HAZOP STUDY REPORT,
SITE A, SECOND COMBUSTOR,
QUANTEM,
PORT BOTANY, NSW

Prepared by: Dean Shewring

28 October 2020

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HAZOP Report, Quantem, Site A,
Second Combustor

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Rev	Date	Description	Reviewed By
A	19/10/20	Draft for Comment	Quantem
B	28/10/2020	Final Revision	Quantem

Contents

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EXECUTIVE SUMMARY

Quantem owns and operates three bulk liquid storage and handling facilities at Port Botany, NSW, i.e. Sites A, B and C. Site A is the original site which was built in 1978 and extended in the early 1980’s. This area is adjacent to Friendship Road and is used to store flammable, combustible and corrosive liquids.

Quantem propose to install an additional combustor at Site A and requested that Dean Shewring from Pinnacle Risk Management chair the required HAZOP study. This report details the results of the HAZOP study in accordance with the requirements of the Department of Planning’s HAZOP Guidelines.

The HAZOP study for the combustor will take place in two separate stages. The first stage reviews the feeds to the combustor and is the subject of this report. The second stage will review the combustor. When the combustor final design details are available, the second HAZOP will be conducted and this report updated.

The study team participants had appropriate experience in the design and operation of waste handling equipment, including combustors, at bulk liquids storage and handling facilities. Therefore, the hazards were generally well known as well as the required control measures to reduce risk to acceptable levels.

None of the identified potential events pose high risk provided good industry practice is implemented (as discussed during the study).

During the study, the Quantem safety management system and existing site operating procedures were discussed and included as potential causes for hazardous events and significant operability problems. Any significant issues identified have been recorded in the HAZOP minutes for inclusion in the final version of the updated procedures for the facility.

The actions recorded during the study were mostly in the design or “improved operability and maintainability” categories. There were no previously unidentified potential hazardous events with significant off-site impact determined.

GLOSSARY

AS	Australian Standard
EPA	Environmental Protection Authority
HAZOP	Hazard and Operability Study
HIPAP	Hazardous Industry Planning Advisory Paper
SIL	Safety Integrity Level
VECS	Vapour Emissions Control System

REPORT

1 INTRODUCTION

Quantem owns and operates three bulk liquid storage and handling facilities at Port Botany, NSW, i.e. Sites A, B and C. Site A is the original site which was built in 1978 and extended in the early 1980's. This area is adjacent to Friendship Road and is used to store flammable, combustible and corrosive liquids.

Quantem propose to install an additional larger combustor (thermal oxidiser) at Site A with the existing combustor to remain to allow for redundancy and peak loads. The existing combustor burns waste vapours. The proposed second combustor will burn waste liquids as well as vapours.

The HAZOP study for the combustor will take place in two separate stages. The first stage reviews the feeds to the combustor and is the subject of this report. The second stage will review the combustor. When the combustor final design details are available, the second HAZOP will be conducted and this report updated.

As part of the project requirements, a HAZOP study compliant with the Department of Planning's Hazardous Industry Planning Advisory Paper No. 8 - HAZOP Guidelines (Ref 1) is required.

This report details the results of the HAZOP study on the proposed second combustor.

Quantem requested that Dean Shewring from Pinnacle Risk Management chair the required HAZOP study.

The aim of the HAZOP study is to identify potential hazardous events and significant operability problems associated with the proposed modifications. This aim is inherent for all HAZOP studies. The scope for this study is detailed in Section 2 of this report.

2 PROCESS DESCRIPTION AND HAZOP SCOPE

The objectives to install a second combustor at Site A are to comply with EPA regulations as well as support the site during peak thermal load scenarios. The existing combustor is operating near to the design capacity and therefore Site A has no vapour destruction redundancy. The existing design relies on the VECS (vapour emission control system) carbon beds to temporarily handle any shutdown of the existing combustor which results in a restriction to Site A activities.

The second combustor will be larger in capacity along with added liquid waste burning capability. It will be used in normal operations with the existing combustor remaining as the back-up combustor for 100% redundancy and also used in conjunction with the second combustor for site thermal peak load scenarios.

The project has the potential value-added benefit of liquid waste burning to reduce export waste disposal from the site.

The vapour supply to the new combustor will be from the existing vapour header to the current VECS and combustor systems. The supply piping design and controls to the new combustor will be identical to the existing combustor.

Waste liquid will be sourced from a number of locations as follows:

- Waste Tanks 2 and 3 at Site A; and
- Transfers from waste tank T-47 at Site C.

As part of this project, Waste Tank 1 and its associated equipment at Site A will be removed. Existing tank, T-261, will be re-purposed as a new waste tank. This is a fixed-roof tank with approximately 200 m^3 capacity. It has redundant high level protection and fire protection (foam injection and exterior cooling water via sprays).

Waste liquid from T-261 will be pumped to the proposed second combustor for treatment. If this combustor is not available, the waste liquid can be transferred via the existing piping systems to a road tanker, or Waste Tanks 2 and/or 3. When the waste liquid enters the proposed combustor, instrument air will be used to spray the waste liquid through a nozzle into the combustor to facilitate the combustion process.

The drawings used in the study which detail the process design are supplied in Appendix A. The HAZOP scope is the equipment shown in light blue on these drawings and, for this report revision, are the feed streams to the new combustor. As the project involves modifications to the existing processes then interactions between the existing and new systems were included in the study.

3 METHODOLOGY

3.1 GENERAL

A HAZOP study is a hazard study which concentrates on how the design will cope with abnormal conditions, rather than on how it will perform under normal conditions. The study is comprised of a review of each unit operation, examining each for possible causes of a wide range of process abnormalities and their consequences.

HAZOP provides the opportunity for people to think creatively and examine ways in which hazards or operating problems might arise. To reduce the chance of missing something, a HAZOP is carried out in a systematic manner, using guide words to consider each system and each type of hazard in turn. The study is carried out by a team so that input from all areas of functional expertise can be provided.

The results of a HAZOP depend heavily upon the experience and attitudes of the team members and on the leadership style adopted. In this study, the members of the team had good experience, knowledge and skills with waste handling and disposal at bulk liquids facilities and had the authority to approve the actions decided upon.

3.2 MEETING PROCEDURES

The HAZOP study of each section of the plant followed the procedure given below:

- The design engineer outlined the broad purpose of the section of design under study. This outline included design features, operating conditions, description of fittings and details of equipment;

- Any general questions about the scope and intent of the design were answered;

- The first section or area of the design was reviewed for study;

- Any general questions about this area were then answered. Minutes may be generated during this discussion;

- The detailed 'line by line' study commenced at this point. The HAZOP leader led the group through the HAZOP guide words. Each guide word is a prompt, such as "HIGH FLOW", which identifies a deviation from normal operating conditions that may lead to a hazardous event or significant operability problem. This is used to prompt discussion of the possible causes and effects of flow at an undesirably high rate. If, in the opinion of the team, the safeguards for the combination of the likelihood of a credible event and the consequences are inadequate then an action is recorded in the minutes.

  For major risk areas the need for action is assessed quantitatively (by Hazard or Reliability Analysis). For less significant risks the need for action can be based on experience and judgement. For this study, all actions could be appropriately addressed by the nominated HAZOP team members;

- The main aim of the meeting was to find problems needing solution, rather than the actual solution. When the group became tied down by trying to resolve a problem, the issue was minuted as requiring further review outside the meeting, and the study proceeded;

- All changes agreed at the meeting were minuted; and

- Note that all actions were recorded in the minutes as well as significant discussion points which did not result in any actions. The latter were recorded as a means to record the basis of safety for a potential hazardous event or operability problem.

The guide words used during the study are listed in Appendix B.

All actions from the study are listed in the HAZOP minutes, contained in Appendix C. It is noted that safeguards are only recorded by exception. It is assumed that the procedures within the Quantem safety management system will be used effectively (as discussed throughout the HAZOP study).

As the purpose of a HAZOP study is to *identify*, i.e. not necessarily solve, potential hazardous events and significant operability problems associated with the process under review, some of the actions require further review post the study. As a general rule, a HAZOP facilitator allows approximately 5 to 10 minutes to resolve any issues identified during the study. If a solution cannot be agreed to within this timeframe then the issue is minuted and the study proceeds.

