EPSC webinar, Sept. 10, 2020

EPSC Human Performance Work Group:

Collection of 'Usefull Practises' to avoid 'Human Error' Incidents in Process Safety

Hans Schwarz, Sept. 2020

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THE PROCESS SAFETY NETWORK

Your presenter: Hans Schwarz

33 years experience in BASF & Chem. Industry,
in Process Safety, Operations,Technology, Projects, R&D

Owner *ProSafeX*, Process Safety services company, Königstein, Germany

- **Part time Director of Business Development at TÜV SÜD Chemie Service**
- **Board member of EPSC**
- **Executive Expert Process Safety, Ludwigshafen, Germany, 2017-2019**
- **VP Process Safety BASF, global head of Process Safety, 2010-2016**

Prior roles in BASF group:

- VP Technology, PU Division, 2003-2010, Brussels, Belgium
- Project Executive new TDI plant, 1999-2003, Geismar, US
- Production & Technology, various roles, 1991-1999, Belgium & US
- R&D Manager and R&D chemical processes, 1986-89, Ludwigshafen

PHD in Physical Chemistry, Heidelberg University, 1986

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EPSC work group ‘Human Performance’

- 2018 - 2019, met 6 times
- Classification of human error types
- Example incidents from several companies
- **Main output:**
  List of ‘Useful Practices’, collected from several companies

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Example Incidents

- Participating companies shared **typical Process Safety Incidents** with **human error background**
  - Valves left open, flange issues, confusion of equipment, bypassing of interlocks,.....

- Statistics from several companies showed human error as the **most frequent 'type'** of Process Safety Incidents
  - Human & organisational failure >> 50% of PSI
  - Technical failure (Asset Integrity, Design) << 50% of PSI

- Several examples in CSB reports and videos
  - E.g. Explosion at Formosa Plastics plant, 2004
  - Link: https://www.csb.gov/videos/explosion-at-formosa-plastics-illinois/

Human error example: PVC plant

Minutes 1:40 to 4:00 of the CSB video on the Fire and Explosion in a PVC plant of company Formosa Plastics in Illiopolis, Illinois, April 2004

You find the video on the CSB website !

Human error example: PVC plant

- 2 errors:
  - Wrong equipment → ‚slip', ‚attention issue' ‚perceptual confusion'
  - Forcing the locked valve open → ‚knowledge based mistake' ‚confirmation bias' ‚normalization of deviation' ?

Are ‘Human Errors’ causes of incidents ?

- Historically ‘Human errors’ were seen as causes of incidents
- Today, **‘Human Errors’ seen as consequences** of deeper ‘root causes’
- **Root causes** leading to **human errors** can be grounded in
  - the person,
  - the organisation of work,
  - the technical condition or design of plant and equipment
- Usefull practises to **avoid human error** should therefore target
  - the organisation of work and work processes, procedures
  - Automation
  - the technical condition and design of plant or equipment

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Classification of Human Errors

