HAZOP Modelling Using Machine Learning

Introduction

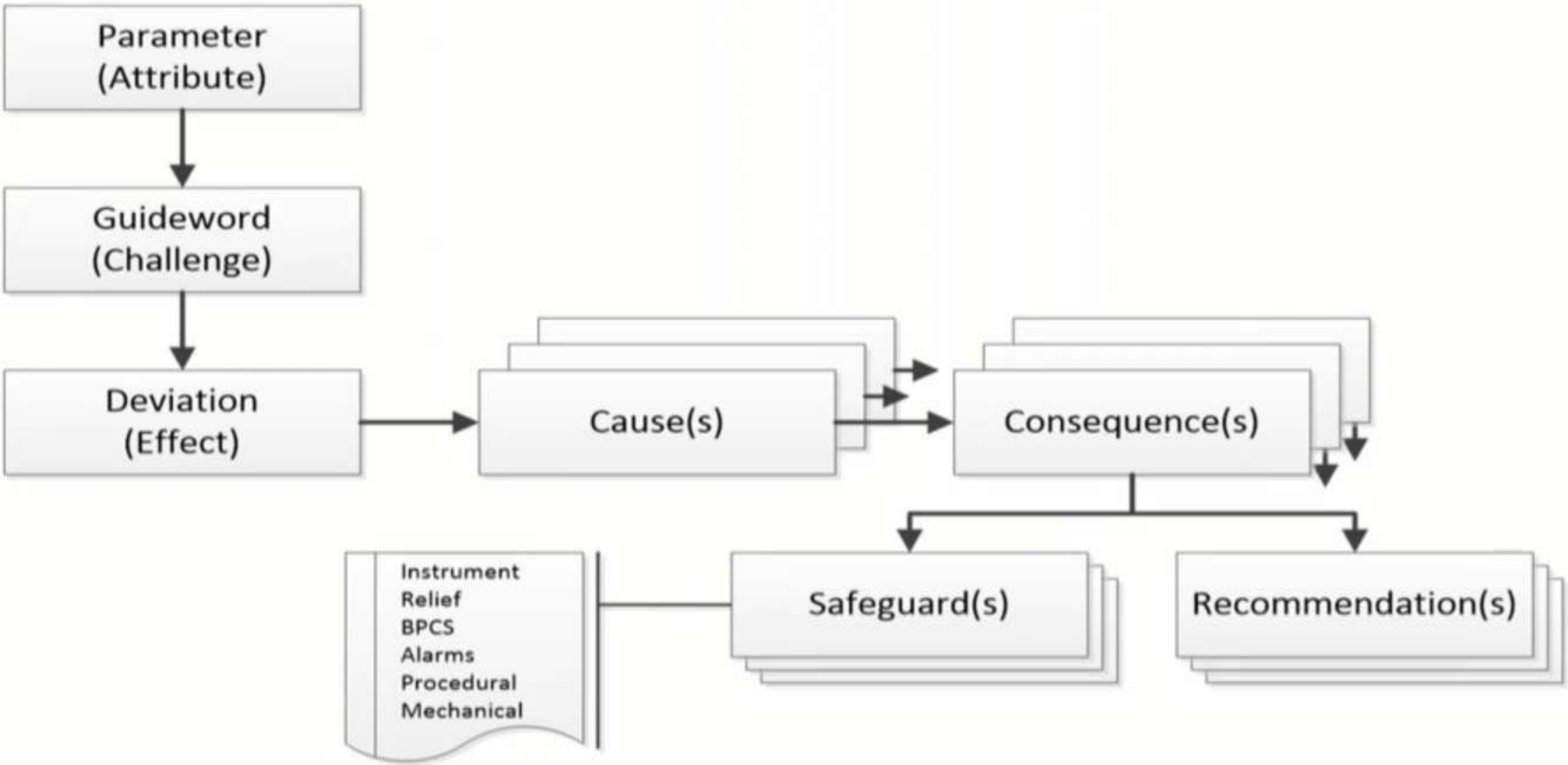
- HAZOP is a systematic hazard identification methodology for determining the causes and consequences of deviations of process variables (flow, pressure, temperature etc..) from design intent.
- HAZOP analysis offers the potential for improved efficiency and effectiveness in identifying hazards, analyzing risks, and implementing appropriate control measures.

