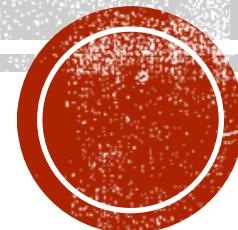


# **STUDI HAZOP BERBASIS *LAYER OF PROTECTION ANALYSIS* PADA *MAIN FRACTIONATOR CRUDE DISTILLATION UNIT* PT. PERTAMINA RU VI BALONGAN**

Oleh :

Muhammad Khamim Asy`ari

24 14 105 018

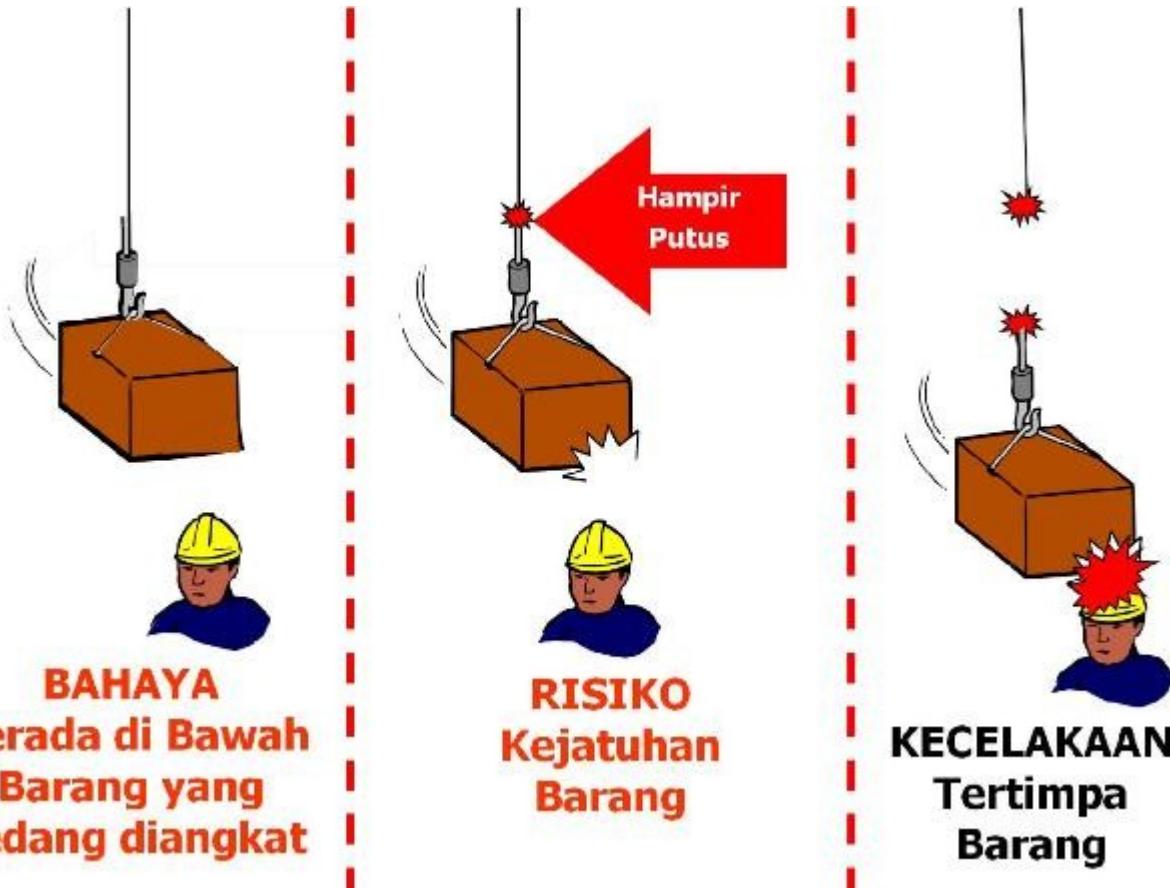


Dosen Pembimbing :

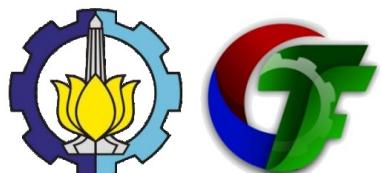
Dr. Ir. Ali Musyafa', M.Sc



# POTENSI BAHAYA

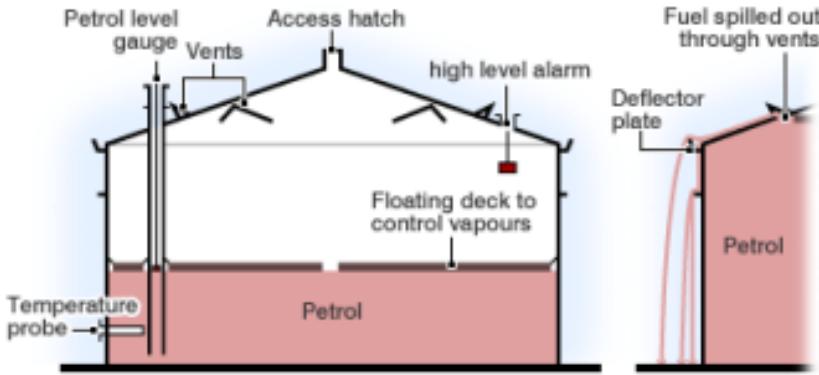


**Potensi bahaya** merupakan sumber **risiko** yang mengakibatkan **kerugian** baik pada material, lingkungan, maupun manusia. Salah satu bentuk risiko bahaya yang dapat muncul adalah **kecelakaan kerja**.



# What we want to avoid!

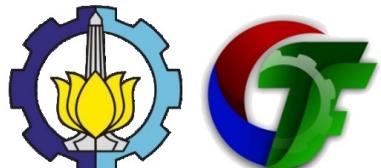
## Major Incidents



### Buncefield UK, December 2005

- UK's biggest peacetime blaze
- Handled around 2.37 million metric tonnes of oil products a year
- Disaster struck early in the morning when unleaded motor fuel was pumped into storage tank
- **Safeguards on the tank failed** and none of the staff on duty realized its capacity had been reached

### Blind Operations



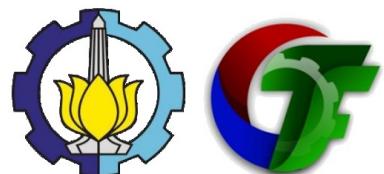
# What we want to avoid!

## Major Incidents



### Texas City, Texas 2005

- Oil refinery explosion
- The third largest refinery in the U.S.
- Killed 15 people



## Operation Practices

# What we want to avoid!

## Major Incidents



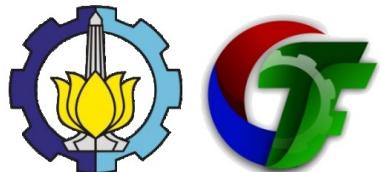
### Deepwater Horizon, Gulf of Mexico, April 2010

Extend of damage:

- HSE:
  - 11 Workers missing
- Economic damage:
  - Sept 2010: 11 Billion \$
- Environmental damage:
  - mid June 2010 approximately 5 million barrels of oil spilled

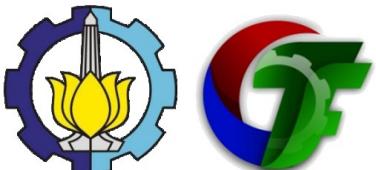
# **PT. PERTAMINA RU VI BALONGAN**

**PT. Pertamina (Persero) Refinery Unit VI Balongan merupakan kilang keenam dari tujuh kilang direktorat pengolahan PT. Pertamina (Persero) dengan kegiatan bisnis utamanya adalah mengolah minyak mentah (*crude oil*) menjadi bentuk-bentuk BBM (Bahan Bakar Minyak), Non BBM dan Petrokimia**



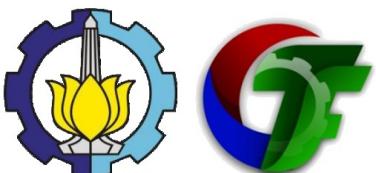
# PERUMUSAN MASALAH

- Bagaimana hasil analisis nilai **HAZOP** pada **main fractionator Crude Distillation Unit** PT Pertamina RU VI Balongan?
- Bagaimana hasil evaluasi nilai **Safety Integrity Level** pada **main fractionator Crude Distillation Unit** PT Pertamina RU VI Balongan dengan metode **Layer of Protection Analysis**?
- Apa saja **rekomendasi** yang dapat diberikan terkait hasil analisis secara keseluruhan yang telah diperoleh?



