

Polyurethane foam spraying



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Good practices
guide

**IRSST
ASP Construction**

Polyurethane foam spraying

GOOD PRACTICES GUIDE

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Glossary

- Hazard :** Any source of potential damage, harm or adverse health effects on something or someone under certain conditions at work.
- Risk :** Probability of a hazard occurring that is related to various risk factors. A person can be harmed or experience an adverse health or safety effect or property losses as the result of a hazard.
- Risk factor :** Aspects, circumstances or sources that have an impact on the degree of possible risk for the purpose of facilitating its evaluation or reducing its consequences.

Introduction

This good practices guide was developed jointly by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) and the Association paritaire pour la santé et la sécurité du travail du secteur de la construction (ASP Construction).

Its intended use is to make people aware of the hazards, risks and risk factors¹ associated with the application of thermal insulation as well as means of controlling them.

The composition and uses of polyurethane foam represent three types of hazards during spraying, namely chemical and ergonomic hazards, as well as those related to safety.

¹ The definitions of hazard and risk in this document have been adapted from those of the Canadian Centre for Occupational Health and Safety (CCOHS): http://www.ccohs.ca/oshanswers/hsprograms/hazard_risk.html (consulted July 2008).

1. Types of polyurethane foams and their uses

The foam sprayed by means of a gun consists of a polyisocyanate (4,4'-diphenylmethane diisocyanate (MDI)) and a polyhydroxylated compound (polyol) containing a foaming agent (mainly a fluorocarbon). It is applied on clean and dry surfaces in variable thicknesses to obtain a thermal resistance. Mainly used inside or outside residential and commercial buildings, this product is also used to insulate refrigerated vehicles, storage tanks, and heating ducts and pipes.

An “approved” foam complies with the standards stipulated under the Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Material – Specification CAN/ULC-S705.1-01 and the Standard for Thermal Insulation – Spray Applied Rigid Polyurethane Foam, Medium Density – Installer's Responsibility – Specification CAN/ULC-S705.2-04 . It must be applied according to the manufacturer's instructions by a trained and certified installer (working for a contractor complying with, among other things, the standards of the quality assurance program of the Canadian Urethane Foam Contractors Association (CUFCA) . A “certified” installer has successfully completed two training programs: the first, recognized by CUFCA, and the second, by the foam manufacturer.



² http://www.cufca.ca/codes/s705-1_e.php (consulted July 2008). This standard requires that polyurethane foam be installed according to standard CAN/ULC S705.2.

³ http://www.cufca.ca/codes/s705-2_e.php (consulted July 2008). This standard establishes the requirements for acceptable environmental conditions for spraying, the requirements for the bottom coat, the daily tests for the products installed, and the documentation requirements.

⁴ <http://www.cufca.ca/> (consulted July 2008).

2. Chemical hazards

During spraying, polyurethane foam installers and their assistants are exposed, by inhalation and by skin or eye contact, to small particles in monomer and oligomer form, as well as to MDI vapours (CAS # 101-68-8). Other workers on the site can also experience the adverse health effects related to the use of this product.

It is important to know that MDI is a skin, eye and respiratory tract irritant as well as a sensitizer that can induce asthma. The commercial products intended for the spraying of rigid insulating foam contain from 25 to 75% MDI in monomer form. In Québec, the Regulation respecting occupational health and safety (RROHS) sets the permissible exposure value (PEV) for MDI at 0.051 mg/m³ or 0.005 ppm.

In addition to a notation about the sensitizing effect of MDI (S notation), the RROHS mentions that exposure to isocyanates in oligomer and monomer form in the fine droplet or vapour state must be reduced to a minimum (EM). Finally, the regulation modifying the Safety Code for the construction industry (SCCI) and the RROHS mention that protection and the reduction of exposure to isocyanates apply to construction sites (RROHS, article 2), at least for diisocyanates or the oligomers of isocyanates.

Several companies manufacture polymeric MDI (PMDI) for insulation. PMDI is marketed under different names: Lupranate®, Rubinate®, Desmodur®, Voranate®, Caradate®, etc.