What is HAZOP?

- HAZOP (Hazard and operability Study) is a systematic, structured and team-based approach to identify potential hazards and operability issues in industrial processes. It has no motive to replace humans but it is for to reduce the amount of time required for human.

- It is based on the principle that a plant is HAZOPed by expert team during development at regular intervals.

HAZOP Overview



System Components

•**<u>AutoHAZID</u> –** This module performs identification on pre-defined process plant description.

•**<u>Graphical Tool-</u>** It is a GUI which enables you to specify process plant.It is developed by TXT.

•**<u>Unit Model Library-</u>** It conatins models of every type of process unit which is represented by HAZID.

•**<u>Model Creation Tool-</u>** It is not possible that unit model library contains all units. So it is good that user can create the unit models within HAZID.

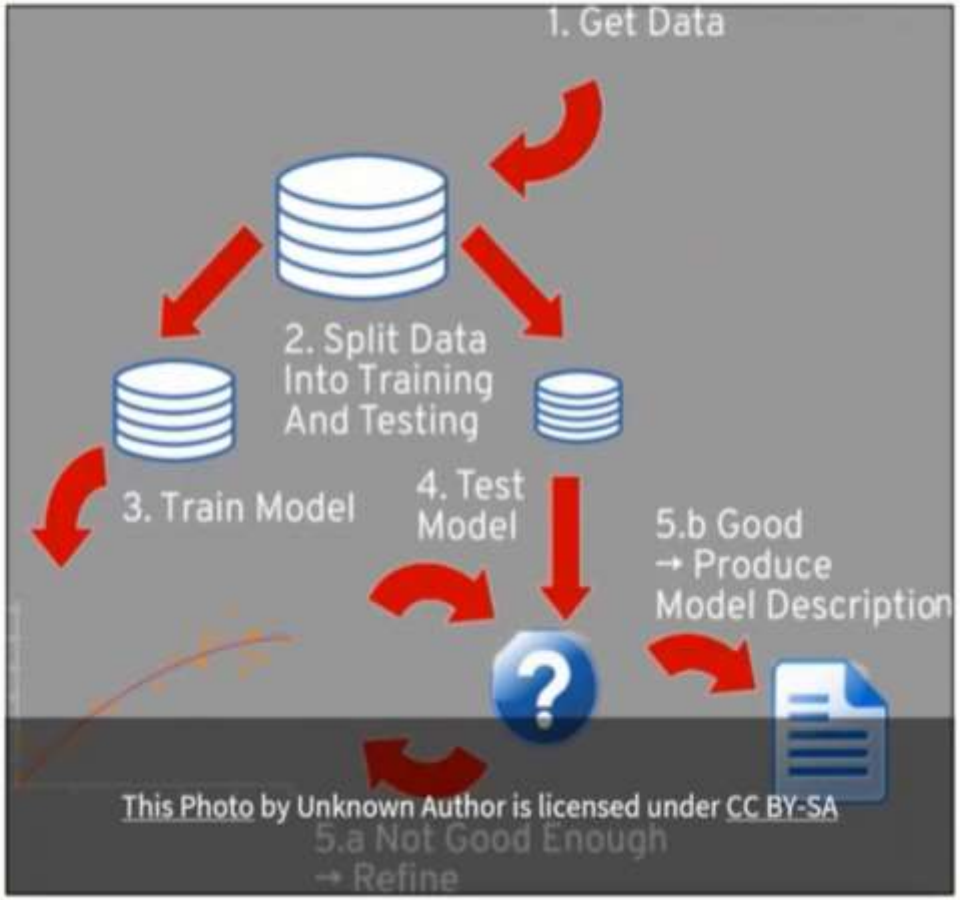
AUTOHAZID

- A process plant description is subjected to hazard identification using the AutoHAZID module. AutoHAZID produces an SDG representation of a process plant using the process data that is recorded in the HAZID database.
- The analysis by AutoHAZID is based on this SDG representation techniques.
- HAZID is being developed in conjunction with a number of industrial companies whose safety experts have been closely involved in both the knowledge acquisition and output validation stages of the project.

