ATC

A SECTOR GROUP OF cefic

August 2004

2-Ethylhexyl nitrate (2EHN)

Best Practices MANUAL

Product Stewardship

Prepared by the 2EHN Industry Work Group (EHNIWG)

ATC Document 79

Copyright © (2004) ATC.

Index

Section 1:	PAGE
Introduction	**5**
1.1 Cetane Number Improver	5
1.2 EHN Industry Work Group	5
1.3 Product Stewardship	5
1.4 Customer Notice	5
1.5 Legal Notice	6
Section 2:	
Composition	**6**
Section 3:	
Hazard Identification	**7**
3.1 Emergency Overview	7
3.2 Potential Health Effects	7
3.2.1 Acute Health Effects	7
3.2.2 Chronic Health Effects	7
3.3 Environmental Hazards	7
3.4 Energetic Properties	7
Section 4:	
First Aid Measures	**8**
4.1 Inhalation	8
4.2 Skin contact	8
4.3 Eye contact	8
4.4 Ingestion	8
4.5 Notes to Physicians	8
Section 5:	
Fire Fighting Measures	**8**
5.1 Suitable extinguishing media	9
5.2 Special fire fighting procedures	9
5.3 Special protective equipment for firefighters	9
Section 6:	
Accidental Release Measures	**9**
6.1 Personal precautions	9
6.2 Environmental precautions	9
6.2.1 Small spillage	10
6.2.2 Large spillage	10
6.2.3 Spills onto water	10

Section 7:

Handling and Storage **10**
7.1 Handling 10
7.1.1 Materials of construction 10
7.1.2 Elastomers and Gaskets 10
7.2 Storage 10
7.2.1 Storage tanks 10
7.2.2 Heat protection 11
7.2.3 Venting 11
7.2.4 Containment wall or Bunding 11
7.2.5 Drum storage 11
7.3 Operations 11
7.3.1 Product sampling 11
7.3.2 Product handling - loading, unloading, pumping 11
7.3.3 Tank to tank transfer 12
7.3.4 Piping / Lines / Hoses 12
7.3.5 Valves 12
7.3.6 Equipment clean-up 12

Section 8:

Exposure controls and personal protection **13**
8.1 Exposure Limit values 13
8.2 Exposure controls 13
8.3 Personal Protective Equipment 13
8.3.1 Respiratory protection 13
8.3.2 Hand protection 13
8.3.3 Eye protection 13
8.3.4 Skin protection 13

Section 9:

Physical and Chemical Properties **14**

Section 10:

Stability and Reactivity **15**
10.1 Conditions to avoid 15
10.2 Materials to avoid 15
10.3 Hazardous decomposition products 15

Section 11:

Toxicological Information **15**
11.1 Acute Health Effects 15
11.1.1 Oral (ingestion) 15
11.1.2 Inhalation 15
11.1.3 Dermal (Skin) 16
11.2 Corrosivity/irritation 16
11.2.1 Skin 16
11.2.2 Eye 16
11.3 Sensitisation 16
11.4 Chronic Health Effects 16

Section 12:

Ecological Information 16

12.1 Ecotoxicity 16

12.2 Mobility 16

12.3 Persistence and degradability 16

12.4 Bioaccumulation potential 16

12.5 Other adverse effects 16

Section 13:

Disposal Information 17

Section 14:

Transport Information 17

Section 15:

Regulatory Information 18

15.1 EU Classification 18

Section 16:

Other Information 18

16.1 Training 18

16.2 Emergency Procedures for 2EHN 18

Appendix 1

Responsible Care® 19

Appendix 2

Explanation of the thermal ignition critical temperature. 20

Glossary 21

Section 1

Introduction



1.1 Cetane Number Improver

2-ethylhexyl nitrate (2EHN) is used to raise the cetane number of diesel fuels.

1.2 2EHN Industry Work Group (EHNIWG)

The 2EHN Industry Work Group (EHNIWG) was formed in 2002 by the Technical Committee of Petroleum Additive Manufacturers in Europe (ATC), an affiliate member of the European Chemical Industry Council (CEFIC). It comprised of several ATC member companies and included all the European and North American manufacturers of 2EHN, with additional input from the Oil companies' European association for environment, health and safety in refining and distribution (CONCAWE).

Members of the Industry Work Group were:

Associated Octel, Bergerac NC - Groupe SNPE, Chevron Oronite Co. LLC., Afton Chemical Corporation (formerly Ethyl Petroleum Additives, Inc.,), Exchem, Forcit, Infineum International Limited, Lubrizol, Nitron S.A. and UEE Chem, S.L.

The objective of EHNIWG was to develop an industry guidance document covering the Health, Safety & Environmental aspects and best practices for handling 2EHN.

This manual is intended to provide you with information you may wish to consider in establishing safe storage and handling systems.

You should always refer to the latest product Material Safety Data Sheet or Safety Data Sheets (MSDS/SDS's) from suppliers as these are updated on a regular basis as new health and safety information becomes available.

Whilst 2EHN is not classified as an explosive substance it demonstrates energetic properties. The manufacture of 2EHN needs to be carried out by companies with an expertise in organic nitration and production of nitrate esters.

Commercial product is supplied by manufacturers of 2EHN to the petroleum additive industry and the petroleum industry.

1.3 Product Stewardship

EHNIWG has a fundamental concern for all who manufacture and/or use 2EHN.

This concern is the basis for our Product Stewardship philosophy by which we assess the safety, health and environmental information on our products and take appropriate steps to protect employee and public health and our environment.

1.4 Customer Notice

EHNIWG strongly encourages the users of 2EHN to review their transportation, storage, use, and disposal of 2EHN from the standpoint of safety, human health and environmental quality.

EHNIWG and its member companies believe the information and suggestions contained in this manual to be accurate and reliable as of the date of issue of this document.

However, since this document, furnished by EHNIWG members is provided without charge and since transportation, conditions of use and disposal are not within its control, EHNIWG members assume no obligation or liability of any kind for such assistance and do not guarantee results from use of such products or other information herein; no warranty, expressed or implied is given nor is freedom from any patent owned by EHNIWG members or others to be inferred.

