AN AFFILIATE OF cefic

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2-Ethylhexyl nitrate (2EHN)

Best Practices MANUAL

Product Stewardship

Prepared by the 2EHN Industry Work Group (EHNIWG)

ATC Document 79

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Section 1

Introduction

1.1 Cetane Number Improver

2-ethylhexyl nitrate (2EHN) is used to raise the cetane number of diesel fuels.
This Best Practice manual is intended to cover the storage and handling of products containing 15% or greater 2EHN.

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), TSA UK PIA and the HSE.

This manual is intended to provide you with information you may wish to consider in establishing safe storage and handling systems for 2EHN. Based on thermal decomposition data generated by ATC member companies and also on published data it is considered that fuel additive packages containing 15% or greater 2EHN may have the same energetic properties as the pure substance.

This manual is not intended to be an authoritive interpretation of the law, however National inspectors may refer to it in making judgements about an operators compliance with the law.

The guidance is not intended to be prescriptive in defining the detailed design criteria for these systems but aims to raise awareness within the industry of existing good practice and highlight where appropriate key areas where operators may review their existing systems.

Following the guidance is not compulsory and operators are free to take other action.

You should always refer to the latest product Safety Data Sheets (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. Commercial product is supplied by manufacturers of 2EHN to the petroleum additive industry and the petroleum industry.

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

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

It is recommended for users of 2EHN to review their transportation, storage, use, and disposal of 2EHN from the standpoint of safety, human health and environmental quality.

ATC believe the information and suggestions contained in this manual to be accurate and reliable as of the date of issue of this document.

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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

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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.

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Copies of the work may not be sold.

Although this manual follows the standard 16-section Safety Data Sheet (SDS) format for easy cross-reference to your supplier's SDS, it shall not be used as an SDS. Since fuel additive packages containing 2EHN may contain solvents and other functional components, readers should always refer to the supplier's latest SDS.

Section 2

Hazard Identification

2.1 Emergency Overview

Effects on health.

Combustible liquid and vapour.

Possible aspiration hazard.

Self-reactive energetic substance.

2.2 Potential Health Effects

2.2.1 Acute Health effects

Ingestion

Ingestion is not expected to be a primary route of exposure although there is increased concern of swallowing by children of After Market products containing 2EHN. Ingestion 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). The above effects are reversible and typically short term.

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Eye Contact

Although not classified as an irritant (according to GHS 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 following skin absorption. The above effects are reversible and typically short term.

The substance is not classified as an irritant (according to GHS criteria) but is classified as "Harmful by skin contact / Harmful in contact with skin" 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. All the above effects are reversible and typically short term.

2.2.2 Chronic Health Effects

No reports of long term systemic effects.

2.3 Environmental Hazards

2EHN is classified as Toxic to aquatic life with long lasting effects (Aquatic Chronic 2, according to GHS criteria). 2EHN is immiscible with water. The material floats on water and may emulsify. May form a film on water surfaces causing impaired oxygen transfer. The substance is readily lost by evaporation from aqueous media.

The substance is not classified as Persistent, Bioaccumulative and Toxic (PBT) or Very Persistent and Very Bioaccumulative (vPvB).

2.4 Energetic Properties

2EHN is a self-reactive organic nitrate. The oxygen balance is -196 but it is not classified as an explosive, according to GHS criteria. The decomposition temperature is 130°C [1,2] and it is known that self accelerating decomposition starts below 100°C, potentially evolving in a runaway reaction.

Section 3

Composition

IUPAC name:	2-ethylhexyl nitrate (2EHN)
EINECS name:	nitric acid, 2-ethylhexyl ester
CAS No.:	27247-96-7
EC No.:	248-363-6
Purity:	Mono constituent substance. May contain traces of unreacted residual 2-ethylhexanol and/or water
Molecular formula:	$C_8H_{17}NO_3$
Molecular Weight:	175.23
REACH:	In Europe, check with your supplier on the REACH compliance status of the product purchased.

The REACH dossier for 2EHN contains useful health and safety information and may be viewed on line at: http://echa.europa.eu/. To access the dossier check the legal notice in "Search for Chemicals" and search using EC No. 248-363-6 or CAS No. 27247-96-7.

