

SLURRY HYDROCRACKER PROJECT

Appendix H - P&ID and HAZOP

PREPARED FOR

Frank Nolte, PEng
Worley Limited

PREPARED BY

Team 15: TR Solutions
Jaryl Schmidt, Student
Jose Te Eng Fo, Student
Naira Correia, Student
Xingming Shan, Student
Yichun Zhang, Student

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Table of Contents

H.1 SUMMARY	3
H.2 PIPING AND INSTRUMENTATION DIAGRAM (P&ID)	3
H.3 RISK ASSESSMENT CRITEREA	5
H.4 HAZARD AND OPERABILITY (HAZOP) STUDY	6
H.5 REFERENCES	9

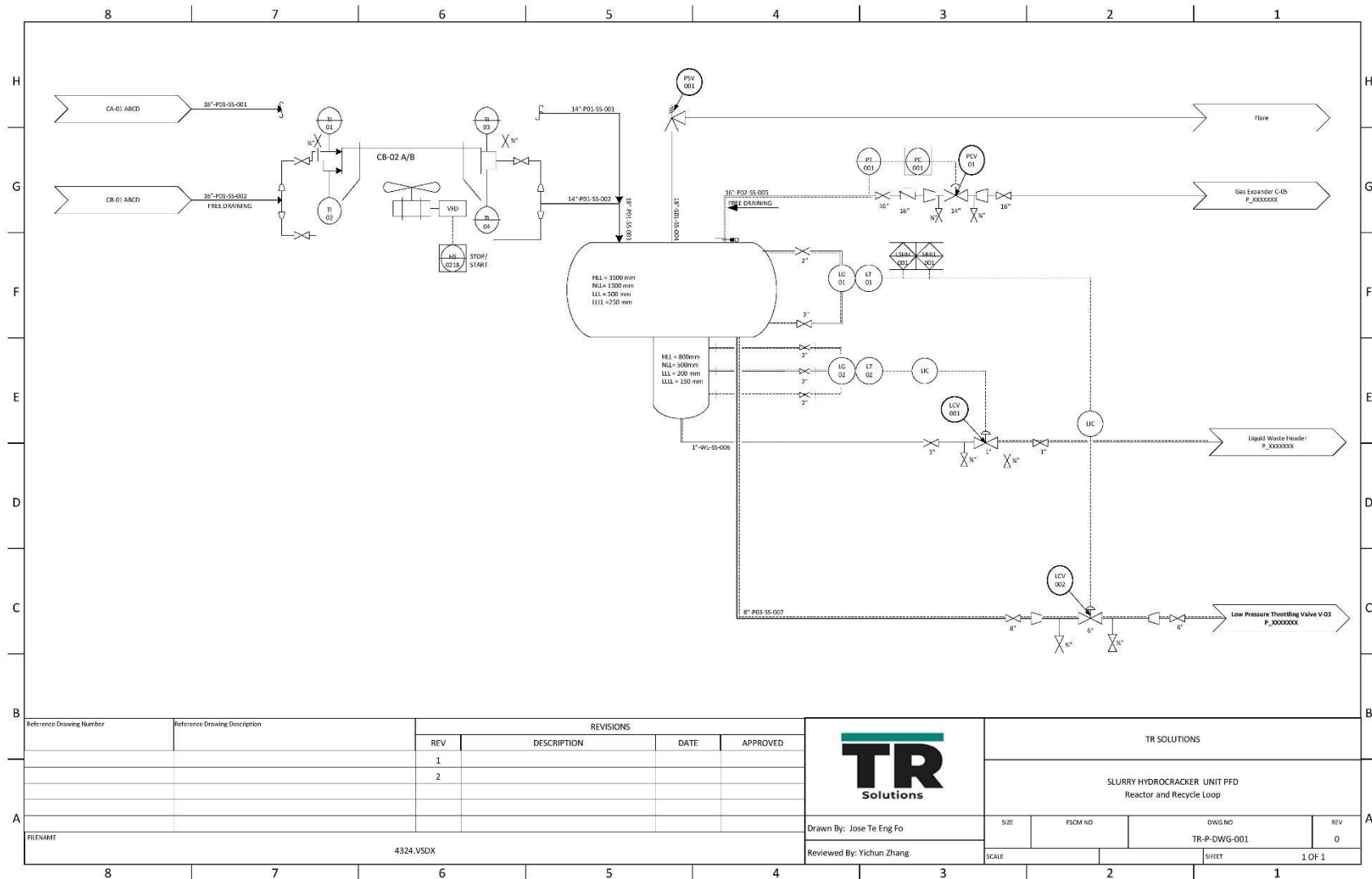
H.1 SUMMARY

This appendix shows a detailed hazard and operability study (HAZOP) on a piping and instrumentation diagram (P&ID). A P&ID for the unit containing the three-phase separator D-03 and the air fin cooler C-01 is shown in Section H2. Section H3 shows the criteria to assess the risks, including a risk matrix and a risk level description table. In Section H3, a HAZOP is performed to examine potential risks associated with deviations in parameters including pressure, temperature, flow, and level.

