Can PHA be Big Data?

How to Make PHA Data Work Smarter

Patrick Nonhof
Managing Partner

27 March 2019

Provenance Consulting

OVERVIEW

Should Process Hazard Analysis (PHA) Information be part of Big Data?

The answer is YES!

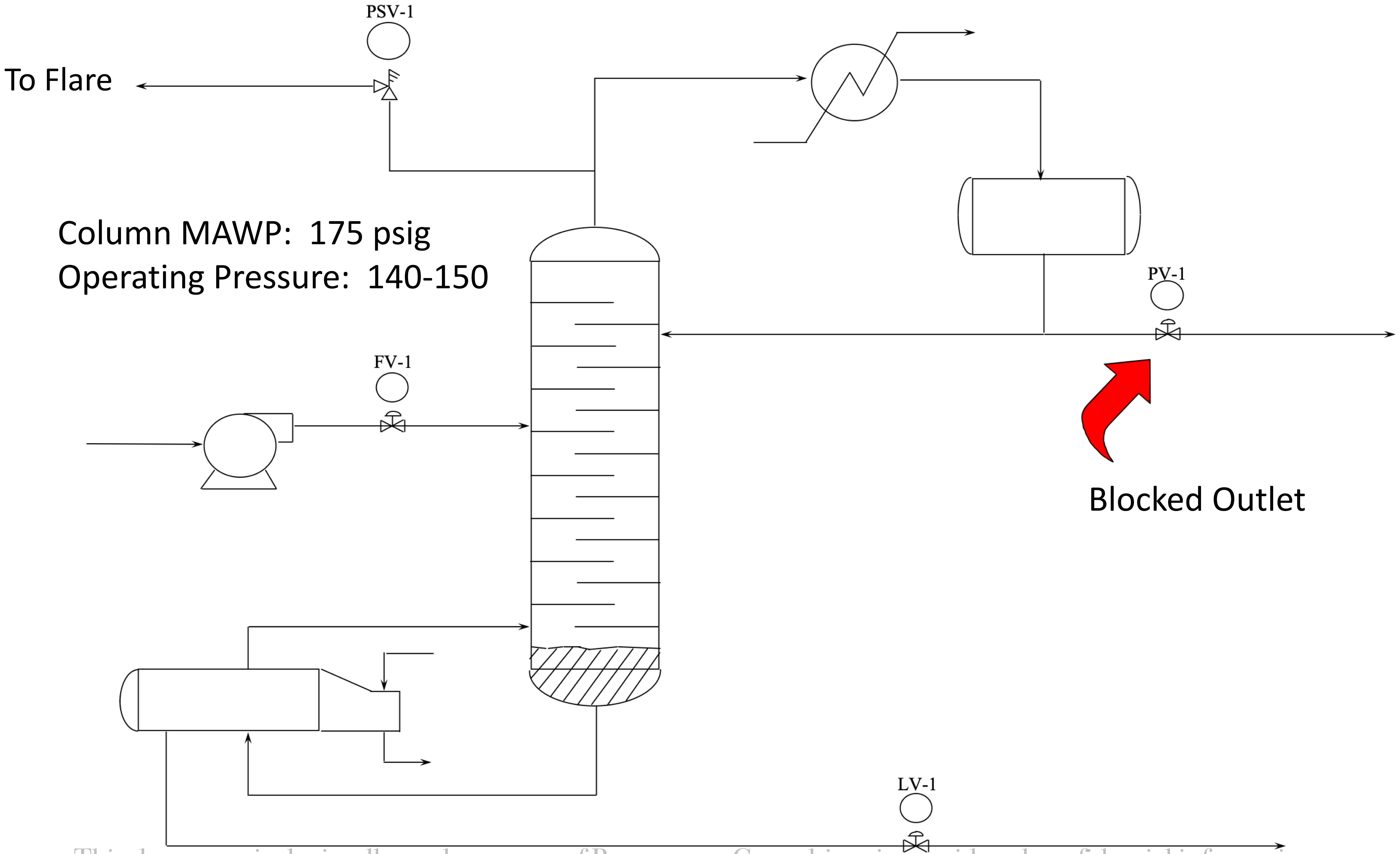
- Today's PHA Process
- Big Data
- PHA Data Limitations
- Finding a Solution

TODAY'S PHA PROCESS & INFORMATION

PHA Refresher: Basic Steps

1. Cause
2. Consequences
3. Unmitigated Risk (UMR) Assessment
4. Safeguards
5. Mitigated Risk (MR) Assessment

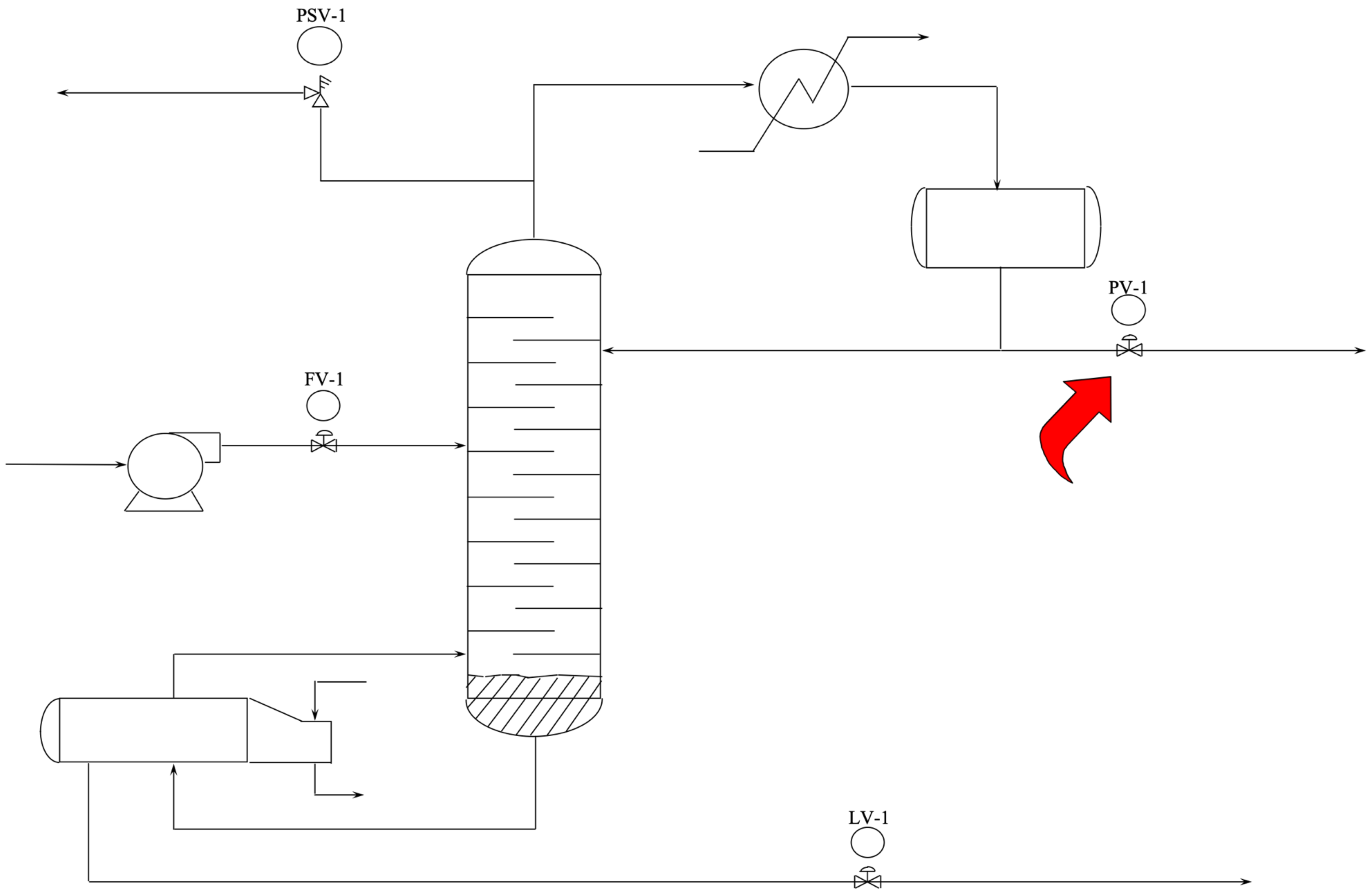
Case Study: Distillation Example



Case Study – Cause

Tower Example – Typical Cause Information:

