OGUK

Contaminants and Chemical Additions

Guidelines

Issue 1
November 2020

Acknowledgments

In preparing and publishing this document, OGUK gratefully acknowledges the contribution of members of the Terminals work group, a sub group of the Production Efficiency Taskforce namely:

- Bacton Gas Terminal, Perenco UK
- CATS Terminal, Kellas Midstream/Wood
- Dimlington Gas Terminal, Perenco UK
- FUKA/SIRGE St. Fergus, NSMP/px
- Morecambe Bay gas terminal, Spirit Energy
- Norsea Terminal, ConocoPhillips
- Oil & Gas Authority
- SAGE St. Fergus, Ancala/Wood
- SEGAL St. Fergus, Shell UK
- Shetland Gas Plant, Total E&P
- Sullom Voe Terminal, EnQuest
- Teesside Gas Processing Plant, NSMP/px

ISBN: 1 903 004 73 2
PUBLISHED BY OGUK

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List of Abbreviations

Abbreviations	Definitions
BOE	Barrels of Oil Equivalent
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CCR	Central Control Room
COD/BOD	Chemical Oxygen Demand / Biological Oxygen Demand
CO_2	Carbon Dioxide
GC	Gas Chromatograph
H_2O	Water
H_2S	Hydrogen Sulphide
LOC	Loss of Containment
MeOH	Methanol
MOC	Management of Change
NGL	Natural Gas Liquids
NORM	Normally Occurring Radioactive Material
OPEX	Operating Expense
PE	Production Efficiency
PETF	Production Efficiency Task Force
PPE	Personal Protective equipment
RPE	Respiratory protective Equipment
UKCS	United Kingdom Continental Shelf

List of Definitions

Term	Definitions
Addition or Additive	Chemical actively injected or dosed into a process stream
Contaminant	Undesirable material present in a process stream, usually naturally occurring
Pipeline measurement manual	A document that typically sets out the minimum requirements for quantity and quality measurement of gaseous and liquid hydrocarbons, which are to be delivered to and redelivered from the pipeline system. The document defines the framework for measurement control and approvals through the pipeline system.

1 Introduction

1.1 Background

Analysis of UKCS production losses since 2015 has indicated that a key factor to improving Production Efficiency (PE) is export route availability. Export route losses were the 4th largest production deferment category in 2015 at 20 million BOE. A Terminals Work Group (TWG) with representation from most UK terminal operators, OGUK and the Oil & Gas Authority was formed in October 2016 to help address this issue.

The TWG identified the negative impact of contaminants and the (unintended) adverse effect of certain chemical additives as a key factor contributing towards the level of unplanned losses.

Many of the contaminant and addition problems arise upstream of the terminal, as either naturally occurring contaminants or as chemical additives injected into the process streams. The consequences, however, are often more severe downstream or at the processing terminals. Additives have been known to migrate through the process into the export pipeline, creating ongoing downstream issues. The TWG created this guidance document, so that recognised hazards and control measures can be more widely shared and understood across the entire business chain.

1.2 Purpose

The intention of this guidance document is raising the awareness of contaminants and additions in pipeline systems in order to minimize negative consequences for shippers, at an individual and cumulative level.

Negative events include safety and environmental impacts associated with a 'loss of containment' event, reduced PE due to unplanned outages, and/or financial penalties. In certain circumstances, where a downstream product/facility is contaminated, the financial liabilities can be substantial and often "unlimited".

1.3 Responsibilities

This guideline identifies potential contaminants and additions that can negatively affect shipper and terminal operations. This list is not exclusive, and it is recognized that there may be specific additional contaminants and additions associated with each individual asset not listed. Shippers are encouraged to use the information within this guide to conduct a review of their own facilities to identify any additional contaminants/additions, and then to produce a similar process to help identify and mitigate the hazard/risks involved. Upstream users may wish to create their own bowtie diagrams based on the examples given in the appendices.

1.4 Industry Examples of Negative Impact

Examples of upstream contaminants and additions causing negative impacts downstream can include:

- UK North Sea – overdosing of H_2S scavenger caused devaluation of oil product.
- UK onshore - mercury contamination degraded aluminum components within a gas processing "cold box", resulting in a need to prematurely replace the components to prevent major deterioration. The

replacement had to be carried out in an unscheduled and extensive maintenance shutdown.

- UK onshore – Untreated sulphate reducing bacteria accumulated at pipeline low points and presented an accelerated corrosion threat. Additional remedial pigging and chemical injection, with associated cost increases, was required to mitigate against an asset integrity failure.

2 Principles of Pipeline Management

Contaminants are recognized as a significant cause of reduced PE throughout the UK pipeline networks.

Contaminants are currently or could potentially be transported in any oil or gas transportation system.

Contaminants can create hazards to personnel, asset integrity and to the environment. Contaminants can also potentially cause operational problems; unplanned shutdowns, repairs and/or increased OPEX spend. The use of additives can mitigate these undesirable effects. Additives, however, can also have negative and unintended consequences of their own, so vigilance is required.

Think beyond your own operation

- Safe and reliable pipeline operation is the responsibility of all.
- Be aware of downstream impacts and limitations.
- Management of Change process should include consideration of downstream users.
- A single asset connected to the pipeline could impact all the other assets.

Individual actions can impact an entire system and shut in many fields

- All chemicals must be approved by the downstream assets or terminals before use.
- In solving a local problem, a single injection of a non-approved chemical can cause an entire pipeline system to go “off-specification” or shut down, resulting in large financial penalties and widespread non-planned outages.

Negative impact can build up over time

- The regular use of non-approved chemicals, even at low dosage rates, can take years to be revealed by blockage or damage to downstream equipment.
- These events require exhaustive investigation with the potential for prolonged outages, until the cause is identified and effectively mitigated.

Meet the contractual specification

- Detection instruments should alarm to a permanently occupied area (CCR) with well understood, documented operator responses.

Take good care of analysers, and sampling equipment

- Contaminants present hazards, and if not controlled degrade plant performance.
- Detection requires vigilance.
- Appropriate initial sampling, then a risk-based sampling frequency.
- Appropriate analysis and auditing regime to give confidence in analysers.
- Offshore operators need to provide reasonable access to allow auditing by pipeline operators of analyser performance and chemical dosing.

Communicate early & often: pipeline & terminal owners want to and can often help

- Where practicable, most pipeline operators can offer a blending service, where the effects of a single off-spec shipper could be mitigated by comingling with other streams. However, it is vital that this is agreed upfront.

Note: The National (Gas) Grid network provide an initial warning to terminals that gas entering their network does not meet Grid specification. The terminal has only 15-minutes to alter the output composition to meet Grid specification. Failure to return to Grid specification within this timeline would result in the terminal being forced to flare export gas or shutdown.

3 Key Pipeline Management Roles & Expectations

A broad range of work functions and roles directly impact safe and reliable pipeline operations. This section looks at these generic functions/roles, why they are important and how they contribute.

3.1 Commercial (and Legal) Representatives

Why: Responsible for contractual terms & conditions, understand what makes a 'good' contract, awareness of technical issues.

Expectation: Ensure that contract language details the pipeline fluid entry composition (limits and units of measurement should be clearly defined).

Include a contractual requirement to notify the terminal operator of any chemical additive used within the process.

3.2 Control Room Operators / Front Line Supervision

Why: Control the offshore plant and wells, which is the main source of contaminants & additives; in communication with downstream assets; typically, the focal point for waiver requests.

Expectation: Understand the pipeline measurement manual.

Maintain regular communication with downstream assets.

Understand how additives can migrate through the process and into export routes.

Early notification of an identified contaminant or the use of a new chemical additive can allow downstream operators to proactively respond and mitigate the potential for disruption across the entire system.

Accurately document chemical usage; obtain waivers ahead of time from the downstream assets or terminals for planned off-specification events.

3.3 Asset Management / Site Leadership

Why: Responsible for meeting production targets; owners of some mitigation measures; procedure owners; set behaviours and tone around pipeline compliance.

Expectation: Understand the pipeline measurement manual.

Drive consistent use of chemicals across shifts.

Minimise use of dosing chemicals and understand implications of over-dosing.

Establish a formal process to review and approve (by appropriate engineering resource) any new or amended chemicals; ensure timely notification to the terminal operator of such.

Maintain an instrumented analyser system to provide early notification of off-specification events.

Verify instrumented system outputs by routine sampling and laboratory analysis of export fluids.

3.4 Onshore Operations Support

Why: Link between onshore and offshore leaders (often the "common denominator"); owner of medium term activity plan; natural point for liaison with other onshore departments e.g. commercial, wells, etc; Management of Change instigator / owner.

Expectation: Assess chemicals for downstream impact and unintended consequences e.g. methanol used for hydrate inhibition subsequently rendering the pipeline fluids off-spec, or drilling fluids migrating through to the export system on well start-up.

Early notification of an identified contaminant or the use of a new chemical additive can allow downstream operators to proactively respond and mitigate the potential for disruption across the entire system.

3.5 Maintenance Personnel

Why: Maintenance of analysers and other measurement devices.

Expectation: Adequately maintain and clean/flush equipment/plant before returning to service.

Maintain and accurately calibrate analysers and other measurement devices.

Maintain adequate spares holdings.

Note: Loss of metering/analysis capability or out of calibration meters may result in the asset having to shut in.

3.6 Pipeline & Terminal Owners/Operators

Why: Responsibility to treat all shippers fairly; owner of some off-spec mitigations; able to advise / support shippers; responsible for re-delivery of on-spec products to downstream users e.g. National Grid, petrochemical plants, etc.; owner of the pipeline measurement manual.

Expectation: Provide clear and unambiguous pipeline entry specifications to shippers.

Actively engage with new shippers to highlight the impact of contaminants and additions.

Obtain early and ongoing samples to confirm export fluids match expectations.

Manage upstream measurement system audit programme.

Supplement sampling with regular "independent" audits of the sampling equipment, the chemical laboratory and instrumented analysis systems.

3.7 Regulators & Industry Associations

Why: Maximising safe, efficient and economic recovery of the UK's hydrocarbon

resources; promote best practice across upstream and midstream operators; encourage collaboration through groups such as the UK Production Efficiency Task Force.

Expectation: Advise shippers on the methods and benefits to effectively manage contamination induced hazards.

Publicize wider industry lessons learned on chemical usage.

3.8 Senior Leadership

Why: Set behaviours and tone; responsible for safely and efficiently meeting production targets; owner of long-term asset plan and strategy; maintain life of field export route availability; managing company reputation.

Expectation: Define and execute appropriate technical assurance programmes, including reviewing findings from audit and assurance activities.

Pay attention to measurement and metering systems compliance during site leadership visits.

Challenge chemical usage.

Audit the process for new chemical assessment.

Note: reduced chemical usage mitigates the risk of unintended consequences and has a direct, immediate impact on lowering operating expense.

3.9 Training Organizations

Why: Imparting core skills and knowledge to the work force.

Expectation: Develop and implement suitable measurement and metering systems training materials.

Update materials using knowledge transfer from industry learnings.

Maintain suitable measurement and metering systems competency assurance process.

4 Contaminants and Additions Summary

Table 1: Contaminants and Additions Summary

Contaminant / Addition	Cause	Effect	Control
Alcohols (Ethanol/Methanol)	Chemical addition to mitigate hydrate risks	Failure to meet export specification Unplanned shutdown Additional flaring Contractual penalties for shipping contaminated product	Online measurement of MeOH content with alarms to the CCR Routine product and water sampling Eliminate or minimise MeOH use Crude washing / gas flaring
Asphaltenes & Waxes	Present as a natural contaminant	Degradation leading to fouling and potential blockage Decrease in transmission capacity Increase of cleaning (pigging) frequency	Monitor cleaning pig condition. Solid deposits from pigs should be sampled for composition Only use approved inhibitors New chemicals must be approved prior to use
Benzene	Present as a natural contaminant	Toxic Carcinogenic	Risk assessment Monitoring required on vessel entry / breaking containment Sampling not routinely conducted
Biocide	Chemical addition to mitigate unwanted organism risk	Highly toxic Excessive dosing can send effluent water off-spec for eco-toxicity limits and / or chemical oxygen demand	Risk assessment Dosing procedure and competence training Only use approved inhibitors New chemicals must be approved prior to use
Carbon Dioxide (CO_2)	Present as a natural contaminant	Potential corrosion damage, when combined with water Threat to life at concentration levels as low as 15% (headaches at 3% for 1 hour) Failure to meet export specification. (flare/shutdown) Shutdown / Increased flaring	Online measurement of CO_2 content with alarms to the CCR Routine sampling Personnel awareness and training Asset Integrity program

Corrosion Inhibitor/Scavenger	Chemical addition to mitigate corrosion risk	Degradation leading to fouling and potential blockage	Monitor cleaning pig condition. Substantial solid deposits from pigs should be sampled for composition No active injection of chemicals into the pipelines. New chemicals must be approved prior to use
Emulsifiers	Process control / mixing issues	Product quality Wastewater treatment plant operation Environmental release	Upstream Understand impact of additives on downstream users Diversion / holding tanks
Glycols (MEG/DEG/TEG)	Used in offshore water removal/inhibition Offshore pipeline dewatering Dehydration carryover	Coking of dehydration units leading to reduction in absorption capacity Potential for solids build-up in process equipment (Reboiler, Slug Catcher, etc) Equipment downtime for cleaning	Establish baseline level in order to trend Monthly regen water sampling for each train Additional ad hoc sampling when high water content or “two stage” regens
Hydrogen Sulphide (H_2S)	Present as a natural contaminant	Highly toxic to personnel Corrosive effect on ‘standard’ pipeline metals Embrittlement (cracking) effect can lead to sudden failure Failure to meet export specification. (flare/shutdown)	Contractual entry specification for every shipper Online Gas Chromatograph (GC) measurement of H_2S with alarms to the CCR Regular audits of H_2S analysers
Mercury	Present as a natural contaminant	Toxic Failure to meet export specification (flare / shutdown) Unplanned shutdown Attacks aluminium components	Initial trial samples Follow on risk-based sampling regime Sampling audits Mercury absorption beds
Sand	Present as a natural contaminant	Pipeline / vessel plugging Accelerated erosion Production downtime & repairs Potential loss of containment	Well completion, sand screens or gravel packs Sand monitoring (ultrasonic detection) Asset Integrity Program Erosion probes
Sulphate Reducing	Present as a	Can accumulate / reproduce in pipeline low points	Dosing of biocides

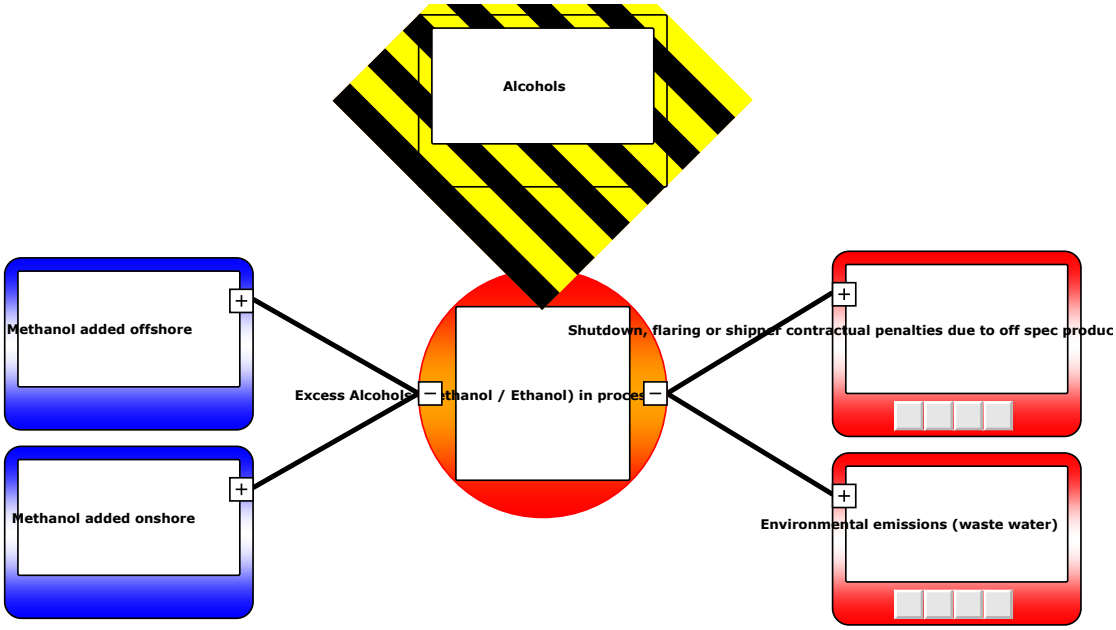
Bacteria	natural contaminant due to reservoir souring, or inadvertent introduction of uninhibited sea water	Accelerated corrosion threat	Routine operational pigging
Water	Present as a natural contaminant Produced water during processing	Hydrate formation in cold plant leading to blockage Failure to meet export specification (flare/shutdown) Free water leading to corrosion in the pipeline Partitioning of water-soluble chemicals impacting water discharge quality; particularly for total suspended solids specifications	Contractual entry specification for every shipper Online Gas Chromatograph (GC) measurement of water content with alarms to the CCR Routine sampling Regular audits of H_2O analysers