Polyurethane foam installers and their assistants can be exposed, in addition to MDI, to other toxic or irritating substances for the skin, eyes and respiratory tract during the performance of related tasks. For example, cleaning of the spray gun with a product containing a substance absorbed through the skin involves risks according to the RROHS. There are also possible harmful effects associated with the masking of the structural elements to be protected (preparation of the substrate).

⁵ CAS #: Registration number for a chemical substance in the database of the Chemical Abstracts Service, a division of the American Chemical Society.

⁶ C.S-2.1, r.19.01, section 1, article 2, in force March 2008. http://www.csst.qc.ca/NR/rdonlyres/A689E06B-EBA7-40FE-A55A-EBAF1239FC21/4177/DC_200_1027.pdf
http://www2.publicationsduquebec.gouv.qc.ca/dynamicSearch/telecharge.php?type=2&file=%2F%2FS_2_1%2FS2_1R19_01_A.htm

Installer's protective equipment



2.1 Preparing the substrate

The substrate onto which the foam is sprayed must be clean, dry and free of greasy or oily substances in order to ensure adherence of the foam. Windows, doors, floors and any other structural elements must be protected by means of tarpaulins, plastic sheeting, etc. These are attached to the surfaces with spray contact glue mainly containing acetone, toluene and hexane. The use of contact glue also exposes the user to harmful vapours. This sheeting protection can also be attached by means of staples or adhesive tape.



2.2 Spraying

The PMDI and resin mixture, applied by passes⁷ on narrow strips, gives off heat that promotes expansion of the foam. The foaming agent causes the foam to expand and adhere better to the substrate.

The foam is sprayed on indoor and outdoor substrates of buildings for thermal insulation purposes or to make some structural components airtight (sealing garage belts, soffits, etc.).

Manufacturers of commercial products recommend taking certain precautions during work carried out at temperatures close to 0°C. They suggest that a specific mixture be used for cold temperatures. However, according to the CAN/ULC-S705.2-05 standard, the difference between the ambient temperature and that of the substrate must not exceed 17°C; the relative humidity of the air must be below 80%, and the wind speed must be below 10 km/h.

It is strictly prohibited to install a temporary shelter to protect the work area from precipitation (rain, snow, etc.) and winds exceeding the prescribed speed. The shelter prevents the aerosols from dispersing, thus increasing the risk of exposure. Finally, it is forbidden to use this type of shelter on elevating equipment (hoisting apparatus). This subject will be discussed in greater detail in section 3, Safety hazards.

Foam spraying in enclosed or confined spaces (within the meaning of article 1 of the RROHS) increases the risk of exposure to MDI and the solvents, but also the ergonomic risk, particularly in low spaces, due to the spraying angle of approximately 90 degrees maintained by the worker.

On the site, a sign should indicate that spraying work is being done, that there is a risk of exposure to isocyanates, and that the appropriate respiratory and eye protection equipment must be worn.

It should be remembered that residual MDI vapours persist for up to two hours following the completion of the spraying work.



⁷ According to the CAN/ULC-S705.2-05 standard, the thickness of one pass must not be less than 15 mm, nor greater than 50 mm. When several passes are required, the foam must be left to cool to avoid scorching (discoloration).

2.3 Changing barrels or transferring MDI

In one day, the workers can transfer the aspiration system from an empty barrel to another barrel of PMDI. These barrels are stored under specific conditions, under nitrogen or dry air pressure, because PMDI reacts with the moisture in the ambient air to produce carbon dioxide (CO₂) and the polyresin of urea in the solid state.

The polyresin tends to accumulate on the walls of the piping and thus reduce the flow. In a humid environment, the release of CO₂ can create pressure and cause a sudden and violent dispersion of this gas. Should crystallization occur, the barrels must not be heated directly; instead, they must be stored in a location with a hot atmosphere for a stabilization period.

There is a risk of skin and eye contact during accidental splashes. Safety goggles must be worn.

Some contractors have a closed pumping circuit (> 100 tonnes or 220,462 pounds) to transfer the PMDI and the resin from one tank to other tanks (20 tonnes or 44,000 pounds) located in the truck. This system reduces the risk of contact with the products.