H.2 PIPING AND INSTRUMENTATION DIAGRAM (P&ID)

Figure H2 shows the P&ID around the three-phase separator D-03 and the air fin cooler C-02. The unit is divided into two nodes. Node 1 is the cooler unit including the stream coming from cooler C-01 and the stream entering the vessel. Node 2 includes the separator vessel, its three outlet streams, and the PSV.

Figure H2. A P&ID of the three-phase separator D-03 and waste heat boiler C-01.



REPUTATION/ SOCIETAL	LEGAL/ FINANCIAL	ENVIRONMENTAL & PUBLIC HEALTH	HEALTH & SAFETY	LIKELIHOOD INCREASING						
	\$300M <-- Cost	Multiple fatalities	Multiple fatalities	CONCENTRATION OF RISK	M(6)	M-H	H	H	H	H
Recurring national attention/punitive action by government/long term impact on market share and share price	Material (corporate) long-term liability	Catastrophic impact			M(5)	M	M-H	H	H	H
	\$30M <-- Cost < \$300M	Permanent disability / fatality	Permanent disability/ fatality							
National news / public outrage / short term drop in market share and share price	Significant long-term liability enforcement action		Temporary disability/ lost time		L(4)	M	M	M-H	H	H
	\$3M <-- Cost < \$30M	Significant adverse impact								
Provincial news/ adverse impact to reputation at provincial level	Permit violation or administrative penalties	Minor environmental impact	Medical aid injury or illness/ restricted work/ nuisance to public		L(3)	L	M	M	M-H	H
	\$300K <-- Cost < \$3M									
Community concern/ local media attention/ no impact to reputation	Un contained release below legal limit	Small uncontained release with minor impacts	First aid/ minor illness possible cumulative impact onsite	L(2)	L	L	M	M	M-H	
	\$30K <-- Cost < \$300K									
Individual concern/ local media attention/ no impact to reputation		Release onsite - contained immediately	Incident - no treatment	L(1)	L(2)	L(3)	L(4)	M(5)	M(6)	
	Cost < \$30K									
REPUTATION/ SOCIETAL	LEGAL/ FINANCIAL	ENVIRONMENTAL & PUBLIC HEALTH	HEALTH & SAFETY	LIKELIHOOD INCREASING						
EVALUATION DESCRIPTOR				Expected never to happen	Not during the lifetime of the project	Could happen once in the project lifetime	Could happen once in ten years	Could happen as much as once per year	Could happen many times per year	
PROBABILITY				p < 1/10,000 years	1/1000 yrs < p < 1/10,000 years	1/100 yrs < p < 1/1000 years	1/10 year < p < 1/100 years	1/year < p < 1/10 years	p > 1/year	

Risk Acceptance Level	
Risk Ranking	Risk Acceptance Level
High	Not acceptable: Management MUST take steps to reduce or control the risks to a tolerable or acceptable level, or terminate the project or activity entirely.
Medium High	Highly Conditional: If this level of risk is accepted, management MUST be involved to ensure the risk is kept under control. Management's responsibilities come to the front line as they are assuming the responsibility for tolerating this level of risk. preference is to implement additional safeguards to reduce the risk.
Medium	Acceptable to tolerable: May consider additional management involvement or design additions. Develop and establish risk management programs specific to these concerns to sustain performance/ does not deteriorate over a period of time.
Low	Acceptable: No further management involvement or design additions. Employees are aware of the risks and follow established procedures. Develop and establish risk management programs that generally cover these concerns to sustain performance such that performance does not deteriorate over a period of time.

H.4 HAZARD AND OPERABILITY (HAZOP) STUDY

HAZOP Study Title: Slurry Bitumen Hydrocracker

P&ID Description: Three-Phase Separator D-03

Node #: 1

Node Description: Air fin cooler

Item #	Guide -word	Parameter	Deviation	Possible Causes	Consequences	CAT	Risk without Existing Safeguards			Safeguards	Risk with Existing Safeguards			Recommendations / Actions
							S	L	RR		S	L	RR	
1	High	Temperature	Feed enters the unit at increased temperature.	Upstream WHB fails to cool down the stream to designed temperature.	Separator operates at higher temperature. Undesired separation may be achieved.	Assets	3	4	6	TIC-002 combined with TT-02 monitors the temperature of the fluid exiting the air fin cooler. If the temperature is higher than designed, the VFD will increase the air flow rate to provide a higher cooling rate.	1	2	2	
2	Low	Temperature	Feed enters the unit at decreased temperature.	Upstream WHB cooled down the stream to a temperature lower than designed.	Separator operates at lower temperature. Undesired separation may be achieved.	Assets	3	4	6	TIC-002 combined with TT-02 monitors the temperature of the fluid exiting the air fin cooler. If the temperature is lower than designed, the VFD will reduce the air flow rate to provide a lower cooling rate.	1	2	2	