Information herein concerning laws and regulations is based on EU and North American regulations except when specific reference is made to those of other jurisdictions. Since conditions of use and governmental regulations may differ from one location to another and may change with time, it is the customer's responsibility to determine whether 2EHN is appropriate for the customer's use, and to assure that the customer's workplace and disposal practices are in compliance with laws, regulations, ordinances, and other governmental enactment applicable in the jurisdiction(s) having authority over the customer's operations.

1.5 Legal Notice

This manual was prepared by the EHNIWG. Neither the EHNIWG nor any of its member companies, their employees, subcontractors, consultants, or other assigns make any warranty, expressed or implied, or assume any liability or responsibility for any use, or the results of such use, of any information, product, or process disclosed in this Manual, or represent that its use would not infringe on privately owned rights.

The Manual is intended to provide helpful ideas for those involved in the manufacture and use of 2EHN. The Manual is necessarily general in nature and leaves dealing with product and site-specific circumstances to entities handling the product. The Manual is not designed or intended to define, create, or terminate legal rights or obligations.

The EHNIWG, including any of its member companies, their employees, subcontractors, consultants, or other assigns, does not make any warranty or representation, either express or implied, with respect to the accuracy or completeness of the information contained in this Manual; nor does the EHNIWG, including any of its member companies, their employees, subcontractors, consultants, or other assigns, assume any liability of any kind whatsoever resulting from the use of or reliance upon any information, procedure, conclusion, or opinion contained in this Manual, except to the extent such disclaimer of liability would be in violation of law in the jurisdiction of its use.

This work is protected by copyright. The EHNIWG, which is the owner of the copyright, hereby grants a nonexclusive royalty free license to reproduce and distribute this Manual, subject to the following limitations:

The EHNIWG, including any of its member companies, their employees, subcontractors, consultants, or other assigns, assumes no responsibility for the accuracy, completeness, or overall quality of any alterations, abridgement, revision, translation, or other modification of this copyrighted work.

All copies of the work must include a cover page bearing the EHNIWG 's and its member companies' Notice of Copyright of the work.

Copies of the work may not be sold.

Copyright © (2004) ATC.

Although this manual follows the standard 16-section Material Safety Data Sheet (MSDS) / Safety Data Sheet (SDS) format for easy cross-reference to your supplier's MSDS / SDS, it shall not be used as a MSDS/SDS.

Section 2

Composition



IUPAC name:	2-ethylhexyl nitrate (2EHN)
EINECS name:	nitric acid, 2-ethylhexyl ester
CAS No.:	27247-96-7
EINECS No.:	248-363-6
Purity:	May contain traces of unreacted residual 2-ethylhexanol and/or water
Molecular formula:	$C_8H_{17}NO_3$
Molecular Weight:	175.23

Section 3

Hazard Identification



3.1 Emergency Overview

Combustible liquid and vapour.

Vasodilation by inhalation or skin contact (reduced blood pressure and other cardiovascular effects to produce such symptoms as throbbing headache, confusion and possible loss of consciousness).

Possible aspiration hazard.

Self-reactive, energetic substance with a low auto-ignition temperature - when heated above 100°C may undergo a self-accelerating, exothermic decomposition that causes a rapid rise in temperature and pressure. Rupture of storage vessels, containers and equipment should be anticipated when pressure is generated by such thermal decomposition.

3.2 Potential Health Effects

3.2.1 Acute Health Effects

Ingestion

Ingestion is not expected to be a primary route of exposure. Although ingestion is not thought to produce harmful effects (as classified under US, Canadian or European criteria) the material may still be damaging to the health of individuals with pre-existing medical conditions.

Eye Contact

Although not classified as an irritant (according to US, Canadian or European criteria), direct contact with the human eye has been reported to produce transient discomfort as characterized by watering of the eyes and redness.

Skin Contact

Skin contact with the material may produce symptoms of vasodilation (reduced blood pressure and other cardiovascular effects to produce such symptoms as throbbing headache, confusion and possible loss of consciousness) following skin absorption. The above effects are reversible and typically short term.

The substance is not classified as an irritant (according to US, Canadian or European criteria) but is classified as "Harmful by skin contact" due to these observed effects in man. Prolonged skin contact may produce temporary discomfort.

There is no evidence of skin sensitisation with this material.

Inhalation

Inhalation of vapours may cause irritation of the mucous membranes (nose, throat and lungs).

Absorption of vapours through the respiratory tract can result in vasodilation (reduced blood pressure and other cardiovascular effects to produce such symptoms as throbbing headache, confusion and possible loss of consciousness).

All the above effects are reversible and typically short term.

3.2.2 Chronic Health Effects

No reports of long term systemic effects.

3.3 Environmental Hazards

2EHN is not acutely toxic to aquatic life at the limits of its solubility. 2EHN is immiscible with water. The material floats on water and may emulsify. May form a film on water surfaces causing impaired oxygen transfer.

3.4 Energetic Properties

2EHN is an organic nitrate. It undergoes a self-sustaining exothermic decomposition when it is heated above 100°C. The product begins to decompose, giving off heat and decomposition gases; the heat energy is absorbed by the product promoting further and more rapid decomposition. Once established the decomposition reaction may be uncontrollable.

Section 4

First Aid Measures

See supplier's MSDS for detailed first aid measures

4.1 Inhalation

If the person is affected by inhaled vapours or combustion products, remove the person to fresh air at once. Provide respiratory support as needed. Get prompt medical attention.

4.2 Skin Contact

Immediately decontaminate contact area. Ensure shoes and clothing are free from material before reuse - discard if necessary. Get prompt medical attention.

4.3 Eye Contact

Immediately decontaminate eyes with plenty of water. Get prompt medical attention.

4.4 Ingestion

DO NOT induce vomiting, as aspiration of liquid product into the lungs can cause chemical pneumonitis. Get prompt medical attention.

4.5 Notes to Physicians

Treat as organic nitrate poisoning. Symptoms of vasodilation may be present following organic nitrate over exposure.