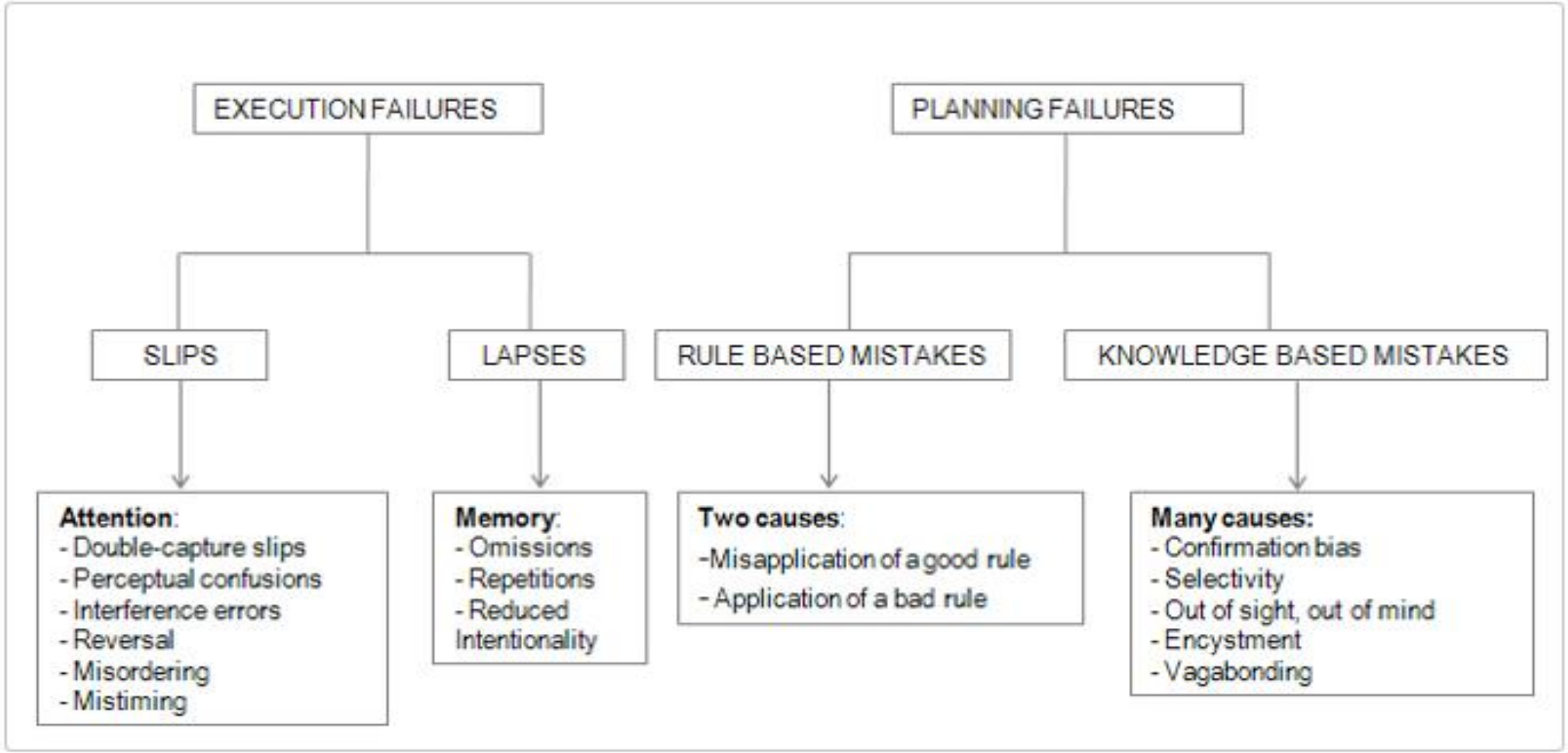

Figure 1: execution and planning failures adapted from Rasmussen

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Classification of Human Errors

