THE LINDE GROUP



EDN[™] Fumigas Introduction. Biosecurity Treatments 2014 Methyl Bromide and Alternatives Conference.

Chris Dolman – Global Business Manager,

Contents



- Fumigant Registration
- What is EDN Fumigas?
- Global Registrations
- Personal Protective Equipment (PPE)
- Product Stewardship
- Training & Support
- Timber Applications & Efficacy
- Soil Applications & Efficacy

Fumigant Registration

THE LINDE GROUP

Worker& Bystander Exposure



A History of EDN Fumigas

C THE LINDE GROUP

- Thirty years ago, CSIRO, sought funding for Methyl Bromide replacements
- Candidates were selected based on chemistry (e.g. persistence) as well as toxicology
- The initial chemicals had limited ability to control fungi, bacteria, viruses and weeds

• This meant there were gaps in terms of Methyl Bromide replacements for both soil fumigation as well as timber and log exports

And EDN Fumigas was born...



EDN Fumigas Key Features

THE LINDE GROUP

EDN Fumigas is 100% ethanedinitrile

- No known green house gas or ozone depleting properties
- A "drop in" Methyl Bromide replacement

Timber Specific

- Quicker fumigation (10 hours) for a range of timber pests
- Higher toxicity to timber pests than methyl bromide controls both surface and cryptic timber insects
- Superior penetration both across and along the timber grain (in wet and dry timber)
- Scrubbing technology available to enhance user and bystander Safety

Soil Specific

- Highly toxic to insect, nematodes, pathogens and weed
- Pre-plant solution to manage risks and protect investments
- Shorter plant-back period than methyl bromide for easier planning and greater productivity

EDN FUMIGAS Proposed Label



• Initially the focus of EDN FUMIGAS is exported (including inter-country) timber and pre-plant soil

Situation	Pests	Rate	Comment
Strawberries - Runners - Fruit	Pathogens, weeds and insects	150 - 500 kg/ha for 24 hours varied by soil type	Data for further crops in development (tomato, cucurbits, cut flowers, melons, egg plant, etc). Focus on high value crops.
Timber and logs for export	Insect pests and pathogens	50g/m3, 6 - 10 hours	Data for a range of insects including surrogate insects where high numbers are hard to find

• Linde has achieved the timber and log registration in Australia with further registrations pending

EDN Fumigas PPE





- AT Linde safety is our number one priority and we recommend the following PPE
- Full face respirator with cartridge suitable for organic vapour
- Long sleeved, flameproof shirt & trousers or coveralls
- Safety gloves
- Safety shoes / boots

EDN Fumigas PPE (continued)

THE LINDE GROUP

Personal Protective Equipment (PPE) is key for all fumigants

3M Mask Filters

- Filters with carbon impregnated with specific metal salts remove ethanedinitrile
- 3M "Multi-gas" and ABEK-type filters incorporate such carbon
- Three filters may be use successfully (6006, 6059, 6099)



Safety & Dosing Monitors

- Linde have worked with Spectros to creating a dosing monitor
- Monitors are also available for personal safety (depending on the ppm level required)







Product Stewardship



BOC have a product stewardship program for sensitive products such as fumigants

A key element is ensuring our customers are set up to manage the product safety and effectively

All new customers must complete risk assessments as well as be trained to use EDN Fumigas



Training & Support



- Linde has experts situated around the world
- Support is available with trials
- Training is also available as part of our Product Stewardship Program
- Engineering support is available for application equipment



Timber Efficacy and Application





EDN Fumigas Application

C THE LINDE GROUP

- Unlike MeBr no vaporiser is required (boiling point: 21°C)
- Product fills the container uniformly when applied through natural drafts within the structure (a FLP fan may be used)
- Linde recommend the application line is purged with Nitrogen after application
- Some registrations will require a scrubber post fumigation
 - This is common for many fumigants and may be related to sensitive populations
 - We are working with Nordiko in Asia Pacific





EDN Fumigas Efficacy

C THE LINDE GROUP

- Trials have been conducted in China, South Korea, Malaysia, Australia & New Zealand
- More trials are expected throughout the Asia Pacific region
- Timber pests controlled to date include

Insects

 European house borer (Hylotrupes bajulus), Asian Long Horn Beetle (Anoplophora glabripennis), Japanese pine sawyer larvae (Monochamus alternatus), Termites (Coptotermes acinaciformis, Coptotermes brevis, Cryptotemes brevis, Mastotermes darwiniensis, Cryptotemes brevis), Bark-Borne Burnt Pine Longhorn (BPL) (Arhopalus ferus (Mulsant)), Reticulitermes speratus, Tomicus piniperda and Hyphanria cunea

Pathogens

• Ganoderma applanatum, Splitgill (Schizophyllum commune)

Nematode

• Pine wilt disease (Bursaphelenchus xylophilus)



EDN Fumigas : DAFF & Murdoch University

C THE LINDE GROUP

Name: Comparison of EDN with MeBr as a biosecurity fumigant for timber and log

Background

- Developed by the Department of Agriculture(DoA) and Murdoch University
- Timber pests are difficult to obtain in large numbers
- Surrogate insects based on order groups allowing large numbers of insects (5-10,000)
- DAFF will be using this data to approve EDN Fumigas for imports and discuss exports with Australia's trading partners





