Process Safety Conference Dordrecht, May 15, 2019

# EPSC Human Performance Work Group:

# Collection of Successful Practises

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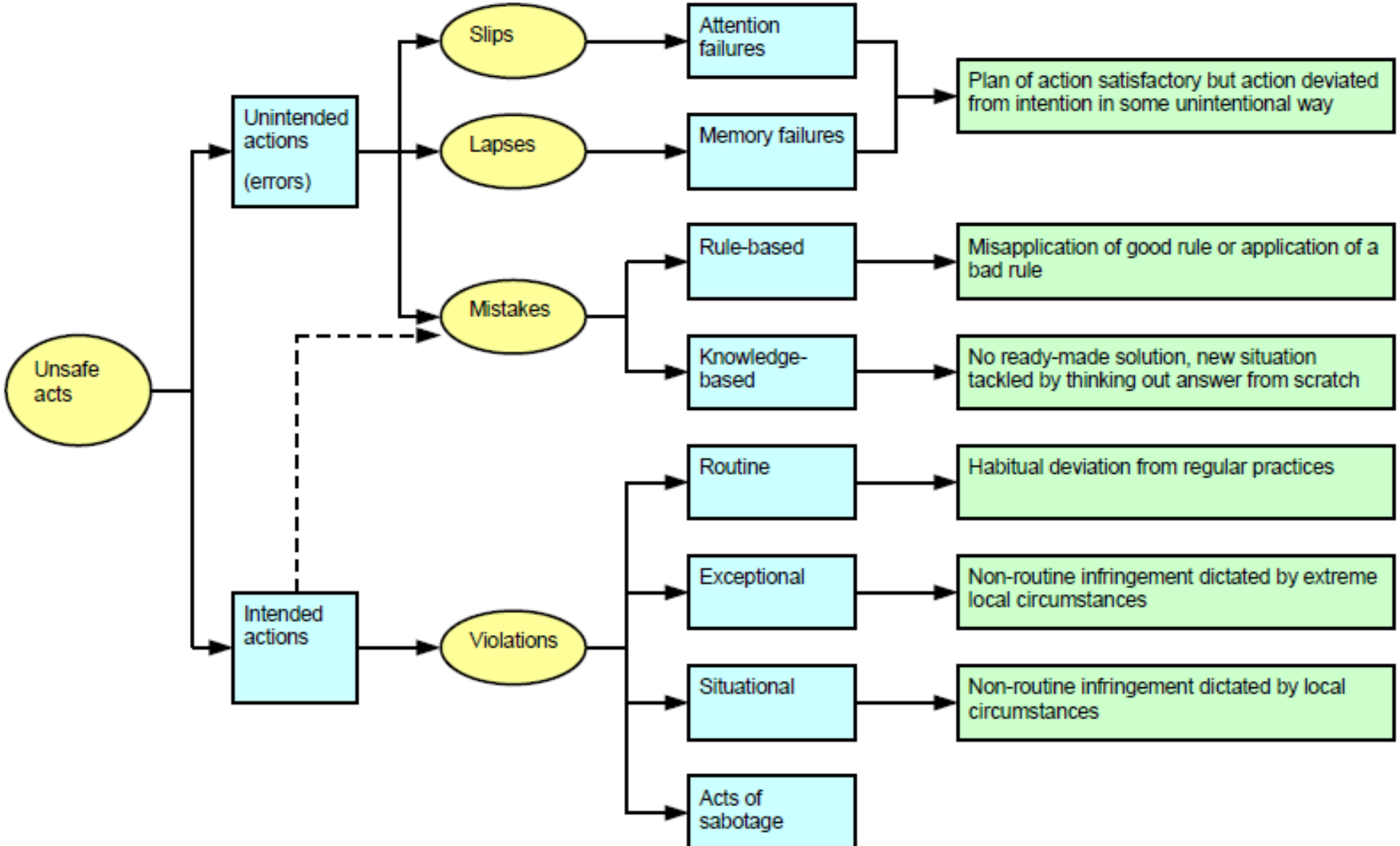
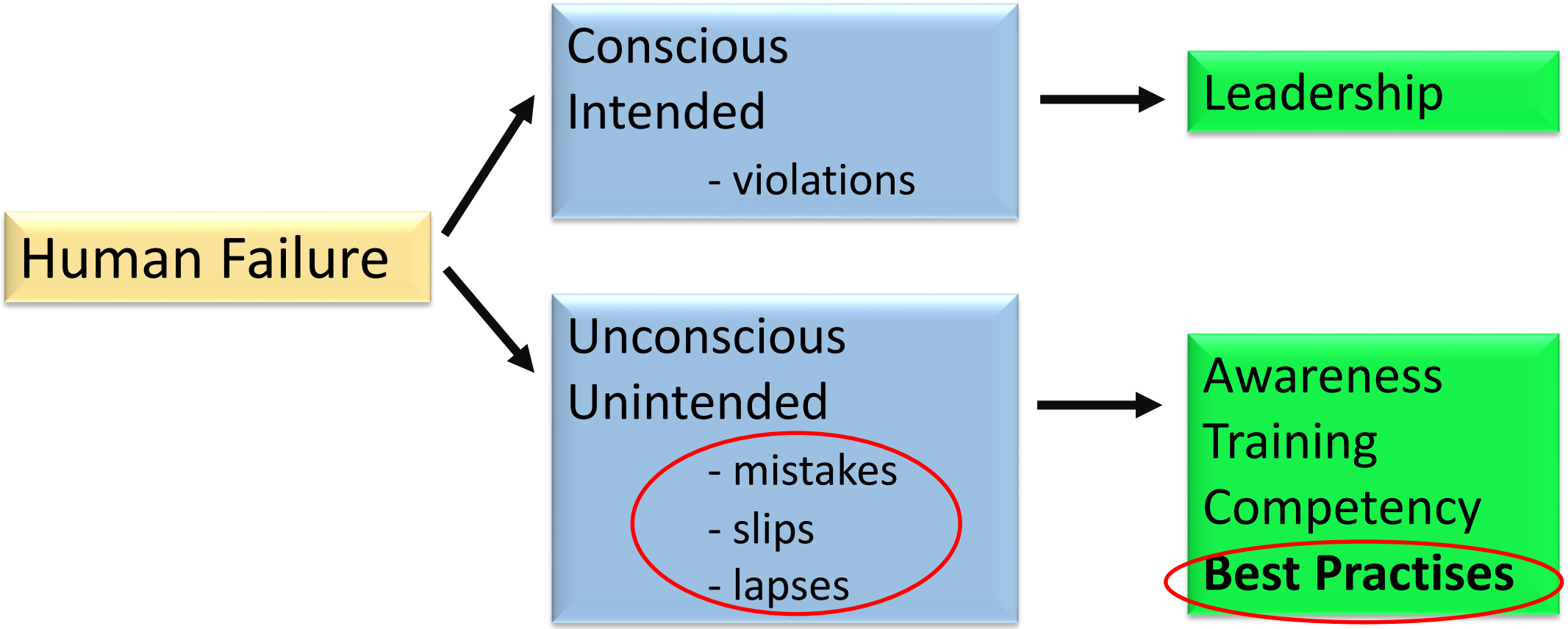
EPSC
THE PROCESS SAFETY NETWORK