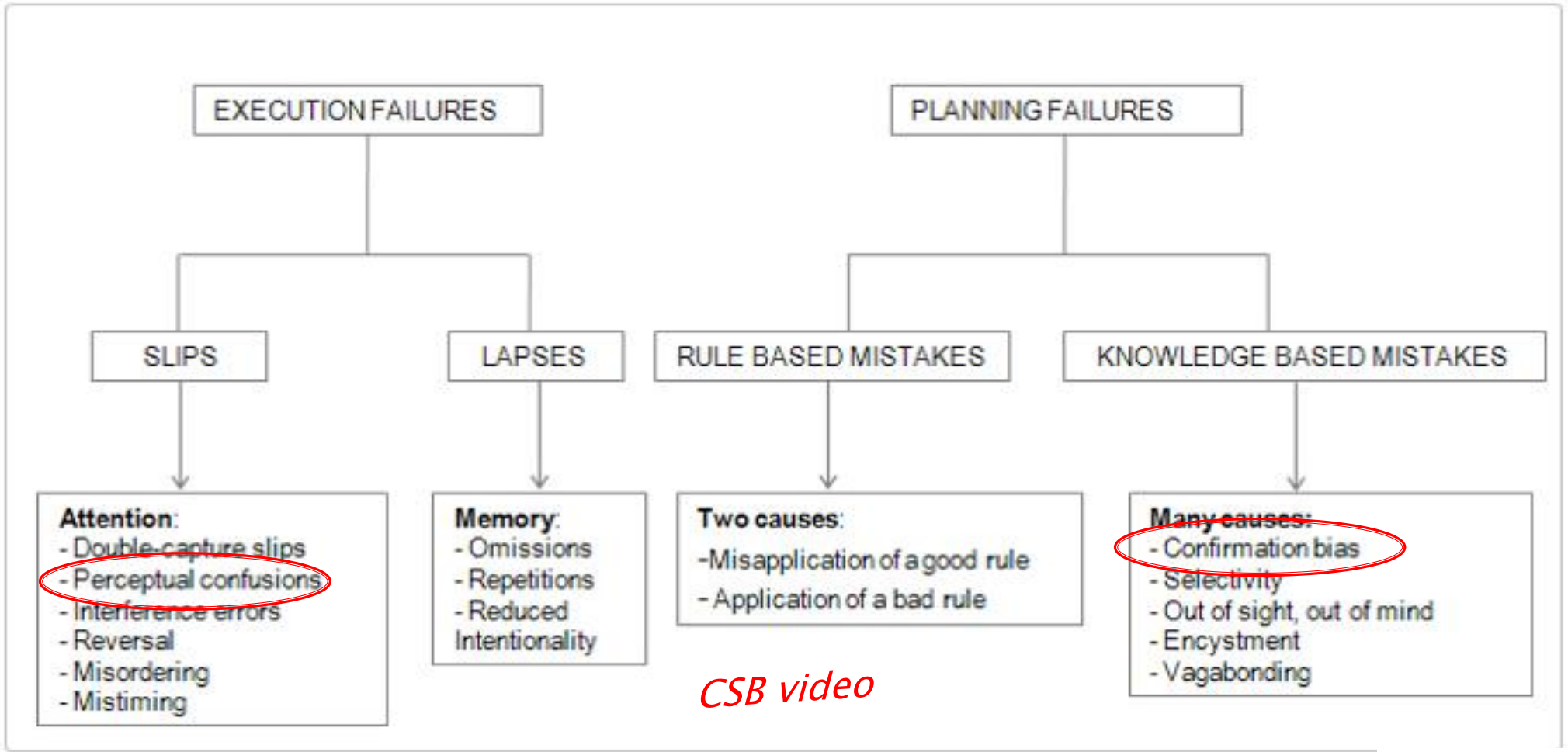

Figure 1: execution and planning failures adapted from Rasmussen

Classification of Human Errors

- **Slips:** **Execution failure** **related to attention, perception**

  E.g. Pushing the wrong button, opening the wrong flange

- **Lapses:** **Execution failure** **related to memory**

  E.g. Forgetting a step in a checklist

- **Mistakes:** **Planning failure** **related to judgement, knowledge**

  E.g Making a wrong decision, based on limited information,
  Confusing two similar looking equipments

- **Violations:** **Intentional deviation** **related to circumstances, habits**

  E.g. Normalized deviation from procedures

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- **Violations:** **Intentional deviation** **related to circumstances, habits**

  E.g. Normalization of deviation

CSB video

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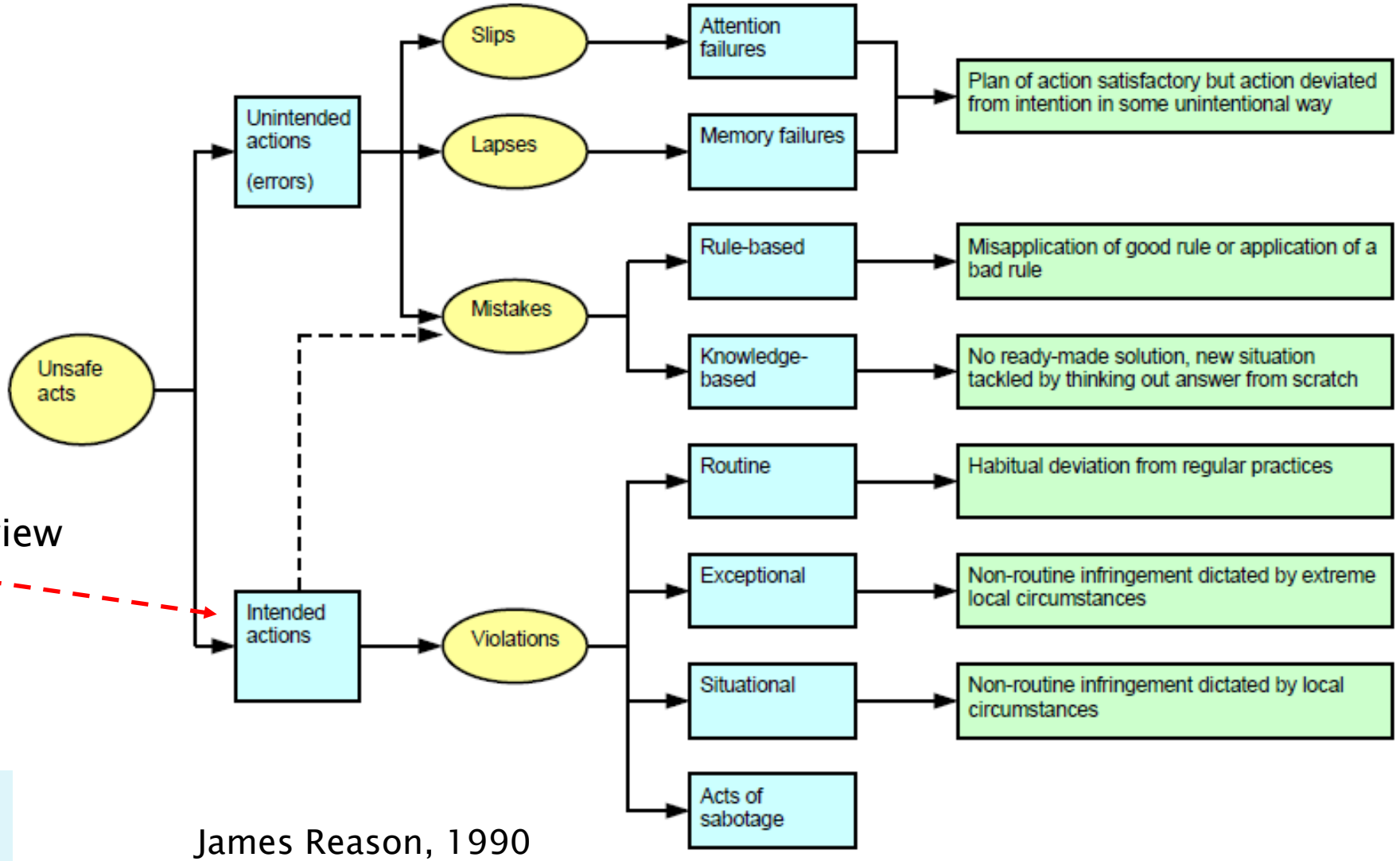
Classification of Human Errors (HSE, UK)