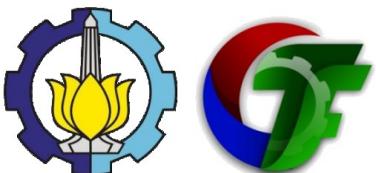
# TUJUAN

- Mengetahui hasil analisis nilai **HAZOP** pada **main fractionator Crude Distillation Unit** PT Pertamina RU VI Balongan
- Mengetahui hasil evaluasi nilai **Safety Integrity Level** pada **main fractionator Crude Distillation Unit** PT Pertamina RU VI Balongan
- Memberikan **rekomendasi** yang bermanfaat kepada perusahaan terkait dengan kondisi sistem *safety* yang telah dianalisis

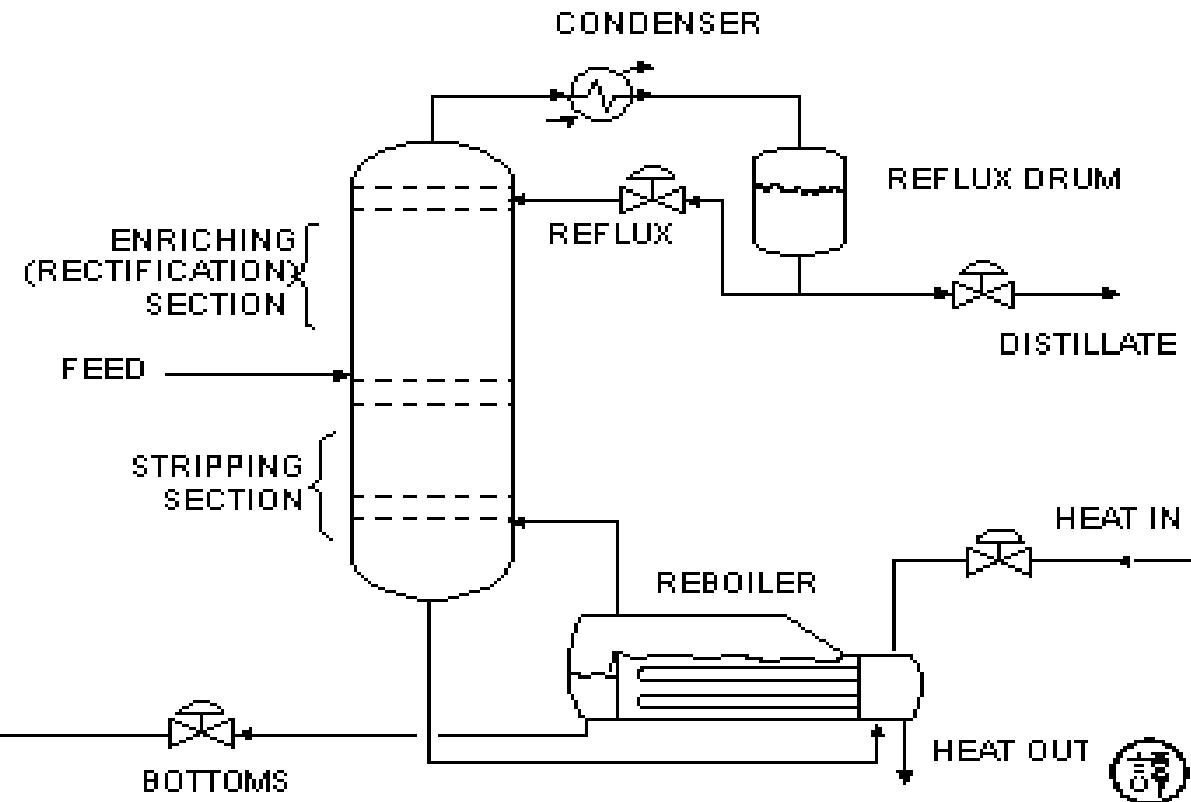


# BATASAN MASALAH

- Plant yang dianalisis adalah ***main fractionator Crude Distillation Unit*** di PT Pertamina RU VI Balongan.
- sistem pada *main fractionator* yang dianalisis merupakan tiga sistem ***pumparound***.
- Data-data yang digunakan diperoleh dari data ***maintenance*** PT Pertamina RU VI Balongan serta ***wawancara*** dengan petugas yang menangani permasalahan yang terkait.
- Perhitungan ***Safety Integrity Level*** menggunakan metode ***Layer of Protection Analysis***.

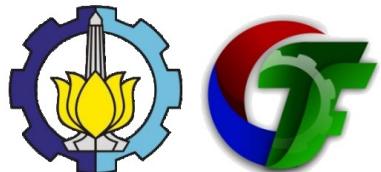


# ***CRUDE DISTILLATION UNIT (CDU)***



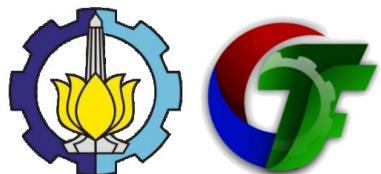
CDU merupakan unit distilasi untuk memisahkan minyak mentah menjadi produk-produknya berdasarkan perbedaan titik didih.

**UNIT MAIN FRACTIONATOR**



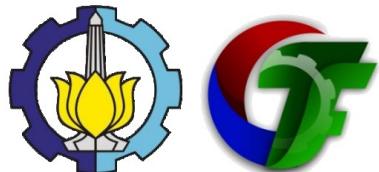
# HAZOP

*Hazard and Operability Study (HAZOP)* adalah suatu teknik identifikasi dan analisis bahaya yang formal, sistematik, logikal, dan terstruktur untuk meninjau suatu proses atau operasi pada sebuah sistem secara otomatis dan menguji potensi deviasi operasi dari kondisi desain yang dapat menimbulkan masalah operasi proses dan bahaya (Marvin Rausaand, 2005).