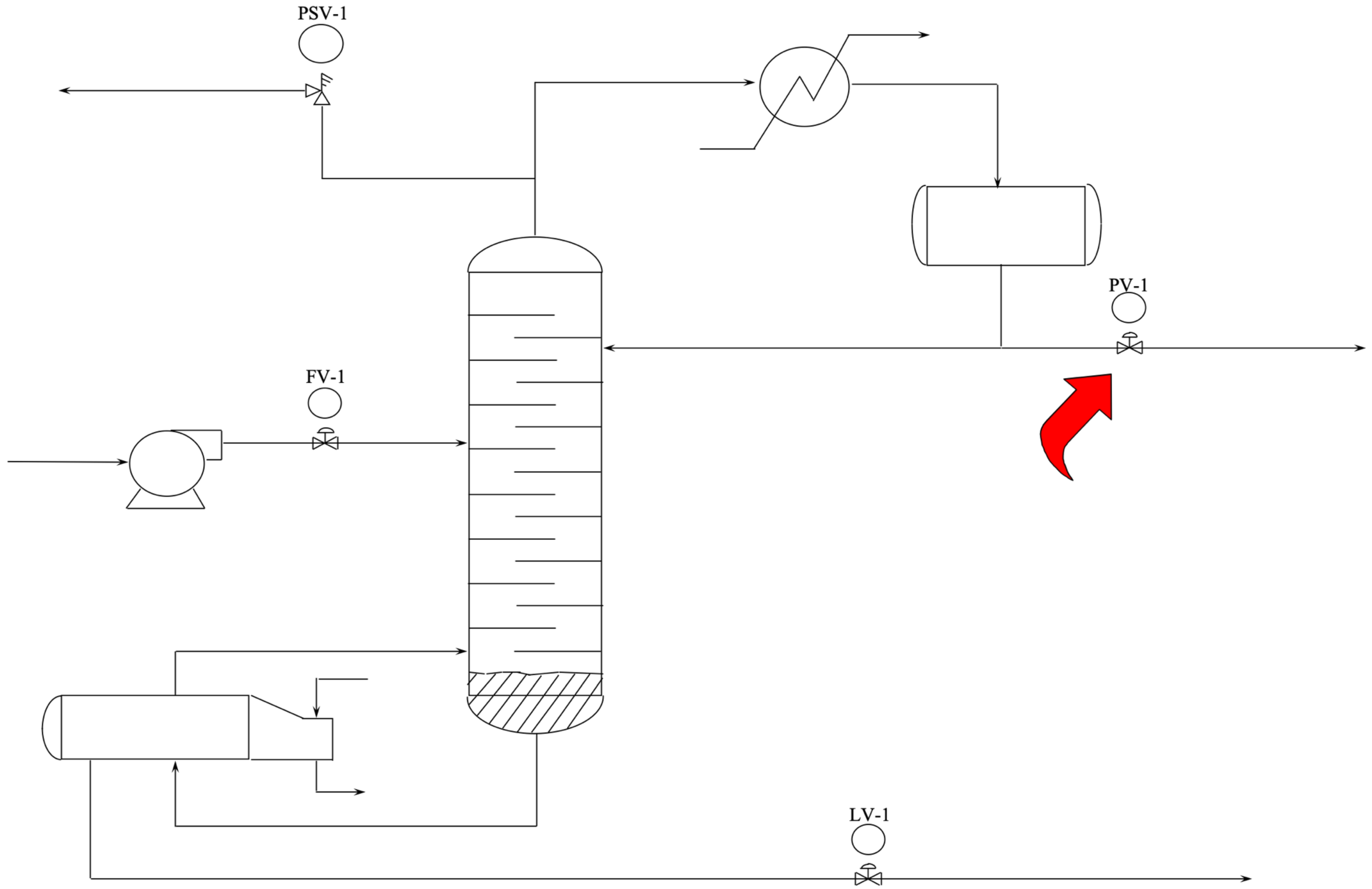
Unit	HF Alkylation Unit
Node	Debutanizer Tower
Deviation	No Flow
Cause	Overhead liquid Control valve FC-109 loses instrument air and fails closed



Case Study - Consequence

Tower Example – Typical Consequence Information:

Consequence	Increase column pressure to vapor pressure of overhead fluid at reboiler steam temperature i. Overpressure: Greater than 3 x MAWP ii. Vessel Failure

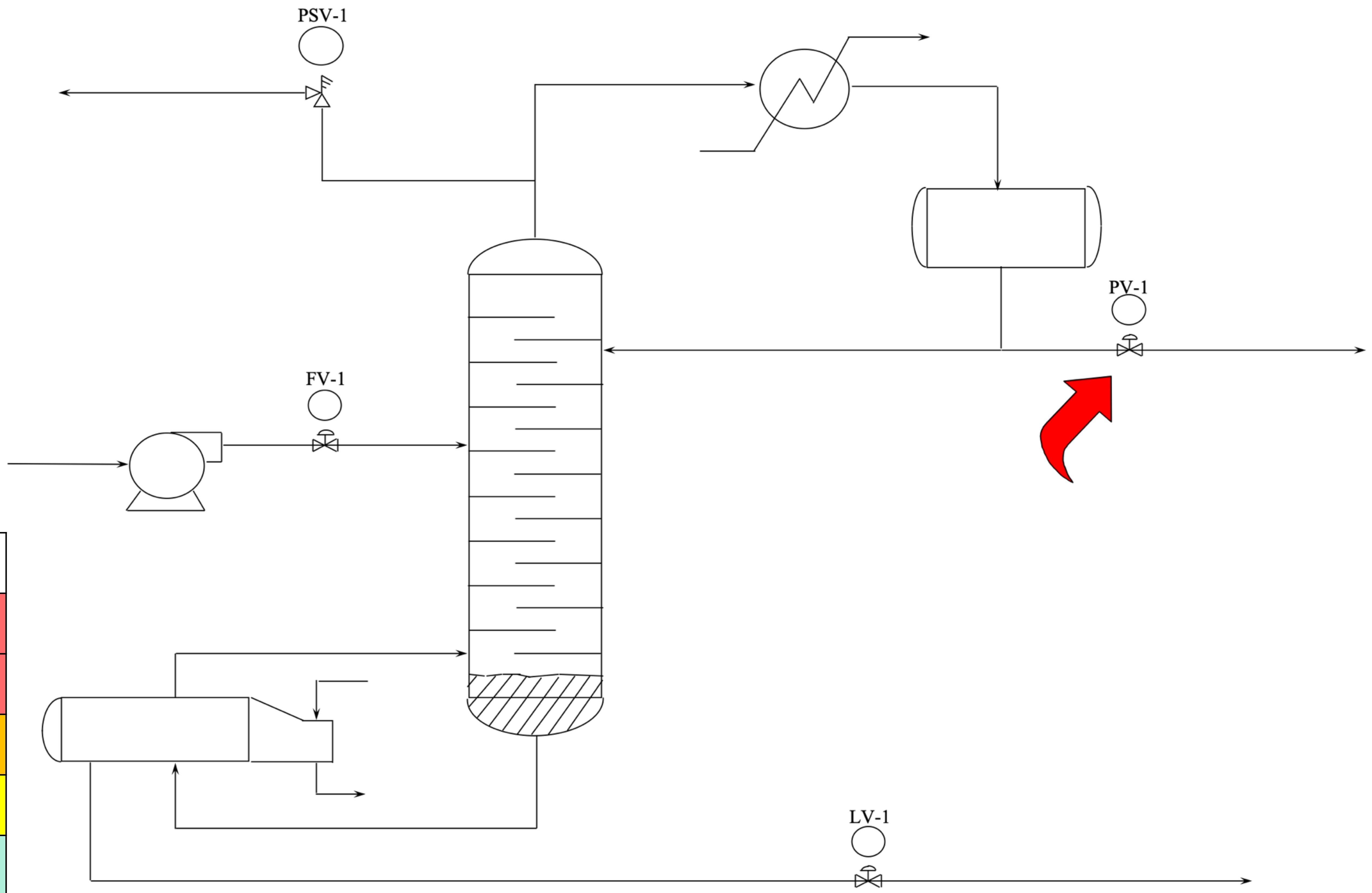


Case Study – Unmitigated Risk Assessment

Tower Example – Typical Risk Determination:

Severity	Catastrophic
Frequency	Occasional
Unmitigated Risk (UMR)	5

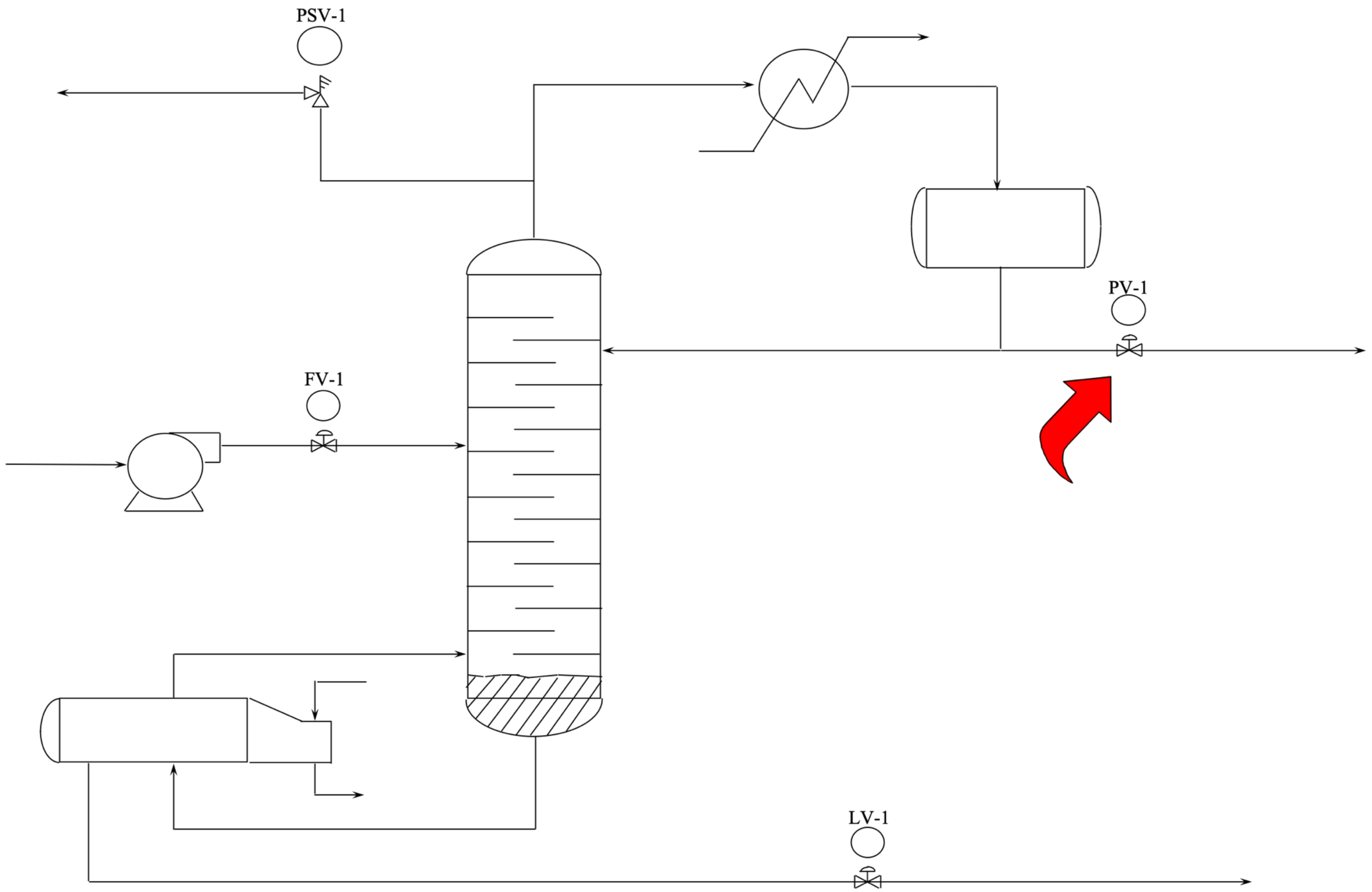
	Negligible	Minor	Moderate	Serious	Catastrophic
Frequent	2	3	4	5	5
Occasional	1	2	3	4	5
Remote	1	1	2	3	4
Improbable	1	1	1	2	3
Very Improbable	1	1	1	1	2



