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Measures for quality and safe application of two-component Spray Polyurethane Foam for the thermal insulation or renovation of buildings

1. Introduction



With the use of Spray Polyurethane Foam (SPF) expected to increase over the coming decades, trade associations like PU Europe* and NVPU** are bundling expertise and are promoting research, training and certification in the field of SPF. The aim is to continue to guarantee the quality and safety of processing and to improve it where possible. These important initiatives will also reach beyond professionals to homeowners and those in the building and construction community.

*PU Europe is the EU Industry association of the polyurethane (PU) insulation industry
 ** NVPU is the Dutch association of PU rigid foam producers

1.1 Objectives

The objectives of these guidelines are to provide guidance to companies who apply high-pressure Spray Polyurethane Foam, to ensure a safe working environment for their workers and to deliver maximum quality of the work. When product quality is assured and the measures described are properly implemented, safety and health risks for building occupants are avoided.

The recommendations set out here are intended to supplement specific and detailed information from the SPF chemical suppliers (i.e. Safety Data Sheet, Product Datasheet and Product Application Guide). Although voluntary, their adoption – and certification at local and national level – would certainly be a welcomed step from market players (authorities are also encouraged to make use of them).

1.2 Content and targeted audience

Buildings can be made more energy efficient, resilient and airtight by insulating in-situ with two-component Spray Polyurethane Foam. These guidelines describe the conditions and measures to carry out this activity with maximum quality of the work while reducing health and safety risks for installers, bystanders and occupants. They are aimed at companies performing in-situ thermal insulation or renovation activities with SPF in buildings and apply to both open-cell and closed-cell SPF systems. In addition, the information is also relevant for clients and designers.

It shall be noted that suppliers of SPF chemicals may have supplementary requirements to those contained in these guidelines which must be adhered to.

1.3 Mandatory training on safe use of diisocyanates

To ensure that workers across the EU can continue to handle diisocyanates safely, new training requirements are mandatory for professional and industrial users under the EU's REACH Regulation from 24th August 2023. The aim is to reduce the number of occupational asthma cases suspected to be caused by diisocyanates by ensuring that all diisocyanates users are informed and trained about potential hazards and how to handle products safely, taking into account the specific exposure prevention aspects.

The official text of the REACH restriction can be accessed [here](#) and you can find [here](#) very useful information on the industry platform put in place to help companies/workers to comply with those requirements.

1.4 Certification of SPF activities

The spray foam industry is rapidly expanding, which means the importance of certification increases.

Unlike other types of insulation, spray foam is not a pre-manufactured good. Hazardous chemicals are taken to the job site, where the actual product is made. The liability of correctly processing the SPF chemicals and proper installation belongs to the installer. Additionally, maintaining employees with the proper spray foam certifications in handling and safety are a crucial aspect of running a successful business.

Secondly, SPF chemical suppliers promote certification. Spray foam has been successfully installed in hundreds of thousands of homes and buildings, and the SPF chemical suppliers want contractors who are properly certified and trained to ensure that they handle equipment responsibly, process chemicals correctly and in a safe way and guarantee a well manufactured product.

The aim of these guidelines is to promote national certification.

1.5 Requirements relating to regulations & guidelines

Spray foam insulation is subject to regulations and guidelines to ensure its safe and effective use.

National building codes typically include requirements for safety, structural stability, energy efficiency, and other aspects of design and construction. Compliance is required with the national building codes.

EN14315 (buildings) and EN14320 (building equipment and industrial installations) are the European standards that specify requirements for in-situ formed Sprayed Polyurethane (PUR/PIR) Foam (SPF). Only Part 1 of each standard is harmonised under the 2011 Construction Products Regulation (CPR).

2. Thermal insulation or renovation with SPF

Spray Polyurethane Foam is a highly effective and widely applied insulation and air-sealing material, suitable for both renovation projects and new buildings.

SPF is an insulation product that is produced on-site by mixing two liquid chemicals, a polyol blend and pMDI (polymeric Methylene diphenyl Diisocyanate) at a high-pressure using a spray gun. These chemicals react very quickly, expanding on contact to create foam that insulates, air seals and, for certain foams, provide a moisture barrier. When properly installed, SPF forms a seamless barrier on walls, around corners and on contoured surfaces. It is highly resistant to heat transfer and is an effective solution for reducing unwanted air infiltration through cracks, seams, and joints.