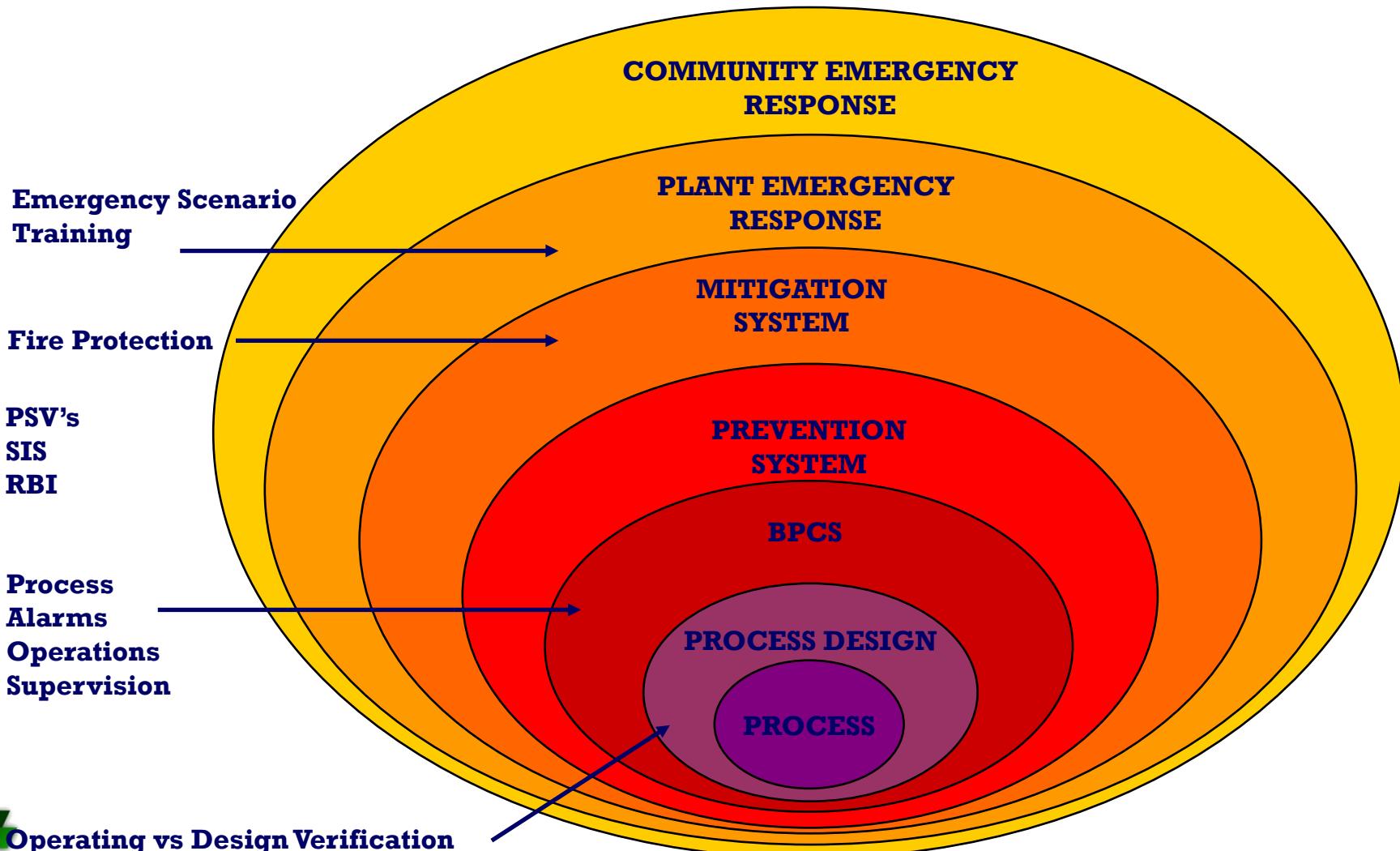


# LOPA

*Layer of Protection Analysis (LOPA)* adalah cara untuk mengetahui nilai SIL serta mengevaluasi layer proteksi pada sistem dengan cara melihat *mitigation risk* dari layer proteksi tersebut.

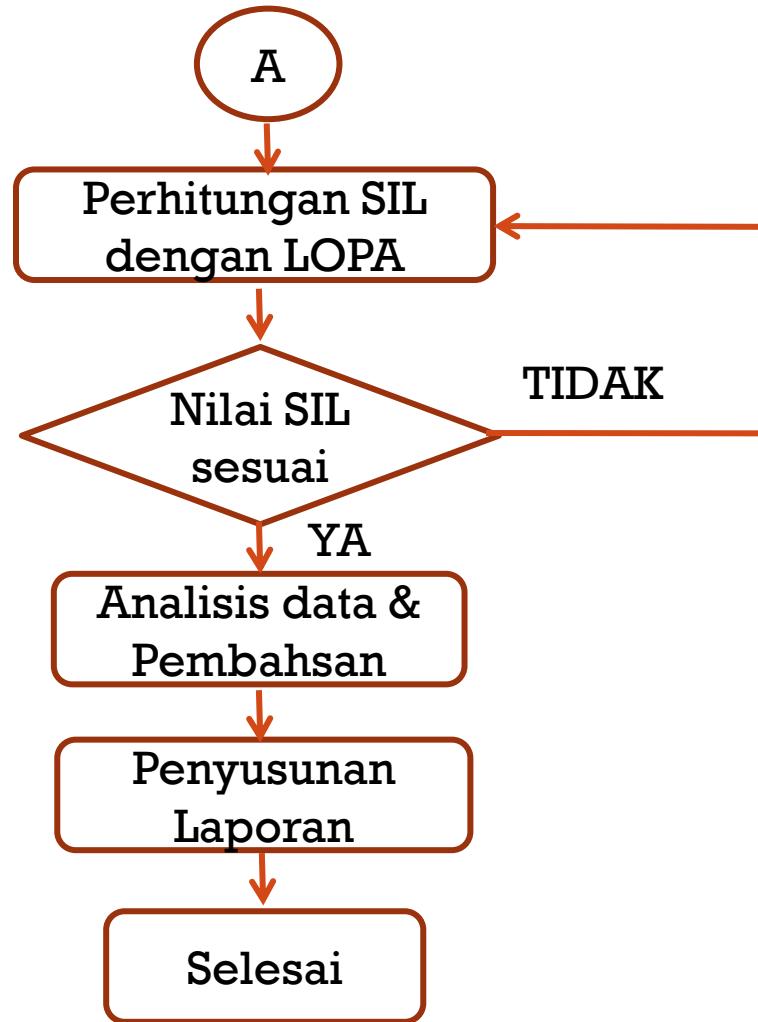
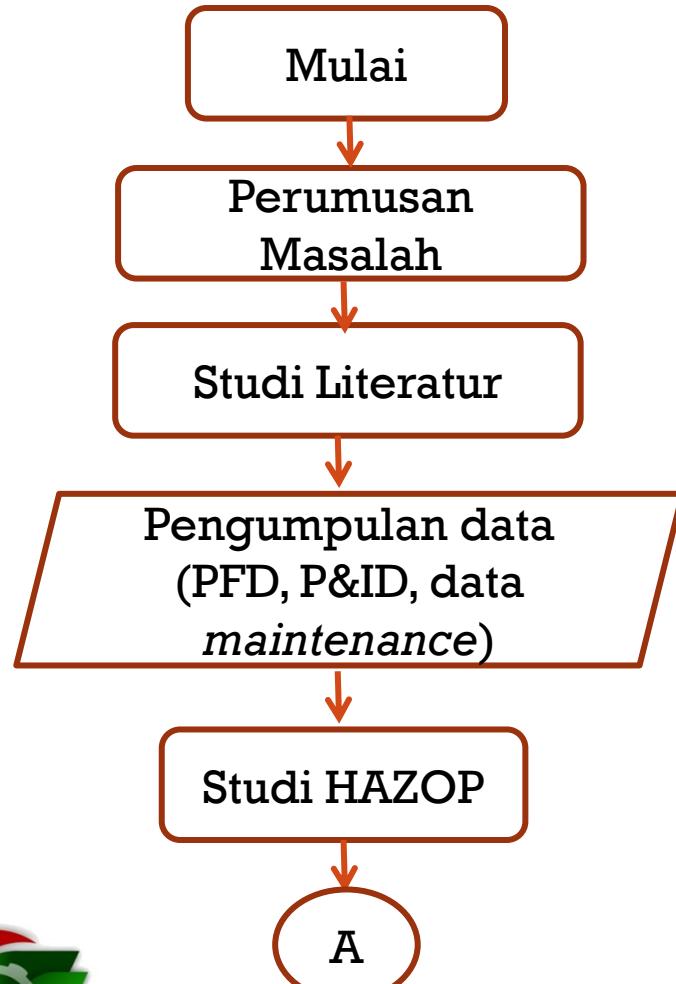