2.4 Poisoning

The compressor for spraying operates by diesel, whereas the elevating equipment operates by gasoline, diesel, propane or by a mixture of these fuels. When a motor is running, carbon monoxide (CO) and nitrogen oxides (NO_x) are released, depending on the fuel used. These noxious gases accumulate rapidly in non-ventilated enclosed or confined spaces, thus creating a risk of poisoning. High importance must be given to the possible impact of these exhaust gases, and the air inlet for the pump that supplies the supplied air respirator must be located far away from them.



CHEMICAL HAZARDS

Risk	Risk factors	Good practices
Inhalation exposure	Aerosols and vapours of MDI and resin solvents : 1. Basement walls 2. Enclosed or confined spaces: attic, refrigerated vehicle, trailer, freight car, etc.	■ Wearing a supplied air respirator. ■ Fit test for cartridge respirators. ■ Training in respiratory protection. ■ Training in the risks related to isocyanates. ■ Appropriate storage of cartridge respirators (sealed bag). ■ Installer certified by a certification organization with a quality assurance program. ■ Compliance with the exclusion zone. ■ Sign announcing the work and the obligatory wearing of respiratory and eye protection. ■ No hot work near the exclusion zone. ■ Removal of coveralls for meals, for transport, etc.
	3. Outdoor structures with use of elevating equipment (see section on safety)	■ The above-mentioned means of control apply. ■ Vigilance with respect to weather conditions. ■ Prohibition to construct a closed shelter on elevating equipment. ■ Presence of authorized people (installer and his assistant) with the wearing of a supplied air respirator. ■ Exclusion zone based on wind direction and speed.
	4. Enclosed area (RROHS art. 300 (1), Division XXVI): crawl space and other types	■ Procedure for entry into a confined space (SCCI, article 3.21). ■ Training of a worker qualified in the hazards and risks (RROHS, art. 298 and 301). ■ Another person posted outside the area to supervise during the work (RROHS, art. 308).
	MDI vapours: : 1. Peripheral workstation 2. Post-spraying	■ Wearing of a respirator. ■ Access prohibited to workers on the site who are not wearing respirators.

Risk		Risk factors	Good practices
Inhalation exposure	Whit the skin	MDI	■ Washing of hands and face before eating, drinking or smoking. ■ Wearing of TYVEX®, SARANEX® or BARRICADE® coveralls with hood. ■ Wearing of nitrile gloves under cotton gloves. ■ Skin rinsing if splashes occur. ■ Daily washing of work clothes at the warehouse and discarding of disposable clothing. ■ No contaminated or stained work clothes taken home.
		Solvents : 1. Gun cleaning 2. Barrel changing or decontamination	■ Wearing of long-cuff gloves made of material appropriate for the products. ■ Skin rinsing if splashes occur. ■ Wearing of a protective apron. ■ Wearing of a respirator. ■ Training adapted to loading and decontamination operations.
	Whit the eyes	Aerosols	■ Wearing of full face mask by the installer. ■ Wearing of eye protection (e.g., goggles) by all other workers. ■ Portable eye-wash device.
		Solvents : 1. Gun cleaning 2. Barrel changing or decontamination	■ Wearing of eye protection (e.g., goggles) (SCCI, art. 2.10.5). ■ Portable eye-wash device. ■ Training adapted to loading and decontamination operations.

3. Safety hazards

The spraying of insulating foam on structures sometimes requires the use of elevating equipment, which involves risks of falls for the workers and of objects falling.

3.1 Stepladder or ladder

The golden rule is never to use a damaged or deformed stepladder or one that is unstable. Choose a stepladder of an appropriate height for the work to be performed, complying with the Portable Ladders CAN3-Z11-M81 standard. The load rating must be sufficient (duty rating of 250 pounds) and class 1.

The stepladder must be installed safely, on a solid and level surface. It must be fully opened, with the spreaders solidly locked, with the pail shelf properly positioned, and free of tools or objects.

The angle of the ladder is also important: the horizontal distance between its foot and the vertical plane must be between $\frac{1}{3}$ and $\frac{1}{4}$ of the length between its side rails.