Extension of Rasmussen's view By J.Reason

James Reason, 1990

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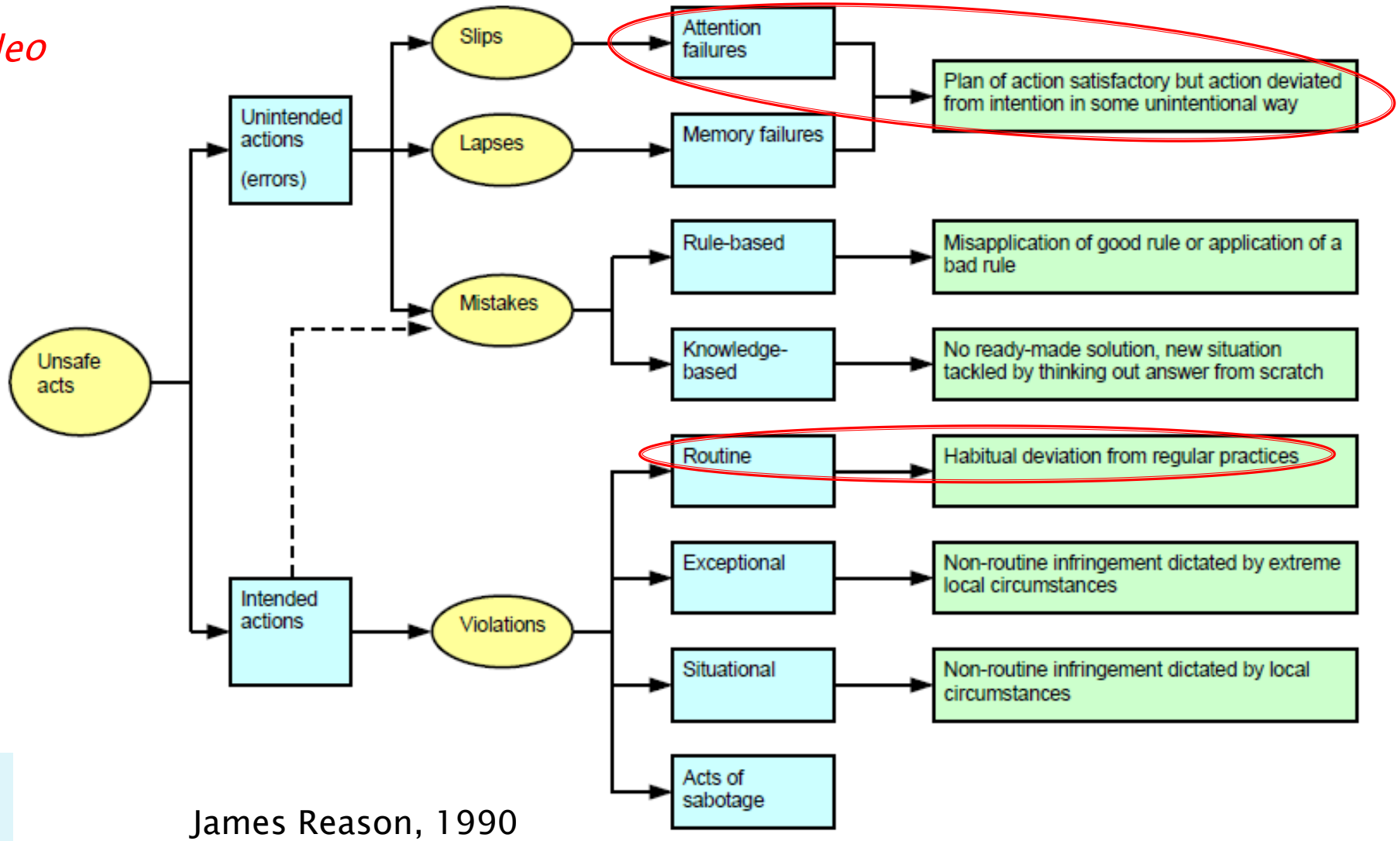
Classification of Human Errors (HSE, UK)

CSB video



James Reason, 1990

How to reduce Human Errors

Unconscious, Unintended:
- → Slips
- → Lapses
- → Mistakes

→ Training, Competency Safer design, Automation, Signs and Colours,..

→ **Useful Practises**

Conscious, Intended:
- → Violations

→ Leadership, Organisation

In hindsight, most such incidents are easily understood and apparently easy to avoid

