

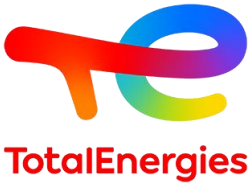
TotalEnergies

Management of Critical Barriers

TSC EPSC

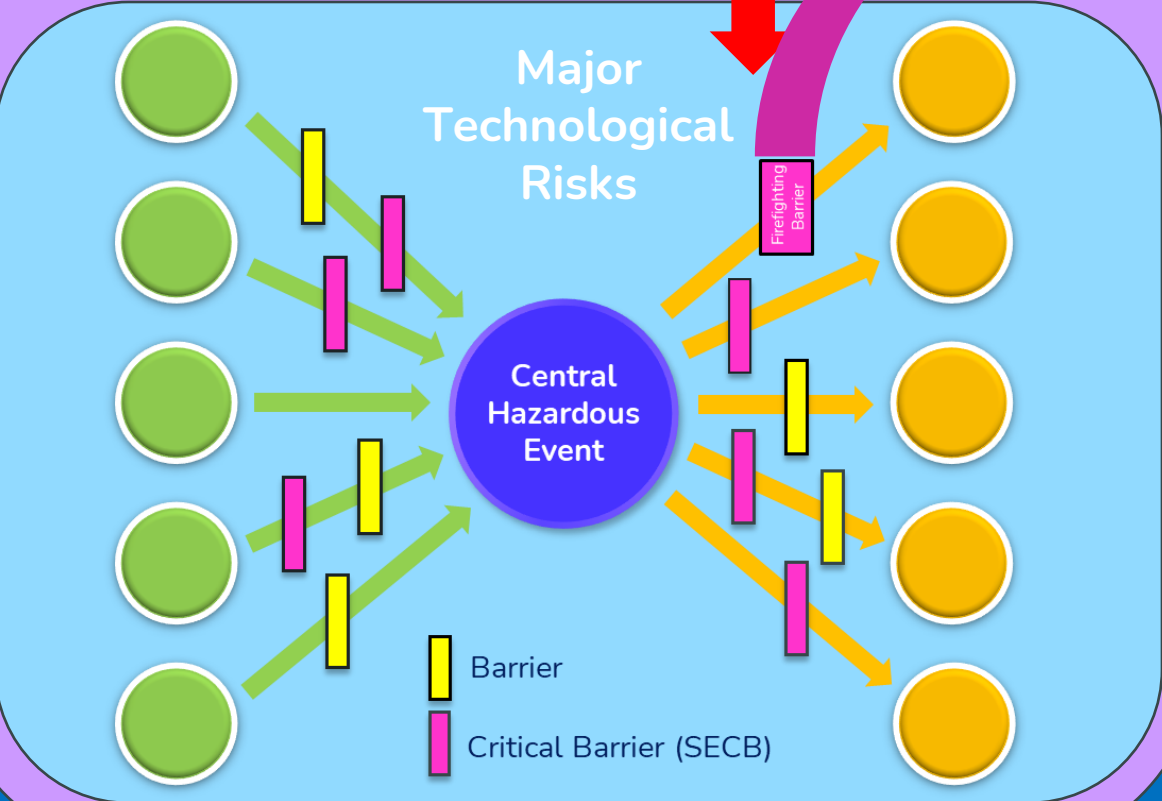
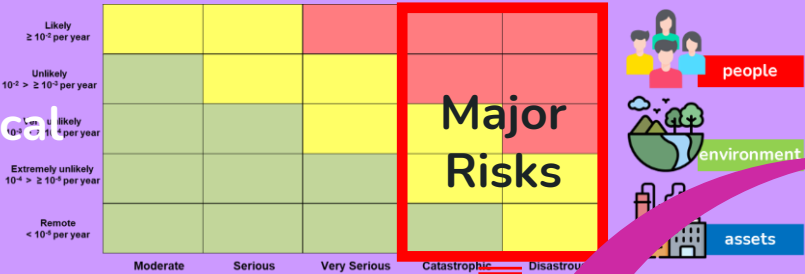
Merseburg, October 2025

Critical Barriers (SECB) and Critical Barrier Elements (SECE)

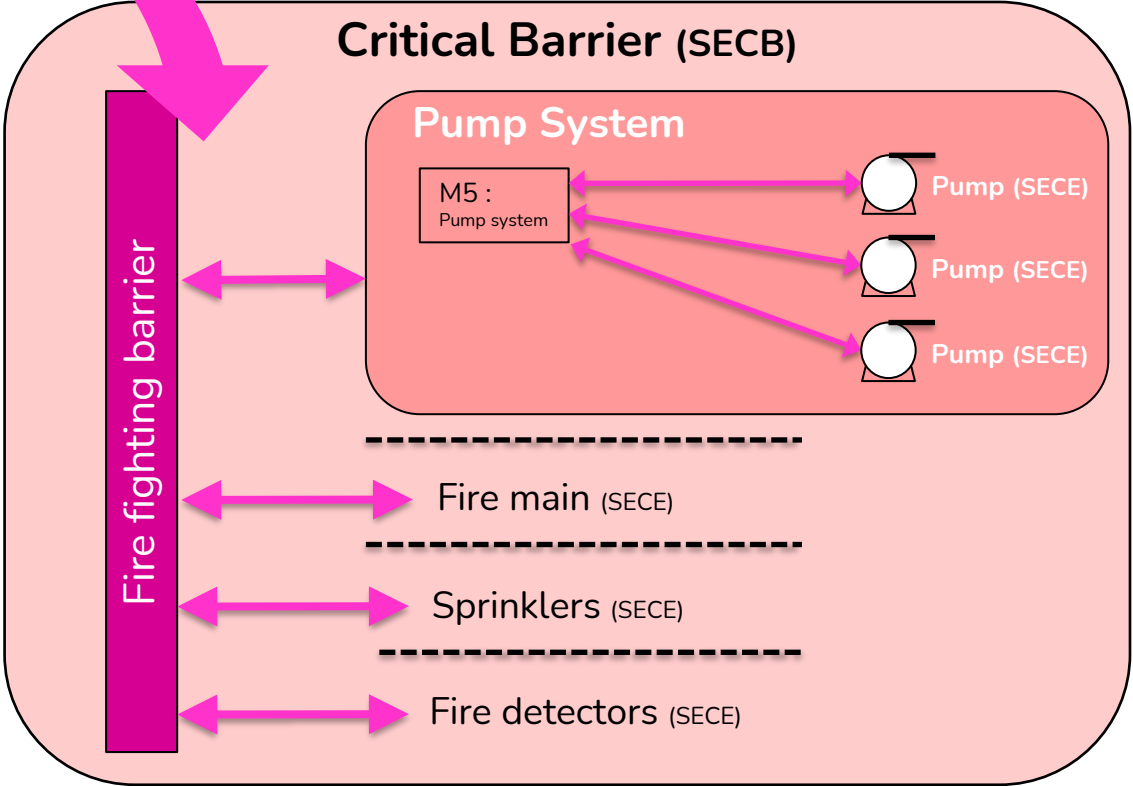


All Risks (occupational, societal, financial,...)

