From PHA to Living BowTies:

Using AI to Close the Gap Between Analysis and Operations

Mariante van der Merwe
Product Manager: PSM
Alwin van Aggelen
PSM SME

Wolters Kluwer

Mariante van der Merwe

Product Manager:
PSM (PHA, BowTieXP & Barrier Management)

Alwin van Aggelen

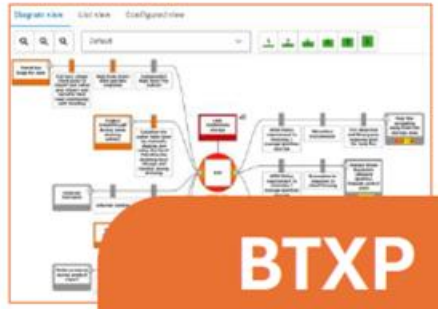
Subject Matter Expert:
PSM (PHA, BowTieXP & Barrier Management)

Are you good or lucky?

1. Do you understand what can go wrong if critical SECB and SECE fail?
2. Do you know what systems prevent this from happening and how they are performing right now?
3. Do you have information to assure they are working effectively in real time?

ADVANCED RA (PHA)

HAZID, HAZOP, LOPA

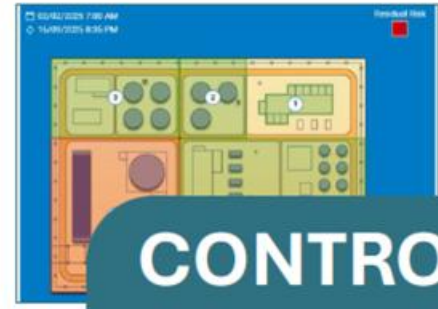


BTXP ENTERPRISE

Bowtie Diagram Intelligence

BARRIER MGMT

Automating Barrier Health Validation



CONTROL of WORK

PtW, JHA/RA, Isolation/LOTO, Cumulative Risk

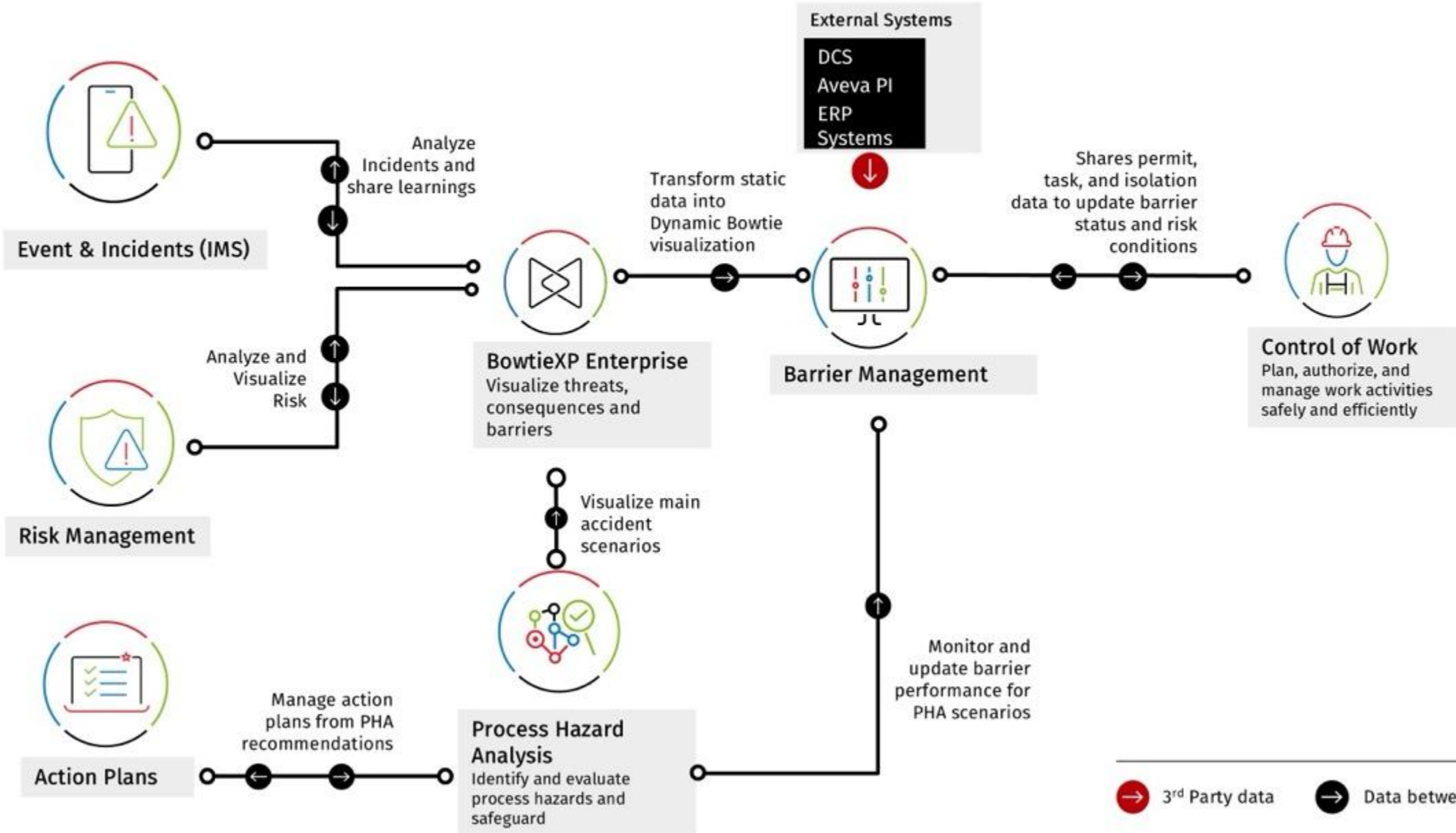
IDENTIFY

UNDERSTAND

PROACTIVELY MANAGE

EXECUTE

Proactive Risk Management in a Process Safety and Control of Work context



Applications

- Action Plans
- Audit
- Authentication
- Barrier Management
- BowTieXP Enterprise
- Business Continuity Management
- Change
- Chemical
- Compliance
- Control of Work
- Environmental
- Field Operations
- Health & Safety
- Metrics
- Open Insights
- Process Hazard Analysis
- Proficiency
- Report Vision

Node

6. Node F (MOC-March 2026) - Reactor Tank #2 to Product Sepa

Open node details

Save node | Complete node

HAZOP worksheet | LOPA worksheet

Undo | Redo | Add | Copy | Paste | Cut | Delete | Full screen

Deviation	Cause	Consequence	CAT	Inherent risk			Safeguard	Current risk			HAZOP recommendation
				S	L	RR		S	L	RR	