Three cases of application are distinguished, spraying in a:

- **Completely open space** (on the top of the roof, external insulation on façades, external ceilings)



- **Partially open space** (spraying in a new building site without installed windows and doors, or in an existing building site with all windows and doors opened, and also inside a very big, closed space like an industrial warehouse)



- **(Practically) Closed space** (crawl space, under roof space, inside a vessel or building, container)

3. Potential chemical exposures from SPF

3.1 Introduction

Like most construction work activities, professionals/workers must know and mitigate the risks they are confronted with. This section only focuses on risks in relation to SPF.

It must be recalled that companies and professionals/workers shall always check (read and understand) the Safety Data Sheets (SDS) of the products they are about to use first. The SDS is a key document in the safe supply, handling and use of hazardous chemicals. It provides the necessary information to help to protect human health and the environment.

Before, during and after the spray activities, exposure to hazardous chemicals is potentially possible, hence appropriate Risk Management Measures are required.

Section 3.2 explains the main ingredients involved in SPF applications, while section 3.3 describes the possible exposure routes and section 3.4 outlines the potential health effects.

As part of the risks that arise when exposed to SPF chemicals, it is recalled that sprayers must abide to fire safety regulations and that in many instances the use of flammable gas (notably as an in-situ blowing agent) will be prohibited to protect the safety of workers and of the structure.

3.2 The composition of SPF

Be aware that:

If pMDI becomes contaminated with water, carbon dioxide (CO₂) is released. The build-up of pressure can give rise to an explosion risk if containers are contaminated with water and subsequently sealed.

SPF is produced on-site by mixing two liquid chemicals, a polyol blend and a pMDI at a high-pressure using a spray gun. These chemicals react very quickly, expanding on contact to create a PU foam.

- The formulation of the **polyol-component** varies depending on the performances requested for the desired end-product (mechanical strength, thermal insulating properties, air permeability...). The formulators could therefore add various components to the polyol such as catalysts (amines), foaming agents, blowing agents and flame retardants. The substances released during and shortly after mixing the components are diverse. Measurements show that both closed-cell and open-cell SPF release the same types of substances. As the names indicate, the final structure of the foam is different for both products. The cell structure is different due to the absence of physical blowing agents for open-cell SPF (more information on the differences between those two products in our [factsheet #22](#)). Since the application is carried out in the same way, these guidelines apply to both open-cell and closed-cell SPF.
- **pMDI** is a very reactive chemical, and reacts with water, polyols, alcohols, amines, bases and acids.

3.3 Possible exposure routes

When SPF is being used, the work site should be restricted to persons wearing appropriate Personal Protective Equipment (PPE). The information on this chapter is meant to underline the importance of wearing protective equipment by explaining ways that chemical exposures from SPF may occur.

Vapours and aerosols:

- Spray application generates diisocyanate vapours and aerosols.
- Research data indicate that inhalation exposures during SPF insulation will typically exceed Occupational Exposure Limits (OELs) and require skin, eye and respiratory protection.
- Vapours and aerosols can migrate through the building if the area is not isolated and properly ventilated.
- After application, vapours may linger in a building until properly ventilated and thoroughly cleaned.

Dust:

- Cutting or trimming the foam as it hardens may generate dust that may contain unreacted diisocyanates and other chemicals.
- After application, dust may linger in a building until properly ventilated and thoroughly cleaned.

Heat-generating processes:

- Activities like drilling, welding, grinding, or sanding near the foam insulation can release airborne degradation chemicals, including diisocyanates, amines, carbon dioxide, carbon monoxide, hydrogen cyanide, or nitrogen oxides.

Fire:

- Fires involving SPF may release diisocyanates, hydrogen cyanide amines, and other toxic chemicals into the air.