The reason for this approach is that a positive, open, questioning mindset is required from the team members. This allows creative brainstorming to identify possible abnormal plant conditions that may lead to potential hazardous events and/or significant operability problems. Teams that become tied down trying to resolve all issues, in particular problems that require further calculations and assessment, lose their creativity and hence the basis for the study effectiveness is lost.

4 STUDY TEAM

The HAZOP study for the feeds to the proposed second combustor was conducted on October 15 and 16, 2020.

The HAZOP team participants had the appropriate level of experience in design and/or operation of waste handling facilities including combustors. Table 1 shows the team members who participated in the HAZOP study.

The meetings were led by Dean Shewring with the minutes being recorded by Trent Gearside.

Table 1 – HAZOP Team

HAZOP Role	Name	Company
HAZOP Chair	Dean Shewring	Pinnacle Risk Management
HAZOP Secretary	Trent Gearside	Quantem
Design Representative	Frank Sachinidis	CEC Engineers
Engineering Representative	Emilie Seris	Quantem
Project Management	Andrew Skeet Trent Gearside	Quantem
Mechanical / Maintenance Representative	Wayne Jarman	Quantem
Operations Representatives	Phil Jones Steve Barclay Murray Barnett	Quantem

5 DISCUSSION AND CONCLUSIONS

The study team participants had appropriate experience in the design and operation of waste handling equipment, including combustors, at bulk liquids storage and handling facilities. Therefore, the hazards were generally well known as well as the required control measures to reduce risk to acceptable levels.

The more significant hazards recorded include:

- Loss of containment of waste liquid in the area surrounding the second combustor (potential for environmental impact);
- High level protection in T41 (an existing knockout pot in the vapour header system);
- Oxygen ingress into the vapour headers (risk of internal pipe explosions);
- Preventative maintenance requirements, e.g. the non-return valves on the low point drains from the vapour header that prevent oxygen ingress;
- Tank overfill protections, e.g. T-47, and Waste Tanks 2 and 3;
- Potential for hammer (slow-closing actuated valves required);
- Pressure relief capacity for T-261;
- The need for top entry to T-261 for waste liquid from the Site A sump pumps to prevent reverse flow; and
- Potential for a pump fire for P-02 (combustor feed pump).

None of the identified potential events pose high risk provided good industry practice is implemented (as discussed during the study).

There will be safety critical instrumented systems in this process, e.g. combustor trips. These are to be routinely maintained to ensure reliability as determined via a Safety Integrity Level (SIL) study.

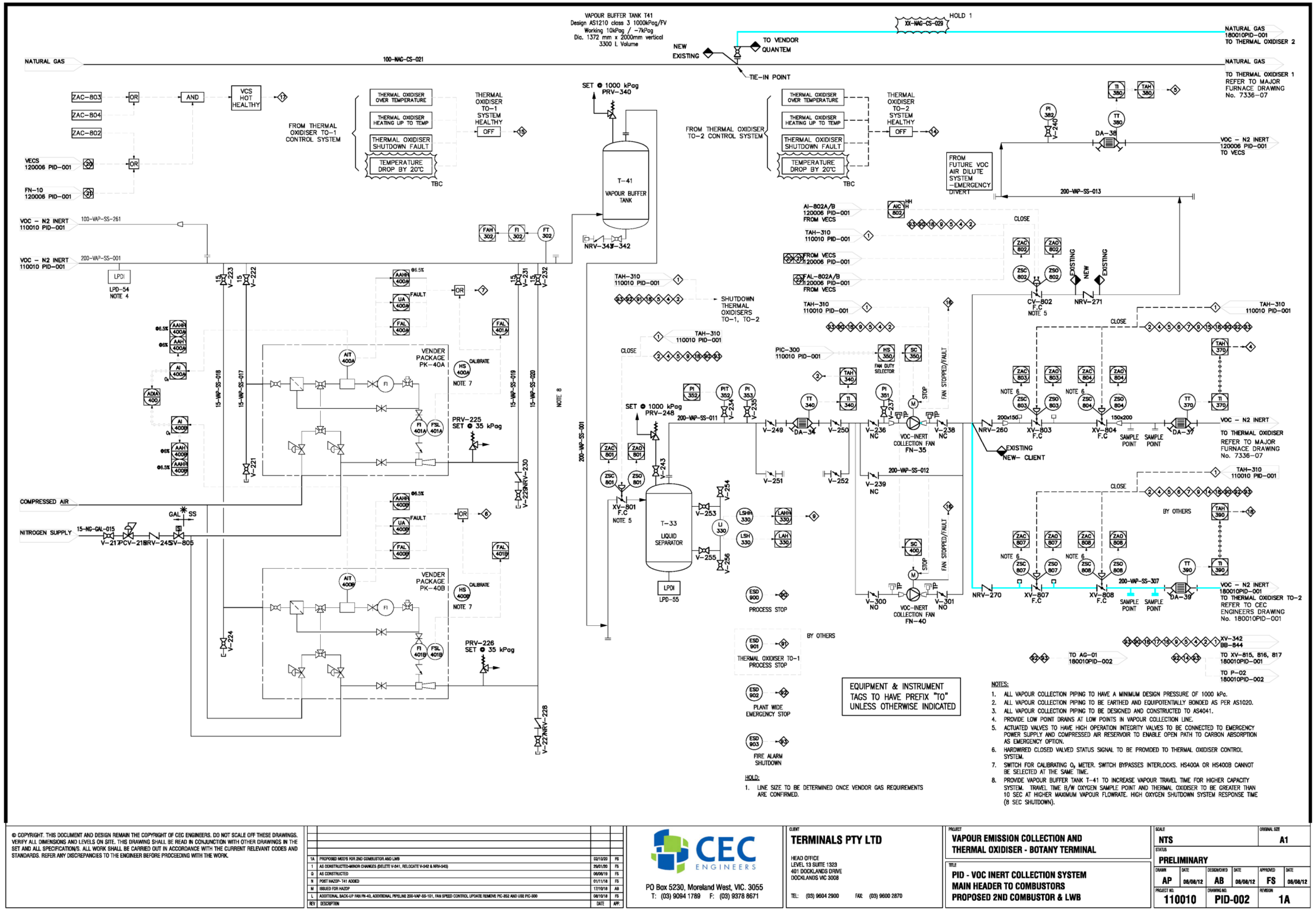
Any significant changes to the HAZOP design should be separately assessed for new potential hazardous events and operability problems. This is commonly achieved by utilising a management of change programme within the project and may require further review using the HAZOP technique.