6.1. More/High Flow	6.1.1. Solenoid valve on the outlet line from the Reactor (R-101) tank fails open.	6.1.1.1. Increased flow from reactor to heat exchanger. Increased demand.	A	C	2	3	1. High pressure alarm 2. Authorized / Controlled Access to Feed Tank(s) Area 3. Redundant pump (Spare) 4. HMI 5. Manual pressure and temperature gauges	D	2	4	1. Implement changes afte the emergency response p
6.2. Spare	6.2.1. Lack of spare parts for Reactor #2 (R-201).	6.2.1.1. Operational shut down or loss due to inadequate spare supplies for the Reactor.	A	B	2	2	1. Authorized / Controlled Access to Feed Tank(s) Area	C	2	3	1. Reactor #2 (R-201) has s sensors and level indicato replacement.
6.3. Low / Less Temperature	6.3.1. Loss of cooling to the Reactor #2 (R-201) cooling jacket from closed valve, SV-2021	6.3.1.1. Over pressurization of Reactor #2 (R-201) leading to loss of containment (chemical release) from reactor. Chemical release to environment and site. Potential safety issues and exposure to employees and environment.	A	B	2	2	1. High pressure alarm 2. High pressure interlock 3. Pressure relief system 4. Safety Cut-Outs 5. Emergency Action / Response Plan 6. Emergency Eyewash / Safety Shower	D	1	4	1. Review emergency actio procedures for emergenci chemical process system
6.4. High / More Temperature	6.4.1. Fire near reactor.	6.4.1.1. Explosion and release of chemicals to environment and site. Offsite release.	A	B	1	1	1. Emergency Action / Response Plan	B	2	2	
6.5. High / More Pressure	6.5.1. Loss of cooling to the Reactor #2 (R-201) cooling jacket from closed valve, SV-2021	6.5.1.1. Over pressurization of Reactor #2 (R-201) leading to loss of containment (chemical release) from reactor. Chemical release to environment and site. Potential safety issues and exposure to employees and environment.	A	A	2	1	1. High pressure alarm 2. High pressure interlock	C	2	3	1. Review emergency actio procedures for emergenci chemical process system