- The main objective of HAZID's development is to mimic the HAZOP analytical method. By applying HAZOP deviations and tracking the effects along the graph to find the sources and effects of the deviations, HAZID conducts a hazard analysis on a sign directed graph (SDG) representation of a process plant.

- The SDG format has been modified to incorporate coded arcs, allowing a more detailed specification of relationships between variables.

How ML works



1. Get Data
2. Split Data Into Training And Testing
3. Train Model
4. Test Model
5.b Good → Produce Model Description
5.a Not Good Enough → Refine

Workflow of the ML algorithm

How Machine Learning Can Improve HAZOP

- By applying machine learning to HAZOP modelling, we can improve the accuracy and efficiency of the process.

- Machine learning algorithms can analyze large amounts of data and identify patterns and correlations that would be difficult for humans to detect. This can lead to more comprehensive risk assessments and better decision-making.

Steps to Apply ML Algorithms

- Step 1: Load the dataset
- Step 2: Split the data into training and testing sets
- Step 3: Train the machine learning model
- Step 4: Make predictions on the testing set
- Step 5: Evaluate the model

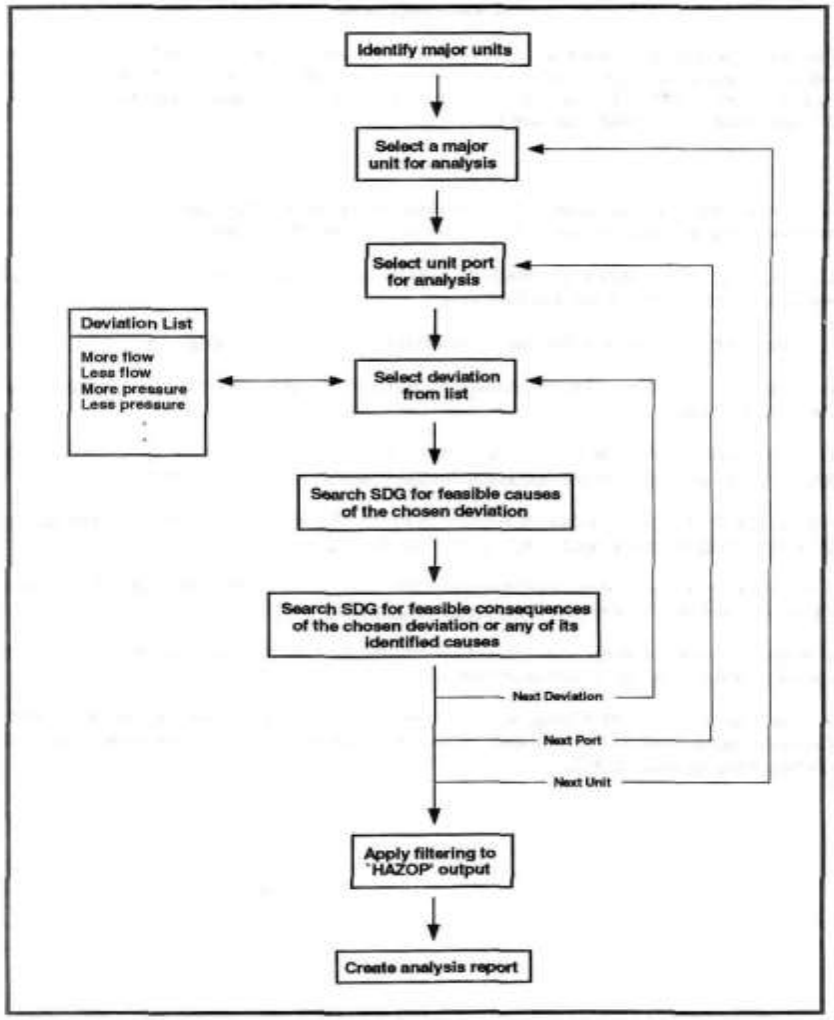


Figure 4: AutoHAZID HAZOP Algorithm.

