Welcome everybody, the title for our presentation today is ---**Applying Process Safety Experiences AND Lessons Learnt, to Achieve Improvements In Plant Up-Time AND Production Stability**

Author Introduction

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- Principal Process Safety Consultant with Pleiades Global Limited, Director Peaksafe India.
- Chemical Engineer, Certified Functional Safety Professional, Certified PHA / HAZOP Leader, NEBOSH PSM.
- 15 years of experience in different geographical regions, including North Sea, Middle East, India and Asia-Pacific.

Mohammad Moonis:

- Principal Consultant and Director, Pleiades Global Limited, UK.
- MSc in Process and Environmental Systems Engineering Certified Functional Safety Engineer, HAZOP leadership and Management (IChemE), Train the Trainer (Highfield, UK)
- 18 years work experience, with majority in North Sea and the Middle East

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Author Introduction

- Pleiades Global Limited (www.PGLTD.co.uk)
  - Involved in Process Safety consultancy work since *2011*. Started in the UK and expanding into other geographical regions.
  - Established high value execution centre in India with *PeakSafe Risk Management Pvt. Ltd.*
  - Prides itself on practical assessments and consideration of operational and implementation issues.
  - Also works beyond process safety in operations and design rationalisation studies
  - Expanding into energy industry related trainings through virtual and classroom modules. – Our training are designed to encourage hands-on experience. We utilise latest technology, 3D visualisations, animations and practical hands on examples.

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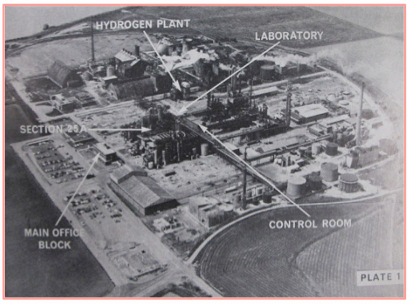
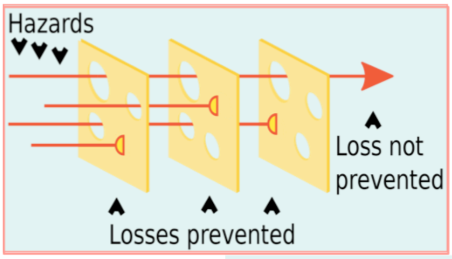
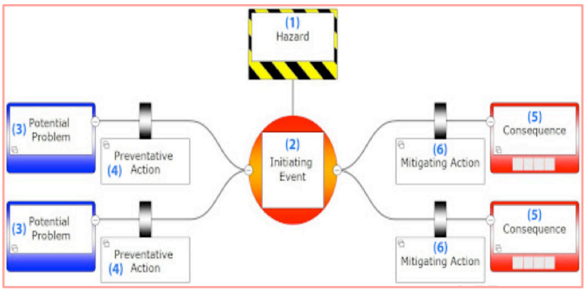
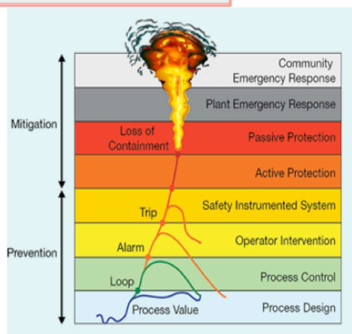
Context

PROCESS SAFETY









Typical application is for identifying potential major hazards, their consequences and the required risk reduction measures.

Context

Experience has shown that there is always some scope for rationalisation of protection and control systems

- Over longer term, process parameters may change.
- Also, Once a plant has been operational for some time, specific bottlenecks or issues get identified.
- Design stage PHAs do not necessarily look at the holistic picture.

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Context

- A holistic, plant uptime focussed study is really useful
- A holistic plant-wide rationalisation study will help to minimise potential downtime and bottlenecks

A process safety or process control measure may get added, improved or even REMOVED as a result.

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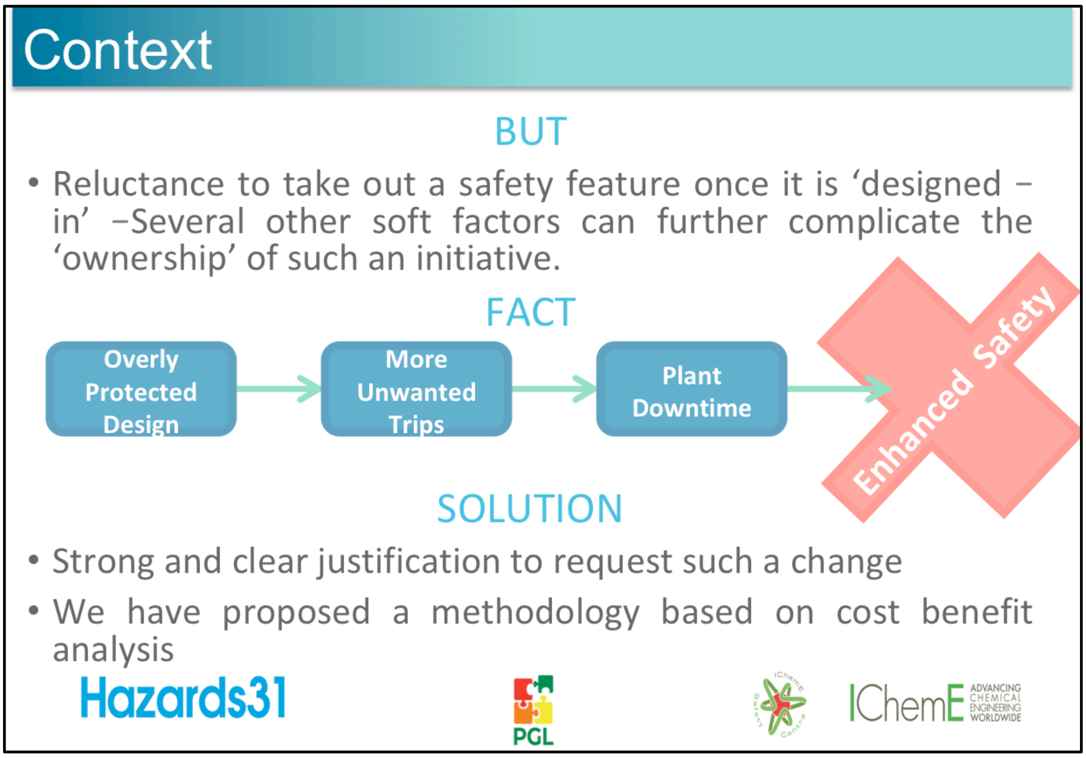

FACT: Irrespective of the organization, an overly protected design will lead to unwanted trips leading to - loss of production and revenue- without providing any enhanced safety.