Appendix 1 Alcohols

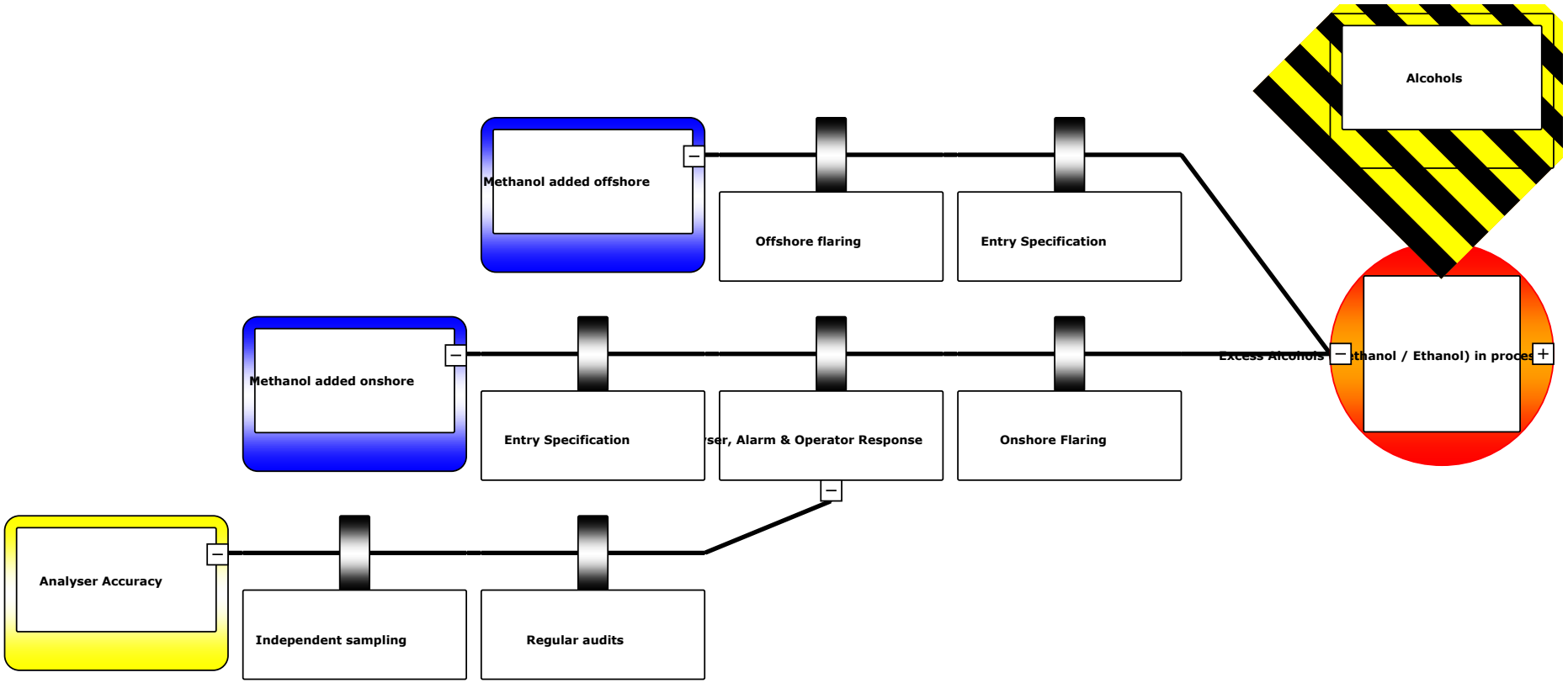
Appendix 1.1 Alcohols Summary

Alcohols (Methanol / Ethanol)

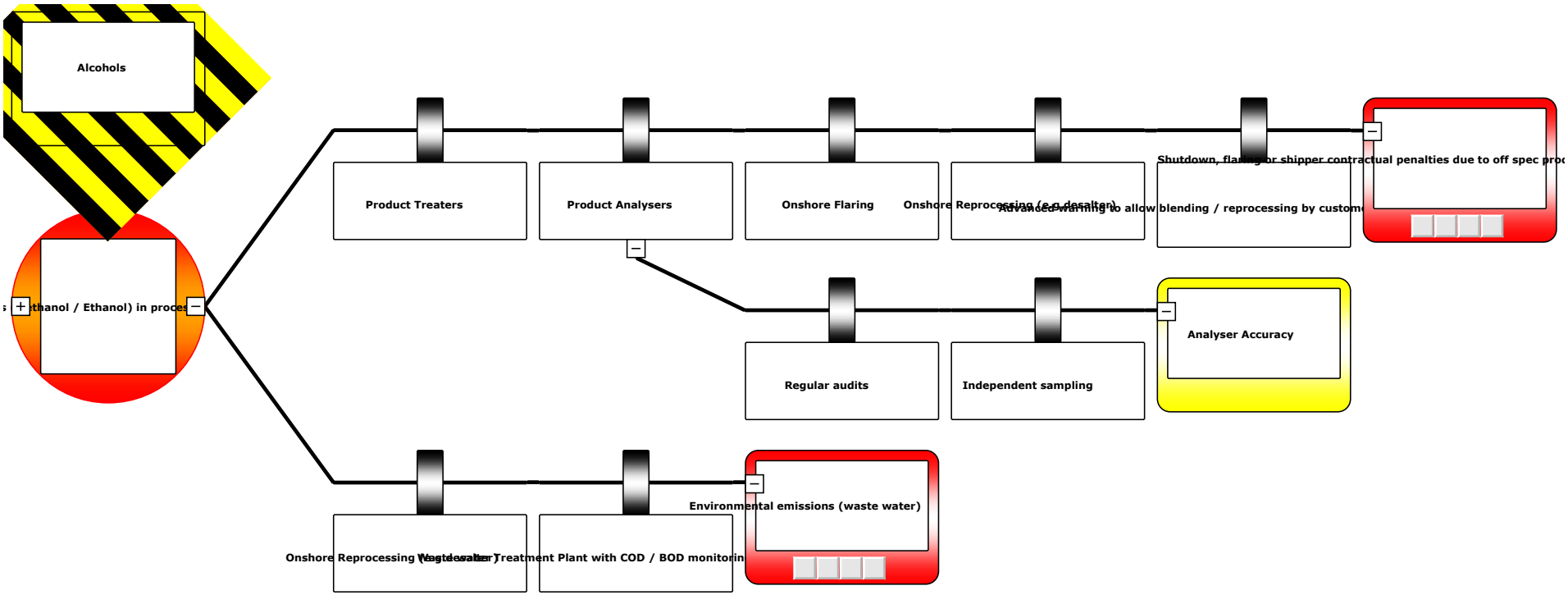
Hazard/Risk	Control
▪ Failure to meet export specification	▪ Online measurement of MeOH content with alarms to the CCR
▪ Unplanned shutdown	▪ Routine product and water sampling
▪ Additional flaring	▪ Eliminate MeOH use
▪ Contractual penalties for shipping contaminated product	▪ Crude washing / gas flaring
▪ Environmental emissions through waste water	



Appendix 1.2 Alcohols Bowtie Diagram - Causes



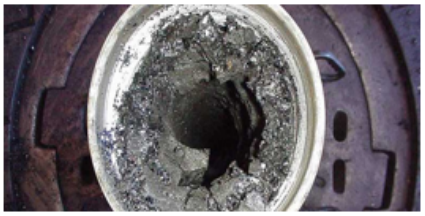
Appendix 1.3 Alcohols Bowtie Diagram - Consequences