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Identify Valve Positions

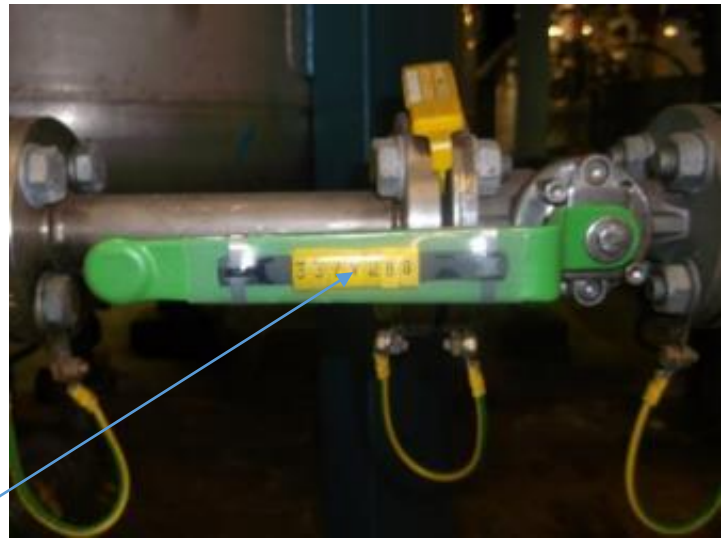
Problem

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

Solution

- Make it easier to spot a valve in wrong position.
  Colour code for manual valve handles, e.g.
  green for normally open and
  red for normally closed
- **Tag numbers** at manual valves that correspond to procedures and P&ID
- Add a label to the valve in case of a special operation that requires a position different from normal

Colour coded and tagged valves (examples):



Normally Open: Green

Normally Closed: Red

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Useful Practises, sorted by Type of Incident or Equipment

- Manual valve position
- Flange leak
- Overfills
- Breaking off small nozzles
- Wrong equipment (opened)
- Equipments which invite human error
- Wrong material or chemical
- Hose issues
- Plant isolation issues
- Interlock issues
- Loading, unloading
- Organisational practises
- Competency related

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LOTO to assure valve position

Problem

Especially after repairs, turnarounds and washout or purging procedures, **valves are left open**, leading to the release of a chemical

Solution

Applying **Lock-out /Tag-out (LOTO)** system will help to ensure that no valves, openings or devices are left in the incorrect position

Sign-off each item on the LOTO checklist

Lock-out /Tag-out cards (examples):

Mechanical locks (example):

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Wrong Manual Valve

Valve position

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 visible **labels**;

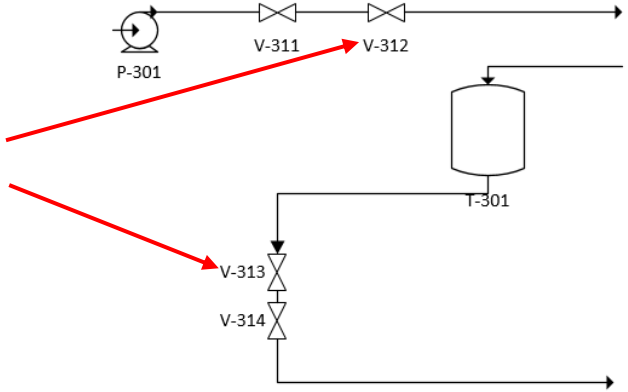
Use **ID numbers** from P&IDs.

Walk the line, for safety-critical isolations to verify the valve numbers in the field.

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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Unique Identification

Problem

Wrong manual valves in the field are **operated** by process operators or maintenance craftsmen

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

Valve position

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Enforcing the right sequence of operation

Problem

A **deviation from the sequence of steps** can result in a hazardous situation.

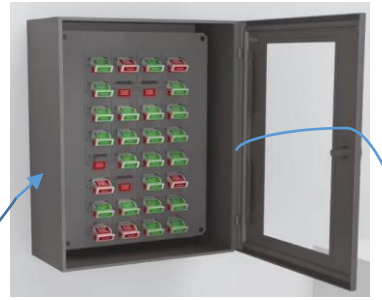
Solution

Mechanical interlocks can enforce the right sequence of opening/closing valves (or other steps). Unique keys are used to only allow the right equipment to be operated in the correct order.

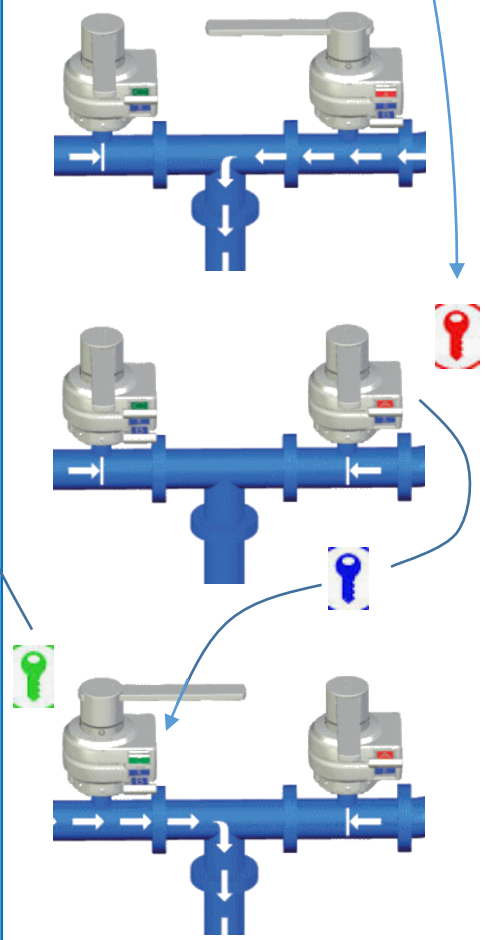
The color of the key in the cabinet in the control room shows the line-up in the field

Well known suppliers are: Netherlocks, Wermac, Castel lock, Alcatraz

Valve position



Key cabinet in control room with unique keys



Switch over chemical:

Right valve is locked open. The blue key is trapped in the shaft. The left valve is locked closed.