Node #: 2

Item #	Guide-word	Parameter	Deviation	Possible Causes	Consequences	CAT	Risk without Existing Safeguards			Safeguards	Risk with Existing Safeguards			Recommendations / Actions
							S	L	RR		S	L	RR	
1	High	Level	Liquid hold-up height in the liquid product separator is increased.	Upstream process sends a higher flow rate of fluid into the vessel.	Liquid-gas engagement volume is decreased, potentially leading to insufficient separation. Liquid droplets can enter turbine EX-01 and cause damages to the equipment.	Assets	4	3	6	LG-02 of the vessel will monitor the liquid level. If it exceeds the HLL, LCV-01 at the bottom of the vessel will be opened to increase liquid draw out of the vessel until liquid level returns to the normal range.	1	2	2	
2	Low	Level	Liquid hold-up height in the liquid product separator is decreased.	Upstream process sends a lower flow rate of fluid into the vessel.	Loss of liquid hold-up in the vessel. Unseparated fluid may bypass at the bottom. Product may not meet specifications.	Assets	4	3	6	LG-02 of the vessel will monitor the liquid level. If it drops below the LLLL, and LCV-01 at the bottom of the vessel will be closed to reduce liquid draw out of the vessel until liquid level returns to the normal range.	1	2	2	
3	High	Pressure	Pressure is built-up in the vessel.	Downstream piping/valve is blocked.	Vessel burst. Flammable and high-pressure fluid is released, potentially leading to fire or explosion hazard.	Workers and the public	6	3	8	1. PSV at the top of the vessel will be opened to release content of the vessel to flare until the pressure is returned to the normal range. 2. Emergency shutdown.	4	2	5	1. Workers on site must wear PPE all the time. 2. Provide adequate training and accessible procedure for emergency shutdown. 3. Prepare an evacuation plan.
4	High	Pressure	Vessel operates at an elevated pressure.	Pressure fluctuations due to changes in the feed and liquid draw flow rates.	The pressure of the fluid being sent to downstream expander EX-01 exceeds normal operating range. It may lead to undesirable expansion outcomes.	Assets	4	3	6	PT-01 will monitor the pressure of the gas and PCV-01 will maintain a normal range of pressure.	2	2	3	
5	High	Pressure	Vessel operates at an elevated pressure.	Pressure fluctuations due to changes in the feed and liquid draw flow rates.	The pressure of the fluid being sent to downstream expander EX-01 exceeds the normal operating range. It may lead to undesirable expansion outcomes.	Assets	4	3	6	PT-01 will monitor the pressure of the gas and PCV-01 will maintain a normal range of pressure.	2	2	3	

6	Low	Pressure	Vessel operates at a reduced pressure.	Pressure fluctuations due to changes in the feed and liquid draw flow rates.	The pressure of the fluid being sent to downstream expander EX-01 is below the normal operating range. It may lead to undesirable expansion outcomes.	Assets	4	3	6	PT-01 will monitor the pressure of the gas and PCV-01 will maintain a normal range of pressure.	2	2	3	
7	High	Level	Liquid hold-up height in the water separator is increased.	Upstream process sends a higher flow rate of fluid into the vessel.	Liquid-gas engagement volume is decreased, potentially leading to insufficient separation. Water content in the liquid product may increase and product value may be downgraded.	Assets	3	3	5	LG-02 of the water separator will monitor the liquid level. If it exceeds the HLL, LCV-002 will be opened up to increase liquid draw out of the vessel until liquid level returns to the normal range.	1	2	2	
8	Low	Level	Liquid hold-up height in the water separator is decreased.	Upstream process sends a lower flow rate of fluid into the vessel.	Loss of liquid hold-up in the vessel. Unseparated fluid may bypass at the bottom, leading to loss of production.	Assets	3	3	5	LG-02 of the water separator will monitor the liquid level. If it drops below the LLLL, LCV-002 will be closed to reduce liquid draw out of the vessel until liquid level returns to the normal range.	1	2	2	

Node Description: Three-phase separator

H.5 REFERENCES

CHE 464 and 465 Class Notes