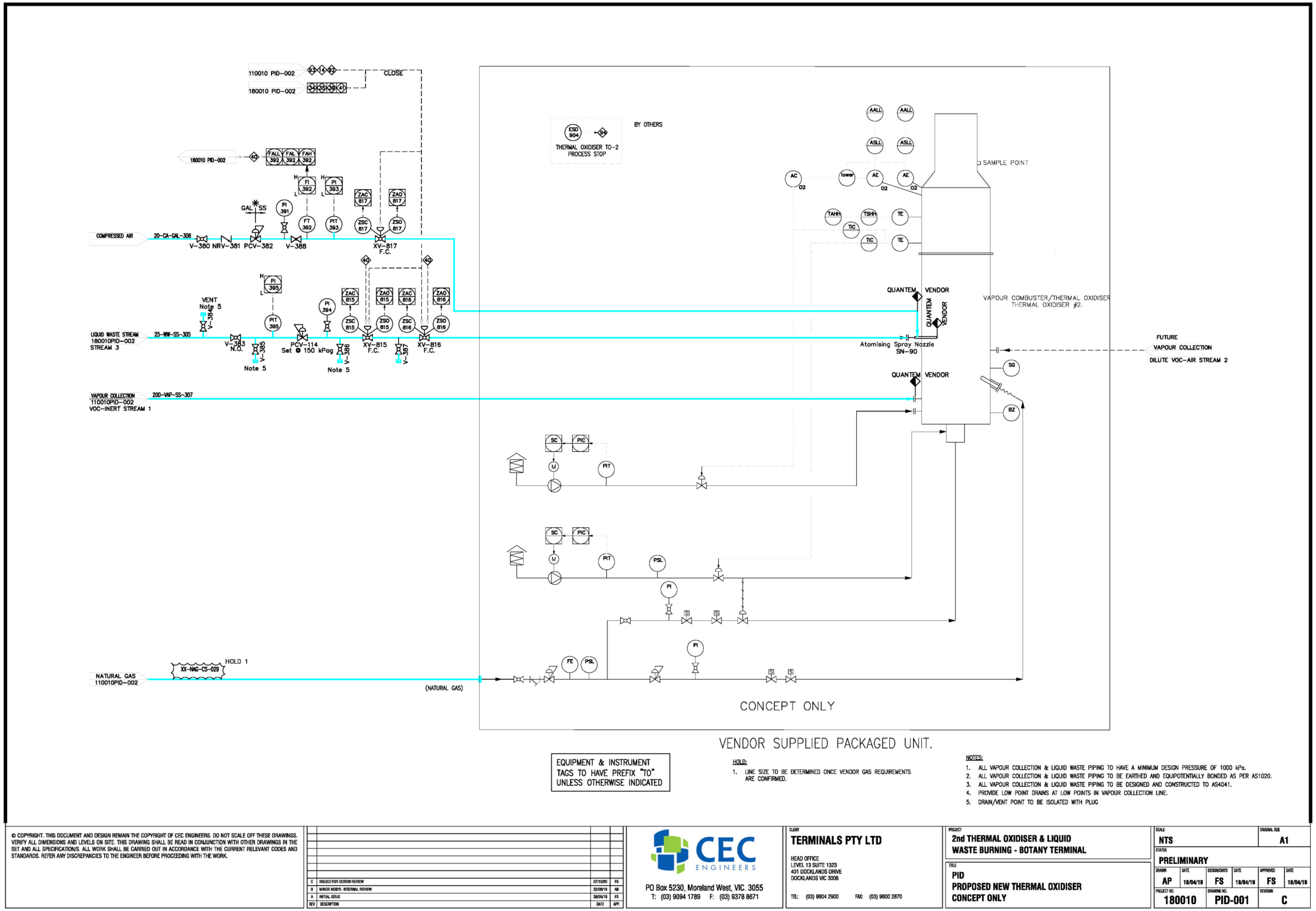
HAZOP studies are, by definition, a qualitative risk assessment. The decisions made by the HAZOP team members are based on their experience and knowledge of the type of facility under review. If the HAZOP team members determined the existing control measures were adequate then no further action is required. Significant points of discussion (generally if significant consequential impacts are possible) were recorded even though the control measures were deemed acceptable by the HAZOP team. All issues requiring a response were included in the HAZOP minutes.

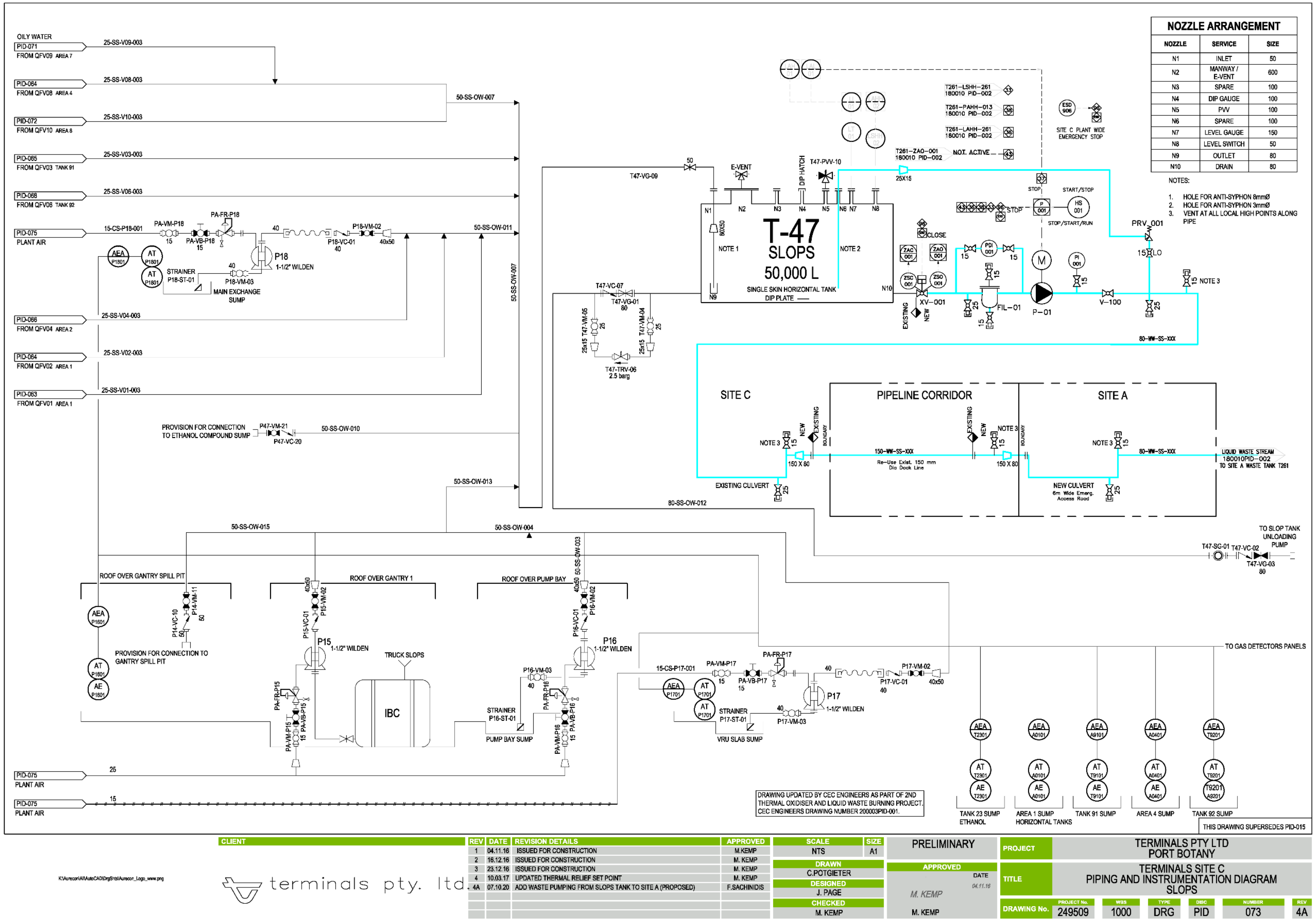
Completed HAZOP actions need to be tracked within the project's HAZOP action register or equivalent. Regular project meetings should include a review of the progress of closing-out all of the actions. It is normally the responsibility of the project manager to ensure that all of the HAZOP actions are completed. The HAZOP drawings and a record of the completed actions should be retained with the plant files.

