5.1 Summary Description

The PolyLevel® product line consists of polyurethane foams and resins for use in a wide range of geotechnical and structural applications. The more commonly used products are two-part urethanes that expand into rigid foam to fill voids, stabilize concrete, lift concrete, and improve soil properties. These products are typically injected at the interface between the concrete slab and the subgrade soils (*Figure 5.1*). In some cases, PolyLevel is injected into the subgrade soils to fill voids and consolidate loose soils. Variations in the formulas of the two-part foams allow for uses in even more specific applications, as mentioned in *Section 5.2*.

Polyurethane is not a new material. The chemistry of polyurethanes was discovered and patented in 1937 and has since been used extensively in a variety of products and materials. Polyurethanes are best known to the public in the form of flexible foams, e.g., upholstery cushions, mattresses, caulking, weather-stripping, vehicle door and dash moldings, tires for toddler bikes and wheelbarrows, etc. Spray foam insulation and foam filler within shells of watercraft are other examples most similar to the line of two-part PolyLevel products.

Polyurethane foam is created by the reaction of a diisocyanate (the "A" or "Iso" side) with a polyol (the "R" or "Resin" side) to form a urethane linkage. Diisocynates are organic compounds that are specifically manufactured to react with polyols. The A side varies little between polyurethanes of similar product lines or use categories. Polyols are simply alcohols with multiple hydroxyl groups. The polyols and other additives within the R side may vary significantly between products to control characteristics such as density and speed of reaction.

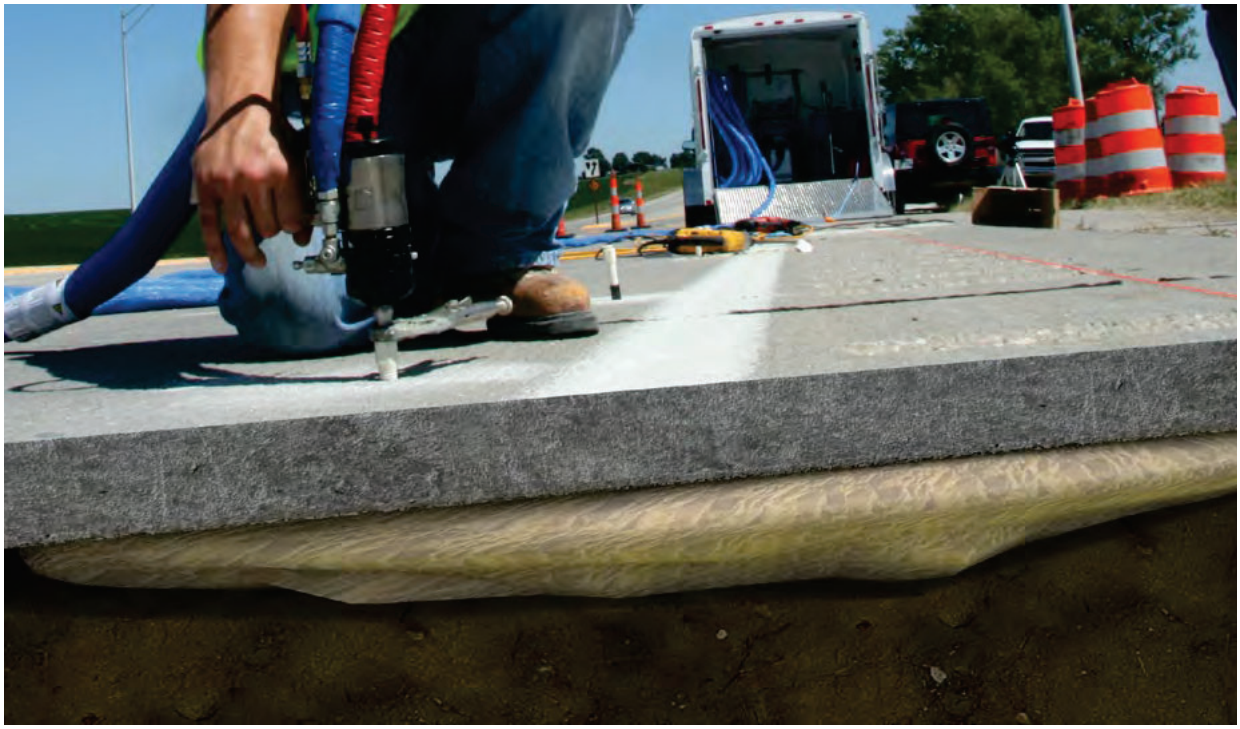

Figure 5.1 Rendering of PolyLevel foam injection beneath concrete pavement

5.2 Applications

5.2.1 Residential

PolyLevel expanding foams are most often used beneath exterior concrete sidewalk and pavement sections for stabilization or releveling, but are also utilized for interior work and other specialty applications. PolyLevel foam is often considered as an alternative to mudjacking or removal and replacement.