Case Study - Safeguards

Tower Example – Typical Safeguards:

Safeguard 1:	Shutdown PSD-301
Safeguard 2:	RV-305 Set at 175 psig

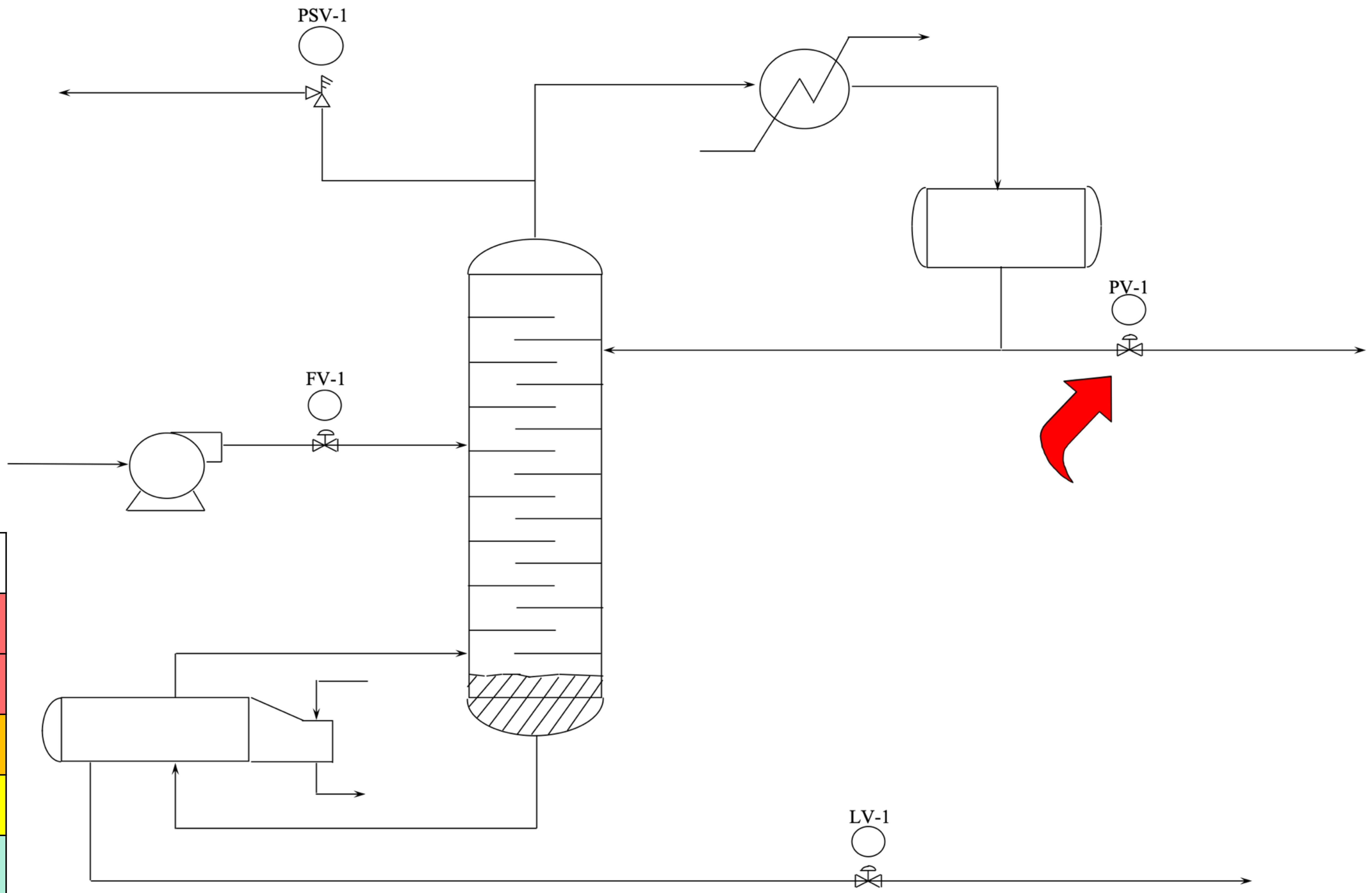


Case Study – Mitigated Risk Assessment

Tower Example – Typical Mitigated Risk:

Severity	Catastrophic
Frequency	Very Improbable
Unmitigated Risk (UMR)	2

	Negligible	Minor	Moderate	Serious	Catastrophic
Frequent	2	3	4	5	5
Occasional	1	2	3	4	5
Remote	1	1	2	3	4
Improbable	1	1	1	2	3
Very Improbable	1	1	1	1	2



Complete Case Study PHA Scenario

CAUSE				CONSEQUENCE	UNMITIGATED RISK ASSESSMENT			SAFEGUARDS	MITIGATED RISK ASSESSMENT		
Unit	**Node**	**Deviation**	**Cause**	**Consequence**	**Severity**	**Freq.**	**Unmitigated Risk (UMR)**	**Safeguards**	**Severity**	**Freq.**	**Unmitigated Risk (UMR)**
HF Alkylation Unit	Debutanizer Tower	No Flow	Overhead liquid Control valve FC-109 loses instrument air and fails closed	Increase column pressure to vapor pressure of overhead fluid at reboiler steam temperature i. Overpressure: Greater than 3 x MAWP ii. Vessel Failure	Cat.	Occasional	5	1. Shutdown PSD-301 2. RV-305 Set at 175 psig	Cat.	Very Improb	2

Cause → Consequences → Unmitigated Risk (UMR) Assessment → Safeguards → Mitigated Risk (MR) Assessment

BIG DATA

Characteristics of "Big Data"

Big Data Defined		
Volume	Variety	Velocity

Big Data Goals	
Veracity	Value

Characteristics of "Big Data"

PHA Data as Big Data

Volume	**Variety**	**Velocity**
One PHA: 1500 scenarios Large Petrochem plant: 30 PHA's One cycle: 45,000 PHA scenarios 6 cycles (30 years): 270,000 scenarios	Complete PHA data sets reside in a variety of forms: PDFs, Excel, PHA facilitation systems, plus the reference/source documents: CAD drawings, etc.	Reports every 5 years **Applies when you use PHA data to add context to operational data which has a much higher velocity.*

PHA Big Data Goals

Veracity	**Value**
Address inconsistencies in PHA teams' wording, risk analysis, rationale, etc. that create uncertainty in the data	Data Comparisons Knowledge capture Predictive model connections

PHA DATA LIMITATIONS

The Big Picture

The Industry Does facilitate its PHAs well

The Industry Doesn't manage its PHA data as well

The In’s and Out’s of PHAs

What Goes In

Manhours:
- Extensive Preparation
- Multi-week, multi-participant event

Expertise Repository
- 20 years of institutional knowledge
- From people ready to or already retired

Resources
- Logistics & budget planning (back-filling team members)
- Retrieving all documentation for reference

PHA Process

What Comes Out

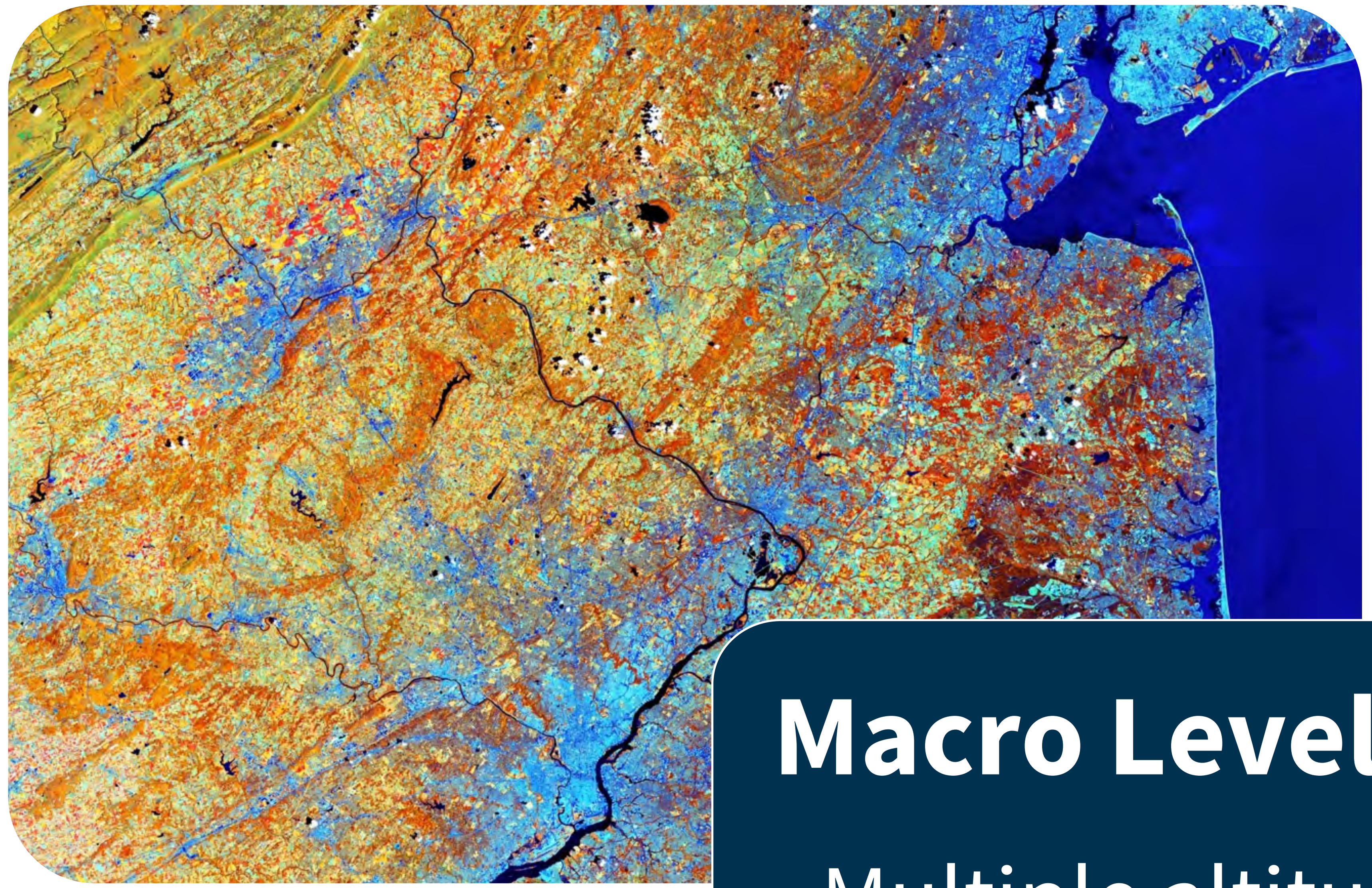
- Up-to-date Process Safety Information (PSI)
- Massive Report *(filed away between PHAs)*
- Recommendations list with action plans
- Independent Protection Layer (IPL) lists