Methodology

- Based on our experience gained and reviews carried out across varied geographical regions, safety cultures and regulatory frameworks, we came up with six representative examples, typically contributing to plant downtime:
  1. Triggers for single point failures resulting in immediate plant shutdown;
  2. Cascaded effects of single point failure in an area or equipment;
  3. Non SIL rated SIFs;
  4. Production critical items not provided with emergency power provisions.
  5. Common equipment shared between identical trains; and
  6. Operator error during maintenance or testing of critical elements

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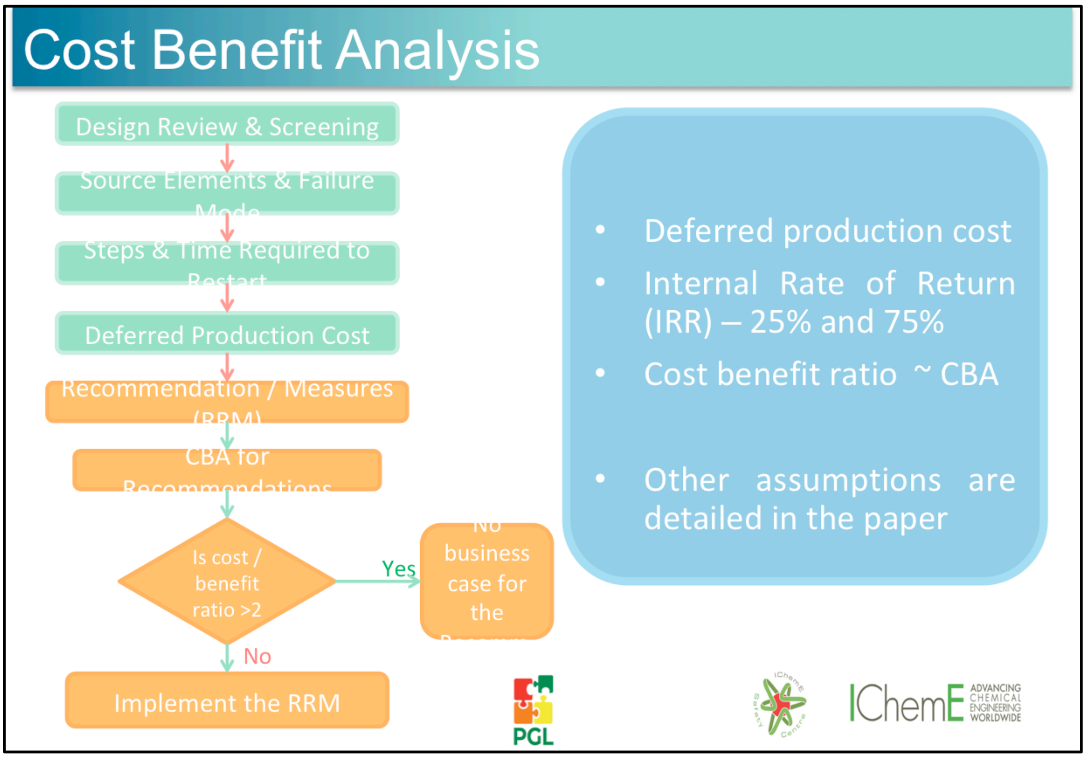
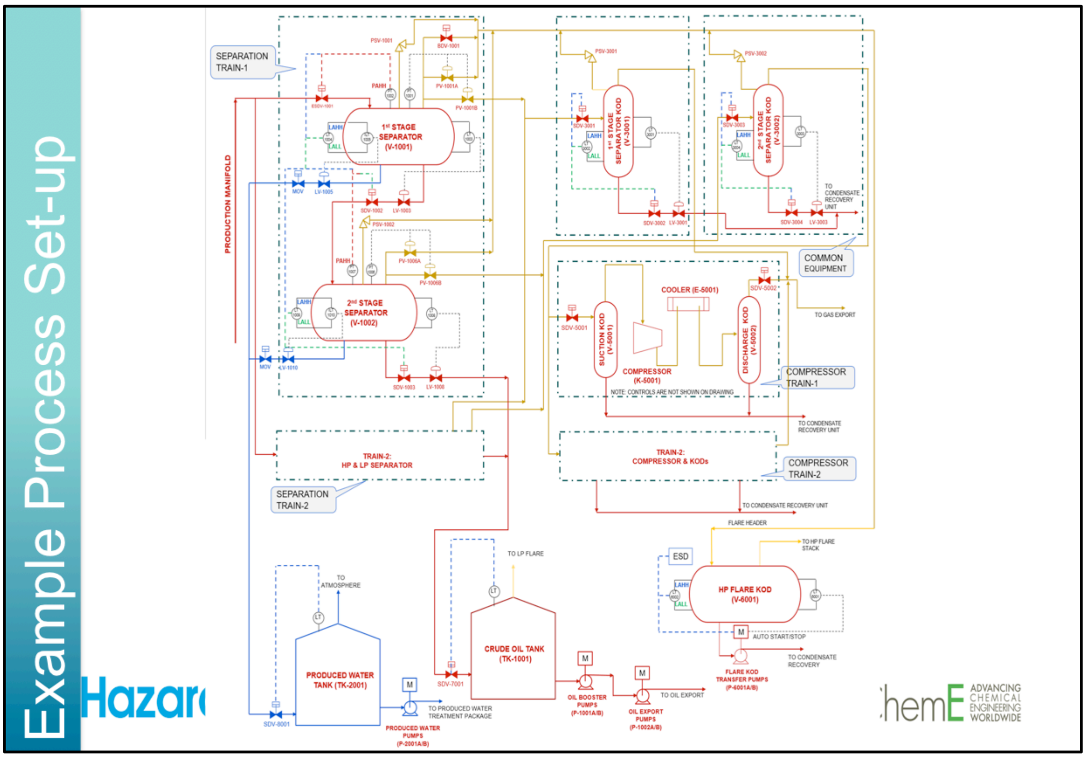
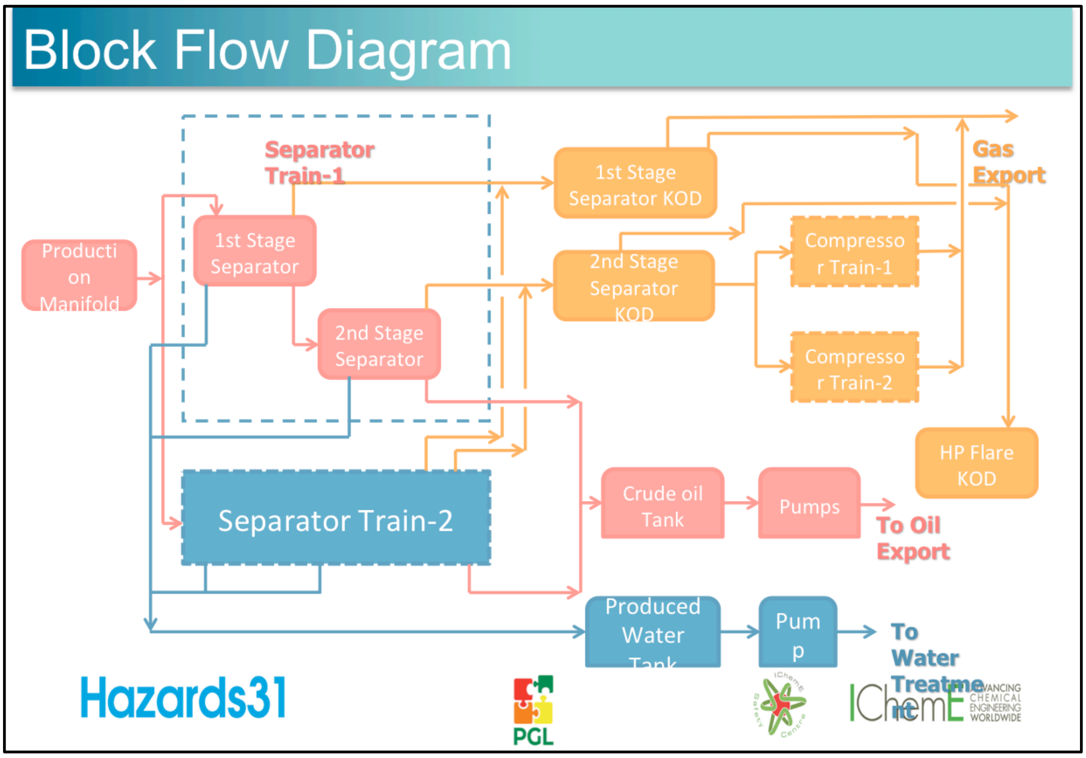