Curing time:

- Curing refers to the chemical reaction that produces polyurethane foam. SPF may appear hardened or “tack-free” shortly after application. However, at this stage, the foam is still curing and still contains unreacted SPF chemicals.
- SPF chemical suppliers recommend different re-entry and re-occupancy times based on the specific SPF product (for guidance on re-entry and re-occupancy, please consult the [Safety Matrix](#) in Appendix 1).
- Remember to consult your supplier for precise guidance on ventilation time and safe re-entry after SPF application. Safety precautions are crucial to minimise risks associated with chemical exposure during and after SPF insulation.

Working in confined spaces:

- Attics and crawlspaces may be considered confined spaces. Work in confined spaces that may produce a hazardous atmosphere should meet the requirements specified in the national regulations.

3.4 Potential health effects of SPF

Potential exposure to diisocyanates and other SPF chemicals, that may be found in vapours, aerosols, dust, or on surfaces during and for a period of time after installation can cause adverse health effects.

Diisocyanates (with pMDI part of that family)

pMDI is classified as hazardous in handling and usage primarily due to its potential to produce respiratory and dermal sensitisation.

The main hazard arises when pMDI is inhaled, either in the form of vapour, aerosol or dust. The hazard is most likely to arise when materials are heated, sprayed, or used in a confined unventilated space, or if correct handling procedures are not followed.

Diisocyanates can be absorbed by the body through the skin and via inhalation (Dutch Health Council, 2018), and that exposure can lead to irritation of the skin and mucous membranes of the eyes, gastrointestinal tract and respiratory tract. In addition, diisocyanates are sensitising, respiratory and/or skin exposure can lead to allergy.

However, diisocyanates are very reactive substances and together with polyols will transform in an inert PU material in a matter of minutes. Therefore, the final end-users (building occupants) will never be exposed to diisocyanates at their premises, in case the prescribed re-occupancy times are adhered to (for guidance on re-entry and re-occupancy, see the [Safety Matrix](#) in Appendix 1).

REACH use restriction for diisocyanates:

The restriction on diisocyanates enhances and harmonises the level of workers protection using diisocyanates across the EU. The restriction entails that all workers who interact

directly with these substances are both informed and trained to manage the associated risks. This obligation is communicated on the SDS and the drums via the label “as from 24th August 2023 adequate training is required before industrial or professional use”.

Workers occupational exposure limit values for diisocyanates:

In addition to the REACH restriction, legislators felt the need to also act via the OSH framework (European directives on Occupational Safety and Health) and new European occupational exposure limit values for diisocyanates have been set.

Occupational Exposure Limits (OELs) are regulatory values which indicate levels of exposure that are considered to be safe (health-based) for a chemical substance in the air of a workplace.

The new law sets, from the 1st of January 2029, Occupational Exposure Limit for diisocyanates at:

- 6 µg NCO/m³ for TWA (the maximum concentration that a worker can be exposed to during an eight-hour working day) and
- 12 µg NCO/m³ for STEL (short-term exposure i.e., a period of 15 minutes).

A transitional value of 10 µg NCO/m³ for TWA and 20 µg NCO/m³ for STEL will apply until 31st December 2028.

These new EU OEL values, in combination with the mandatory training for workers required by the EU restriction under REACH, will provide a framework which fully protects workers, and which represents an important step towards achieving further reduction of occupational asthma cases.

Volatile Organic Compounds (VOCs)

Because of the high-pressure spraying nature of this activity, various VOCs can be released during spraying. The effects depending on the exposure are:

- Short-term exposure to certain VOCs can lead to behavioural effects, intoxication symptoms and irritation of skin and mucous membranes.
- With long-term exposure, adverse effects on organs and the central nervous system may occur. This can cause permanent damage to motor skills, perception, intelligence and memory. One of the best-known consequences of exposure to Volatile Organic Compounds is painter's disease or psychoorganic syndrome (POS), also known as organic psychosyndrome.

Obviously, after the SPF application and once the foam is fully cured, tests have demonstrated that VOCs emissions are negligible.

Fully cured SPF

Shortly after the spraying of SPF, the final stage of the product is reached. Fully cured SPF is considered to have no adverse health effects since all the substances have transformed into a rigid matrix or are part thereof (for guidance on re-entry and re-occupancy, see the [Safety Matrix](#) in Appendix 1).