Red key from key cabinet is inserted into the right interlock. Right valve can be closed and then the blue key is released. Valve is now locked closed.

Blue key is inserted in left interlock. Left valve can be opened. Then the **green key** is removed and placed in key cabinet. Valve is locked open.

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Manual Valve position recorded by portable device

Problem

Manual valves in the field are in wrong position, e.g. causing release through a left open valve that should be closed.

How to ensure all valves are in correct position and how to record closing or opening ?

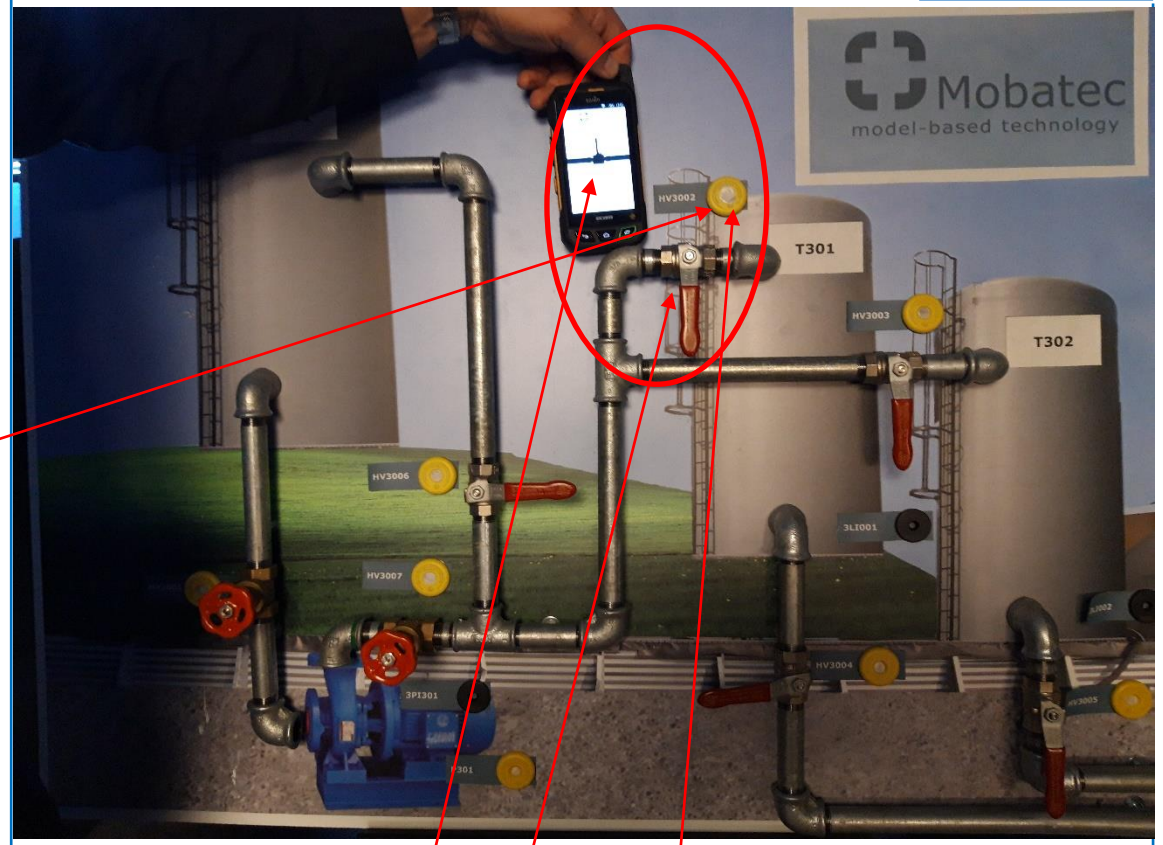
Solution

Operator records valve position with ex-proof **portable device**, which identifies the valve by the valve's NFC code (see yellow dot near valve). No batteries needed. Manual valve position is shown on DCS screen.

Available **also as automated** version, where the valve communicates its position by wireless FID signal directly to DCS. This requires a position indicator with battery.