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Section 4

First Aid Measures

See supplier's SDS 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 is above 70°C.

Though flash point is well above normal operating temperatures (ambient), 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 fixed sprinkler/deluge system or by sufficient firewater monitors to cool containers and avoid catastrophic rupture of the storage vessel. Continue to cool containers with flooding quantities of water until well after the fire is out.

Dry chemical powder and carbon dioxide are effective with minor fires. Sand or earth might also be used to extinguish small fires.

Firewater supply and pump capacity should be adequate to bring the fire under control.

5.1 Suitable extinguishing media

For large fires involving 2EHN: water spray or foam.
For small fires involving 2EHN: dry chemical powder or CO2.
The use of water jets are not recommended unless for cooling down fire exposed containers – water spray evaporates very quickly, cooling down the seat of the fire due to heat absorption. 2EHN is lighter than water and therefore will float on the surface of water making use of water as an extinguishing agent less effective.

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5.2 Special firefighting procedures

Removal of radiant heat from nearby fire is vital to prevent:

1. 2EHN reaching its auto-ignition temperature
2. 2EHN commencing an exothermic decomposition

Radiant heat from surrounding fires can heat up tanks containing 2EHN, and possibly 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 (176°C [(3)]) of 2EHN. This will lead to an air-vapour explosion in the headspace of the tank, which could generate projectiles if the over-pressure is not adequately relieved.

One method of reducing the heat from nearby fires is to apply deluge water onto the 2EHN tank wall to keep the product cool. The deluge water is to control heating from an external source but is unlikely to control heat from exothermic decomposition.

Applying a deluge rate of 10 l/m^2 per minute has been shown to provide a continuous water film on LPG tanks subject to fire attack and it is suggested that this is an appropriate standard to maintain the tank temperature at no more than 100°C[(4)].

2EHN is thermally unstable when heated above 100°C, it may undergo a self-accelerating exothermic decomposition. Such decomposition may result in the tank failing catastrophically, with the subsequent risk of projectiles and exposure to toxic decomposition products.

Cooling should be maintained on storage tanks even after any nearby fires have been extinguished. This is important to reduce the risk of delayed exothermic decomposition.

If a rail wagon or road tanker is involved in the fire, the storage tank should be isolated, and personnel evacuated to ensure safety. Cooling water should be applied to the rail wagon and road tanker where possible.

Note: calculations indicate the exposure of an 18-tonne un-lagged road tanker to a sustained fire will result in runaway after about 30 minutes exposure, even if the fire is put out at that time[(5)].

If the tank is allowed to rise to its self-sustaining decomposition temperature the resulting runaway will generate very high rates of vapour evolution from the boiling mass.

Drums and IBC's should be immediately cooled by spraying firewater. 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. Fires should be tackled from a safe distance or protected locations. Drums and IBC's should not be approached if suspected to be hot.

When modelling the effects of fire or decomposition products the dispersion of toxic Nitrogen Oxide vapours should be considered.

5.3 Special protective equipment for firefighters

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

Exhaust gases from fire or products of decomposition are toxic (they contain oxides of nitrogen, carbon monoxide and other 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 exposure 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.

Risk assessments are the standard approaches used to determine what PPE is required.

6.2 Environmental precautions

Prevent product from entering sewers and watercourses.

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.

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, appropriate 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. Appropriate 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.

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 will increase the corrosion rate of mild steel (there have been several incidents where corrosion has occurred).

For this reason stainless steel is the preferred material for storage of 2EHN. However, 2EHN may be stored in mild steel tanks provided they are protected from corrosion (for example by coating the bottom of the tank) and kept free of water by routinely draining from the bottom of the tank and the tank is regularly maintained.

Unsuitable

Galvanized steel, copper and copper bearing alloys are unsuitable for all 2EHN service as they can cause discolouration of the product. 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.