/……….. And we have created a generic flow scheme for a typical upstream hydrocarbon process facility for the purpose of this presentation..



We can see the Process Safeguarding Flow Scheme for our generic process. For ease, let me talk you through, on a Block flow diagram.



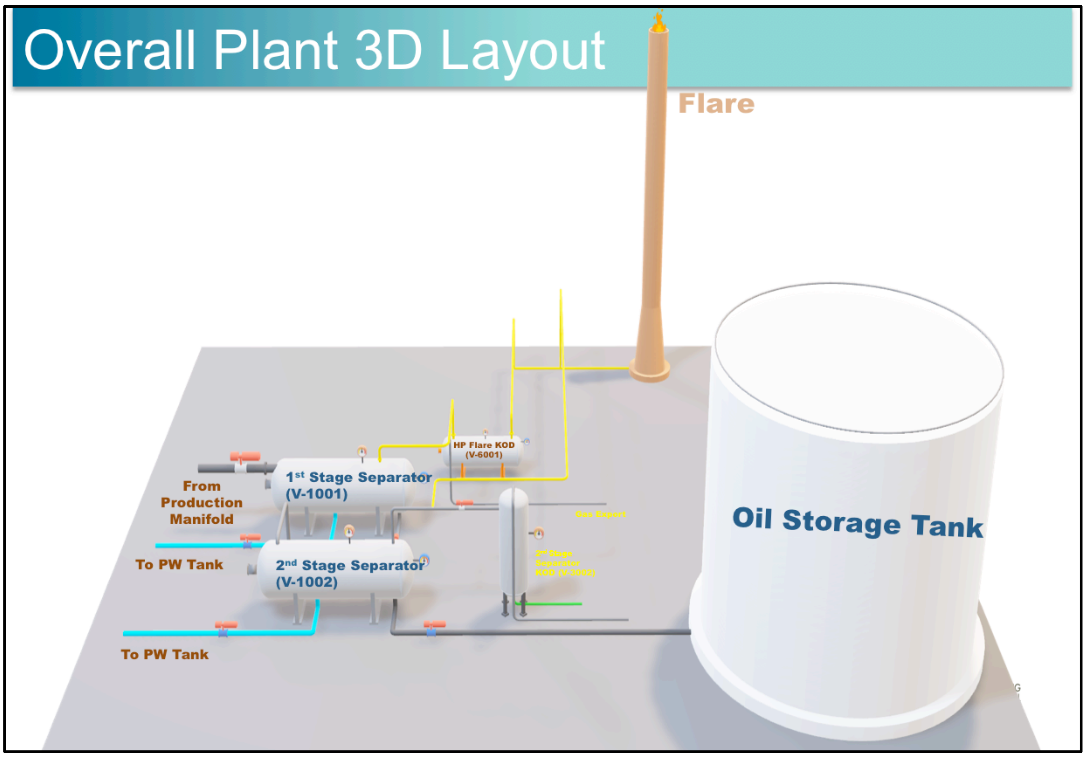
As we can see here, the well fluids received at the common production manifold, are sent to first stage separation for trains 1 and 2.

The oil stream, separated at the 1st stage, is channeled to 2nd stage separation,,,,, From where it is routed to the crude oil tank, Before being exported through the booster and main pumps.

Now looking at the gas stream – shown here in yellow - Gas stream separated in the 1st stage separation is sent to the gas export via 1st Stage Separator KOD. While gases from the 2nd Stage separation, which obviously will be at a lower pressure, are sent to compressors before being exported off,

In case of any emergency or operational upset, off-gases will be routed to the HP flare KOD (V-6001)

Finally, Produced Water (PW), shown in blue, is routed to the produced water treatment units.



Here is a 3D layout which We developed for the facility.

