SOLVENTS FOR ACETYLENE FILLING

AIGA 112/20

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1 Introduction

Acetylene is a chemically unstable gas which can decompose violently under pressure. The acetylene gas is dissolved into a liquid solvent within the cylinder to improve the acetylene's chemical stability. This reduces the hazards involved in filling, transport and use.

This publication explains the safe use of solvents with acetylene.

2 Scope and purpose

2.1 Scope

This publication describes the properties of the two solvents used for acetylene filling, acetone and dimethylformamide (DMF). It highlights the properties and the precautions to be taken when working with them.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publications terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May and Need not

Indicate that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

The complete list of technical definitions related to acetylene are given in AIGA 022 *Code of Practice Acetylene* [1] [1].

For this publication the following definitions might be useful:

3.2.1 Acetone

The common and historic solvent used in cylinders for dissolving the acetylene.

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

3.2.2 Dimethylformamide (DMF)

The alternate solvent to acetone, commonly used in bundles of acetylene cylinders.

4 General requirements

Solvent quality is very important with respect to cylinder filling. Both solvents, acetone and DMF, are hygroscopic and will absorb water upon exposure to the atmosphere. It is important to preserve the quality of the solvent to ensure that acetylene is efficiently dissolved.

Acetone and DMF shall never be mixed as it will be impossible to determine residual gas content or the solvent loss. In the case of accidental mixing, the cylinder should be either scrapped or returned to the cylinder manufacturer for reconditioning.

4.1 Solvent characteristics

When handling or using solvents precautions shall be taken as stipulated on the Safety Data Sheets (SDS). These products are flammable (in particular the acetone because it is more volatile) and have harmful properties (see Table 1).

Table 1 Properties

	Acetone	Dimethylformamide (DMF)
Refractive index at 25 °C	N=1.36	N = 1.427
Molecular weight	58.08	73.09
Boiling point at 1 013 hPa	56.1 °C	153 °C
Freezing point	- 94.6 °C	- 61 °C
Relative density of vapour (air = 1)	2	2.5
Flash point (closed cup)	- 18 °C	58 °C
Auto-ignition temperature	538 °C	410 °C
Lower explosive limits (% by volume in air)	2.15	2.2
Upper explosive limits (% by volume in air)	13	16
Vapour pressure at 20 °C	0.247 bar	0.0035 bar

4.2 Solvent specifications

Recommended solvent specifications are given in Table 2.

Table 2 Specifications

	Acetone	Dimethylformamide (DMF)
Density Range at 20°C	0.789 – 0.792 kg/L	0.947 – 0.951 kg/L
Minimum Purity	99.7% by mass	99.8% by mass
Maximum Water Content	0.3% by mass	0.2% by mass
Visual appearance	Clear and transparent	Clear and transparent

Contaminated or sub-standard solvents can result in poor acetylene cylinder performance and/or compromise the safety of the cylinder. This could require that affected cylinders are to be scrapped.

Solvents should only be purchased from a reputable supplier capable of supplying detailed analysis documentation for the solvent. Generally, recovered solvents are not recommended for re-use in acetylene cylinders.

4.3 Material compatibility

Acetone and DMF react negatively with certain plastics and polymers, causing them to swell and disintegrate or lose mechanical strength. When sourcing or selecting synthetic materials to be used with these solvents, materials shall be investigated to ensure compatibility.

Examples of polymers NOT compatible with acetone include:

- nitrile
- chloroprene
- viton.

Examples of polymers NOT compatible with DMF include:

- polyacrylates
- hypalon
- natural rubber.

4.4 Use of equipment in explosive atmospheres

For the classification of equipment, refer to IEC60079-0, *Explosive atmospheres - Part 0: Equipment - General requirements* [2] or applicable local regulations

Equipment approved for acetylene use is classified as Gas Group IIC and Temperature Class T2. It will be suitable for acetone and DMF as well. However, the reverse is not true. true.

Equipment for acetone shall at least meet the following requirements (or equivalent):

Gas Group: IIA

Temperature Class: T1 (AIT ≥ 450ºC)

Equipment for DMF shall at least meet the following requirements (or equivalent):

Gas Group: IIA

Temperature Class: T2 (300ºC < AIT ≤ 450ºC)

All equipment and piping used with solvents shall be earthed and bonded to ensure electrical continuity and avoidance of static build-up. When solvents are decanted from a drum, the receiving container shall be bonded to the source drum before transferring the solvents. This is to avoid any static discharge between the containers. Solvents shall not be decanted into plastic buckets.

5 Solvent properties

5.1 Properties of acetone

Acetone is a clear, colourless liquid. It is low in density and gives off a strong odour which smells like nail polish remover. Liquid acetone is very volatile at normal temperatures and will generate a significant amount of acetone vapour. Acetone vapour in air is highly flammable and will burn vigorously if ignited. All sources of ignition shall be kept away from the area where acetone is used. Acetone vapour will accumulate in low-lying areas. Acetone vapour can travel a long way from the point of release, and if ignited can burn back to the source of release. Only use acetone in well ventilated areas. Acetone is hygroscopic enabling it to absorb moisture directly from the air.