EDN Fumigas : DAFF & Murdoch University

C THE LINDE GROUP

3 Stage Testing process

- 1. Determine dose/response to establish kill concentration (Complete)
- 2. Assess cross grain penetration of EDN in parallel with MeBr (Complete)
- 3. Commercial testing of logs (50% loading factor) (end of May)

Insects & Relatives

- Selected pests provides broad coverage to beetle Order Coleoptera e.g. powder post beetle, Asian long horn beetle, European house borer and burnt pine long horn beetle
- Cigarette beetles, rust red flour beetle, warehouse beetles were selected because their adults or pupae or larvae or eggs have a high tolerance to methyl bromide
 - Lasioderma serricorne (Cigarette beetle)
 - Sitophilus oryzae (Rice weevil)
 - Trogoderma variable (Warehouse beetle)
 - Rhyzopertha dominica (Lesser grain borer)
 - Tribolium castaneum (Rust red flour beetle)



THE LINDE GROUP

Name: Material damage assessment of EDN to apply cultural assets in Korea





Damage Assessment

- Slight on copper, silver, copper, cotton
 Insects Controlled
- Termite (Reticulitermes speratus) Pine shoot beetle (Tomicus piniperda) and Fall web worm (Hyphanria cunea)

EDN Fumigas : Plant & Food Research NZ

THE LINDE GROUP

- Linde is working with STIMBR and Plant & Food Research in New Zealand to • establish EDN Fumigas as a replacement for Methyl Bromide
- 1 a) Finding: Sorption has a greater relationship with the loading factor than moisture content in timber
- 1 b) In process: Sorption for a commercial fumigation of kiln dried timber
- 1 c) In process: Desorption study to establish accurate aeration standards
- 1 d) In process: Sorption for wet logs
- 2 a) In process: Efficacy data on all life stages of Arhopalus ferus





New Zealand's Methyl Bromide Use

EDN Fumigas : Indonesian Research Plan

C THE LINDE GROUP

- EDN Fumigas is in the registration process in Indonesia
- Working with PT Biosecurity the following research protocol will be completed
- The key pest is the Dry wood termite (cynocephalus cryptotermes) all life stages
- The results will support the use of this fumigant in the timber export trade



Wood Stack Worker Exposure Trial









Soil Efficacy and Application





EDN Fumigas Application



- The fumigant is into the soil pre-planting for disease and weed control
- This supports the intensive farming required for feeding a growing population
- There are two methods of application (Chemigation and Shank Injection)







Over 50 trials conducted in Israel, Turkey and Australia

Key Crops of interest

• High value crops are the focus: nursery stock, strawberry (runners & fruit), cut flowers, tomatoes, cucumber, water melons, egg plant, pepper, ginger

• Treatment must be under plastic for all crops (for efficacy and safety)



Key Pests

THE LINDE GROUP

Trials on pests have been conducted in the lab and in the field

Key Pests of interest

• Includes some biosecurity pests – weed seeds, nematodes and pathogens

• Key weed seeds: Poa annua, Spergula arvensis , Agrostis tenuis, Raphanus raphanistrum Conyza Canadensis, Lolium sp. Solanum nigrum, Amaranthus retroflexus, Portulaca oleracea, Orobanche aegyptiaca, Cyperus rotundus

• Key pathogens: Pythium ultimum, Phytophthora cactorum, Fusarium oxysporum, Rhizoctonia fragariae, Schlerotium rolfsi, Pythium sulcatum, Rhizoctonia solani, Fusarium acuminatum, Phytophthora cactorum, Phytophthora cryptogea, Bipolaris soroikiniana

Key nematodes: Meloidogyne spp., Steinernema spp., Pratylenchus sp. Helicotylenchus dihystera, Rotylenchulus parvus, Criconemella sp



23

Shank Injection Worker Exposure trial





Chemigation Worker Exposure Trial











Future Developments

THE LINDE GROUP

Trial work continues on new commodities and pests

Potential Markets

- Fresh Fruit disinfestation e.g. Apples
- Fruit fly on a range of produce
- Grain and oil seed commodities
- Grain devitalisation
- Where do you think it fits????



Questions?



Visit our Linde Crop Science Website (<u>http://cropscience.linde-gas.com</u>)

This site includes

- Product labels & registrations
- Product fact sheets
- Case studies
- Product stewardship information
- Contact details to request more information

EDN™ Fumigas are registered trademarks of The Linde Group



Questions?





Question 1



The active ingredient of EDN Fumigas is

- a) Ethanedinitrile
- b) Formic acid
- c) Hydrogen Cyanide
- d) Carbon Dioxide



Which of the following PPE is recommended by Linde?

- a) Full face respirator with cartridge suitable for organic vapour
- b) Long sleeved, flameproof shirt & trousers or coveralls
- c) Safety gloves
- d) Safety shoes / boots
- e) Safety Monitor
- f) All of the above





The TWA-TLV over 8 hours period for ethanedinitrile is

- a) 10 ppm
- b) 5 ppm
- c) 50 ppm
- d) 100 ppm

→ EDNTM FUMIGAS manual for fumigation





EDNTM FUMIGAS fumigant. Manual for fumigation.

Contents.