Node

6. Node F (MOC-March 2026) - Reactor Tank #2 to Product Sep:

Open node details

Save node | Complete node

HAZOP worksheet | LOPA worksheet

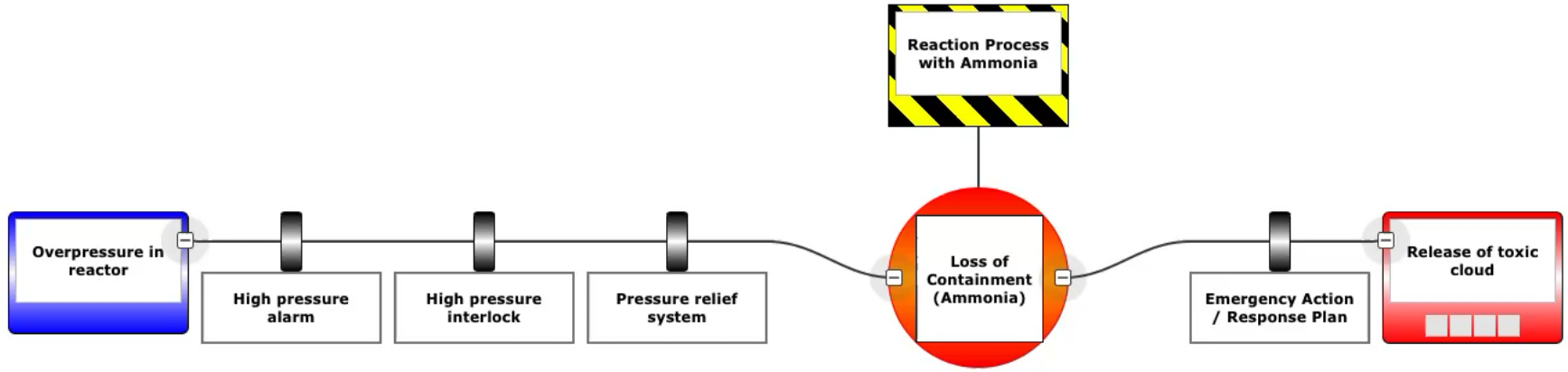
Undo | Redo | Add | Copy | Paste | Cut | Delete | Full screen

Deviation	Initiating event	IEF	Enabling condition	ECP	Consequence	CAT	S	L	RR	TMEL	Conditional modifier	CMP	Safeguard	IPL?	PFD	MEL
6.5. High / More Pressure	6.5.1. Loss of cooling to the Reactor #2 (R-201) cooling jacket from closed valve, SV-2021	5E-1	Not required	1	6.5.1.1. Over pressurization of Reactor #2 (R-201) leading to loss of containment (chemical release) from reactor. Chemical release to environment and site. Potential safety issues and exposure to employees and environment.	A	A	2	1	5E-4	Occupancy factor (0.3)	0.3	High pressure alarm	☑	0.1	1.50E-5
													High pressure interlock	☑	0.01	
													Pressure relief system	☑	0.1	
													Safety Cut-Outs	☐		
													Emergency Action / Response Plan	☐		