4. Risk Management Measures

4.1 General

This chapter identifies measures that, according to the current state of technology and science, reduces exposure to hazardous substances. The measures are presented per construction phase. Four construction phases are distinguished: design, work preparation, execution and cleaning, maintenance and repairs. It is recalled that the Safety Data Sheet of the products used shall be read and understood before performing the job. It should always be available in the vicinity of the construction works.

When spray applicators follow appropriate risk reduction measures, the potential hazards associated with spray chemicals in the work area can be effectively managed using:

- Engineering controls, Local Exhaust Ventilation (LEV)
- Work instructions/practices, training
- Personal Protective Equipment (PPE)
- Restricting unauthorised access to the work zone

Adherence to re-entry times limits exposure to spray chemicals to (other) workers after application.

Adherence to re-occupancy times limits exposure to spray chemicals to habitants after the curing process.

Only workers who successfully followed the mandatory training required by the EU restriction under REACH are allowed to perform the job.

4.2 Measures in the design phase

The building as a whole should be designed so that it can be built, maintained and dismantled in a safe and healthy way. This is the responsibility of the client and the designer. The spraying company shall respond to the customer's demands always considering quality and performance aspects, the health and safety of its employees and of the occupants, when recommending the insulation to be used. Unhealthy and unsafe options shall never be offered.

4.3 Measures during site preparation

In both interior and exterior SPF applications, restrict the work areas to required personnel. Check that all workers have been trained and are wearing the required PPE. As a general rule, always follow chemical suppliers' application instructions and operating parameters, including pressures, temperatures and pass thickness.

TECHNICAL MEASURES

Storage & transport:

It is important that SPF chemicals are stored according to the chemical suppliers' recommendations.

- pMDI reacts with water, therefore containers should be kept carefully sealed, protected from moisture. If pMDI becomes contaminated with water, carbon dioxide (CO₂) is released. The build-up of pressure can give rise to an explosion risk if containers are contaminated with water and subsequently sealed.
- Furthermore, open flames and direct sunlight must be avoided at all times.

Products should be transported in well-sealed drums which are fixed to the vehicle during transport. The vehicle used to transport the products should have ventilation. Drums should be inspected for damage in transit.

Site preparation:

- Post warning signs communicating site restrictions to workers not in PPE.
- When moving in/out the pumping system from the drums, great care should be applied to organise the area and to avoid droplets falling on the vessel or on the skin.
- Check and adjust the temperature and pressure of the spray system (lines, spray gun) in accordance with the chemical suppliers' guidelines.
- Domestic HVAC (Heating, Ventilation and Air Conditioning) systems must be switched off and sealed prior to the spray activities.
- Designate an area for putting on and removing Personal Protective Equipment.
- Protect adjacent surfaces for interior applications and take necessary measures to avoid overspray for exterior applications (wind).

Ventilation:

- Depending on the application case (not needed for completely open space), the work area/room is mechanically or naturally ventilated (see [Safety Matrix](#) in Appendix 1). If necessary, ventilation openings are made prior to the work as well as the sealing of openings to other rooms. If mechanical ventilation is required, a fan with a flow rate of at least 300 m³/h shall be used.
- When placing an exhaust hose, it should be ensured that spray mist does not leak out and that the extracted air is discharged in a safe way i.e.:
 - » the wind direction is taken into account;
 - » the exhaust is placed outside the building, away from workers or other people;
 - » the exhaust is placed away from air intakes of neighbouring buildings;
 - » the area of the exhaust is restricted, using warning signs.
- Make sure the ventilation system is on before the application work commences (if applicable).