Technological Risks



A barrier (SECB) is usually composed of one or more systems, each of them being themselves composed of either a single or a group of similar, sometimes redundant equipment (SECE)



SECB: Safety & Environment Critical Barrier
SECE: Safety & Environment Critical Element

Basics of Barrier Management

Application of our Technical Referential
and Industry Good Design Practices



CR-GR-HSE-GR-301 / GS-GR-HSE-312

Step 1: Hazard Identification

- Inventory of hazards
- Reduction of hazards
- Central hazardous events register

Step 2: Preliminary Risk Analysis

- Semi-quantitative selection of scenarios to be studied in detail

Step 3: Detailed Risk Analysis

- Quantitative analysis of scenarios
- Evaluation of risk using Company risk matrix

Step 4: Risk Treatment

- Risk reduction measures
- ALARP demonstration

Step 5: Risk Control

- Action Plan
- TRA summary report including major risks and (critical) barriers

Critical Barriers



Step 1: Decomposition of Critical Barriers

- Decompose critical barriers (SECB) in their critical elements (SECE and HCBC)

Step 2: Development of Performance Standards

- Develop minimum assurance tasks (requirements) for all critical barriers (SECB) and all associated critical elements (SECE)

Step 3: Integration in CMIMS Workflow

- Integrate SECB and SECE information in the CMIMS workflow (TAGs, inspection frequencies, procedures to be used,...)

Step 4: Assurance Activities

- Develop assurance activities for critical barriers (SECB) and associated critical elements (SECE) to ensure that performance standards are met upon activation of the critical barrier
- Develop test program for SECB and ITPM plan for all SECE

Step 5: Execution of Assurance Activities

- Execute the barrier test program and ITPM program (including preventive and corrective maintenance)

Step 6: Management of Non-Conformities

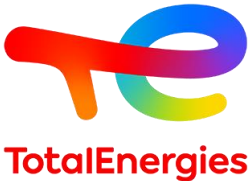
- Manage non-conformities with respect to performance standards or assurance activities (e.g. compensating measures for degraded or bypassed critical barriers, management of inspection or maintenance backlog,...)

Step 7: Monitoring of Performance

- Periodic reporting of the status of critical barriers
- Steering committee managing the performance of critical barriers and the major technological risks action plan

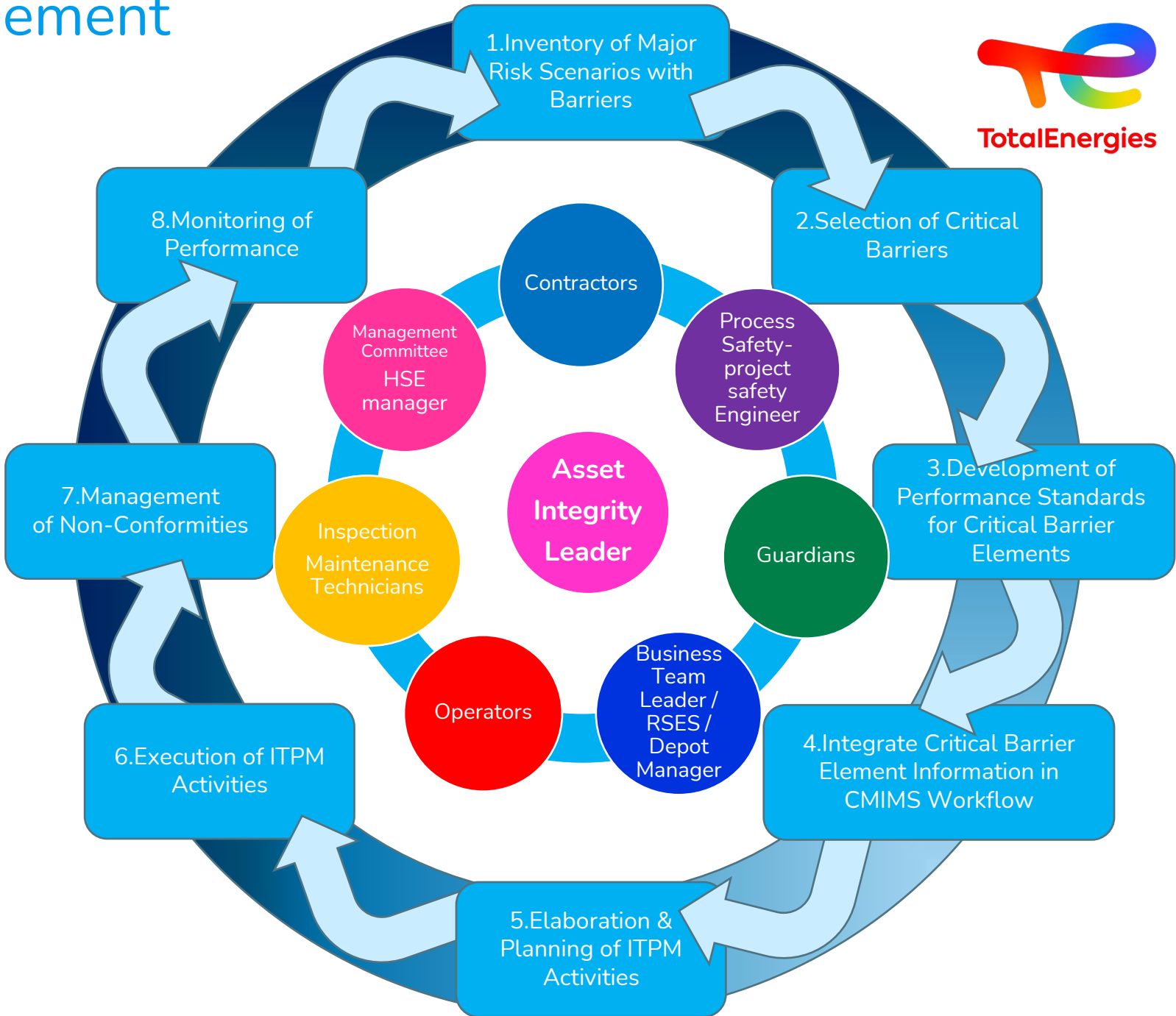
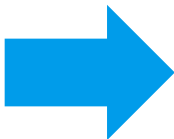
CR-GR-HSE-GR-401 / GS-GR-HSE-311