Section 5

Fire Fighting Measures



2EHN is combustible but it is not classified as a flammable liquid. The closed-cup flash point of 2EHN is above 70°C.

Though flash point is well above recommended maximum transport, storage and handling temperature (40 - 60°C), fire and explosion hazard is to be considered very high due to the resulting decomposition in case of fire.

Use chemical foam to extinguish the fire and large amount of water spray preferably via a reliable fixed sprinkler/deluge system or by sufficient firewater monitors to cool containers and avoid catastrophic rupture of the storage vessel. Cool containers with flooding quantities of water until well after fire is out.

Alcohol-resistant foam directly injected into the 2EHN storage vessel via a dedicated internal fixed system is the most effective extinguishing medium. Dry chemical powder and carbon dioxide are also effective with minor fires. Sand or earth might also be used to extinguish small fires.

Firewater capacity provided by firewater storage is to be sufficient to deliver firewater for long enough time to put fire under control (minimum of 6 hours at the maximum usage rate is recommended).

Protection of emergency personnel against smoke and combustion gases generated by large fires is vital.

5.1 Suitable Extinguishing Media

For large fires: water spray, foam (alcohol resistant preferably)

For small fires: dry chemical powder or CO_2.

Do not use water jet.

5.2 Special Fire Fighting Procedures

Removal of radiant heat from nearby fire is vital.

Radiant heat from surrounding fires can heat up tanks containing 2EHN, and in theory start a bulk liquid phase decomposition with potential catastrophic effects. A credible scenario is that when a storage tank is involved in a fire, the upper tank surfaces in contact with the vapour will rapidly reach the auto-ignition temperature (130°C) of 2EHN. This will lead to an air-vapour explosion in the headspace of the tank, which could become projectiles if its roof is not frangible.
The hazard is well recognised for kerosene and gas-oil storage tanks where the auto-ignition temperatures are of the order of 250°C, more than 100°C higher than 2EHN.

Apply deluge water onto tank walls to keep the product cool.

The calculated amount of water needed for effective removal of radiation heat coming from a fire in a nearby tank (15 m distant) is a minimum of 15 litre/minute/m^2 of exposed tank surface.

Spray firewater at the required flow rate should be available for 6 or more hours.

2EHN is thermally unstable - when heated above 100°C, it may undergo a self-accelerating exothermic decomposition. Cool containers exposed to flames with flooding quantities of water until well after the fire is out. Be aware of the danger of a container bursting under pressure followed by combustion of vapours. Fight any fire from a safe distance or protected locations. Do not approach containers suspected to be hot.

If tank, rail car or tank truck is involved in fire, ISOLATE the container and evacuate personnel to ensure safety.

Drums and IBC's should be immediately cooled by spraying firewater from a fixed deluge. Sealed drums of 2EHN in an intense fire will rupture after a short period of exposure (practical tests and theoretical examples indicate a time to rupture of 10 to 20 minutes, depending on conditions). Bursting drums will give rise to projectiles/ flying fragments and fireball formation, which will add to the severity of the incident.

5.3 Special Protective Equipment for Firefighters

Exhaust gases from fire or products of decomposition are toxic (they contain oxides of nitrogen and combustion products). Therefore, fire fighters must be protected by wearing self contained breathing apparatus (SCBA). Wear chemical protective clothing; however, such clothing may provide little or no thermal protection. Fire fighter's protective clothing will only provide limited chemical protection.

Section 6

Accidental Release Measures



6.1 Personal Precautions

When conducting operations which might lead to overexposure by skin contact or inhalation, adequate personal protective equipment (PPE) should be worn. Ensure that the area is completely free from any residue of the spill.

6.2 Environmental Precautions

Prevent product from entering sewers.

Adequate PPE should be used to avoid exposure to skin or risk of inhalation during clean up operations.

6.2.1 Small Spillage:

Suitable materials, such as commercial synthetic absorbent or sand can be used to absorb spills or leaks of 2EHN.

Solid absorbent material should be shovelled up and placed in adequate sealed and properly labelled containers suitable for disposal.

2EHN should not be allowed to enter the sewers. Do not flush out the product from contaminated areas.

6.2.2 Large Spillage:

Contain spilled material within bunds or by creating temporary barriers. Use sand, earth, or other inert material to prevent the liquid entering drains, ditches or watercourses.

Transfer the liquid by pumping into a dedicated, closed and properly labelled container. Ensure proper pumps are used and set-up as recommended for safe 2EHN pumping (see section 7.3). Seek expert advice to dispose of large volumes of recovered product.

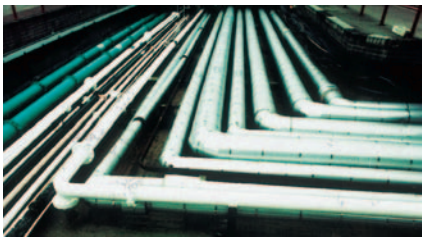
6.2.3. Spills onto Water

2EHN will float. Apply oil spill control procedure. Spilled product can be confined by using floating barriers. Traditional oil spill control procedure should be applied as soon as possible to remove product from water.

Local Authorities should be promptly notified about the potential adverse effect of 2EHN on the aquatic environment since it can create a film on the surface of water and limit oxygen exchange.

Section 7

Handling and Storage



7.1 Handling

7.1.1 Materials of Construction

Suitable

Proper selection of materials of construction for 2EHN service is essential to ensure the integrity of the handling system and to maintain product quality.

Although stainless steel tanks are always preferred, 2EHN may be stored in mild steel tanks provided they are kept free from water bottoms through regular maintenance.

Mild steel in general is a material that requires careful consideration for use in a 2EHN handling system. 2EHN in the presence of water bottoms can hydrolyse slowly to form nitric acid which can increase the corrosion rate of mild steel. For this reason stainless steel is the preferred material for storage of 2EHN.

Unsuitable

Galvanized steel, copper and copper bearing alloys are unsuitable for all 2EHN service. Special care should be taken when selecting such items as pumps and valves to ensure that no copper alloys (e.g., brass or bronze) are used in bearings or other internal components that may come in contact with the product.

