# Major Process Safety Incident vs Root Cause Map

(Quick Reference Guide)

IChemE

Safety & Loss Prevention Special Interest Group

### Context / Natural Hazards ("Natech" Triggers)

| Sector | | Date | Event | Country | Type | Fatalities | Injuries | Abnormal Operations | Escalation Potential | Earthquake | Tsunami | Flood | Cyclone/Hurricane | Extreme Cold/Ice | Links (Investigation Reports) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Oil & Gas | Upstream | 06-Jul-88 | Piper Alpha | UK | Explosion | 167 | ? | | | | | | | | Click |
| Oil & Gas | Upstream | 27-Jul-05 | Mumbai High North | India | Explosion | 22 | ? | | | | | | | | |
| Oil & Gas | Upstream | 20-Apr-10 | Macondo | USA | Explosion | 11 | 17 | X | | | | | | | Click |
| Oil & Gas | Upstream | 11-Feb-15 | Camarupim | Brazil | Explosion | 9 | 26 | X | | | | | | | Click |
| Oil & Gas | LNG | 19-Jan-04 | Skikda | Algeria | Explosion | 27 | 74 | | X | | | | | | |
| Oil & Gas | GPP | 25-Sep-98 | Longford | Australia | Fire | 2 | 8 | X | | | | | | | Click |
| Oil & Gas | Ship | 24-Mar-89 | Valdez | USA | Pollution | 0 | 0 | | X | | | | | X | |
| Oil & Gas | Rail | 06-Jul-13 | Lac Mégantic | Canada | Fire | 47 | ? | | | | | | | | |
| Oil & Gas | Downstream | 04-Jan-66 | Feyzin | France | BLEVE | 18 | 84 | | | | | | | | Click |
| Oil & Gas | Downstream | 23-Jul-84 | Romeoville | USA | Explosion | 17 | 22 | | | | | | | | |
| Oil & Gas | Downstream | 22-Mar-87 | Grangemouth | UK | Explosion | 1 | 0 | X | X | | | | | | Click |
| Oil & Gas | Downstream | 24-Jul-94 | Milford Haven | UK | Explosion | 0 | 26 | X | X | | | | | | Click |
| Oil & Gas | Downstream | 23-Feb-99 | Avon | USA | Fire | 4 | 1 | X | | | | | | | Click |
| Oil & Gas | Downstream | 17-Aug-99 | Izmit | Turkey | Fire | 0 | 0 | | X | X | | | | | Click |
| Oil & Gas | Downstream | 16-Apr-01 | Humber | UK | Explosion | 0 | 5 | | X | | | | | | Click |
| Oil & Gas | Downstream | 23-Mar-05 | Texas City | USA | Explosion | 15 | 180 | X | | | | | | | Click |
| Oil & Gas | Downstream | 05-Nov-05 | Delaware City | USA | Asphyxiation | 2 | 0 | | | | | | | | Click |
| Oil & Gas | Downstream | 16-Feb-07 | McKee | USA | Fire | 0 | 4 | | X | | | | | X | Click |
| Oil & Gas | Downstream | 02-Apr-10 | Anacortes | USA | Explosion | 7 | 0 | X | | | | | | | Click |
| Oil & Gas | Downstream | 11-Mar-11 | Chiba | Japan | BLEVE | 0 | 6 | | X | X | | | | | Click |
| Oil & Gas | Downstream | 06-Aug-12 | Richmond | USA | Fire | 0 | 26 | | | | | | | | Click |
| Oil & Gas | Downstream | 18-Feb-15 | Torrance | USA | Explosion | 0 | 4 | X | X | | | | | | Click |
| Oil & Gas | Terminal | 19-Nov-84 | San Juan Ixhuatepec | Mexico | BLEVE | 542 | 4,248 | | | | | | | | |
| Oil & Gas | Terminal | 11-Dec-05 | Buncefield | UK | Explosion | 0 | 43 | | X | | | | | | Click |