# LOPA



Operating vs Design Verification

# METODOLOGI PENELITIAN



# HAZOP

Tabel Format Lembar Kerja Analisa HAZOP

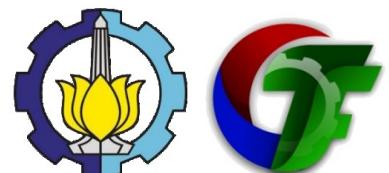
Instrument Component	Guideword	Deviation	Causes	Possible Consequences	S	L	RR	Existing Safeguard
<b>Deviation = Guideword + Parameter</b>								

Tabel Guideword

Guide Words	Meaning
No	Negation of the design intent
Less	Quantitative decrease
More	Quantitative decrease
Low	Quantitative decrease
High	Quantitative decrease
Over	Quantitative decrease

Tabel Parameter Proses

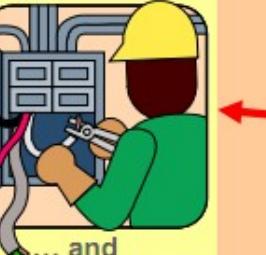
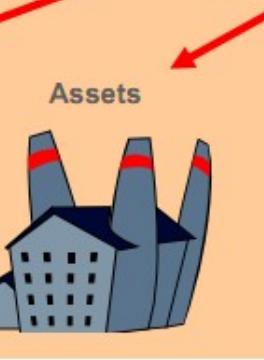
Flow	Pressure
Temperature	Level



Sumber : CCPS, 2004

# HAZOP

# Tabel Format Lembar Kerja Analisa HAZOP

Instrument	Guideword	Deviation	Causes	Possible Consequences	S	L	RR	Existing Safeguard
<b>Consequences Classification</b>								
<b>Society</b>								
People outside plant 	 ... and inside plant	<b>RISK</b>			<b>S : Severity</b> <b>L : Likelihood</b> <b>RR : Risk Ranking</b>			
Environment 		<b>RISK</b>						

# HAZOP

Matriks Resiko Terhadap Manusia di PT. Pertamina Persero

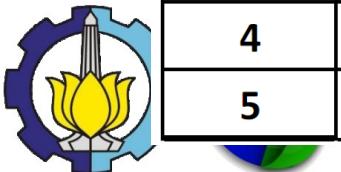
	KONSEKUENSI TERHADAP OBJEK	KEMUNGKINAN KEJADIAN (PROBABILITY)				
		A (Terendah)	B	C	D	E (Tertinggi)
		Pernah	Pernah terjadi di	Terjadi beberapa kali per	Terjadi beberapa	
	Industri Migas & Panas Bumi	Migas & Panas Bumi	Migas & Panas Bumi di Indonesia	industri Migas & Panas Bumi di Indonesia	salah satu kegiatan/operasi Perusahaan	
Tanpa Cedera	R	R	R	R	R	
Cedera Ringan	R	R	R	R	R	
Cedera Sedang	R	R	R	M	M	
Cedera Berat	R	R	M	M	T	
Fatality	R	M	M	T	T	
Fatality Ganda	M	M	T	T	T	



# HAZOP

Matriks Resiko Terhadap Aset di PT. Pertamina Persero

TINGKAT KEPARAHAAN	KONSEKUENSI TERHADAP OBJEK <b>ASET</b>	KEMUNGKINAN KEJADIAN (PROBABILITY)				
		A (Terendah)	B	C	D	E (Tertinggi)
	Tidak pernah terdengar di Industri Migas & Panas Bumi	Pernah terdengar di Industri Migas & Panas Bumi	Pernah terjadi di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di salah satu kegiatan/operasi Perusahaan	
0	Tanpa Kerusakan	R	R	R	R	R
1	Kerusakan sangat kecil	R	R	R	R	R
2	Kerusakan kecil	R	R	R	M	M
3	Kerusakan sedang	R	R	M	M	T
4	Kerusakan besar	R	M	M	T	T
5	Kerusakan parah	M	M	T	T	T



# HAZOP

Matriks Resiko Terhadap Lingkungan di PT. Pertamina Persero

TINGKAT KEPARAHAAN	KONSEKUENSI TERHADAP OBJEK  LINGKUNGAN	KEMUNGKINAN KEJADIAN (PROBABILITY)				
		A (Terendah)	B	C	D	E (Tertinggi)
	Tidak pernah terdengar di Industri Migas & Panas Bumi	Pernah terdengar di Industri Migas & Panas Bumi	Pernah terjadi di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di salah satu kegiatan/operasi Perusahaan	
0	Tanpa dampak	R	R	R	R	R
1	Dampak ringan	R	R	R	R	R
2	Dampak sedang	R	R	R	M	M
3	Dampak besar (Skala Daerah)	R	R	M	M	T
4	Dampak besar (Skala Nasional)	R	M	M	T	T
5	Dampak luar biasa (Skala Internasional)	M	M	T	T	T