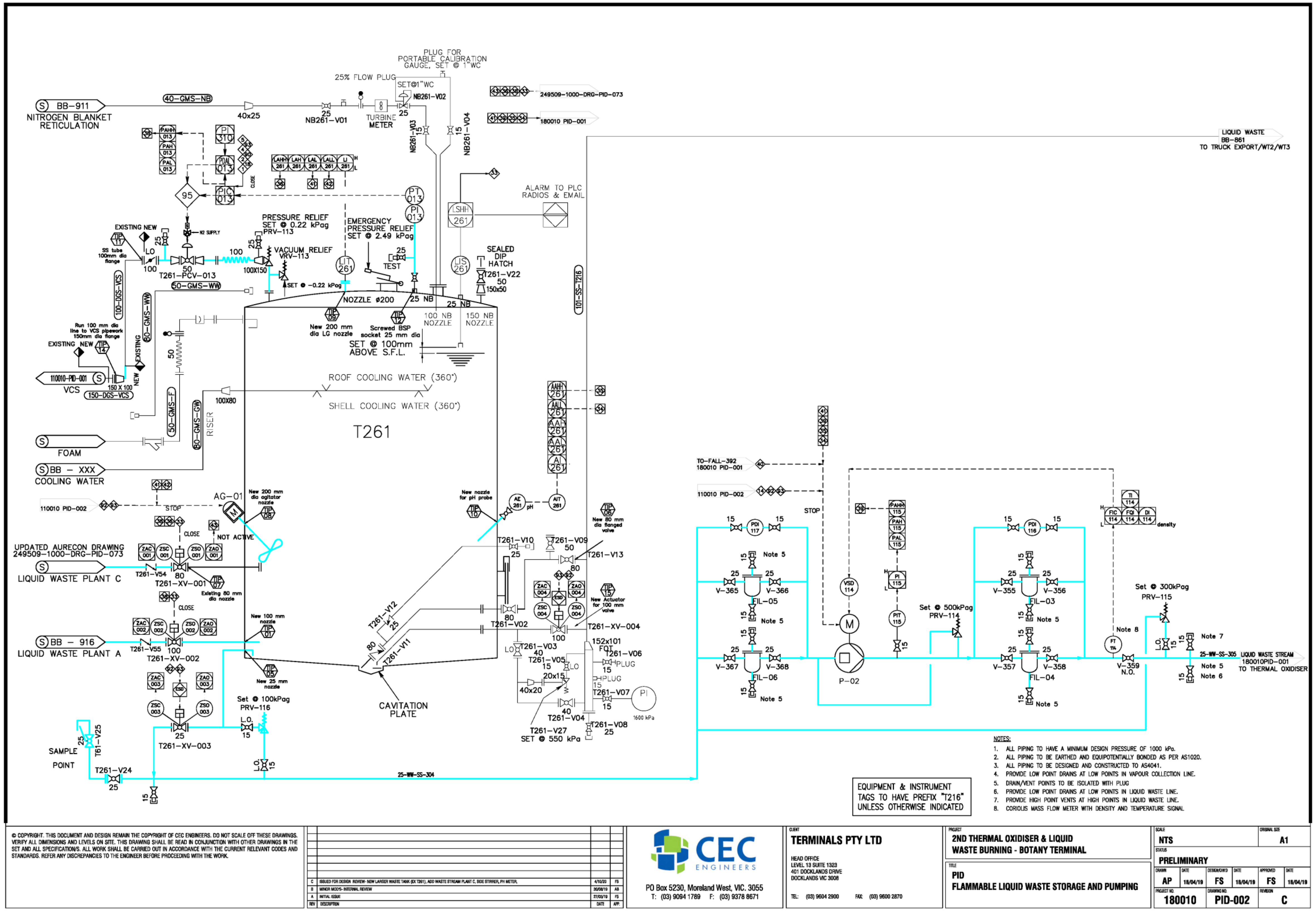
6 APPENDIX A - HAZOP DRAWINGS

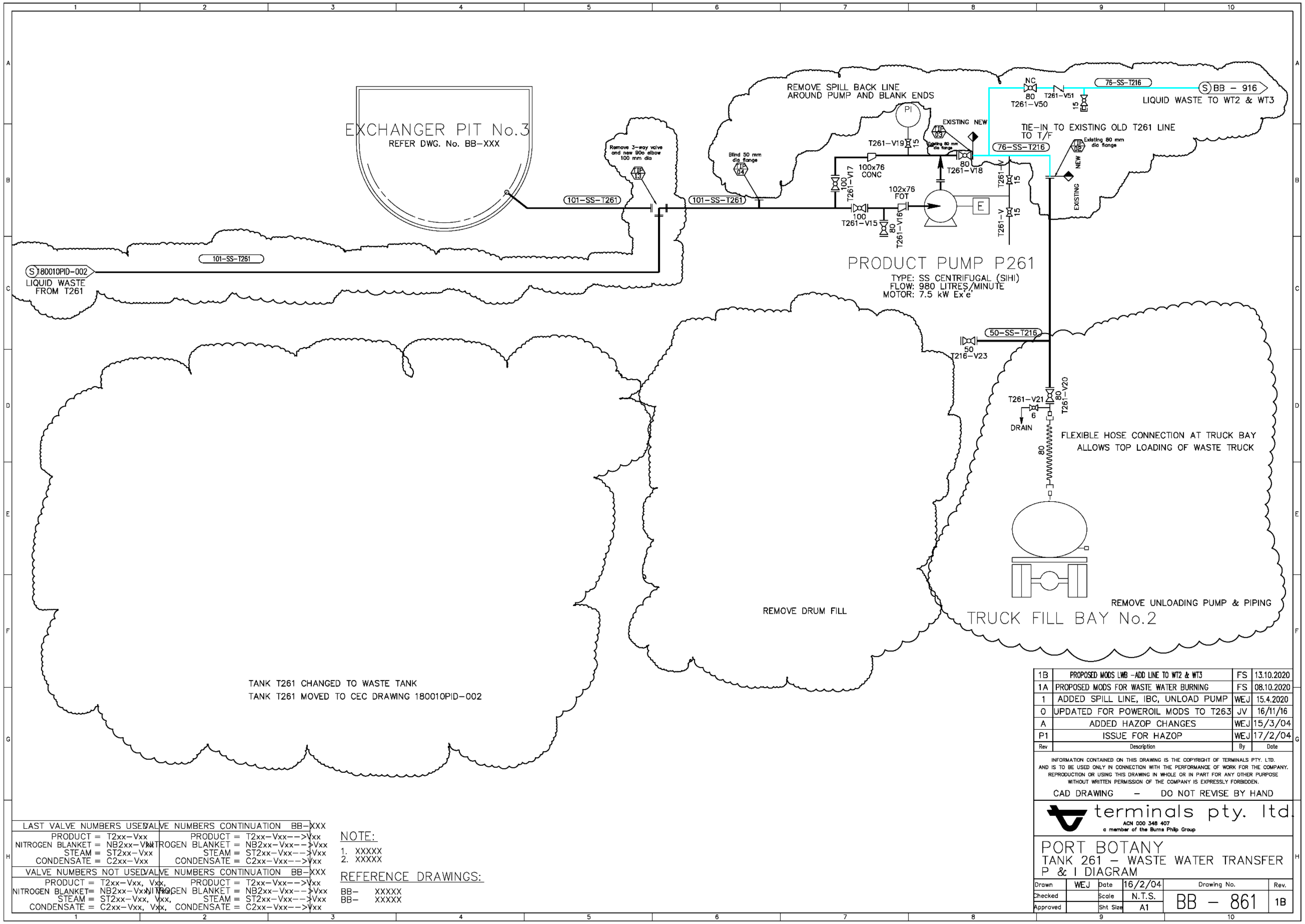
Appendix A - HAZOP Drawings

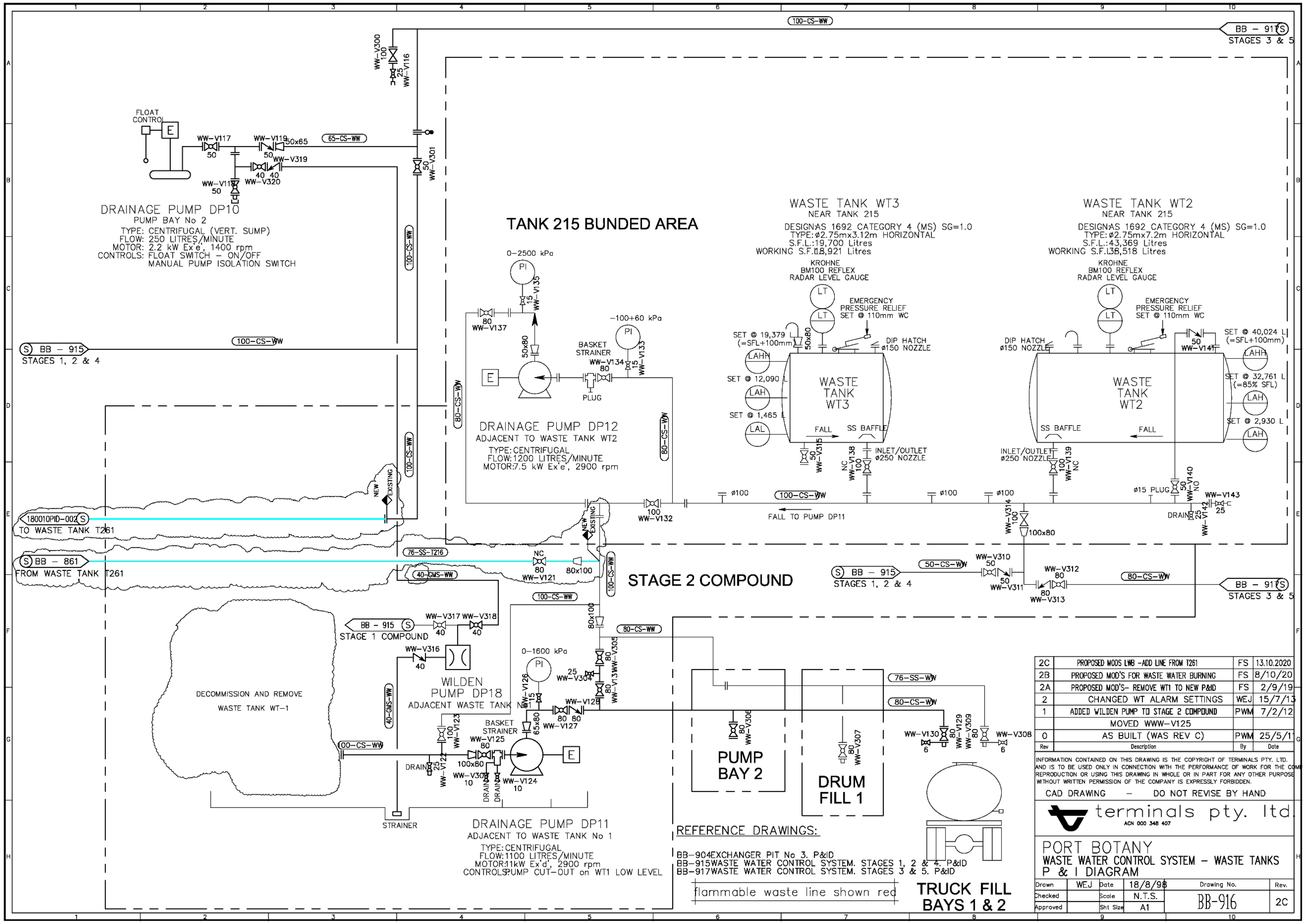



110010 PID-002
180010 PID-002
CLOSE
BY OTHERS
THERMAL OXIDISER TO-2 PROCESS STOP
SAMPLE POINT
COMPRESSED AIR
20-CA-GAL-306
V-380 NRV-381 PCV-382
V-388
XV-817 F.C.
VENT Note 5
LIQUID WASTE STREAM 180010PID-002 STREAM 3
25-WW-SS-305
V-383 N.O.
Note 5
PCV-114 Set @ 150 kPag
XV-815 F.C.
XV-816 F.C.
QUANTEM VENDOR
VAPOUR COMBUSTER/THERMAL OXIDISER THERMAL OXIDISER #2.
Atomising Spray Nozzle SN-90
FUTURE VAPOUR COLLECTION DILUTE VOC-AIR STREAM 2
VAPOUR COLLECTION 110010PID-002 VOC-INERT STREAM 1
200-VAP-SS-307
NATURAL GAS 110010PID-002
XX-NAG-CS-029
HOLD 1
(NATURAL GAS)
CONCEPT ONLY
VENDOR SUPPLIED PACKAGED UNIT.
EQUIPMENT & INSTRUMENT TAGS TO HAVE PREFIX "TO" UNLESS OTHERWISE INDICATED
HOLD:
1. LINE SIZE TO BE DETERMINED ONCE VENDOR GAS REQUIREMENTS ARE CONFIRMED.
NOTES:
1. ALL VAPOUR COLLECTION & LIQUID WASTE PIPING TO HAVE A MINIMUM DESIGN PRESSURE OF 1000 kPa.
2. ALL VAPOUR COLLECTION & LIQUID WASTE PIPING TO BE EARTHED AND EQUIPOTENTIALLY BONDED AS PER AS1020.
3. ALL VAPOUR COLLECTION & LIQUID WASTE PIPING TO BE DESIGNED AND CONSTRUCTED TO AS4041.
4. PROVIDE LOW POINT DRAINS AT LOW POINTS IN VAPOUR COLLECTION LINE.
5. DRAIN/VENT POINT TO BE ISOLATED WITH PLUG
© COPYRIGHT. THIS DOCUMENT AND DESIGN REMAIN THE COPYRIGHT OF CEC ENGINEERS. DO NOT SCALE OFF THESE DRAWINGS. VERIFY ALL DIMENSIONS AND LEVELS ON SITE. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH OTHER DRAWINGS IN THE SET AND ALL SPECIFICATIONS. ALL WORK SHALL BE CARRIED OUT IN ACCORDANCE WITH THE CURRENT RELEVANT CODES AND STANDARDS. REFER ANY DISCREPANCIES TO THE ENGINEER BEFORE PROCEEDING WITH THE WORK.
CEC ENGINEERS
PO Box 5230, Moreland West, VIC. 3055
T: (03) 9094 1789 F: (03) 9378 8671
TERMINALS PTY LTD
2nd THERMAL OXIDISER & LIQUID WASTE BURNING - BOTANY TERMINAL