7.1.1 Elastomers and Gaskets

2EHN is an excellent solvent which can degrade the performance of some seals and gaskets, therefore careful selection is necessary.
Contact your supplier for information.

7.2 Storage

7.2.1 Storage Tanks

Many different sizes and types of tanks may be used to store 2EHN. It is not possible to define one set of rules that covers every possibility. Heat must be allowed to dissipate. The use of thermal ignition critical temperature calculations may help to define the safety precautions appropriate for any given tank (see appendix 2 for further information). In most respects, vertical tanks are the most

practical overall solution. The low auto-ignition temperature (130ºC) of 2EHN can lead to an air-vapour explosion in the headspace of vessels, which can rupture, spilling the contents. Vapour-air explosions release less energy per unit volume than those resulting from self-reaction of the liquid. Peak blast force is a key design criterion. Vertical tanks can be fitted with a frangible roof to minimize damage in case of a pressure blow-out. API 650 is a widely used standard that can be used as reference for specifying such tanks. Vertical tanks are also easier to configure with water deluge systems.

Horizontal tanks are used for the storage of 2EHN; however, they have no 'roof' so the fitting of a frangible roof is not an option. If the contents are heated above 100ºC, then there is a risk that the tank will fail at the dished ends and form a "missile" with potentially catastrophic effects. Safety principles should be strictly applied to prevent heating of the product.

A fire in the storage area will heat the storage tanks. A fixed cooling-water deluge system to supply cooling water in event of fire must be present to minimize this risk. API 650 standard indicates that a system that delivers a cooling-water flow rate of at least 15 litre/minute/m^2 of storage tank surface area can achieve effective cooling. If this volume of water is not continuously available for cooling purposes, additional non-insulating fire cladding of the tank walls could be considered within the context of the overall risk assessment of the storage facility.

Risk of tanks bursting under pressure should be minimized - See also Sections 7.2.2 and 7.2.3.

7.2.2 Heat Protection

The principle here is to protect the product from heat.

A deluge system provides the best protection against product overheating. No heating system of any kind should be installed and existing heating systems must be permanently disabled. When laying out the route for new pipe work to carry 2EHN, the designer should avoid sources of heat and potential fire. When using existing pipe work installations, the designer should ensure that heated pipes are not used for 2EHN.

As a general principle, locating 2EHN storage tanks in an open area away from inhabited buildings is recommended. The site should be remote from possible fire hazards to minimize their exposure to external heat and fire impingement if fire breaks out. The extent of this separation is a local decision to be determined by the site risk assessment. For example, the NFPA 30 standard may be used to help determine the appropriate distance from other storage tanks and equipment to maintain protection in case of fire.

Firewalls between the tanks will improve thermal protection. If sufficient space is not available for firewalls, then non-insulating tank-wall fire cladding may provide additional protection. Screening walls and non-insulating fire cladding may be used in combination to achieve acceptable protection. The better the protection, the longer the time the stored 2EHN will endure external heating and the lower the risk of thermal decomposition within the storage system. Instrumented fire and heat detection systems should be installed.

7.2.3 Venting

Bulk storage vessels should preferably be vented directly into the atmosphere far from ignition sources if local regulations permit. Conservation vents with frangible roof seams are also acceptable. For smaller equipment, standard engineering practices for design of emergency discharge should be followed.
Tanks containing 2EHN should preferably be at atmospheric pressure. The vent outlet is to be positioned in a safe area sufficiently high and far from ignition sources.

7.2.4 Containment Wall or Bunding

To minimize the consequences of a spill and leakage into the environment, a containment wall (bund) should surround tanks with a minimum capacity to handle tank contents and deluge water.

7.2.5 Drum Storage

Ensure good ventilation during drumming/ de-drumming.

Filled drums are to be stored far from heat sources and other flammable products and protected by firewater. Special care should be taken when opening drums, which may be pressurized.

7.3 Operations

7.3.1 Product Sampling

Product sampling is a potential source of personnel exposure to 2EHN. Design and procedures should be developed to minimize exposure of personnel and the environment to 2EHN.

7.3.2 Product Handling - Loading, Unloading, Pumping

Product handling is a potential source of personnel exposure to 2EHN. Design and procedures should be developed to minimize exposure of personnel and the environment to 2EHN.

Loading

Use a dedicated loading arm. Control static electricity. If a multi-compartment tank wagon is loaded, ensure 2EHN is not shipped adjacent to heated cargoes. Ensure proper electrical grounding and electrical continuity on all installations.

Unloading

Use a dedicated hose. Control static electricity. Avoid manifolds to prevent accidental ingress of 2EHN into heated lines.

Pumping

2EHN is a self-reactive substance and can decompose in the absence of air in the bulk liquid phase if heated. This occurs most commonly under pressure in a blocked or dead headed pump, or other sealed system, and can lead to violent bursting of the equipment. The principle here is to use equipment that does not have the potential to heat the product. Pumped transfer of 2EHN should always be done under controlled conditions and all transfer valves must be open before pumps are started. Do not pump 2EHN against a closed outlet; this may heat the product within the pump, depending on the type of pump in use. Pneumatically powered diaphragm pumps provide an inherently safe and reliable means of pumping 2EHN.

Centrifugal pumps are not as inherently safe as pneumatic diaphragm pumps for 2EHN service. In any case, extra control systems are required:
Gear pumps and other positive displacement systems can heat 2EHN rapidly when the pump outlet is closed or blocked. Consequently, their use is not recommended.

Safety pump trip controls and instrumentation must be fitted with:

- A temperature trip set to stop the pump at a product temperature of 50-60ºC.
  In exceptional circumstances, specific operations may require a higher temperature trip set up to a maximum of 75ºC, subject to detailed expert risk assessment in conjunction with your supplier.
- A pressure switch to stop the pump if the outlet is blocked or closed and/or
- A low flow switch to stop the pump if the outlet is blocked or closed.

To prevent the risk of heating the product, closed circuit pumping, including that through pressure relief valves when the pump outlet is closed or blocked must be avoided.