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7.1.2 Elastomers and Gaskets

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

7.2 Storage

7.2.1 Storage tanks

Many different sizes and types of tanks may be used to store 2EHN and it is not possible to define one set of guidelines that covers every possibility. However, due to the thermal hazard characteristics associated with 2EHN it is crucial that heat can dissipate in the chosen storage vessel. 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 relatively low auto-ignition temperature (176ºC) 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 and 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 (EEMUA 180 provides a useful guide to designers and users) or explosion vent panels installed in the tank roof of the vessel. API 650 is a widely used standard that can also 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 and fuel additives containing 2EHN; however, they have no 'roof' so the fitting of a frangible roof or explosion panel is not an option. Should a runaway decomposition occur, there is a risk that the tank will fail. Potential consequences include fire and explosion. Safety principles should be strictly applied to prevent heating of the product.

Underground storage tanks (UST) have also been used to store 2EHN and fuel additive blends containing 2EHN. They have the advantage that effects of heating from nearby fires is greatly reduced. The greatest potential hazard from UST are leaks and contamination of soil, surface and groundwater. Measures to prevent pollution by maintaining the integrity of the tank and pipework system should be considered throughout the design, installation, decommissioning and removal of a UST system. Many local Authorities apply strict controls over their installation and decommissioning[(6)].

Information to help with the design of 2EHN storage tanks are provided in Appendices 2,3 and 4.

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 passive fire protection using intumescent coatings (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.

7.2.3 Temperature Monitoring

Tanks should have instrumented systems which can detect temperature within the tank at appropriate positions and set to alarm to allow early response on detection of a rising temperature.

7.2.4 Venting

Bulk storage vessels should preferably be vented directly into the atmosphere where local regulations permit. For smaller equipment (for example pumps and pipe work), standard engineering practices 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.

7.2.5 Containment Wall or Bunding

To minimize the consequences of a spill and leakage into the environment, consideration should be given for providing containment for 2EHN and deluge water / firefighting water which may be used in an emergency situation. As a minimum a wall (bund) should surround tanks with capacity in accordance with local regulations

7.2.6 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.

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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 or hose. 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 or lines containing incompatible products.

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 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.

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.

When selecting a pumping/transfer system, the approach should be to understand the risks associated with the different pumping and transfer systems which can be used, and to select a system which minimises the risk while remaining suitable for the task to be accomplished. This ensures that the risks associated with the pumping/transfer system selected are properly controlled.

Transfer can be safely carried out using nitrogen or air padding although consideration should be given to the potential for 2EHN to come into contact with hot surfaces on any air compressor used particularly where these have been fitted to a road tanker.

Pneumatically powered diaphragm pumps provide an inherently safe and reliable means of pumping 2EHN, but are not well suited to some operations for example accurate dosing.

Centrifugal pumps are not as inherently safe as pneumatic diaphragm pumps for use with 2EHN and deadheading of these pumps will heat the 2EHN and lead to an unsafe situation. Control and instrumentation systems as described below are required when using this type of pump.

Gear pumps and other positive displacement systems can heat 2EHN rapidly when the pump outlet is closed or blocked. These types of pump present the highest risk when pumping 2EHN, but for some operations remain the only viable option (for example dosing). When using this type of pump careful attention must be paid to ensure that the design of pump cut outs are adequate in all foreseeable circumstances, including the failure of safety control instrumentation.

Safety controls to prevent heating in the case of closed valve or blocked line leading to pump deadheading should include pump trip controls and instrumentation as below.

- A temperature trip set to stop the pump at a product temperature as low as reasonably practicable, but never normally higher than 50-60°C. (This is based on historic operation of installations with a wide range of ambient temperatures).
- 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.
- Pumping system design must consider safety in the event of failure of one or more of the above safety control systems.

While it has been shown that pressure relief systems can prevent an explosion in this type of equipment, designers should take into account that to prevent the risk of heating the product, closed circuit pumping (including through pressure relief valves when the pump outlet is closed or blocked) must be avoided. This can best be arranged by ensuring relief valve or minimum flow loops discharge back to the tank and not to the pump suction.

The design of the return pipework needs to consider that the product may be above optimum operating temperatures. The system controls to prevent hot product heating the bulk liquid in the storage tank need to be addressed at installation design.