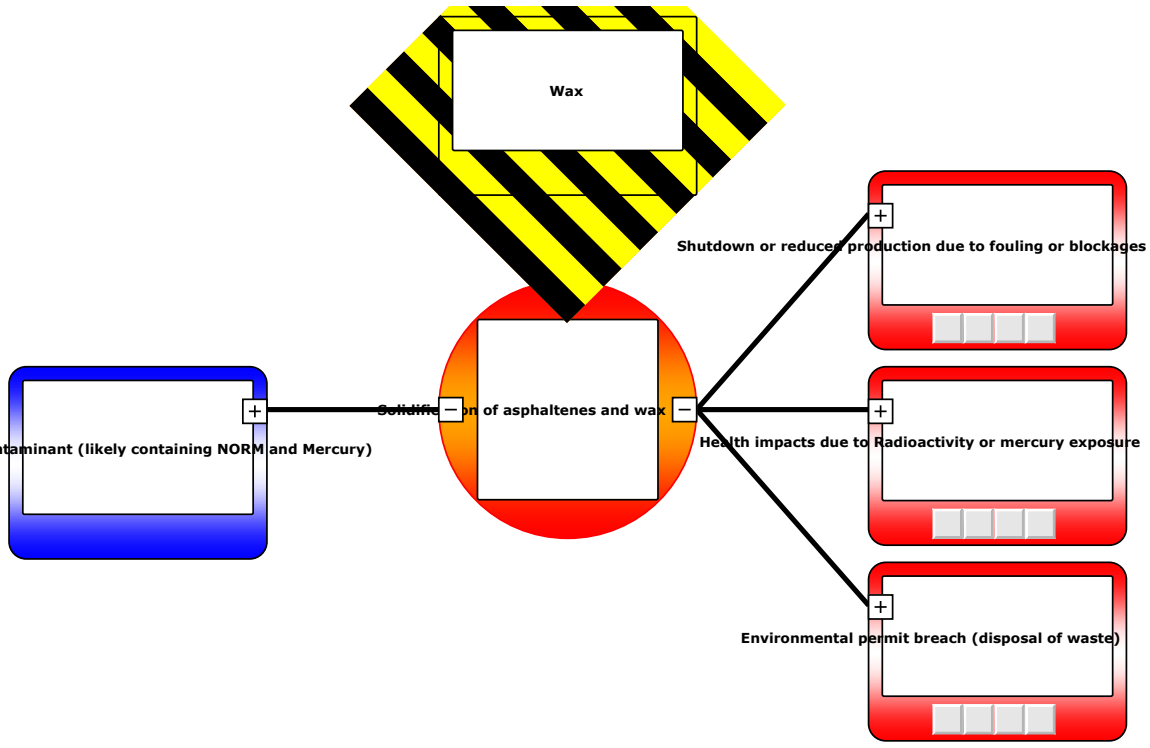
Appendix 2 Asphaltenes & Waxes

Appendix 2.1 Asphaltenes & Waxes Summary

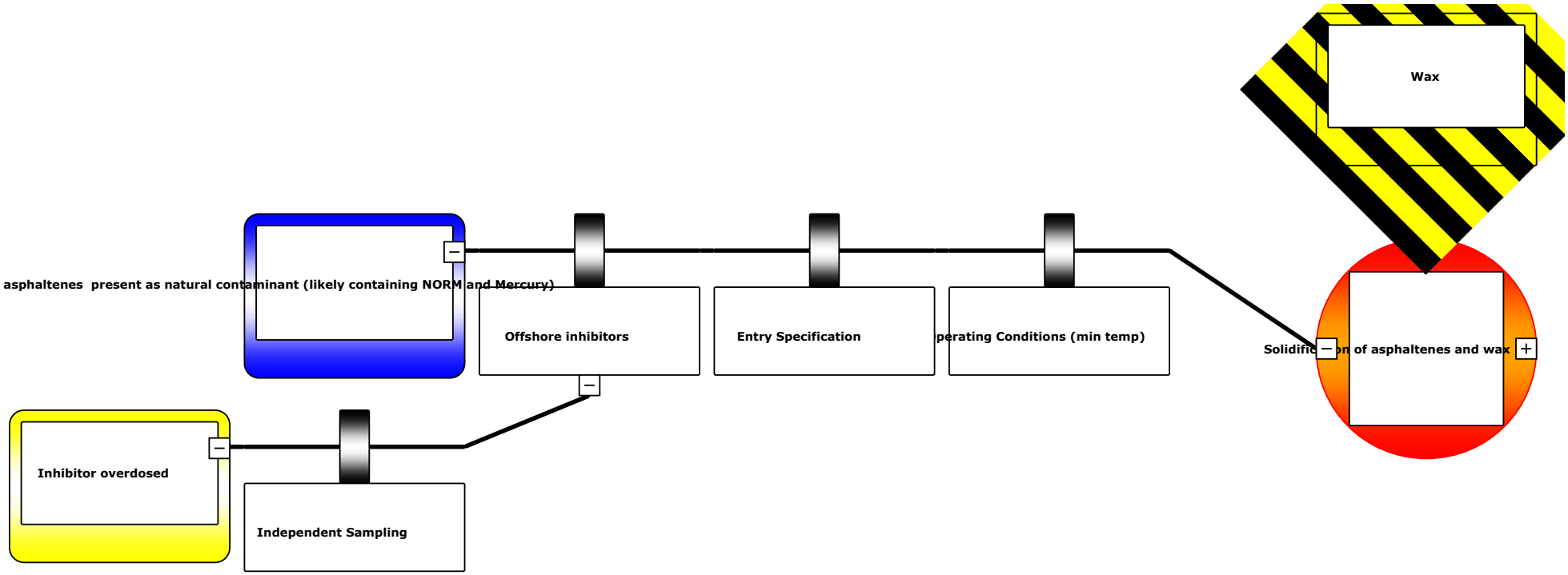
Asphaltenes and Waxes



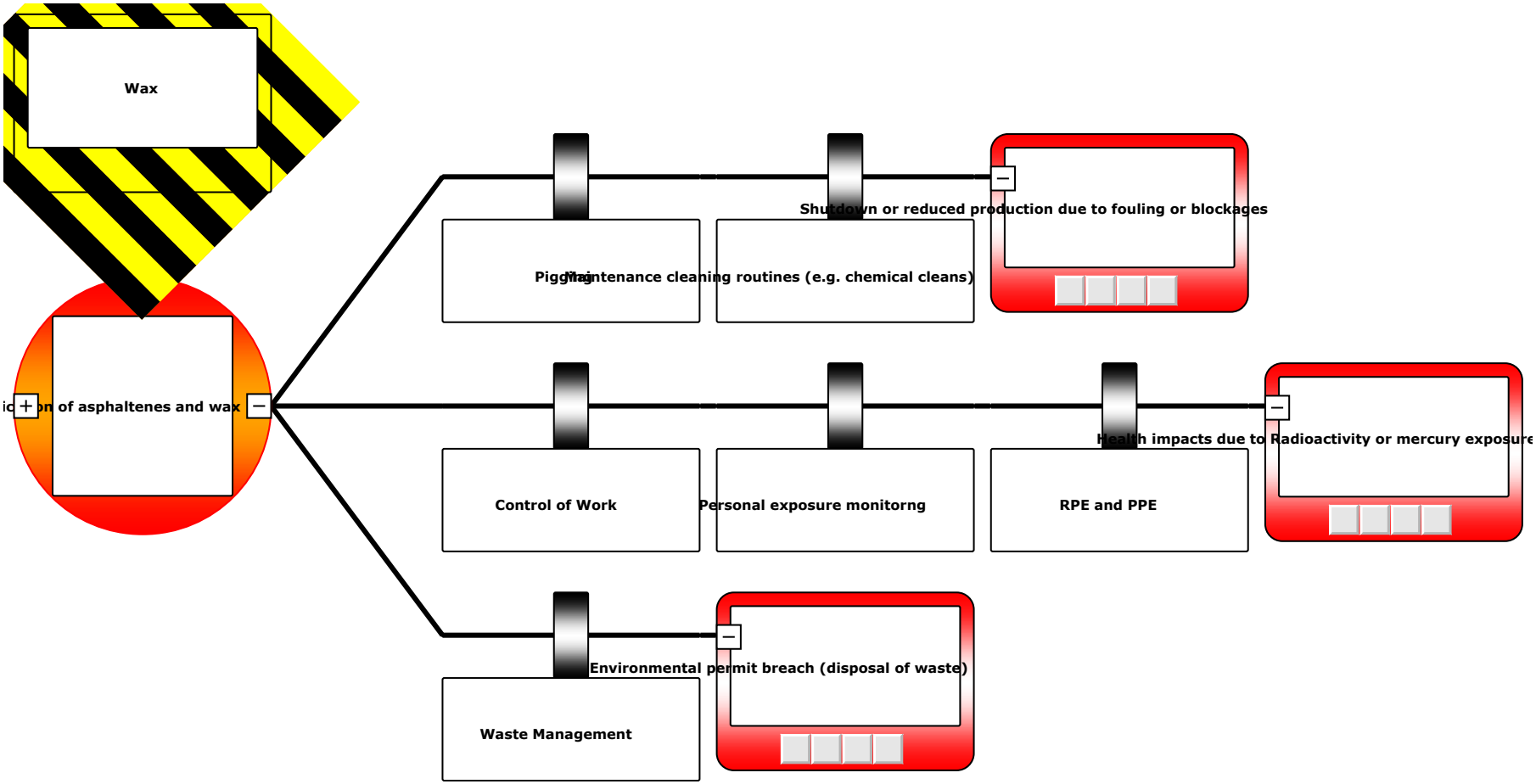
Hazard/Risk	Control
▪ Hazardous substances in wax (mercury, NORM) ▪ Degradation leading to fouling and potential blockage ▪ Decrease in transmission capacity ▪ Increase of cleaning (pigging) frequency	▪ Monitor cleaning pig condition. ▪ Substantial solid deposits from pigs should be sampled for composition ▪ Only use approved inhibitors ▪ New chemicals must be approved prior to use



Appendix 2.1 Asphaltenes & Waxes Bowtie Diagram - Causes



Appendix 2.3 Asphaltenes & Waxes Bowtie Diagram – Consequences

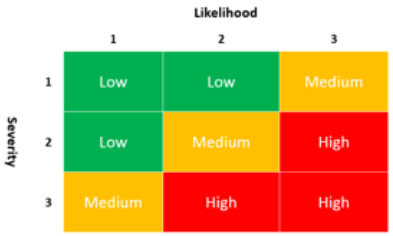


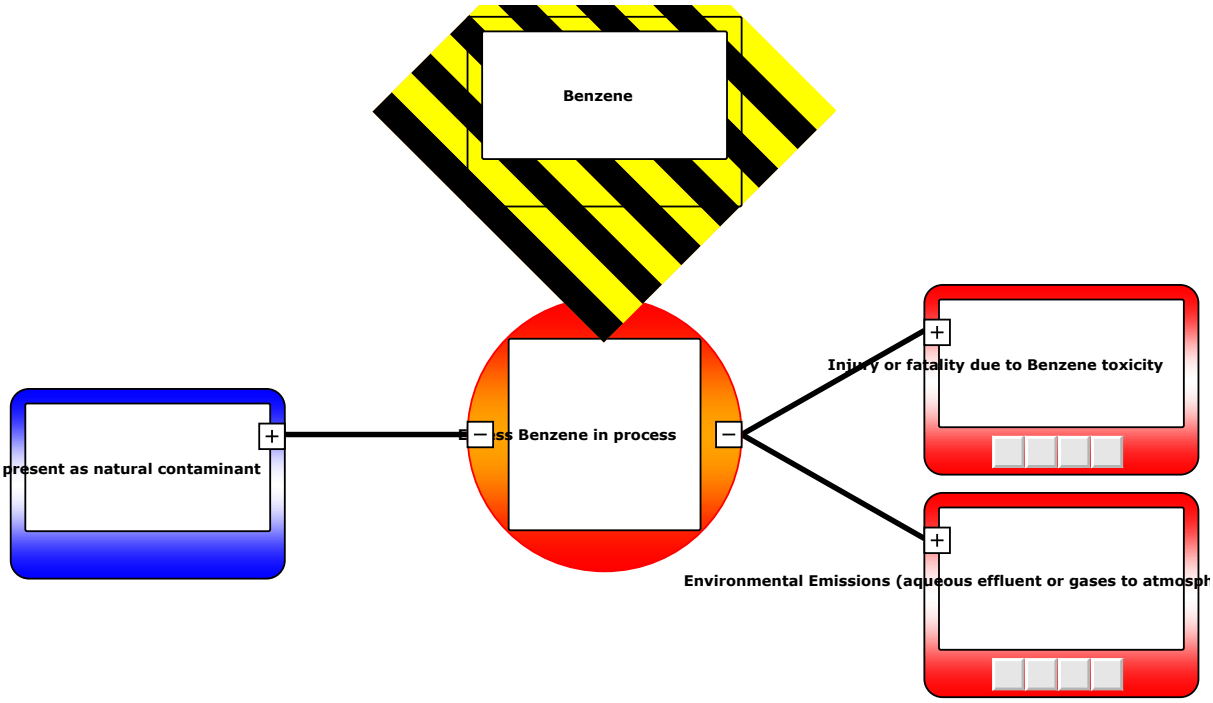
Appendix 3 Benzene

Appendix 3.1 Benzene - Summary

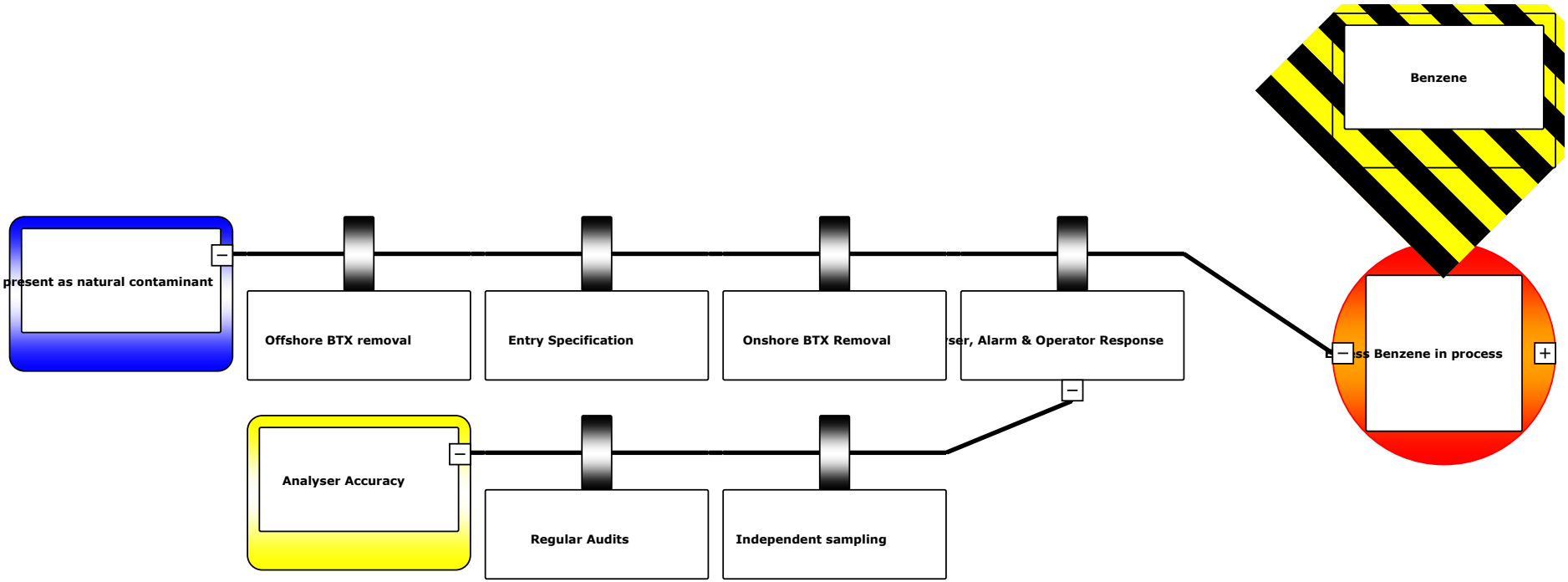
Benzene

Hazard/Risk	Control
▪ Toxic ▪ Carcinogenic	▪ Risk assessment ▪ Monitoring required on vessel entry / breaking containment ▪ Sampling not routinely conducted

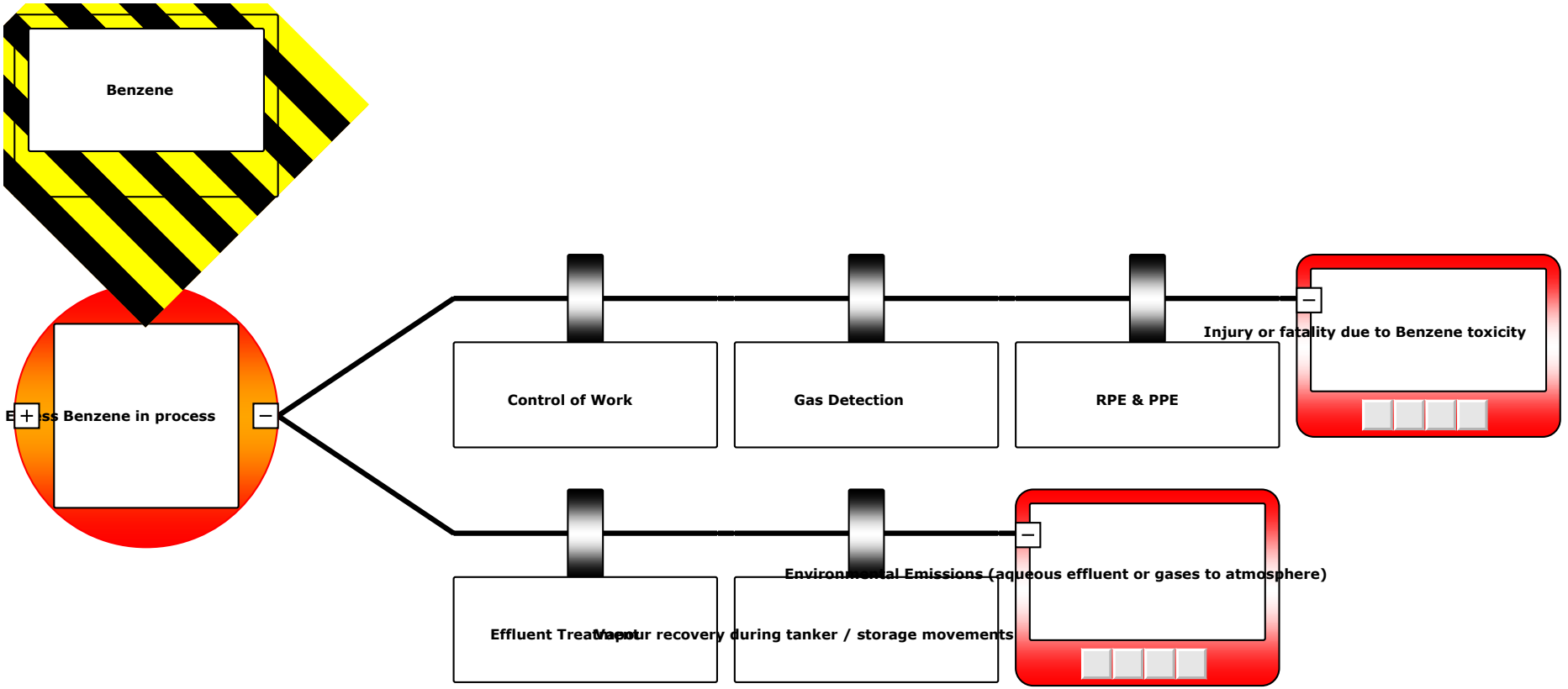




Appendix 3.1 Benzene Bowtie Diagram – Causes



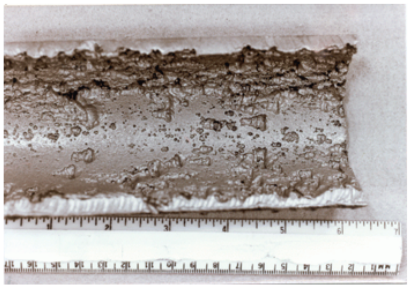
Appendix 3.2 Benzene Bowtie Diagram – Consequences

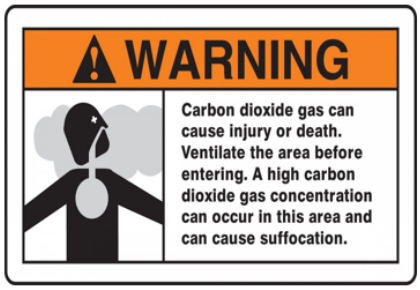


Appendix 4 Carbon Dioxide

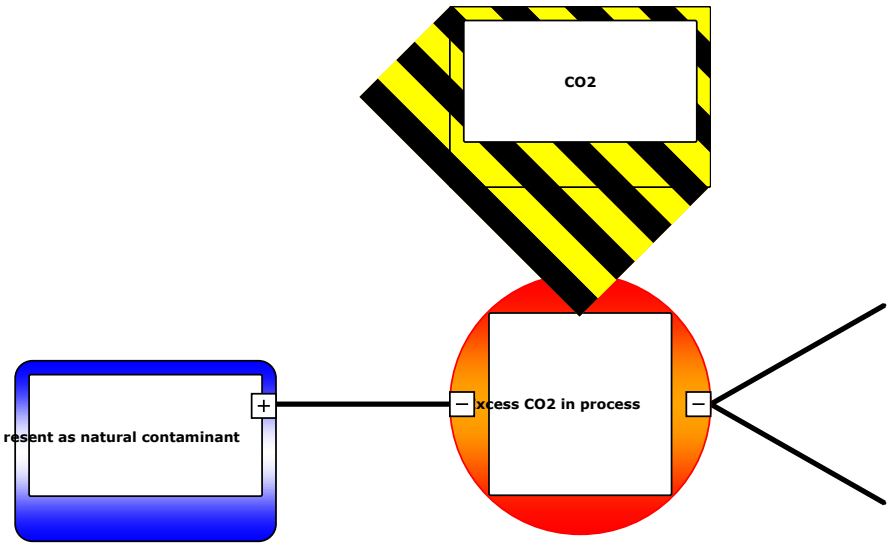
Appendix 4.1 Carbon Dioxide Summary

Carbon Dioxide (CO_2)