The majority of incidents involving 2EHN have been due to overheating of pumps and resulting bursting of the equipment, therefore careful consideration of the siting of pumps needs to be made and the consequences of pump failure need to be fully assessed.

7.3.3 Tank to Tank Transfer

Tank to tank transfer of 2EHN can be safely carried out using nitrogen or air padding, by using a pneumatic driven pumping system or pumps as described above.

7.3.4 Piping / Lines / Hoses

Use non-insulated Mild Steel or Stainless Steel (SS) piping.

Any steam or electrical tracing must be physically disconnected.

Wherever possible, dedicated lines for 2EHN are preferred to avoid safety/environmental problems.

Experimental fire testing of gantry-type pipe-work filled with an additive containing approximately 70% 2EHN, showed that a pressure relief valve set at 10 bar was sufficient to relieve pressure caused by the self-heating accelerating decomposition of 2EHN. The pressure relief valve should discharge to a safe location.

7.3.5 Valves

SS full-bore ball valves are preferable.

Traditional ball, gate and butterfly valves may also be used.

SS, cast iron and cast steel are all suitable materials.

Copper, Zinc and its alloys, aluminium and most plastics are inadequate or incompatible materials.

Contact your supplier for details of suitable packing materials.

7.3.6 Equipment Clean-up

Inadequate cleaning of equipment or pipe work introduces the risk of environmental contamination and potential for decomposition of 2EHN residues.

A specific procedure should be developed by skilled personnel, which recognises the health and environmental hazards and the temperature limits to ensure that cleaning operations are conducted in effective and safe manner.

Section 8

Exposure Controls and Personal Protection



8.1 Exposure Limit Values

Manufacturers and suppliers have set an internal exposure guideline for 2EHN. This is an exposure guideline that is intended to set a level which does not overexpose the employee while handling the material. It is not a regulated limit that is established by a governmental or other agency.

The internal exposure guideline for 2EHN is 1 ppm based on an 8hr time weighted average (TWA). In the light of the potential temporary effects of overexposure, it is suggested that 1 ppm is also adopted as reference standard for short term exposures averaged over 15 minutes (STEL).

8.2 Exposure Controls

If an operation creates the potential for employee overexposure, accepted engineering or administrative controls should be the first choices for control. When effective engineering or administrative controls are not feasible, or when they are being implemented or evaluated, appropriate respiratory and skin protection can be used to control employee exposures.

8.3 Personal Protective Equipment

See suppliers MSDS/SDS for specific recommendations. Contact supplier with any questions.

8.3.1 Respiratory Protection

Respiratory protection is required for open systems or where concentration of 2EHN in the working environment is higher than the recommended exposure guideline of 1 ppm TWA / STEL. 2EHN has a very persistent odour with a low odour threshold. The respirator chosen should be appropriate for the exposure potential, level of exposure and working conditions.

8.3.2 Hand Protection

When contact is likely, appropriate wrist long chemical resistant gloves (neoprene or nitrile rubber) should be worn.

8.3.3 Eye Protection

Eye protection should be chosen based on the exposure potential and working conditions.

8.3.4 Skin Protection

When skin contact is likely, appropriate skin protection should be used. Leather clothing can be hazardous when they have become contaminated with 2EHN. Leather can absorb 2EHN and maintain a continuous low level exposure over a prolonged period of time. Thus, leather clothing and other items should not be specified as protective clothing for handling 2EHN, and should be removed and destroyed promptly if they become contaminated.

Section 9

Physical and Chemical Properties

Refer to suppliers MSDS/SDS for specific data

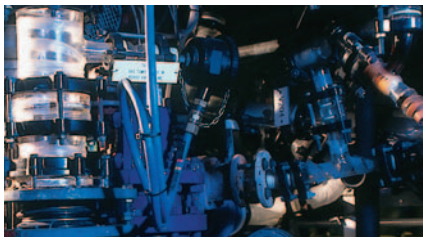
Typical Physical property information for 2EHN is given below:

Physical Properties

Appearance	Colourless to pale yellow liquid
Odour	Fruity, pungent, ester, characteristic
Molecular weight	175.23
Flash point	>70°C (closed-cup)
Freezing point	<-45°C
Boiling point	>100°C (decomposes)
Vapour pressure	27 Pa @ 20°C
Vapour pressure	40-53 Pa @ 40°C
Vapour pressure	1.33 kPa @ 82°C
Density	0.96 g/ml @ 20°C
Kinematic Viscosity	1.8 cSt @ 20°C
Solubility in water	12.6 mg/L @ 20°C
Heat of vaporization	368 kJ/kg
Coefficient of thermal expansion (between 10°C and 20°C at atmospheric pressure)	1.010
Lower Explosive Limit	0.25% v/v in air (literature value – source unknown)
Auto / Self ignition temperature	130°C - (decomposes)
Thermal Ignition Critical Temperature - Self-accelerating decomposition temperature	Function of time and geometry of the container (see appendix 2 for explanation of Thermal Ignition Critical Temperature).
Log Pow	3.74 (calculated) - 4.14, (iso-octyl nitrate)
Decomposition temperature	>100°C

Section 10

Stability and Reactivity



2EHN is stable at ambient temperatures, however it has a low auto-ignition temperature and will decompose when heated above 100°C. This temperature is significantly lower than auto-ignition temperature of normal hydrocarbons and represents a key factor in designing equipment dedicated to storage, handling and transportation of 2EHN.

10.1 Conditions to Avoid

Avoid all contact with sources of heat, flames, sparks or any other source of ignition. Vapours may be explosive. Avoid overheating of containers. Containers may violently rupture in heat of fire.

10.2 Materials to Avoid

Avoid contamination with acids, alkalis, reducing and oxidising agents, amines and phosphorus.

Alkyl nitrates as a class of compounds react violently with strong mineral acids, tin (IV) chloride, boron trifluoride, and other Lewis acids after an induction period of up to several hours to produce a vigorous evolution of gas such as oxides of nitrogen. Traces of nitrogen oxides can promote decomposition of alkyl nitrates. This can lead to container rupture on heating or pressure build up on prolonged storage at ambient temperatures. Transition metal oxides or their chelates also greatly accelerate the decomposition rate.