What's the Problem?

A paradigm shift is needed for the industry's approach to PHAs

Micro Level

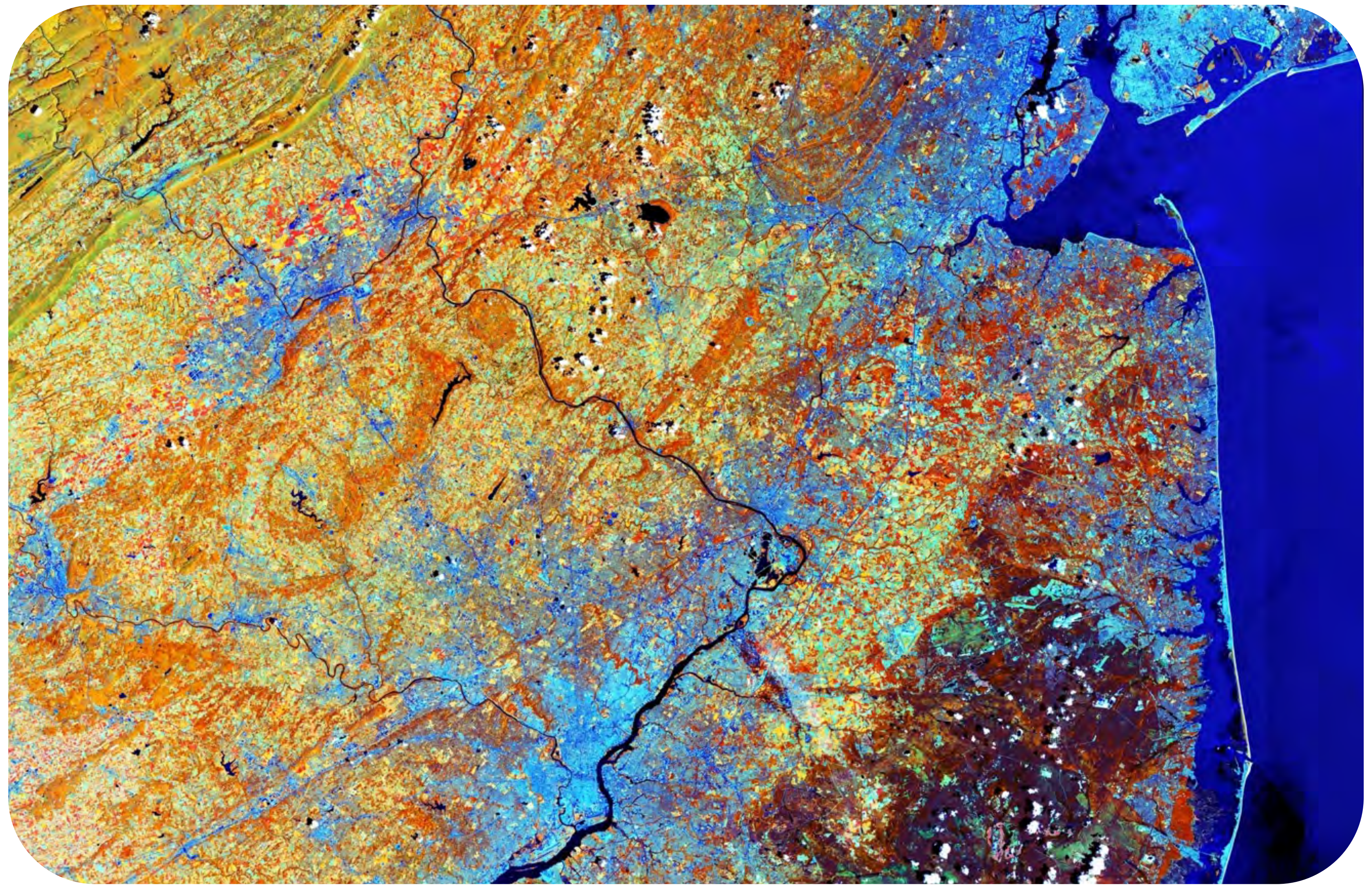
- Single focus
- Siloed Data
- Snapshot in album



Macro Level

- Multiple altitudes
- Compare and analyze
- Easy access

What are the Barriers?



1. Lack of Accessibility
2. Lack of Structure

Barrier: Lack of Accessibility

- Not easily searchable

- Data stored in stand-alone software
  - Restricted ability to view native files
  - Different file formats

- Most common form is hard copy binders on a shelf

Barrier: Lack of Structure

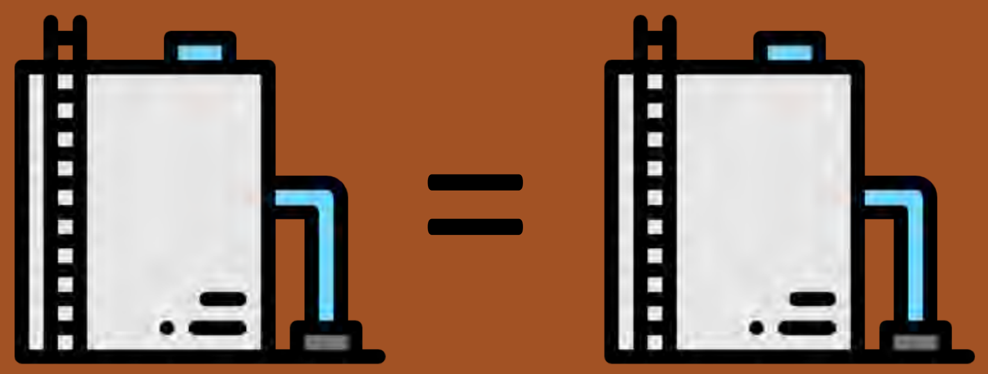
- “Free text” fields used to document/embed extremely important data:
  - Process fluid
  - Equipment involved
  - Safeguards
  - Consequence details

Causes	Consequences	S-S	S-E	S-C	Safeguards	Cause likelihood	Unmitigated risk rankings		
							Safety	Environment	Asset
1. Failure of control loop LIC-101A such that valve is open too much.	1. Potential for gas blowby into the low-pressure separator V-102. Potential for overpressure of low-pressure separator. Potential for loss of mechanical integrity. Potential for rupture of vessel or associated piping. Potential release of flammable materials. Potential fire or explosion.	5	3	4	1. Relief valve PSV-102, which is sized for gas blowby. 2. Low-level shutdown LT-101B closes low-pressure separator inlet SDV-102A. 3. Operator response to low-level alarm LT-102A, not independent from control loop failure. 4. High-pressure shutdown PT-102B closes SDV-102A. No credit taken for this IPL due to shared final element with LT-101B low-level shutdown.	3	[illegible]	3	4
2. Invert and opening of bypass around control LV-101A	1. Potential for gas blowby into the low-pressure separator V-102. Potential for overpressure of low-pressure separator. Potential for loss of mechanical integrity. Potential for rupture of vessel or associated piping. Potential for release of flammable materials. Potential fire or explosion.	5	3	4	1. Relief valve PSV-102, which is sized for gas blowby. 2. Low-level shutdown LT-101B closes low-pressure separator inlet SD-102A. 3. Operator response to low-level alarm LT-101A. 4. High-pressure shutdown PT-102B closes SDV-102A. No credit taken for this IPL due to shared final element.	2	4	2	1

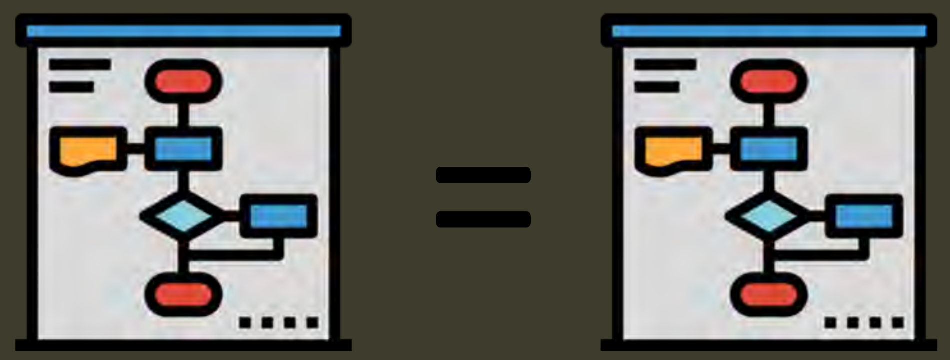
- Puts undue limits on the usability of the data

Result: Lack of Consistency

Without intentional structure, how consistent are your PHA’s for:



The Same Process?