Of course, only one person can be on a ladder at a time. Any exaggerated extension movement of the arms and body can cause a loss of balance and result in a fall.

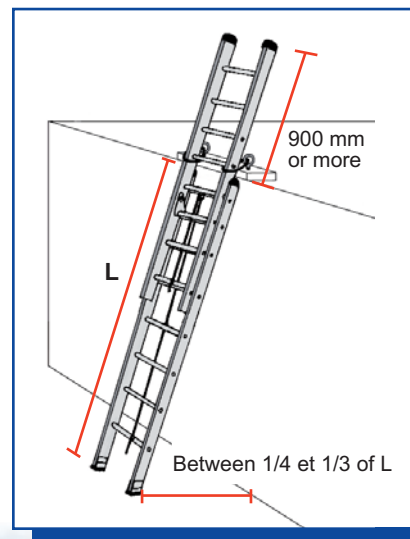
3.2 Work area approach equipment

The hoisting equipment and scaffolds used on a construction site must comply with the requirements of the Safety Code for the construction industry (SCCI, art. 2.4.2 (k)).

The choice of equipment must take into account the following factors:

- the workers' safety
- the working load
- the necessary height
- the specific characteristics of the work zone to be reached
- the manoeuvrability of the equipment
- the ground conditions

No modification must be made to the equipment without a duly signed and sealed authorization by an engineer specifying that the change provides the safety level equivalent to that of new equipment (SCCI, art. 3.10.1 (h)) and standard CSA B354.2-01.



3.2.1 Platform and guard-rail

The platform of elevating equipment is appropriate if it has, around its entire perimeter, a guard-rail with a midrail, and a toe board at the bottom (SCCI, art. 2.9.2). Some models of scissor-type platforms allow the addition of a side extension made of wooden or aluminum planks.

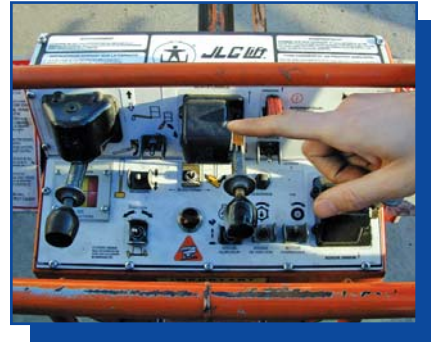
The worker must be attached to a fall arrest system if part of the platform's guard-rail is removed, and the maximum load must be respected.

IMPORTANT SAFETY INSTRUCTION : Never climb on or lean over the platform guard-rails, or use a plank, ladder or any other piece of equipment to reach a location that is out of reach or higher.

When a motorized elevating platform (scissor-type or with an articulated arm) is used, it is important, first, to protect it from foam contamination by means of plastic sheeting wrapped around the vertical and cross members of the guard-rail system.

There are two controls on this type of equipment: upper controls on the platform, and lower controls on the base. The controls must be of the “deadman” type and return to the neutral position when released (SCCI, art. 3.10.7 (1)).

IMPORTANT : It is prohibited to add a closed shelter made of tarpaulins or plastic sheeting to the platform because wind increases its likelihood of tilting and tipping over. Particular attention must be paid to the anchor points of the fall arrest system and to the access door. They must remain accessible at all times.



3.2.2 Safety devices

The auxiliary supports (outriggers or stabilizers) must be equipped with a device that prevents the platform from being raised if the operation is not performed properly. When they are used, the ground must always be checked to ensure that it has the bearing capacity appropriate for the weight of the equipment. On soft soil, use sole plates and pay attention to backfilled areas around building foundations.

A functional emergency stopping device is essential to stop all the systems in the event of failure. A device that prevents the free fall of the platform is also necessary in case of a defect of the hydraulic or electrical system (SCCI, art. 3.10.7 (1)).

3.2.3 Personal protective equipment

The wearing of a safety harness is recommended when elevating equipment is used. This harness must have an energy absorber connected to a lanyard to eliminate a free fall of more than 1.2 m (4 ft) (SCCI, art. 2.10.12). The attachment point for this lanyard must be a solid component of the platform that provides a breaking strength of at least 18 kN (SCCI, art. 2.10.12 (1),(3)). TYVEK® Saranex® or BARRICADE® coveralls, worn over the harness, must have an opening in the back for attaching the lanyard with the energy absorber.