Discharging bulk cargo from a ship will involve the use of the ship's own discharge system. If the cargo is held in multiple ship tanks it may be off-loaded through a manifold system within the vessel. This in turn may require the use of a pump management system as each tank empties. One incident where such a system was in use has been reported. As the first tank became nominally empty, the hydraulically-driven pump was throttled back to balance outlet pressure with the back-pressure in the manifold (standard procedure instead of isolating the tank and turning off the pump. This resulted in the 2EHN still contained in the pump impellor housing being churned by the rotating impellor. The pump manufacturer estimated that a 5 to 10°C/minute rise in temperature was possible. In this case there was sufficient rise in temperature to provoke a local flash fire causing surface damage to the impellor housing and the pressure relief valve together with disabling the level sensing equipment.

It is beyond the scope and remit of this document to discuss ship design. Operators and Safety Managers must be aware of the risks inherent in heating 2EHN. Equipment should be selected and operated to minimize risk of heating during pumping. Procedures should be designed to minimize risk of heating during pumping and to overcome any known issues inherent in the equipment.

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

The use of Stainless Steel piping is recommended for the reasons previously stated, however non-insulated Mild Steel may be an alternative.

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 by Shell 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[7]. The pressure relief valve should be correctly sized and discharge to a safe location.

7.3.5 Valves

SS full-bore ball valves are preferable. Based on risk assessment, fire safe valves should be considered in critical locations.

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 (causes colouration of the product) and most plastics (degrades) are inadequate or incompatible materials.

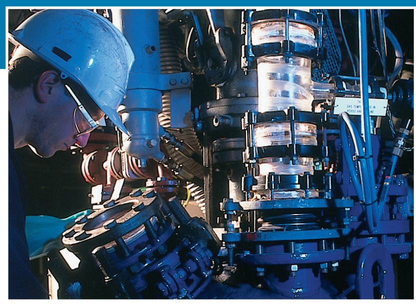
7.3.6 Equipment Clean-up

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

Only Poland has a published National Occupational Exposure Limit for 2-ethylhexyl nitrate, and these are provided below.[8]

8hr TWA is 3.5 mg/m^3 (0.5 ppm)
15min STEL is 7 mg/m^3 (1 ppm) (Absorbed Through Skin)

Note: to convert ppm 2EHN to mg/m^3

$$\text{TLV in mg/m}^3 = \frac{\text{TLV in ppm x gMW of 2EHN}}{24.45}$$

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).

It is recommended that users of 2EHN adopt this same standard, unless local national regulations set a lower threshold.

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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 should be used to control employee exposures.

8.3 Personal Protective Equipment

Refer to the suppliers SDS for specific recommendations.

8.3.1 Respiratory Protection

Respiratory protection is required for open systems or where concentration of 2EHN in the working environment is higher than any National Occupational Exposure Standard or the recommended exposure guidelines 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

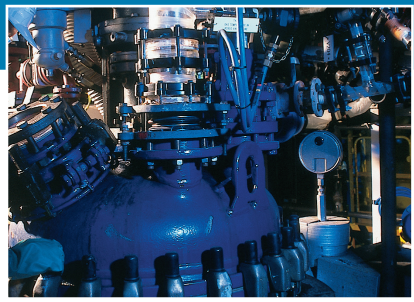
Refer to suppliers SDS for specific data

Typical Physical property information for 2EHN is given below (consult REACH Registration dossier for further information):

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	<-50°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
Relative density	0.967 g/ml @ 15°C
Kinematic Viscosity	1.8 cSt @ 20°C; 1.3 cSt @ 40°C
Solubility in water	12.6 mg/L @ 20°C
Heat of vaporization	368 kJ/kg
Heat of decomposition	1900[10] – 2100[13] J/g
Coefficient of thermal expansion (between 10°C and 20°C at atmospheric pressure)	1.010
Lower Explosive Limit	1.1 % @ 80°C[11]
Upper Explosive Limit	19.8% @ 80°C[11]
Auto / Self ignition temperature	176°C[3] (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	5.24
Decomposition temperature	130°C[1,2]

Section 10

Stability and Reactivity



2EHN is stable at ambient temperatures; however it may go into self-accelerating decomposition (runaway) if exposed to elevated temperatures (Appendix 2). The decomposition behaviour represents a key factor in designing equipment dedicated to storage, handling and transportation of 2EHN.