10.3 Hazardous Decomposition Products

Combustion or thermal decomposition products of 2EHN are oxides of carbon and nitrogen.

Section 11

Toxicological Information



11.1 Acute Health Effects

11.1.1 Oral (Ingestion)

2EHN has a low acute oral toxicity when tested in animals.

LD50 is >5000 mg/kg (rat) and therefore is not classified as harmful or toxic if swallowed (under OSHA, WHMIS and EC Directives).

2EHN has a viscosity of less than 7 cSt at 40°C, and consequently, if vomited, it could enter the lungs and cause lung damage. However, it is not classified with R65 “Harmful: May cause lung damage if swallowed” because this classification is only applicable to hydrocarbons and no practical experience in humans has been reported.

11.1.2 Inhalation

Absorption of 2EHN through the respiratory tract can result in vasodilation (reduced blood pressure, and other cardiovascular effects to produce such symptoms as throbbing headache, flushing, light headiness, transient dizziness or weakness, heart palpitations, nausea, fatigue, confusion and possible loss of consciousness).
Due to these observed effects in man, 2EHN is classified as “Harmful by inhalation” in the EU.

11.1.3 Dermal (Skin)

Skin contact with 2EHN can result in vasodilation (reduced blood pressure and other cardiovascular effects to produce such symptoms as throbbing headache, flushing, light headiness, transient dizziness or weakness, heart palpitations, nausea, fatigue, confusion and possible loss of consciousness).
Due to these observed effects in man, 2EHN is classified as “Harmful by skin contact” in the EU.

11.2 Corrosivity/irritation

11.2.1 Skin

Studies have shown that 2EHN does not meet the US, Canadian or European criteria for skin irritancy classification. Prolonged skin contact may produce temporary discomfort.

11.2.2 Eye

Studies have shown that 2EHN does not meet the US, Canadian or European criteria for eye irritancy classification. Eye contact may produce temporary discomfort.

11.3 Sensitisation

2EHN has not been shown to cause skin sensitization in approved tests. There are no reports of human skin sensitization.

11.4 Chronic Health Effects

No significant chronic, mutagenic, carcinogenic, reproduction or developmental effects are known for 2EHN.

Section 12

Ecological Information

12.1 Ecotoxicity

Acute toxicity to fish

LC50 (Danio rerio, 96 hour): above solubility limit.

Acute toxicity to daphnia

EC50 (Daphnia magna, 48 hours): above solubility limit.

Algal growth inhibition

EC50 biomass: above solubility limit.
EC50 growth rate: above solubility limit.
Microtox®: EC50 (15 min.): 0.01% (100mg/l)
Slightly soluble in water: solubility limit 12.6 mg/l at 20ºC (may emulsify with water).

12.2 Mobility

The octanol/water partition coefficient predicts moderate mobility/moderate affinity for soil or sediment.

12.3 Persistence and degradability

The substance shows no evidence of biodegradability in water.
Hydrolysis test - readily hydrolysed:
Half-life at pH 7 (25ºC) is approximately 7 days.
Half-life at pH 7 (50ºC) is approximately 24 hours.

12.4 Bioaccumulation potential

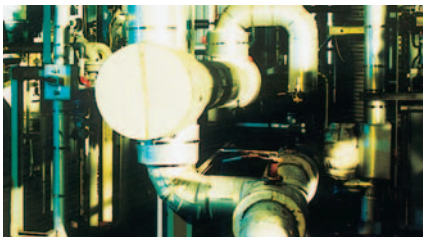
The substance is completely miscible with fat and has potential for bioaccumulation.

12.5 Other adverse effects

May form a film on water affecting oxygen transfer.

Section 13

Disposal Information

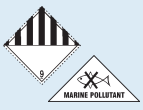


Recover product whenever possible. Incineration in approved onsite or offsite facilities equipped with flue gas post-combustion, wet scrubbing and de-dusting systems is the preferred disposal practice. Provided that 2EHN is not confined, there should be no risk of violent decomposition. 2EHN is not suitable for landfill or treatment by biological processes. Decomposition and fire may also occur with wastes containing 2EHN if overheating or contact with reactive materials occurs.

Section 14

Transport Information



Regulatory Information	UN No.	Proper Shipping Name	Class	P.G	Label	Additional Information
DOT Classification (USA)	NA 1993	Combustible liquids, n.o.s. (2-ethylhexyl nitrate)	Combustible liquid	III		
TDG Classification (Canada)	UN 3082	Environmentally hazardous substance, liquid, n.o.s. (2-ethylhexyl nitrate)	9	III		
ADR/RID (Road/Rail)	UN 3082	Environmentally hazardous substance, liquid, n.o.s. (2-ethylhexyl nitrate)	9	III		Hazard Identification Number 90 CEFIC Tremcard 90GM6-III
IMDG (Sea)	UN 3082	Environmentally hazardous substance liquid, n.o.s. (2-ethylhexyl nitrate)	9	III		Marine Pollutant
IATA (Air)	UN 3082	Environmentally hazardous substance liquid, n.o.s. (2-ethylhexyl nitrate)	9	III		

IMO Marine Bulk: Alkyl (C7-C9) nitrates, S.T. 2, Cat. B.

To meet the requirements of ADR, CEFIC Tremcard 90GM6-III for UN 3082, Class 9, or an equivalent safety instruction sheet is to be given to the driver of any road bulk shipment in Europe.

Although 2EHN does not meet the criteria for Class 9, it is classified as an environmental hazard (marine pollutant) according to the IMO's IMDG and BCH codes. This classification was based on data submitted on a blend of alkyl (C7-C9) nitrates, predominately C8, which are no longer marketed. Since 2EHN does not meet the criteria of any of the other transport classes, all suppliers of 2EHN currently classify 2EHN as Class 9 for transport. In view of the energetic properties of 2EHN, there is a proposal to obtain a specific entry for 2EHN in the UN orange book to more accurately reflect its hazardous properties.