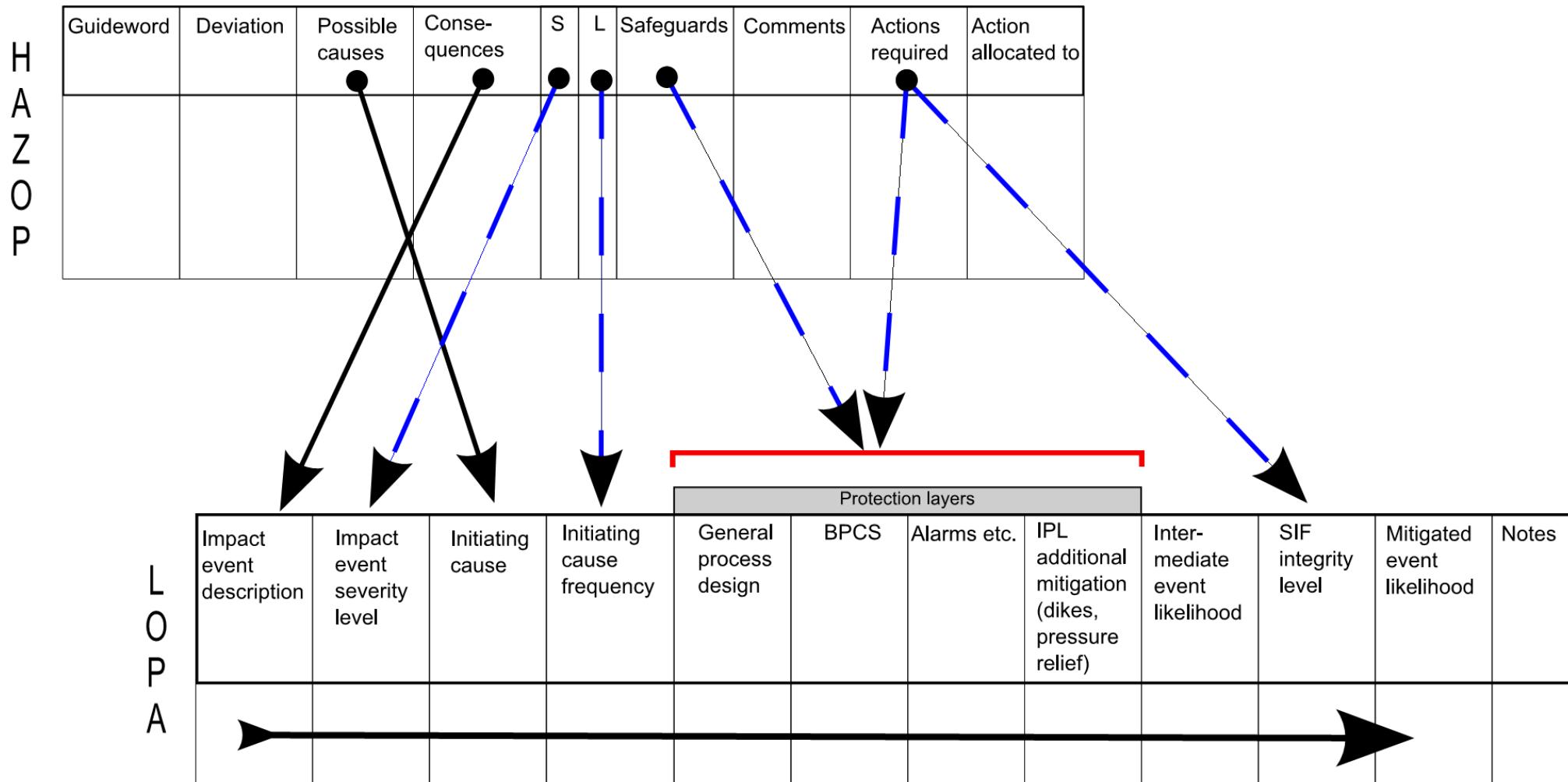
# HAZOP

Matriks Resiko Terhadap Citra di PT. Pertamina Persero

TINGKAT KEPARAHAAN	KONSEKUENSI TERHADAP OBJEK  CITRA	KEMUNGKINAN KEJADIAN (PROBABILITY)				
		A (Terendah)	B	C	D	E (Tertinggi)
	Tidak pernah terdengar di Industri Migas & Panas Bumi	Pernah terdengar di Industri Migas & Panas Bumi	Pernah terjadi di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di sebuah industri Migas & Panas Bumi di Indonesia	Terjadi beberapa kali per tahun di salah satu kegiatan/operasi Perusahaan	
0	Tanpa dampak	R	R	R	R	R
1	Dampak ringan	R	R	R	R	R
2	Dampak sedang	R	R	R	M	M
3	Dampak besar (Skala Daerah)	R	R	M	M	T
4	Dampak besar (Skala Nasional)	R	M	M	T	T
5	Dampak luar biasa (Skala Internasional)	M	M	T	T	T



# HAZOP VS LOPA



Sumber : Lassen, 2008

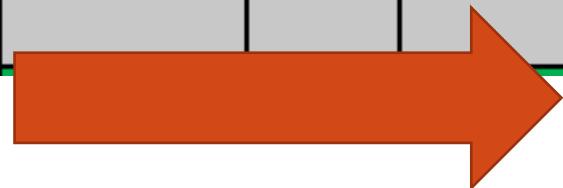
— Directly from HAZOP to LOPA

— Needs evaluation and / or transformation

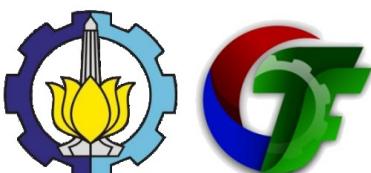
# LOPA

Tabel *Worksheet Layer of Protection Analysis*

1	2	3	4	Protection Layers (PLs)				8	9	10	
				General Process Design	BPCS	Alarms, Etc.	Additional Mitigation, Restricted Access				
Impact event Description	Severity level	Initiating Cause	Initiation Likelihood					Intermediate Event Likelihood (IELt = ICL x PFDMA WP x PFDPVC x PFDPSV x Pi x Pp x Ptr)	Target Mitigated Event Likelihood (TMEL)	PFD = TMEL/IELt	SIL (determined by ratio of TMEL and IELt)



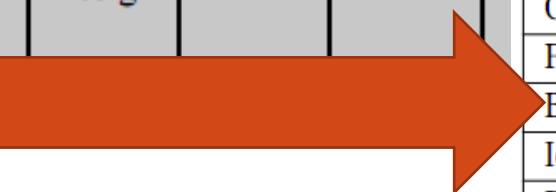
Merupakan transformasi pada kolom HAZOP



# LOPA

Tabel Worksheet Layer of Protection Analysis

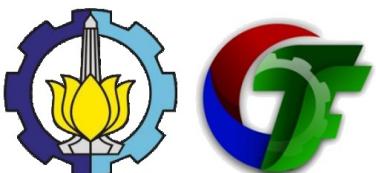
1 Impact event Description	2 Severity level	3 Initiating Cause	4 Initiation Likelihood	5 Protection Layer		
				General Process Design	BPCS	Alarms, Etc.



Tabel PFDs for IPLs

IPL	PFD
BPCS, if not associated with the initiating event being considered	$1 \cdot 10^{-1}$
Operator alarm with sufficient time available to respond	$1 \cdot 10^{-1}$
Relief valve	$1 \cdot 10^{-2}$
Rupture disc	$1 \cdot 10^{-2}$
Flame / detonation arrestors	$1 \cdot 10^{-2}$
Dike / bund	$1 \cdot 10^{-2}$
Underground drainage system	$1 \cdot 10^{-2}$
Open vent (no valve)	$1 \cdot 10^{-2}$
Fireproofing	$1 \cdot 10^{-2}$
Blast-wall / bunker	$1 \cdot 10^{-3}$
Identical redundant equipment	$1 \cdot 10^{-1}$ (max credit)
Diverse redundant equipment	$1 \cdot 10^{-1}$ to $1 \cdot 10^{-2}$
Other events	Use experience of personnel

Sumber : CCPS (2001) dan BP (2006)



# LOPA

Tabel Worksheet Layer of Protection Analysis

	5	6	7	8	9
	Protection Layers (PLs)				
on food	General Process Design	BPCS	Alarms, Etc.	Additional Mitigation, Restricted Access	Distance (Burden, Pressure, Re)



$$PFD_{AM} = P_p \times P_{tr}$$

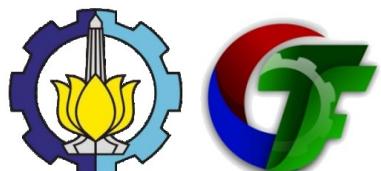
$$P_{tr} = \frac{\text{time at risk}}{\text{total time}}$$

$$P_p = \frac{\text{time present to hazards}}{\text{total time}}$$

dengan :

$P_{tr}$  = *Probability of Fatal Injury*

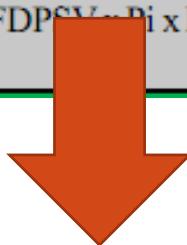
$P_p$  = *Probability of Personal in Affected Area*



# LOPA

Tabel Worksheet Layer of Protection Analysis

7	8	9	10
ditional ations ike nds), ssure elief	Intermediate Event Likelihood (IELt = ICL x PFDMA WP x PFDPCV x PFDPSV x Pi x Pp)	Target Mitigat Event Likelihood (TMEL)  IELt = TMEL/IELt  (determ by ratio of TMEL and IELt)	

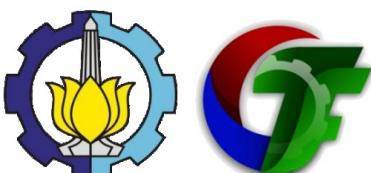


Tabel Target mitigated event likelihood for safety hazards

Severity Level	Safety Consequences	Target mitigated event likelihood
C <sub>A</sub>	Single first aid injury	3.10 <sup>-2</sup> per year
C <sub>B</sub>	Multiple first aid injuries	3.10 <sup>-3</sup> per year
C <sub>C</sub>	Single disabling injury or multiple serious injuries	3.10 <sup>-4</sup> per year
C <sub>D</sub>	Single on-site fatality	3.10 <sup>-5</sup> per year
C <sub>E</sub>	More than one and up to three on-site fatalities	1.10 <sup>-5</sup> per year