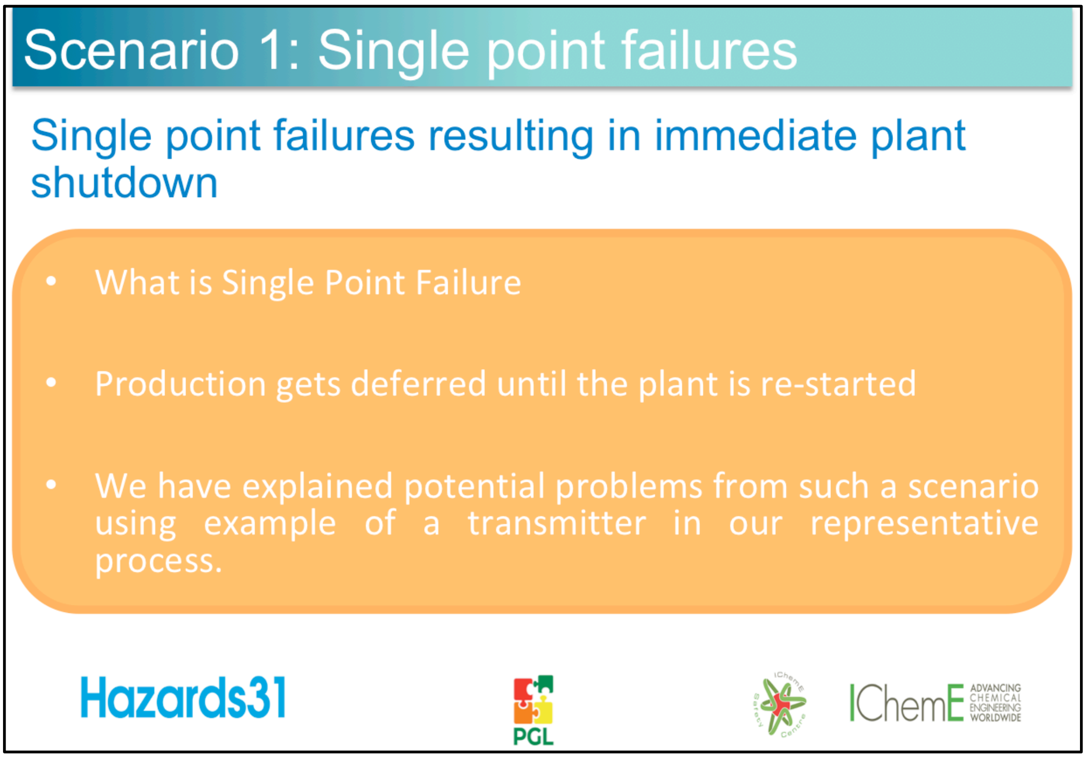
Process Parameters

Table: Process Parameters

Equipment	Pressure (Operating / Design), barg	Temperature (Operating / Design), degC	Remarks
1st Stage Separator (V-1001)	20/27	37/86	-
2nd Stage Separator (V-1002	4.8/20	37/67	-
1st Stage Separator KOD (V-3001)	19.5/27	37/86	-
2nd Stage Separator KOD (V-3002)	4.5/20	37/67	-
Compressor Trains	19.5/27	37/86	Not on emergency load
PCV-1001A	20/27	37/86	Not designed for full blocked outlet
PSV-1001	27	-	Full blocked outlet case/fire case
PCV-1006A	4.8/20	37/67	Not designed for full blocked outlet
PSV-1002	20	-	Full blocked outlet case/fire case
HP Flare KOD (V-6001)	1.5/5	27/86	-

Here are the Process Parameters for the equipments in the facility.

Now lets discuss our example scenarios..

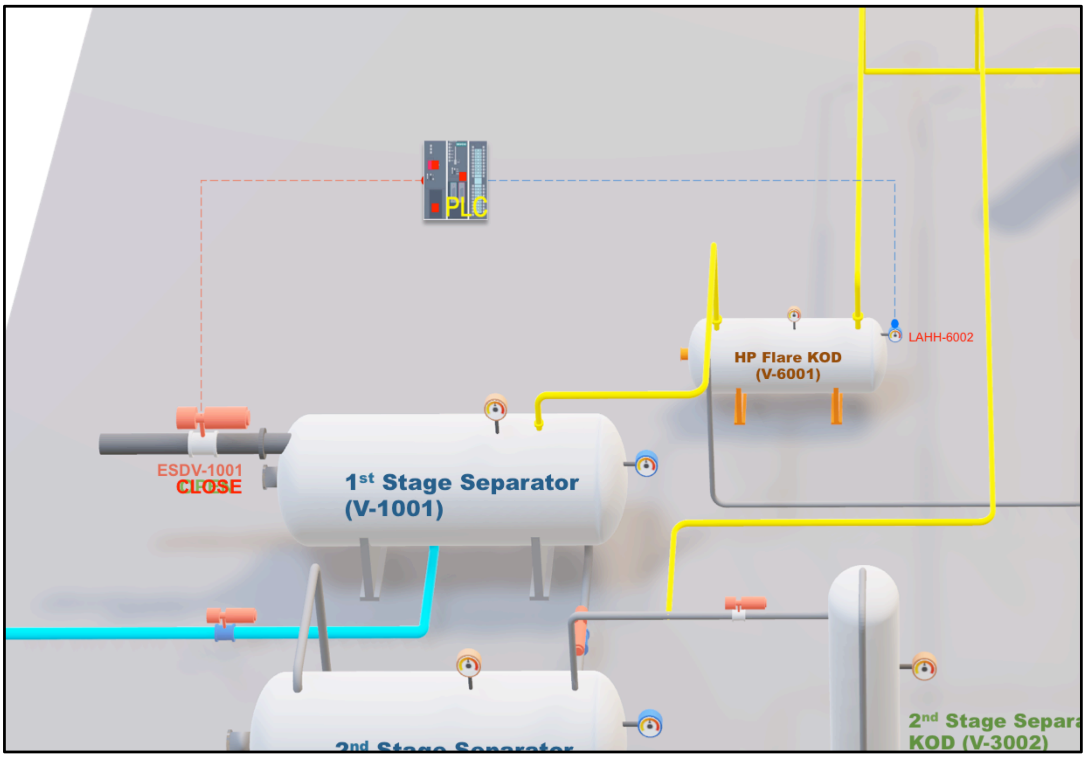


Our 1st example is about "Single point failures resulting in immediate plant shutdown"

Single point failure, as the name suggests, is shutdown of a process caused by malfunction of any single component; e.g. transmitters, switches, fusible plug loops etc.

Re-starting the plant will involve several steps, each of which will contribute to the time required to re-start. Re-starting may be MORE complicated when it involves facilities spread over a bigger area or a larger sequence of operations

Here, we have explained potential problems from such a scenario, using example of a transmitter in our representative process.



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This scenario considers that high level trip LAHH-6002 on the HP Flare KOD, malfunctions and initiates an unintended ESD level 2. ESD level 2 is plant shutdown without depressurization and will obviously lead to deferment of production. For example closure of ESDV on the 1st stage separator shown here.

Scenario 1: Single point failures

Total representative time required for re-starting normal operations following ESD -2

Action Initiated	Time Required in seconds and (minutes)
Time required to plant Shutdown	900 (15)
Decision making to restart the plant	1800 (30)
Time required for plant start-up (Table 1)	9000 (150)
Total time taken for plant back to Normal operation	**3 hours**

A recommendation to avoid this scenario may be to provide 2 additional Level Transmitters with LT-6002 with 2oo3 logic

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Steps required to re-start after an ESD Level 2, along with the estimates of time required, are provided in this table.

