Standard Operating Procedure

Title:	Dealing with Ammonia Standard Operating Procedure		
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1 Introduction and Purpose

At Todd Energy's Kapuni Gas Treatment Plant (KGTP), gas from the Kapuni Field is processed through a Benfield solution which removes the carbon dioxide (CO_2), the carbon dioxide is purified, compressed, and cooled using ammonia refrigerant. The CO_2 is stored as a liquid before being transported to clients.

This procedure shall be used to ensure personnel safety whilst working on plant and process equipment that contains ammonia or has the potential to release ammonia into the atmosphere.

This procedure identifies testing methods, Respiratory Protective Equipment (RPE) and Personnel Protective Equipment (PPE) requirements.

This SOP focus on protection of personnel from toxic properties of Ammonia.

2 Definitions and Abbreviations

Table 1: Abbreviations

CO_2	Carbon Dioxide
IDLH	Immediately dangerous to life and health
KGTP	Kapuni Gas Treatment Plant
PPE	Personnel Protective Equipment
PPM	Parts per million
PICWS	Person in Charge of the Work site
RPE	Respiratory Protective Equipment
SCBA	Self-Contained Breathing Apparatus
STEL	Short-Term Exposure Limit
TWA	Time Weighted Average
WES	Workplace Exposure Standards

Exposure Limits

Worksafe Guidelines, New Zealand Workplace Exposure Standards and Biological Exposure Indices for: Ammonia

- 25 ppm for 8-hour Time Weighted Average (TWA)
- 35 ppm Short-Term Exposure Limit (STEL) up to a fifteen-minute excursion.
- 300 ppm or more, Immediately Dangerous to Life and Health (IDLH).

The Workplace Exposure Standards (WES) and Biological Exposure Indices (BEI) are intended to be used as guidelines for health risk management by people qualified in occupational health practice.

3 Ammonia Hazards

Ammonia is colourless irritating gas with a sharp suffocating odour. It is toxic, whether inhaled, absorbed through the skin, or ingested. It is corrosive and can burn the skin or damage mucous membranes such as eyes, and the nasal cavity. A table of gas concentrations and expected consequences is given in Appendix A.

Ammonia is categorised in the Kapuni Safety Case as a major accident hazard at Kapuni.

Ammonia is used in the Kapuni process as a refrigerant and is a liquid at cryogenic temperatures. Auto-refrigeration occurs when ammonia is released to atmosphere. Contact with the very cold liquid or inhalation of cold gas can cause cryogenic burns.

Liquified Ammonia can expand 850 times when released to ambient air and can form a large vapour cloud. Even though the gas is normally lighter than air, it may form droplets with the moisture in the air and behave as a dense gas. In this form, it may spread along the ground and collect in low-lying areas with poor ventilation.

Ammonia gas dissolves easily in water to form ammonia hydroxide liquid, a caustic solution that can cause burns when in contact with the skin.

Ammonia has a relatively low heat of combustion. The flammable range of ammonia is 15.5-25%. More information can be found in the SDS for Ammonia Anhydrous in Chemwatch.

3.1 Routes of entry into the body

Ammonia can enter the body from inhalation, the act of breathing and the most common route, from absorption through the skin and eyes (burns), there is a possibility of ingestion from liquids but not a relevant route for gas.

TE Exposure Limit

Standard operating, routine maintenance and inspection tasks in the carbon dioxide recover unit have the potential to exposure personnel to ammonia. Any potential exposure should be categorised against the following exposure levels for occupational work and working limits.

Ammonia Working Limits

Safe Working Level 1: < 25ppm Breaking into Ammonia process equipment.

Safe Working Level 2: >25ppm - <300ppm working with, and the potential for splashes.

Safe Working Level 3: >300ppm - <1000ppm working with and the potential for splashes.

Safe Working Level 4: >1000ppm or unknown is for Emergency Response and containment of events.

At >300ppm you must STOP Work and review the task, SCBA is required.

Implement controls as necessary.

3.2 Emergency Response – Ammonia escape hoods

Ammonia escape hoods are issued to all people accessing site and are also at the primary muster locations. Ensure you have your ammonia escape hood on your person whenever you are onsite. If you do not have a permanently issued escape hood, you can be temporarily issued with one at the Permit Control Facility.

For further informanation on ammonia escape hoods refer to the Standard Operation Procedure: Use Inspection and Maintenance of Ammonia Escape Hoods.