PID
PROPOSED NEW THERMAL OXIDISER CONCEPT ONLY
NTS
A1
PRELIMINARY
AP 18/04/19 FS 18/04/19 FS 18/04/19
180010
PID-001
C


NOZZLE ARRANGEMENT
NOZZLE SERVICE SIZE
N1 INLET 50
N2 MANWAY / E-VENT 600
N3 SPARE 100
N4 DIP GAUGE 100
N5 PVV 100
N6 SPARE 100
N7 LEVEL GAUGE 150
N8 LEVEL SWITCH 50
N9 OUTLET 80
N10 DRAIN 80
NOTES:
1. HOLE FOR ANTI-SYPHON 8mmØ
2. HOLE FOR ANTI-SYPHON 3mmØ
3. VENT AT ALL LOCAL HIGH POINTS ALONG PIPE
T-47
SLOPS
50,000 L
SINGLE SKIN HORIZONTAL TANK
DIP PLATE
OILY WATER
FROM QFV09 AREA 7
FROM QFV08 AREA 4
FROM QFV10 AREA 8
FROM QFV03 TANK 91
FROM QFV06 TANK 92
PLANT AIR
FROM QFV04 AREA 2
FROM QFV02 AREA 1
FROM QFV01 AREA 1
PROVISION FOR CONNECTION TO ETHANOL COMPOUND SUMP
MAIN EXCHANGE SUMP
SITE C
PIPELINE CORRIDOR
SITE A
EXISTING CULVERT
NEW CULVERT
LIQUID WASTE STREAM TO SITE A WASTE TANK T261
SITE C PLANT WIDE EMERGENCY STOP
TO SLOP TANK UNLOADING PUMP
ROOF OVER GANTRY SPILL PIT
ROOF OVER GANTRY 1
ROOF OVER PUMP BAY
PROVISION FOR CONNECTION TO GANTRY SPILL PIT
TRUCK SLOPS
IBC
PUMP BAY SUMP
VRU SLAB SUMP
TO GAS DETECTORS PANELS
TANK 23 SUMP ETHANOL
AREA 1 SUMP HORIZONTAL TANKS
TANK 91 SUMP
AREA 4 SUMP
TANK 92 SUMP
DRAWING UPDATED BY CEC ENGINEERS AS PART OF 2ND THERMAL OXIDISER AND LIQUID WASTE BURNING PROJECT. CEC ENGINEERS DRAWING NUMBER 200003PID-001.
THIS DRAWING SUPERSEDES PID-015
CLIENT
terminals pty. ltd.
REV DATE REVISION DETAILS APPROVED
1 04.11.16 ISSUED FOR CONSTRUCTION M.KEMP
2 16.12.16 ISSUED FOR CONSTRUCTION M. KEMP
3 23.12.16 ISSUED FOR CONSTRUCTION M. KEMP
4 10.03.17 UPDATED THERMAL RELIEF SET POINT M. KEMP
4A 07.10.20 ADD WASTE PUMPING FROM SLOPS TANK TO SITE A (PROPOSED) F.SACHINIDIS
SCALE NTS SIZE A1
DRAWN C.POTGIETER
DESIGNED J. PAGE
CHECKED M. KEMP
PRELIMINARY
APPROVED M. KEMP DATE 04.11.16
PROJECT TERMINALS PTY LTD PORT BOTANY
TITLE TERMINALS SITE C PIPING AND INSTRUMENTATION DIAGRAM SLOPS
DRAWING No. 249509 1000 DRG PID 073 4A