GOOD PRACTICES : Good safety practices recommend that a harness be worn at all times when elevating equipment is used, if there is a possibility of a fall of more than 3 metres.

3.2.4 Authorization

It is strictly prohibited for a worker under 18 years of age to perform any task whatsoever from a motorized elevating platform (motorized hoisting apparatus, (SCCI, art. 2.15.10). This equipment must be used solely by a competent operator or under his supervision (SCCI, art. 3.10.4 (1)). It is the employer's responsibility to ensure that the operator knows the type of equipment and how to use it safely and efficiently (SCCI, art. 2.4.2 (f)(ii)).



The safety harness must be worn under the coveralls.



3.2.5 Tipover

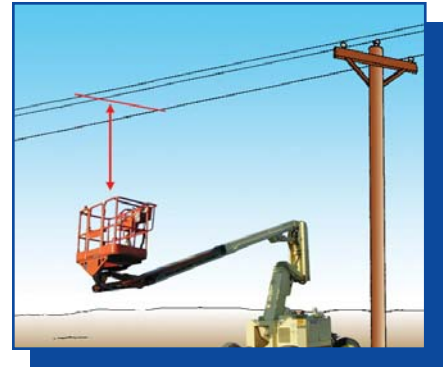
To create a safe work area, it is important that traffic lanes and access routes always be clear (SCCI, art. 3.2.4). No hazard must result from the storage of material and equipment, the accumulation of waste, or the condition of a material or piece of equipment (SCCI, art. 3.2.1).

Make sure that there is a solid and level surface for using the platform. The work area must be free of hazards such as trenches, ditches, steep slopes, holes, bumps, debris and floor or overhead obstructions. Also, delimit this area and place signs to indicate any hazard where manoeuvres take place from the platform (SCCI, art. 3.2.5 (b)). For slopes of more than five degrees ($> 5^\circ$) on inclined ground, the alarm system must be respected.

3.2.6 Electrical lines

No task must be performed when a part, load, scaffolding, machine component or an assistant is closer to a power line than the minimum approach distance specified (SCCI, art. 5.2.1).

On an elevating platform, a warning sign must be posted that mentions the following (SCCI, art. 5.3.1) at a location visible by the user.



3.2.7 Weather conditions

If weather conditions (violent winds, storms, fog, etc.) make the use of an elevating platform hazardous (SCCI, art. 3.10.1 (e)), do not use it. Check the condition of the ground and traffic lanes following heavy rain or during thawing. Traffic lanes must be cleared of snow and ice and covered with sand or, if need be, another product in order to prevent the platform from slipping when it is moved. A platform with an articulated arm cannot be used in stormy conditions and in excessive wind ($> 45 \text{ km/h}$).

3.2.8 Inspections

There are four types of mandatory inspections for platforms. The employer, or the person whom he designates, must inspect the equipment when it is delivered to the site.

Users perform the daily inspection (an inspection form produced by ASP Construction is available). Inspections after 200 hours of use and annual inspections (or after 700 hours of use) as well as structural inspections (after 10 years and subsequently every 5 years) are the responsibility of the rental company or the owner. All inspection attestations must be retained and made available upon request.



SAFETY HAZARDS

a. Work performed from a stepladder or ladder

Risk	Good practices
Falls from heights	■ Choose the stepladder or ladder based on the work to be performed (height). ■ Must comply with the Portable Ladders CAN3-Z11-M81 standard, class 1, duty load of 250 pounds (110 kg) (SCCI, art. 3.5.3 and 3.5.7). ■ Make sure that the stepladder is not deformed. ■ Install the stepladder or ladder on a firm, level and solid surface. ■ Completely open the stepladder with its spreaders solidly locked. ■ Incline the ladder so that the horizontal distance between its foot and the vertical plane is between 1⁄3 and 1⁄4 of the distance between its side rails. ■ Have the ladder extend by at least 900 mm beyond the upper landing if the ladder is used as a means of access (SCCI, art. 3.5.6(e)(ii)). ■ Avoid extreme extension of your arms and body beyond the reach of the stepladder or the ladder. ■ Never have more than one person climb on it at a time. ■ Never stand on the last step or rung.