Important notice

1. Introduction	4
2. Product stewardship	1
3. Background	1
4. Physical and chemical properties	6
5. Safety	-
General	
5.1 Toxicity	Ţ
5.2 Flammability	Ţ
5.2.1 Fire prevention 5.2.2 Fire fighting	
5.3 Safety equipment	8
5.3.1 Full-face respirator 5.3.2 Self-contained breathing apparatus (SCBA 5.3.3 Gas detection systems	.) :
5.4 Material compatibility	5
5.5 Public safety	5
5.6 Personal safety	5
5.7 Confined spaces hazard	9
5.8 Handling emergencies	9
5.9 Emergency procedures	9

6. Legal requirements	10
7. Environment	10
8. Cylinder safety	11
8.1 Cylinder storage	11
8.2 Cylinder transport	11
8.3 Cylinder leaks	11
9. EDN FUMIGAS efficacy	12
9.1 Mode of action	12
9.2 Dose calculation	12
10. Application technology	13
10.1 Basic fumigation set up	13
10.2 Fans	13
10.3 Temperature control	13
11. Fumigation preparation	14
11.1 Risk assessment	14
11.2 Fumigation chamber	14
11.3 Leak testing	15
11.4 Monitoring hoses	15
11.5 Placarding and securing fumigated areas	15

12. Monitoring equipment	16
13. Monitoring frequency	16
14. Fumigation	17
15. Preparing for ventilation	17
15.1 Natural ventilation	17
15.2 A scrubbing unit	17
16. Troubleshooting	18
16.1 Valves	18
16.2 Cylinder condition	18
16.3 Failure to control the target pests	18
16.4 Non-target organisms	18

Important notice.

This manual for fumigation is intended for training purposes only

The purpose of this manual is to provide general instructions for the application of EDN[™] FUMIGAS. This information is provided for guidance only. It is not intended to replace the registered product label. Compliance with the product label is a legal requirement and failure to comply can result in prosecution. We make no warranties expressed or implied and assume no liability in connection with the use of this information. Users are responsible for ensuring full compliance with the applicable registered product label as this is a legally binding document. For further support, please contact your local Linde supplier. Fumigant registration is country-specific. In the US, it is a violation of federal law to use this product in any manner inconsistent with its labelling. Read the entire label before using this product. If the terms and conditions are unacceptable, return the unopened container at once. Please refer to your local Linde representative for information on the registration status in your region. For use by certified fumigators using Linde-approved dispensing equipment and re-capture equipment if required.

Linde reserves all rights to the contents of this document. No part of the document may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without the prior permission of Linde.

In case of emergency, call the customer service number on your local label.

1. Introduction.

EDN FUMIGAS is a fumigant used by professional fumigators for the eradication of insects, fungi and nematodes in timber products ranging from fresh logs to sawn timber. EDN FUMIGAS has no ozone depleting properties and no known global warming potential. The active constituent, ethanedinitrile, is a colourless, flammable, toxic gas at room temperature and atmospheric pressure with a characteristic almond-like odour.

2. Product stewardship.

Linde is committed to responsible care during the manufacture, distribution, handling, use and disposal of its products. This commitment includes training and auditing customers to ensure that they are set up to use the product safely and comply with the relevant regulatory requirements and standards. Supply of this product is subject to customer screening checks. Contact your local Linde representative for further details.

3. Background.

EDN FUMIGAS was developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia as a replacement for the ozone depleting methyl bromide. Ethanedinitrile is a cyanide derivative. Many naturally occurring cyanides are found in nuts, sorghum, cassava and stone fruits.

EDN FUMIGAS is a liquefied gas.

Constituent Name	CAS Number	
Ethanedinitrile	460-19-5	

4. Physical and chemical properties.

EDN FUMIGAS has the following chemical properties:

Appearance	Colourless gas	
Odour	Almond-like	
Volatiles	100%	
Relative density (air=1)	1.8 @ 101.325 kPa @ 20 °C	
Boiling point	-21.17 °C @ 101.325 kPa	
Flammability	Ethanedinitrile is classified as an extremely flammable gas with a flammability range of	
	3.9% to 32%.	
Liquid mixture in cylinder	Withdrawn as a liquid and vaporised at temperatures above -21.7 °C	
Solubility (in water)	4500 ml gas in 1.0 L water @20 °C @101.325 kPa	
Molecular weight	52.031 g/mol	
Chemical structure	$N \equiv C - C \equiv N$	
Chemical formula	$\overline{C_2N_2}$	
Cylinder pressure (when full at 25°C)	5.16 bar	
Hazchem code	2PE	
Dangerous goods	2.1	
UN number	1026	

See below example of EDN FUMIGAS cylinder label. Please refer to your local label for the details specific to your region.

1 UN No. poison identification number 2 Customer service number 3 BOC gas code 4 Hazard warning diamonds 5 Product weight



5. Safety.

EDN FUMIGAS is for use by certified fumigators using Linde-approved equipment and people under their direct supervision.

General

- 1. Carefully read the Material Safety Data Sheet, container label and product specimen label and follow instructions explicitly.
- 2. Never work alone when applying fumigant from within the storage structure (if re-entry is required) or aerating commodities after the fumigation is over.
- 3. Never allow untrained personnel to handle EDN FUMIGAS.
- 4. The use of respiratory protection is required if ethanedinitrile exceeds 10 ppm, although this may differ by region. Please consult your local label for more information.
- 5. Prior to EDN FUMIGAS application place placards on fumigated areas, including all entrances and exits. Ensure that no personnel are inside any of the structures to be fumigated prior to initiating fumigation.
- 6. Notify appropriate owners, employees and/or operators at the facility each time prior to initiating fumigation and provide relevant safety, health and environmental information to local fire and rescue officials annually for use in the event of an emergency.
- Do not connect containers to dispensing equipment until all fumigation notice placards have been posted and the space to be fumigated is clear and secured.
- 8. Wear protective clothing and respiratory protection equipment as described in this fumigation manual.