Basics of Barrier Management



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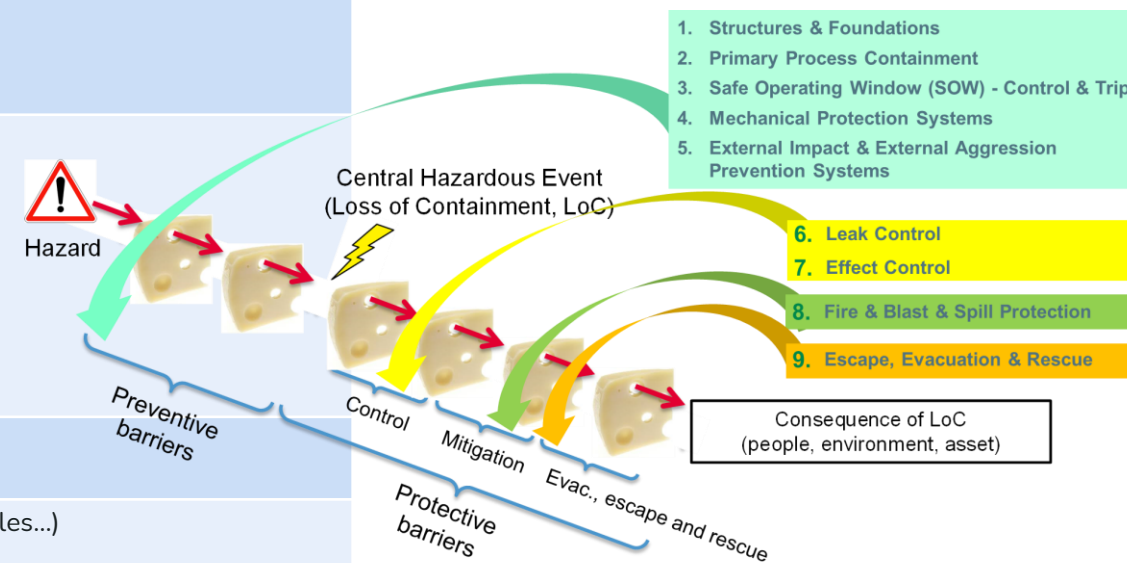
CR-GR-HSE-GR-401 / GS-GR-HSE-311



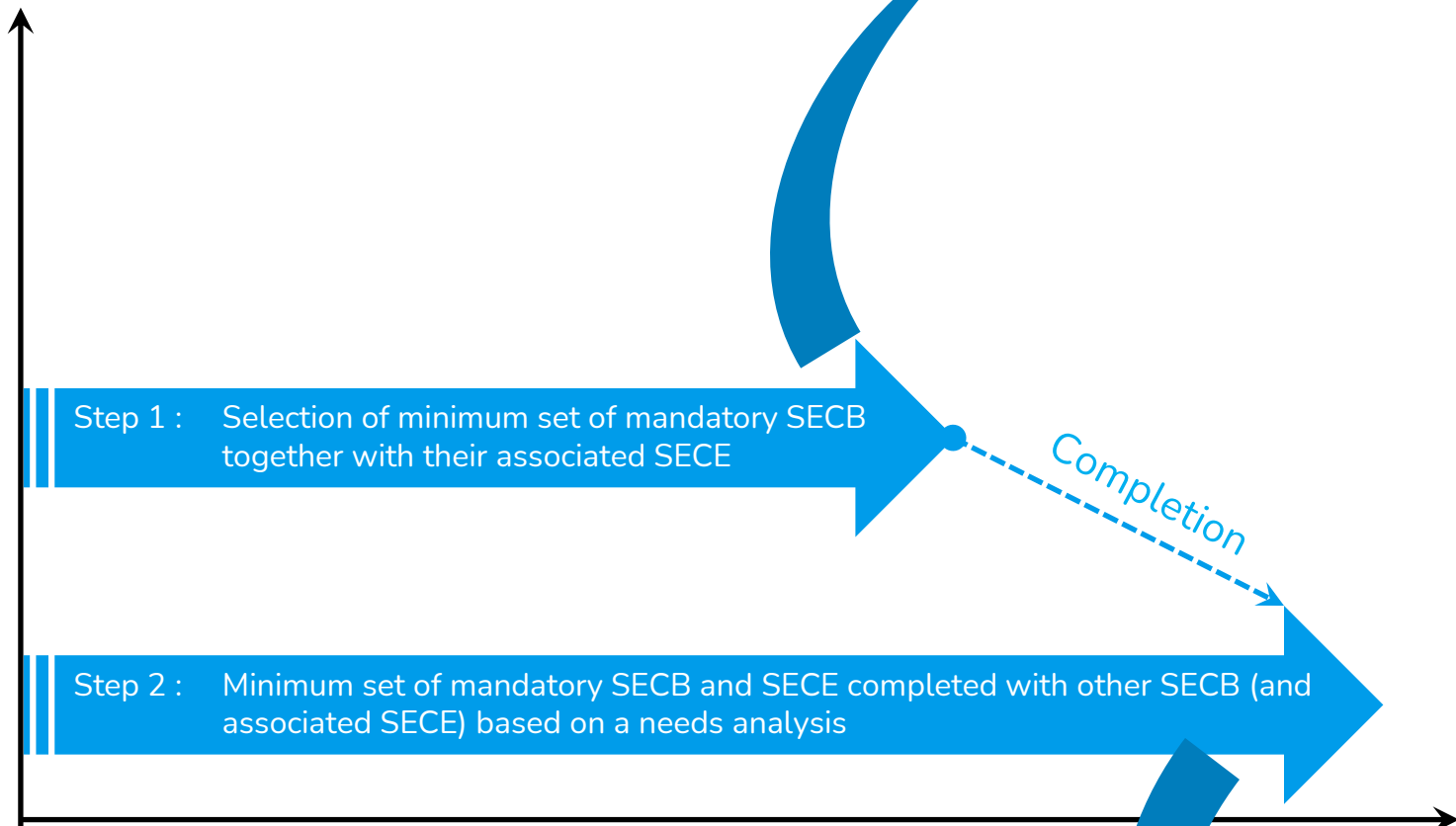
CMIMS Computerized Maintenance & Inspection Management System
ITPM Inspection, Testing & Preventive Maintenance

Barriers Categories: Examples

Critical Barrier Category	Applicable Systems
Structures and Foundations	Supporting structures
Primary Containment Systems	- Storage vessels - Process vessels - Piping - Pipelines
Safe Operating Window, Control & Trip	Safety Instrumented Systems (sensor +logic solver + actuator). Examples include: - Overfill protection - Overpressure protection - High temperature protection - Reaction killing systems
Mechanical Protection Systems	- Pressure relief devices (safety valves, 2-way pressure/vacuum valves, RD,...) - Mechanical interlocks and mechanical safety systems
External Impact & External Aggression Protection	- Riser protection - Cathodic protection - Building pressurization
Leak Control Systems	- Detection with operator action - Emergency shutdown & isolation systems - Blowdown & emergency depressurization systems - Rapid dump systems - Fire detection systems (with automatic action) - Gas detection systems (with automatic action) - Liquid detection systems (with automatic action) - Breakaway system or coupling
Effect Control Systems	- Ignition prevention systems - Secondary containment systems
Fire, Blast & Spill Protection Systems	- Firewater systems (including pumps, headers, nozzles...) - Explosion mitigation systems
Escape, Evacuation & Rescue Systems	- Lifeboats - Other rescue & evacuation systems