A recommendation to avoid this scenario may be to provide 2 additional Level Transmitters with 2oo3 logic

Scenario 1: Single point failures

Cost Benefit Evaluation of Scenario 1 (Single Point Failure)													
Equipment	**Source Element**	**Failure Mode**	**Frequency of occurrence per year, (F)**	**Sequence of Events**	**Expected duration of plant outage (hrs)**	**Total planned production (BBLs) per day**	**Total Deferred production Loss (USD) 60 USD/BBL per year**	**Recommendations**	**Potential total cost of implementing the RRM (USD)**	**Per year cost of implementing the RRM (plant life = 10 years) (USD)**	**Cost to Benefit Ratio (CBA)**	**Implement the RRM (Y/N)**
25% IRR)												
HP Flare KOD (V-6001)	LT-6002	Malfunction of LT-6002 showing level high but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	938	Provide additional LT-6002 with voting logic 2oo3 to avoid spurious trip.	8000	800	0.85	YES
(75% IRR)												
HP Flare KOD (V-6001)	LT-6002	Malfunction of LT-6002 showing level high but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	2813	Provide additional LT-6002 with voting logic 2oo3 to avoid spurious trip.	8000	800	0.28	YES

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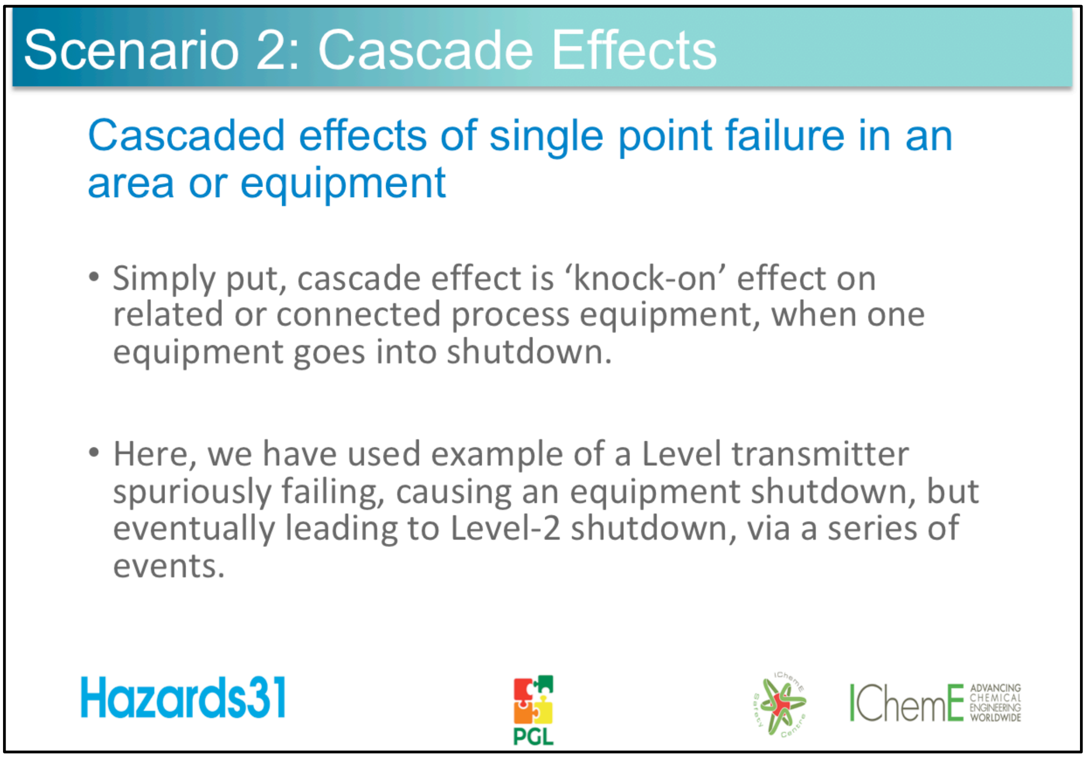
The cost of implementing the recommendation can then be compared against the potential value of deferred production.

In our methodology, Value of deferred production is calculated for two different IRRs as was explained in the beginning.

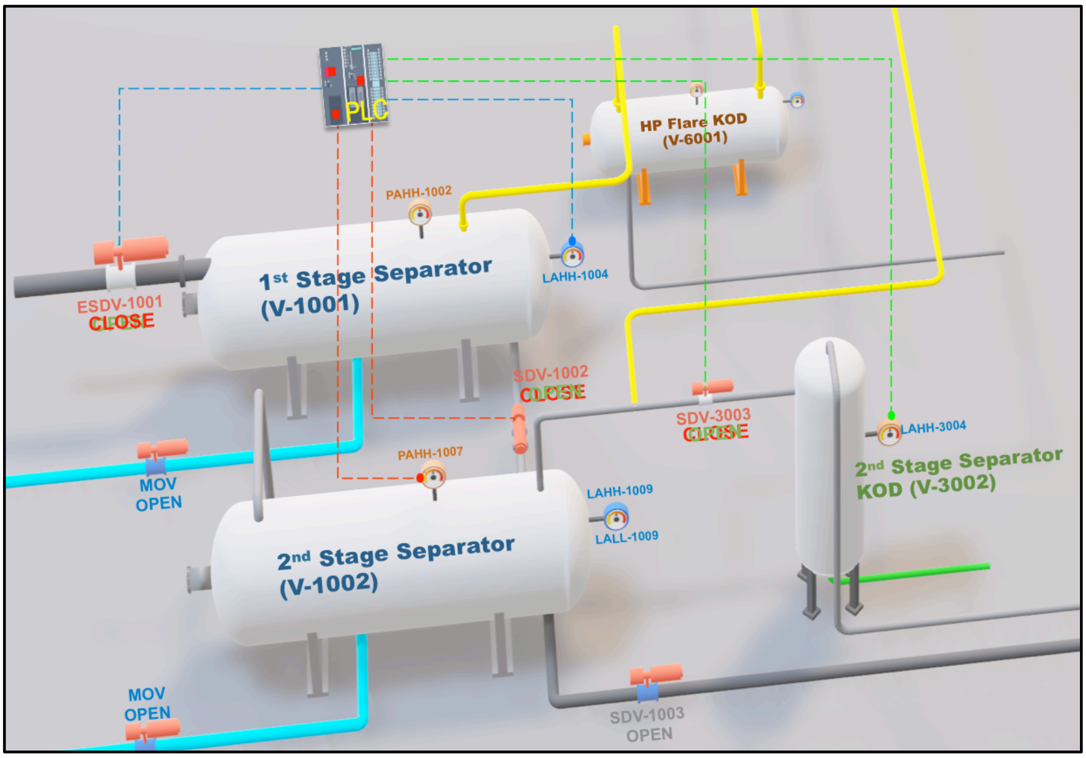
As can be seen from the assessment table, even for very low daily production rates, the calculated ratio is quite low and therefore, the recommendation of installing 2oo3 Level Transmitters can be easily justified.



Our second scenario is about cascade effects of single point failure in an area or equipment

Simply put, cascade effect is ‘knock-on’ effect

Here, we have used example of 1 level transmitter failing, and eventually leading to a ESD level 2 via a series of events.



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Here we assume LT-3004 on 2nd Stage Separator KOD (V-3002) causing a spurious high-high level trip during normal operations and initiating closure of SDV-3003 on inlet of the 2nd Stage Separator KOD (V-3002).

This will lead to compressors not receiving any feed from V-3002 and therefore going into shutdown following low suction pressure. Both the trains will be impacted

As in our process, the PCV at the 2nd stage separator to flare is not designed for the blocked outlet case,

The following sequence of events will take place:

- Overpressurisation of the 2nd Stage Separation, up to the High-High Pressure trip set point.
- PAHH-1007 on 2nd stage separator will actuate and close SDV-1002, at the 1st stage separator outlet.
- This will cause liquid level built-up in the 1st Stage Separator (V-1001), eventually leading to actuation of LAHH-1004 to close ESDV-1001 at the inlet.