ORGANISATIONAL MEASURES

- Prior to the spray work, the area to be insulated is inspected for the presence of construction debris, obstacles, leaking (gas) pipes, unshielded electrical cables, (ground)water et cetera. If necessary, provisions are made for clearing obstacles, levelling the ground, providing a dry surface (drainage) and so on.
- Check the conditions of the surface/substrate to be sprayed. All surfaces to be sprayed must be free of oil, grease, waxes, rust scale, loose dirt and water. In addition, the substrate must be structurally sound and must be able to withstand the heat generated by the exothermic reaction. Avoid applying SPF to hot surfaces and keep a safe distance between the foam and these surfaces. The moisture content of wood substrates must not exceed 19% before foam is applied. For brick or concrete, SPF can usually be applied when dry to touch. For other substrates, verify the manufacturer recommendations. Some metal surfaces may require sandblasting and priming prior to foam spraying to ensure adequate adhesion. When in doubt about the potential for adhesion to a substrate, build a mock-up and spray the foam under similar conditions to that expected in the field, then test for adhesion and cohesion.
- All possible risks should be identified in advance.
- No chemical substances are stored in the room intended for storing, preparing and/or consuming food and drink.
- There is no overnight stay in the area where substances are stored or where exposure to hazardous substances may otherwise occur.
- A (skin) cleanser is used for cleaning hands.
- A lamp is provided that can be used in case of emergency to illuminate a dark area (if this case can be encountered).
- A marking (like hazard tape) is placed to keep people at a safe distance (at least 10 meters of the spraying work area and possibly for restricting the exhaust air area).
- Tools for communication between the sprayer to the helper are provided, e.g. by means of a wireless transmitter and receiver and/or an acoustic and optical signal.
- When planning, it is ensured that there is no language barrier. Workers should be able to communicate with each other.
- Companies provide periodic instructions to employees for careful changing at breaks and after spraying, so that all contact with contaminated clothing and protective equipment is prevented.

4.4 Measures during SPF application

Only applicators and helpers using effective workplace practices (including ventilation), appropriate Personal Protective Equipment, and other steps to control exposure should be present during and for a period of time (see the [Safety Matrix](#) in Appendix 1) after SPF installation. To avoid chemical exposure as these products cure, the workers from other trades, as well as the occupants of the home/building, should not enter the site until the chemical suppliers' "re-entry and re-occupancy times" are adhered to.

TECHNICAL MEASURES

- Check that the spraying machine (pump, spray gun – pressure, temperature and so on...) continues to operate as specified by the manufacturers and SPF formulators.
- Check that the performance of the ventilation system (if any) supporting the spray foam application is maintained through the work (check the exhaust hose if needed).
- The compressor for the air feeding apparatus of the sprayer is positioned so that it draws in clean air.
- Spray foam in passes such that the total thickness will be built up in discrete layers with average thicknesses according to the chemical suppliers' technical information.

ORGANISATIONAL MEASURES

- At the start of the work, check the quality of the material and the efficacy of the spray machine; a test spray shot could be carried out (into a bag or on a cardboard). For this, the sprayer wears the same personal protection as during application of the spray foam.
- Waste (including used cloths, used gloves, used filters, etc.) is kept in a separate container.
- Spray helper to check the safety of the sprayer (proper communication, checking ventilation, et cetera).
- The helper remains nearby so that communication with the sprayer is possible.
- Direct contact with fresh spray foam is avoided.
- There is no eating, drinking or smoking in the vicinity of hazardous substances (from the store of chemicals to the work area).
- The only people who are present in the spraying area are those who really need to be there (no unnecessary exposure – this is a spray helper task).
- For closed space, after completion, the insulated area forced ventilation stays on for at least 15 minutes. Additionally, do not remove PPE in areas where there is a potential for exposure to spray chemicals.
- For partially open and closed spaces, upon departure, the insulated space is sealed, or marked to prevent access until the re-entry time/re-occupancy limit (see Appendix 1, [Safety Matrix](#)) is reached.

PERSONAL PROTECTIVE MEASURES

Personal Protective Equipment (PPE) for applicators and helpers in spraying area:

- During spraying independent respiratory protection is required i.e. an approved, full-face or hooded-type Supplied Air Respirator (SAR). This also applies when entering the area to be insulated within the re-entry times according to the [Safety Matrix](#) (Appendix 1).
- The use of a full-face or hooded-type respirator can provide eye and face protection.
- Before each use, clothing in general (including respirator) is checked for damage. Damaged clothing is replaced immediately and stored separately in the sealed waste bin.
- A disposable coverall that provides protection against chemicals/mist, made of PVC or Tyvek® (category III, type 4, 5 or 6 according to EN340/EN13034) is required.
- During all work where contact with spray chemicals is possible, suitable chemical resistant gloves (e.g. nitrile, neoprene, butyl or PVC) shall be used, as indicated in the SDSs.