Sumber : Nordhagen, 2007

$$IEL = ICL \times PFD_1 \times PFD_2 \times \dots \times PFD_n$$



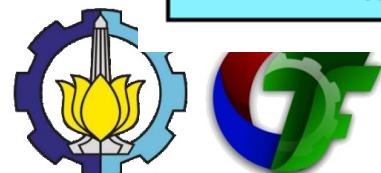
# LOPA

Tabel Worksheet Layer of Protection Analysis

1	2	3	4	Protection Layers (PLs)				8	9	10
				5	6	7				
Impact event Description	Severity level	Initiating Cause	Initiation Likelihood	General Process Design	BPCS	Alarms, Etc.	Additional Mitigation, Restricted Access	Additional Mitigations Dike (Bunds), Pressure Relief	Intermediate Event Likelihood (IEL <sub>t</sub> = ICL x PFDMA WP x PFDPVC x PFDPSV x Pi x Pp x Ptr)	Target Mitigated Event Likelihood (TMEL)
									PFD = TMEL/IEL <sub>t</sub>	SIL (determined by ratio of TMEL and Lt)

LOPA Ratio (w/o SIS)	SIL
10 <sup>-0</sup> - 10 <sup>-1</sup>	No special integrity requirements
10 <sup>-1</sup> - 10 <sup>-2</sup>	SIL 1
10 <sup>-2</sup> - 10 <sup>-3</sup>	SIL 2
10 <sup>-3</sup> - 10 <sup>-4</sup>	SIL 3

$$\text{SIL} = \text{necessary risk reduction} = \frac{f_{\text{Acc}}}{f_{\text{IEL, total}}} = \frac{f_{\text{TMEL}}}{f_{\text{IEL, total}}}$$



Sumber : Nordhagen, 2007

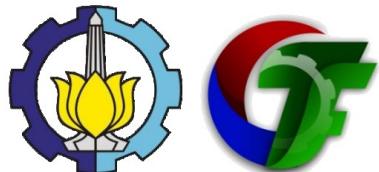
# ANALISIS DATA DAN PEMBAHASAN

Pada unit *main fractionator*, terdapat tiga **pumparound system** yang berfungsi menghilangkan panas aliran minyak dari unit *main fractionator*.

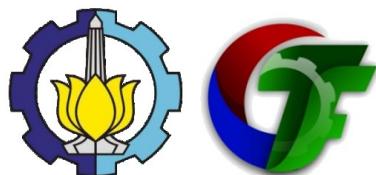
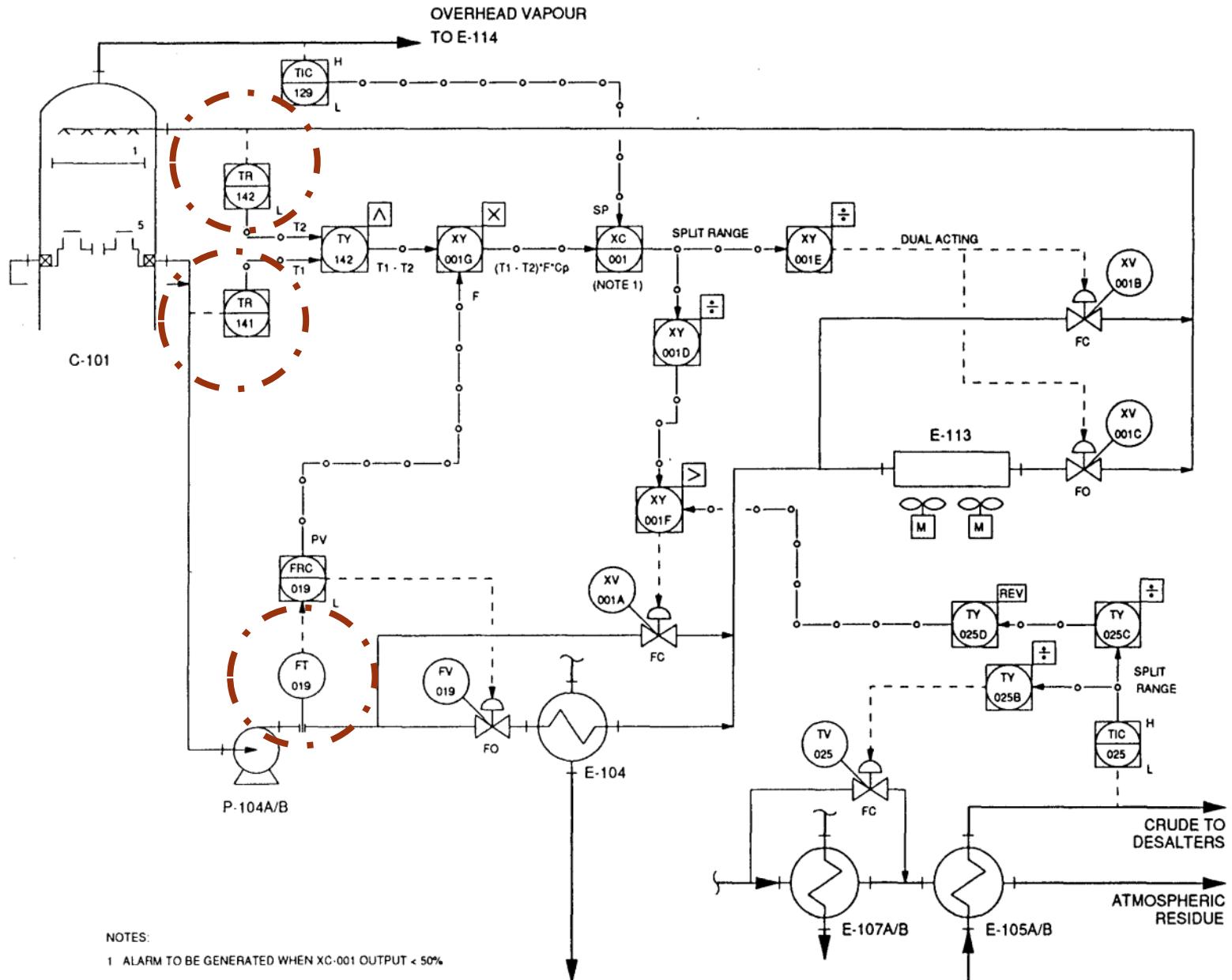
**TPA system** : dari tray no. 5 menuju exchanger 11-E-104 kembali ke top tray

**MPA system** : dari tray no. 15 menuju splitter reboiler 11-E-122 menuju exchanger 11-E-106 kembali ke tray no. 12

**BPA system** : dari tray no. 25 menuju stabilliser reboiler 11-E-120 menuju exchanger 11-E-109 kembali ke tray no. 22



# PFD Top Pumparound System

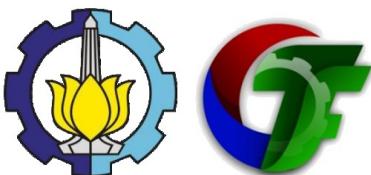


NOTES:

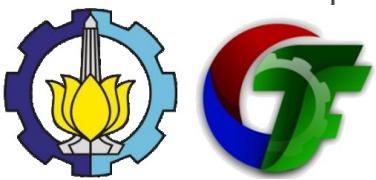
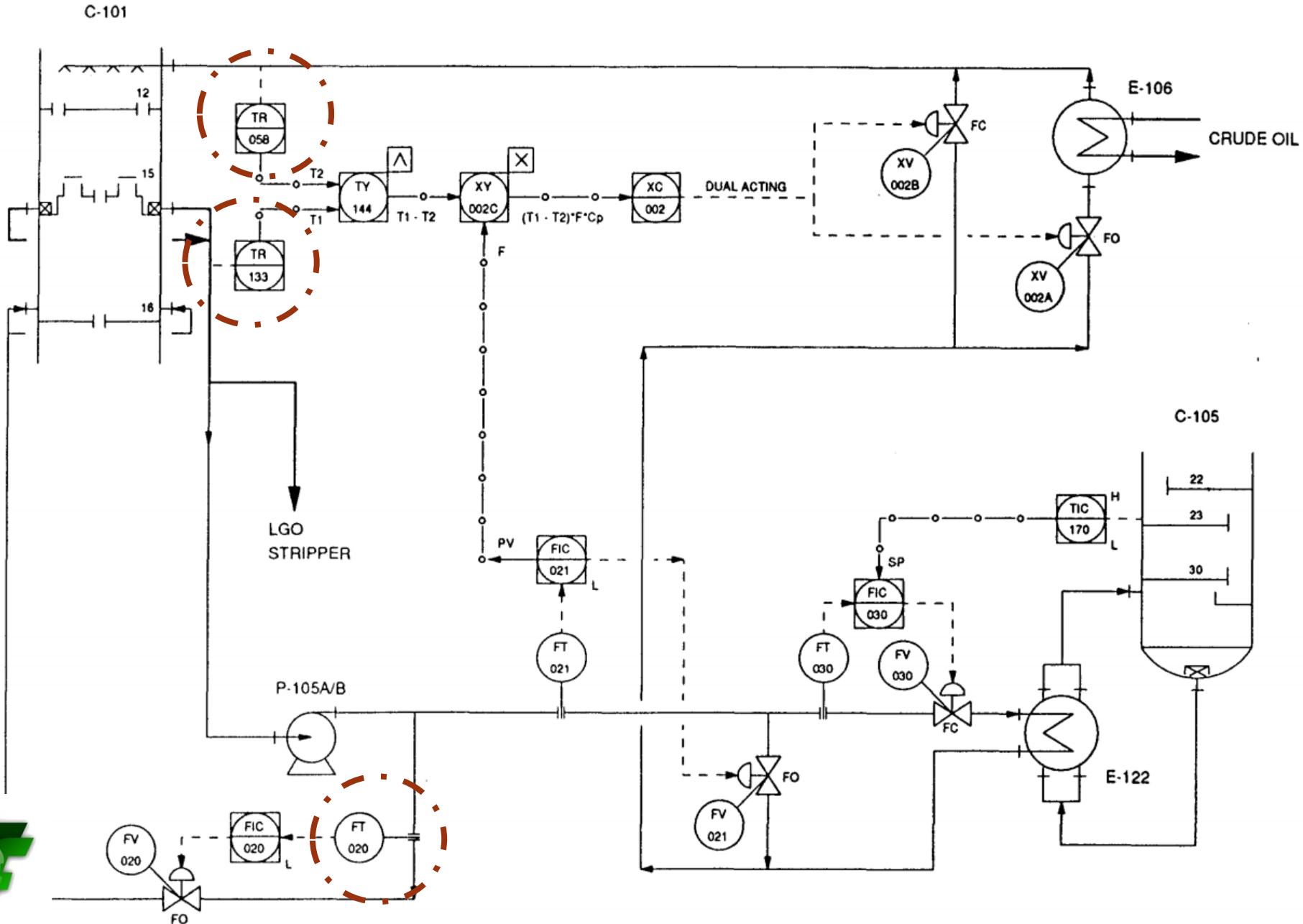
1 ALARM TO BE GENERATED WHEN XC-001 OUTPUT < 50%

Tabel Worksheet HAZOP pada TPA System berdasarkan Matriks Risiko di PT. Pertamina Persero

Instrument Component	Guide Words	Deviation	Cause	Possible Consequences	Consequences Classification	S	P	RR	Existing Safeguard
FT 019	No	No Flow	TPA Pumps failed to work	Failed of reflux in TPA system	Injury	0	C	R	Redundance Pump
					Asset	5	C	T	
					Environtment	0	C	R	
					Reputation	1	C	R	
	Less	Less Flow	Unoptimal TPA Pumps	Unoptimal of reflux in TPA system	Injury	0	C	R	Redundance Pump
					Asset	3	C	M	
					Environtment	0	C	R	
					Reputation	1	C	R	
FT 019	More	More Flow	FV 019 failed to close	Overheating stream	Injury	0	C	R	Develop SOP, Stand by operator
					Asset	3	C	M	
					Environtment	0	C	R	
					Reputation	1	C	R	
TR 141	High	High Temperature	XV 001 A failed to open	Failed of reflux in TPA system, Negativepressure at main fractinatior	Injury	0	C	R	Develop SOP, Stand by operator
					Asset	4	C	T	
					Environtment	0	C	R	
					Reputation	1	C	R	
TR 142	Low	Low Temperature	XV 001 C failed to close	Low temperature stream, material unbalance in top product	Injury	0	C	R	Alarm temperature L
					Asset	3	C	M	
					Environtment	0	C	R	
					Reputation	1	C	R	



# PFD Mid-Pumparound System

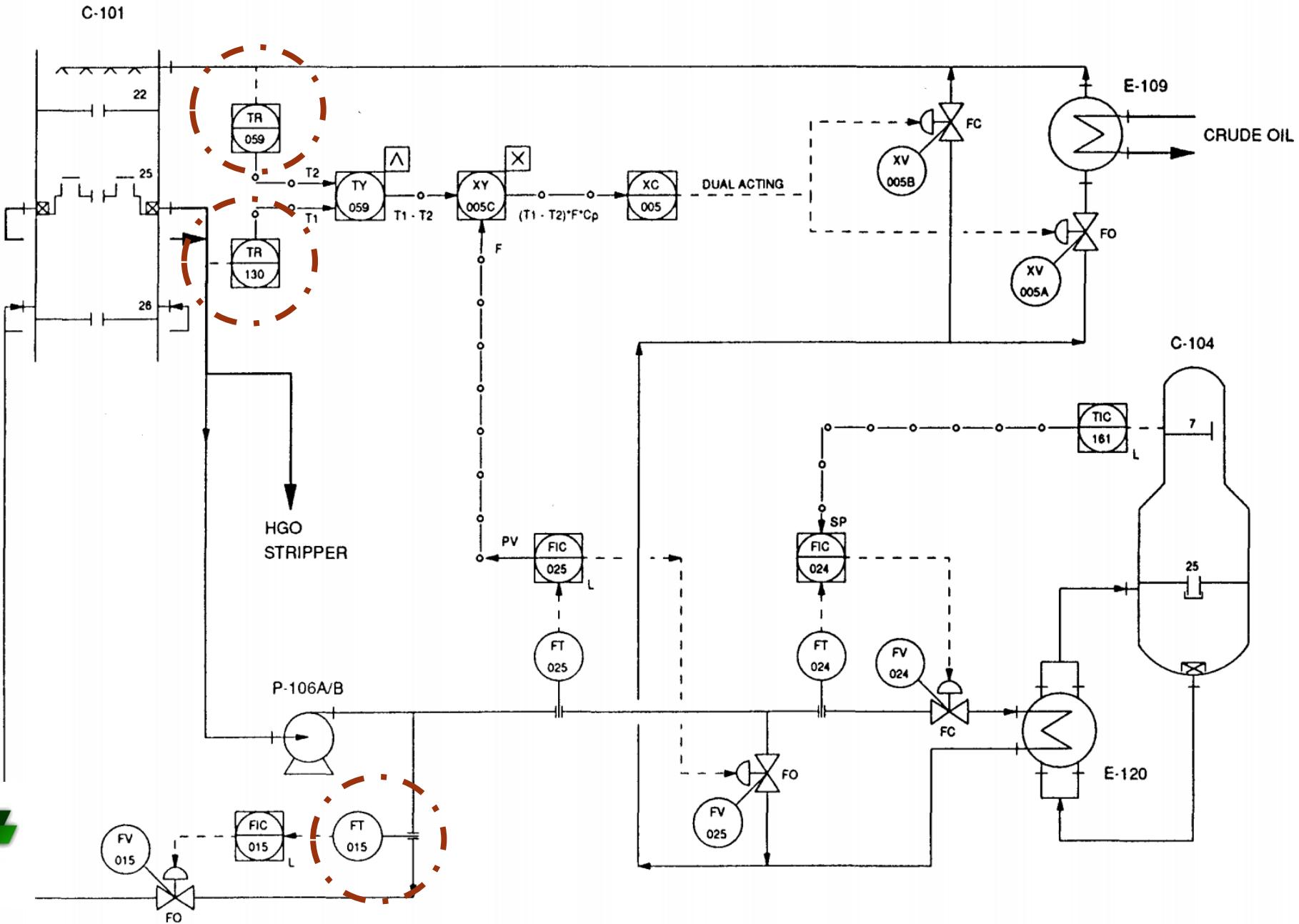


Tabel Worksheet HAZOP pada MPA System berdasarkan Matriks Risiko di PT. Pertamina Persero