Scenario 2: Cascade Effects

Total representative time required for re-starting in Scenario 2 (~ESD 2)

Action Initiated	Time Required in seconds and (minutes)
Time required to plant Shutdown	900 (15)
Decision making to restart the plant	1800 (30)
Time required for plant start-up (Table 1)	9000 (150)
Total time taken for plant back to Normal operation	**3 hours**

A recommendation to avoid this scenario may be to provide 2 additional Level Transmitters with LT-3004 with 2oo3 logic

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So, we can see that cascading effect leads to shutdown of major equipment or let's say ESD-2.

A recommendation to avoid this scenario may be to provide 2 additional Level Transmitters with 2oo3 logic

Scenario 2: Cascade Effects

Cost Benefit Evaluation of Scenario 2 (Cascade Effects)

Equipment	Source Element	Failure Mode	Frequency of occurrence per year, (F)	Sequence of Events	Expected duration of plant outage (hrs)	Total planned production (BBLs) per day	Total Deferred production Loss (USD) 60 USD/BBL per year	Recommendations	Potential total cost of implementing the RRM (USD)	Per year cost of implementing the RRM (plant life = 10 years) (USD)	Disproportionation factor (CBA)	Implement the RRM (Y/N)
(25% IRR)												
2nd Stage Separator KOD (V-3002)	LT-3004	Malfunction of LT-3004 showing level high but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	938	Provide additional LT-3004 with voting logic 2oo3 to avoid spurious trip.	8000	800	0.85	YES
(75% IRR)												
2nd Stage Separator KOD (V-3002)	LT-3004	Malfunction of LT-3004 showing level high but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	2813	Provide additional LT-3004 with voting logic 2oo3 to avoid spurious trip.	8000	800	0.28	YES

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Again, having evaluated the time required to re-start, value of deferred production can be calculated, for two different IRRs.

Also for this case, it can be seen that, even for very low daily production rates, the calculated cost / benefit ratio is quite low. Therefore, the recommendation of installing 2oo3 Level Transmitters can be easily justified.

Scenario 3: Rationalisation of Non SIL Rated SIFs

Non SIL Rated Safety Instrumented Functions

- IEC-61511 on non SIL rated SIFs – No special Safety requirements.
- In some cases, such loops can easily be replaced by only an alarm.

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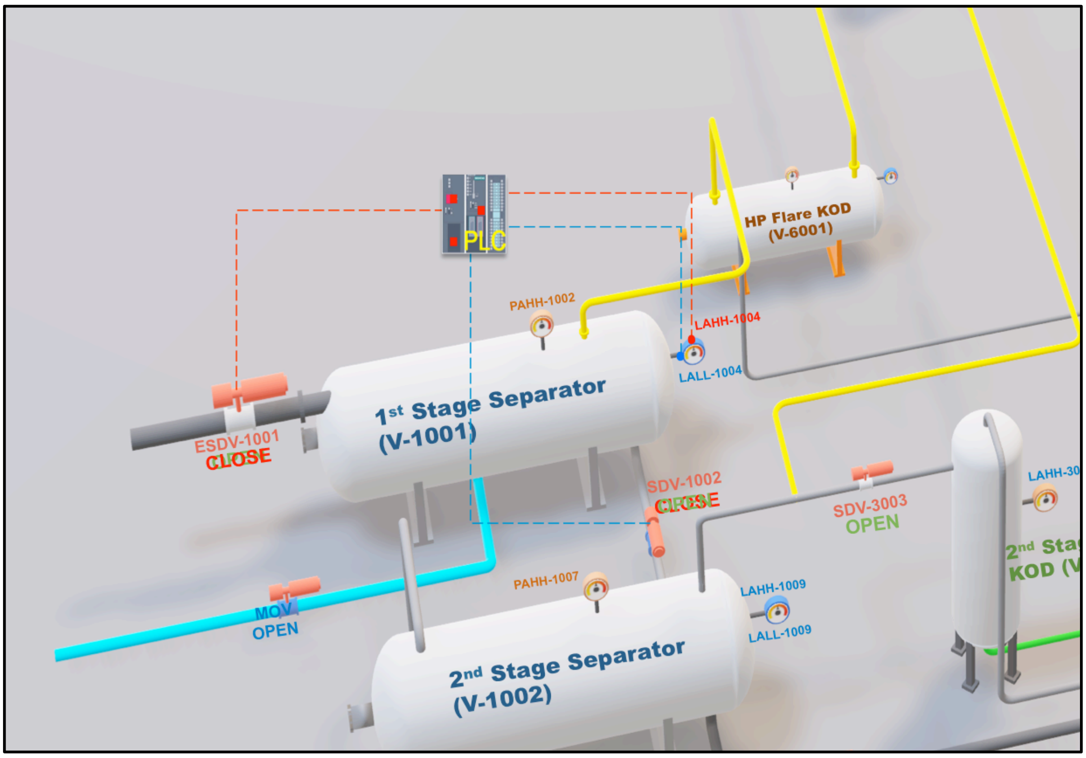
Non SIL rated Safety Instrumented Functions are the ones where required SIL ratings are assessed as SIL 0 or as SIL a.

As per IEC 61511-3 , no special safety requirements are to be implemented if a SIF loop is classified as non SIL rated. This may lead to use of lower reliability components in such loops.

This example aims to cover scenarios where such loops may contribute to shutdowns, however, only an alarm function could have been adequate. In these cases, such instrumented functions are more of a nuisance without adding any safety benefit.

To explain this scenario in our example process, lets get to the plant layout.



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As per our assumptions and common engineering practice, design pressure of 2nd Stage Separator (V-1002) is equal to the maximum operating pressure of the 1st Stage separator. Therefore, it can be safely assumed that SIL rating for the low low level SIF loop LALL-1004, provided on the first stage separator would have been assessed as SIL 0. Note that, in reality this information shall be referenced from plant's SIL classification study.

For this assessment, we assume LT-1004 causing a spurious low-low level trip during normal operations.
Also, it is assumed that HP separator will be at 'normal liquid level' when the spurious trip occurs. This will lead to the closure of SDV-1002 on the outlet of V-1001, which, in turn will lead to Liquid build-up in the 1st Stage Separation, which may initiate closure of ESDV-1001 via LAHH-1004. Other possible impacts following this trip are already discussed under cascade effects scenario.

Scenario 3: Rationalisation of Non SIL Rated SIFs

RECOMMENDATION: Change functionality of LT-1004 loop from high-high level ESD trip to an alarm in DCS.

- However, resulting change in risk profile shall be assessed.
- This step will be akin to reverse hazard identification – starting from the existing risk control measure and back-assessing the risk if the control measure was not available.

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The recommendation in this scenario will be to change functionality of LT-1004 loop from Low-low level ESD trip to an alarm in DCS. As risk reduction measure does not recommend providing extra prevention or control measures, a CBA is not required in this case.