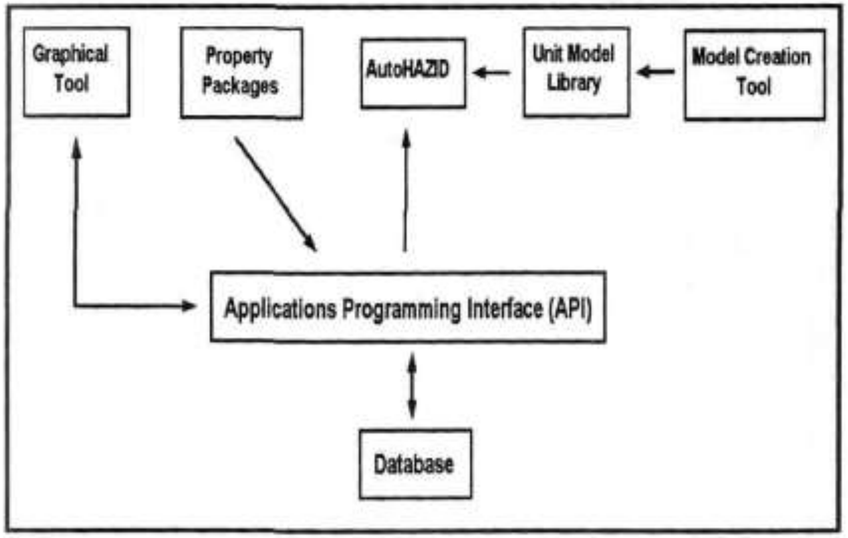
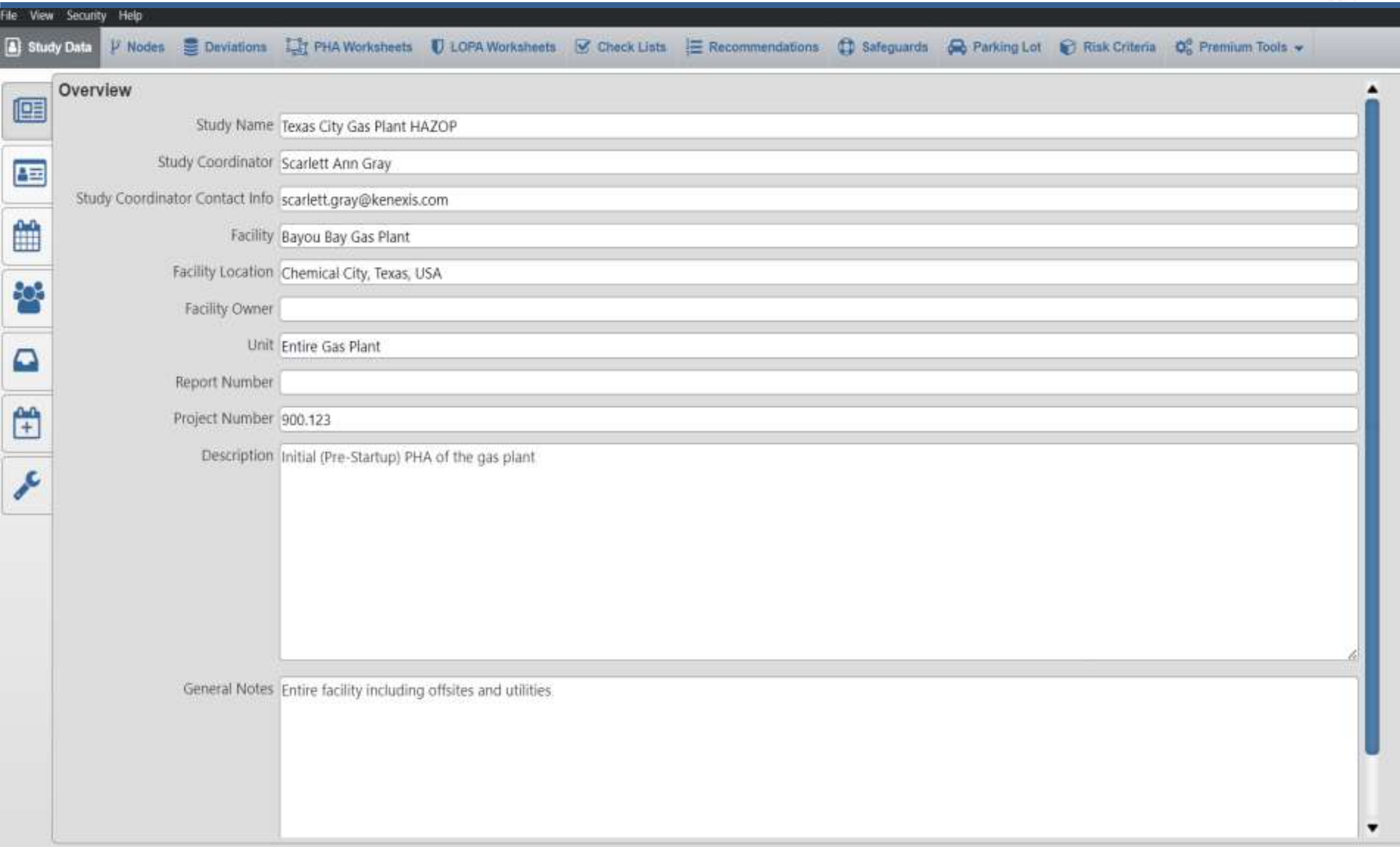