Settlement of residential slabs is typically the result of consolidation of poorly compacted fill soils around foundations and within utility trenches, softening of weak native soils and fill due to increases in moisture content, and erosion or washout conditions resulting from poor drainage. Cracked slabs, faulting between slab sections, and/or other obvious downward vertical movement are typically the first observable symptoms of settlement from the surface, though voids may also be present below as rigid slabs can span between support points.

When voids are present, using inert, hydrophobic PolyLevel expanding foam allows for undersealing of the region, minimizing the likelihood of any further washout and acting to again provide uniform support to the bridged concrete. When slabs have settled, with or without the presence of voids, foam can be injected to create lift without adding significant weight to the underlying soil.

PolyLevel foam is used to stabilize, lift, and relevel sidewalks (*Figure 5.2*), patios, driveways (*Figure 5.3* and *Figure 5.4*), garages slabs, and slab-on-grade concrete floors. Concrete decks surrounding swimming pools (*Figure 5.5*) can also settle over time due to localized erosion of subgrade soils or consolidation of poorly compacted fill and backfill. These repairs can often be completed in a matter of hours with immediate results, less mess, and no "wait time" for typical, continued use of the areas. When the work is done, all the concrete sections will still match and not take on the appearance of a checkerboard, as is the case with typical removal and replacement.

Figure 5.2 PolyLevel foam injected to relevel faulted sidewalk sections

Figure 5.3 Before: Driveway settled up to 4 inches relative to garage slab

Figure 5.4 After: Driveway lifted back to near original elevation

Figure 5.5 Pool deck slab settlement

5.2.2 Commercial

Commercial/industrial applications include similar types of projects as residential, but also include areas and facilities with heavier use pavements. More common commercial PolyLevel foam applications include resupport of concrete pavement at and around loading docks, and concrete floor slabs within warehouses (*Figure 5.6*), plants and manufacturing facilities. Heavy wheel loads from semi-trucks and from fork trucks can overstress subgrade soils and lead to pavement/slab cracking, settlement, and faulted sections.

Settled slab-on-grade office and retail space are generally ideal candidates for stabilization or releveling with PolyLevel. The installation process is clean with small slab penetrations (compared to mudjacking) and work can typically be completed after business hours and then reopened to cause little to no disruption to normal operations.

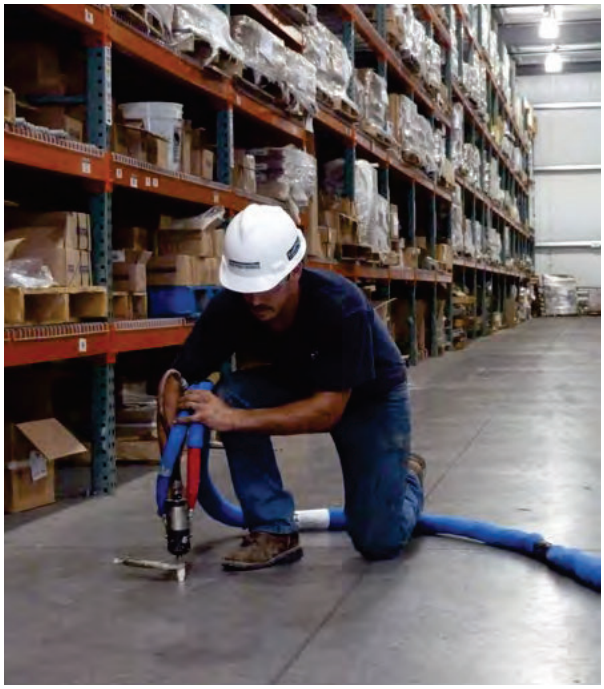

Figure 5.6 PolyLevel stabilizes warehouse floor slab

5.2.3 Roadwork

There are several applications where PolyLevel foam injections can be used for roadway maintenance and repair. This includes repair of general slab settlement, repair and remediation of bridge approach slab settlement, and undersealing and stabilization.