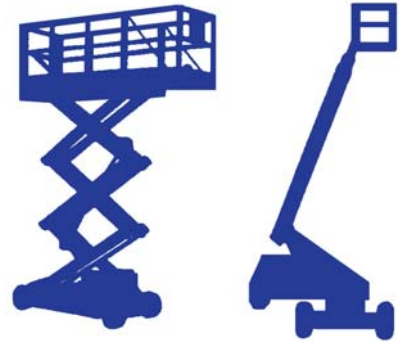
b. Work performed from mobile and stationary scaffolding

Risk	Good practices
Falls from heights	■ Move the scaffolding when no worker is on it or when he has been informed of the move (SCCI, art. 3.9.19 (d)) (mobile scaffoldings). ■ Install a guard-rail complying with the regulations (SCCI, art. 3.8). ■ Have a floor with a minimum width of two planks stamped in accordance with the Access Scaffolding for Construction Purposes CSA S269.2-M87 standard. It must neither topple nor slide (SCCI, art. 3.9.8). ■ Keep the distance between the platform and the building less than 350 mm (or 14 in) when there is no guard-rail (SCCI, art. 3.9.8 (7)). ■ Never climb on the scaffold guard-rail or on any other equipment (stepladder or other) located on the platform (SCCI, art. 3.10.7 (2)(i)). ■ Access the platform from the outside up to 2.2 m (7 ft) in height by using the side built-in access ladder (mobile scaffolding). ■ Access the platform beyond 2.2 m (7 ft) from the inside by means of vertical or inclined ladders (mobile scaffolding). ■ Use personal or collective protective equipment when erecting and dismantling the scaffolding (SCCI, art. 3.9.4 (5)).
Falling objects	■ Avoid overloading the platform with tools, materials, equipment or any other objects. ■ Never throw objects on the ground. ■ Put away unused tools. ■ Delimit a work area limiting access to other workers and place signs to indicate a hazard. ■ When dismantling the scaffolding, carry the components down rather than throwing them on the ground.

Risk	Good practices	
Electrification	■ Comply with the minimum approach distances for work near electrical lines or when moving the scaffolding (SCCI, art. 5.2.1). Note: For more information, refer to the ASP Construction prevention fact sheet entitled <i>Les travaux près des lignes électriques aériennes</i> (November 2008).	
	Tension between phases	Minimum approach distance
	Less than 125,000 V	3 m
	125,000 to 250,000 V	5 m
Overturning or collapse	250,000 to 550,000 V	8 m
	More than 550,000 V	10 m
	■ Lay out the traffic lane so that the scaffolding does not overturn when it is moved. ■ Use wheels or casters equipped with a locking device or brakes (SCCI, art. 3.9.19 (a)). ■ Install a system (guys or outriggers) ensuring the scaffolding is stable when its height reaches or exceeds three times the width of its base (mobile scaffolding) (SCCI, art. 3.9.10 (4)). ■ Anchor the scaffolding to the building structure along the vertical plane, at intervals not exceeding three times the minimum width of the scaffolding, and on the horizontal plane, at every three spans of the scaffolding (SCCI, art. 3.9.10 (4)). ■ Avoid overloading the scaffold platform (SCCI, art. 3.9.2). ■ Use a jackscrew to level the scaffolding, and base plates or mudsills. ■ Use vertical bars between the frames and horizontal bracing every three tiers in height for a scaffold more than 3 m high.	

c. Work performed from scissor-type elevating platforms or ones with articulated arms

- Use equipment complying with standards CSA B354.2-01 and CSA B354.4-02.
- Choose equipment based on needs (height, rated load capacity, terrain, zone to be reached, accessibility, etc.).
- Train the operators in the safe use of the equipment.
- Clear the access to the lower controls on the base (near buildings or obstacles).
- Have another person posted on the worksite to supervise from outside the work area at all times.