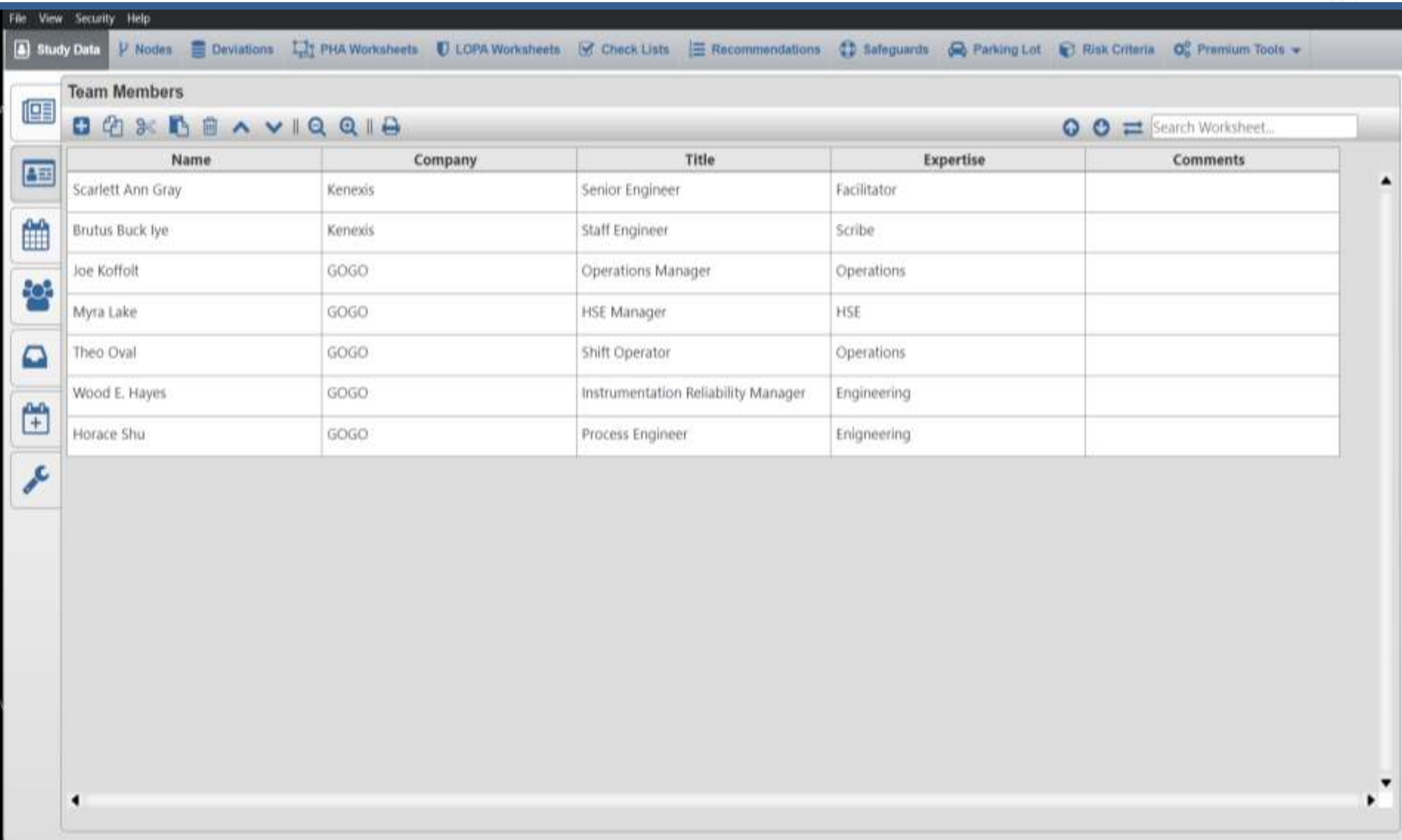