- Workers require training on when to use gloves, how to use them and especially how to take them off without contaminating the skin.
- Safety shoes or boots are required with a minimum level S3 according to EN ISO 20346.
- For short-term stays in sprayed area, the helper has the same level of protection as the sprayer. This applies to the extent possible in case of emergency.
- Fine spray mist containing diisocyanates will be present in the air after spraying has finished and the respirator must be kept on until the sprayer has moved to an area where there is no risk of exposure.

PPE for helpers/other workers in the restricted area:

If a helper is not working in the immediate area (> 10 meters), where the spraying is taking place, and if there is proper air ventilation, the helper(s) may wear a full-face or half-face Air Purifying Respirator (APR) with an A2P3 filter. All other PPE must be worn i.e. protective clothing, gloves and safety glasses/goggles in case of half-face mask.

When?:

- Combining drums / liquid handling
- Cleaning guns
- Inspections
- During trimming, cutting and sanding of the foam
- Dealing with diisocyanate waste
- Dealing with a diisocyanate spillage

At the time of writing this guide, the following Respiratory Protective Equipment (RPE) is deemed satisfactory in case of spray activities:

- EN138: a fan-assisted (non-fan-assisted air hoses is limited to a wear time less than 1 hour) fresh air hose with full-face mask providing the fresh airline hose inlet can be located well away from the work area, e.g. outside the building and upwind of any local sources of airborne contamination, such as vehicle exhaust.
- EN269: a powered fresh air hose hood providing the fresh airline hose inlet can be located well away from the work area, e.g. outside the building and upwind of any local sources of airborne contamination, such as vehicle exhaust.
- EN14594: LDH3 constant flow airline breathing apparatus with a hood or full-face mask.

Illustrative examples of Supplied Air Respirator (SAR):



EN138: a fan-assisted fresh air hose with full-face mask providing the fresh airline hose inlet can be located well away from the work area, e.g. outside the building and upwind of any local sources of airborne contamination, such as vehicle exhaust.



EN269: a powered fresh air hose hood providing the fresh airline hose inlet can be located well away from the work area, e.g. outside the building and upwind of any local sources of airborne contamination, such as vehicle exhaust.



EN14594: LDH3 constant flow airline breathing apparatus with a hood or full-face mask

When the helper has to enter the area to be isolated (within 10 meters of the actual spray activity), he/she also wears RPE as listed above.

4.5 Cleaning, maintenance and repairs

Ensure that the spray equipment is properly maintained and cleaned in accordance with the manufacturer's instructions, which includes:

- regular visual checks;
- technical controls;
- procedures for reporting and repairing defective equipment, registration of service, maintenance, repair and testing of the equipment.

During cleaning, maintenance and repair, there is a risk of inhalation and skin contact with SPF substances chemicals and/or organic solvent(s), hence appropriate PPE is required.

The professional use of aprotic polar solvents for cleaning is not recommended, since MDA can be formed.

It is important to again refer to the SDSs, to the mandatory training set under the REACH diisocyanates legislation and to the chemical suppliers' equipment/tools recommendations.

In addition to mitigating health issues, cleaning/maintenance/repairing of the equipment will help avoiding the blocking of lines which could cause undesired mixing ratio and will ensure the quality of the SPF final product.

In any cases:

- Cleaning of the equipment is carried out outside the spray area.
- Information and instructions on cleaning and storage of Respiratory Protection Equipment is provided.

4.6 Emergency facilities

It is strongly recommended to have a fire extinguisher, an emergency eye wash station and a comprehensive, well-stocked first aid kit available and know their location.

Additionally, it is strongly recommended to have an emergency spill containment kit available that contains:

- Nitrile, neoprene, butyl rubber or PVC gloves and disposable coveralls
- Respirator
- Industrial absorbing towels and absorbent materials such as clay, pads, or sand
- Neutralisation liquid for spill of diisocyanates
 - » Sodium Carbonate: 5-10 %
 - » Liquid soap: 0.2-0.5 %
 - » Water up to 100 %
- Shovel and brush and waste bag or container

5. Disclaimer

While all the information and recommendations in this publication are to the best of our knowledge, information and belief accurate at the date of publication, nothing herein is to be construed as a warranty, express or otherwise.

