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Subject: ENVIRONMENTAL COMPATIBILITY POLYURETHANE FOAMS

The stabilisation intervention carried out by the company on building structures consists in injecting polyurethane foams into the ground below the foundations.

Polyurethane foams develop through the reaction that happens between two components: a polyol preparation and an isocyanate-based preparation.

The work phases conducted on the site comprise:

- *Preliminary operations*. At first an analysis is conducted on the conditions of the building that has to be stabilised, evaluating the damages in the structure and deciding where to intervene. Following that, holes are drilled in the subsoil - using a manual drill - inside and outside the building, reaching the area between the foundations and the underlying ground. Small metal tubes are then positioned inside the holes. Before the injection, laser sensors are placed in various spots, in order to gauge - in millimetres - the push of the polyurethane to lift the structure.
- *Polyurethane foam injection*. After installing and checking the pistol injector, the two reagents (polyol preparation and the isocyanate-based preparation) are pumped by pressure into the small metal tubes. The mixing of the reagents happens when they exit the injector and before entering the small tubes, and in a few seconds the polyurethane foam forms. The foam expands into the subsoil solidifying and pushing in every direction until its vertical thrust starts lifting the structure. The injection continues until the lifting is judged to be suitable and stable. Then, the process moves to another injection spot.

The process through which the polyurethane foam is formed consists in the chemical reaction between the isocyanate and the OH group of the polyol that constitutes the second reagent.

During the reaction carbon dioxide is developed, the polymer expands itself as a foam and quickly solidifies, filling the subsoil's cavities.

The polymerisation reaction, described above, completes itself inside the small metal tubes before the polyurethane foam is injected into the ground. In addition to that, the dosage of the two reagents is mechanically controlled in order to obtain that the reaction occurs in a complete fashion and to guarantee the quality of the foam produced, hence it is evident that the possibility that unpolymerized reagents are released into the ground is very remote.

During the process three topologies of polyurethane foams can be utilized, depending on the characteristics of the intervention required:

- ultracompact resin HDR 1000,
- expanding resin HDR 300 STATICA,
- expanding resin HDR 200 PAV.

The different features of the resins are obtained by combining different reagents.

The reagents used during the process have the following characteristics, as deducted from the safety data sheets (*attachment n.1*):

Reagent	Commercial Name	Contains	CAS Number
Isocyanate	ONGRONAT 2100	Polymethylene polyphenyl isocyanate	9016-87-9
	MDI AK-200	Polymethylene polyphenyl isocyanate	9016-87-9
	INVERATE P-200	Diphenylmethane diisocyanate, isomers/counterparts Diphenylmethane-4,4'diisocyanate	9016-87-9 101-68-8
Polyols	HDR 1000	Tertiary amine 1	--
	HDR 300	Propoxylated ethylenediamine Tertiary amine 1	25214-63-5 --
	HDR 200	Tertiary amine 1 Tertiary amine 7	-- --

In order to verify experimentally the environmental compatibility of the polyurethane foams, a sample of material, obtained by mixing the three resins HDR 1000, HDR 300 and HDR 200, has been analytically tested to gauge the concentration of present polluting substances and the release of those polluting substances into water, this according to the protocol used to gauge the pollution level of a soil for the purposes of determining whether or not to execute an environmental remediation.

The reference values are established by the Title V of the D.Lgs *(Legislative Decree)* 152/2006, in the attachment 5 at the IV part, where:

- table 1, column A, defines the threshold concentration for the soil and subsoil contamination for sites that are used for public, private and residential green areas (which are the most restrictive limit values);
- table 2 defines the threshold concentration for the contamination of underground waters.

The test's execution required two different analytical procedures:

1. analysis of the chemical composition of the material as it is for comparison against the acceptability limit values for the soil and subsoil, in order to assess the contribution of pollutants in the soil;

2. water release test according to UNI EN 12457-2 and analysis of the eluates for comparison against the acceptability limit values for underground waters in order to assess the release of pollutants into the aquifer.

Having considered the characteristics of the reagents as reported on the safety data sheets and of the possible components not mentioned on the safety data sheets, in the eventuality that these components have concentration levels below which there is not an obligation for them to be declared, it has been established to determine the following parameters, among all those listed in table 1:

INORGANIC COMPOUNDS

- metals with the largest diffusion
- cyanides (free)

AROMATICS

- all the listed compounds

CARCINOGENIC AND NON CARCINOGENIC CHLORINATED ALIPHATICS

- all the listed compounds

HYDROCARBONS

- light (C < 12) and heavy hydrocarbons (C > 12)

CONCLUSIONS

According to the results of the analytical test, as reported in attachment 2, it is detected that:

- the presence of pollutants in the polyurethane foam's composition is compliant to the limits provided by table 1, column A;
- the concentrations of pollutants in the water release test' eluates are compliant to the limits provided by table 2 for the underground waters.

According to the above mentioned elements, it is reasonable to conclude that the material in question does not contain pollutants, nor it can give rise, in any form, to the release of dangerous substances for the environment, hence it can be deemed to be in compliance to the expected use into the soil.

S. Ambrogio di Valpolicella, 21st March 2019.

Dott. Alessandro Zanon

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ATTACHMENTS

1) Test report 19-00695
2) Safety data sheets