10.1 Conditions to Avoid

Avoid heat input that could bring the product or the surface of the vessel above the intended (storage) temperature. e.g. running a pump deadheaded.
Avoid ignition sources especially when the product is or could get above flashpoint.
Avoid transport or non permanent storage without taking the energetic properties into account.

10.2 Materials to Avoid [14]

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 which are toxic. Operators should complete specific site risk assessments and liaise with the supplier for specific details on decomposition products.

Section 11

Toxicology 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). Ingestion of 2EHN can result in symptoms of vasodilation. Due to these observed effects in man, 2EHN is classified as “Harmful if swallowed – H302” under GHS.

2EHN has a viscosity of less than 20.5 mm^2/s at 40°C and consequently, if vomited, it could enter the lungs and cause lung damage. However, it is not classified as an aspiration hazard (Category 1) 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 symptoms of vasodilation. Due to these observed effects in man, 2EHN is classified as “Harmful if inhaled – H332” under GHS.

11.1.3 Dermal (Skin)

Skin contact with 2EHN can result in symptoms of vasodilation. Due to these observed effects in man, 2EHN is classified as “Harmful in contact with skin – H312 “ under GHS.

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11.2 Corrosivity/irritation

11.2.1 Skin

Studies have shown that 2EHN does not meet the GHS 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 GHS 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[9]

Acute toxicity to fish

LC50 (Danio rerio, 96 hour): 1.88 mg/l
The No Observed Effect Concentration, NOEC (96 hour): 1.42 mg/l.

Acute toxicity to daphnia

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

Algal growth inhibition

EC50 biomass: 1.57 mg/l (nominal concentration)
EC50 growth rate: 3.22 mg/l (nominal concentration)

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[9]

The substance shows no evidence of biodegradability in water.

Hydrolysis test - readily hydrolysed:

Half-life at pH 7 (25°C) is approximately 7 days

Half-life at pH 7 (50°C) is approximately 24 hours

2EHN was shown to hydrolyse in each of the pH conditions tested following a pseudo-first order reaction. Half-life of the hydrolysis reaction at 25°C ranged from 370 hours (pH 4.0) to 108 hours (pH 9.0).

12.4 Bioaccumulation potential

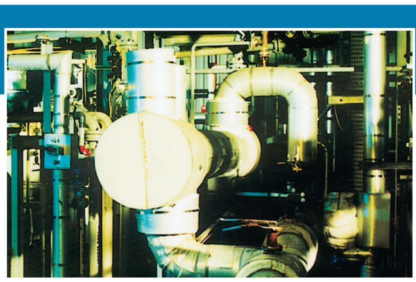
The substance is completely miscible with fat and has potential for bioaccumulation.

12.5 Other adverse effects

May form a film on water affecting oxygen transfer, which may be harmful to aquatic life.

Section 13

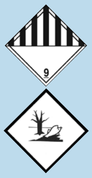
Disposal Information



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.

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		Marine Pollutant
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
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		

Section 15

Regulatory Information

UN GHS Classification of 2-ethylhexyl nitrate

Flammable Liquid Category 4

Acute toxicity: Category 4 (by oral, dermal and inhalation based on anecdotal evidence from human exposure that indicates potential harmful cardiovascular and physiological effects similar to other nitric esters (nitroglycerin, ethylene glycol dintrate and glycerol trinitrate)

Hazardous to the aquatic environment – Acute hazard: Category 2

Hazardous to the aquatic environment – Chronic hazard: Category 2

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GHS Pictogram

Signal Word:

Warning

Hazard Statements:

Combustible liquid (Not applicable in all countries including EU)
H302: Harmful if swallowed
H312: Harmful in contact with skin
H332: Harmful if inhaled
H411: Toxic to aquatic life with long lasting effects

Supplemental Hazard Statements for CLP Label

EUH044: Risk of explosion if heated under confinement
EUH066: Repeated exposure may cause skin dryness or cracking

The R44 and R66 risk phrases are not yet covered by Hazard Classes in GHS and so, according to the repealed Dangerous Substances Directive (67/548/EEC), the supplemental hazard statement EUH044 and EUH066 from Annex II part 1 of CLP have been used.