Fumigators must comply with the relevant governmental regulations for fumigation when using EDN FUMIGAS.

General safety guidelines are provided in this EDN FUMIGAS Fumigation Manual. The following paragraphs identify the main hazards that should be taken into consideration when working with EDN FUMIGAS. A proper risk assessment and fumigation management plan should be carried out in relation to both the specific conditions where the operations are performed and the possible emergency situations which may occur.

5.1 Toxicity

Exposure standards for ethanedinitrile, the active ingredient in EDN FUMIGAS, is TWA = 10 ppm (or 21 mg/m³) (NOHSC) (http://www.cdc. gov/niosh/npg/npgd0161.html). This may differ by region, so consult your local label for more information.

TWA-Time Weighted Average: The average airborne concentration of a particular substance when calculated over a normal eight hour work day for a five hour working week.

The maximum allowable exposure level for ethanedinitrile in the working atmosphere (8 hour shift, 40 hour week) is 10 ppm.

Test animal	Route	Lethal dose or concentration
Rat	Inhalation	LC_{50} 750 mg/m ³ (350 ppm) for
		1 hour (McNerney and Schrenk,
		1960)
Rat	Oral	LD ₅₀ 8 mg/kg (NaCN) bw
		(Smyth et al., 1969)

Short term (acute) exposure & first aid

In the unlikely event of an individual being unconscious or not responding, ensure that you are safe before attempting a rescue. The appropriate personal protective equipment should be used (coveralls, full-face respirator with ABEK1 combination or self-contained breathing apparatus (SCBA) or an air-line respirator).

Inhalation

Inhalation is the primary route of exposure. Humans exposed to 16 ppm of EDN have felt eye and nasal irritation (McNerney and Schrenk, 1960). Monitors should always be used to ensure safe levels are not exceeded.

If inhaled, remove from contaminated area. Apply artificial respiration if not breathing. Give oxygen if breathing is difficult. Seek immediate medical attention. For advice, contact a Poison Information Centre (see Material Safety Data Sheet) or a doctor.

Skin contact

Cold burns: Remove contaminated clothing and gently flush affected areas with warm water (30 °C/85 °F) for 15 minutes. Apply sterile dressing and treat as for a thermal burn. For large burns, immerse in warm water for 15 minutes. DO NOT apply any form of direct heat. Seek immediate medical attention.

Eye contact

Cold burns: Immediately flush with tepid water or with sterile saline solution. Hold eyelids apart and irrigate for 15 minutes. Seek medical attention.

Ingestion

Ingestion is not considered a potential route of exposure.

5.2 Flammability

EDN FUMIGAS is flammable and will ignite in the presence of a spark or open flame or other ignition sources within its flammable range. Do not use or store near heat or an open flame. Do not puncture or incinerate the container. Store tightly sealed containers in a cool dry area.

The registered dose rates for timber and log fumigation may differ by country (please see your local label) but will generally be less than 2.31% by volume, which is less than 75% of the LEL limit. Ethanedinitrile is a flammable gas with its flammability range in air 3.9 vol% (LEL)–32 vol% (UEL) at 15 °C.

Flammability may be managed by a range of measures:

- The use of flameproof equipment e.g. fans or heaters
- Potential ignition sources (e.g. fans) to be introduced only if the ethanedinitrile level is 25% of the LEL (<0.975 vol%.)

5.2.1 Fire prevention

The dosing equipment must be suited to a potentially explosive atmosphere according to the relevant regulation. The fumigation chamber must be equipped with explosion-proofed devices where these are needed in the chamber, e.g. lighting, fan, heater, etc. according to the relevant regulation. Any potential ignition sources not needed during or after the fumigation process must be eliminated/removed.

All equipment is to be earthed (grounded) as a precaution against build-up of static electricity (ignition source). Feed lines/pipes must be regularly cleaned and maintained.

5.2.2 Fire fighting

Extreme temperatures caused by a fire may cause cylinders to rupture. The fire service should be notified when cylinders have been involved in a fire. Cylinders can be cooled by applying water from a protected location. Do not approach any cylinders suspected of being exposed to high temperatures.

5.3 Safety equipment

Protective clothing should be worn during the fumigation process to ensure worker safety. Where the TLV is exceeded for ethanedinitrile (10 ppm or lower as per your local Material Safety Data Sheet), respiratory protection must be worn. A full-face respirator (with an appropriate ABEK1 combination filter) or self-contained breathing apparatus (SCBA) must be worn where the TLV is exceeded. Gloves, goggles, steel capped safety boots and earplugs are also recommended by Linde.

Linde can supply a wide range of safety equipment.

5.3.1 Full-face respirator

Linde recommends the use of an appropriate ABEK1 combination respiratory filter cartridge where ethanedinitrile levels are found above 1 ppm (or the level shown on your local Material Safety Data Sheet). The recommendations of the filter manufacturer regarding best practice for cartridge use and maintenance should be followed.