The portable device, can also **inform operators on the desired position** of the valve, depending on plant situation (normal operation, vs e.g. lock out/tag out)

Valve position



Portable device for registration of valve open/close

Wireless FID contact point, Allowing the portable device To identify valve

Manual valve

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Useful Practises, sorted by Type of Incident or Equipment

- Manual valve position
- Flange leak
- Avoiding overfills
- Avoiding breaking off small nozzles
- Wrong equipment (opened)
- Avoiding equipments which invite human error
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Flange 4 step Label

Flange

Problem

Flanges can leak if certain steps are forgotten or not well executed

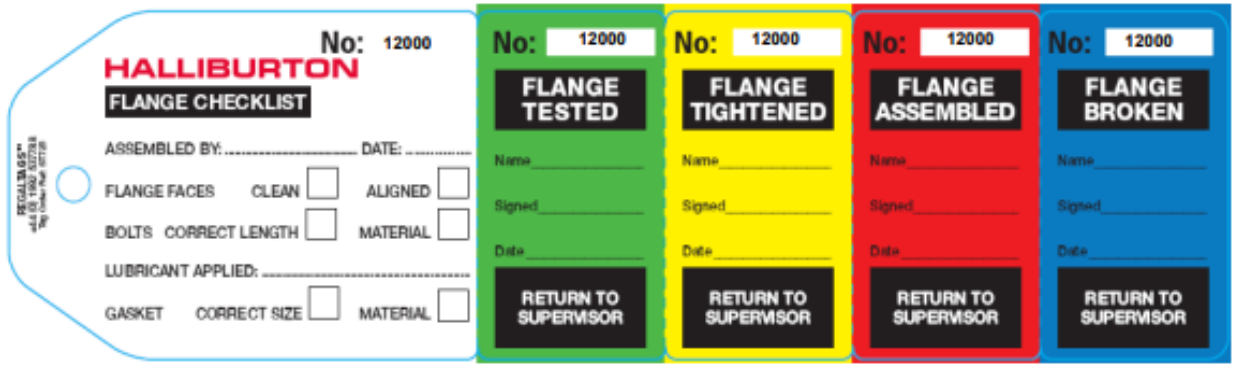
Story

Companies / Contractors use a 3 or **4 folded label** that indicates the critical steps and bolt tension. At each step a part of the label is removed and given back to the foreman or to production

Solution:

Use a label at flanges that need to be opened, so that the critical **steps can be validated, step by step**. The label is made of strong and water resistant material. Each part can be torn off, after completion.

Four folded flange label, attached to flanges before opening. From outside: 1 Broken, 2 Assembled, 3 Tightened at set tension, 4 Leak test performed



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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 responsibility for the correct installation.

Solution:

All flanges get seals or **labels with a personal identifier for employee / contractor** worker who assembles the flange,
+ for the person who ensures the tightness of the flange (seal quality).

Modern version: **QR code**
+ technical information, e.g. type & material of gasket

Flanges identified by lead seal system:

QR code identification:

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Flange

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 **hydraulic torque tensioning tool** during flange assembly.

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

Tightness check (examples):

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Avoid working on the wrong equipment

Problem

Many incidents have occurred because of **field work on the wrong equipment or pipe** such as:

- Working on pump A when pump B was locked out
- Line breaking on the line next to the one that was emptied and flushed

Solution

Instruct contractors/maintenance **at the worksite** and point out exact location just before starting the work

Add a **label to identify the exact work location** (pump or flange to be opened)

Indicate ‘State of operation’, e.g. in a Batch Process

Right Location

A&B pump Confusion is probable

Point out equipment in the field

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Removal of gearbox or actuator from valves

Problem

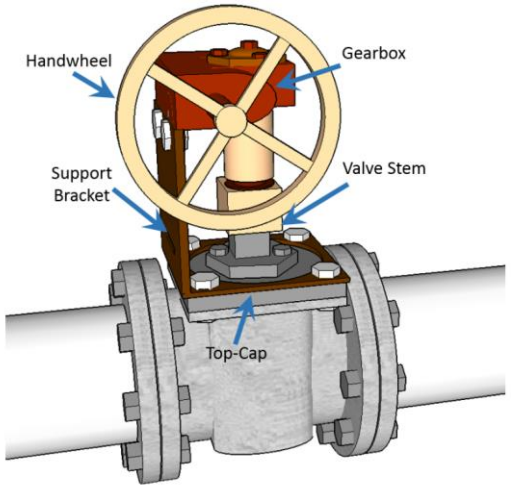
During removal of an inoperable gearbox on a plug valve, the operator **mistakenly removed critical bolts** securing the pressure-retaining component of the valve. The valve came apart and released the process fluid.

Solution

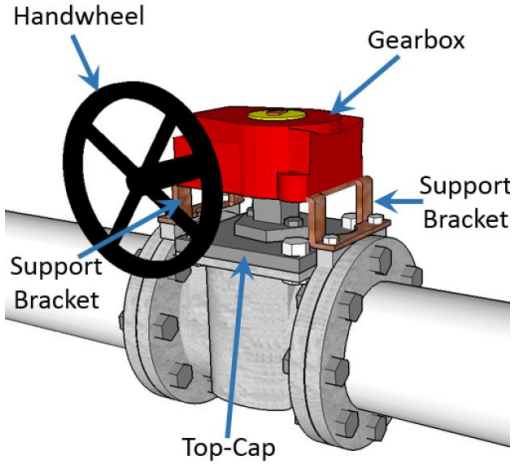
Evaluate human factors associated with equipment design and apply the hierarchy of controls e.g. **improve design to mitigate identified hazards**

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.