	To deploy the Duram Kimi escape hood in an emergency. • Pull the yellow strap to take the hood out of the pouch • Tear open the sealed pouch, unfold it, hold upside down with the visor facing your body • Stretch the opening and pull it over your head • Move the elastic strap to the back of your head • Once donned, make your way to the closest muster point.
	The PARAT® escape hood is easily deployed in an emergency. • When the case is opened, the filter plug automatically releases and the filter moves into operational position so the escape hood can be immediately donned. • The self-adjusting internal head harness requires no additional tightening. • All you have to do is open the packaging, remove, and don the hood—and leave the danger zone. • Once donned, make your way to the closest muster point.

3.3 Procedure

Pre-Work

- Prior to engaging in any work activity where ammonia might be present a review of the work programme should be undertaken to determine where the breaking of systems will occur and whether there is the potential for any ammonia to be present.
- The permit applicant must prepare a permit to work with supporting documentation/JHA.
- Permit applications must be submitted 14 normal working days in advance of the issue of the PTW, this allows the Permit Issuer time to review the documentation, access whether proposed controls and recovery actions adequately cover the proposed work risk and consider any conflicting work activities at that time.
- The work permit provided must document the required standard of PPE for performing the task within the job hazard analysis.

3.4 Testing and PPE

- A personal ammonia detector should be carried by at least one person in each work party undertaking work in the carbon dioxide recovery unit. This includes Operations personnel conducting operations routines, such as operator rounds.

- Personal detectors are set to alarm at 20ppm. This alarm indicates that the WES-TWA for 8 hours is approaching, and that action is required to protect persons in the area from harmful exposure to ammonia. RPE must be located and worn.

- The RAE Systems MiniRea 3000 Ammonia detector is used for the testing of ammonia levels in the atmosphere in accordance with its operating instructions and by a competent person. An overview of the instrument is provided in Appendix B.

- Testing for ammonia should be undertaken when breaking into ammonia systems or when the task has the potential for ammonia to be released.

- Testing should be undertaken in the expected “breathing zone” 30cm away from the nose, mouth, and work areas where personnel will be working. Not inside of pipework or at pressurised vent areas from pipework.

- All sample readings are to be recorded on the results form (Appendix C) of this procedure. Results must be recorded in the site’s Health Hazards Register by the Person responsible for the work.

- Where it is deemed to be unsafe to take readings, it is to be treated as immediately dangerous to life or health, workers must use a self-contained breathing apparatus (SCBA) and level 4 gas tight suit, when the ammonia concentration is unattainable (Unknown).

3.5 RPE

- Full Face Respiratory Protective Equipment with a specific or combination filter that has a (ammonia) K (P3) rating must be worn when performing work where there is a risk of ammonia gas being released directly into the breathing zone or the working area.

- There are several factors to consider in regard to the life of a filter, the concentration of the contaminates in the atmosphere, the combination of contaminates, air humidity, temperature, duration of use, physical exertion of the user and the breathing rate of the user.

- Since the life of a filter has many different factors, it's not possible to give an estimated lifetime for filters, the end of a filters life is generally recognisable by the following:
    a) A noticeable taste or smell of the contaminate while wearing a mask, this is called, break through.
    b) An increased breathing rate while wearing a mask. It's harder to breathe as the filter is becoming blocked.
    c) In combination filters a noticeable taste or smell and or an increased in breathing resistance by the user, while wearing a mask.
    d) Any recommendation given by the manufacture, e.g., an expiry date is given, the manufacture has given a recommended time frame that the filter can be used, these recommendations are normally written on the packaging of the filter, or on the filter, check all packaging and the filter for recommendations before usage.
    e) Filters should be changed when they have been in a contaminated atmosphere.
- Examples of work that might lead to these situations include transferring of and the topping up of ammonia systems, system or line purging or draining, draining of oils, filter changing, leak detection and repair.
- Personnel that are required to wear respiratory protection, must have been fit tested and been assessed competent to wear a face mask.

3.6 RPE & PPE Requirements

<table>
<tr><td>Safe Working Level 1
< 25 ppm</td><td rowspan="2">RPE, Full face mask with a specific or combination filter that have an Ammonia K (P3) rating.
  </td><td> 
Standard site PPE (Including gloves)</td><td colspan="2">For the breaking of Ammonia process equipment, breathing zone & area testing, Todd standard PPE requirements plus RPE.