The Same Technologies & Equipment?

<u>Consider</u>:

Do they have similar **causes, consequences, or risk levels?**

Envision the Possibilities

What if we could use PHA data to:

- Understand the Risk Profiles for your units?
- Match spending with risk and tolerance levels?
- Maintain centralized documenting and reporting?
- Use analytics to make decisions?
- Provide better access to your knowledge repository?

FINDING A SOLUTION

Step 1: Start with Structure

1. Structure improves **Consistency**

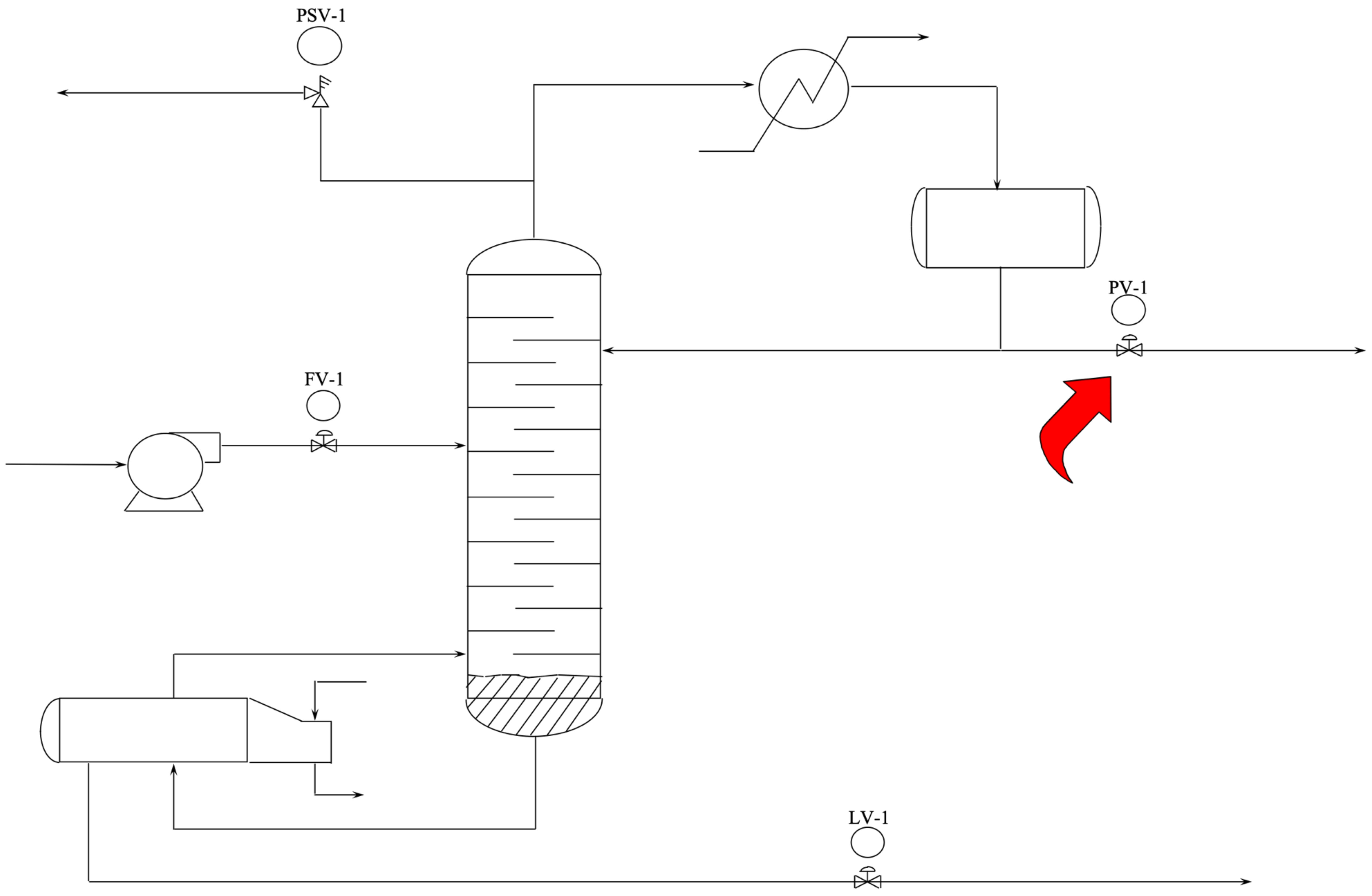
2. **Consistency** allows for **Analytics**

3. **Analytics** directs and supports **Decisions**

Improving Structure – Cause

Tower Example – Add Cause Categories:

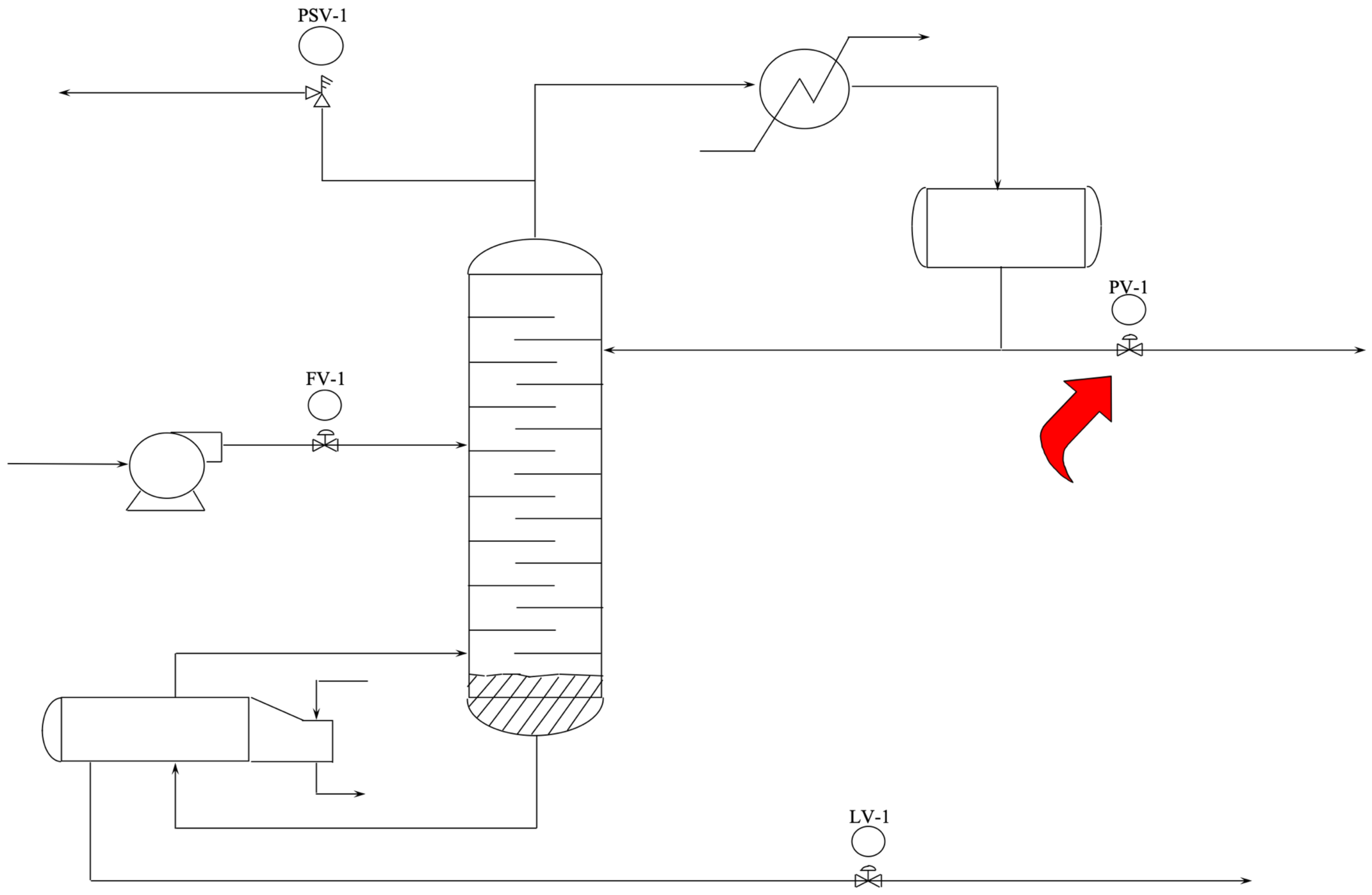
Unit	HF Alkylation Unit
Node	Debutanizer Tower
Deviation	No Flow
Cause	Overhead liquid Control valve FC-109 loses instrument air and fails closed
Technology	HF Alkylation
Cause Category	Blocked Outlet
Process Fluid	Butane
Location	Overhead of Debutanizer