Instrument Component	Guide Words	Deviation	Cause	Possible Consequences	Consequences Classification	S	P	RR	Existing Safeguard
FT 021	No	No Flow	MPA Pumps failed to work	Failed of reflux in MPA system	Injury	0	C	R	Redundance Pump
					Asset	5	C	T	
					Environtment	0	C	R	
					Reputation	1	C	R	
	Less	Less Flow	Unoptimal MPA Pumps	Unoptimal of reflux in MPA system	Injury	0	C	R	Redundance Pump
					Asset	3	C	M	
					Environtment	0	C	R	
					Reputation	1	C	R	
FT 020	More	More Flow	FV 021 failed to close	Failed of reflux in MPA system	Injury	0	C	R	Develop SOP, Stand by operator
					Asset	2	C	R	
					Environtment	0	C	R	
					Reputation	1	C	R	
FT 021	More	More Flow	FV 021 failed to close	Overheating stream	Injury	0	C	R	Develop SOP, Stand by operator
					Asset	2	C	R	
					Environtment	0	C	R	
					Reputation	1	C	R	
TR 058	High	High Temperature	XV 002 A failed to close	High temperature stream, material unbalance in middle product	Injury	0	C	R	Develop SOP, Stand by operator
					Asset	2	C	R	
					Environtment	0	C	R	
					Reputation	1	C	R	
LT 012	Low	Low Level	LV 012 failed to open	Material unbalance in LGO product	Injury	0	C	R	Alarm Low
					Asset	5	C	T	
					Environtment	0	C	R	
					Reputation	1	C	R	



# PFD Bottom Pumparound System



Tabel Worksheet HAZOP pada BPA System berdasarkan Matriks Risiko di PT. Pertamina Persero

Instrument Component	Guide Words	Deviation	Cause	Possible Consequences	Consequences Classification	S	P	RR	Existing Safeguard	
FT 015	No	No Flow	BPA Pumps failed to work	Failed of reflux in BPA system	Injury	0	C	R	Redundance Pump	
					Asset	5	C	T		
					Environtment	0	C	R		
					Reputation	1	C	R		
	Less	Less Flow	Unoptimal BPA Pumps		Injury	0	C	R	Redundance Pump	
					Asset	3	C	M		
					Environtment	0	C	R		
					Reputation	1	C	R		
FT 015	More	More Flow	FV 015 failed to close	Failed of reflux in bPA system	Injury	0	C	R	Develop SOP, Stand by operator	
FT 025	More	More Flow	FV 025 failed to close	Overheating stream	Asset	2	C	R	Develop SOP, Stand by operator	
TR 059	High	High Temperature	XV 005 A failed to close	High temperature stream, material unbalance in bottom product	Environtment	0	C	R	Develop SOP, Stand by operator	
LT 013	Low	Low Level	LV 013 failed to open	Material unbalance in HGO product	Reputation	1	C	R	Alarm Low	
Injury	0	C	R							
Asset	5	C	T							
Environtment	0	C	R							
Reputation	1	C	R							



Tabel Presentase *Risk Rangking* dari HAZOP

<b>Risk Ranking</b>	<b>Persentase</b>
Rendah	35,29 %
Menengah	29,41 %
<b>Tinggi</b>	<b>35,29 %</b>



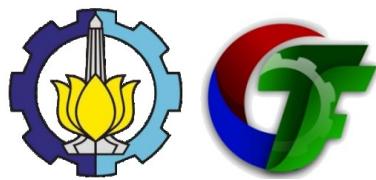
Tabel Perhitungan ICL

<b>Impact Event Description</b>	<b>Initiating Cause</b>	<b><math>\lambda/Jam</math></b>	<b><math>\lambda/Tahun</math></b>	<b>Reliability</b>	<b>ICL</b>
Failed of reflux in TPA system	TPA Pumps failed to work	$9,82.10^{-5}$	0,860	0,423	0,577
Failed of reflux in TPA system, Negative pressure at main fractinator	XV 001 A failed to open	$1,41.10^{-4}$	1,237	0,290	0,710
Failed of reflux in MPA system	MPA Pumps failed to work	$1,06.10^{-4}$	0,929	0,395	0,605
Material unbalance in LGO product	LV 012 failed to open	$1,44.10^{-4}$	1,258	0,284	0,716
Failed of reflux in BPA system	BPA Pumps failed to work	$1,12.10^{-4}$	0,976	0,377	0,623
Material unbalance in HGO product	LV 013 failed to open	$1,29.10^{-4}$	1,136	0,321	0,679



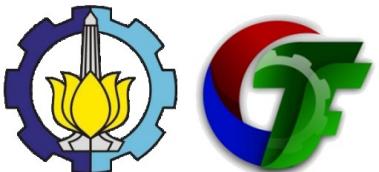
**Tabel Worksheet Layer of Protection Analysis**

Impact Event Description	Severity Level	Initiating Cause	Initiation Likelihood	Protection Layers (PLs)					Intermediate Event Likelihood (IEL)	Target Mitigate Event Likelihood	PFD	SIL
				General Process Design	BPCS	Alarm, Etc.	Additional Mitigation, Restricted Access	Additional Mitigation Dike (Bunds), Pressure Relief				
Failed of reflux in TPA system	5	TPA Pumps failed to work	0,577	0,1	1	0,1	0,5	0,01	2,88.10 <sup>-5</sup>	10 <sup>-5</sup>	0,346	SIL 0
Failed of reflux in TPA system, Negative pressure at main fractinator	4	XV 001 A failed to open	0,710	0,1	0,1	1	0,5	0,01	3,54.10 <sup>-5</sup>	10 <sup>-5</sup>	0,281	SIL 0
Failed of reflux in MPA system	5	MPA Pumps failed to work	0,605	0,1	1	0,1	0,5	0,01	3,03.10 <sup>-5</sup>	10 <sup>-5</sup>	0,330	SIL 0
Material unbalance in LGO product	5	LV 012 failed to open	0,716	0,1	0,1	1	0,5	0,01	3,58.10 <sup>-5</sup>	10 <sup>-5</sup>	0,279	SIL 0
Failed of reflux in BPA system	5	BPA Pumps failed to work	0,623	0,1	1	0,1	0,5	0,01	3,12.10 <sup>-5</sup>	10 <sup>-5</sup>	0,321	SIL 0
Material unbalance in HGO product	5	LV 013 failed to open	0,679	0,1	0,1	1	0,5	0,01	3,39.10 <sup>-5</sup>	10 <sup>-5</sup>	0,294	SIL 0



# KESIMPULAN

- hasil analisis HAZOP pada *main fractionator* didapatkan resiko bahaya dengan tiga kategori *risk ranking* yaitu **35,29 %** untuk kategori rendah, **29,41 %** untuk kategori medium, dan **35,29 %** untuk kategori tinggi.
- nilai SIL pada *main fractionator* bernilai **SIL 0** untuk seluruh loop sistem.
- rekomendasi yang diberikan berupa penambahan **BPCS** dan **alarm** untuk komponen yang kritis.





# TERIMA KASIH

Once we know our weaknesses, they cease to do us any harm

G.C. (GEORG CHRISTOPH) LICHTENBERG (1742-1799)

GERMAN PHYSICIST, PHILOSOPHER