Section 15

Regulatory Information



EU Classification

Label for Supply



Harmful Xn

Risk Phrases

R20/21 - Harmful by inhalation and in contact with skin.
R44 - Risk of explosion if heated under confinement

Required Safety Phrases

S36/37 Wear suitable protective clothing and gloves.
Additional Safety Phrases may be used at the discretion of suppliers.

International Inventory Status

TSCA (USA): Listed
DSL (Canada): Listed
EINECS (European Union): Listed
ENCS/METI/MOL (Japan): Listed
AICS (Australia): Listed
KECL (Korea): Listed
PICCS (Philippines): Listed
IECSC (China): Listed

Section 16

Other Information

16.1 Training

A comprehensive and ongoing training programme in the handling, use, storage and disposal of 2EHN is of significant value to all personnel. Contact your supplier for assistance if needed.

16.2 Emergency Procedures for 2EHN

Written emergency procedures should be in place when handling 2EHN.
This procedure should include fire and decomposition scenario.

Appendix 1

Responsible Care®

Many of the member companies of EHNIWG have a long standing policy to ensure that their operations do not have an adverse impact on the community or the Environment. Responsible Care®, a continuing effort by the chemical industry to improve the responsible management of chemicals is one way member companies of EHNIWG are meeting this commitment.

What is Responsible Care®?

Responsible Care® is the Chemical Industry's commitment to continuous improvement in all aspects of environmental, safety and health protection. Although voluntary, all member companies throughout the world have committed to the principle of continuous improvement through self-evaluation and regular assessment with key indicators of performance being published on an annual basis. Responsible Care® continues to strengthen its commitments and enhance the public credibility of the industry. New program enhancements adopted by the American Chemistry Council as a condition of membership include:

1) A Responsible Care® Management System;
2) An independent third party certification of the management system to ensure appropriate actions are taken to improve performance;
3) Tracking and publicly reporting performance based on economic, environmental, health and safety, societal and product related metrics;
4) A Security Code that helps protect people, property, products, processes, information and information systems by enhancing security throughout the chemical industry value chain.



Appendix 2

Explanation of thermal ignition critical temperature

The thermal ignition critical temperature (T_C) is the lowest surface temperature at which an energetic material can go into runaway self-heating reaction. However, when this temperature is reached, self-heating does not immediately ensue.

After a sample reaches thermal ignition critical temperature there is a finite amount of time before self-heating occurs.

One concern with energetic materials like 2EHN (i.e. those that release large amounts of heat when they decompose) is their potential to initiate a runaway self-heating cycle. At the temperature where the rate of 2EHN decomposition exceeds the rate at which the generated heat can be dissipated to the surroundings, the product begins to self-heat. The surface-to-volume ratio of a product container is an important factor in determining how fast heat can be dissipated: the smaller the surface-to-volume ratio of the container, the lower the temperature at which runaway self-heating begins.

When the quantity of energetic material is very large, such as found in very large storage tanks, self-heating and thermal runaway could become a problem at very high constant ambient temperatures.

Various scenarios have been modelled using the Frank-Kamenetskii equation, which postulates the heating to runaway reaction of an unstirred, insulated energetic substance. The ambient temperature and the size or shape of the reactant system are important. There is a range of data available on 2EHN from different sources, however, small variations in the assumptions can have a very large effect on the results. If the maximum long-term storage temperature is kept below 40°C then no problems with self-heating and thermal runaway are envisaged.



Glossary

TERM	WHERE	DEFINITION
Product stewardship	Front page	Product-centred approach to environmental, health and safety protection. It calls on those in the product life cycle - manufacturers, retailers, users, and disposers-to share responsibility for reducing the environmental, safety and health impacts of products.
Cetane number	Section 1.1	The performance rating of a diesel fuel, corresponding to the percentage of cetane in a cetane-methylnaphthalene mixture with the same ignition performance.
Cetane number improver	Section 1.1	A chemical compound, typically 2-Ethylhexyl nitrate (2EHN), used to reduce combustion noise and smoke. Also known as Diesel Ignition Improvers.
ATC	Section 1.2	Additives Technical Committee. This is also known as the Technical Committee of Petroleum Additive Manufacturers in Europe. ATC provides a forum for additive companies to meet and discuss developments of a technical and/or statutory nature concerning the application of additives in fuels, lubricants and other petroleum products.
CEFIC	Section 1.2	Conseil Européen des Fédérations de l'industrie Chimique (or the European Chemical Industry Council). This is the largest association of chemical companies in Europe and represents directly or indirectly, about 40,000 large, medium and small chemical companies.
Explosive substance	Section 1.2	A compound or mixture susceptible (by heat, shock, friction or other impulse) to a rapid chemical reaction, decomposition or combustion with the rapid generation of heat and gases with a combined volume much larger than the original substance.
Energetic properties	Sections 1.2 / 3.4	The substance can possess or exert energy.
IUPAC name	Section 2	A chemical name assigned using nomenclature rules recommended by the International Union of Pure and Applied Chemistry.
EINECS name	Section 2	A chemical name as it appears on the European Inventory for Existing Commercial (Chemical) Substances.
CAS number	Section 2	The unique identification number for a chemical substance listed on the Chemical Abstracts Service.
EINECS number	Section 2	The unique identification number for a chemical substance listed on the European Inventory for Existing Commercial (Chemical) Substances.
Energetic substance	Section 3.1	Substances which because of their chemical structure are capable of undergoing rapid exothermic decomposition with release of energy.
Vasodilatation	Section 3.1	Dilation of blood vessels possibly leading to reduced blood pressure and other cardiovascular effects to produce such symptoms as throbbing headache, confusion and possible loss of consciousness.