Recommended Precautionary statements

Prevention

P280 - Wear protective gloves/protective clothing/eye protection/face protection
P273 - Avoid release to the environment

Response

P302 + P352 IF ON SKIN: Wash with plenty of soap and water
P304 + P340 + P312 - IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing Call a POISON CENTRE or physician if you feel unwell

Storage

P403 + P235 Store in a well-ventilated place. Keep cool

Disposal

P501 Dispose of contents/container in accordance with local, regional, national and international regulations.

Classification under the Globally Harmonised System of Classification and Labelling of Chemicals (GHS) Classification under GHS will enter into force when countries adopt it as a national regulation. In Europe, GHS was implemented by Regulation (EC) No. 1272/2008 (as amended) on classification, labelling and packaging of substances and mixtures (CLP).

International Inventory Status

TSCA (USA): Listed
DSL (Canada): Listed
EINECS (European Union): Listed
ENCS/METI/ISHL (Japan): Listed
AICS (Australia): Listed
KECL (Korea): Listed
PICCS (Philippines): Listed
IECSC (China): Listed
NZIoC (New Zealand): Listed
TCSI (Taiwan): Listed

Section 16

Other Information

16.1 Training

Comprehensive and ongoing training programmes in the handling, use, storage and disposal of 2EHN is of significant value to all personnel.

16.2 Emergency Procedures for 2EHN

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

Staff should be trained in the use of these procedures.

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.

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Appendix 2

Explanation of thermal ignition critical temperature

The thermal ignition critical temperature (Tc) is the lowest surface temperature at which an energetic material can go into a self-accelerating reaction (runaway). However, when this temperature is reached, self-heating does not immediately ensue; i.e. there is a finite amount of time before self-heating becomes apparent.

Self-heating starts at the temperature where the rate of reaction / decomposition exceeds the rate at which the generated heat can be dissipated to the surroundings. As the reaction / decomposition rate increases with temperature the self-heating is self-accelerating (runaway).

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 self-heating begins. 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 significant effect on the results. If the maximum long-term storage temperature is kept below 40°C then no problems with self-heating and runaway reactions are envisaged[1,2,10]. Nevertheless, the storage temperature should be monitored to make sure that the temperature remains below 40°C.

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Appendix 3

Reported historical incidents involving 2EHN

Year	Incident location and type	Operator	Best Practice Section ref.
1970s and 1980s	USA. No specific record available. Examples of 2EHN being stored in tanks previously used for Pour Point Depressant or Cold Flow Improver or similar high viscosity products – tank heating not disabled. Heating turned on in error – one example in horizontal tank resulted in the end cap being blown off the tank with consequent fire. Many incidents said to have been reported. General lack of awareness of the thermal hazards until report issued by Du Pont Petroleum Additives. Major incidents declined sharply as industry implemented bulk handling safety measures but minor incidents related to incorrect selection of pumps or inadequate operating procedures continued for some time.	All	All especially 7
1990s	UK. Decomposition leading to ignition in storage tank and lifting of frangible roof. Investigation found that heating had been applied in the discharge line from the tank. Product began decomposition and primed back into the tank where a vapour phase ignition occurred, lifting the frangible roof of the vertical tank. No bulk fire occurred. No injuries.	Loading operators	7 especially 7.2.1 and 7.2.2
1995	Hungary. Operator exposure. Closed truck carrying 20 kgn drums of blend approx 40% 2EHN. Product leaked on to floor of truck – driver cleaned up spill with rags - apparently without using any form of PPE. Nausea, headaches and respiratory distress requiring hospital treatment.	Driver	6, 8 and 4
2000s	Pressurization in transit. Iso-tank on-board ship was connected to ship's heating system in error. Pressure relief valve was observed to be in operation and heating shut down before any significant incident occurred. No injuries.	Carrier	7
2001	Germany. Pressurization. Refinery bulk-additive receiving lines pass through manifold connection. One line heated, another line for 2EHN. Lubricity Improver additive was to be discharged through the heated line – heating turned on to heat line prior to delivery. Joint gasket in the line failed emitting a brown plume. Finally confirmed that 2EHN had entered the heated line via the manifold. No injuries.	Refinery off-loading operators	7 especially 7.3.2
2003	UK. Fire in effluent pump. Effluent treatment at site handling 2EHN. 2EHN was allowed to enter an effluent handling pump under low / no flow conditions. Pump churning heated product causing decomposition and fire. Fire fighters misinformed and tried to extinguish flames with water jet, correct use of foam quenched flames immediately. No injuries.	Effluent system operators	6