| Oil & Gas | Terminal | 23-Oct-09 | Bayamón | Puerto Rico | Explosion | 0 | 3 | | X | | | | | | Click |
| Power Gen | Nuclear | 28-Mar-79 | Three Mile Island | USA | Near Miss | 0 | 0 | | X | | | | | | |
| Power Gen | Nuclear | 26-Apr-86 | Chernobyl | Russia | Explosion | > 30 | ~ 7,000 | X | X | | | | | | |
| Power Gen | Nuclear | 11-Mar-11 | Fukushima Daiichi | Japan | Explosion | 0 | 13 | | X | X | X | | | | |
| Power Gen | Coal | 08-Apr-99 | Gannon | USA | Explosion | 3 | 48 | | | | | | | | |
| Power Gen | Coal | 10-Nov-07 | Dallman | USA | Explosion | 0 | 0 | X | X | | | | | | |
| Petrochemical | Manufacture | 01-Jun-74 | Flixborough | UK | Explosion | 28 | 104 | X | X | | | | | | |
| Petrochemical | Manufacture | 23-Oct-89 | Pasadena | USA | Explosion | 23 | 314 | X | | | | | | | |
| Petrochemical | Manufacture | 21-Sep-92 | Castleford | UK | Fire | 5 | 201 | X | | | | | | | Click |
| Petrochemical | Manufacture | 01-Feb-94 | Ellesmere Port | UK | Fire | 0 | 18 | | X | | | | | | Click |
| Petrochemical | Manufacture | 27-Mar-98 | Hahnville | USA | Asphyxiation | 1 | 1 | | | | | | | | Click |
| Petrochemical | Manufacture | 13-Jun-13 | Geismar | USA | BLEVE | 2 | 167 | X | | | | | | | Click |
| Petrochemical | Manufacture | 03-Jun-14 | Moerdijk | Netherlands | Explosion | 0 | 2 | X | | | | | | | Click |
| Petrochemical | Manufacture | 31-Aug-17 | Crosby | USA | Decomposition | 0 | 21 | | | | | X | X | | Click |
| Agrochemical | Manuf. | 10-Jul-76 | Seveso | Italy | Toxic Release | 0 | ~ 500 | X | X | | | | | | |
| Agrochemical | Manuf. | 03-Dec-84 | Bhopal | India | Toxic Release | 2153 | >200,000 | X | | | | | | | |
| Agrochemical | Manuf. | 21-Sep-01 | Toulouse | France | Explosion | 31 | 2442 | | X | | | | | | Click |
| Agrochemical | Manuf. | 15-Nov-14 | La Porte | USA | Toxic Release | 4 | 0 | X | | | | | | | Click |
| Agrochemical | Store | 17-Apr-13 | West | USA | Explosion | 15 | > 160 | | X | | | | | | Click |
| Pharma | Manuf. | 04-Jan-92 | Grimsby | UK | Runaway | 0 | 0 | X | X | | | | | | |
| Pharma | Manuf. | 29-Jan-03 | Kinston | USA | Explosion | 6 | 38 | | | | | | | | Click |
| Pharma | Manuf. | 28-Apr-08 | Cork | Ireland | Runaway | 1 | 1 | | | | | | | | Click |
| Water | Dist | 23-May-84 | Abbeystead | UK | Explosion | 16 | 28 | X | | | | | | | Click |
| Water | Treat | 06-Jul-88 | Camelford | UK | Pollution | 1 | ~ 400 | | | | | | | | |
| Water | Treat | 05-Apr-93 | Milwaukee | USA | Disease | 69 | >403,000 | | | | | | | | |
| Food | | 03-Sep-91 | Hamlet | USA | Fire | 25 | 54 | | | | | | | | Click |
| Food | | 11-Apr-03 | Louisville | USA | Explosion | 1 | 0 | | X | | | | | | Click |
| Food | | 07-Feb-08 | Port Wentworth | USA | Explosion | 14 | 36 | | | | | | | | Click |