5.3.2 Self-contained breathing apparatus (SCBA)

Self-contained breathing apparatus may also be used where ethanedinitrile levels are found well above 10 ppm (or the level shown on your local Material Safety Data Sheet). Ensure that the SCBA manufacturer's instructions are followed when using SCBA.

5.3.3 Gas detection systems

Personal exposure monitoring must be conducted by using a gas detection monitor or detection tubes. These devices must be able to detect ethanedinitrile in the range of 1-10 ppm.

5.4 Material compatibility

When using EDN FUMIGAS, care must be taken to ensure that compatible materials are used in both the fumigation chamber and the application equipment. A guide for suitable materials is shown below:

Material	Good	Fair	Avoid
Aluminium	X		
Buna N			X
Brass			X
Butyl rubber			X
Carbon steel		X	
Kel-F	X		
Neoprene®	X		
Polyethylene	X		
PVC	X		
Stainless steel	X		
Teflon®	X		
Viton®	X		

5.5 Public safety

When fumigating in or adjacent to a public area, fumigators must be aware of the potential dangers and their (legal) responsibilities in this area.

When assessing a fumigation site, a fumigant management plan covering the safety of the technician, the customer and his staff and the general public should be carried out on the particular job, and procedures modified where necessary to reduce these risks to an acceptable level.

5.6 Personal safety

The risk of exposure to gases like ethanedinitrile which have defined occupational exposure limits and the risk of explosive atmosphere creation are the most obvious and important issues to manage. Good monitoring of the fumigation site and the enclosure is the best way to control this risk.

09

5.7 Confined spaces hazard

Access to and working in confined spaces is covered by legislation in many cases.

As a general rule, for any entry or work in a confined space, a particular risk assessment must be carried out and a permit to work used to ensure a safe working environment.

When fumigating, a technician may encounter various types of confined spaces:

- A chamber used for fumigation
- A cavity, drain, sub floor area, roof void contained in or adjoining a fumigation area.

It is also very important when fumigating to be aware of:

- Low oxygen atmospheres (particularly when using controlled atmospheres) and the need for a complete aeration of the fumigation area post-treatment. A minimum of 19.5% oxygen is required in a workspace at all times and this needs to be confirmed by monitoring
- Working around ducts and drains when sealing a fumigation enclosure
- Working around power lines during sheet fumigation
- Working near potential heat sources.

5.8 Handling emergencies

Whilst no fumigator wants to experience them, emergencies do happen!

An emergency is experienced when a normally controlled system breaks down for whatever reason. Surprise, danger and often confusion accompany this breakdown. To add to this, personal injury is also common.

A cool head is required when all this happens suddenly, and so the most important response to an emergency is rehearsed calmness together with immediate action.

Train for emergencies and draw up procedures based on a risk assessment of the type of jobs being done so that if an emergency happens, you know what to do and are in a position to make the right decisions.

5.9 Emergency procedures

Draw up emergency and operational procedures to cover any risk or hazard relating to a risk that you have identified. For example:

- A person affected by fumigant (the hazard) exposure
- A person injured by a fall (the hazard is the height)
- Pets injured during fumigation
- Property damage
- \cdot Handling the media

When planning to prevent a potential emergency, you may need to consider:

- · What would the effect of the weather be?
- Are you near a main road or other public area? Traffic accident risk exposure of drivers to fumigant.
- Will you need to use access equipment?
- Will you need to involve police/ambulance/emergency services?
- What are the risks of personal injury?
- What is the risk of property damage?
- What is the risk of damage to a valuable commodity?

6. Legal requirements.

Governmental pesticide legislation deems it an offence to use a fumigant in a way that is likely to cause injury to another person or harm a nontarget plant or animal. It is a legal requirement to read and to follow the instructions on the label of a registered pesticide.

In addition to this, Occupational Health and Safety legislation requires that employers provide a safe work environment that includes adequate training, supervision, safe work practices and provision of appropriate personal protective equipment. Material Safety Data Sheets must be held for all registered pesticides (including EDN FUMIGAS), and these should be made available to anyone who has been exposed. The MSDS must be readily available at all times as it contains vital information for use in emergencies.

7. Environment.

EDN FUMIGAS is non-ozone depleting and has no known global warming potential. As such, it is more environmentally friendly than a number of conventional fumigants.

11

8. Cylinder safety.

EDN FUMIGAS cylinders must be properly labelled with Linde product specimen labels. EDN FUMIGAS is supplied in high pressure cylinders in a range of sizes to meet customer portability and volume requirements. Best practice guidelines for the transport, storage and handling of gas packages should be followed at all times to ensure the health and safety of all users/operators.

8.1 Cylinder storage

EDN FUMIGAS should not be stored near combustible or incompatible materials. Cylinders should be stored below 45 °C in a dry, well-ventilated area on a firm level floor. All cylinders should be secured to prevent them from falling over.

8.2 Cylinder transport

During transport, the following principles should be followed. Cylinders should:

- be transported upright
- be secured
- have their valves protected
- · be separated from the driver
- have the appropriate placards displayed

Visit your local Linde website for more information.

8.3 Cylinder leaks

In the unlikely event of a cylinder leak, follow emergency procedures, evacuate personnel within the area, and contact your local Linde representative. Linde will then confirm the best action based on your individual situation. Refer to your local label for contact information.