Risk	Good practices
Falls from heights	■ Use only the equipment's anchor points to attach the type A harness (SCCI, art. 2.10.12). ■ Do not cover the anchor points with plastic sheeting or any similar material. ■ Keep the floor of the platform well cleared. ■ Use the planned means of access to get on and off the platform. ■ Face the platform to get on it or off it by using three-point contact (two hands and one foot, or two feet and one hand). ■ Never climb on the platform's guard-rail or on any other equipment (stepladder or other) located on the platform.
Falling objects	■ Determine a work zone limiting access to other workers and place a sign indicating a hazard. ■ Avoid overloading the work floor of the platform. ■ Never throw anything on the ground. ■ Put away unused tools. ■ Never transport any material above the platform's guard-rail.

Risk	Good practices
Overturning	■ Use the outriggers and sole plates or mudsills on soft or backfilled surfaces. ■ Do not build a closed shelter made of tarpaulins or plastic sheeting on the platform. ■ Do not use the equipment during storms, strong winds (> 45 km/h), etc. ■ Check the route and ground conditions when moving the equipment. ■ Start the warning system for slopes of 5 degrees. ■ Lower the platform before moving it.
Jamming, collision	■ Plan the route for moving the equipment. ■ Make sure that there is good visibility in order to identify the obstacles on the ground (vehicles, workers, etc.). ■ Check that there are no obstacles above or below (conveyor, machinery, overhead crane, electrical line, etc.) before raising or lowering the platform. ■ Maintain surveillance on the ground when moving the equipment. ■ Keep other workers 2 m away when moving the platform.

Risk	Good practices	
Electrification	■ Comply with the minimum approach distances during work near electrical lines or when moving the scaffolding (SCCI, art. 5.2.1). Note: For more information, refer to the ASP Construction prevention fact sheet entitled <i>Les travaux près des lignes électriques aériennes</i> (November 2008).	
	Tension between phases	Minimum approach distance
	Less than 125,000 V 125,000 to 250,000 V 250,000 to 550,000 V More than 550,000 V	3 m 5 m 8 m 10 m
Fire, explosion	■ Turn off the platform's motor when filling the gasoline tank or changing the propane cylinders. ■ Follow the safety instructions: don't smoke, don't use cell phones, etc. ■ Never do refuelling during a storm, in the 30-m zone from an electrical line whose voltage exceeds 250,000 V (SCCI, art. 5.2.3). ■ Make sure that the fuel tank cap is locked when using the platform.	

4. Ergonomic hazards

During spraying, the back-and-forth movements are repetitive; arms are not supported and the hands are often above the shoulders. The worker performs slow movements while holding the gun (approximate weight of 1.4 kg [about 3 lbs]) with one hand, and applying pressure with one finger to produce the jet of foam.

The method used for spraying is linked to the risk factors for musculoskeletal disorders (MSDs). These factors are described briefly below in relation to the tools and clothes used, the tasks performed, the arrangement of the work site, and work organization.

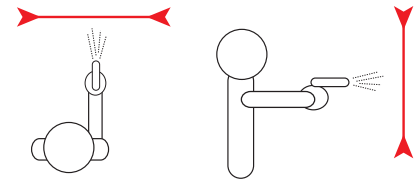
4.1 Tools and clothing

The installer holds the gun with one hand and pulls the feed hose with the other. In winter, the hose is more rigid and can hinder movement. The gun is activated by pressing on the trigger to produce the spray jet. This jet must be kept perpendicular to the surface of the substrate to be coated, while minimizing the number of coats (passes), with an ideal thickness varying between 15 and 50 mm.

The installer must wear respiratory protective equipment as well as clothing adapted to the weather conditions. In winter, during outdoor work, the heavy clothing can restrict movement. With the hot and humid summer temperatures, cotton coveralls or street clothing are not appropriate because these fabrics do not breathe.

4.2 Tasks

To cover each of the strips of the total surface, such as basement walls, spraying requires repeated horizontal and vertical passes of the arm and hand. This task is physically demanding because one hand maintains the angle (90°) of the gun, and the other hand measures with a gauge the thickness sprayed. Horizontal and vertical passes have to be performed repeatedly over a surface of approximately 0.5 m by 0.5 m.