### Root Causes – Design Factors / Operations Factors

| Event | Hazard Identification | Process Design | Equipment/Piping Design | Matterials of Construction | Instrumentation | Safety Instrumented Systems | Protective Systems | Plant Layout | Occupied Buildings | Process Monitoring | Process Control | Cyber Security Breach | Alarm Management | Creeping Change | Hazard Awareness | Operations Risk Assessment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piper Alpha | | | X | | | | X | X | | | | | | | | |
| Mumbai High North | | X | | | | | | X | | | | | | | X | X |
| Macondo | X | X | X | | X | X | | | | X | | | | | | X |
| Camarupim | X | X | | | X | | | X | | | | | | | X | X |
| Skikda | | X | | ? | X | ? | | **X** | X | | | | | | | |
| Longford | **X** | | | | | X | | | | X | | | X | | X | |
| Valdez | | | X | | X | | | | | X | | | | | | |
| Lac Mégantic | X | | X | | | | X | | | | | | | X | | X |
| Feyzin | | X | X | | | | X | | | | | | | | X | |
| Romeoville | X | | | X | | | | | | | | | | | X | |
| Grangemouth | X | | X | | X | **X** | X | | | | | | | | X | |
| Milford Haven | | | X | | X | | | | | X | | | X | | | X |
| Avon | X | | | | | | | | | | | | | X | | X |
| Izmit | | X | X | X | | | X | X | | | | | | | | X |
| Humber | X | | X | | | | | | | | | | | | | |
| Texas City | X | X | | | X | | | | X | X | | | | X | | X |
| Delaware City | | | | | | | | | | | | | | | X | |
| McKee | X | X | | | | X | X | X | | | | | | | | |
| Anacortes | X | | X | **X** | X | | | | | X | | | | X | | X |
| Chiba | | | **X** | | | | X | X | | | | | | X | | X |
| Richmond | | | | **X** | | | | | | | | | | | | X |
| Torrance | **X** | | | | X | X | | | | X | | | | | | |
| San Juan Ixhuatepec | | | X | | X | X | X | X | | | | | | X | | X |
| Buncefield | **X** | X | | | X | X | | X | | X | X | | | X | | |
| Bayamón | **X** | X | | | X | X | | X | | X | X | | | | X | X |
| Three Mile Island | X | X | | | X | | | X | | | | | **X** | | | X |
| Chernobyl | X | X | X | | | X | | | | | | | | | X | X |
| Fukushima Daiichi | X | | | | X | | | X | | | | | | | | **X** |
| Gannon | | | | | | | | | | | | | | | | X |
| Dallman | | | X | X | X | X | X | | X | | | | | | | X |
| Flixborough | | | | | | | | X | X | | | | | | X | X |
| Pasadena | | | X | | X | | X | X | | | | | | | | |
| Castleford | | | | | | | | X | X | | | | | | X | |
| Ellesmere Port | X | | X | | X | | | | | | | | | | X | |
| Hahnville | X | | | | | | | | | | | | | | X | X |
| Geismar | X | | | | | | | | | | | | | | X | X |
| Moerdijk | X | | | | X | X | | | | | X | | | | X | |
| Crosby | **X** | | | | | | X | X | | | | | | X | X | X |
| Seveso | X | X | | | X | X | | | | | X | | | | X | X |
| Bhopal | X | **X** | | X | | | | | | | | | | | X | X |
| Toulouse | X | | | X | | | | X | | | | | | | X | X |
| La Porte | X | | X | | | | X | | X | | | | X | | X | X |
| West | X | | | **X** | | | | X | | | | | | | X | |
| Grimsby | X | **X** | | | X | | | | | | X | | | X | | X |
| Kinston | **X** | | X | | | | X | | X | | | | | | X | X |
| Cork | **X** | X | X | | | | | | | | | | | | | X |
| Abbeystead | **X** | X | | | X | | | | | | | | | | X | |
| Camelford | X | | | | | | | X | | | | | | | | X |
| Milwaukee | X | **X** | | | | | | | | X | X | | | | | |
| Hamlet | X | | | X | X | X | X | X | X | | | | | | | |
| Louisville | **X** | | X | | X | | X | | | X | X | | | | X | |
| Port Wentworth | X | X | | | | | X | | | | | | | | **X** | X |