Note: Where there is the potential for splashes an apron or splash suit must be worn regardless of the ppm level.</td><td rowspan="4">Portable Gas Detection
  </td></tr>
<tr><td>Safe Working Level 2
>25ppm TWA.
< 300 ppm</td><td>Chemical apron or Microchem 5000 splash suit or equivalent splash protection must be available, worn if required.
  </td><td>Chemical Resistant Gloves and gumboots
  </td><td>Working with, and the potential for liquid splashes in Ammonia process equipment.</td></tr>
<tr><td>Safe Working Level 3
> 300 ppm
< 1000 ppm</td><td>Breathing Apparatus
SCBA
 
Worn over the splash suit.</td><td>Microchem 5000 splash suit or equivalent splash protection must be worn.
  </td><td colspan="2"></td></tr>
<tr><td>Safe Working Level 4
> 1000 ppm
or
Unknown</td><td>Gas Tight Suit
  </td><td>Breathing Apparatus
SCBA
 
SCBA must be worn within this level 4 gas tight suit, the wearer will require assistance to gear up and for the removal of the equipment.</td><td colspan="2">Level 4 is for emergency response and for the containment of events.

SCBA will confirm to PTW requirements, e.g., back up team and BA board.</td></tr>
</table>

Note:

- Respirators must be carried or worn whenever a worker goes into a restricted area such as the CO2 Plant.
- RPE / PPE requirements may vary depending on the risk of the activity e.g., consider potential for escalation, size, and duration of release.

3.7 PPE Information

Respiratory Protection >12.5 ppm for 12-hour period > 25 ppm during an 8-hour period >35 ppm up to a 15-minute excursion.	Full-face Respirators must be worn whenever working on Ammonia process as per safe working level 1. Full-face Respirators must be worn at >25ppm and follow safe working level 2. Always remember that concentrations can spike suddenly. If the concentration of ammonia is greater than 300 ppm, Filter cartridges cannot be worn, and a self-contained breathing apparatus (SCBA) and a Microchem 5000 splash suit or equivalent splash protection must be worn. Filter cartridges must be replaced after use in a hazardous atmosphere.
Skin Protection **>25ppm**	Working with Ammonia and potential for liquid splashes in Ammonia process, workers must wear, gumboots, chemical resistant gloves a chemical apron or a full-body splash suit. When gumboots are worn protective splash suit must be worn over the boot to prevent any possible liquid from entering the boot. Work must stop at 300 ppm, and Level 3 Respiratory and Personnel Protection precautions put in place. 300ppm or more causes immediate irritation of moist body areas. (Ammonia reacts instantly with moisture.)
Eye Protection **All work**	Eye protection starts with the use of a Full-Face respirator for levels 1 & 2 leading to breathing apparatus at level 3 and a gas tight suit and breathing apparatus for level 4.
Self-Contained Breathing Apparatus **>300ppm**	When a leak has been identified, assess if a reading can be taken with full-face respirator or it can be quickly stopped with the use of a full-face respirator (e.g., a small leak) to prevent a larger release. Should it be deemed to be unsafe to take readings, it is to be treated as immediately dangerous to life or health, workers must use a self-contained breathing apparatus (SCBA) and level 4 gas tight suit when the ammonia concentration is unattainable (Unknown) task. Under normal working circumstances the wearing of SCBA requires a Permit to Work and adhere to PTW requirements, under emergency situations the PIC/Incident Controller will follow STA-01.14 Use of Breathing Apparatus operating procedure. When managing an ammonia release under an emergency response event follow the requirements of the TENZ Emergency Management Plan.
Self-Contained Breathing Apparatus and level 4 gas tight suit . **>1000ppm**	10000 ppm is sufficient to cause skin damage and be caustic to the throat. Emergency response procedures are invoked at this level. Breathing apparatus and a level 4 gas tight suit must be worn when the concentration is unknown or >1000ppm

You must STOP WORK at 300ppm, and the task assessed.

Implement controls as necessary.

When working on the Ammonia system, you must be prepared for high levels of ammonia and evacuation

3.8 Decontamination of RPE/PPE

- For safe working level 1 workers will be able to clean their own RPE/PPE by following applicable methods below.
- For safe working level 2 & 3 workers may or may not be able to decontaminate their own RPE/PPE before disrobing. If they feel unsafe to carry out their own decontamination and assistance is required, they will contact the Control Room Operator who will assemble a team to assist with the decontamination. The decontamination team will wear level 2 RPE/PPE and follow the decontamination methods below.
- For emergency response level 4 a decontamination area is to be set up, a team of personnel will be made available for decontamination of workers that have been wearing RPE & PPE in hazardous atmospheres, they will be required to wear chemical splash suits, gumboots, rubber gloves and full-face masks with specific or combination filter of a (ammonia) K (P3) rating, level 2 RPE/PPE.
- The gas tight suits go through the initial first stage of decontamination while being worn, the wearer is disrobed, after disrobing the suits can have a more thorough clean, allowed to dry before they are stored for future use. The MiniRea 3000 Ammonia detector can be used to determine if RPE/PPE is still required to be worn for the second stage of cleaning of the gas tight suits.
- SCBA will go through the initial first stage of decontamination, once removed will have a more thorough clean before being stored for future use. The MiniRea 3000 Ammonia detector can be used to determine if RPE/PPE is still required to be worn for the second stage cleaning of the SCBA.