# EPSC work group ‘Human Performance’

- Started March 2018
- Classification of human error types
- Example incidents from several companies
- **List of ‘Best Practices’, collected from several companies**

# Classification of Human Errors (HSE-UK)






Most such incidents are simple, easily understood ‚easy' to avoid

# Identify Valve Positions

## Problem

Manual valve left in the wrong position after maintenance, start-up, cleaning, etc.

## Solution

Make it easier to spot a valve in wrong position.
Color code for manual valve handles, e.g. **green** for normally open and **red** for normally closed,
and tag numbers at each manual valve.

Color coded and tagged valves (examples):

Normally Open: Green


Normally Closed: Red



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# Wrong Manual Valve

Missing or incorrect Hazard Perception

## Problem

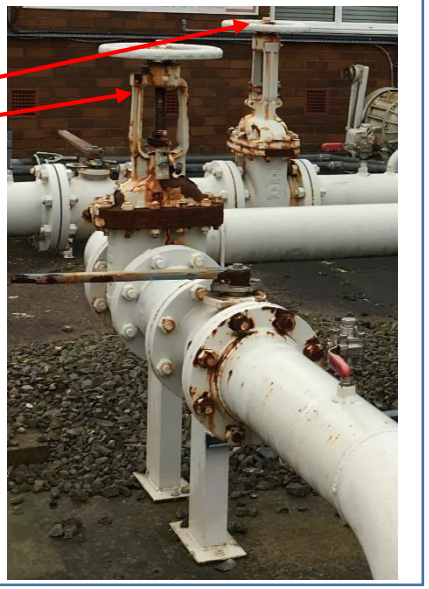
Operation of the wrong manual valve due to lack of labelling in the field, leading to potential for loss of containment.
Original labels may have not existed or been painted over.

## Solution

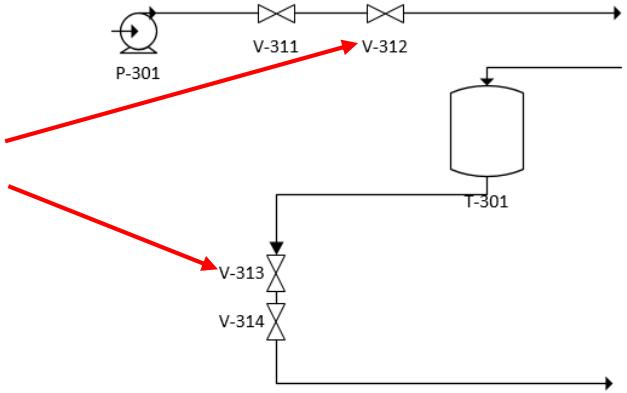
Tag manual valves with easily visible and unambiguous **labels**; referencing numbers from P&IDs.
Walk the line. For safety-critical isolations with Four-eyes principle to allow effective checking.

Which is the correct valve to close ?

Nothing is labelled/ tagged in the field



Valves are in a similar location but on completely different systems

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# Four Eyes Principle

Incorrect Working Patterns

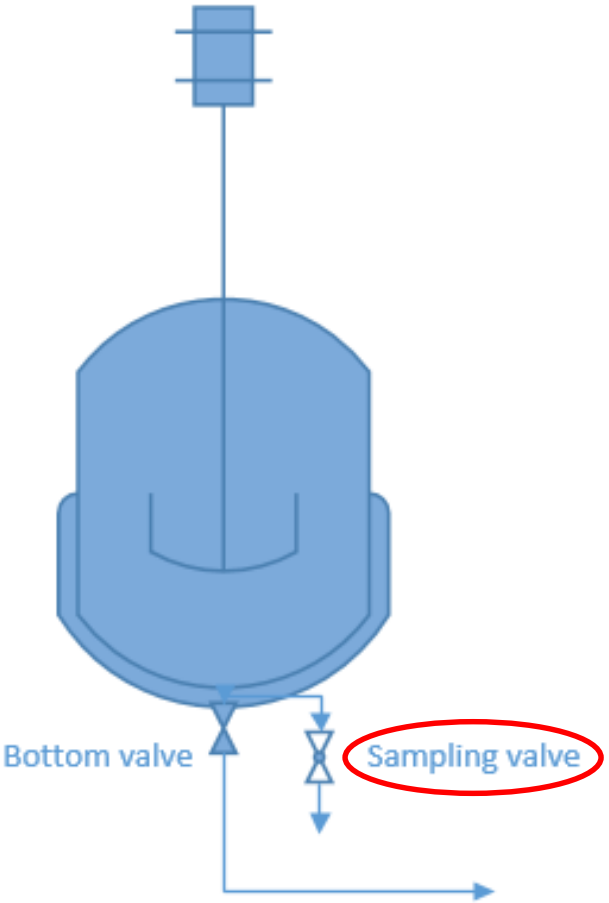
Missing or incorrect Hazard Perception

## Problem

A reactor was cleaned before running the next batch. Cleaning step was not completed during the shift (note in shiftbook). **Two valves** (bottom and sampling valve) were left open. Operator on next shift passed by the reactor and **closed only bottom valve** but believed to have closed both. Next batch was started leading to a major spill to the production room floor and process sewer.