The paper authored along with this presentation, provides a detailed methodology and guidance on points to consider in such risk assessments.

Scenario 3: Rationalisation of Non SIL Rated SIFs

Table: Evaluation of Scenario 3

Equipment	Source SIF	Failure Mode	Frequency of occurrence per year, (F)	Sequence of Events	Expected duration of plant outage (hrs)	Total planned production (BBLs) per day	Total Deferred production Loss (USD) 60 USD/BBL per year	Recommendations
(25% IRR)								
1st Stage Separator (V-1001)	LT-1004	Malfunction of LT-1004 showing level low but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	938	Change ESD trip (LALL-1004) to alarm (LAL-1004) in DCS.
(75% IRR)								
1st Stage Separator (V-1001)	LT-1004	Malfunction of LT-1004 showing level low but actual level is normal	0.1	Leading to Level 2 shutdown (ESD-2)	3	5000	2813	Change ESD trip (LALL-1004) to alarm (LAH-1004) in DCS.

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As no new instrument have been added in this example, therefore there is no need to perform CBA in this case. The table for this example only shows the potential monetary loss due to this trip.

Scenario 4: Emergency Power

Production critical items left out of emergency load list

- A quick and simple methodology for this review may involve considering each process stream on the facility PFD.
- looking for possible bottlenecks, which may be caused upon loss of power.
- Once this assessment is completed, a list of items, which shall be on the emergency load shall be prepared. and compared with the existing emergency load list

- Few potential scenarios presented based on our representative process
- Here we will explain one of the examples, of produced water pumps.

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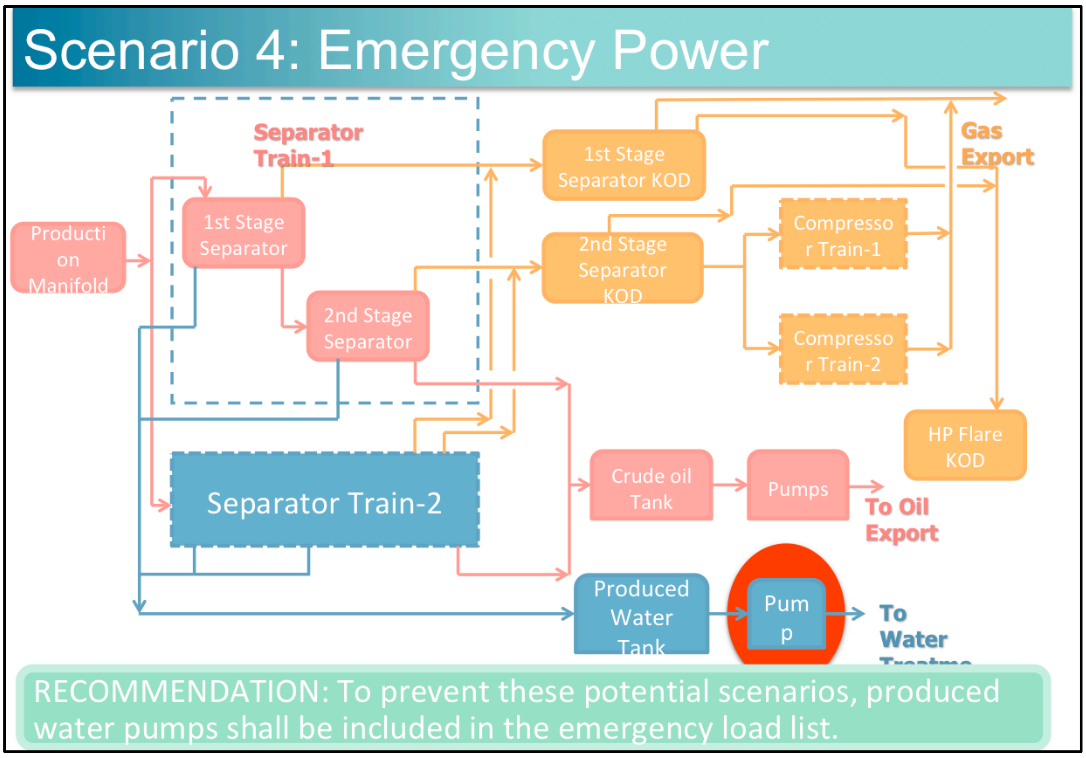
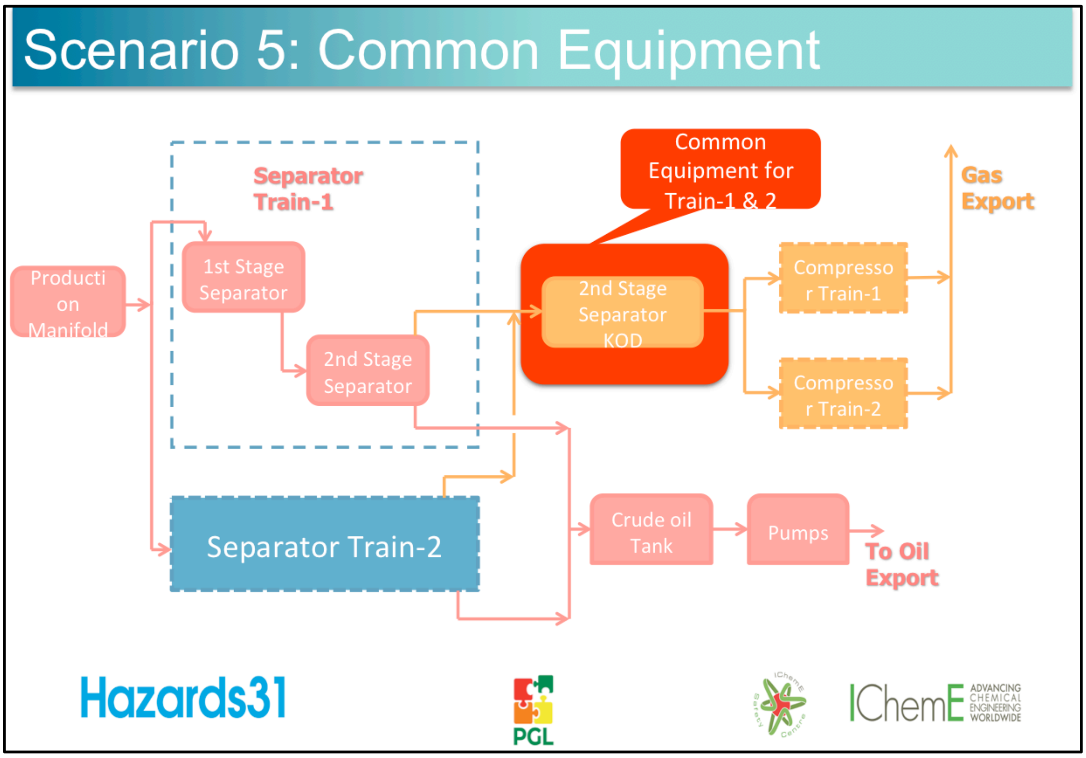


For The PW stream in this set-up, it was identified that the produced water pumps were not on the emergency load list.