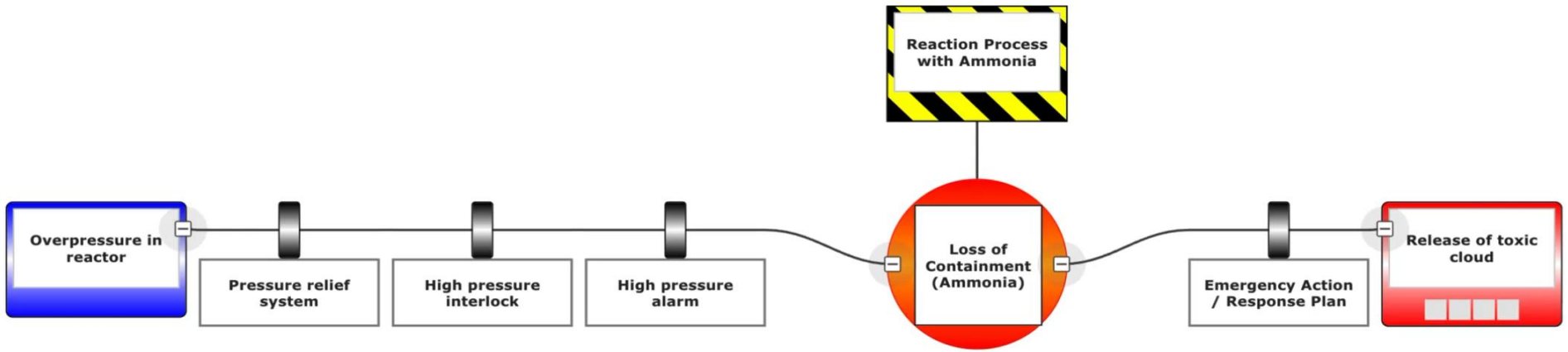
Filter | New Hazard | Drafts 0 | Add action | Default | 1 2 3 4 5 6

Search

- Road Safety (Global)
- Road Safety (Local NL)
- Road Safety (Local UK)
- Road Safety (Local NO)
- Road Safety (Not Assigned)
- Oil & Gas
- Aviation
- Maritime
- Mining
- Healthcare
- IT
- SIR BowTies
- H&S Severe and Fatal Hazards
- H&S Job Hazard Analysis
- Chemical
- Water Treatment
  - Cooling Tower Operation / Contaminated Cooling Water
  - Reaction Process with Ammonia / Loss of Containment (A
  - Discharge to River of Treated Water / Bioreactor upset
- Occupational Safety
- Others
- MAH
  - Reaction Process with Ammonia / Loss of Containment (A
- Shell Energy and Chemicals Park Rotterdam (Pernis) - Unit 5



Save changes | Cancel editing | Expert AI | Default



Filter | + New Hazard | Drafts 0 | Add action | 2 Eff. + Barrier type | 1 2 3 4 5 6