Acetone is totally miscible with water and most common solvents.

Acetone that has been used in acetylene cylinders shall not be used as a degreasing agent for equipment and piping for oxygen service. Acetone can contain impurities that leave a residue after evaporation. Guidelines on the use of acetone as a degreaser are described in AIGA 012 *Cleaning of Equipment for Oxygen Service* [3]

Exposure to acetone can result in the following conditions:

- Prolonged breathing of acetone vapours can result in irritation of the respiratory system, headaches, coughing and slight fainting spells. Inhalation of acetone vapour is not toxic, but it is a central nervous system (CNS) depressant and can lead to light-headedness and drowsiness. If such effects are felt when in the presence of acetone, leave the area immediately and go to an open area that is well ventilated by fresh air.
- Acetone vapour can cause asphyxiation by the displacement of air. Because acetone vapour is heavier than air, it will settle in low-lying areas or confined spaces. Exercise caution when going into low-lying areas or confined spaces where acetone is used or present, as it can cause drowsiness and eventually unconsciousness or death.
- Contact with the skin can result in de-fatting and can lead to dermatitis. To prevent any contact, wear impervious protective clothing such as neoprene or butyl rubber gloves, apron, boots or whole bodysuit, as appropriate.
- Contact with the eyes can lead to severe irritation and discomfort. Reversible and/or irreversible corneal damage can occur.

5.2 Properties of DMF

Below is a description of potential hazardous exposure to DMF associated to use of acetylene cylinders. Before reading further it is noteworthy that the most common users (a refiller of cylinders, 5.2.2, and a user of the acetylene cylinder, 5.2.3) will not be exposed to values above the derived no-effect level (DNEL). Only for the initial filler (5.2.1), the requalifier of the cylinder (5.2.4) and the waste disposer of the cylinder (5.2.5) there is potential exposure above DNEL. For these three activities / workers there is need for further reading and understanding regarding the properties of DMF.

DMF is a clear, colourless liquid. It has a similar density to water. It gives off a mild slight fishy or ammonia-like odour. DMF is not volatile and evaporates slowly. DMF is hygroscopic enabling it to absorb moisture directly from the air. It is completely miscible with water and most common solvents.

There are two routes of exposure to DMF:

- Contact: DMF is readily absorbed by the skin with deleterious effects; therefore, liquid exposure to the skin is harmful.
- Inhalation: Inhalation of DMF vapour or mist can cause irritation in the respiratory tract. Wear appropriate respiratory equipment if exposed to DMF vapours.

Companies need to make sure that worker exposures are below the Occupational Exposure Limit Value (OELV) as per local country regulation. In absence of a local country OELV guideline , OSHA, NIOSH, ACGIH standard should be used. The control measures should be suitable and sufficient. To achieve this, it will be necessary to carry out worker exposure monitoring for DMF. This will provide evidence that the control measures (extraction, respiratory protection etc.) are effective.

Exposure to DMF can result in the following conditions:

- damage fertility;
- harm the unborn child;
- irritate skin, mucous membranes and eyes;
- damage the liver in case of long-term exposure;

- DMF vapour can cause asphyxiation by the simple displacement of air. Because DMF is heavier than air, it will settle in low-lying areas or confined spaces. Exercise caution when going into low lying areas or confined spaces where DMF is used or present, as it can cause drowsiness and eventually unconsciousness or death.

DMF is a very powerful solvent particularly relative to resins, plastics and rubbers. Care shall be taken when selecting materials for both plant and customers. DMF is not very volatile, but it does give off a highly flammable vapour. All sources of ignition shall be kept away from the area where DMF is used or stored. DMF gives off poisonous gases when burned.

The lifecycle of an acetylene cylinder using DMF as a solvent involves the following potential exposures:

- initial filling of DMF into the cylinder;
- refilling of the cylinder with acetylene;
- use of the cylinder by the customer;
- inspection of the cylinder and replenishment of DMF;
- disposal of the cylinder.

5.2.1 DMF exposure at initial filling of DMF into the cylinder

The initial filling of the cylinder and the replenishing are closed processes with limited exposure. The operator connects the filling hose to the cylinder, starts a pump and fills until the required weight of DMF is added (typically 20 kg for a 50L cylinder). The exposure to DMF is the residual in the dead space between the cylinder valve and the hose connector at disconnection. To ensure the exposure is below DNEL regulation, safeguards during the initial filling and replenishing of DMF include:

- enclosed process (no DMF to be handled openly);
- provision of a ventilated work area;
- use of Personal Protective Equipment (PPE) as determined by work place risk assessment.

5.2.2 DMF exposure at refilling of the cylinder with acetylene

DMF replenishment is not part of the acetylene fill process, which is an enclosed process. Therefore, there is no exposure of DMF to the operator.