Failure of power to these pumps will lead to level build-up in the produced water tank.
Now that the water route is blocked, the oil and water comingled stream from separators will find its way to the export route.

This will lead to few other upsets, which are explained in the paper submitted.

To prevent these potential scenarios, produced water pumps shall be included in the emergency load list.



In our example set-up, the common equipment is e.g. 2nd Stage Separator KOD. Potential process issues with these KODs have already been discussed under the previous scenarios.

Scenario 6: Operator Error

Operator errors during maintenance or testing of critical elements

Trips caused through fire and gas detection can lead to ESD-1, i.e. plant shutdown with depressurization.

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Let us see this in our example

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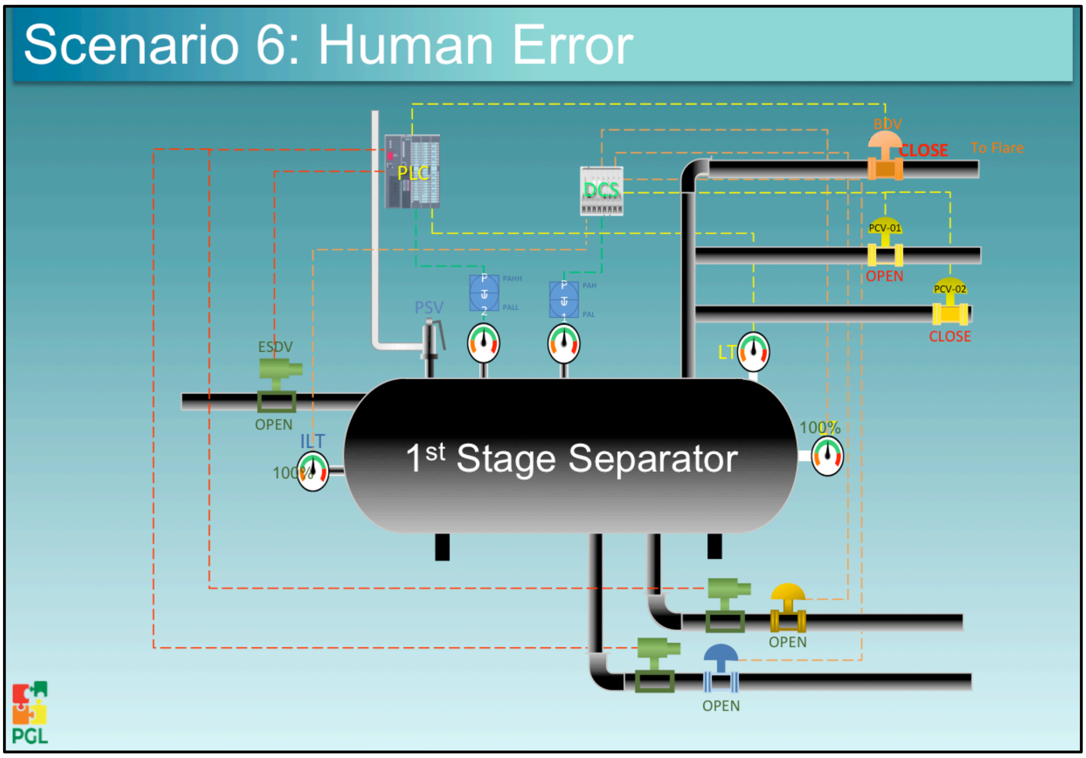

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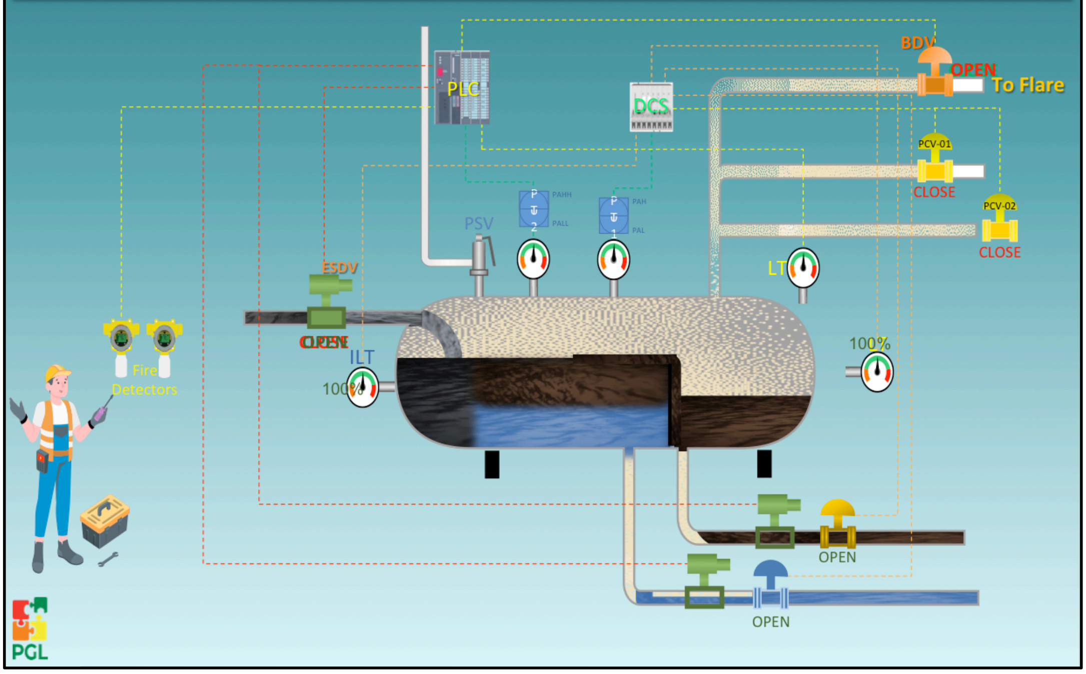
Scenario 6: Human Error

Fire Detectors Testing



Scenario 6: Operator Error

Recommendations - Operator training, awareness of overrides and criticality, competence, work culture, contractor vetting,

Authors have experience of advising on contents of such trainings and have provided some guidance in the paper.

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Further Advice can be provided upon request

Conclusion

- Even for low production rates ratio of costs to benefits obtained is very low. Hence, it can be easily demonstrated that the benefits of a similar exercise will far outweigh Cost Time and Resources spent.
- However, the level of preparation and competence of the team is crucial for such studies or reviews
- A robust contractor selection process shall be in place, in case the reviews are outsourced to a third party
- The holistic approach and system thinking presented here, can also be applied in revalidation of process hazard analysis studies
- Authors will be more than happy to provide any advice and share their experience of previous studies.

Thank You

Let us Join Hands in making the World Safer!!