## Solution

If a safety critical step can only be managed by organizational measures, the four eyes principle has to be applied. Hence double check (two independent persons e.g. operator and shift leader) whether valves are closed or pressure test result proofs tight equipment, before starting a new batch.

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# .. Volker Hautzel, Clariant

# Unique Identification

## Problem

Wrong manual valves in the field are manupilated by manufacturing or maintenance operators

## Solution

Unique identification of all components in the field and on P&ID.

In example **stainless steel ID** plates are used to prevent wear of inscription.
Example of unique ID: 030-CC02-HV25:

- 030: plant code
- CC02: main equipment code (centrifuge 02)
- HV25: handvalve 25

Incorrect Working Patterns


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# .. Jan Weckx, Monsanto

# Personalization of Flanges

Problem

Leaking flanges because bolts not tightened with the correct torque, or missing;
or the flange seal face damaged,
or gaskets not suitable or incorrectly installed.

Story

Make the Craftsman, who assembles the flange, **'sign' his work**. Instill sense of responsability for the correct installation.

Solution:
All flanges get seals or labels with a personal identifier for employee / contractor worker who assembles the flange, and for the person who ensures the tightness of the flange (seal quality). + technical information, e.g. type & material of gasket
Modern version: QR code

Flanges identified by lead seal system:

QR code identification:



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# Gasket Display Board

## Problem

Use of the **wrong gasket** types or material often leads to inadvertent chemical releases

## Solution

Displaying plant specific gasket materials and types along with descriptions and pipe service index designations.

Gasket board:




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# Tightness of large flanges

## Problem

Large flanges leaking due to different torques on the bolts

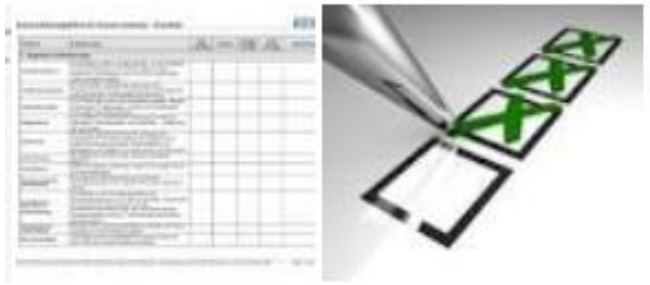
## Solution

Use of **bolts with force indicator** or use of **pretorquing tool** during flange assembly.

## Solution:

Tightness test with e.g. nitrogen, gradually increase the nitrogen pressure and perform check with an adequate leak detection substance (e.g. spray) or do a pressure test

Tightness check (examples):