General slab settlement describes differential movement between slab sections or lengths of pavement along a concrete road, highway, or interstate to the extent that ride quality is compromised. Slab faulting describes specific conditions where abrupt differential vertical movement is observed at joints or cracks between adjacent slab sections. Slab movement can be the result of consolidation of utility trench backfill, consolidation of deeper fill embankments, consolidation of native soils beneath the weight of fill soils, erosion, poor subgrade preparation, and subgrade deterioration due to traffic loading and seasonal wet/dry and freeze/thaw cycles.

Signs of general slab settlement include slab cracking, sagging of multiple adjacent slabs, and differential movement at longitudinal joints (lane-to-lane or lane-to-shoulder) or transverse joints perpendicular to the direction of traffic (more common). In all instances, PolyLevel foam can be used to lift settled concrete, provide a stabilized base, and reduce road roughness. PolyLevel has also been used successfully to produce similar results at airports along runways and taxiways, and at railway crossings where rails are embedded within precast slab sections (*Figure 5.7*).

Figure 5.7 Commuter train track settled up to 2 inches at roadway intersection

Bridge approach slab settlement occurs over time to at least some degree at most bridge structures. This settlement is so common that it is widely referred to by consultants and Department of Transportation representatives as "the bump before the bridge." The bridge itself is typically supported on a deep foundation where little settlement is anticipated. The issue arises due to conditions of the embankment approach construction. Where deep fill is placed, lower layers of fill can be compressed by the weight of the upper fill layers. More common, however, is the consolidation of the native soil beneath the weight of the overlying fill. As the embankment consolidates, supported slabs settle relative to the stable bridge abutments, which can result in either faulted slab sections or dips and sags in the pavement leading up to the abutments. More recent bridge construction details may include structural approach slabs supported on one end by the bridge abutment and on the other end by either a footing (sleeper slab) or a grade beam that incorporates deep foundation elements. These details theoretically serve to soften abrupt movements but generally only move problematic pavement settlement farther from the structure.

PolyLevel foam provides a fast, noninvasive, lightweight option to fill voids and lift slabs without further burdening the embankment soils. Work can often be scheduled to limit impact to commuters, or put another way, cause less inconvenience to the public. It is common to stabilize and lift concrete road and bridge approach sections and then open those areas back up to traffic at the end of the work period.

Undersealing and joint stabilization is often completed prior to resurfacing or dowel bar retrofitting. PolyLevel foam can be used to recreate uniform bearing support for roads by filling voids that exist between the slab and the subgrade, thereby reducing the likelihood of soil/subgrade pumping, faulting and slab cracking. In addition, it also acts to seal cracks and joints from the underside of the slab to minimize water intrusion, again reducing the risk of future issues developing. This work can often be performed in one lane while maintaining traffic flow in adjacent lanes (*Figure 5.8*).

Figure 5.8 PolyLevel injection while maintaining an open lane for traffic

5.2.4 Pipeline & Trenching Applications

Pipeline construction along sloping terrain often includes features to prevent surface water infiltration from flowing longitudinally along the pipe and eroding the backfill. Historically, this has been done by pouring concrete collars or stacking sandbags at intervals within the confines of the trench. Steeper terrain generally requires more of these "trench breakers". Concrete and sandbag breakers are labor intensive and often dangerous to construct without proper shoring of the excavations (*Figure 5.9*). These materials are also difficult to deliver to remote locations.

PolyLevel trench breakers are an excellent alternative to the traditional methods involving concrete or sandbags. PolyLevel foam breakers form perfectly to whatever contour is encountered, including under and around the pipeline, as well as along the trench walls. Further, they can be installed from above the trench, eliminating safety concerns and the need for shoring (*Figure 5.10*). Each breaker can also generally be completed within 5 to 10 minutes, allowing backfilling operations to follow without delay.

Figure 5.9 Sandbag trench breaker for pipeline

Figure 5.10 Placement of polyurethane foam trench breaks

5.2.5 Soil Stabilization

The PolyLevel Soil Improvement system is a deep injection method that is non-invasive and often used to increase the strength of the bearing soils below existing footings and concrete slabs, stabilize soils behind sea walls, and densify weak native soils and consolidating fill soils around foundations. The process of injecting polyurethane into soil is commonly referred to as “deep injection”. Supportworks’ custom two-part polyurethane blend (PLSI400H) can be injected into loose granular and soft cohesive soils to significantly improve the soil’s properties. Several seconds after the PolyLevel foam is injected into the soil, the foam expands and exerts stress onto the surrounding soils. The expansion pressure from the foam results in an increase in density and soil strength.