Selection of SECB / SECE

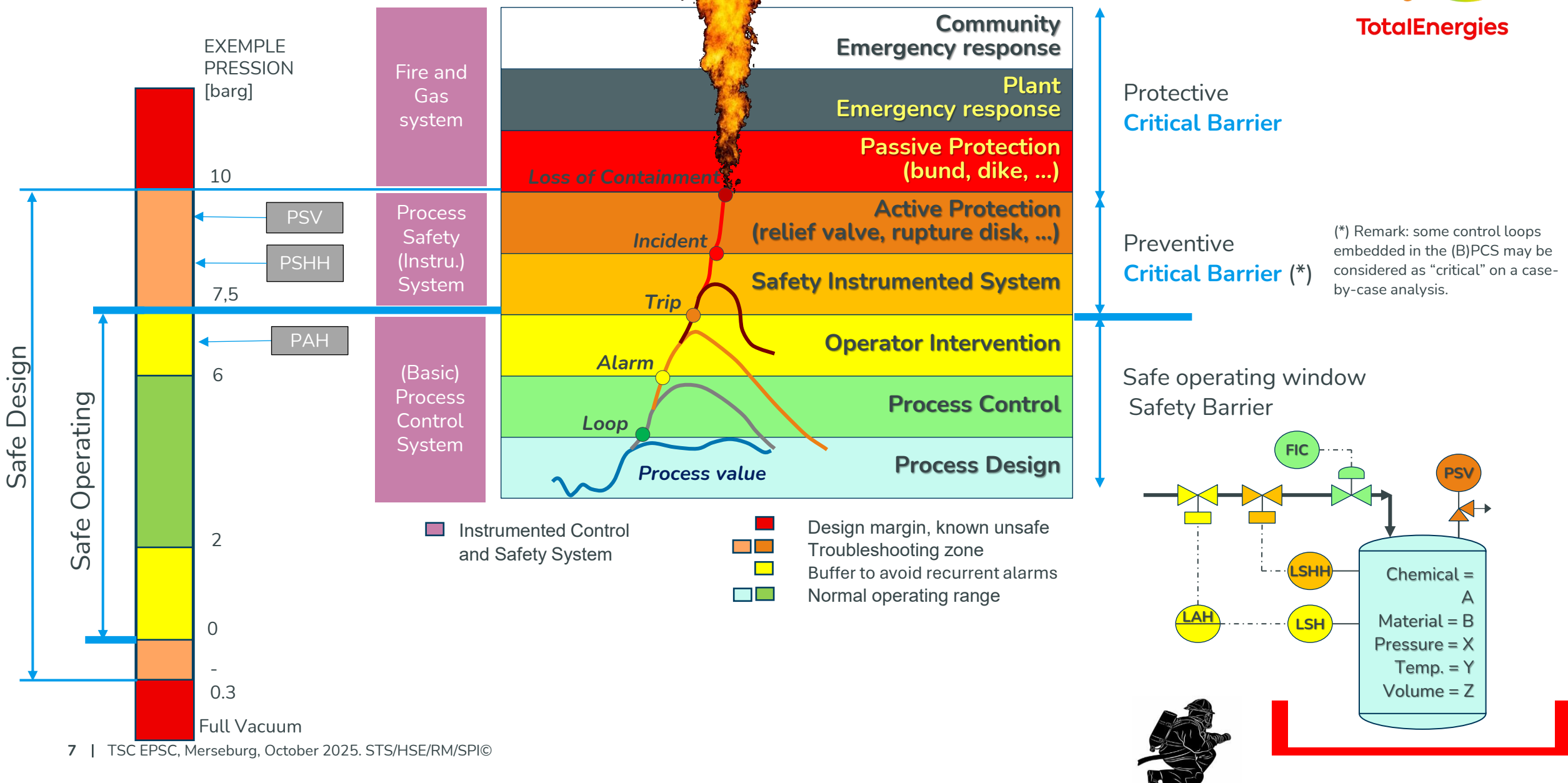
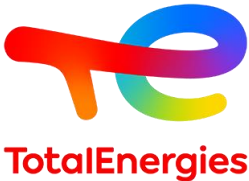


Number of critical barriers

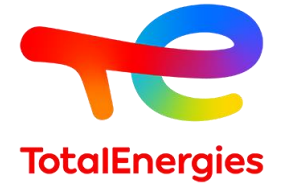
Critical Barrier Category	Examples of Mandatory Critical Barriers
Safe Operating Window, Control & Trip	Safety Instrumented Systems (SIS) or logic solver + actuator). Examples include: ○ Overfill protection ○ Overpressure protection ○ High temperature protection (RC) ○ Reaction killing systems (RC) ○ HIPS ○ Cathodic protection
Mechanical Protection Systems	○ Pressure relief devices (safety valves, 2 ways pressure vacuum valves, , rupture discs,...) ○ Mechanical interlocks and mechanical safety systems
Leak Control Systems	○ Emergency shutdown & isolation systems ○ Blowdown & emergency depressurization systems ○ Rapid dump systems (RC) ○ Fire, gas or liquid detection systems with automatic action ○ Breakaway system or coupling
Fire, Blast & Spill Protection Systems	○ Firewater systems (including pumps, headers, nozzles...) ○ Explosion mitigation systems ○ Pollution detection and associated equipment
Offshore Specific Barriers	○ Temporary Refuge with HVAC / Fire Dampers ○ Mooring Systems, hull of floating systems (FPSO,...) ○ Equipment needed for the Escape Barrier (including routes, rescue systems, Emergency Lighting, Lifeboats,...)

- REQ1 The SECB is a passive or an active barrier that interacts directly with the system during the propagation (prevention or protection of a major accident scenario)
- REQ2 The SECB is independent from the considered initiating event and other barriers intervening in the same scenario path.
- REQ3 The technological part of the SECB is testable and maintainable (supported by a performance standard)
- REQ4 The SECB is reliable, available, robust, effective, with a response time compatible with the speed of propagation of the major accident scenario and able to fulfill its function under emergency conditions.
- REQ5 Process related SECB have a Probability of Failure on Demand of maximum 0.1 and have an adequate test interval to ensure the reliability level. They must on its own reduce the probability of the major accident scenario by at least a factor of 10 or reduce the potential consequences by at least 1 severity category in the TotalEnergies risk matrix