# Small nozzles are vulnerable

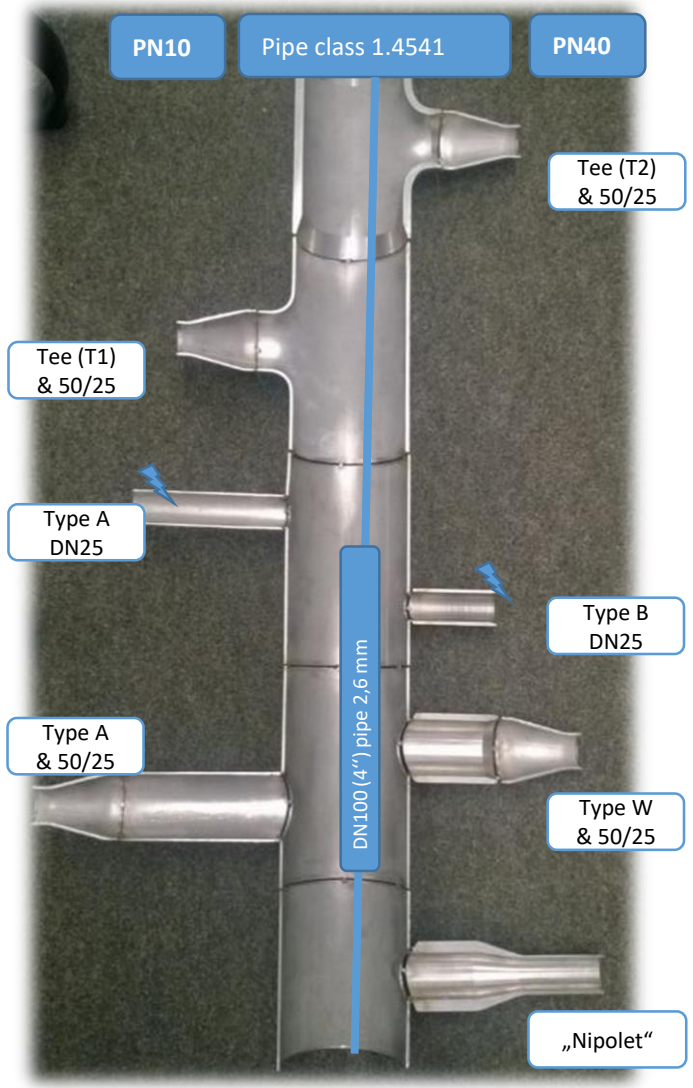
Missing or incorrect Hazard Perception

## Problem

Small nozzles on pipes and equipment are potential weak points of a pipe system. **Vibrations** create fatigue, and impact (**stepping on them**) can knock them off, leading to releases

## Solution

Nozzles ≤ DN25 should be avoided. Use instead a forged T piece DN50 (50mm) with a **50/25 reduction**, which increases stiffness and tolerates higher loads.
With hazardous materials, also a thicker pipe than minimum requirement is recommended.
In case of potential for vehicle impact, unavoidable small nozzles should be protected by ram protection (steel bar etc)

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# Marker for Line Cutting

## Problem

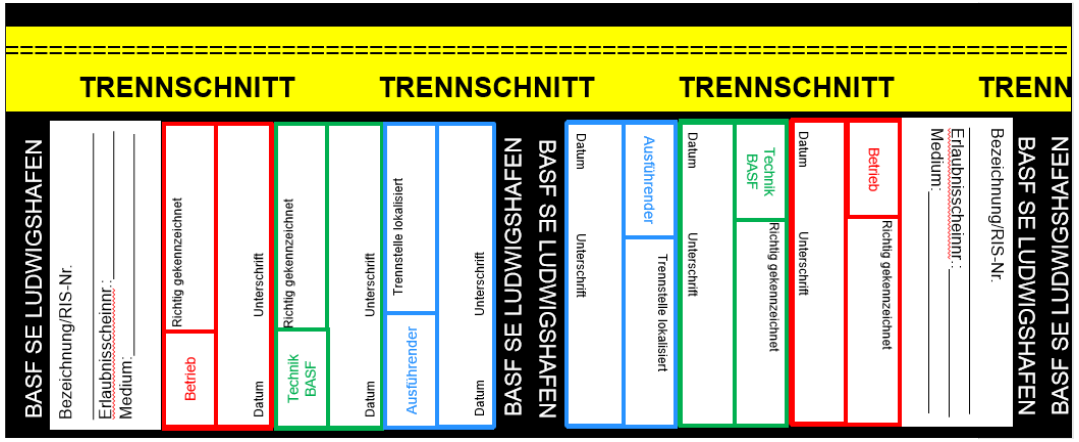
Cutting into the wrong pipe during technical changes, or maintenance work. Avoid consequences of a single human failure.