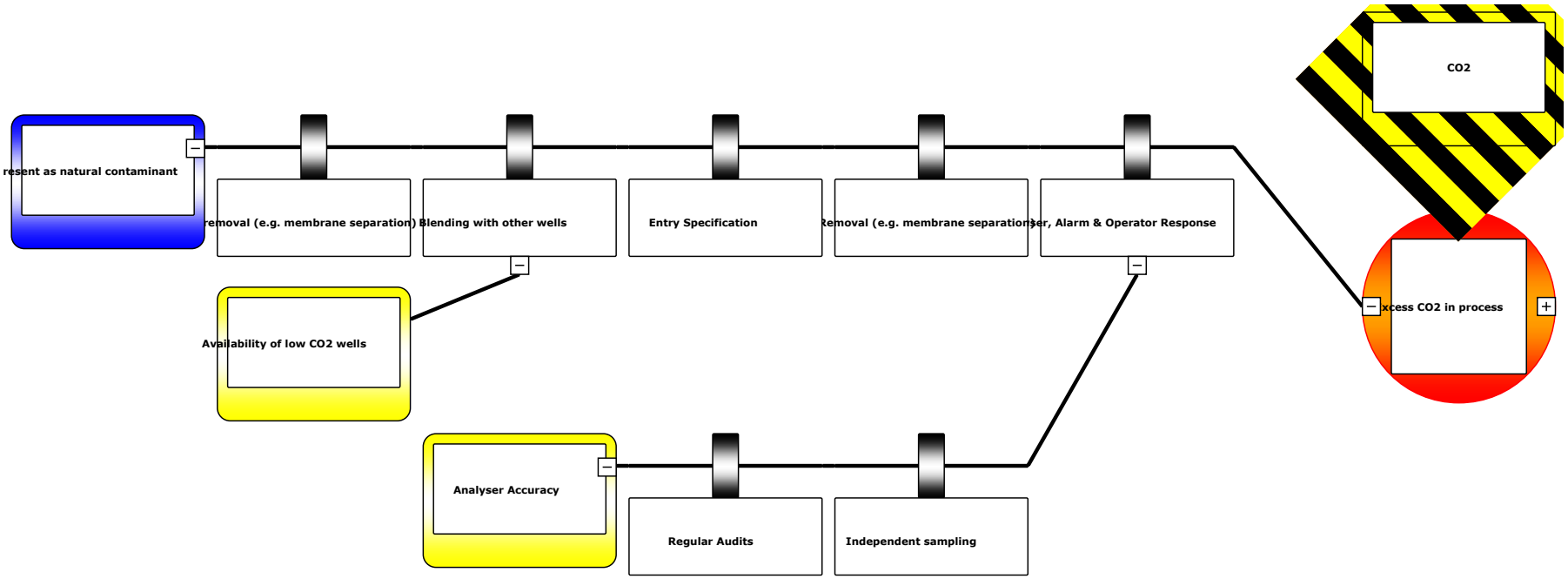




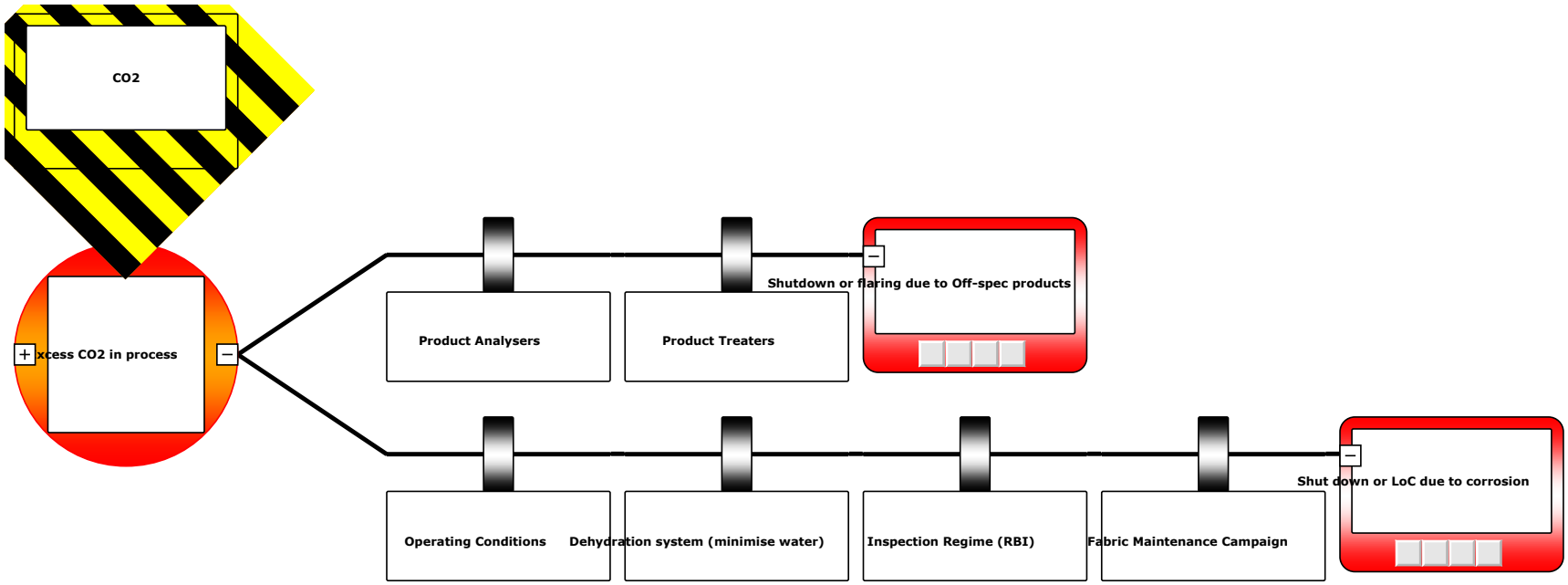
Hazard/Risk	Control
▪ Potential corrosion damage, when combined with water ▪ Hazardous at concentration levels as low as 15% (headaches at 3% for 1 hour) ▪ Contaminated product, off spec cost ▪ Shutdown / Increased flaring	▪ Online measurement of CO_2 content with alarms to the CCR ▪ Routine sampling ▪ Personnel awareness and training ▪ Asset Integrity program



Appendix 4.2 Carbon Dioxide Bowtie Diagram – Causes



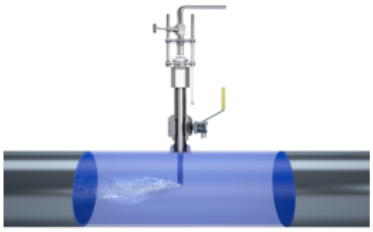
Appendix 4.3 Carbon Dioxide Bowtie Diagram – Consequences



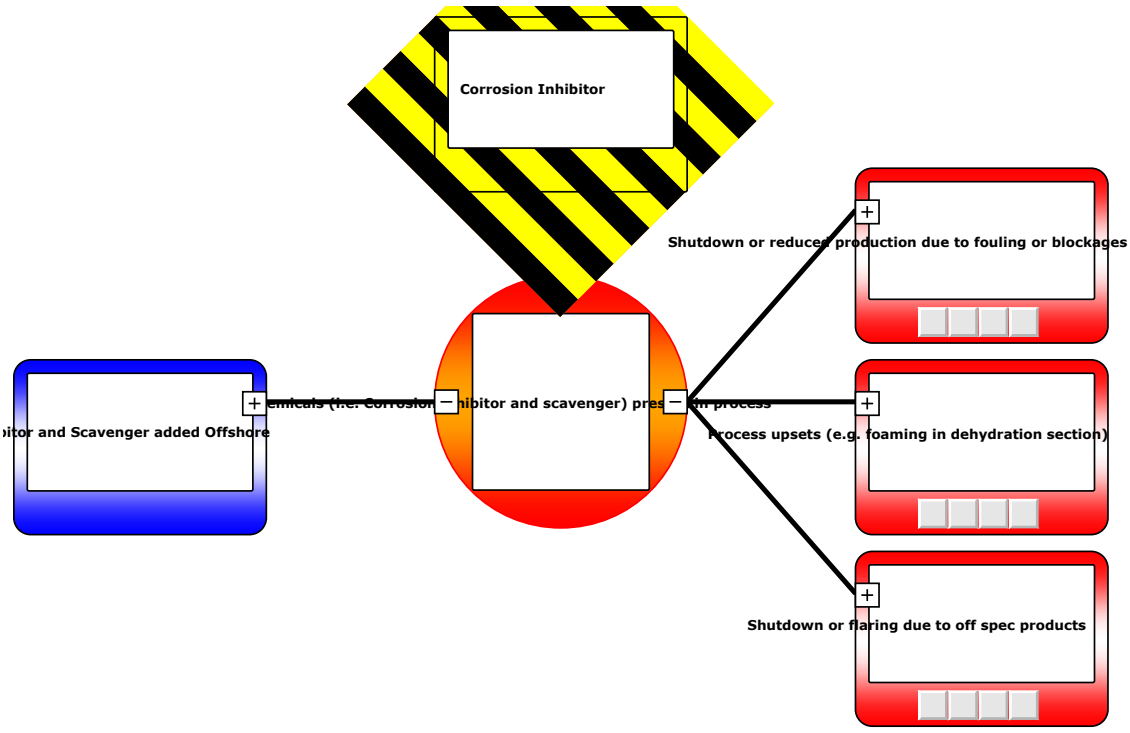
Appendix 5 Corrosion Inhibitor/Scavenger

Appendix 5.1 Corrosion Inhibitor/Scavenger Summary

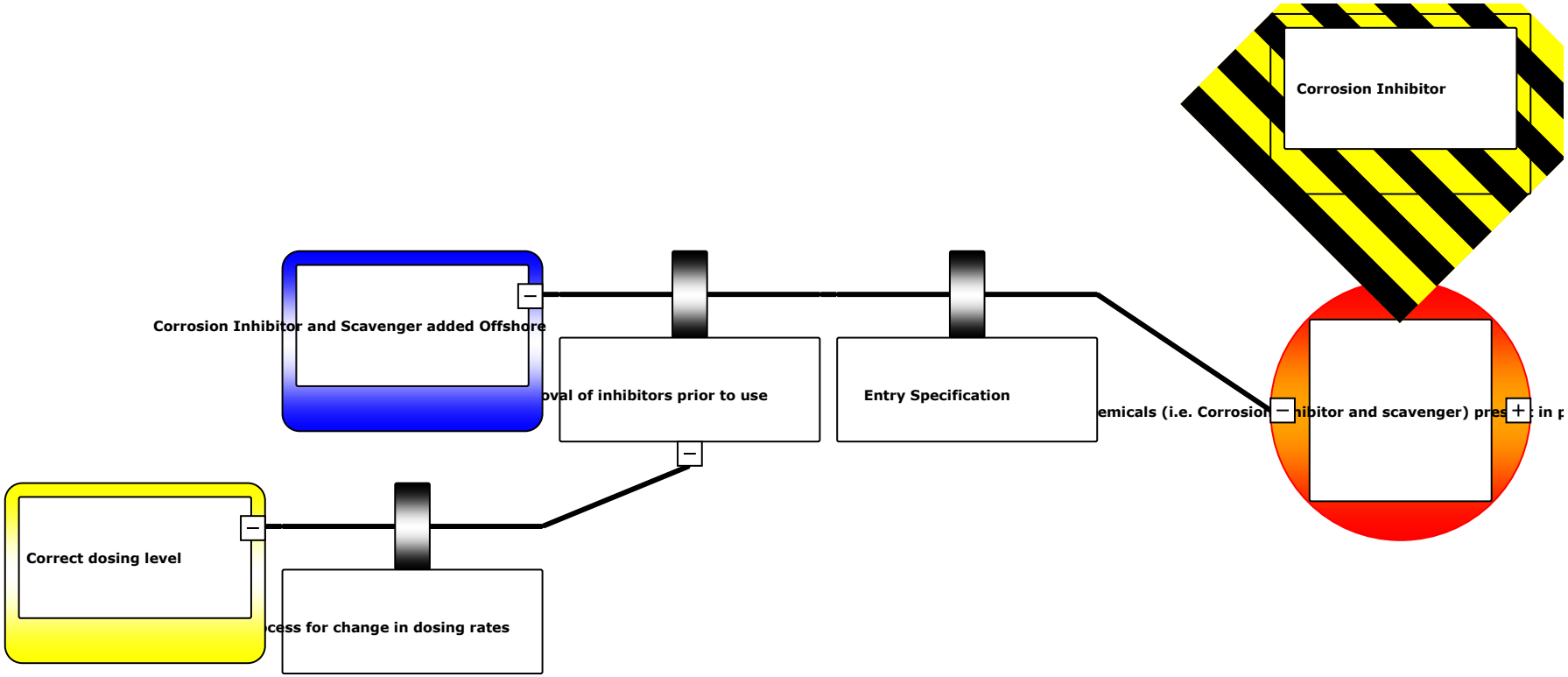
Corrosion Inhibitor and Scavenger



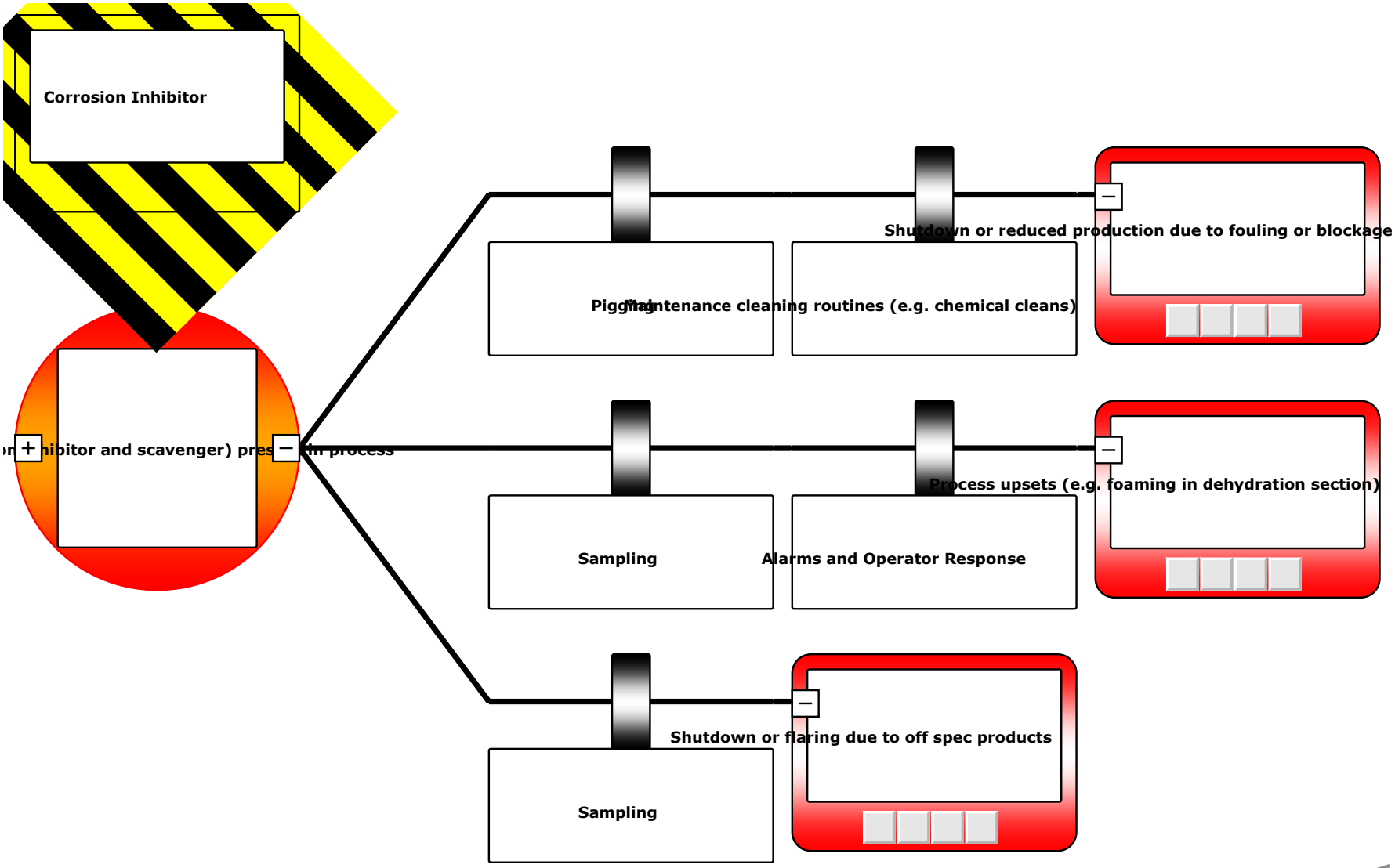
Hazard/Risk	Control
▪ Degradation leading to fouling and potential blockage ▪ Corrosion risk remains if dosing rate insufficient	▪ Monitor cleaning pig condition. ▪ Substantial solid deposits from pigs should be sampled for composition ▪ No active injection of chemicals into the pipelines. ▪ New chemicals must be approved prior to use