PLUG FOR PORTABLE CALIBRATION GAUGE, SET @ 1"WC
25% FLOW PLUG
NITROGEN BLANKET RETICULATION
TURBINE METER
LIQUID WASTE BB-861 TO TRUCK EXPORT/WT2/WT3
ALARM TO PLC RADIOS & EMAIL
PRESSURE RELIEF SET @ 0.22 kPag PRV-113
EMERGENCY PRESSURE RELIEF SET @ 2.49 kPag
VACUUM RELIEF VRV-113
SEALED DIP HATCH
ROOF COOLING WATER (360°)
SHELL COOLING WATER (360°)
T261
FOAM
COOLING WATER
LIQUID WASTE PLANT C
LIQUID WASTE PLANT A
UPDATED AURECON DRAWING 249509-1000-DRG-PID-073
CAVITATION PLATE
SAMPLE POINT
P-02
EQUIPMENT & INSTRUMENT TAGS TO HAVE PREFIX "T216" UNLESS OTHERWISE INDICATED
NOTES:
1. ALL PIPING TO HAVE A MINIMUM DESIGN PRESSURE OF 1000 kPa.
2. ALL PIPING TO BE EARTHED AND EQUIPOTENTIALLY BONDED AS PER AS1020.
3. ALL PIPING TO BE DESIGNED AND CONSTRUCTED TO AS4041.
4. PROVIDE LOW POINT DRAINS AT LOW POINTS IN VAPOUR COLLECTION LINE.
5. DRAIN/VENT POINTS TO BE ISOLATED WITH PLUG
6. PROVIDE LOW POINT DRAINS AT LOW POINTS IN LIQUID WASTE LINE.
7. PROVIDE HIGH POINT VENTS AT HIGH POINTS IN LIQUID WASTE LINE.
8. CORIOLIS MASS FLOW METER WITH DENSITY AND TEMPERATURE SIGNAL
LIQUID WASTE STREAM 180010PID-001 TO THERMAL OXIDISER
CEC ENGINEERS
PO Box 5230, Moreland West, VIC. 3055
TERMINALS PTY LTD
2ND THERMAL OXIDISER & LIQUID WASTE BURNING - BOTANY TERMINAL
PID
FLAMMABLE LIQUID WASTE STORAGE AND PUMPING
NTS
A1
PRELIMINARY
180010
PID-002
C


EXCHANGER PIT No.3
REFER DWG. No. BB-XXX
REMOVE SPILL BACK LINE AROUND PUMP AND BLANK ENDS
LIQUID WASTE TO WT2 & WT3
TIE-IN TO EXISTING OLD T261 LINE TO T/F
PRODUCT PUMP P261
TYPE: SS CENTRIFUGAL (SIHI)
FLOW: 980 LITRES/MINUTE
MOTOR: 7.5 kW Ex'e'
LIQUID WASTE FROM T261
FLEXIBLE HOSE CONNECTION AT TRUCK BAY ALLOWS TOP LOADING OF WASTE TRUCK
REMOVE DRUM FILL
REMOVE UNLOADING PUMP & PIPING
TRUCK FILL BAY No.2
TANK T261 CHANGED TO WASTE TANK
TANK T261 MOVED TO CEC DRAWING 180010PID-002
1B PROPOSED MODS LWB -ADD LINE TO WT2 & WT3 FS 13.10.2020
1A PROPOSED MODS FOR WASTE WATER BURNING FS 08.10.2020
1 ADDED SPILL LINE, IBC, UNLOAD PUMP WEJ 15.4.2020
0 UPDATED FOR POWEROIL MODS TO T263 JV 16/11/16
A ADDED HAZOP CHANGES WEJ 15/3/04
P1 ISSUE FOR HAZOP WEJ 17/2/04
CAD DRAWING - DO NOT REVISE BY HAND
terminals pty. ltd.
PORT BOTANY
TANK 261 - WASTE WATER TRANSFER
P & I DIAGRAM
BB - 861
1B


TANK 215 BUNDED AREA
STAGE 2 COMPOUND
DRAINAGE PUMP DP10
PUMP BAY No 2
TYPE: CENTRIFUGAL (VERT. SUMP)
FLOW: 250 LITRES/MINUTE
MOTOR: 2.2 kW Ex'e', 1400 rpm
CONTROLS: FLOAT SWITCH – ON/OFF
MANUAL PUMP ISOLATION SWITCH
WASTE TANK WT3
NEAR TANK 215
DESIGN AS 1692 CATEGORY 4 (MS) SG=1.0
TYPE: ø2.75mx3.12m HORIZONTAL
S.F.L.:19,700 Litres
WORKING S.F.L.18,921 Litres
WASTE TANK WT2
NEAR TANK 215
DESIGN AS 1692 CATEGORY 4 (MS) SG=1.0
TYPE: ø2.75mx7.2m HORIZONTAL
S.F.L.:43,369 Litres
WORKING S.F.L.36,518 Litres
KROHNE BM100 REFLEX RADAR LEVEL GAUGE
EMERGENCY PRESSURE RELIEF SET @ 110mm WC
DRAINAGE PUMP DP12
ADJACENT TO WASTE TANK WT2
TYPE: CENTRIFUGAL
FLOW:1200 LITRES/MINUTE
MOTOR:7.5 kW Ex'e', 2900 rpm
WILDEN PUMP DP18
ADJACENT WASTE TANK No 1
DECOMMISSION AND REMOVE WASTE TANK WT-1
DRAINAGE PUMP DP11
ADJACENT TO WASTE TANK No 1
TYPE: CENTRIFUGAL
FLOW:1100 LITRES/MINUTE
MOTOR:11kW Ex'd', 2900 rpm
CONTROLS: PUMP CUT-OUT on WT1 LOW LEVEL
PUMP BAY 2
DRUM FILL 1
TRUCK FILL BAYS 1 & 2
REFERENCE DRAWINGS:
BB-904 EXCHANGER PIT No 3. P&ID
BB-915 WASTE WATER CONTROL SYSTEM. STAGES 1, 2 & 4. P&ID
BB-917 WASTE WATER CONTROL SYSTEM. STAGES 3 & 5. P&ID
flammable waste line shown red
2C PROPOSED MODS LWB -ADD LINE FROM T261 FS 13.10.2020
2B PROPOSED MOD'S FOR WASTE WATER BURNING FS 8/10/20
2A PROPOSED MOD'S- REMOVE WT1 TO NEW P&ID FS 2/9/19
2 CHANGED WT ALARM SETTINGS WEJ 15/7/13
1 ADDED WILDEN PUMP TO STAGE 2 COMPOUND PWM 7/2/12
MOVED WWW-V125
0 AS BUILT (WAS REV C) PWM 25/5/11
CAD DRAWING – DO NOT REVISE BY HAND
terminals pty. ltd.
PORT BOTANY
WASTE WATER CONTROL SYSTEM – WASTE TANKS
P & I DIAGRAM
Drawn WEJ Date 18/8/98 Drawing No. BB-916 Rev. 2C
Scale N.T.S.
Sht Size A1

7 APPENDIX B - HAZOP GUIDE WORDS

Appendix B – HAZOP Guide Words

Note that the main headings are shown only. Some main headings included various sub-prompts as well.