Improving Structure – Consequence

Tower Example – Add Consequence Categories

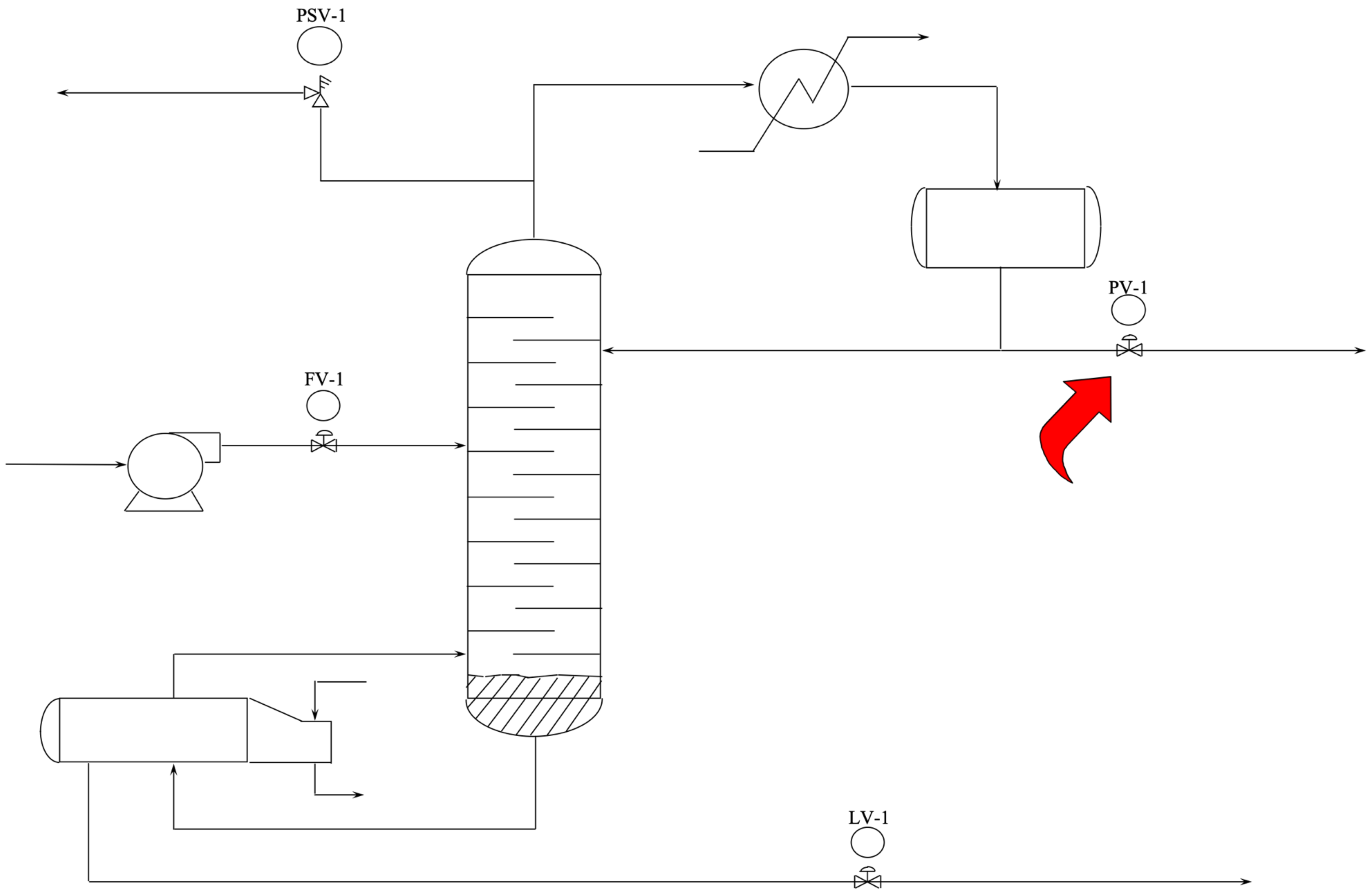
Consequence	Increase column pressure to vapor pressure of overhead fluid at reboiler steam temperature i. Overpressure: Greater than 3 x MAWP ii. Vessel Failure
Simplified Consequence	Tower overpressure
Equipment	Debutanizer V-300



Improving Structure – Safeguards

Tower Example - Add Safeguard categories:

Safeguard 1: Description	Shutdown PSD-301
Safeguard 1: **Type**	Safety Instrumented System
Safeguard 1: **Priority**	1
Safeguard 2: Description	RV-305 Set at 175 psig
Safeguard 2: **Type**	Pressure Relief Device
Safeguard 2: **Priority**	2



Step 2: Compare the Data - Analytics

1. **Structure** improves **Consistency**

2. **Consistency** allows for **Analytics**

3. **Analytics** directs and supports **Decisions**

Analytics: Identify & Manage Discrepancies

Now that we've structured the scenarios:

Identify

related scenarios **using categories.**

Compare

that specific scenario **across multiple PHAs** to review patterns or discrepancies.

Identify

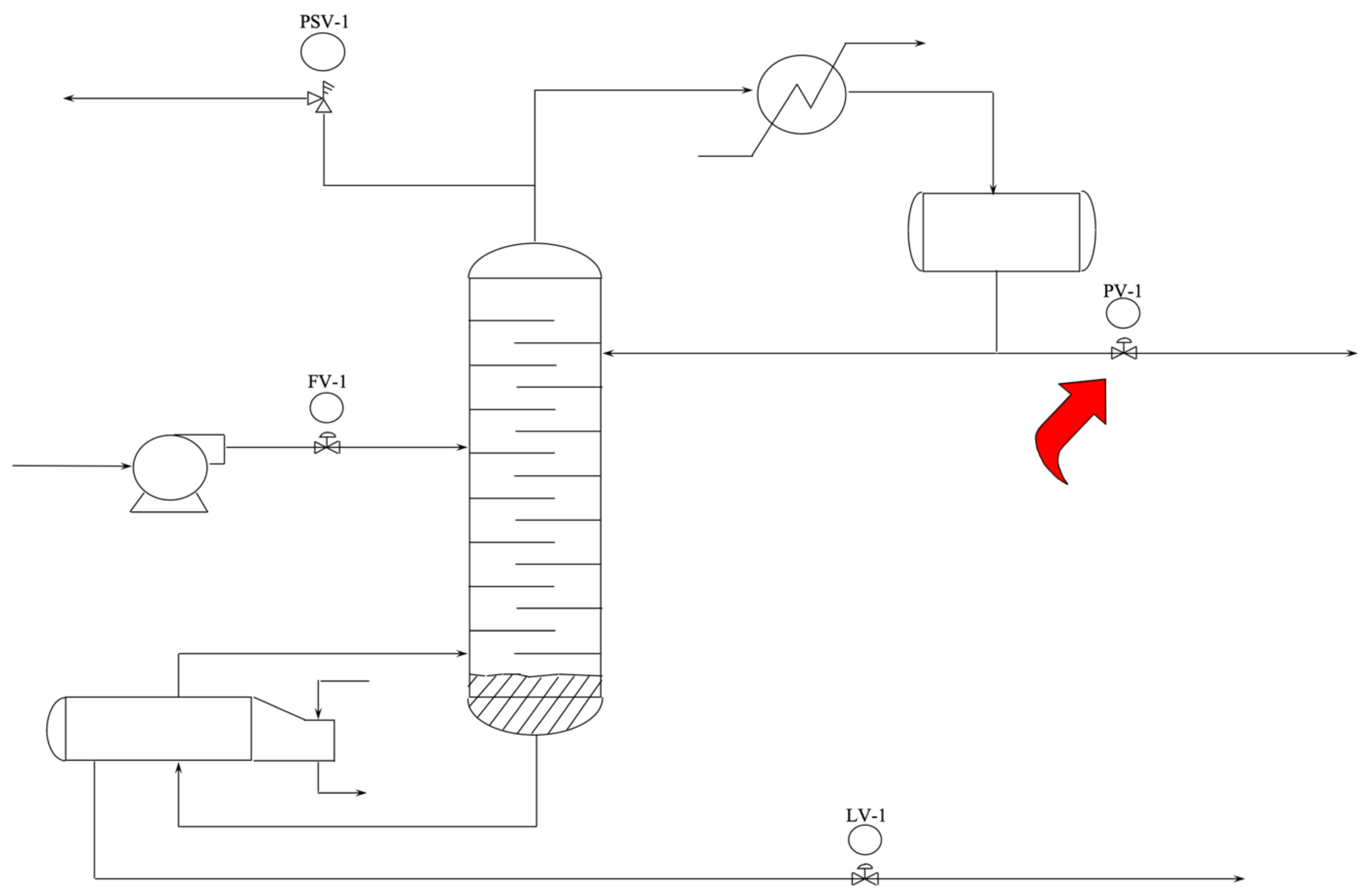
discrepancies **to be resolved or justified** at the scenario level.