Search

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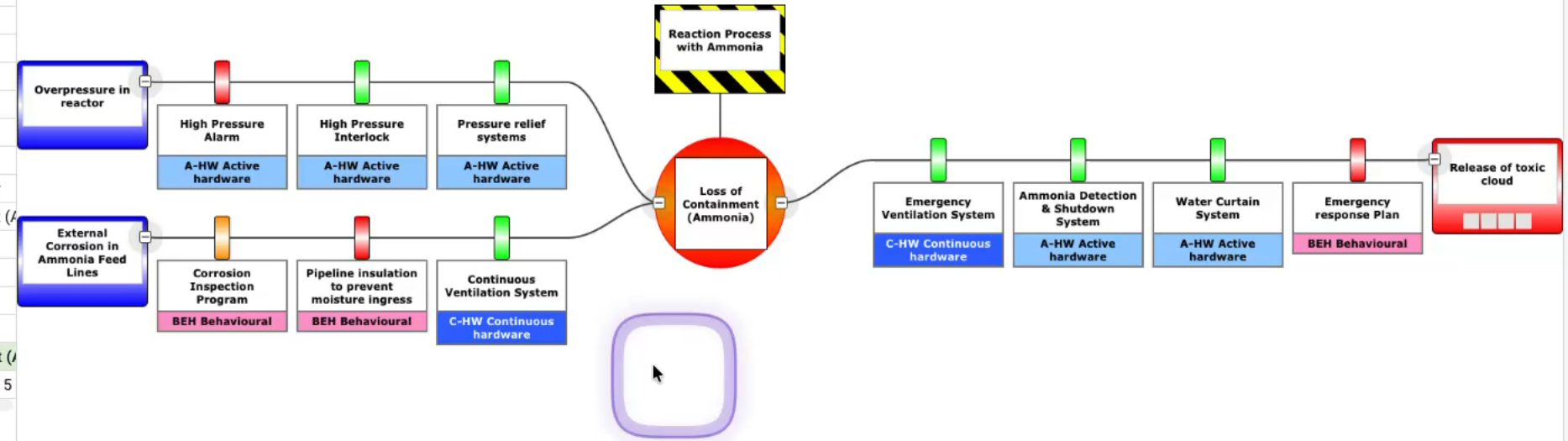


03/10/2026

Home
Saved
Apps
Help
BR

Set to current shift

Mon	Tue	Wed	Thu	Fri	Sat	Sun
DS NS	DS NS	DS NS	DS NS	DS NS	DS NS	DS NS
Apr 20	Apr 21	Apr 22	Apr 23	Apr 24	Apr 25	Apr 26

Health calculated at 2026-04-20 09:13 UTC

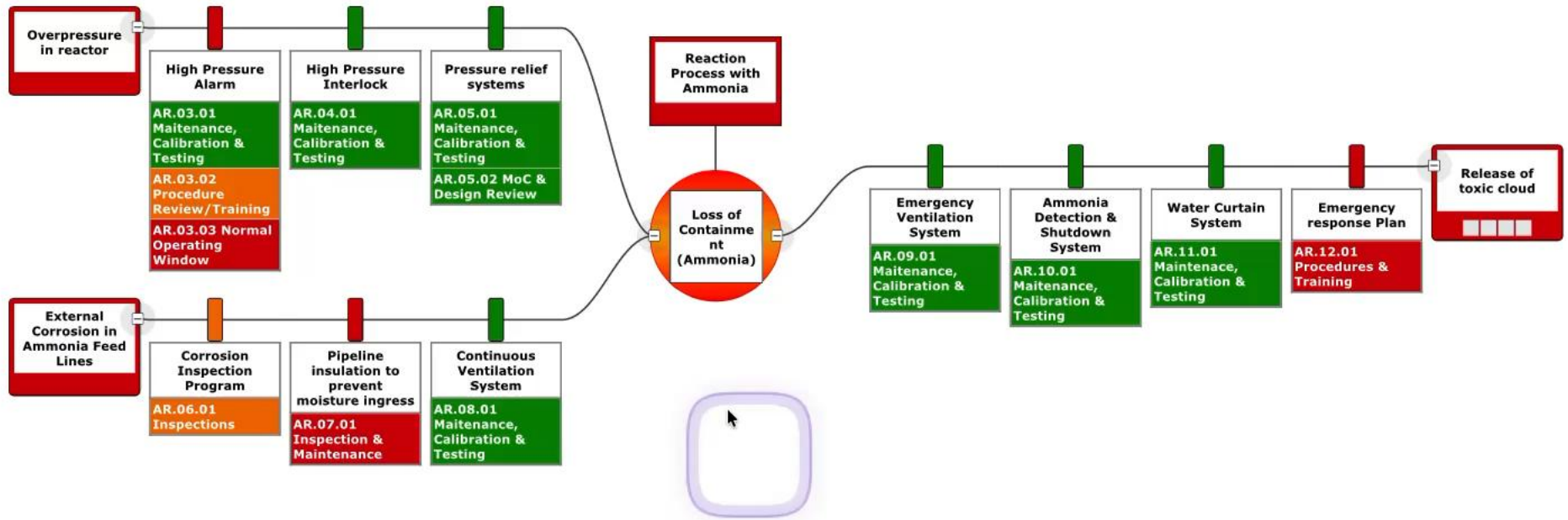
STRUCTURAL INTEGRITY | PROCESS CONTAINM... | IGNITION CONTROL | DETECTION SYSTEMS | PROTECTION SYSTEMS | SHUTDOWN SYSTEMS | EMERGENCY RESPONSE | LIFESAVING SYSTEMS | CRITICAL PROCESSES | BOWTIES