Appendix 5.2 Corrosion Inhibitor/Scavenger Bowtie Diagram – Causes



Appendix 5.3 Corrosion Inhibitor/Scavenger Bowtie Diagram – Consequences

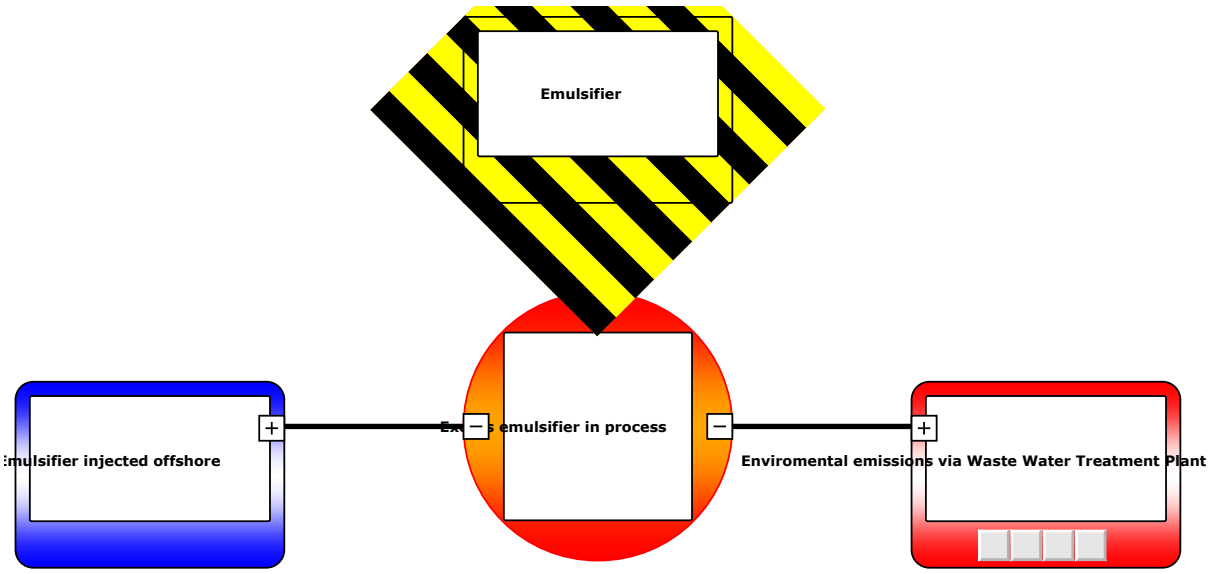


Appendix 6 Emulsifiers

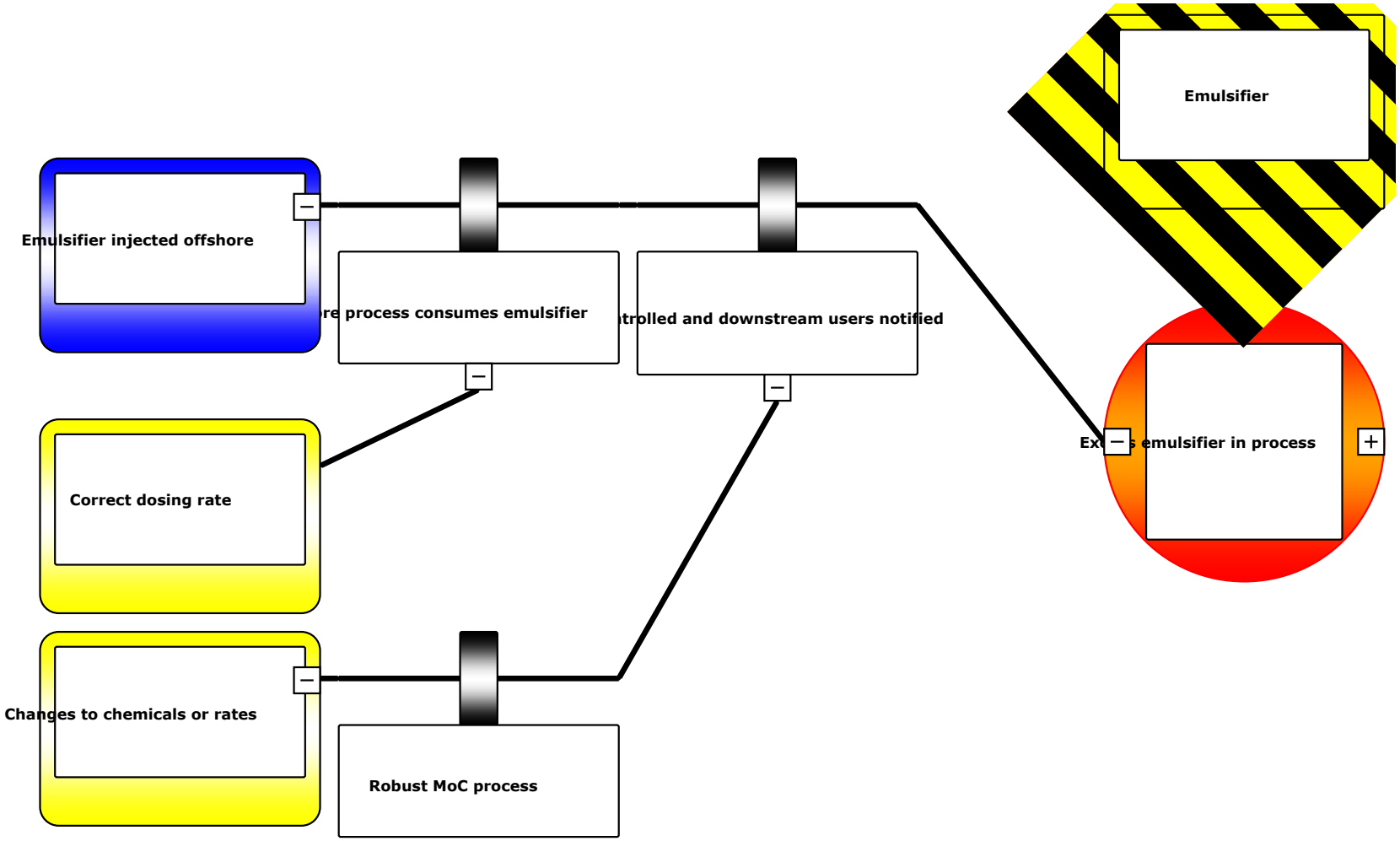
Appendix 6.1 Emulsions - Summary

Emulsions

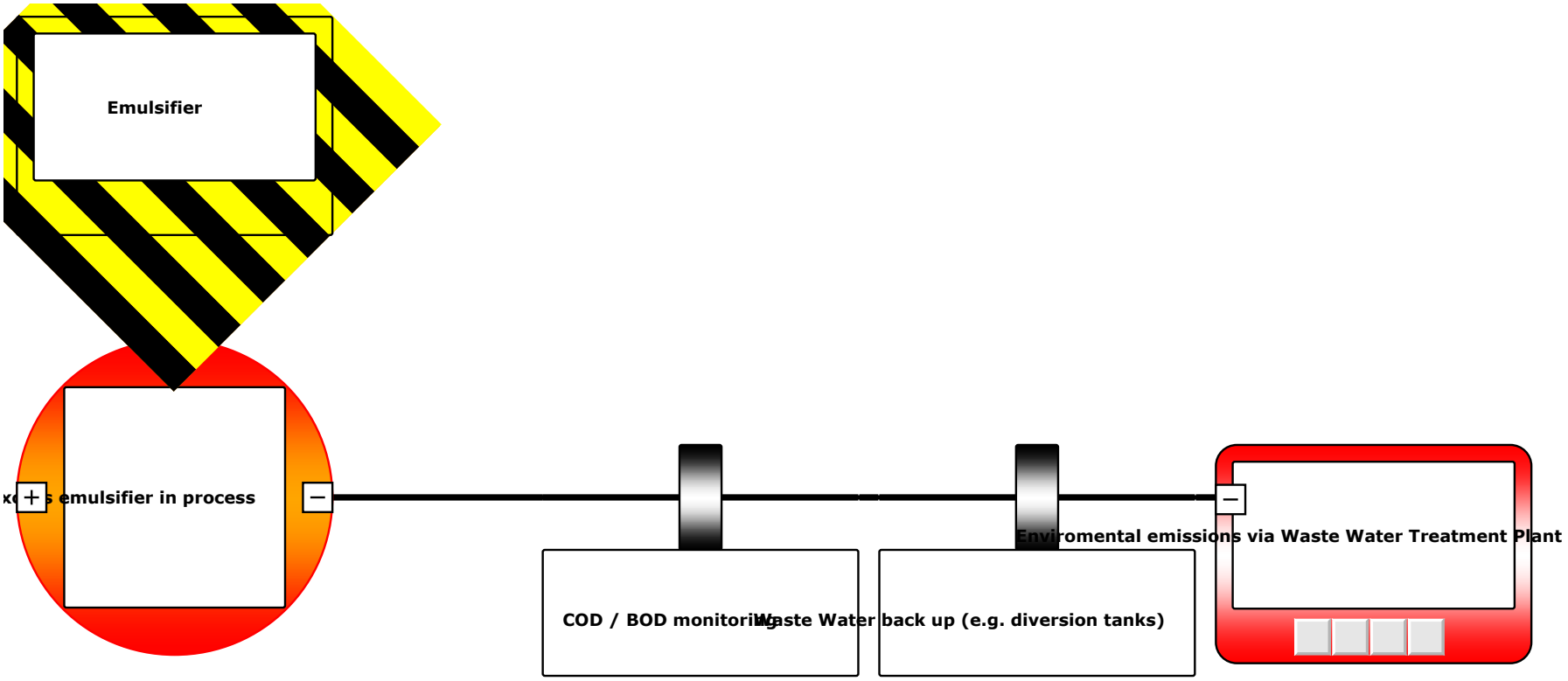
Hazard/Risk	Control
▪ Unplanned shutdown ▪ Product quality ▪ Waste Water treatment plant operation ▪ Environmental release	▪ Upstream ▪ Understand impact of additives on downstream users ▪ Diversion / holding tanks



Appendix 6.2 Emulsions – Causes



Appendix 6.3 Emulsions – Consequences

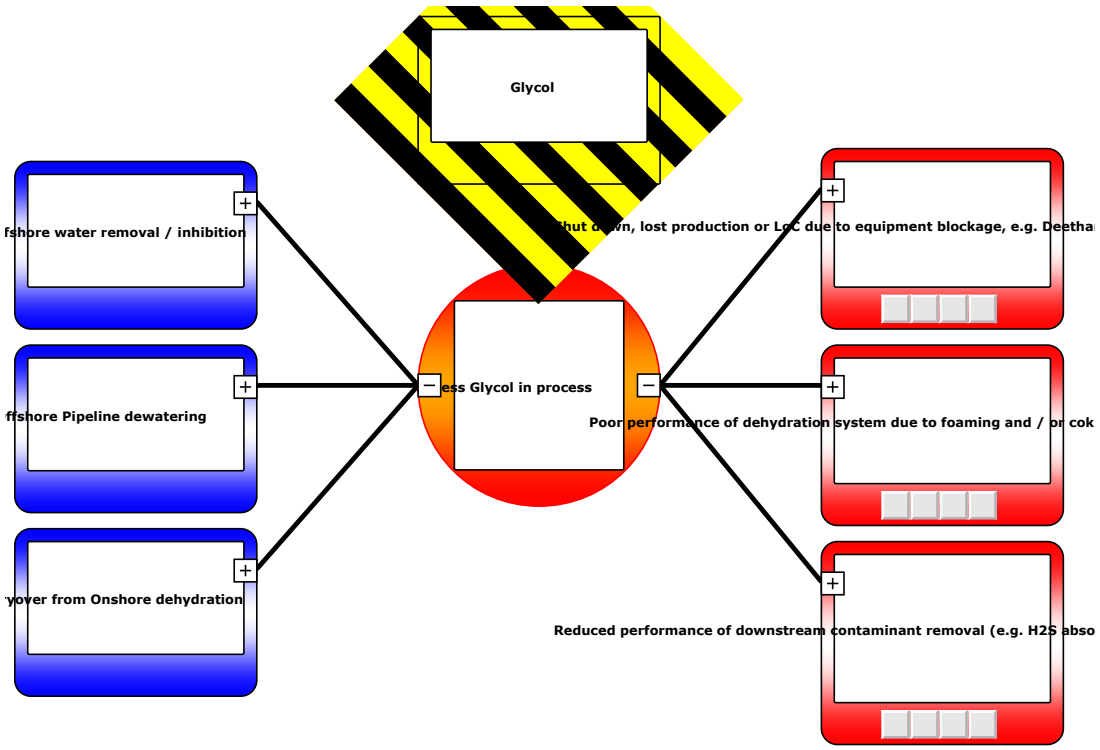


Appendix 7 Glycols

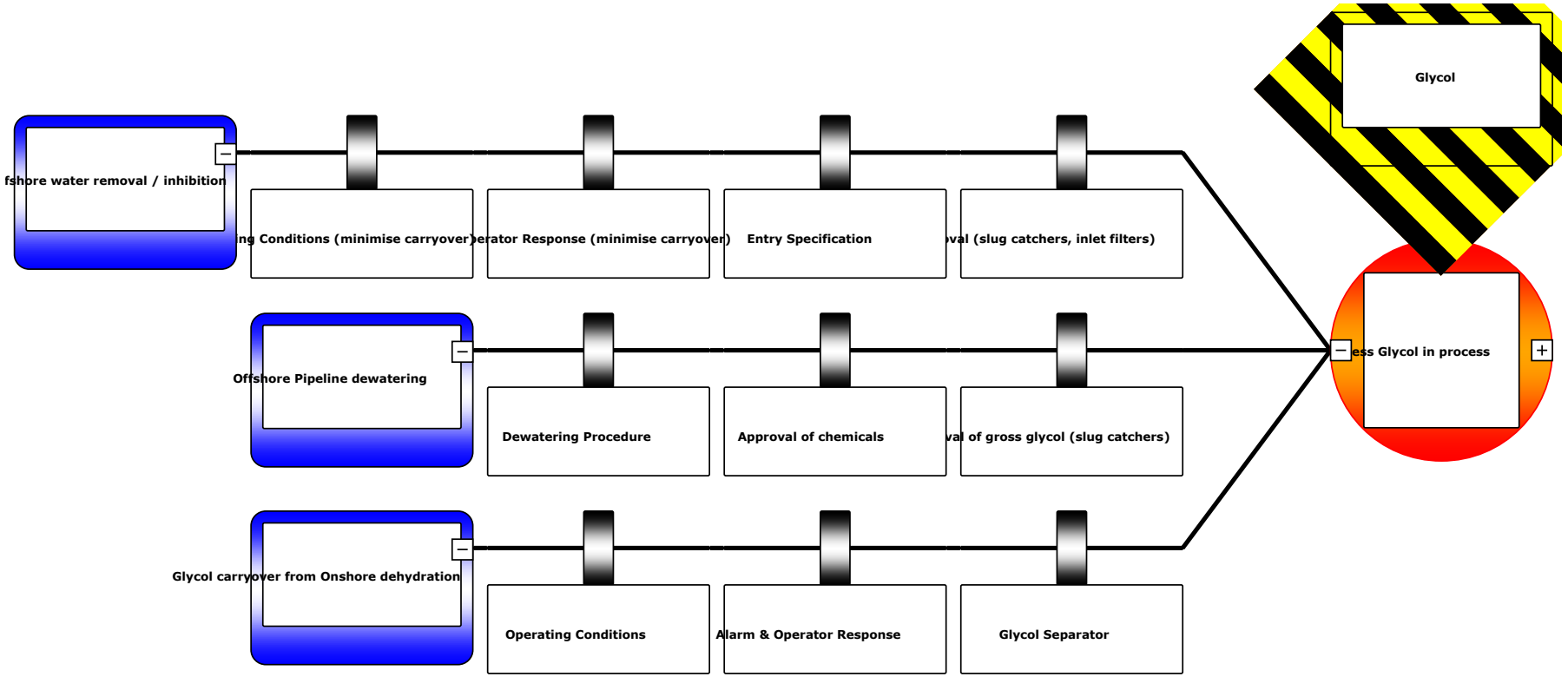
Appendix 7.1 Glycols Summary

Glycols (MEG, DEG, TEG)