Analytics: Compare Related Scenarios

Sort and find related scenarios easily

- Use Cause Categories

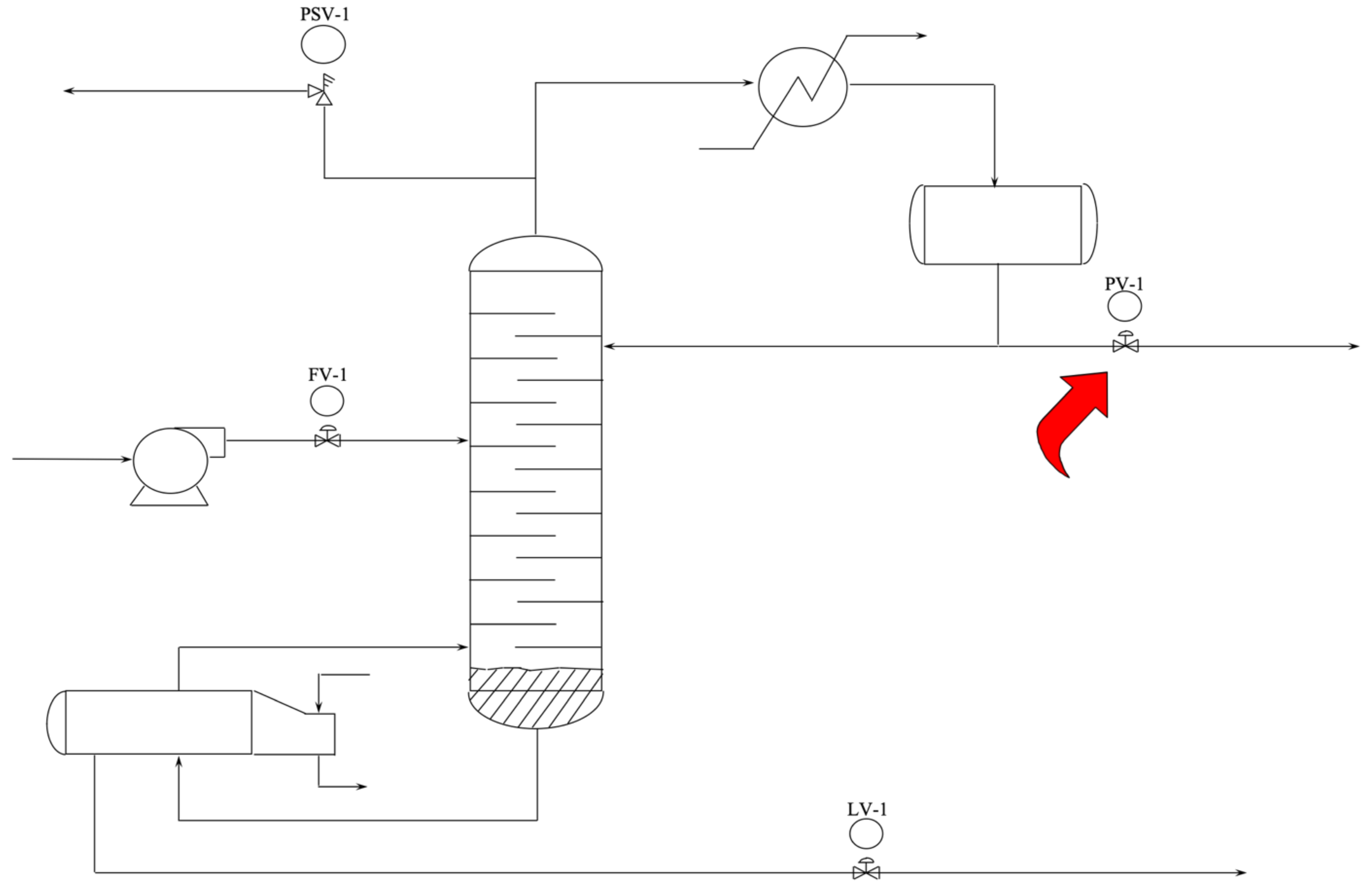
	Plant 1	Plant 2
Node	Debutanizer Tower	Debutanizer Tower
Deviation	No Flow	No Flow
Cause	Overhead liquid Control valve FC-109 loses instrument air and fails closed	Loss of instrument air to overhead receiver liquid flow control FIC-315 which fails closed.
Technology	HF Alkylation	HF Alkylation
Cause Category	Blocked Outlet	Blocked Outlet
Process Fluid	Butane	Butane
Location	Overhead of Debutanizer	Overhead of Debutanizer



Analytics: Compare Consequences

Comparing Consequences & Risk

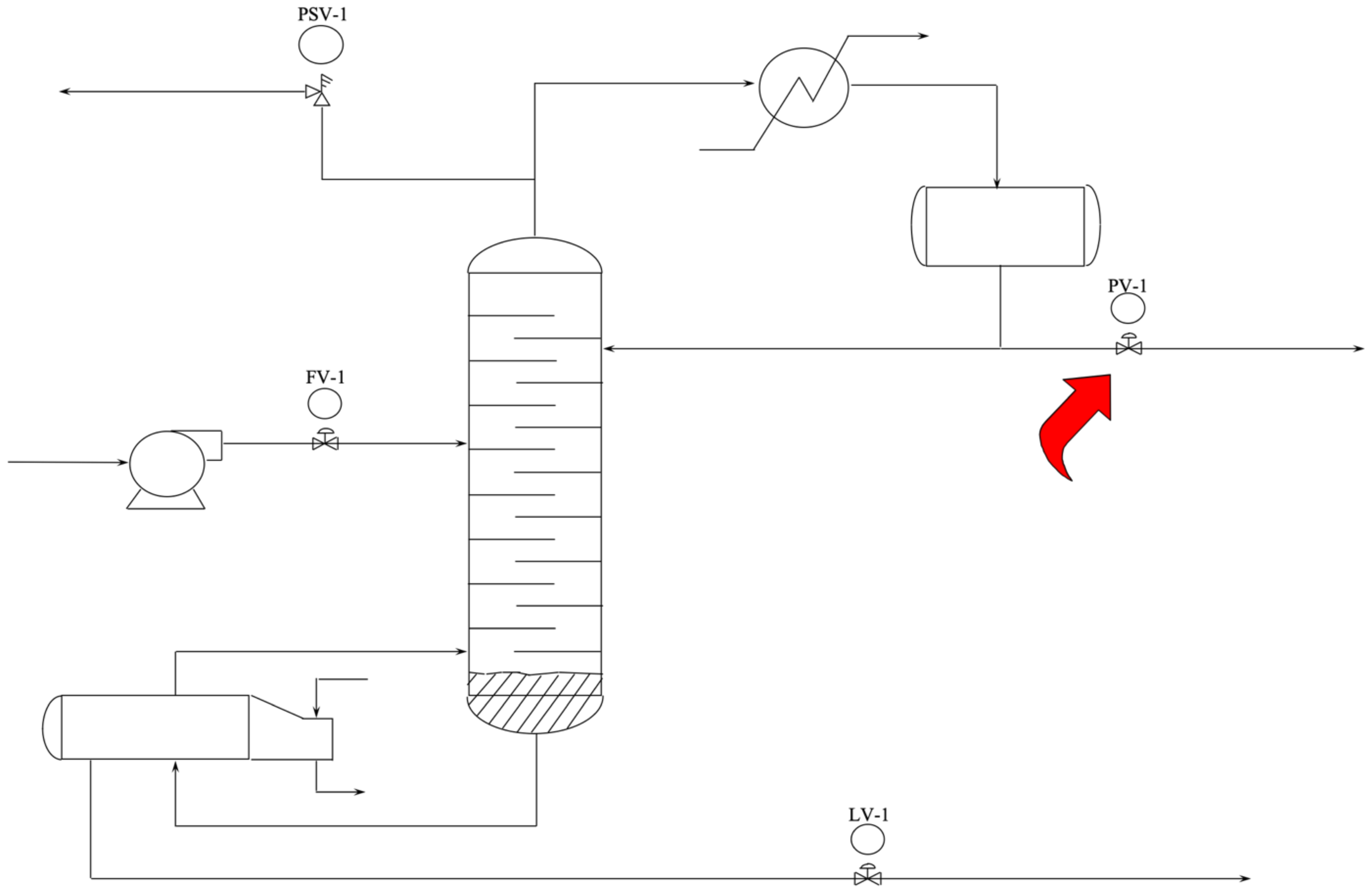
	Plant 1	Plant 2
Consequence	Increase column pressure to vapor pressure of **overhead fluid** at reboiler steam temperature • Overpressure: Greater than 3 x MAWP • Vessel Failure	Increase column pressure to vapor pressure of **bottoms fluid** at reboiler steam temperature • Overpressure: Ranges from 1.2-2.2 x MAWP • Gasket Failure
Simplified Consequence	Tower overpressure	Tower overpressure
Equipment	Debutanizer V-300	Debutanizer T-5
Severity	Extreme	Moderate
Frequency	Occasional	Occasional
Unmitigated Risk	5	3



Analytics: Compare Safeguards

Comparing Safeguards

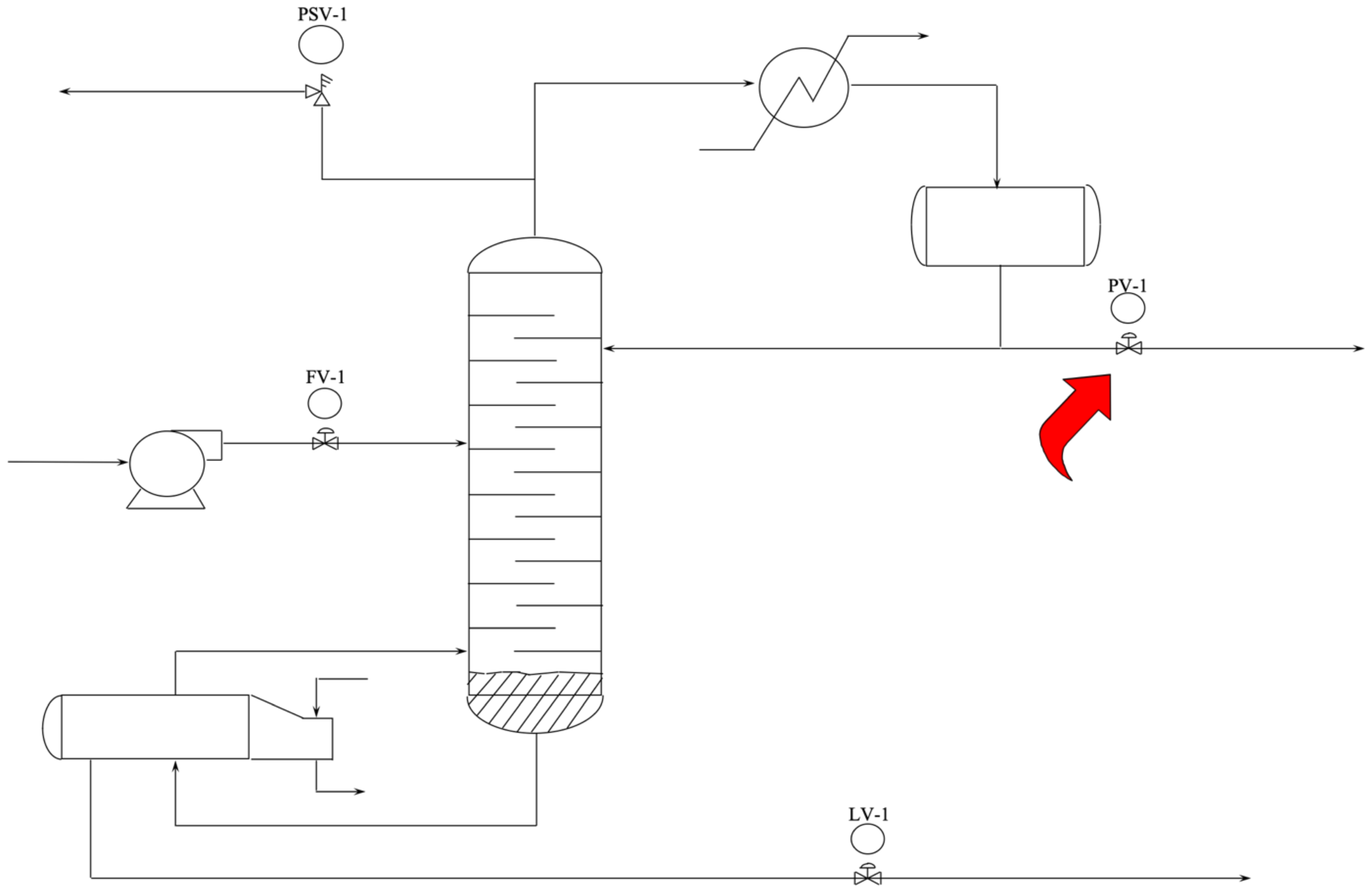
	Plant 1	Plant 2
Safeguard 1: Description	Shutdown PSD-301	PSV-1 Set at 200 psig
Safeguard 1: Type	Safety Instrumented System	Pressure Relief Device
Safeguard 1: Priority	1	1
Safeguard 2: Description	RV-305 Set at 175 psig	Alarm PAH-115
Safeguard 2: Type	Pressure Relief Device	Alarm
Safeguard 2: Priority	2	2