The safety data sheet informs users about chemical and physical properties of a material and its generic use, provides advice on the safe handling, storage, transport, use and disposal of the material, provides information about the health effects, exposure control, environmental effects and emergency procedures.



Cylinder valves must be protected against damage by screwing on cylinder caps.



Road vehicles are only suitable for transporting gas receptacles if the receptacles can be reliably secured to prevent them rolling away or falling.



Road vehicles are only suitable for transporting gas receptacles if they can be suitably ventilated.

9. EDN FUMIGAS efficacy.

Linde, in conjunction with numerous partners, has conducted a number of studies with EDN FUMIGAS. This has enabled Linde to create a comprehensive label for timber treatments in a number of countries based on local conditions and pests of concern.

9.1 Mode of action

Ethanedinitrile enters the organism through inhalation or penetration through the cuticle and reacts with moisture (biological system), producing hydrogen cyanide and a cyanate ion. Cyanide targets cytochrome C oxidase (an enzyme in the mitochondrial respiratory chain) and prevents the tissue from using oxygen. This results in a reduction in oxygen sufficient to cause tissue damage throughout the body, with the most vulnerable tissues being those with high oxygen demands. The inhibition of oxygen use by cells causes oxygen tensions to rise in peripheral tissues. This results in a decrease in the unloading gradient for oxyhaemoglobin and death of the target organisms.

Below is the current registered use pattern – please ask your local representative for the most up-to-date label.

Situation	Pest	A
Timber and logs in a sealed fumigation	Fungi infesting timber	<u>ex</u> 50 6
chamber	Insect pests for	50
or in shipping	timber	1(
containers sealed		
under tarpaulins		
or as stacks sealed		
under tarpaulins		

Application rate & exposure time 50g/m³, 6 hours exposure 50g/m³, 10 hours exposure

9.2 Dose calculation

Dose rate is calculated by determining the volume of the empty fumigation area in cubic metres and then applying EDN FUMIGAS by weight. The treatment chamber must remain completely sealed for the recommended exposure period to allow EDN FUMIGAS fumigant to work.

An example is provided below for timber fumigated in a 20 foot (33 m^3) container.

Container volume Recommended dosage EDN FUMIGAS required

- = 33 m³
- = 50 g/m³ (24 hours exposure)
- = Dose x volume
- $= 50 \text{ g/m}^3 \text{ x } 33 \text{ m}^3$
- = 1.65 kg EDN FUMIGAS
- (to be applied by weight)



10. Application technology.

Successful fumigation is reliant upon the fumigator applying EDN FUMIGAS using appropriate application technology. This may differ by country so please check your label in advance.

10.1 Basic fumigation set up

To apply EDN FUMIGAS in a fumigation structure, compatible material must be used for the pipework e.g. stainless steel or Polyethylene tube (see section 5.5). A weighing scale must be used to apply the product to ensure the correct dose rate is achieved (see figure 1 below).



Figure 1: Basic EDN FUMIGAS fumigant application diagram

Multiple distribution lines within the fumigation structure may be used to help spread the fumigant within the structure. An example of a manifold is shown in figure 2. A fan may also be required depending on your local fumigation standard. The fumigation distribution lines should be purged with nitrogen prior to disconnection.



Figure 2: Manifold with unequal length of gas piping

10.2 Fans

Flameproof fans may be used in large fumigation chambers to ensure that EDN FUMIGAS fumigant is distributed evenly throughout the chamber. The fan is switched on 10–15 minutes before the gas is introduced and 30 minutes after application, or until an equilibrium is attained. For large structures like tarps, recirculation fans can be installed as an integral part of a permanent fumigation facility. Fans must be flameproof if used during application.

10.3 Temperature control

To ensure EDN FUMIGAS efficacy, the fumigation chamber must be maintained at a constant temperature equal to or above 15 °C. In colder climates, a heater may be required to maintain the required temperature during fumigation. Heaters must be flameproof if used during application.

Temperature is an important factor for successful fumigation. Insects are cold-blooded, so increasing the temperature increases the metabolism of an insect. Increasing the metabolism means increased respiration of the insect. This is mainly due to the increased rate of activity and respiration of insects in response to the rise in temperature. Relatively large changes in temperature are not required. Achieved temperatures of 15 to 30°C, for example, can have a very positive effect on fumigation efficacy and efficiency. Conditions for successful fumigation improve as the temperature rises.

11. Fumigation preparation.

EDN FUMIGAS fumigation must be conducted by a licensed fumigator. Safe work procedures, protective equipment and first aid procedures must be in place before the first fumigation.

Prior to fumigation, all people, non-target animals, desirable growing plants and medicine must be removed from the fumigation area.

Requirements for licensed fumigators to be present and responsible for all workers:

The responsible licensed fumigator must be physically present and maintain visual and/or voice contact with all fumigation workers during the application of the fumigant. Once the application is complete and the structure has been made secure, the licensed fumigator does not need to be physically present at the site.

The responsible licensed fumigator must be physically present and maintain visual and/or voice contact with all fumigation workers during the initial opening of the fumigation structure for aeration. Once the aeration process is secured and monitoring has established that aeration can be completed safely, the certified licensed fumigator does not need to be physically present and trained personnel can complete the process and remove the placards.

Persons with documented training in the handling of EDN FUMIGAS must be responsible for receiving, aerating and removing of placards from vehicles, transport containers and trailers that have been fumigated in transit.