Figure 1: HAZID Modules.

Texas City Gas Plant HAZOP



List of Members



Name	Company	Title	Expertise	Comments
Scarlett Ann Gray	Kenexis	Senior Engineer	Facilitator	
Brutus Buck Iye	Kenexis	Staff Engineer	Scribe	
Joe Koffolt	GOGO	Operations Manager	Operations	
Myra Lake	GOGO	HSE Manager	HSE	
Theo Oval	GOGO	Shift Operator	Operations	
Wood E. Hayes	GOGO	Instrumentation Reliability Manager	Engineering	
Horace Shu	GOGO	Process Engineer	Enigneering	

Nodes

File View Security Help

Nodes

Description	Intention	Design Conditions	Operating Conditions	Color	Session	Drawing
1 (HP Gas) Production Header through High Pressure Separator (V-101) to Gas Export Pipeline	Entry of high pressure gases into the process from the wellheads and production manifold, and transfer of low pressure gas for delivery to the sales gas export pipeline.	MAWP = 1200 psig @ 300 F	700 psig @ 70 F (From production header) 350 psig @ 40 F (From HP separator)			D-254-002 Sh. 2 of 6 D-254-002 Sh. 5 of 6
2 (Liquid Stream) High Pressure Separator (V-101) to Low Pressure Separator (V-102)	Low pressure separator receives knockout liquid hydrocarbons from the high pressure separator.	MAWP = 75 psig @ 300 F	50 psig @ 38 F			D-254-002 Sh. 2 of 6 D-254-002 Sh. 3 of 6
3 (Gas Stream) Low Pressure Separator (V-102), Gas Compressor (C-104), and Compressor Discharge Cooler (H-105) (includes gas spillback to Low Pressure Separator)	Transfer of low pressure gas for compression and delivery of compressed gas to the sales gas export pipeline. Compressor discharge gas is cooled by H105 before delivery to the export pipeline or spillback to M102.	MAWP = 75 psig @ 300 F (LP Separator) 50 psig @ 70 F (Compressor Suction) 350 psig @ 300 F (Compressor Discharge)	50 psig @ 70F (LP Separator) 50 psig @ 70 F (Compressor Suction) 350 psig @ 300 F (Compressor Discharge)			D-254-002 Sh. 3 of 6 D-254-002 Sh. 5 of 6
4 (Liquid Stream) Low Pressure Separator (V-102) through Export Pump (P-103) to Export Liquid Pipeline (includes liquid spillback to Low Pressure Separator from Export Pump)	Delivery of high pressure liquid to export liquid pipeline.	MAWP = 75 psig @ 300 F (LP Separator) 2150 psig @ 300 F (Pump Discharge)	50 psig @ 50 F (LP Separator) 2150 psig @ 55 F (Pump Discharge)			D-254-002 Sh. 3 of 6 D-254-002 Sh. 4 of 6
5 Global Considerations						