1. Re-usable chemical aprons, splash suits, gumboots, and chemical gloves can be washed and cleaned for re-use if they are in good condition.

2. A hand-held hose on a spray setting or one of the site shower eye wash stations can be used for decontamination, using a medium density bristle brush/broom for the cleaning of RPE/PPE.

3. Washing down is to be undertaken in a bunded area where the wastewater can be collected and disposed of by appropriate means.

4. Ensure that the wastewater does not enter any drain system that leads to the stream.

5. Respirators should go through the same cleaning process as other re-usable RPE & PPE, then taken off and cleaned in a cleaning solution or by alcohol-free cleaning wipes and left to dry for re-use.

6. Disposable splash suits should be tested using the MiniRea 3000 Ammonia detector to determine if they have been contaminated.

7. Uncontaminated suits can be disposed of in the general waste bin.

   Contaminated splash suits are disposed of in the site Hazardous Waste bin.

3.9 References

References for the development of this procedure were:

- Work Safe BC Canada Ammonia in Refrigeration Systems guideline.
- Workplace Health and Safety Queensland emergency planning for ammonia-based refrigeration systems guide
- Meat Industry Association ammonia & refrigerant management
- AS/NZS anhydrous ammonia – storage and handling standard.
- Midwest Consortium for Hazardous Waste Worker Training on anhydrous ammonia emergency responder participant guide
- Safety guide for ammonia refrigeration in New Zealand
- Technical papers for the 36th annual meeting of the international institute of ammonia refrigeration
- Victorian Code of Practice for ammonia refrigeration
- Worksafe NZ technical bulletin for ammonia refrigeration
- Worksafe NZ Workplace exposure standards and biological exposure indices

Controls from these were applied to provide a safe working environment for the management of ammonia at Todd Energy sites.

Appendix 1: Toxic effects of Ammonia

Ammonia concentration Parts Per Million (ppm)	Health Effect	Performance
25 ppm	Ammonia easily detected by most people	Eight-hour (TWA). Wear Respiratory Protection (Full face mask)
35 ppm	Inexperienced persons are repulsed by the pungent smell	Fifteen-minute exposure Standard (STEL). Wear Respiratory Protection (Full face mask)
50 ppm	Very distinct smell, will want to naturally evacuate the area.	Wear Respiratory Protection
70 ppm	Irritation to eyes, nose, or throat, can cause watering of eyes, sneezing and coughing.	Wear Respiratory Protection
100 ppm	No serious danger, but very unpleasant, irritation, stinging or burning in eyes, and respiratory system.	No deliberate exposure for long periods without the Wearing of Respiratory Protection and assessment for PPE.
300 ppm (IDLH level) Stop work at 300 ppm and assess the task.	Severe irritation of eyes, nose, or respiratory tract, which becomes intolerable after a few minutes, difficulty breathing, possible burning in lungs.	Immediate danger to life and health (IDLH), Confined space procedures apply. Full skin protection and SCBA is required.
400 ppm	Immediate nose and throat irritation	Above IDHL. Full skin protection and SCBA is required.
700 ppm	Immediate eye, nose, and throat irritation	Above IDHL. Full skin protection and SCBA is required.
1**,000 ppm**	Cause skin damage and be caustic to the throat.	Above IDHL. Full skin protection and SCBA is required. Wear SCBA with a level 4 gas tight suit
1,700 ppm	Convulsive coughing. Severe eye, nose, and throat irritation	Could be fatal after 30 minutes, wear SCBA with Level four (4) gas tight suit.
2,000 ppm	Can be fatal after a few breaths. Immediately dangerous to life and health (IDLH)	15 min or less may result in death, wear SCBA with Level four (4) gas tight suit.
>5,000 ppm	Respiratory arrest, Pulmonary oedema	Lethal in seconds Shelter where safe to do so and wait for decline in concentration. Do not enter visible aerosol cloud.