Read all directions completely before use and follow all directions and precautions when using this product.

11.1 Risk assessment

A risk assessment should be conducted before the first fumigation to control any hazards that may adversely impact the fumigator, nearby residents and/or the environment. Appropriate control measures such as working and emergency procedures, personal protective equipment, etc. should be put in place and included in the fumigation plan/ documentation.

The risk assessment should consider the following hazards (as a minimum):

- Exposure to ethanedinitrile higher than the defined occupational exposure limits i.e. TLV-TWA, max. workplace concentration
- Fire/explosion
- Pressure release
- Cold burns
- Liquid trapped in pipes or equipment
- \cdot Hazards related to cylinder handling/storage

11.2 Fumigation chamber

Effective sealing of the fumigation chamber will reduce the need to apply additional fumigant as well as maintain a safe environment for those working in the general vicinity.

Leaks can be identified by carefully examining the fumigation chamber and associated application equipment. Particular attention should be paid to walls, roof, floor, door seals and pipework joints. Entry and exit points for fumigation and sample tubes should also be checked and sealed if necessary. Polyethylene sheeting, nonporous panels, fumigation tape, spray adhesives, foams and insulation materials can be used to help seal the fumigation structure.

If EDN FUMIGAS is used in shipping containers, best practice is to pressure test before the product is applied. Pressure testing can be performed using a compressed air supply from a portable compressor or gas cylinder into the closed container at a pressure up to 250 Pa. When the pressure reaches 250 Pa, turn off the compressed air supply and allow the pressure to decay to 200 Pa. Then start measuring the time from 200 Pa to 100 Pa. Record the pressure decay time. The pressure decay time should be 10 seconds or more. If the container does not pass the pressure tests, it must be enclosed under a gas-proof sheet before fumigation.

Sand or water snakes should be used for gas-proof sheet fumigation. A single continuous water snake (75%–85% fill) should be used to create a continuous seal with the ground surface. Please check your local regulations for further requirements.

Do not introduce EDN FUMIGAS into a vacuum chamber.

11.3 Leak testing

Personal protective equipment (respiratory protection) should be worn when leak testing. Leak testing procedures should be followed to verify the integrity of all components, lines and connections. Leak tests are conducted by passing an inert gas (nitrogen) through the system and spraying leak detection fluid (soap/water solution) on all joints and outlets. The appearance of fine bubbles indicates the presence of a leak.

11.4 Monitoring hoses

To monitor concentrations of EDN FUMIGAS in the fumigation chamber during exposure and ventilation periods, gas sampling lines (3 mm) may be installed. For large volumes (above 20 m³), three sampling lines can be used (sample line 1: top rear headspace of the chamber/container, sample line 2: middle of the chamber/container, sample line 3: bottom/ front of the chamber/container). Each sample line can be colour coded to avoid confusion while sampling.

The EDN FUMIGAS levels inside the container/chamber need to be checked for equilibrium 15 or 30 minutes after application. If the dose rate from the three sampling points is close to the recommended dose rate, the treatment period will begin (the variation from the three points of gas samples within the shipping container should be less than 15%). If it is above 15%, then topping-up can be undertaken based on the dose required to compensate the loss.

11.5 Placarding and securing fumigated areas

A hazard zone must be identified and maintained in accordance with the relevant national standards. The zone should be marked with high visibility barriers/tape, and the area monitored to prevent unauthorised entry. Unauthorised/unprotected persons should be kept outside the hazard zone until the concentration of ethanedinitrile has reduced to the safe levels defined on the label.

The following placards should be prominently displayed at all approaches to the hazardous area prior to fumigation:



Do not remove placards until fumigation and ventilation are complete and fumigant concentrations have reduced to safe levels. Above is an indicative sign – please refer to your local regulations.

"Signal Word" placards may vary from one country to another depending on local regulations.

The buffer zone required for EDN timber or log fumigation is 50 m (Australia only). Contact your local authority for buffer zone requirements.

12. Monitoring equipment.

The safe application of EDN FUMIGAS requires the monitoring of ethanedinitrile for both fumigation as well as safety during the ventilation period. In summary, concentration must be monitored during fumigation to ensure a successful fumigation as well as to ensure that the TLV (or labelled bystander level) is not exceeded in the surrounding areas.

Use an appropriate detection device or detection tube where deemed appropriate. Contact your local Linde representative for more information.

13. Monitoring frequency.

EDN FUMIGAS concentration in the fumigation enclosure should be monitored on at least two occasions during the fumigation exposure period, i.e. at the start and at the end of the fumigation exposure period. The fumigator should make sure that equilibrium is attained at the start of the fumigation.

14. Fumigation.

EDN FUMIGAS is delivered under pressure into the fumigation structure. Effective results depend on the required concentration of EDN FUMIGAS being maintained for the time specified in the directions for use. This requires the fumigation enclosure to be gas-tight.

Mechanical mixing by flameproof recirculation fans will ensure that the EDN FUMIGAS reaches equilibrium within the fumigation chamber as quickly as possible.

The exposure time for fumigation should not start until equilibrium has been achieved. To ensure compliance with relevant bio-security standards, records of times, concentrations, dates, exposure times and dosage should be maintained.