To cover a strip, the installer moves in various ways: kneeling or having his back bent, standing on the floor, on a ladder or a stepladder, with his hands above his shoulders.

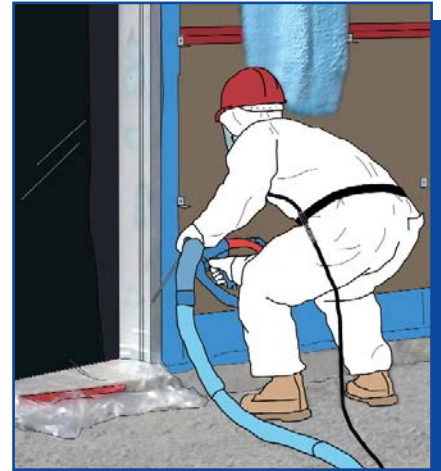
The challenge of maintaining the spray angle requires a frequent change in posture, depending on the height of the surface to be sprayed, the elevating equipment used, the configuration of the site, the type of work to be performed (wall spraying or belt sealing).

The main awkward postures are the following :

- working with his hand above his head or elbow above his shoulder;
- repeated raising of his hand above his head or elbow above his shoulder more than once a minute;
- working in the kneeling position
- bending his back while working;
- working in a crouched position.

4.3 Arrangement of the work site

On a construction site, clutter is a common phenomenon that hinders the movement of the feed hose, among other things. The installer has to do the spraying while avoiding coating some parts of the structure with foam; he must do this without a physical support such as an armrest. For indoor and outdoor work, he uses different equipment to reach various levels: stepladder, ladder, stationary or mobile scaffolding, scissor-type platform or telescoping ladder (see section 3, Safety hazards).



4.4 Work organization

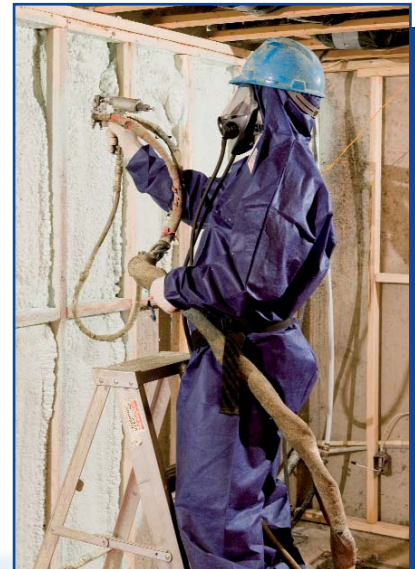
The assistant, who works with the installer, is responsible for preparing the site, the necessary equipment, etc. Quality control, the spraying angle, the temperature of the equipment (100°F to 110°F), the conditions of the substrate and the ambient conditions (temperature, humidity and wind speed) are the complete responsibility of the installer.

The actual duration of consecutive working hours is another aspect to be considered. In general, the schedule starts early, between 5:30 and 6:30 a.m., and can extend after the scheduled hours. Added to this are the hours devoted to transport between the warehouse and the site or from one site to another, because the workers may have to work on more than one site on the same day.

MSD risk factors	Good practices
Repetitive movements	■ Posture training in order to minimize efforts and improve comfort. ■ Narrow spraying strips. ■ Rotation of tasks between installer and assistant.
Awkward postures	

4.5 Other exacerbating ergonomic factors on a ladder or stepladder

1. The adoption of a rigid posture to remain in a stable position on a ladder causes stress on the back muscles. Also, depending on the height to be reached (above the head, for example), the worker may have to extend his body.
2. If the support surface is too narrow to allow the user to pivot his feet, this also limits arm movement and translates inevitably into body rotation, which involves a risk of torsion.



For more information:

ROBERGE, Brigitte, Daniel Drolet and Rodrigue Gravel. 4,4'-Diphenylmethane diisocyanate- (MDI) – Safety practices and concentration during polyurethane foam spraying. Report R-606, IRSST, September 2009, 61 p.

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