Safe Operating Windows



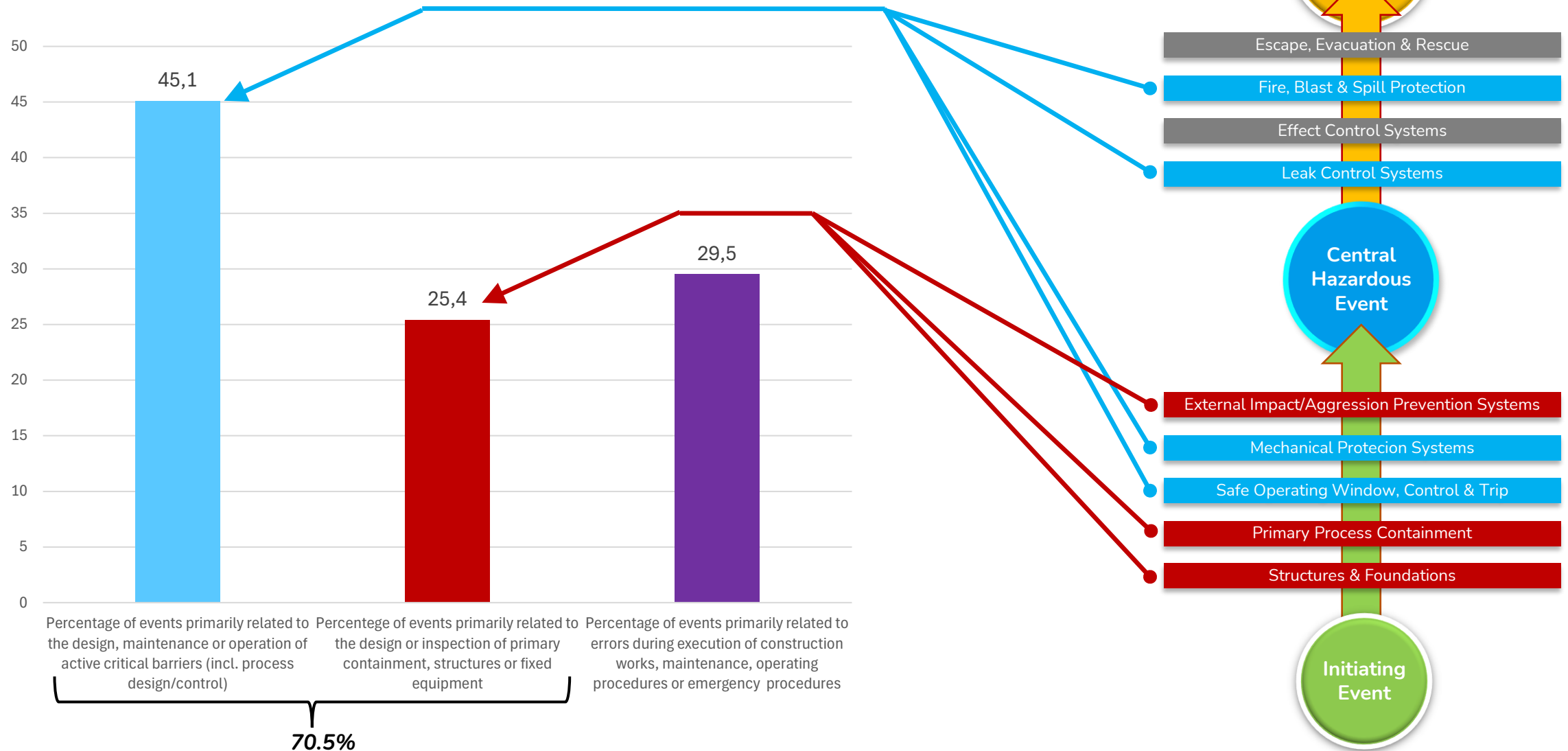
Return on Experience



- A review was performed of 120 major accidents in oil & gas industry, following the criteria of TotalEnergies for major accidents, being
 - ≥ 2 fatalities, or
 - ≥ 10 M€ asset damage, or
 - Extensive pollution affecting ecosystems of recognized ecological interest
- For each of these cases, a classification was done in the following categories.
 - Event primarily related to the design, maintenance or operation of active critical barriers (including process design & control)
 - Event primarily related to the design or inspection of primary containment or equipment
 - Event primarily related to errors during execution of construction works, maintenance, operating procedures or emergency procedures

Major Accidents in All Categories (people, environment, assets)