The fumigation area should be secure at all times, preventing unauthorised access. If the area cannot be physically secured, a watchman should be stationed to keep intruders out of the hazardous area in accordance with local standards. Complete control of listed pests may not always be achieved. Factors contributing to less than 100% control include gas leakage, poor gas distribution, unfavourable exposure conditions, etc. Improperly sealed areas may allow escape to non-fumigated areas. In addition, some insects are less susceptible to EDN FUMIGAS than others. To maximise control, extreme care must be observed in sealing, correct dosages must be used, EDN FUMIGAS levels should be measured within the chamber and if necessary topped up to ensure the correct concentration over time is maintained, proper application procedures must be followed, and temperature and humidity must be favourable.

The EDN FUMIGAS application temperature will vary depending on the commodity fumigated. This is attributed to crop safety and product efficacy. Please contact your Linde representative for optimal temperature recommendations for the commodity being treated.

15. Preparing for ventilation.

The chamber must be thoroughly ventilated of ethanedinitrile as determined by a detection monitor or detection tubes before out-loading or re-entry. EDN FUMIGAS may be vented to atmosphere naturally or pushed through a scrubber unit in accordance with local standards.

15.1 Natural ventilation

Prior to ventilation, all unauthorised persons should be cleared from the hazard zone. Persons remaining within the hazard zone must be equipped with personal protective equipment including appropriate respiratory protection.

Natural ventilation may be performed passively by allowing EDN FUMIGAS to escape from opened vents in the fumigation enclosure or by forced air movement using flameproof fans.

Ventilation is complete when the concentrations within the fumigation enclosure are less than the safe levels defined on the product label. This should be checked using the EDN FUMIGAS safety detection device.

Once the safe level has been reached, the hazard signs can be removed.

15.2 A scrubbing unit

A scrubber may be required to be used as part of the ventilation process. A scrubbing unit comprises a fan system that is used to pull the EDN FUMIGAS out of the fumigation structure when the fumigation is complete. This stream of fumigant and air is pulled into a chemical or other unit that breaks down or captures the fumigant, ensuring that zero or a nominal level of fumigant is released into the environment around the fumigation structure. This may differ by country or even within a country. Please check your label and your local government requirements in advance.

Ventilation is complete when the concentrations within the fumigation enclosure are less than the safe levels defined on the product label. This should be checked using the EDN FUMIGAS detection device.

Once the safe level has been reached the hazard signs can be removed.

16. Troubleshooting.

The information given here is of a generic nature and should only be used as a guide. For more information, contact your local Linde representative and/or refer to the EDN FUMIGAS MSDS.

16.1 Valves

EDN FUMIGAS cylinders are fitted with specialised valves that may be damaged if excess force is used to open or close them. Valves should be fully opened and then backed off by a ¼ turn. This helps to prevent the valve sticking open during use. Valves should be closed by hand – no special tooling should be used in the opening or closing process as this may damage the valve.

Stuck valve

Never use excessive force to open a valve as this will damage it. If a valve will not open or close using the maximum allowed torque, tag the valve appropriately and return the cylinder to Linde as faulty.

Leaking valve

Linde has strict quality control procedures for all cylinder packages. Despite this, a cylinder leak should be considered as part of the fumigation risk assessment. The MSDS should be referred to where human exposure takes place and the defective cylinder should be isolated in a safe area. Call your local Linde representative if assistance is required.

In case of emergency, call the customer service number on your local label

16.2 Cylinder condition

If the cylinder looks to have suffered some damage, care must be taken before continuing to use the cylinder. Call your local Linde representative if assistance is required.

16.3 Failure to control the target pests

EDN FUMIGAS efficacy data has been documented over many years, with much of the data appearing in peer-reviewed journals. This data is then reviewed by the regulatory authorities which have approved the EDN FUMIGAS claims. Where 100% mortality has not been achieved, one of the following factors may apply:

- The dosage recommended on the product label has not been followed
- The volume to be fumigated has not been calculated properly, leading to under-dosing
- Fumigation has not been maintained for the required length of time
- Failure of, poorly calibrated or inaccurate monitoring devices
- Loss of fumigant through leaks and poor sealing and confinement of fumigant
- Fumigation has taken place below the required temperature 15 °C or above
- High winds during fumigation can cause excessive loss of gas
- The dosage requirements vary for different pests

Linde is keen to work with customers to ensure successful fumigation. Where issues occur, contact your account manager.

16.4 Non-target organisms

After fumigation, there may be signs of non-target organism activity. This does not mean that the fumigation has failed, but may be a result of:

- Organisms may require higher dosage compared with the target organisms
- · Organisms may have received a toxic dosage and will eventually die
- The non-target organisms may have entered during the aeration period

Getting ahead through innovation.

With its innovative concepts, Linde is playing a pioneering role in the global market. As a technology leader, it is our task to constantly raise the bar. Traditionally driven by entrepreneurship, we are working steadily on new high-quality products and innovative processes.

Linde offers more. We create added value, clearly discernible competitive advantages and greater profitability. Each concept is tailored specifically to meet our customers' requirements – offering standardised as well as customised solutions. This applies to all industries and all companies regardless of their size.

If you want to keep pace with tomorrow's competition, you need a partner by your side for whom top quality, process optimisation and enhanced productivity are part of daily business. However, we define partnership not merely as being there for you but being with you. After all, joint activities form the core of commercial success.

Linde – ideas become solutions.

For more information about our fumigation solutions and details of current or pending regulatory tests and approvals, visit www.linde-gas.com/fumigants