## Solution

Before a line cutting task, a risk assessment is needed.
**Each pipe cut location marked** with adhesive tape.
Note on the tape the work permit number, signature of plant supervisor, date of work

Clearly identified and marked pipeline


Example of an identification adheisve tape

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# Removal of gearbox or actuator from valves

Incorrect Working Patterns

Missing or incorrect Hazard Perception

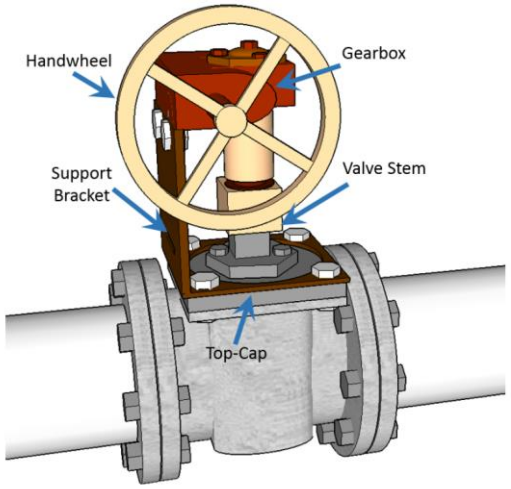
## Problem

During removal of an inoperable gearbox on a plug valve, the operator mistakenly removed critical bolts securing the pressure-retaining component of the valve. The valve came apart and released the process fluid.

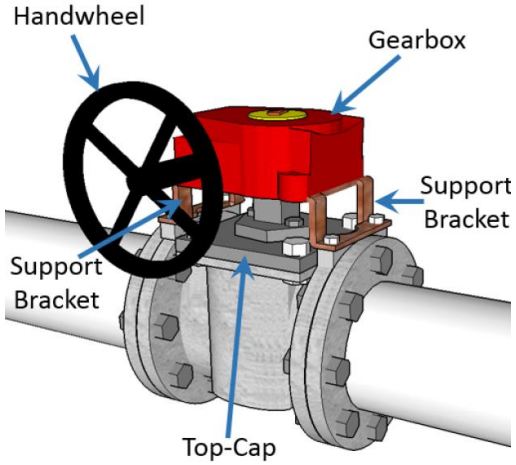
## Solution

Evaluate human factors associated with equipment design and apply the hierarchy of controls e.g. improve design to mitigate identified hazards

Establish detailed and accurate written procedures and provide training to ensure workers know the hazards and how the plug valve gearbox should be disassembled safely.




By design, removing the gearbox did not require removing the four vertical bolts that secured the pressure-retaining top-cap




Improved design, showing how gearbox connects to all four dedicated attachment points on the valve flanges that are not pressure-retaining parts.

Reference: CSB see https://www.csb.gov/

#26 Bob van Woezik, DSM

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# Similar, but very different

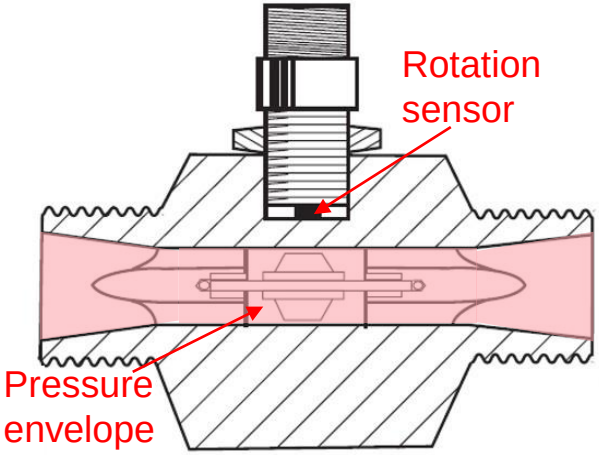
## Problem

Potential for loss of containment where there are two similar pieces of equipment but with different pressure envelopes. One can be safely maintained whilst in service and it might be assumed by staff that this is the case for both items. However, the other loses containment when similar work is performed. E.g. Removal of turbine flowmeter rotation sensors (example shown) or valve gearbox bolts (CSB video https://youtu.be/QyIIe5T5beM)