120 Cases

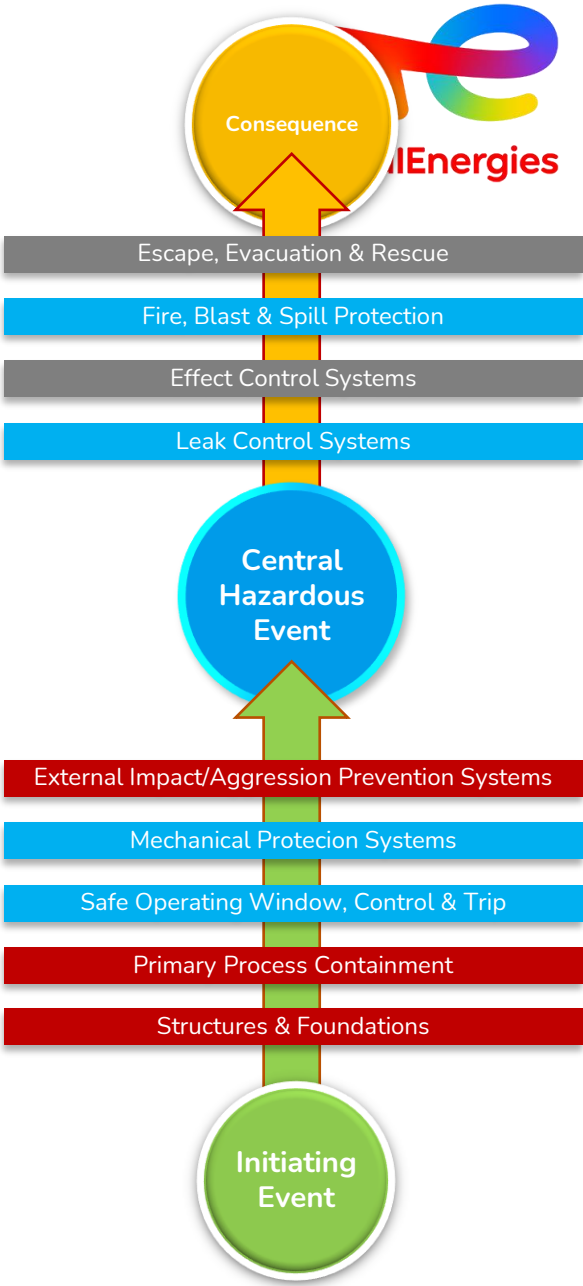
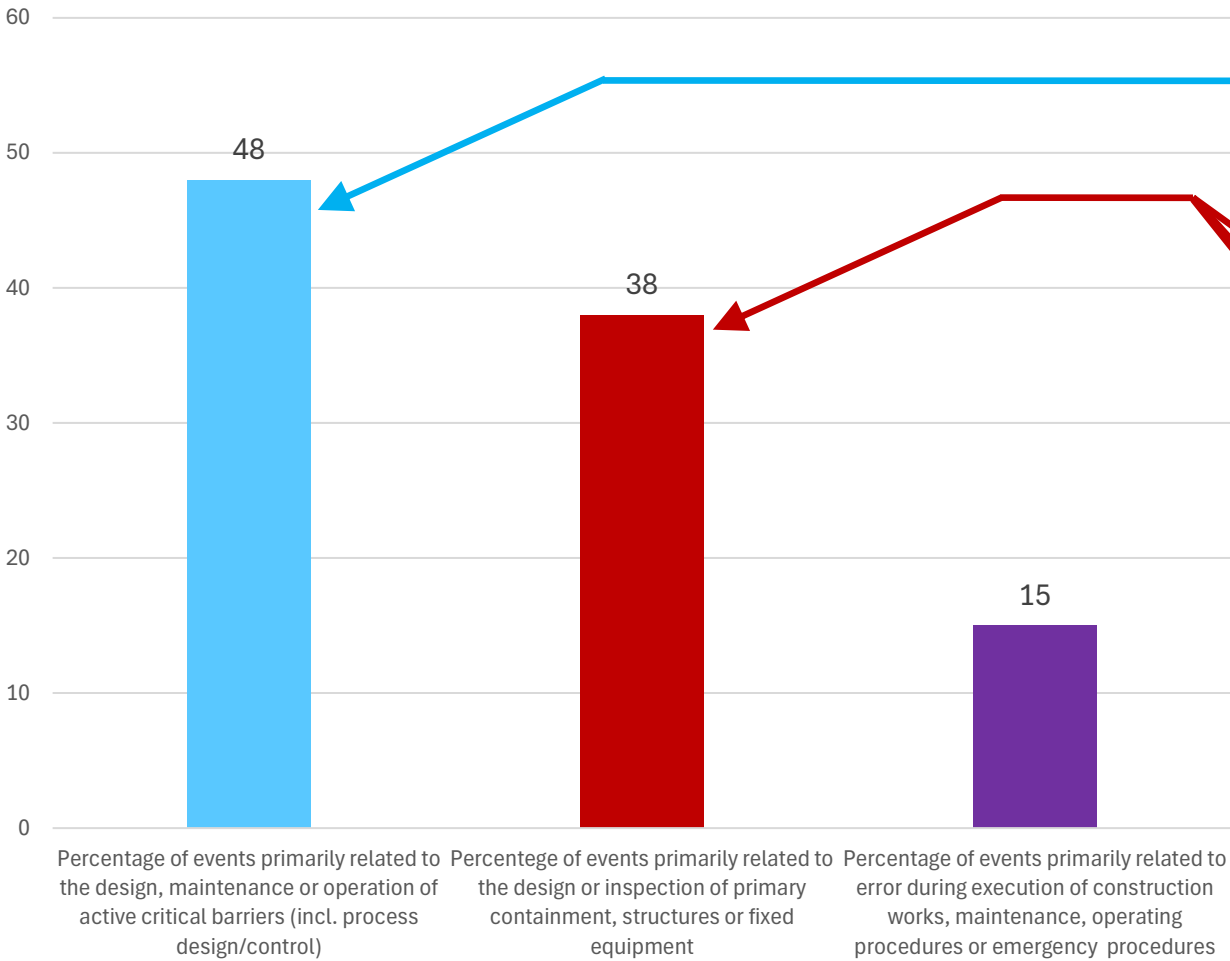




Landmark Historical Major Accidents (40 Cases)

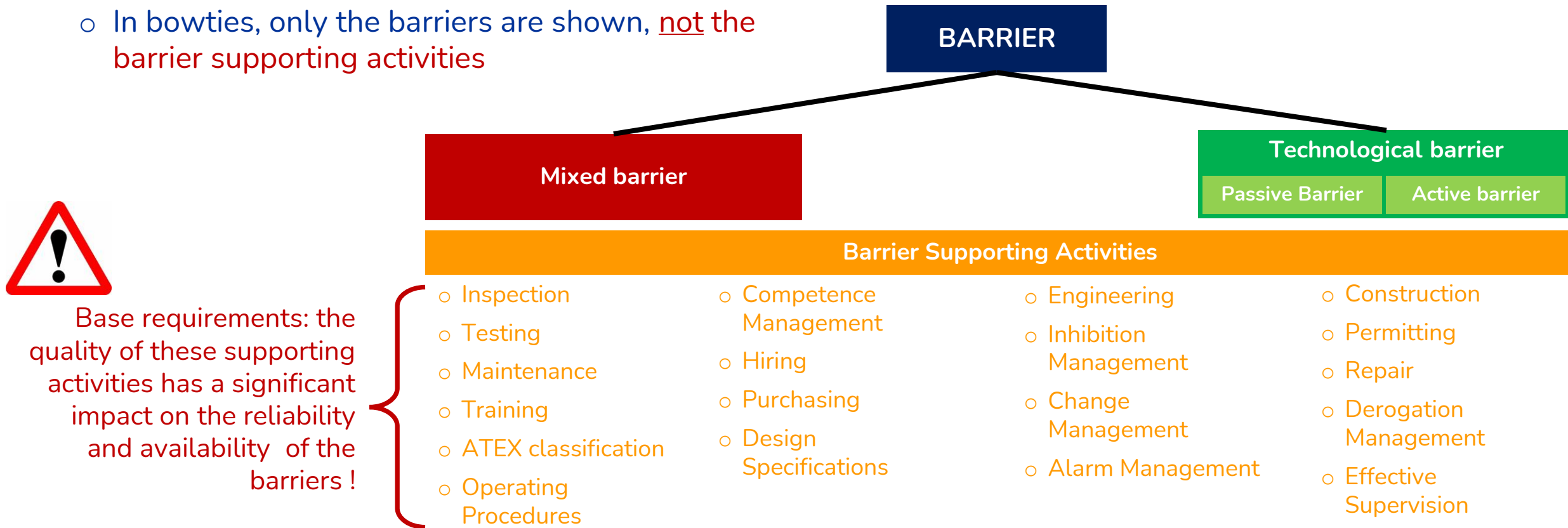
Landmark Historical Major Accidents

40 Cases



Critical Barriers vs Critical Barrier Supporting Activities

- If the interaction with a major accident scenario is **not direct and immediate**, then we do not speak of a barrier as such but more of a **barrier supporting activity** that are base requirements to ensure that the barrier is well designed, kept fit for purpose and working in the appropriate environment
- In bowties, only the barriers are shown, **not the barrier supporting activities**



Barriers and Barrier Supporting Activities

Initiating events

High Pressure

Overfilling

Drain left open by operator (due to lack of training or unclear procedures)