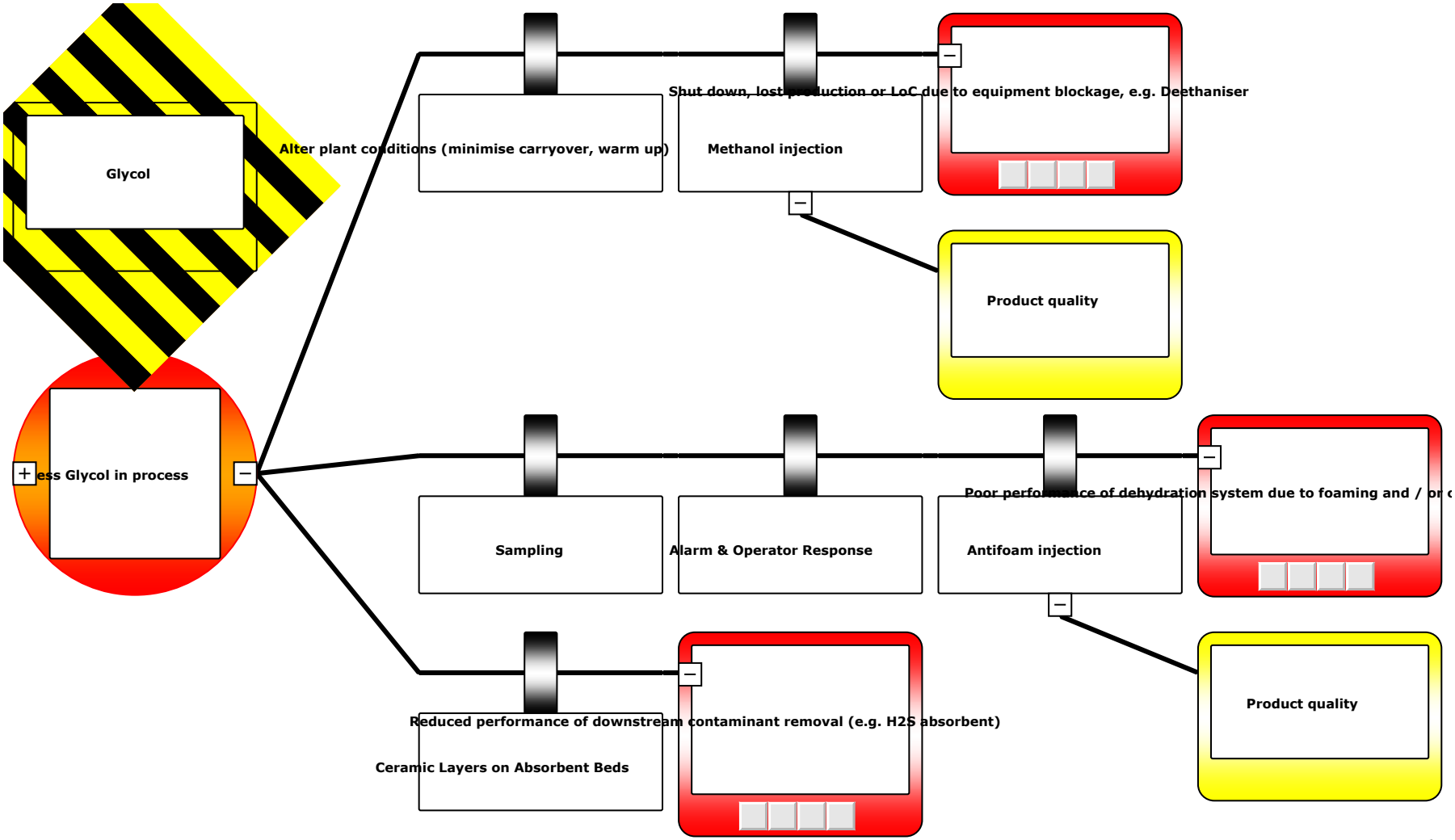
Hazard/Risk	Control
▪ Carry over from upstream shippers to downstream terminals	▪ Establish baseline level in order to trend
▪ Potential for solids build-up in process equipment (De-ethaniser reboiler, Slug Catcher, etc.)	▪ Monthly regen water sampling for each train
▪ Equipment downtime and additional costs for cleaning	▪ Additional ad hoc sampling when high water content or “two stage” regens



Appendix 7.2 Glycols Bowtie Diagram – Causes



Appendix 7.3 Glycols Bowtie Diagram – Consequences

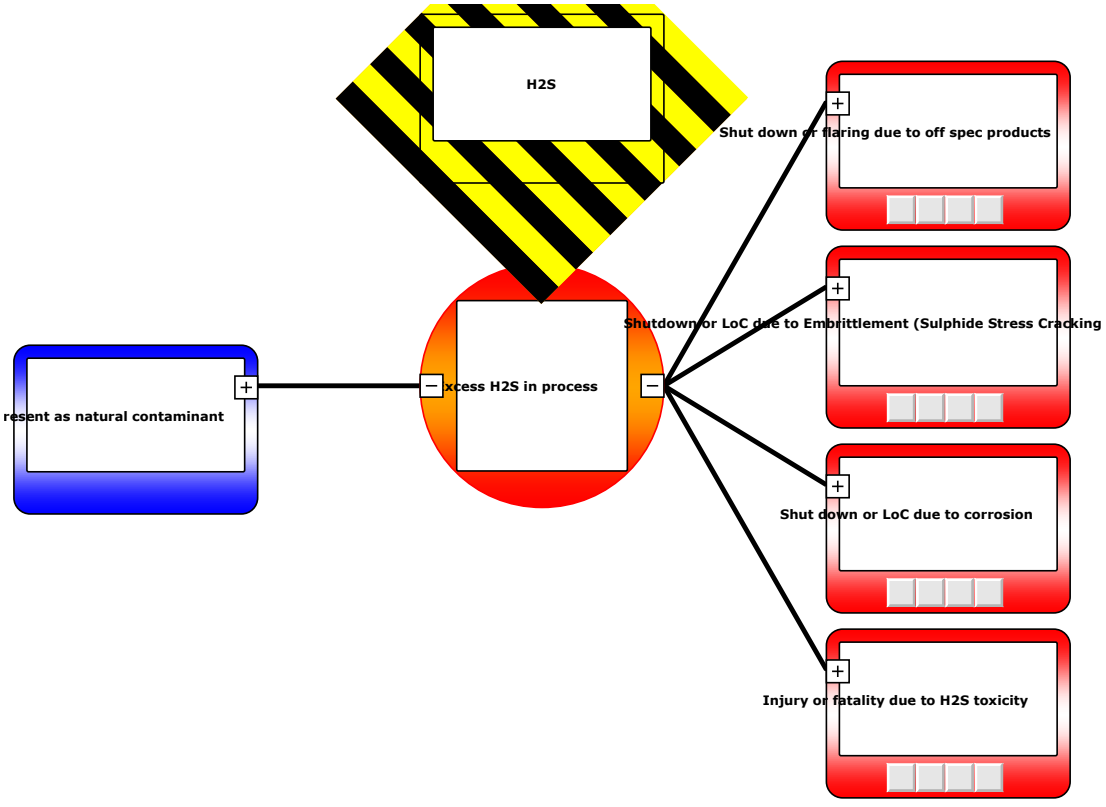


Appendix 8 Hydrogen Sulphide

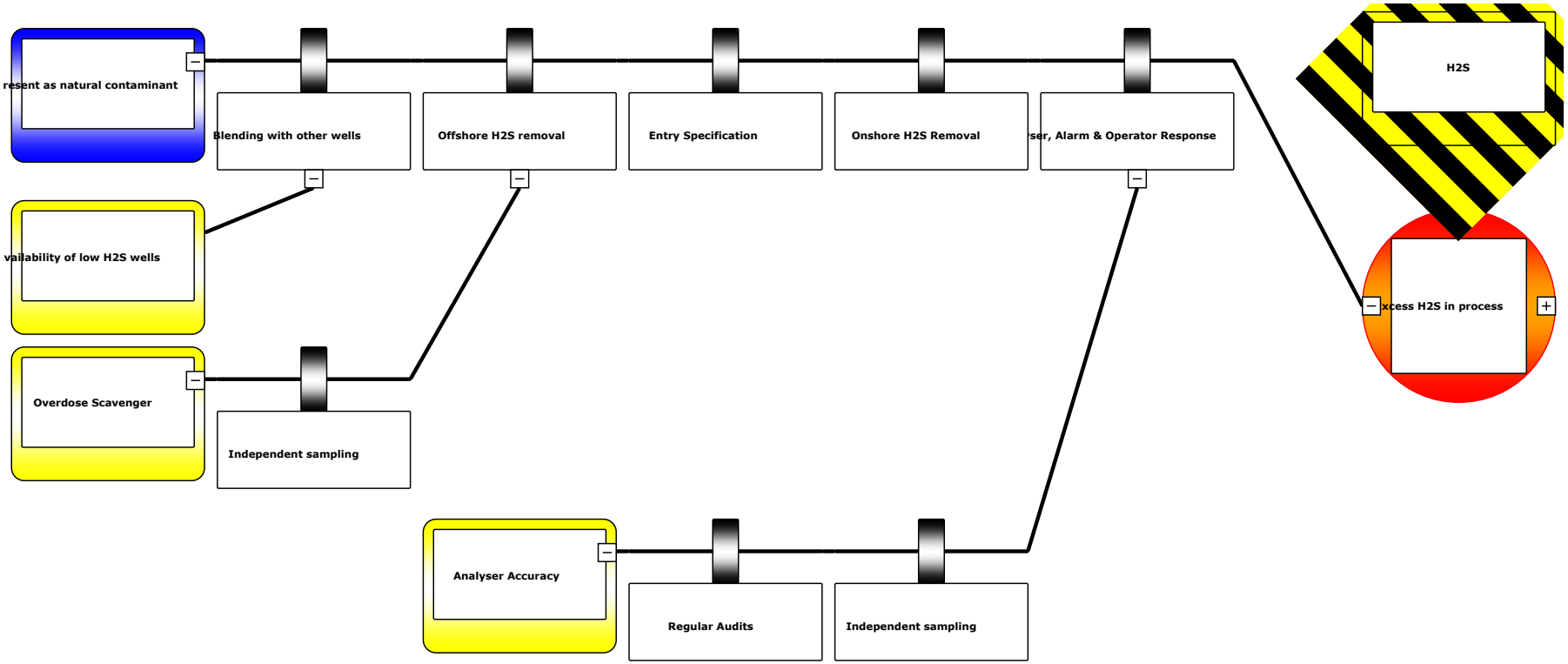
Appendix 8.1 Hydrogen Sulphide Summary

Hydrogen Sulphide (H_2S)

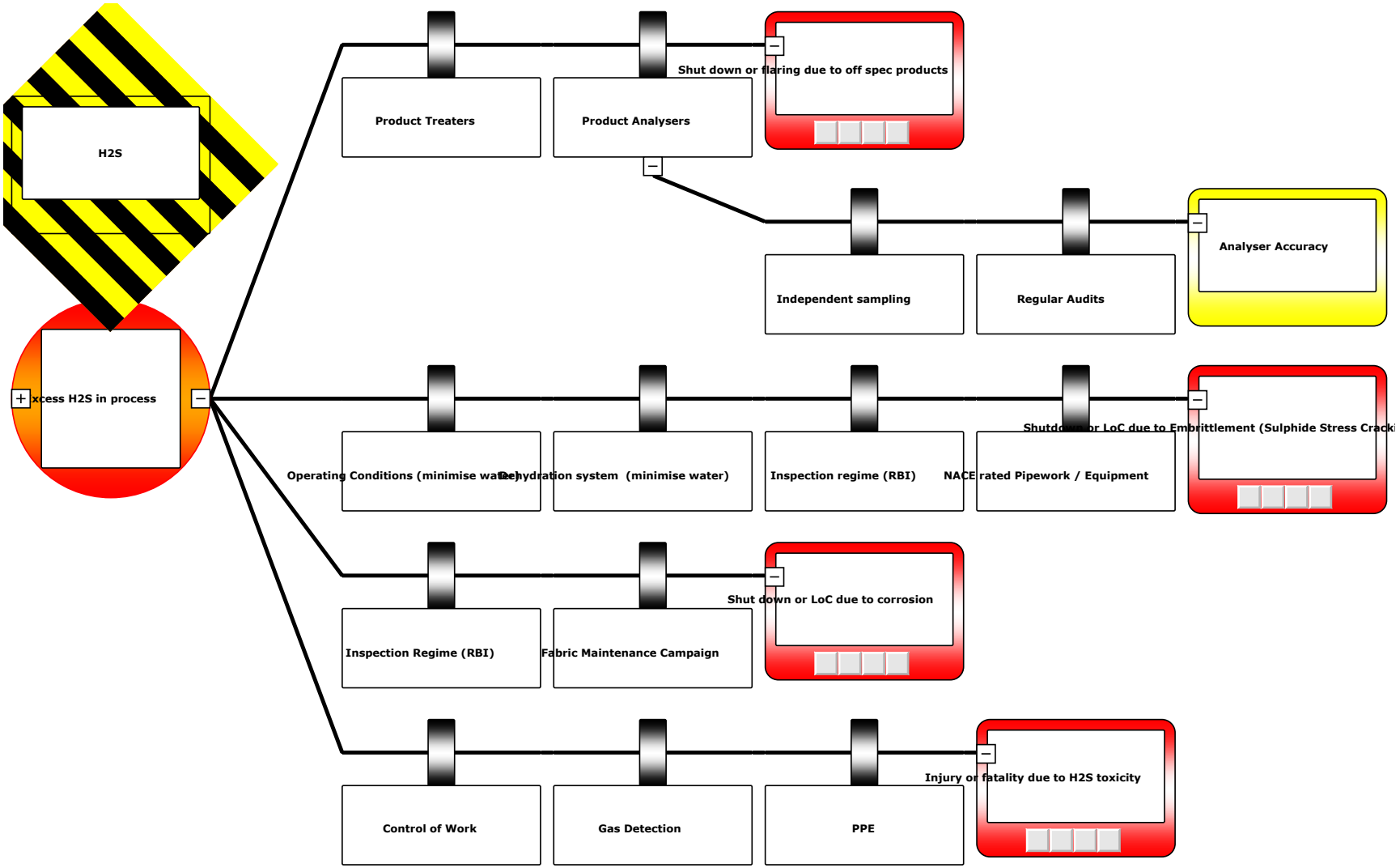
Hazard/Risk	Control
▪ Highly toxic to personnel ▪ Spent H2S absorbent is pyrophoric ▪ Corrosive effect on 'standard' pipeline metals ▪ Embrittlement (cracking) effect can lead to sudden failure ▪ Unable to meet export specification (Unplanned shutdown)	▪ Contractual entry specification for every shipper ▪ Online H2S Analyser or Gas Chromatograph (GC) measurement of H_2S with alarms to the CCR ▪ Regular audits of H_2S analyzers ▪ H_2S scavenger