Appendix 2: REA System MiniREA Ammonia detector

Operating the instrument

To turn the device **on**, press and hold the  Key until the display turns on and then release the button, the devise will run through its start-up and self-test mode.

After the start-up and self-test mode have been completed the device will show its main screen 

it's now ready to be used for sampling.

To turn the device **off** hold the MODE key for 3 seconds, the device will count down and turn off, release the key when the device has turned off

The instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. This instrument has been calibrated so it specifically measures Ammonia only.

It gives real-time measurements and activates alarm signals whenever exposure exceeds pre-set limits.

The instrument is pre-set with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, you should test the instrument and verify the calibration before the first use.

After the instrument is fully charged and calibrated, it is ready for immediate operation.

Once you have turned the devise on  you simply use the  key and the  key to navigate through the screens to instigate the sampling and obtain a reading, the readings are continuous.

IMPORTANT! BUMP TEST THE MONITOR BEFORE EACH DAY'S USE

Prior to each day's use, the detector should be bump tested to confirm the response of all sensors and activation of all alarms by exposing the monitor to a concentration of target gas that exceeds the low alarm set point.
A bump test is also recommended if the monitor has been subjected to physical impact, liquid immersion, an Over Limit alarm event, or custody changes, or anytime the monitor's performance is in doubt.
To ensure greatest accuracy and safety, only bump test and calibrate in a fresh air environment.
The monitor should be calibrated every time it does not pass a bump test, but no less frequently than every six months, depending on use and exposure to gas and contamination, and its operational mode.

Note: The device needs to be **turned off** for Bump Testing.

User interface:

The instruments user interface consists of the display. LEDs, an alarm transducer, and four keys.

The Keys are:

Y/+

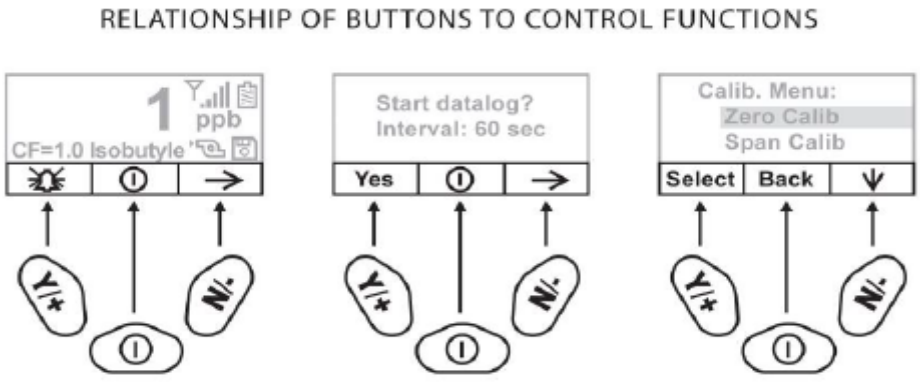
MODE, On off Key

N/+

Flashlight on/off

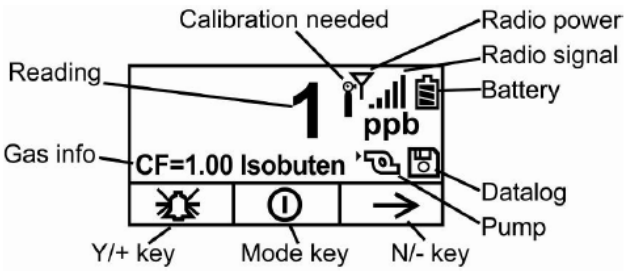
The LCD display provides visual feedback that indicates the reading, time, battery condition, and other functions.

In addition to their labelled functions, the keys labelled Y/+, MODE, and N/- act as “soft keys” that control different parameters and make different selections within the instrument’s menus. From menu to menu, each key controls a different parameter or makes a different selection. Three panes along the bottom of the display are “mapped” to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the centre pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:



Display

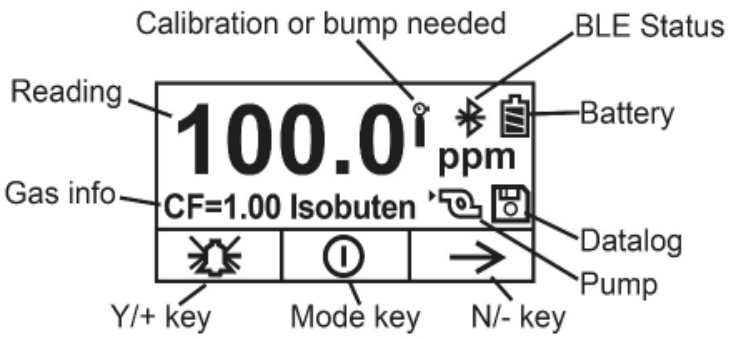
The display shows the following information:



Gas info	Tells the correction factor and type of calibration gas
Reading	Concentration of gas as measured by the instrument
Calibration needed	Indicates that calibration should be performed
Calibration (or bump) needed	Dark icon indicates that calibration should be performed; light icon indicates bump should be performed
Radio power	Indicates whether Mesh radio connection is on or off
Radio signal	Indicates signal strength (more bars = greater strength)
Battery	Indicates levels in 3 bars
Pump	Indicates pump is working
Datalog	Indicates whether Datalog is no or off
Y/+	Y/+ key function for this screen
MODE	MODE key's function for this screen
N/+	N/+ key's function for this screen

Note: The Radio power icon and radio signal icon are only shown if a Mesh radio is installed in the instrument. If the instrument has a BLE radio, the Bluetooth icons shown below are shown.

If the instrument is equipped with BLE instead of wireless, the BLE status icon is shown.



Icons

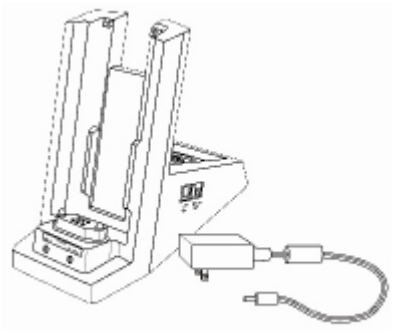
These are the icons shown on the display to indicate functions or status.

✓	The instrument has been bump tested and calibrated in compliance with the policy settings
	Battery level
	Charging error
	Calibration required
	Bump test required
	Datalog on
	Radio Power
	Radio signal
	Pump operational
	Pump blocked or stalled
	BLE status: Installed, Connected, Turned Off

Charging the instrument's battery

Always fully charge the battery before use. Contacts on the bottom of the instrument meet the Charger Stand's contact pins, transferring power. Make sure the charger is firmly attached. Then connect the AC Adapter's plug to the charger and plug its transformer into an AC outlet. While charging, the LED on the cradle glows red. When the battery is fully charged, the LED glows green.

Put the instrument into the charger stand, the instrument faces out, and end down, by pushing down and backwards at the same time so the mid-way section of the devise can click into a clamp down bracket at the top of the stand.



Charger Stand

When the instrument is charged, and you want to release the instrument you push down on the devise in the charger stand and at the same pull the instrument out to release it from the mid-point where it is attached and from its charger stand.

Personnel are to have read the Dealing with Ammonia Safe Operating Procedure and adhere to RPE and PPE requirements before undertaking atmospheric readings and associated activities.

Site: _____ **Location:** _____

Process Equipment-System: _____

Ammonia Atmospheric Measurement Form

Date:	Day/Night Shift:	Measurements performed by:

Reason for test:

Ammonia: (25 ppm 8hr TWA) (12.5 ppm 12hr TWA) (35 ppm 15min STEL)	**Reading 1**	**Reading 2**	**Reading 3**	**Reading 4**	**Reading 5**	**Reading 6**
Ammonia Readings (a)						
Time readings taken:						
Ammonia Readings (b)						
Time readings taken:						
Ammonia Readings (c)						
Time readings taken:						
Ammonia Readings (d)						

Appendix 3: Ammonia Vapour Measurement Form

Note: The below form is to be retained and readings recorded into the sites Health Hazards Register. Contact Chris Berry cberry@toddenergy.co.nz for locations of the registers.

Link to registers: Health Hazards Register

Time readings taken:						
Analyser Name &						
Serial No						
Weather conditions: (Sun, rain, wind – Light, Moderate, Strong & direction)						
Comments on any readings:						

Appendix 4: TWA Exposure Limits Conversion for 12-hour shift

WorkSafe Guidelines, New Zealand Workplace Exposure Standards (WES) for Ammonia are:

- 25 ppm - 8-hour Time Weighted Average (TWA)

On Todd Energy site, work is usually conducted over 12-hour shifts. To obtain a 12h WES-TWA an adjustment using the Brief and Scala model is used:

$$\text{WES-TWA} = \frac{8 \times (24-12) \times \text{WES-TWA}}{16 \times 12}$$

In this case = 12.5 ppm for 12-hour Time Weighted Average (TWA)

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