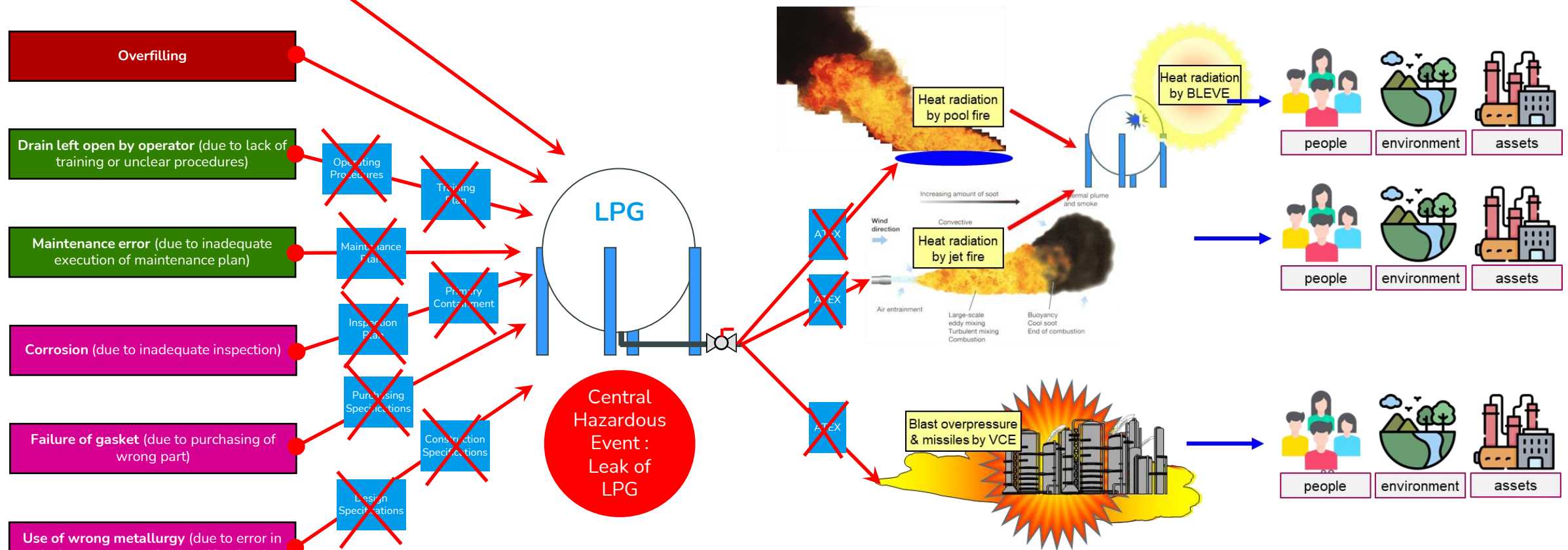
Maintenance error (due to inadequate execution of maintenance plan)

Corrosion (due to inadequate inspection)

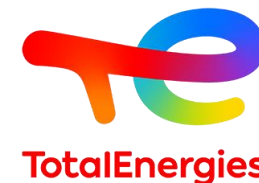
Failure of gasket (due to purchasing of wrong part)

Use of wrong metallurgy (due to error in design or construction specifications)

- Barriers need to be fully independent of their corresponding initiating event. An inspection plan or primary containment cannot be a barrier for corrosion since corrosion (as an initiating event) is related to failure of the inspection plan (wrong or incomplete plan, wrong execution of the plan etc.) and also related to failure of the primary containment. The same is true for other programs or plans (training, operating procedures, maintenance plans etc.) that are related to the initiating event (see examples in the bowtie below).
- Barriers need to be independent of design characteristics of equipment. ATEX certification of equipment is not to be considered as a barrier since part of the design basis.