5.2.3 DMF exposure during use of the cylinder by the customer

The use of the cylinder is an enclosed process. It is credible that the customer blows off a minor part of the cylinder to check its contents, even though this is not recommended. The physical properties of DMF (the high boiling point and associated low vapour pressure under normal conditions) mean that the release of DMF is small (typically 1 gram per 1kg of acetylene withdrawn from the cylinder). When the acetylene is used this is normally done in a burning process which means that any released DMF is consumed in the flame.

5.2.4 DMF exposure at inspection or replenishment

When the valve is removed for inspection of the internal porous material of the cylinder there is a potential exposure to DMF. Members of the European Industrial Gas Association (EIGA) have undertaken measurements of inhalation exposure to compare to the 8h-DNEL (5 ppm or 15 mg/m^3) and found that the exposure is less than 10% of the current 8h-DNEL.
The exposure levels and safeguards at inspection or replenishment, are the same as described for the first fill (5.2.1). (If replenishment is required it is typically not more than 0.5kg for a 50L cylinder).

5.2.5 DMF exposure at disposal of the cylinder

At the end of cylinder life, all acetylene cylinders are scrapped via licensed waste handling contractors. The waste handlers license requires them to undertake a risk assessment that will consider the potential operator exposure to DMF.

6 Storage of solvents

The main requirements for the storage of solvents are the following:

- Outside storage separated from buildings is preferred, segregated from incompatible materials and gas cylinders.
- Storage tanks and drums shall be protected from extremes of temperature.
- Tanks and drums shall be designed to avoid ground water and sub-soil pollution from spills and leaks and have secondary containment capable of holding 110% of the largest tank or drum volume.
- Spillage kits shall be available to contain and dispose of any spilled solvent.
- Receptacles shall be kept sealed when not in use.
- The storage installation shall be protected against physical damage.
- The storage installation shall be protected against electrostatic charges by earthing.
- Non-sparking type tools and equipment shall be used, including certified electrical equipment.
- Signs shall be posted indicating the identity and hazardous properties of the solvent.
- Safety Data Sheets shall be available.
- Storage and use areas shall be signed “No Smoking and no naked flames”.
- Ventilation shall be maintained at all times.
- Containers of solvents can be hazardous when empty as they can retain product residues (vapours, liquid). Observe all warnings and precautions listed for the product.
- PPE shall be worn when handling solvents (see AIGA 066, *Selection of Personal Protective Equipment* [4]).
- Obtaining permission or approval from local regulatory agencies, wherever applicable

6.1 Drums /Intermediate Bulk Container (IBC)

Solvent should be stored in metallic containers made of carbon steel, stainless steel or aluminium. Plastic materials may also be used if they are compatible. When in use, containers shall be earthed and should be placed within a bund which is able to contain 110% of the full contents of a single vessel in the event of a leaking, damaged vessel.

6.2 Bulk transfer (to storage)

Road tanker unloading points shall be protected from impacts from vehicles and be separated from passing traffic during unloading operations. Anti-tow-away systems/procedures shall be in place (please refer to AIGA 092, *Prevention of Tow-Away Incidents* [5]).

The surrounding ground should be such that any spillage drains to a safe containment area away from the tanker and cannot enter surface water drains. Temporary cover plates can be fitted to the drains to meet this requirement. Earthing connections shall be provided for the road tanker to prevent electrostatic build-up during transfer.

If using single membrane pumps, a risk assessment shall be carried out considering the consequences of a defective membrane and a release of the utilities used, typically compressed air or compressed nitrogen, into the process, (e.g. air ingress) or into the environment (e.g. a nitrogen release into a confined space).

6.3 Bulk storage

Tanks that are underground shall be of double walled construction with systems in place to detect any leakage of solvent between the double walls.

Tanks installed in a sealed underground pit shall not be covered with sand, soil or other materials as it is very difficult to detect leaks or inspect for corrosion of a tank covered in this way.

Low-level and high-level alarms should be installed.

Storage tanks can be either atmospherically vented or a nitrogen gas atmosphere maintained in the tank above the solvent. Where applicable, national codes for the storage of flammable liquids in bulk shall apply.

Atmospherically vented tanks shall be fitted with a device to prevent any external fire of solvent vapour from burning back into the tank. These devices are normally flame arrestors and should be installed on all return lines back into the tank.

7 References

Unless otherwise stated the latest revision shall apply.

[1] AIGA 022, *Code of Practice Acetylene*. www.asiaiga.org

[2] IEC60079-0**,** *Explosive atmospheres - Part 0: Equipment - General requirements.* www.iecex.com

[3] AIGA 012, *Cleaning of Equipment for Oxygen Service*. www.asiaiga.org

[4] AIGA 066**,** *Selection of Personal Protective Equipment***.** www.asiaiga.org

[5] AIGA 092**,** *Prevention of Tow-Away Incidents***.** www.asiaiga.org