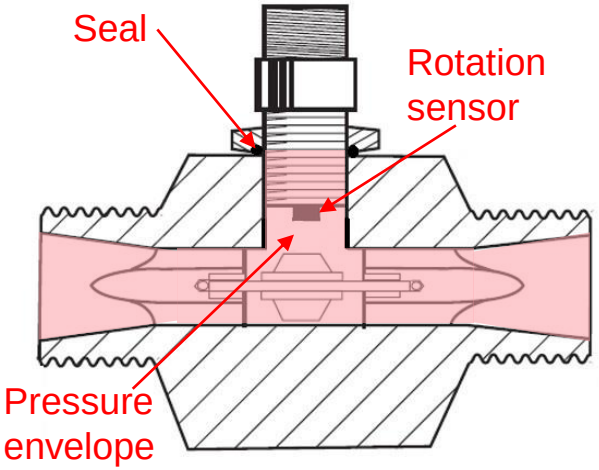
## Solution

Identify where there are different designs for similar items of equipment that perform the same function, but have a different pressure envelope. Standardise on one design and ensure the pressure envelope is clearly identified and understood/ documented to prevent future mistakes.

Safe to remove rotation sensor without compromising pressure envelope




Removal of rotation sensor would lead to major loss of containment

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# Wrong Chemical

Missing or incorrect use of Color Signals

## Problem

Wrong chemicals can be dosed to reactors, when identification and storage is poor. This can result in hazardous reactions

## Solution

Chemicals in an organization are handled by suppliers, logistic people and operators. Clear storage rules and principles help to avoid errors:
**Use different colours for different drums**, clear names and identification, separated storage location, a **barcode** scan for validation

Organized storage of chemical drums helps to avoid that the wrong chemical ends up in the wrong reactor


- Separate storage location
- Product and location well indicated
- Use of different colours
- Name easily related to the use, process & location
- Barcode scanning before use for validation



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Violation; Conscious incorrect Behavior or: -> | Missing or incorrect Hazard Perception

# Bypassing a Z-Switch

## Problem

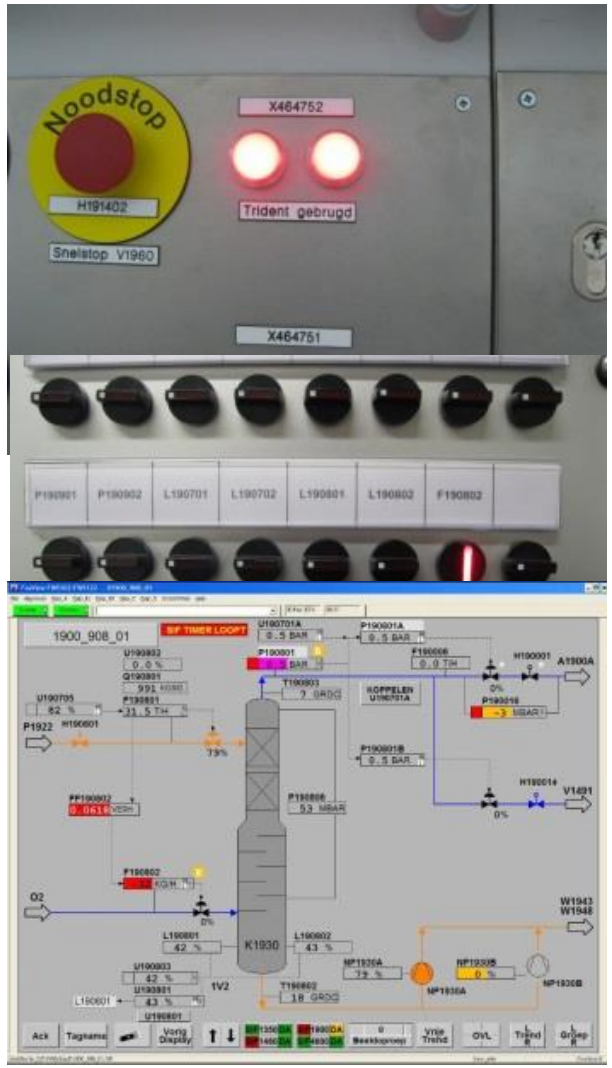
Sometimes an interlock (Z-switch) is bypassed, e.g. when tested. Although this can only be done with a permit ('high level authorization'), it is not always known by everybody.