Line-By-Line Guide Words – Continuous Fluid Systems

- High Level / High Flow
- Low Level / Low Flow
- Zero Flow / Empty
- Reverse Flow
- High Pressure
  - Venting, relief
- Low Pressure
  - Venting, relief
- High Temperature
- Low Temperature
- Impurities
  - Gaseous, liquid, solid
- Change in Concentration or Composition / Two Phase Flow / Reactions
- Testing
  - Equipment / product
- Plant Items
  - Operable / maintainable
- Electrical
- Instruments

Overview Guide Words

- Toxicity
- Commissioning
- Startup
- Shutdown (isolation, purging)
- Breakdown (including services failure)
- Effluent
- Fire and Explosion
- Safety Equipment
- Noise / Vibration
- Materials of Construction
- Simplicity

8 APPENDIX C – HAZOP MINUTES

Appendix C – HAZOP Minutes

SUMMARY: Vapour to TO2

Node #	Node/Step								
1	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
1.01	High level	Potential for high level in the vapour buffer tank T-41, e.g. due to long term liquid accumulation	High level in this tank will result in reduced residence time in the vapour piping system to the combustors and hence the potential for a flammable vapour stream to flow to the combustors prior to the oxygen trip analysers shutting down the combustors. This can lead to internal explosions within the vapour piping system due to flashback from the combustors	Historically, only small quantities of liquid are present in the vapour stream		5	1. Provide high level protection for T41 2. Include in the procedures the requirement for draining of the low point drains in the vapour piping system and T-41 as appropriate	1. FS 2. SB	
1.02	Change in concentration	Potential for oxygen to be introduced to the combustor feed vapour line when draining low points and/or T-41	Potential for flashback from the combustors and internal pipe explosions	Detonation arrestors with high temperature trips on the inlet to the combustor		6	Include in the PMs the need for routine inspection of all low point drain non-return valves	WJ	
1.03	Design issue					7	Include in the detail design for the new combustor the ability to achieve and prove the 1 second residence time as per the EPA licence	FS	
1.04	Reverse flow	Both combustors (thermal oxidisers - TO's) online and no forward flow occurs from the tanks	Potential for reverse flow from one TO to the other TO due to the chimney effect. This will introduce oxygen and hot gases into the system, i.e. explosion and equipment damage risks, respectively	High temperature trips on the detonation arrestors will close the double block valves. NRV's 260/270		8	Install an isolation valve upstream of both NRV-260 and NRV-270, i.e. to allow maintenance checks on the NRVs. The valve type is to be determined. Alternatively, review the option of relocating the NRV's to immediately upstream of the detonation arrestors so that the double block valves can be used for maintenance	FS	
1.05	Impurities	If one TO is offline for a significant period of time then there is potential for air ingress into the vapour feedline to the double block valves	Potential for internal pipe explosion during combustor startup	Detonation arrestor located on the TO inlet nozzle. Short length of line minimises the volume of gas		9	Review the need for a startup nitrogen purge for each of the TO's feedlines	FS	
1.06	Change in concentration	Operating FN-40 at high speed	Potential to exceed the design residence time through T41 and 33 and hence oxygen flowing to the TO's. This can lead to internal explosions within the vapour piping system due to flashback from the combustors	Operator response to FAH-302		10	Provide means to limit the flow to the TO's to ensure that the oxygen trip residence time requirement is met	FS	

SUMMARY: Liquid waste from Site C to T261

Node #									
2	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
2.01	Design issue					11	Mark up the P&ID to show XV-001 as fail closed. Apply this action to all actuated valves in the modified piping systems	FS	
2.02	Design issue					12	Review if the pipe in the pipeline corridor and through the culvert from Site C to Site A is stainless steel or carbon steel. Mark up the P&ID accordingly	WJ	
2.03	Plant items					13	Install an isolation valve upstream of NRV T261-V54 to allow isolation for maintenance of this NRV	FS	
2.04	Project issue					14	Confirm with NSW Ports that the pipe within the pipeline corridor can be left full with liquid as waste water is a utility service, not a product. Note: As below, T261-XV-001 is to be closed when there are no transfers from Site C and therefore, this will lower the risk of the tank emptying to the pipeline corridor	SL	
2.05	Reverse flow	Pump P-01 stops and NRV T261-V54 fails to the open position	Potential to overflow T47 as T261 is the larger volume tank	Maintenance on T261-V54		15	Include in the functional description the need to close T261-XV-001 and T47-XV-001 when P-01 stops (i.e these actuated valves will open and close with pump operation)	FS	
2.06	High level	High level in T261	Overflow T261 to the bunded area	Transfer pump P-01 tripped via LIS-261 and LAHH-261			No further action required	-	
2.07	High flow	Potential for pipeline failure in the pipeline corridor	Environmental impact due to loss of containment of waste liquid	Routine pipeline inspection. PM's, e.g. annual pressure testing and painted line. All new pipework is stainless steel. Pipeline is in a dedicated corridor, e.g. reduced risk of impact events		16	Include in the project scope the need to remove the existing flange in the pipeline corridor, i.e. the pipe is to be fully welded in the pipeline corridor	TG	
2.08	Plant items					17	Include an elbow at the inlet to T261 to promote tank mixing and minimise splashing, i.e static generation. This action applies to the line from Site A through T261-XV-002 as well	FS	
2.09	Reverse flow	Shaft or coupling failure during pump P-01 operation	Potential for reverse flow through the pump from T261 to T47 and hence overflow	NRV T261-V54		18	Include a high level trip on T47 to close T47-XV-001. Include an override to allow this valve to be opened to empty T47 when it is full with a watchdog timer on the override	FS	
2.10	Zero flow	T261-XV-001 closes during transfer	Potential for hammer in the transfer pipeline which may lead to piping damage			19	T261-XV-001 is to be a slow closing valve to avoid hammer	FS	

SUMMARY: Liquid waste from Site C to T261

Node #									
2	Deviation/ Guideword	Causes	Consequences	Safeguards	Risk	Act #	Actions	Action By	Close-out Status
2.11	Design issue	All pumps on site that are cast iron are being replaced with cast steel				20	P-01 is to be specified as cast steel rather than cast iron as cast iron pumps, when deadheaded for sufficient time, can crack when cooler product flows through the pump	FS	
2.12	Plant items					21	All high point vents and low point drains are to be double valved or plugged (single valves)as per site requirements	FS	
2.13	Plant items					22	As per Quantem site standard, provide a manual isolation valve between the tank and T47-XV-001. Apply this action to T261-XV-001, 2, and 3 as well	FS	
2.14	Plant items					23	Provide an isolation valve immediately upstream of T47-FIL-01 to limit the quantity of liquid that needs to be drained for filter and/or pump maintenance	FS	

SUMMARY: Transfer from T261 to road tanker, WT2 and WT3 via P261

Node #									
3	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
3.01	Fire/explosion	Valve WW-V140 (to WT2) open during waste tank filling	Potential for static generation in WT2 due to splash filling and hence the potential for an internal tank explosion			24	Replace NRV WW-V141 with a thermal relief valve. The set pressure needs to be reviewed to avoid potentially overpressuring any of the equipment items in the WT2/WT3 inlet/outlet piping system. Alternatively, review the option of installing a dip pipe with a syphon breaker where NRV WW-V141 enters WT2	FS	
3.02	High level	Potential to overfill WT2 and/or WT3	Loss of containment of waste (flammables, combustibles, water potentially with caustic)	Procedural controls to monitor transfer and level		25	Provide high level trips on P261 from WT2 and WT3. Also, close T261-XV-004 on high level in these tanks	FS	
3.03	Project issue					26	Remove drainage pump DP11 as this will be redundant in the future design when WT1 is removed	FS	
3.04	High pressure	Thermal relief philosophy - procedural controls are acceptable for this supervised activity				27	Valve WW-V121 (new inlet line to WT2 and WT3) is to be shown as "normally open" to provide thermal relief for the discharge line from P261 to WT2. Apply this action to valves WW-V132, WW-V140 and T261-V18 (P261 discharge) as well. Valve T261-V50 will be the valve the operators close following transfer and hence thermal relief from line 76-SS-T216 (line to the road tanker) is provided through P261	FS	
3.05	HAZOP note						Note only: The transfers from T261 to road tanker, WT2 and/or WT3 are to be infrequent events and therefore supervisory control of tank levels and pump operation is deemed acceptable. No further action required		