Different design



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/

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Poka Yoke

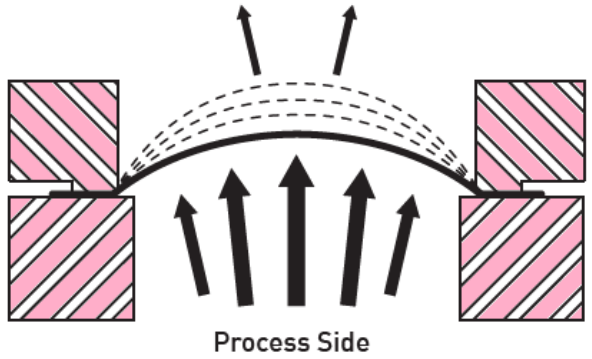
Rupture disk installation

Problem:

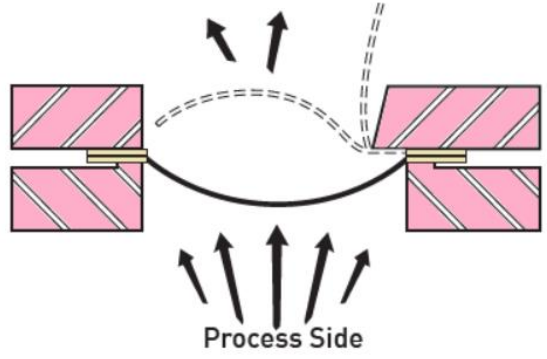
Rupture disks can be of the type "Forward-acting" or "Reverse-acting". Depending on the type, the dome must be placed upwards or downwards. **Installing a rupture disc upside down, is an easy mistake**, that changes the bursting pressure, and may result in tank rupture before the rupture disk breaks.

Solution:

- 1 Use **disk holders that only allow correct installation** (Poka Yoke principle).
- 2 If not available: Always check the **flow direction indicator** on the rupture disc, and have an independent verification by 4-eye principle to confirm correct installation.

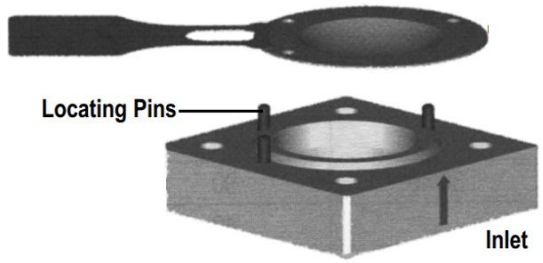


Forward-acting (Tension loaded) type Rupture DisK



Reverse-acting(Compression loaded) Type Rupture Disk

1 Disk holder with locating pins to assure correct installation



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Indication of flow direction

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Bob van Woezik DSM
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Pipe station with hose connectors minimize hoses for special line-up

Hoses

Problem

Long hoses in the plant can cause **a weak point in the line-up** and also cause a trip hazard. When the connection points **cannot be seen, wrong line-ups** can be made.

Solution

Not-dedicated piping with manual valves can be used with **short hoses** to couple pipelines from one part of the plant to another part.
Indication on valve location where pipeline is going.
Information labels to indicate the transferred chemical.

Photo: connection board with 'from' (red) 'to' (blue) locations

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Protection of Interlocks

Interlock

Problem

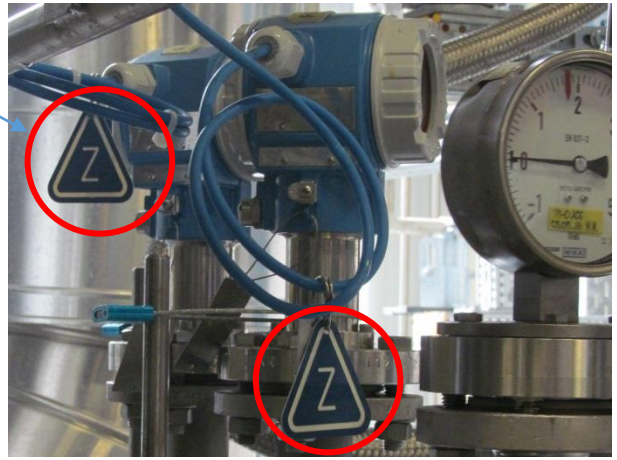
Safety interlocks are sometimes **deactivated** (unintentionally, or intentionally to solve production issues) during operation **without proper permission**. Accidents can result.

Solution

- Make Safety interlocks visible e.g.: label in the field, on documents, P+IDs and DCS-screens.
- Avoid easy bypassing by technical means, e.g. use **key cards or passwords** for DCS-systems or locks at operation panels.
- **Enforce the rule,** to work on safety interlocks **never** without a specific authorization/Permit to Work

Key card to protect access to SIS

Labeling of Safety Interlock Instrumentation



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EPSC members can find the Useful Practises on

EPSC.be

Thanks for listening !

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THE PROCESS SAFETY NETWORK

Title – the aspect (Template)

Category

Problem

Telling the issue to be solved

Solution

Telling how the issue can be solved / explaining the best practice

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Explaining foto 1

Explaining foto 2