Deviations

File View Security Help

Deviations

1. (HP Gas) Production Header through High Pressure Separator (V-101) to Gas Export Pipeline

Deviation	Guide Word	Parameter	Design Intent	Comments
1.1 High Pressure	High	Pressure		
1.2 Low Pressure	Low	Pressure		
1.3 High Temperature	High	Temperature		
1.4 Low Temperature	Low	Temperature		
1.5 High Level	High	Level		
1.6 Low Level	Low	Level		
1.7 High Flow	High	Flow		
1.8 Low Flow	Low	Flow		
1.9 Reverse Flow	Reverse	Flow		
1.10 Misdirected Flow	Misdirected	Flow		
1.11 Other Than Flow	Other Than	Flow		
1.12 Composition	Abnormal	Concentration/Composition		

Safegaurds

File View Security Help

Study Data | Nodes | Deviations | PHA Worksheets | LOPA Worksheets | Check Lists | Recommendations | Safeguards | Parking Lot | Risk Criteria | Premium Tools

Safeguards

Search Worksheet...

Safeguard	Type	Safeguard	IPL	Tag	PFD	Reference
1 Relief valve PSV-101 opens to flare		Yes	No			1.1.1.1 1.1.1.2
2 PT-101D high pressure shutdown closes HP separator inlet valve SDV-101.		Yes	No			1.1.1.1 1.1.1.2
3 Control valve PV-101B will open to flare.		Yes	No			1.1.1.1
4 Fire detection system allowing time for personnel evacuation		Yes	No			1.1.1.2 2.1.1.1
5 Control valve PV-101B will open to flare. No credit taken for this IPL due to inadequate sizing.		Yes	No			1.1.1.2
6 PT-101D low pressure shutdown mitigates hazard by closing SDV-101.		Yes	No			1.2.1.1
7 Automated low pressure shutdown upstream of the production header.		Yes	No			1.2.1.1
8 High level shutdown LT-101B closes inlet valve SDV-101		Yes	No			1.5.1.1 1.5.1.2 1.5.1.3
9 Operator response to high level alarm LT-101A - not independent from control loop failure		Yes	No			1.5.1.1 1.5.1.2 1.5.1.3
10 Relief valve PSV-102, which is sized for gas blow-by		Yes	No			1.6.1.1 1.6.1.2

Risk Criteria

Conclusion

- Machine learning-powered HAZOP modelling has the potential to revolutionize process safety management, improving the accuracy and efficiency of risk assessments and reducing the risk of accidents in the workplace.

- It is also an exciting area of research and development that promises to make our workplaces safer and more productive.

References

1.F.D. Larkin, A. G. Rushton, P. W. H. Chung, F. P. Lees, S. A. McCoy and S. J. Wakeman. COMPUTER-AIDED HAZARD IDENTIFICATION: Methodology and System Architecture. ICHEME SYMPOSIUM SERIES NO. 141

2.JOHANNES SINGLE, JÜRGEN SCHMIDT & JENS DENECKE. COMPUTER-AIDED HAZOP STUDIES: KNOWLEDGE REPRESENTATION AND ALGORITHMIC HAZARD IDENTIFICATION. WIT Press 2019 (www.witpress.com, ISSN 1743-3509).

3. https://www.kenexis.com/open-pha-sample-studies/

Thank you