Use of Major Accident Bowties with SECB

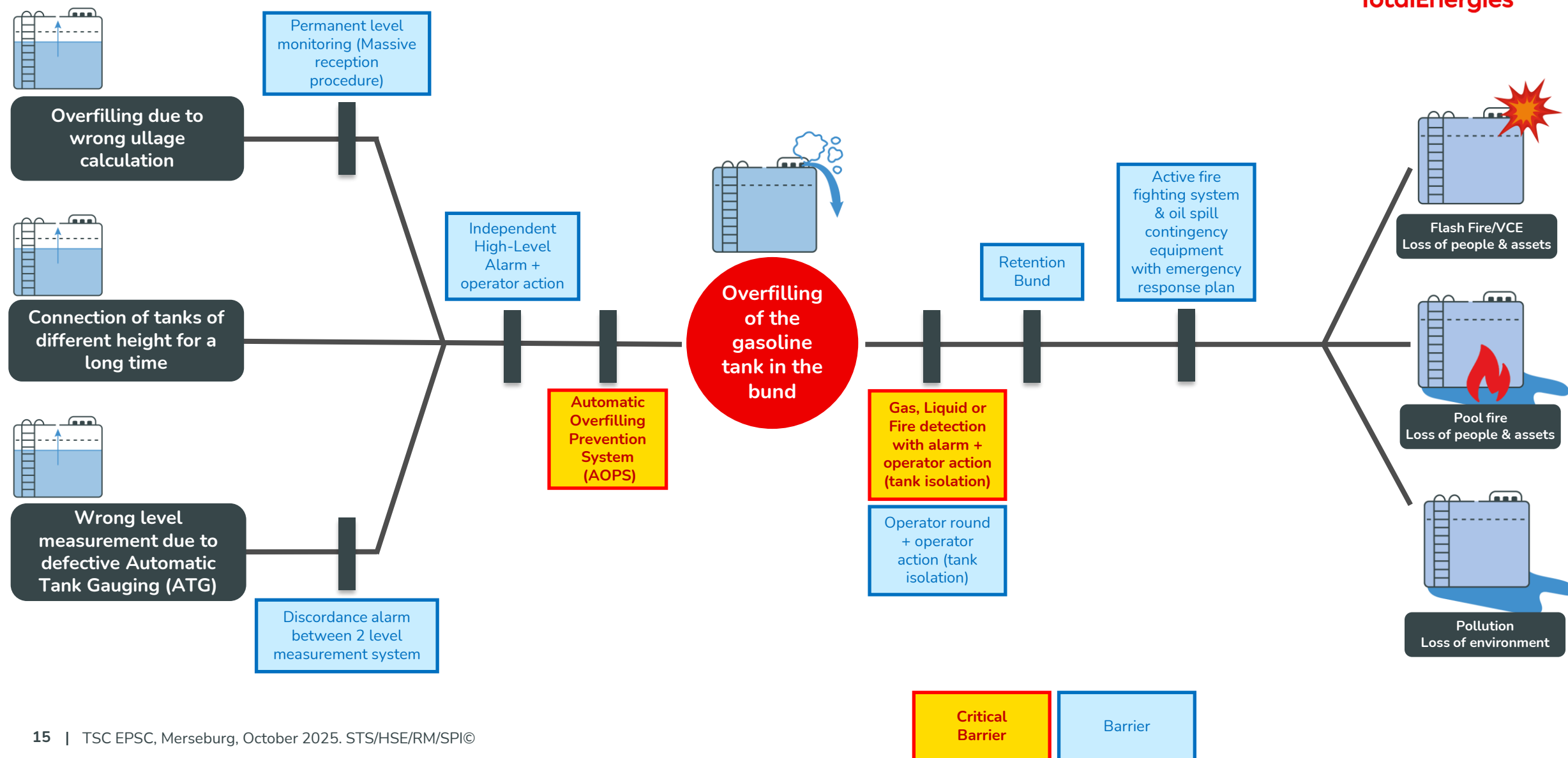


- The use of bowties for generic major accident scenarios together with the indication of barriers as well as SECB for each of these scenarios may be interesting for the following reasons:
 - ✓ Rationalization of the total number of SECB and SECE
 - ✓ Consistency of selection of major accident scenarios with SECB between sites of the same Branch
 - ✓ Consistency of SECB selection for similar major accident scenarios in different Branches
 - ✓ A simplified example is given on the following slide
- The use of Guides & Manuals with generic major accident scenarios for units in TotalEnergies can be used for this purpose. The ambition is to produce these Guides & Manuals for all activities in TotalEnergies exposed to major accident risks (long term plan).

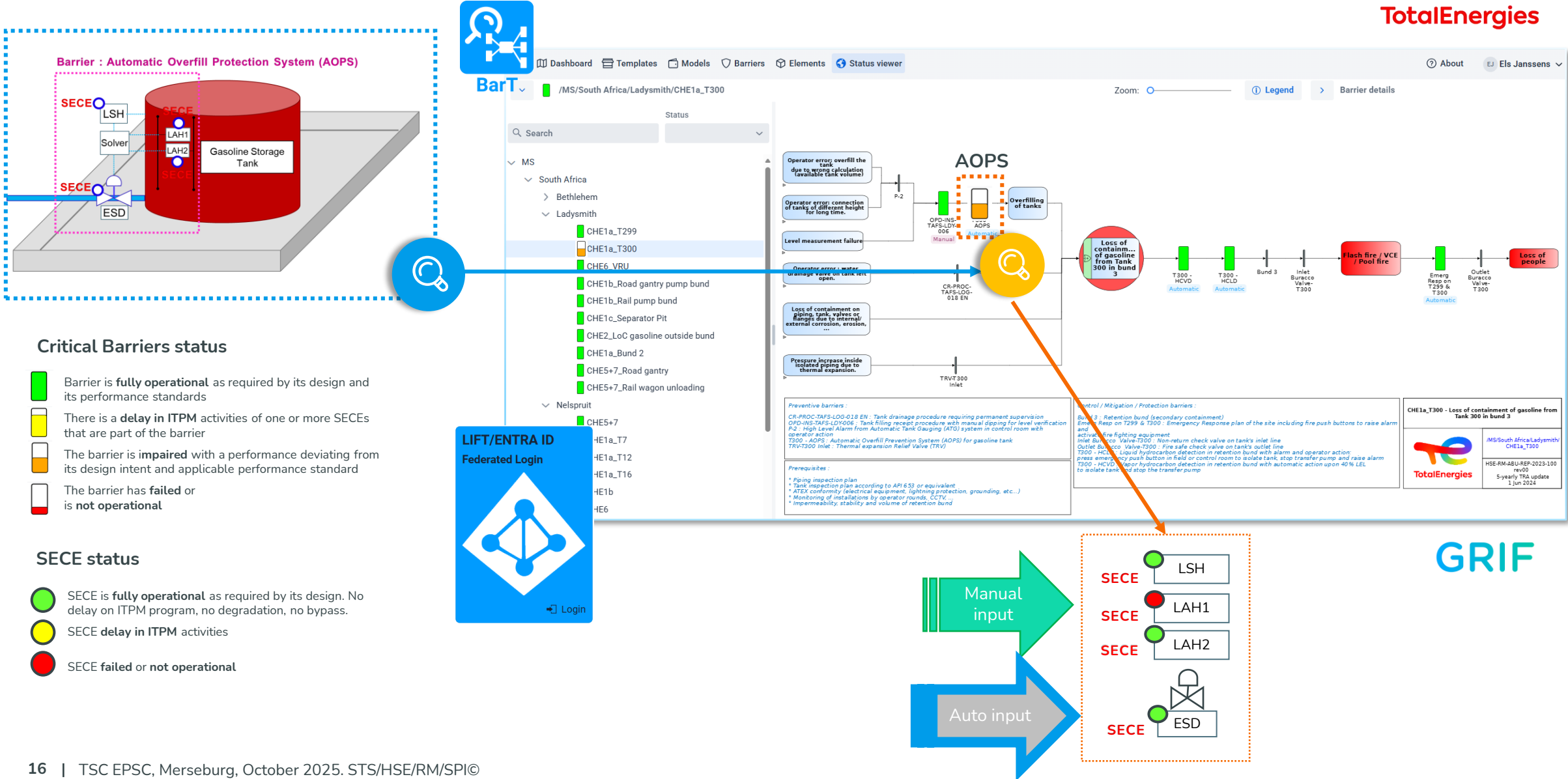
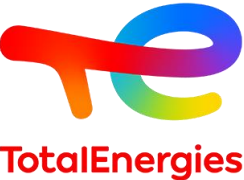


GM-GR -HSE-316 Integrity and Critical Barriers Management
GM-GR -HSE-320 Major scenarios and Safety & Environment barriers for Fluid Catalytic Cracker (FCC)
GM-GR -HSE-321 Major scenarios and Safety & Environment barriers for Steam Cracker
GM-GR -HSE-322 Major scenarios and Safety & Environment barriers for HDPE
GM-GR -HSE-323 Generic HAZOP for Thermal Fluid Heaters
GM-GR -HSE-324 Major scenarios and Safety & Environment barriers for HydroDeSulfurisation (HDS)
GM-GR -HSE-325 Major scenarios and Safety & Environment barriers for Reformer
GM-GR -HSE-326 Major scenarios and Safety & Environment barriers for Distillation
GM-GR -HSE-327 Major scenarios and Safety & Environment barriers for PolyPropylene Units (PP)
GM-GR -HSE-328 Major scenarios and Safety & Environment barriers for HF Alkylation
GM-GR -HSE-329 Generic Scenarios for Storage tanks
GM-GR -HSE-330 Generic Scenarios for LPG storage
GM-GR -HSE-331 Generic HAZOP for Boilers
GM-GR -HSE-332 Generic HAZOP for Low Temperature Furnaces
GM-GR -HSE-333 Generic HAZOP for Pumps and Compressors

Use of Generic Major Accident Bowties with SECB



Digital Tool for Follow-Up of the Status of Critical Barriers



Demo of Visualization Tool



BarT - Login

[illegible]