TERM	WHERE	DEFINITION
Aspiration hazard	Section 3.1	A substance that poses a threat to the body if inhaled.
Auto-ignition temperature	Section 3.1	The lowest temperature at which a flammable gas or vapour/gas mixture will ignite from its own heat or from contact with a heated surface without the necessity of a spark or flame. Vapours and gases will spontaneously ignite at lower temperatures in oxygen than in air. Auto-ignition temperatures may be influenced by the presence of other substances.
Acute health effect	Section 3.2.1	Adverse effects resulting from a single exposure to a substance.
Chronic health effects	Section 3.2.2	Hazards such as cancer, reproductive or developmental damage, neurological or other organ damage to animals or humans related to repeated or long term exposure.
Environmental hazards	Section 3.3	Intrinsic properties of a chemical substance or mixture that present a danger to the environment, and in particular to aquatic organisms.
Flash point	Section 5	Lowest temperature at which a flame will propagate through the vapour of a combustible material to the liquid surface. It is determined by the vapour pressure of the liquid, since only when a sufficiently high vapour concentration is reached, can it support combustion. Two general methods are called closed-cup and open-cup.
Closed-cup	Section 5	The closed-cup method prevents vapours from escaping and therefore usually results in a flash point that is a few degrees lower than in an open cup. Because the two methods give different results, one must always list the testing method when listing the flash point. Example: 110ºC (closed-cup).
IBC /IBC's	Section 5.3	Intermediate Bulk Container. For liquids this is normally a rigid or flexible portable package with a capacity of less than $3m^3$ that is designed for mechanical handling.
Commercial synthetic absorbent.	Section 6.2.1	A material having capacity or tendency to absorb another substance.
Floating barriers	Section 6.2.3	A device designed to float on the surface of water, specifically to contain and/or absorb floating oily substances i.e. "oil boom".
API 650	Section 7.2.1	A standard for welded steel tanks for oil storage. Published by the American Petroleum Institute. This standard is designed to provide the petroleum industry with tanks of adequate safety and reasonable economy for use in the storage of petroleum, petroleum products, and other liquid products commonly handled and stored by the various branches of the petroleum industry. It is intended to help purchasers and manufacturers in ordering, fabricating, and erecting tanks. Standard 650, Tenth Edition, covers material, design, fabrication, erection, and testing requirements for vertical, cylindrical, aboveground, closed- and open-top, welded steel storage tanks in various and capacities for internal pressures approximating atmospheric pressure, but a higher internal pressure is permitted when additional requirements are met. This standard applies only to tanks whose entire bottom is uniformly supported; and to tanks in non-refrigerated service, that have a maximum operating temperature of 93.3ºC (200ºF).

TERM	WHERE	DEFINITION
Thermal ignition critical temperature	Section 7.2.1	The temperature at or above which heat is generated faster than it can be dissipated. Reaching the critical temperature can be expected to result in a self-accelerating reaction. See appendix 2 for further details.
Frangible roof tank	Section 7.2.1	A tank with a roof to shell connection which is designed to fail before the bottom to shell joint. This type of failure prevents loss of tank contents and feeding the fire.
Non-insulating fire cladding/non-insulating tank-wall fire cladding	Section 7.2.1	A protective layer fixed to the outside of a structure, in this case a tank wall.
NFPA 30	Section 7.2.2	Flammable and Combustible Liquids Code published by the National Fire Protection Association, USA. Applies to all flammable and combustible liquids except those that are solid at 37.8°C (100°F) or above. Covers tank storage, piping, valves and fittings, container storage, industrial plants, bulk plants, service stations and processing plants.
Firewalls	Section 7.2.3	A wall of incombustible construction which subdivides a building or separates buildings to restrict the spread of fire and which starts at the foundation and extends continuously through all stories to and above the roof, except where the roof is of fireproof or fire-resistive construction and the wall is carried up tightly against the underside of the roof slab.
Conservation vents with frangible roof seams	Section 7.2.3	A device designed to limit the breathing of a storage tank, through use of a liquid or mechanical seal. Often used in conjunction with inert gas in order to preclude introduction of air into a storage tank. Frangible roof seams - a vertical tank roof seam specially designed to split open should the tank be subjected to pressures above its design rating.
Static electricity	Section 7.3.1	Electrical charge generated by friction between two materials or substances.
Exposure limit values: 8hr time weighted average (TWA) and Short-term exposure limit (STEL).	Section 8.1	The 8hr TWA Exposure Limit Value is the concentration to which it is believed that nearly all workers may be repeatedly exposed, day after day, without adverse health effects. A STEL is the concentration to which it is believed that workers can be exposed continuously for a short period of time and it should not occur more than 4 times per day.
Self-Accelerating Decomposition Temperature (SADT)	Section 9	Used in the classification of substances for transport. The lowest temperature at which a self-accelerating decomposition (runaway) may occur in the package as used in transport. The SADT varies with the mass of substance and the shape of the package. It is used to determine safe temperatures during transport and can offer a guide to instability in storage and use.
Log Pow	Section 9	Pow is the partition coefficient (P) of a substance dissolved in a two-phase system consisting of n octanol and water. The concentration (C) of a substance is measured during each phase after achieving equilibrium and is represented as a quotient of the two concentrations *C octanol/C wate*r. The partition coefficient is usually presented in the form of its logarithm to the base ten. It may also be referred as a *Log Ko*w, or *Log* P.

TERM	WHERE	DEFINITION
Lewis acids	Section 10.2	A chemical species that can accept a pair of electrons and form a covalent bond. Examples include boron trifluoride, sulphur dioxide, sulphur trioxide and phosphorus pentachloride.
Transition metal oxides or their chelates	Section 10.2	Compounds comprising a metal with an unfilled "*d*" sublevel and oxygen. Examples are iron oxide, zinc oxide, copper oxide and manganese oxide. **Chelates:** Compounds comprising a metal with an unfilled "*d*" sublevel and an organic chemical with two or more functional groups. Such chelates have a ring structure.
LD50 (oral, dermal)	Section 11.1.1	The single dose that will kill 50% of the test animals by any route other than inhalation such as by ingestion or skin contact.
LC50	Section 12.1	The concentration in the air that will kill 50% of the test animals when administered in a single exposure in a specific time period, usually 4 hours.
EC50	Section 12.1	Median Effective Concentration (required to induce a 50% effect)