Appendix 8.2 Hydrogen Sulphide Bowtie Diagram – Causes



Appendix 8.3 Hydrogen Sulphide Bowtie Diagram – Consequences



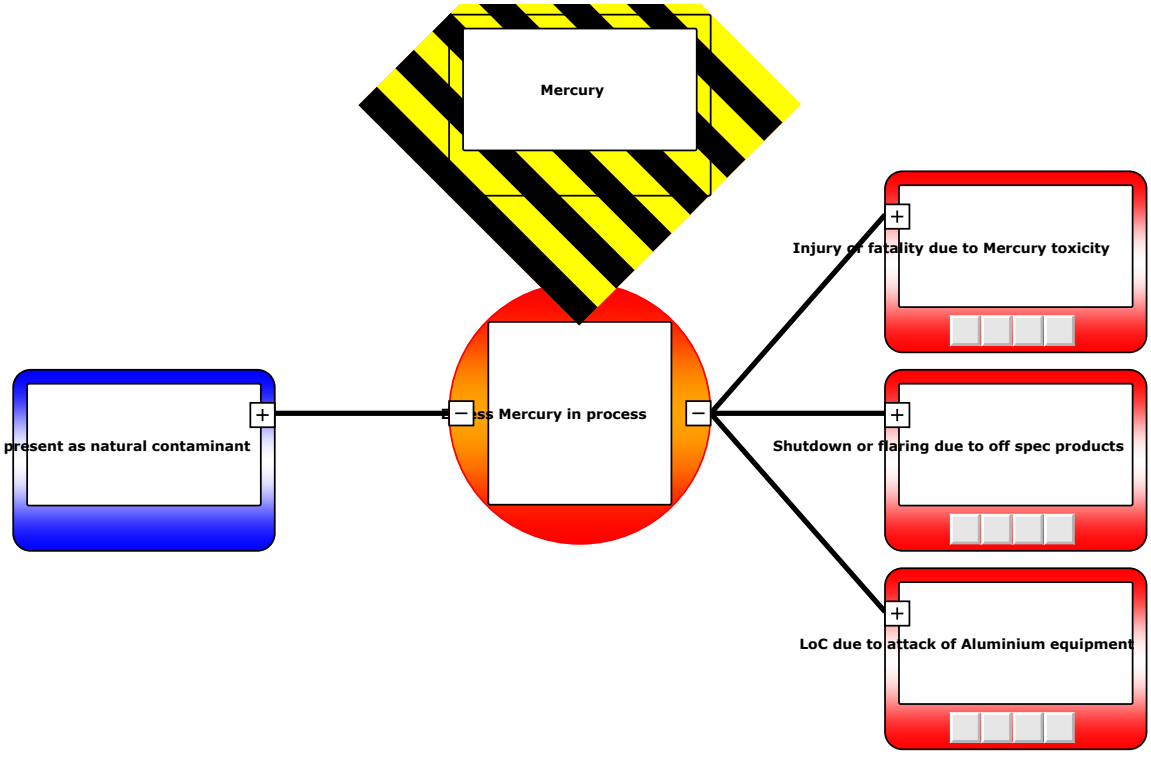
Appendix 9 Mercury

Appendix 9.1 Mercury Bowtie Diagram – Overall

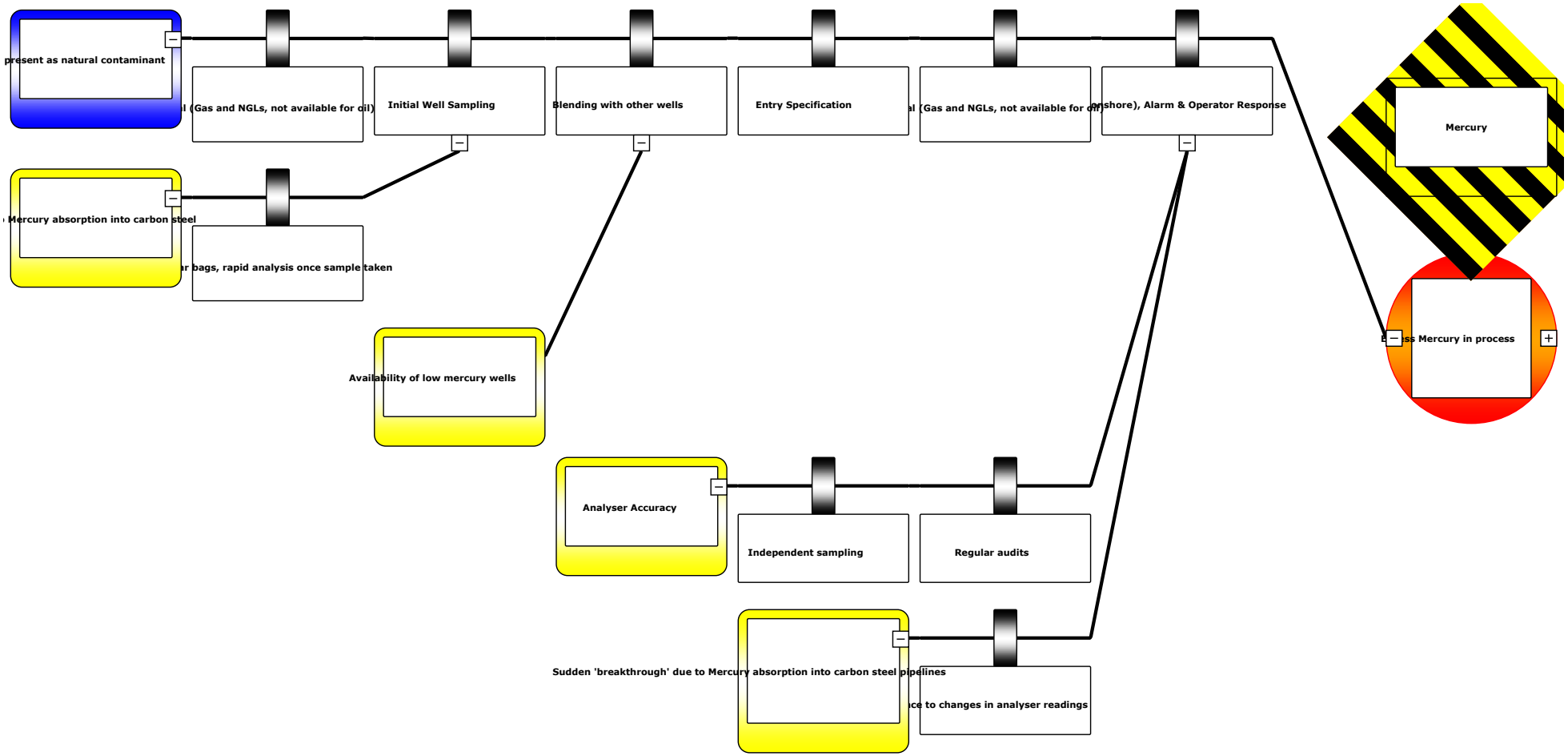
Mercury

Hazard/Risk	Control
▪ Toxic	▪ Initial trial samples
▪ Failure to meet export specification	▪ Follow on risk based sampling regime
▪ Unplanned shutdown	▪ Sampling audits
▪ Attacks aluminum components	▪ Mercury absorption beds

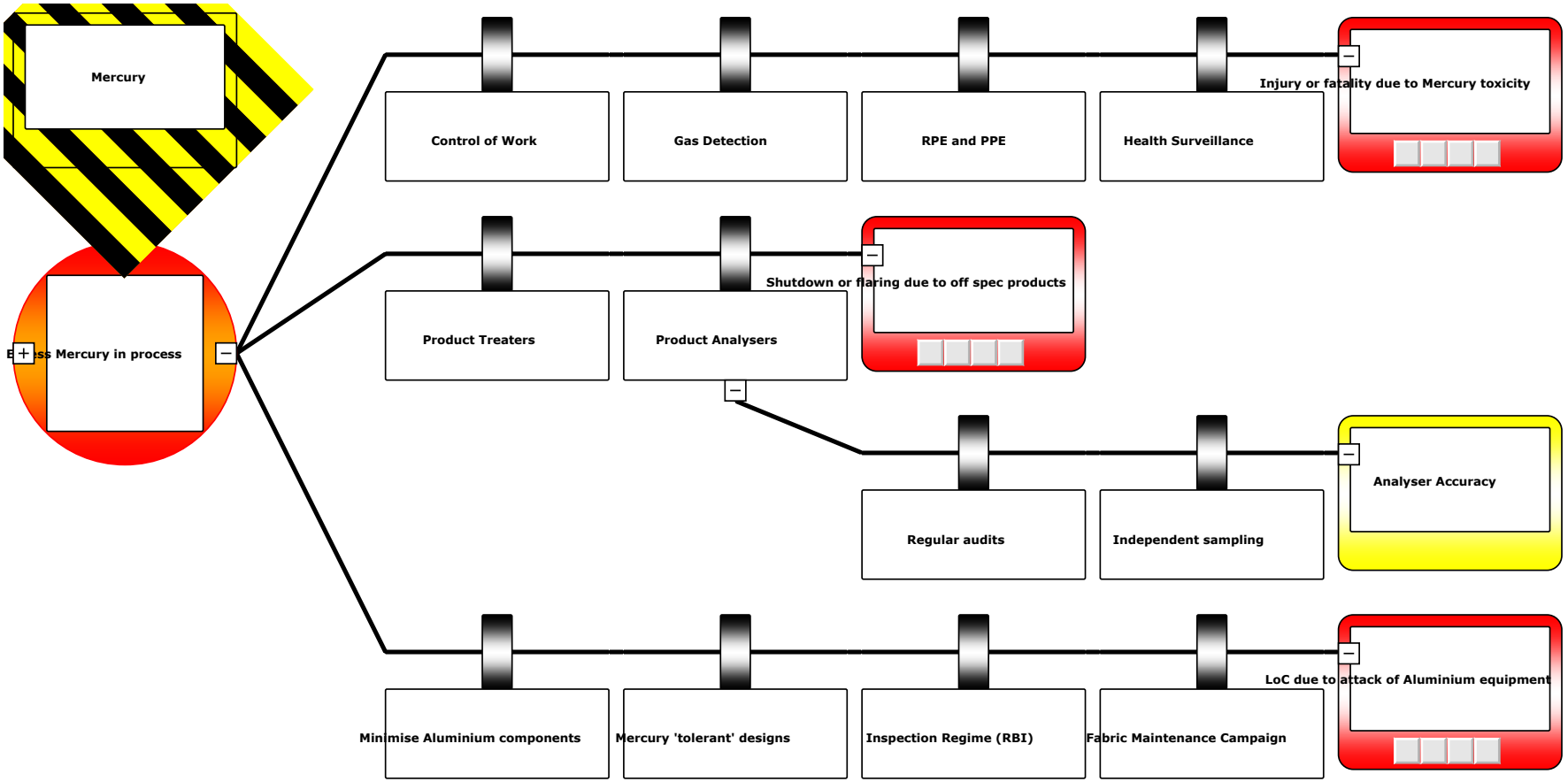
▪ ***Note:*** *Concentrations as low as parts per billion (PPB) may be enough to cause significant damage. Sample regimes may need to identify tiny/trace quantities.*



Appendix 9.2 Mercury Bowtie Diagram – Causes



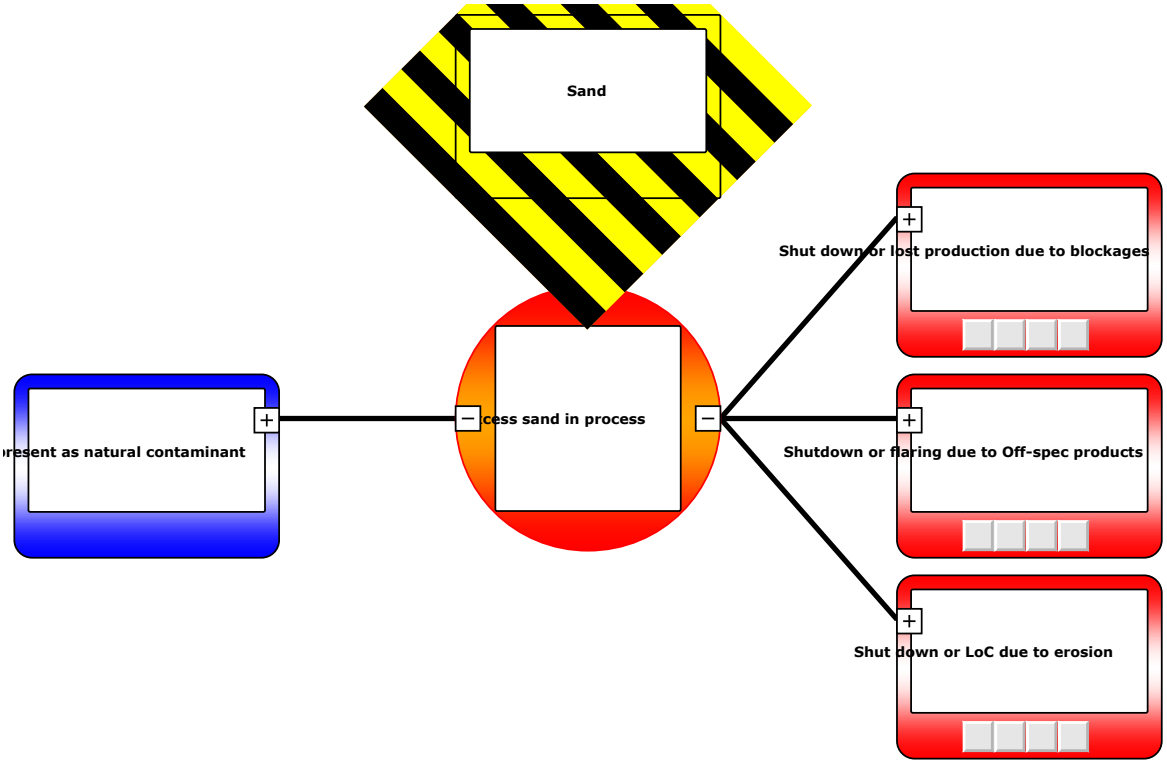
Appendix 9.3 Mercury Bowtie Diagram – Consequences