Year	Incident location and type	Operator	Best Practice Section ref.
2003	Operator exposure. Two 20' iso-tanks filled at depot and loaded onto ferry at Zeebrugge. Removed from ferry after ship's report of tanks 'smelling and leaking'. No leaks found. One tank found to have slightly worn seals on man lids, with 'minor trace of product around man lids'. Seals replaced and tanks shipped without any further issues or problems. Four dockworkers affected by inhaling vapours sent for medical check-up. No injuries. Note health effects produced by what was described as 'a very minor trace leak'. The then current local procedures did not require any respiratory protection for operators handling 2EHN cargo – subsequently reviewed.	Carrier (tank maintenance) Safety managers (procedures)	7 6 and 8
2009	USA. Off-loading incident. Bulk-carrier vessel off-loading 2EHN. Cargo discharged through ship's manifold system with several tanks emptying at same time. First tank to become nominally empty causes hydraulic pump for that tank to be throttled back to balance with manifold pressure. This can result in churning of the 2EHN in the pump impellor housing. Pump manufacturer estimates 5 to 10ºC/minute temp rise possible. In this case a localized flash fire resulted in damage to the impellor housing, pressure relief valve and level-sensing equipment.	Off-loading operators Safety managers (procedures)	7 7 especially 7.3

No authorization to publish has been sought or given. No identification of sites involved is made.

- **The majority of these incidents were caused by heating the product. Best Practice recommends that all heating systems connected to 2EHN storage and handling equipment should be permanently disconnected to prevent accidental heating.**
- **Best Practice recommends a vertical storage tank with frangible roof. In the event of a major incident this is a significant safety feature.**
- **There are many ways to heat the product – careful system design and correct pump selection can eliminate many of them at source.**
- **The incident in the effluent treatment system was caused by a failure of control systems and procedures that allowed 2EHN to enter a system that was not designed for 2EHN service.**
- **Operator exposure resulted from the driver taking action without the recommended PPE. Advice can only be effective if implemented.**
- **Issues around firefighting arose because incorrect information was given to the fire fighters. Training is essential. Accurate information must be available at all times.**
- **Off-loading procedures must always be thoroughly investigated for potential to heat the product. System and procedure design must minimize the risk of heating.**

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Appendix 4

Various collected thermodynamic data from member companies

Year	Substance	Test House/ Sponsor	Test Method	Contact for further information
1980's	2-ethylhexyl nitrate	Ethyl Corp.	Heated bomb with pressure and temperature measurement - temperature increased at 1.5°C/minute	Afton
1984	Iso-octyl nitrate	ICI - NEC	Final Chemical Reaction Hazard Assessment Report 2201787 TK Wright AOC	Innospec
1984	Iso-octyl nitrate	ICI - NEC	Rate of Vapour Generation at Boiling Point : Vent requirements (for isooctly nitrate)	Innospec
1985	Iso-octyl nitrate	ICI - NEC	Lead Block Test	Innospec
1985	Iso-octyl nitrate	ICI - NEC	Time-Pressure Test	Innospec
1985	Iso-octyl nitrate	ICI - NEC	Fall Hammer Tests	Innospec
1985	Iso-octyl nitrate	ICI - NEC	5 Kg Torpedo Friction Test	Innospec
1985	Iso-octyl nitrate	ICI - NEC	BAM Friction Test	Innospec
1985	Iso-octyl nitrate	ICI - NEC	Koenan Steel Tube Test	Innospec
1985	Iso-octyl nitrate	ICI - NEC	Summary of explosive properties by Dr D. Pittam, Study Director	Innospec
1988	Iso-octyl nitrate	ICI - NEC	Addendum to Chemical Hazard Assessment Report 2201998 CW Butterworh TK Wright	Innospec
1994	2-ethylhexyl nitrate in diesel	Innospec	DSC	Innospec
1995	2-ethylhexyl nitrate in diesel	Exxon Research Centre, Abingdon	Exotherm Initiation Temperature (EIT) Study 2EHN in Diesel	Infineum
1995	2-ethylhexyl nitrate in diesel	Exxon Research Centre, Abingdon	Exotherm Initiation Temperature (EIT) Study 2EHN in Diesel	Infineum
1995	2-ethylhexyl nitrate in diesel	Exxon Research Centre, Abingdon	DSC Summary	Infineum
1996	2-ethylhexyl nitrate	Innospec America	Closed vessel test. Steel bomb 100 cc, 5-10 g sample	Innospec
1996	2-ethylhexyl nitrate	Innospec America	Pressurized differential scanning calorimeter. Gold cup, 1-10 mg sample	Innospec