## Solution

Visualizing the bypassing of a Z-switch:

- Lamps in the control room, which light up if a measurement or a valve is bypassed.
- Clear bypass buttons in the switch room
- Visualization on the schematics
- Perform an interlock test within a shift

Visualization of Z-bypassing (examples):

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# Bypass Safety Function

Incorrect Working Patterns

Missing or incorrect Hazard Perception

Problem

A polymerization reactor needed to be high pressure cleaned for a repair to the agitator. In order to prevent damage during the cleaning, vulnerable instruments such as the high level probe were removed and suspended outside the vessel. After the repair, the probe was not put back in place and the reactor operated for several weeks without high level interlock until an operator noticed the suspended probe during a field tour.

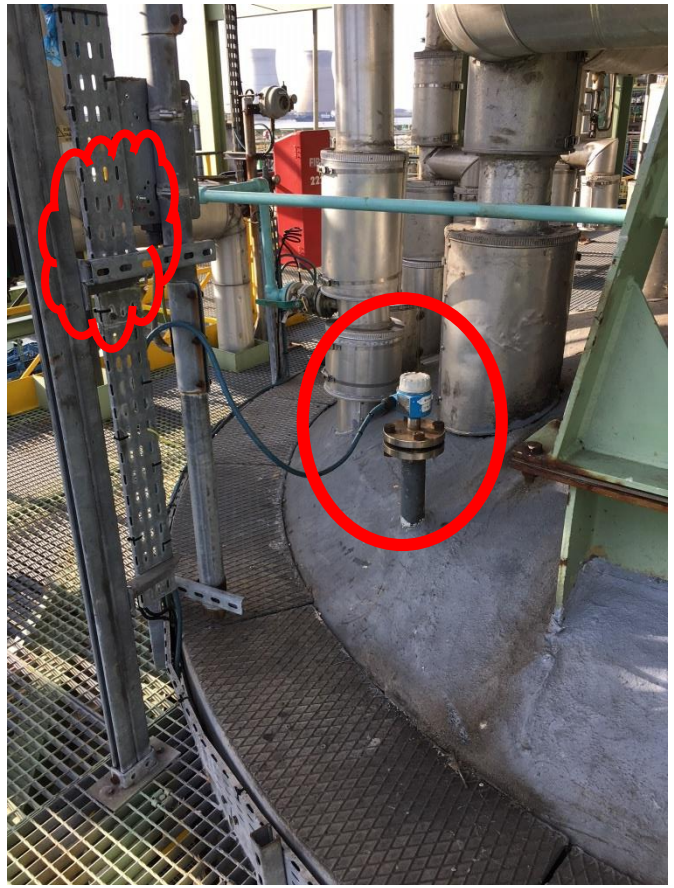
Story

Removal of critical instruments is normally managed by an interlock bypass procedure. However, this is not always applied when risks are not present (vessel emptied and opened, turnover or shutdown situations …)

Solution

- Always use the interlock bypass procedure when critical instruments are removed. In safe conditions (empty systems, shutdown ..) the approval level can be reduced but the procedure will ensure that the interlock is taken back in service before startup.
- Alternatively, always disconnect an instrument electrically if it is removed from the equipment. This will bring it to it's safe state, even when it is not put back in place.
- Pre Start-up Safety Review (PSSR) can be used to validate all safety functions are restored after a project or maintenance work

Validate that all safety functions are reinstalled and work well after maintenance work:
use an Interlock by pass form when safety instrumentation function (SIF) is temporarily out of service



# 20 Jan Weckx Bayer

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# Currently ~ 40 such ‘successfull practises’ from 7 companies