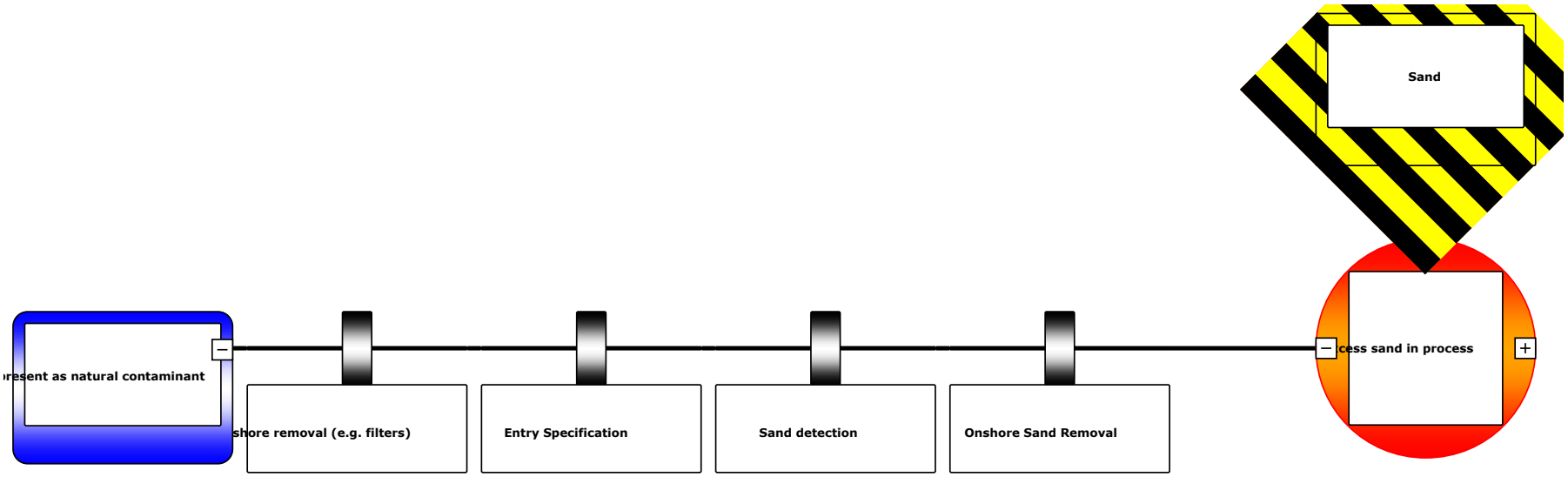
Appendix 10 Sand & Solids

Appendix 10.1 Sand Summary

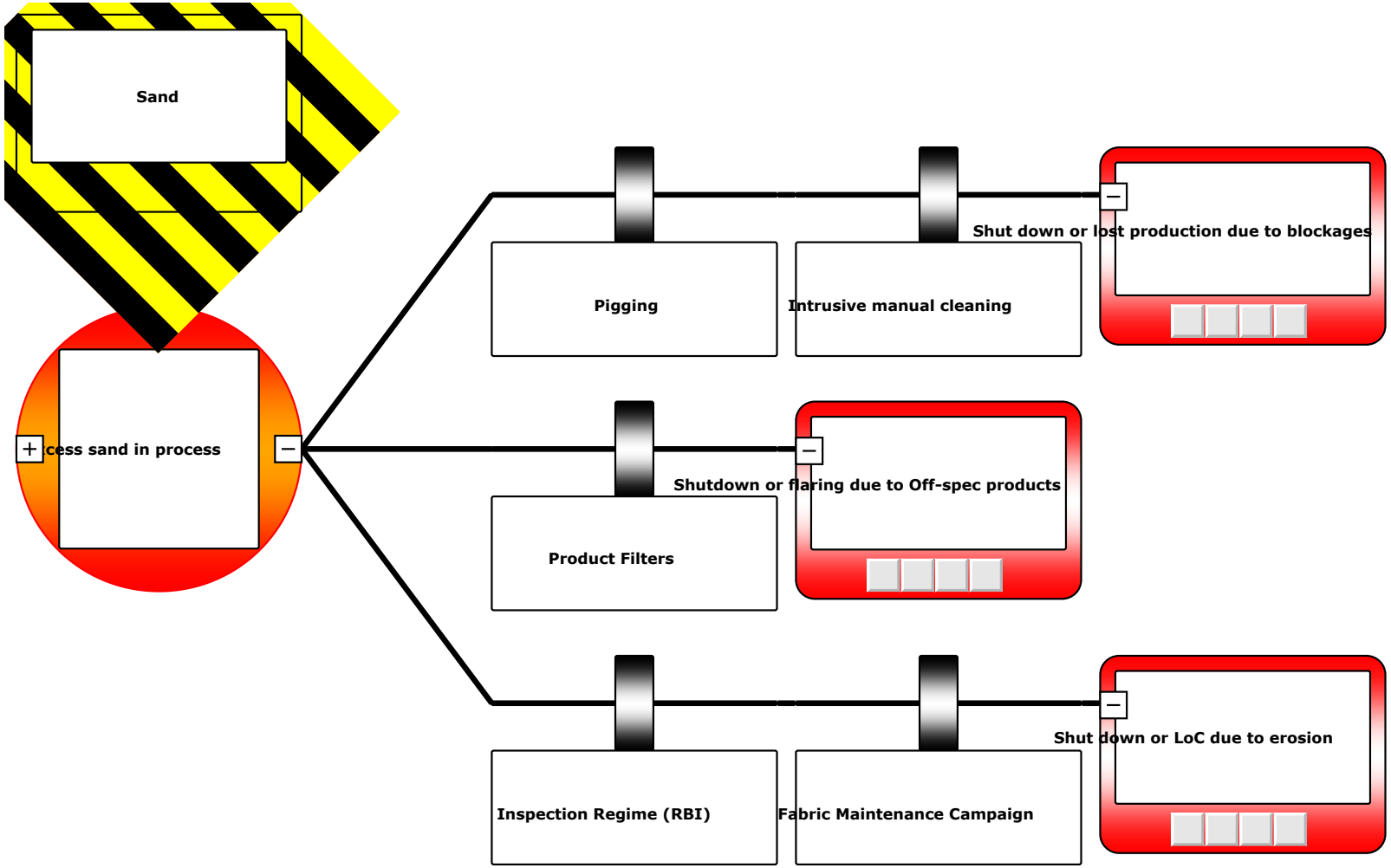
Sand & Solids	
Hazard/Risk	**Control**
▪ Pipeline blockage ▪ Separator (vessel) plugging ▪ Accelerated erosion, and wear of valves and pipelines (bends) ▪ Production downtime & repairs ▪ Potential loss of containment	▪ Upstream & downstream ▪ Well completion, sand screens or gravel packs ▪ Sand monitoring (ultrasonic detection) ▪ Asset Integrity Program ▪ Erosion probes



Appendix 10.2 Sand Bowtie Diagram – Causes



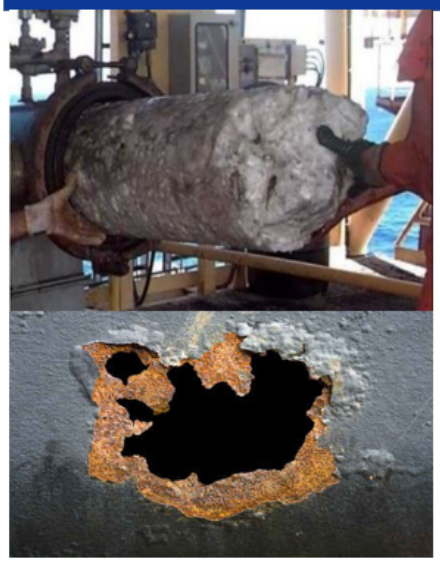
Appendix 10.3 Sand Bowtie Diagram – Consequences



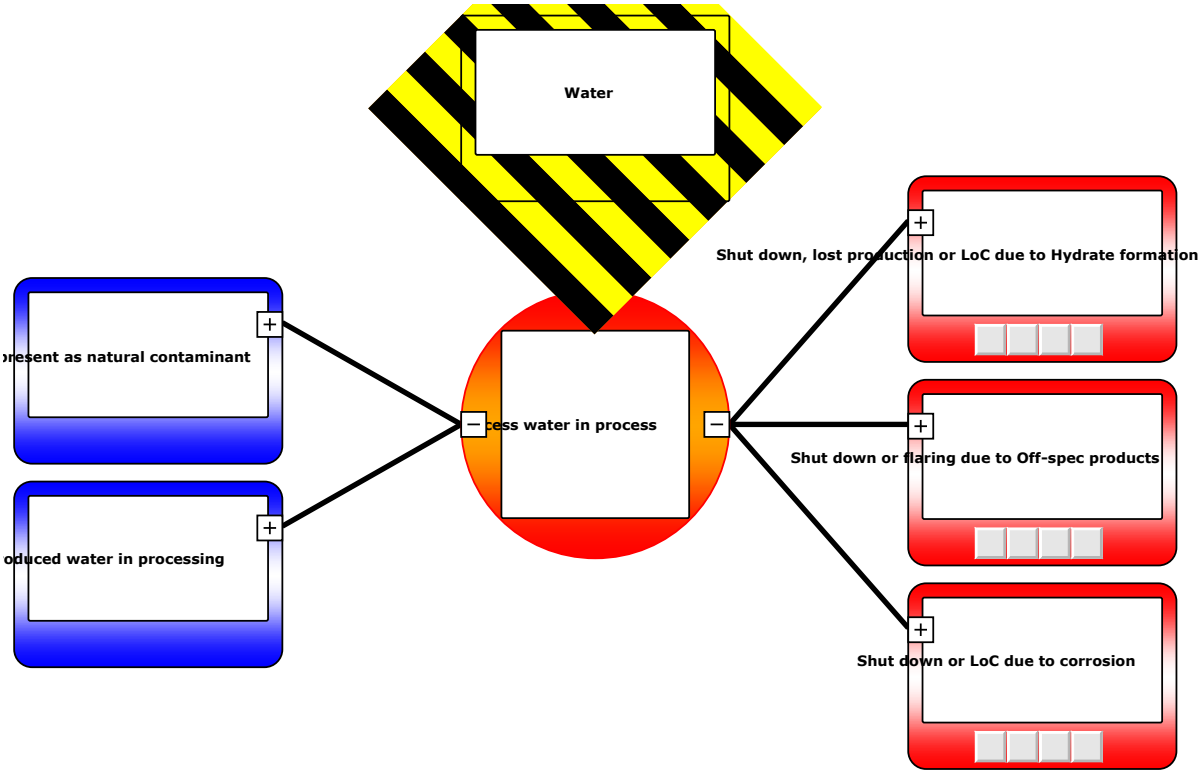
Appendix 11 Water

Appendix 11.1 Water Summary

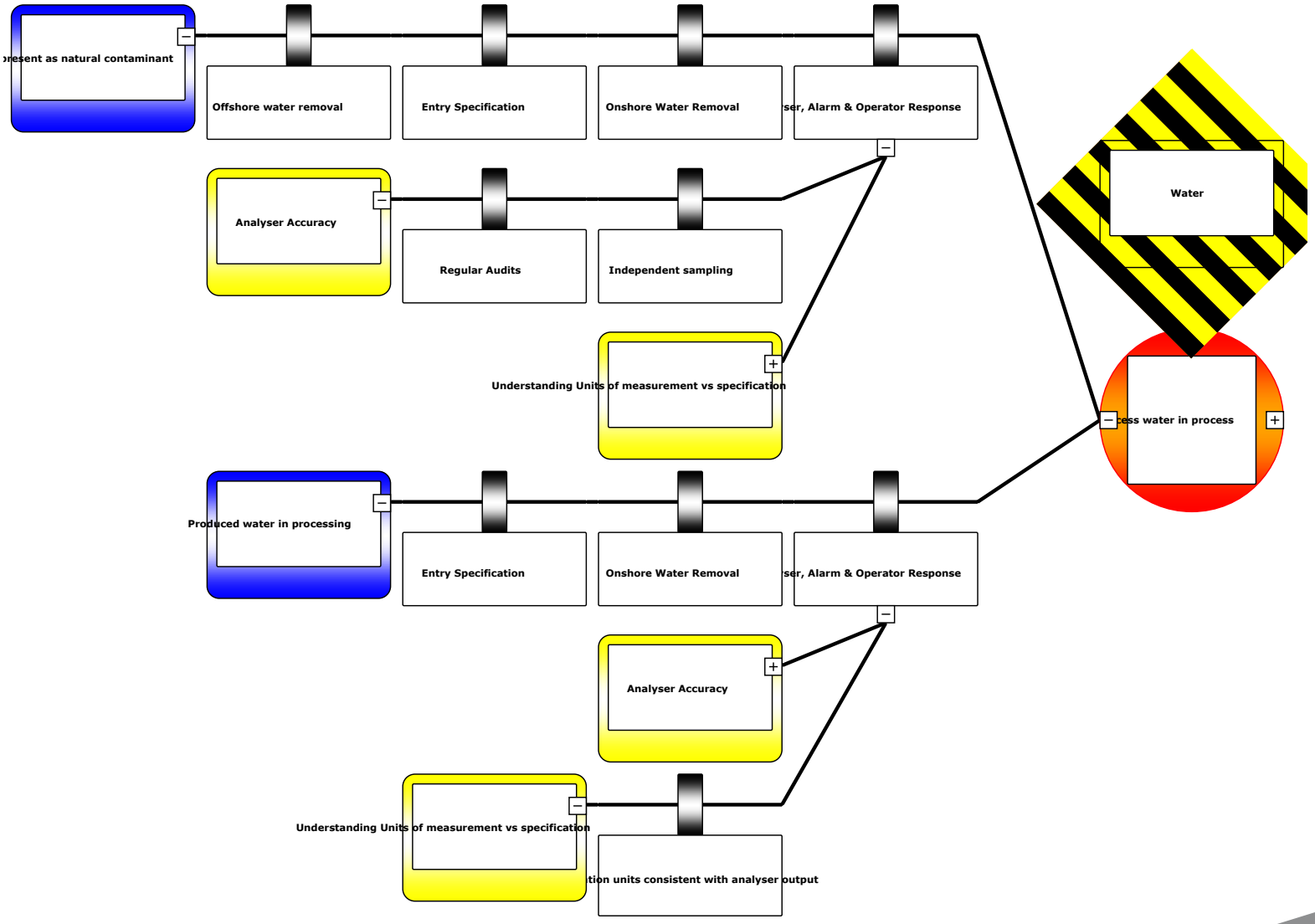
Contaminants - WATER



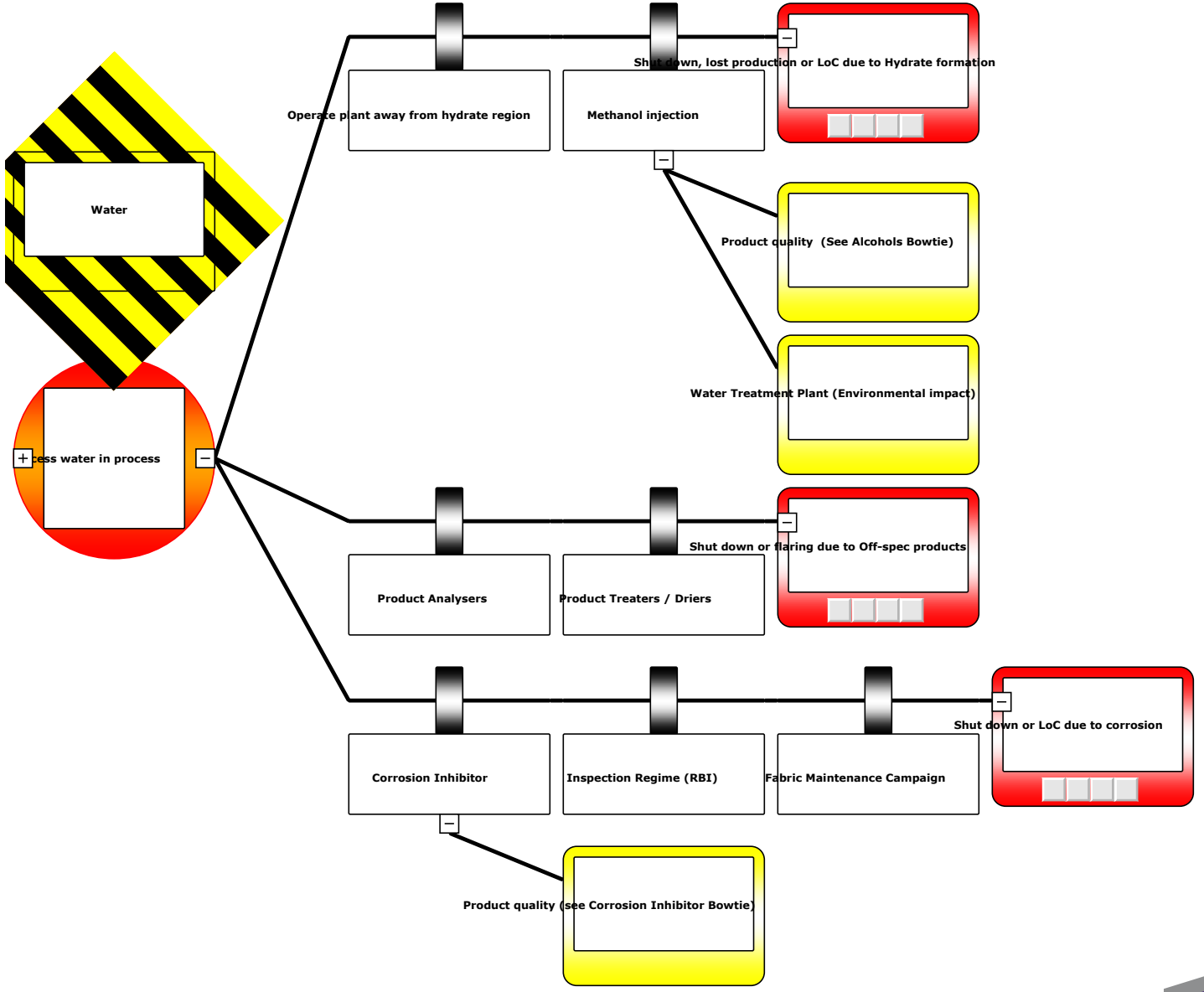
Hazard/Risk	Control
▪ Hydrate formation in cold plant leading to blockage	▪ Contractual entry specification for every shipper
▪ Failure to meet export spec. (flare/shutdown)	▪ Online Dew point measurement of water content with alarms to the CCR
▪ Free water leading to corrosion in the pipeline	▪ Routine sampling
	▪ Regular audits of H_2O analyzers



Appendix 11.2 Water Bowtie Diagram – Causes



Appendix 11.3 Water Bowtie Diagram – Consequences



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