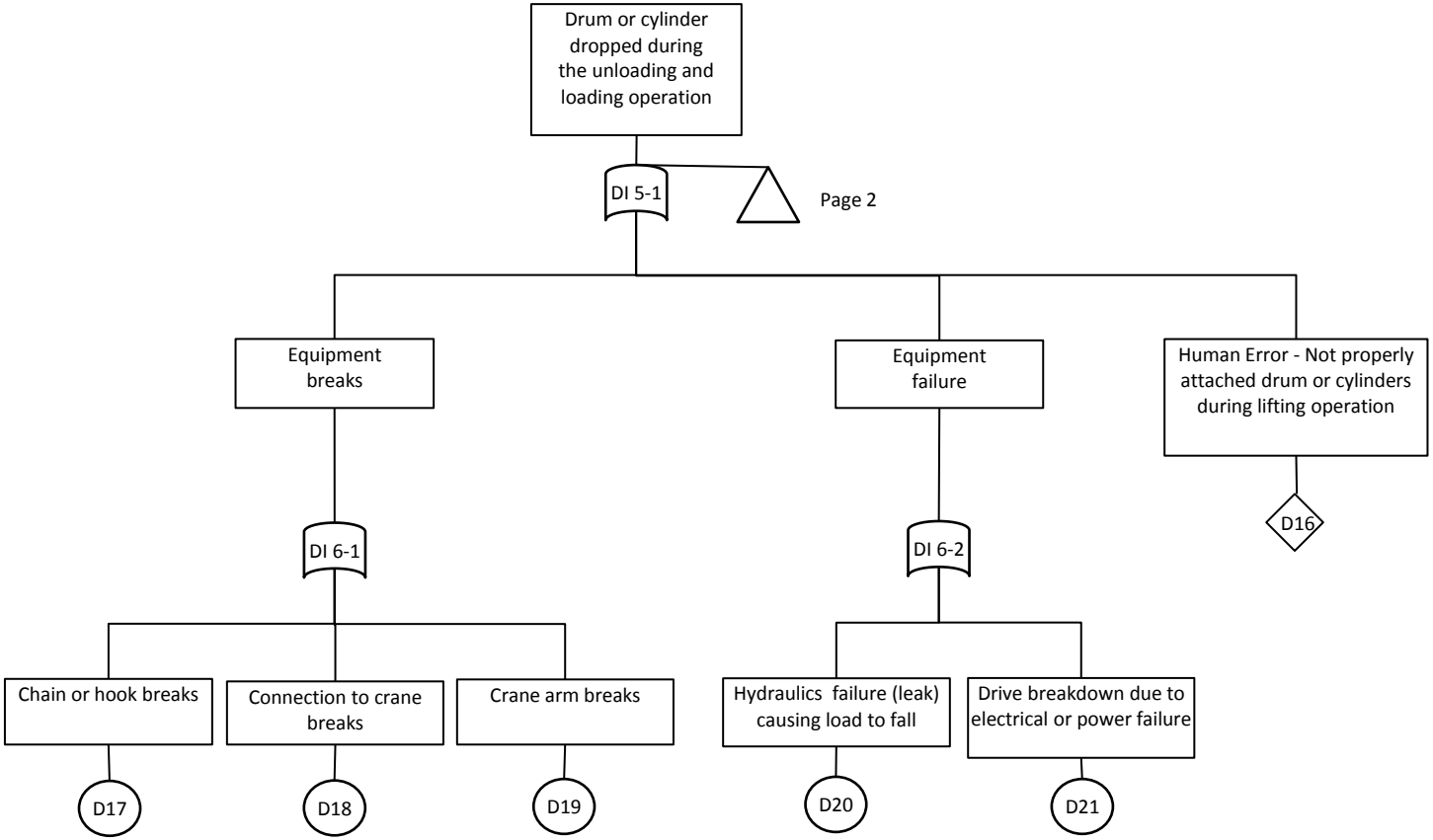

Remarks:
Fault tree for Dock Event (page 4 of 7)

Figure D.2 (5/7) Fault Tree for Dock (Unloading and Loading) Events



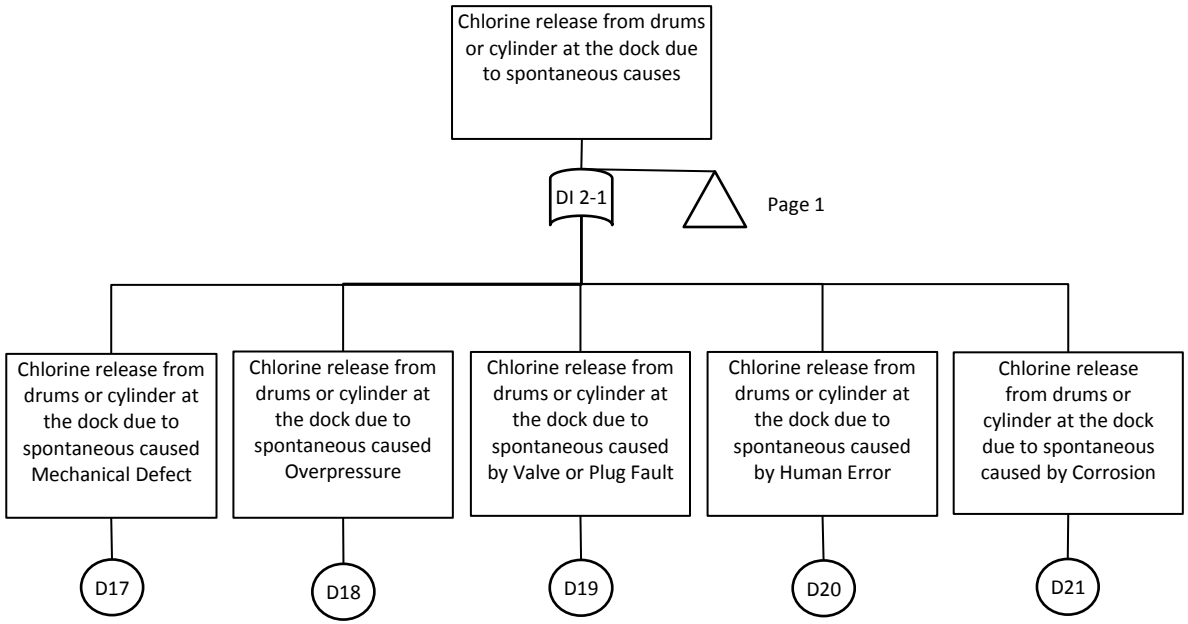

Remarks:
Fault tree for Dock Event (page 5 of 7)
Cl2 – chlorine
D/C – drum or cylinders

Figure D.2 (6/7) Fault Tree for Dock (Unloading and Loading) Events




Remarks:
Fault tree for Dock Event (page 6 of 7)

Figure D.2 (7/7) Fault Tree for Dock (Unloading and Loading) Events




Remarks:
Fault tree for Dock Event (page 7 of 7)