REACTION PROCESS WITH AMMONIA - LOSS...

Diagram view | List view | Configured view

Barrier Management

1 2 3 4 5 6



Saved Filters

No filter selected

Search by Registration Number

More filters

Certificate State 18

From-To

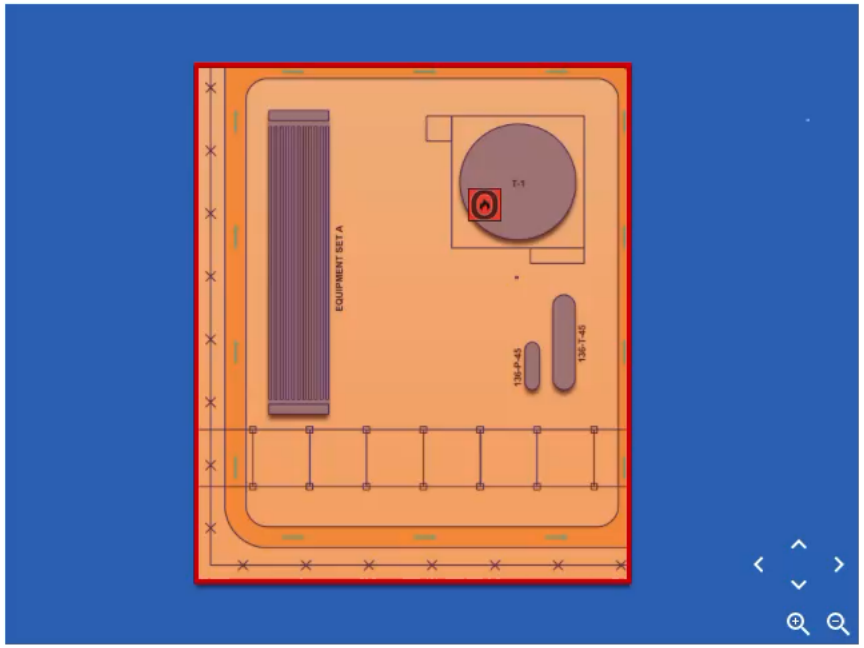
Site Graphics 6

Work Plar

Show hazardous areas

Location

Site Location Path:	Atlanta > Area 3
Period:	04/20/2026 / 04/27/2026
Isolation:	Isolation in Place (Live), Isolation in Place (DFT), Isolation in Place (LTI)
NPW:	Live (Awaiting Activation), Live, Overdue, Expired
ORA:	Awaiting Reapproval, Live
Permit:	Live, Live for Test, Overdue, Expired
Risk Record:	Approved, Overdue
TDIC:	Isolated (Live), Isolation in Place (LTD)
Work Pack:	Live



Site Locations

- Area 3

Active Work

- Permit 0-OFB-00000029 (Hot Work - Overdue) - Welding repair of structure

Real-time Integrity Barriers State

04/20/2026

07:00 | 19:00

OFB Area 3

Process Containment	
Ignition Control	
Detection Systems	
Protection Systems	
Shutdown Systems	
Emergency Response	
Lifesaving Systems	
Critical Processes	
BowTies	

Close

Set to current shift

Tue	Wed	Thu	Fri	Sat	Sun	Mon
S1 S2	S1 S2	S1 S2	S1 S2	S1 S2	S1 S2	S1 S2
Apr 14	Apr 15	Apr 16	Apr 17	Apr 18	Apr 19	Apr 20