### Root Causes – Maintenance Factors / Personal

| Event | Preventative Maintenance | Inspection | Material Degradation | Work Planning | Maintenance Risk Assessment | Energy Isolation | Control of Work | Housekeeping | Human Factors | Role Clarity | Personal Protective Equipment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Piper Alpha | | | | | X | X | **X** | | X | | |
| Mumbai High North | | | | | | | | | **X** | X | |
| Macondo | X | | | | | | | | X | X | |
| Camarupim | | | | | | | X | | X | X | |
| Skikda | X | X | X | | | | | | X | | |
| Longford | | | X | | | | | | X | | |
| Valdez | | | | | | | | | **X** | | |
| Lac Mégantic | | | X | | | | | | X | | |
| Feyzin | | | | | | | | | | | |
| Romeoville | | X | **X** | | | | | | | | |
| Grangemouth | | | | | | | X | | | | |
| Milford Haven | X | **X** | X | | | | X | | X | | |
| Avon | X | X | X | X | | X | **X** | | | | |
| Izmit | | | X | | | | | | X | | |
| Humber | X | X | X | | | | | | | | |
| Texas City | X | | X | | | | X | | X | X | |
| Delaware City | | | | | X | | **X** | | X | | |
| McKee | | X | | | X | | | | | | |
| Anacortes | | | X | | | | | | | | |
| Chiba | | X | | X | | | | | | | |
| Richmond | | X | X | | | | | | | | |
| Torrance | X | X | X | | | X | X | | | | |
| San Juan Ixhuatepec | X | | | | | | | | | | |
| Buncefield | X | | | | X | | | | X | | |
| Bayamón | X | | | | | | | | X | | |
| Three Mile Island | | | | | | | | | X | | |
| Chernobyl | | | | | | | | | X | | |
| Fukushima Daiichi | | | | | | | | | | | |
| Gannon | | | | | X | X | **X** | | X | | |
| Dallman | **X** | | X | | | | | | | | |
| Flixborough | | X | X | | X | | | | X | | |
| Pasadena | X | | | | X | X | **X** | | | | |
| Castleford | | | | | X | | **X** | | X | | |
| Ellesmere Port | **X** | X | X | | | | | | | | |
| Hahnville | | | | | | | **X** | | | | |
| Geismar | | | | | | | | | | | |
| Moerdijk | | | | | | | | | X | | |
| Crosby | | | | | | | | | X | | |
| Seveso | | | | | | | | | X | | |
| Bhopal | X | | | | | | | | X | | |
| Toulouse | | | | | **X** | | | X | | | |
| La Porte | X | | | | | | X | | X | | X |
| West | | | | | X | | | | | | |
| Grimsby | | | | | | | | | | | |
| Kinston | | | | | | | | X | | | |
| Cork | | | | | | | | | X | | |
| Abbeystead | | | | | | | | | | | |
| Camelford | | | | | | | | | **X** | | |
| Milwaukee | | | | | | | | | | | |
| Hamlet | | X | | | X | | | | X | | |
| Louisville | X | X | | | | | | | | | |
| Port Wentworth | | | | | | | | X | X | | |