Analytics: Compare Mitigated Risk

Compare Mitigated Risk

	Plant 1	Plant 2
Severity	Catastrophic	Moderate
Frequency	Very Improbable	Improbable
Mitigated Risk (MR)	2	1



Analytics: Big Picture Comparisons

Compare Consequences and Risks

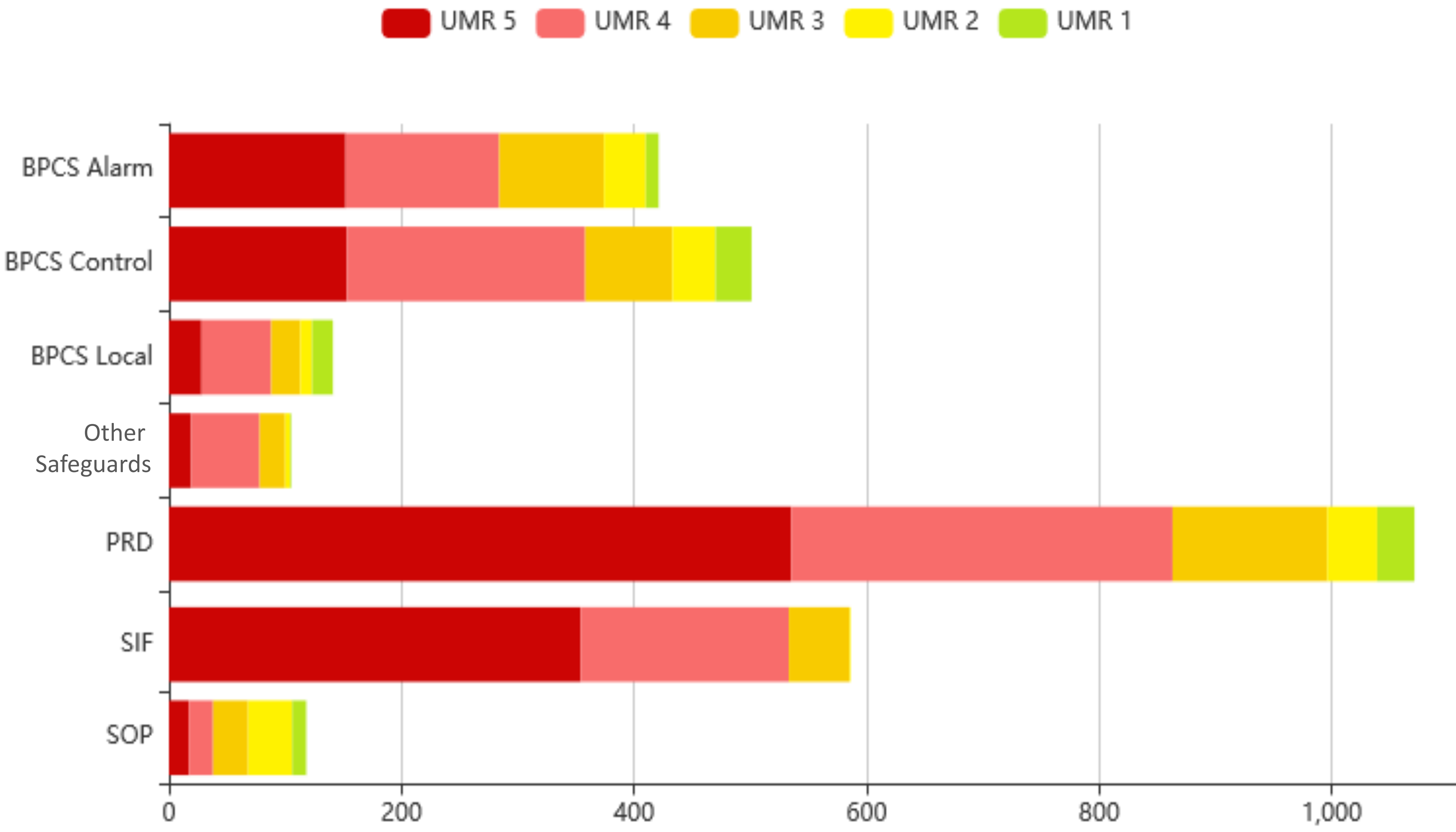
NUMBER	CAUSE CATEGORY	CONSEQUENCE	UMR	MR
1.1.1.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	3	1
1.1.2.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	4	2
1.1.3.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	4	3
1.1.4.1.	Pump Failure -1	Loss of feed to Column 1 resulting in lo...	5	3
1.1.5.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	5	3
1.1.6.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	3	2
1.1.7.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	3	2
1.1.8.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	4	2
1.1.9.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 and loss of flo...	4	3
1.1.10.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 resulting in lo...	5	3
1.1.11.1.	Operator or Maintenance Action -2	Loss of feed to Column 1 resulting in lo...	4	2
1.1.12.1.	Operator or Maintenance Action -1	Loss of feed to Column 1 resulting in lo...	3	2

Analytics: Compare Safeguards

Compare Safeguards by Unmitigated Risk Level

View most common/frequently used safeguards for entire facility:

- Basic process control system (BPCS) Alarms, Controls and Local
- Pressure Relief Device (PRD)
- Safety Instrumented Function (SIF)
- Standard Operating Procedure (SOP)
- Other Safeguards



Analytics: Risk Metrics Example

Looking at Risk in a Plant...

Unmitigated Risk Value Weighted average: URV 3.4

	Negligible	Minor	Moderate	Serious	Catastrophic
Frequent	*2* **185**	*3* **117**	*4* **167**	*5* **238**	*5* **142**
Occasional	*1* **233**	*2* **183**	*3* **313**	*4* **460**	*5* **259**
Remote	*1* **24**	*1* **13**	*2* **12**	*3* **50**	*4* **22**
Improbable	*1* **0**	*1* **0**	*1* **0**	*2* **0**	*3* **0**
Very Improbable	*1* **0**	*1* **0**	*1* **0**	*1* **0**	*2* **0**

Step 3: Make Informed Decisions

1. **Structure** improves **Consistency**

2. **Consistency** allows for **Analytics**

3. **Analytics** directs and supports **Decisions**

Example Continued: Risk Metrics

Calculating a Risk Profile (weighted averages):

URV		MRV		RRV*
3.4	-	1.9	=	1.5

- URV – unmitigated risk value
- MRV – mitigated risk value (after safeguards applied)
- RRV* - reduced risk value: impact of your safeguards

Decisions: Risk Metrics Example

- Overall – Corporate Risk Profile

URV		MRV		RRV*
2.7	-	1.7	=	1.0

- Plant 1 Unit Risk Profile

URV		MRV		RRV*
2.0	-	1.4	=	0.6

- Plant 2 Unit Risk Profile

URV		MRV		RRV*
3.4	-	1.9	=	1.5

Questions to ask:

- Is Plant 1's URV too low?
- Why is Plant 2 unmitigated risk so high?
- Is Plant 2 taking too much credit for safeguards?
- Does Plant 2 have more robust safeguards?

Decisions: Connect the Big Data Dots

- Start with an "I wonder" statement:
  "I wonder if any alarms are safeguards for more than one scenario?"
  - Examine the safeguard connections to indicators/alarms
  - Filter for the facility's 50 highest risk scenarios
    - What does it tell you? Do you have one alarm that is critical for your facility? Is that wise? Are you maintaining it accordingly? Is your team training on it appropriately? Routinely enough?

- Don't set the course, let the data lead – see where it takes you!

Decisions: Connecting the Dots

- Key in on critical scenarios

- Analyses could help determine where to:

  - Focus manpower and budget resources
  - Emphasize training
  - Direct mechanical integrity efforts

MOVING FORWARD

Key Take-aways

- A paradigm shift is needed to embrace Big Data concepts for PHA Data

  Micro ⇢ Macro

- Realizing Big Data possibilities for PHA data **begins with addressing accessibility and structure issues**.

- Big Data tools can move us forward.

Questions?

For additional questions, contact:
Patrick Nonhof at

Patrick.Nonhof@provpsm.com

www.provpsm.com

Patrick Nonhof
Managing Partner
27 March 2019

Provenance Consulting