Health calculated at 2026-04-14 11:45
Europe/Amsterdam UTC+02

NO IMPACT BARRIER | STRUCTURAL INTEGRITY | MECHANICAL INTEGRITY | IGNITION CONTROL | DETECTION SYSTEMS | PROTECTION SYSTEMS | SHUTDOWN SYSTEMS | EMERGENCY RESPONSE | LIFESAVING SYSTEMS | BOWTIES

FLAMMABLE LIQUIDS IN FIXED ROOF STORAGE...

TERMINAL TRANSPORT - ROLL-OVER

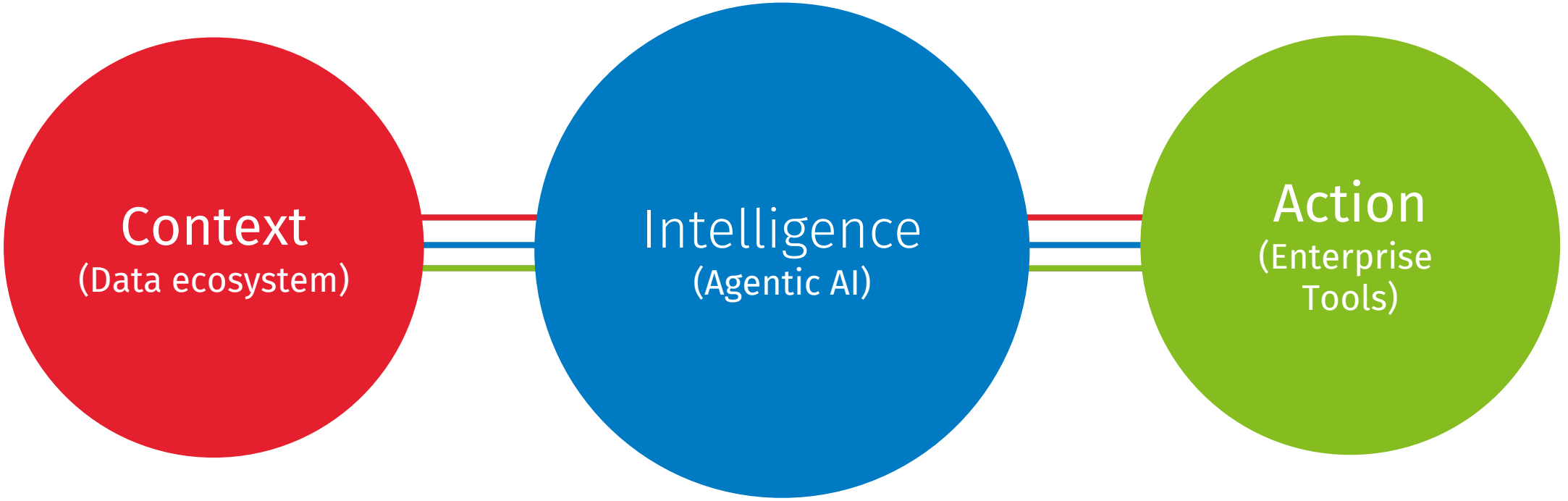
FLAMMABLE MATERIALS AND IGNITION...

Diagram view | List view | Configured view

Name	Summary	Actions
Flammable materials and ignition sources in station - Fire in public area in station	3 1 1	
Threats		
Misuse of welding tools	0 0 1	
Flammable liquid reaches ignition source	1 0 0	
Overloading/ overheat of electrical appliances	1 0 0	
Lighted cigarette	0 0 0	
Consequences		
Panic in passengers	1 0 0	
Poor visibility of exits due to smoke	0 0 0	
Severe injuries	1 2 0	

EN English (United States)

Integrated **Process Safety** Management


Context
(Data ecosystem)
Intelligence
(Agentic AI)
Action
(Enterprise Tools)

Thank you

Wolters Kluwer