### Root Causes – Competency / Culture / Regulator

| Event | Communication | Procedures | Training | Supervision/Leadership | Contractor Selection | Production over Safety | Normalisation of Deviance | Quality Assurance/Control | Management of Change | Failure to Learn | Emergency Preparedness | Process Safety Management | Design Standards | Land Use Planning | Regulatory Compliance Audits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Piper Alpha | X | X | X | X | | | | | X | | X | X | | | |
| Mumbai High North | X | X | X | | | | | | | | | | | | X |
| Macondo | X | X | **X** | X | | | | | | | X | X | X | | X |
| Camarupim | X | X | X | X | | X | | | **X** | | X | X | | | X |
| Skikda | | | X | | | | | | | | X | X | X | X | |
| Longford | X | X | X | X | | | X | | | | X | X | | | X |
| Valdez | X | X | X | X | | | | | | | X | X | | | X |
| Lac Mégantic | | **X** | X | X | | X | | | X | | X | X | | | X |
| Feyzin | | **X** | X | | | | | | | | X | | X | | |
| Romeoville | | X | | | | | | | | | | | X | | |
| Grangemouth | | X | X | | | X | | | X | X | | X | | | |
| Milford Haven | X | | X | | | | | | X | | X | X | | | |
| Avon | | X | X | X | | X | | | X | | | X | | | |
| Izmit | X | | X | | | | | | | | **X** | X | | | X |
| Humber | X | | | | | | | | **X** | | | X | | | |
| Texas City | X | **X** | X | | | X | X | | X | X | | X | | | X |
| Delaware City | | X | X | | | | | | | | | | | | |
| McKee | | | | | | | | | **X** | | | | X | | |
| Anacortes | | X | | | | | X | | | | | X | X | | X |
| Chiba | | | X | | | | | | | | X | X | | X | |
| Richmond | | | | | | X | | | | | X | X | X | X | |
| Torrance | | X | | X | | | | | X | X | | X | | | |
| San Juan Ixhuatepec | | | X | | | X | | | **X** | | X | X | X | X | |
| Buncefield | X | X | X | | | X | | | X | | X | X | | X | |
| Bayamón | | X | X | | | X | | | | X | X | X | X | | |
| Three Mile Island | X | X | X | | | | | | | | X | | | | X |
| Chernobyl | X | X | X | | | X | | | **X** | X | X | X | | | X |
| Fukushima Daiichi | | X | X | | | | | | | | X | X | | | X |
| Gannon | X | X | | X | | | | | | | | X | | | X |
| Dallman | | X | X | | | | X | | | | | | | | |
| Flixborough | X | X | X | X | | X | | X | **X** | | X | X | | X | |
| Pasadena | X | X | X | | | | X | | X | X | X | X | | | |
| Castleford | | | X | X | | | | | X | X | X | X | | | |
| Ellesmere Port | X | X | X | | | | | | | | X | X | X | | |
| Hahnville | | X | | | | | | | | | | | | | |
| Geismar | X | X | | | | | | | **X** | X | | X | | | |
| Moerdijk | **X** | X | X | | | | | | X | X | X | X | | | X |
| Crosby | X | | | | | | | | | | X | X | X | X | |
| Seveso | X | **X** | | | | | X | | | | X | X | X | | |
| Bhopal | | X | X | X | | X | | | X | | X | X | | X | |
| Toulouse | | X | X | | | | | | | X | X | X | | X | X |
| La Porte | X | X | X | | | | X | | X | X | X | **X** | X | | X |
| West | | | X | | | | | | | X | X | | | X | X |
| Grimsby | | X | | | | | X | | X | | | | | | |
| Kinston | X | X | X | | | | | | | | | X | X | | |
| Cork | | X | X | | | | | | | | X | | X | | |
| Abbeystead | | X | X | | | | | | X | | | | X | | |
| Camelford | X | X | X | | | | | | | | X | X | | | |
| Milwaukee | | | X | | | X | | | | | X | | | | |
| Hamlet | X | | X | | | X | X | | X | X | X | X | X | | **X** |
| Louisville | X | X | X | | | | | | | X | | | | | X |
| Port Wentworth | X | X | X | X | | | X | | X | X | X | X | | | X |