Year	Substance	Test House/ Sponsor	Test Method	Contact for further information
1996	2-ethylhexyl nitrate	Innospec America	Accelerating Rate Calorimeter. Ti or Hastelloy C 10 cc bomb, 1-5 g sample. Adiabatic System. State-of-the art apparatus.	Innospec
1999	Increasing conc. of 2EHN in diesel.	Lubrizol	DSC & TGA	Lubrizol
2001	2-ethylhexyl nitrate	SNPE	Audibert-Koenen test	Eurenco
2001	2-ethylhexyl nitrate	SNPE	Julius PETERS Impact Sensitivity test, 30 mm diameter encased product test initiated by a detonation	Eurenco
2001	2-ethylhexyl nitrate	SNPE	Decomposition temperature	Eurenco
2001	2-ethylhexyl nitrate	SNPE	Enthalpy of combustion	Eurenco
2001	2-ethylhexyl nitrate	SNPE	DSC thermal analysis	Eurenco
2001	2-ethylhexyl nitrate	SNPE	Flash point	Eurenco
2001	2-ethylhexyl nitrate	SNPE	SADT 50 kg package	Eurenco
2001	2-ethylhexyl nitrate	SNPE	SADT Non insulated 25m^3 ISO tank	Eurenco
2001	2-ethylhexyl nitrate	Chimec/ Stazione Sperimentale per i Combustibili	2-ethylhexyl nitrate as a cetane improver: classification and safety problems	Chimec

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 1.2/2.4	The energy releasing properties of a substance
GHS	Section 2.1	Globally Harmonised System
Energetic substance	Section 2.1	Substances which because of their chemical structure are capable of undergoing rapid exothermic decomposition with release of energy.
Aspiration	Section 2.1	The entry of a liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system.
Vasodilatation	Section 2.2.1	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.
Acute health effect	Section 2.2.1	Adverse effects resulting from a single exposure to a substance.
Chronic health effects	Section 2.2.2	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 2.3	Intrinsic properties of a chemical substance or mixture that present a danger to the environment, and in particular to aquatic organisms.
Decomposition temperature	Section 2.4	The decomposition temperature in this document is the temperature at which the chemical decomposition of 2EHN is detected in calorimeters. Note that the self heating of 2EHN depends on several factors, including the size and shape of containers and ambient conditions. See thermal ignition critical temperature.

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Term	Where	Definition
REACH	Section 3	REACH is a European Union regulation concerning the **R**egistration, **E**valuation, **A**uthorisation & restriction of **CH**emicals.
IUPAC name	Section 3	A chemical name assigned using nomenclature rules recommended by the International Union of Pure and Applied Chemistry.
EINECS name	Section 3	A chemical name as it appears on the European Inventory for Existing Commercial (Chemical) Substances.
CAS number	Section 3	The unique identification number for a chemical substance listed on the Chemical Abstracts Service.
EC No.	Section 3	The unique identification number for a chemical substance listed on the European Inventory for Existing Commercial (Chemical) Substances.
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: 110°C (closed cup).
Auto-ignition temperature	Section 5.2	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.
IBC /IBC's	Section 5.2	Intermediate Bulk Container. For liquids this is normally a rigid or flexible portable package with a capacity of less than 3 m3 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".
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.
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 93.3°C (200°F).

Term	Where	Definition
Non insulated 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.
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.
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 water. The partition coefficient is usually presented in the form of its logarithm to the base ten. It may also be referred as a Log Kow, or Log P.
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	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)

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