SUMMARY: Waste liquid / nitrogen from Site A to T261

Node #									
4	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
4.01	High pressure	T261-XV-002 closed when nitrogen is in the reticulation supply piping to T261	Increase in pressure up to 8 bar upstream of T261-XV-002 and when this valve is opened, there will be a surge of nitrogen flow into tank T261 and hence the potential high pressure	T261-PCV-013 (set point 1.3kPa) Emergency pressure relief set point 2.49kPa			Confirm that the pressure relief for T261 is adequate for this scenario. Once this confirmation is achieved then high pressure trip #38 can be removed, i.e. to prevent cycling the tank in pressure up and down by opening and closing T261-XV-002. Also, the high pressure trip can be removed from T261-XV-001 as tank pressure relief will also be adequate for this feed line	FS	
4.02	Environment	Excessive nitrogen flow when depressurising a dockline (i.e any flow that exceeds the capacity of T261-PCV-013)	Lifting the emergency vent and hence hydrocarbons released to atmosphere, potential for environmental impact and odour				Ensure all dockline connection points cannot exceed 200m3/hr (i.e. the capacity of T261-PCV-013)	WJ	
4.03	Design issue						To be consistent with current plant designs, change the set pressure of the nitrogen blanket regulator to 0.4kPa	FS	
4.04	Reverse flow	NRV T261-55 fails to the open position without detection	If a drainage pump discharge NRV subsequently fails to the open position then tank T261 will drain into the corresponding sump, i.e significant waste liquid disposal issue and flooding of the area				Redesign the reverse flow protection of the transfer line from the Site A reticulation system to T261. Preference is to install top entry into T261 with a dip pipe and syphon breaker. Also, check that the sump pumps have sufficient head to pump waste liquid to the top of T261	FS	
4.05	Reverse flow	Potential for reverse flow of vapour from another tank to T261 via PCV-013	No significant issues identified	High pressure monitoring in the combustor header interlocks to PCV-013 operation. PRV 113 to prevent reverse flow			No further action required		
4.06	High pressure	T261-XV-002 closed	Potential for thermal overpressure when the trapped upstream liquid is heated by the sun and hence a loss of containment				Provide thermal relief around T261-XV-002	FS	
4.07	High pressure	Potential for hammer when T261-XV-002 closes	Potential for piping system damage and hence a loss of containment				Ensure valve T261-XV-002 is slow closing	FS	
4.08	Reactions	Potential for incompatible materials to be mixed in T261 leading to a reaction	Heat, fumes, high pressure			28	Review the reticulation network to determine if there is a credible risk of incompatible materials being transferred into T261 and therefore reacting. If so, review the need for further controls	WJ	

SUMMARY: Waste liquid / nitrogen from Site A to T261

Node #									
4	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
4.09	Impurities	Known foreign objects from the sumps include pieces of pigs	Potential to block the liquid outlet line from T261	All drainage pumps have strainers (however, these do not always stop debris such as pieces of pigs entering the system). The liquid outlet line at TIP05 is approx. 300mm above tank floor level and located away from the inlet pipe, i.e. this lowers the likelihood of foreign objects entering the liquid outlet line		29	Provide an additional flush point immediately before FIL-05/6 to clear line 25-WW-SS-304. Review the option of installing a strainer immediately upstream of NRV T261-55 with an isolation for maintenance and means for draining	FS	
4.10	Instruments	Potential for foaming within the tank	Potential for poor level measurement			30	Confirm that the level instruments will provide acceptable level monitoring in the presence of foam within the tank	FS	
4.11	Plant items	T261 out-of-service due to the 10 yearly inspection	Need to handle and store liquid wastes in alternate areas of the facility			31	Ensure all waste liquids can be adequately handled when T261 is out-of-service. One option is to bypass T261 to the existing T261 pig trap	WJ	
4.12	Instruments	Potential for failure of pH meter AE261	Caustic flowing to the combustor with potential impact on some materials of construction. Also, accumulation of non-combusted caustic wastes	Regular zero / span calibration and manual sampling via T261-V25			No further action required		
4.13	Plant items					32	Review and revise as appropriate the waste liquid handling procedures to minimise the likelihood of getting caustic waste into Tank T261 as this will help prevent liquid waste flowing to the combustor	SB	

SUMMARY: Waste liquid from T261 to TO2

Node #									
5	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
5.01	High flow	Pump P-02 running at maximum speed	Potential to overload the TO and hence smoke emissions	Flow measurement FT114 and excess oxygen measurement in the thermal oxidiser. Liquid feed rate limited by the positive displacement pump capacity			No further action required		
5.02	High flow	PCV-114 fails open	Potential to overload the TO and hence smoke emissions	Flow measurement FT114 and excess oxygen measurement in the thermal oxidiser. Liquid feed rate limited by the positive displacement pump capacity. Operator response to PI395 low pressure alarm			No further action required		
5.03	High flow	P-02 stops	Potential to syphon from T261 to TO2	Backpressure regulator PCV-114 set point is above tank head. XC-815, XV-816 and T261-XV-003 will be closed by the control system when P-02 stops			No further action required		
5.04	Plant items	Loss of containment of hydrocarbons or high pH waste water, e.g. during sampling or maintenance	Potential injury/health impacts to personnel	Procedures and PPE		33	Confirm that the existing safety showers comply with SafeWork / the Australian Standard requirements	SL	
5.05	Fire/explosion	P-02 seal failure when pumping a flammable liquid	Potential for a pump fire if ignited and hence propagation to adjacent equipment	PMs on pumps		34	Further review of the controls for this scenario is required, options discussed during the study included: 1. Installing LEL detection and foam deluge at the proposed pump location 2. Possibly relocating the pump to the existing pump bay with improved line-of-sight by the operators	SL	
5.06	Plant items	P-02 failure	Unable to pump liquid effluent to the combustor	Liquid waste disposed via the existing systems		35	Review what critical spares are required for P-02 (and all equipment items within the project scope) with reference to the West Melbourne combustor, e.g. having a spare nozzle for the liquid inlet to the combustor	WJ	
5.07	Plant items					36	Provide a locked open isolation valve on the outlet of PRV-115 to allow maintenance	FS	

SUMMARY: Compressed air to TO2

Node #									
6	**Deviation/ Guideword**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
6.01	High flow	V-388 open too much or PCV-382 fails open	Excess air used			37	Check with the nozzle supplier if there are adverse consequences for high air flow, e.g. greater risk of nozzle erosion and hence the need for additional controls	FS	
6.02	Zero flow	Loss of compressed air due to V-388 closed, PCV-382 fails closed, V-380 closed and/or XV-817 closing	Loss of atomising air flow to the combustor, potential for liquid jet fire/pool fire and hence damage to the combustor	Procedural controls to keep the in-line manual valves open, operator response to low flow and low pressure alarms, low flow combustor trip, limit switches on XV-817		38	Include in functional description a low pressure trip from PIT-393	FS	
6.03	Impurities	Site instrument air system is known to have water present. Also potential for grit, e.g. scale, to be within the instrument air	Corrosion of equipment. Scale can damage the regulator diaphragm seat			39	Provide means to knock out any water/grit in the compressed air. Locate this equipment item between V-380 and NRV-381 so that V-380 can be used for maintenance isolation	FS	
6.04	Plant items					40	Provide means to vent the air pipe downstream of PCV-382 (section of pipe between PCV-382 and XV-817) for maintenance work	FS	

SUMMARY: Overview of System

Node #	Node/Step	Overview	Description 1						
0	**Issues**	**Causes**	**Consequences**	**Safeguards**	**Risk**	**Act #**	**Actions**	**Action By**	**Close-out Status**
0.01	Breakdown	Erosion of the liquid injection nozzle into the combustor	Erratic combustor performance during waste burning			1	Include in the annual combustor PMs (preventative maintenance) the need to check the integrity of the liquid injection nozzle	WJ	
0.02	Effluent	Loss of containment of the liquid waste stream from the piping system at the combustor, i.e. leaking joint or pipe, valve passing or left open	Potential for environmental impact as the liquid waste can flow through the roadway drainage valves (stormwater pits in the road and isolation valve at boundary) to off-site	The stormwater pits have isolation valves at the site boundary that are left in the closed position. Procedural controls to leave all drain valves closed. All drain valves are plugged in this area, Fully welded line as much as possible		2	Further assessment for additional controls for this scenario is required. Options discussed during the study included: 1. Installing LEL detection or means of leak detection with pumping to the site effluent system 2. Installing a catch tray under the liquid waste feed line to the combustor with LEL or level detection	FS	
0.03	Services	Reliability of instrumented protections				3	Perform a SIL study to determine which functions need to be included in the safety system PLC	SL/TG	
0.04	Noise	Additional noise from the new combustor, e.g. fans and pump	Potential to impact people on and off site and possibly exceed the site parameter licence limit	The expected noise levels are expected to be similar to the existing system, i.e. low		4	Ensure that the new equipment does not generate noise that exceeds the site's boundary limit	FS	

9 REFERENCES

1 Department of Planning, *Hazardous Industry Planning Advisory Paper No. 8, HAZOP Guidelines*, 2011