To verify the effectiveness of the deep injection process, Supportworks’ engineers recommend that soil testing be conducted before the project is started and after the injection process has been completed. Common testing methods include Dynamic Cone Penetrometer (DCP), soil borings, and plate testing. DCP testing is the most common testing method due to its simplicity, efficiency, cost, and acceptance. The strength of the soil using a DCP is determined by measuring the penetration of the shaft into the soil for each drop of a known weight. The distance per blow measurement is known as the Penetration Index (DPI) which can easily be correlated to a California Bearing Ratio (CBR) and bearing pressure. Soil borings and plate testing are more time consuming and less economical than DCP testing, but they do provide more detailed soil information which is sometimes required for large projects.

Figure 5.11 Injecting PolyLevel PLSI400H into the soil.

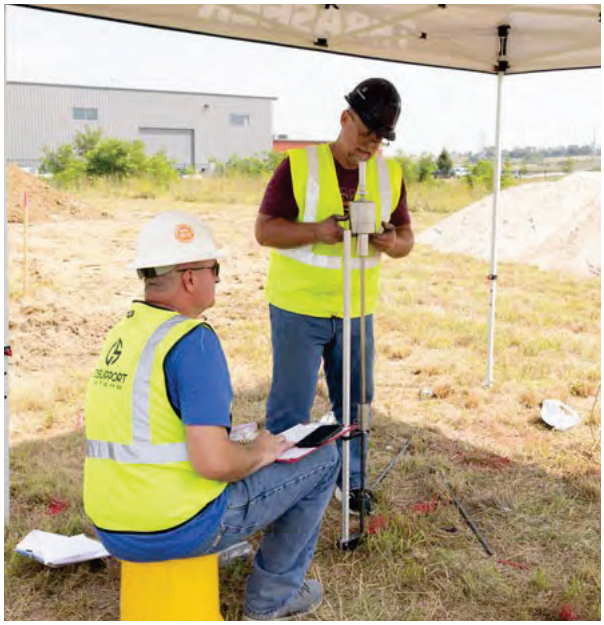

Figure 5.12 Conducting pre-injection DCP testing.

5.3 Benefits

- **Lightweight and High Capacity** – The standard PolyLevel foam formulations are designed to meet the needs of their respective applications. PolyLevel foam for road and highway repair has a nominal density of 4 pounds per cubic foot (pcf), and nominal strength values exceeding most project requirements, including the 60 psi compressive strength performance specification set by AASHTO. Custom PolyLevel foam blends can also be formulated to meet any relevant state and municipality material specifications or provisions when unique requirements are in place.

- **Accurate Lift** – Lifting takes place as a result of a controlled chemical reaction under the slab, compared to mudjacking which relies on hydraulic pressure being contained under the slab. When mudjacking slurry "blows out", additional lift is not possible. PolyLevel injection allows for a controlled lift that can be accurately monitored with survey equipment (*Figure 5.13*), string lines (*Figure 5.14*), or other measuring equipment.

Figure 5.13 Survey equipment used to monitor rail lift from PolyLevel injection

Figure 5.14 Monitoring pavement lift with string lines

- **Waterproof** – PolyLevel foam is a closed-cell polyurethane which exhibits minimal long-term water absorption, will not wash out from under the slab, and is not damaged by freeze/thaw cycles. In addition, PolyLevel foam is a hydrophobic system capable of reacting in the presence of water, allowing it to be used to underseal slabs and mitigate a variety of water intrusion issues even when free water is present. PolyLevel soil stabilizer is a hydrophilic system that will actually use moisture in the soils to assist in its chemical reaction, but remains waterproof once fully cured.

- **Safe for the Environment** – All of Supportworks' PolyLevel blends are NSF/ANSI/CAN 61 -2022 and NSF/ANSI/CAN 372 – 2022 certified. These two certifications verify that no harmful material or contaminants from the polyurethane foam will be introduced into the groundwater system. PolyLevel foam restores concrete that may otherwise need to be removed and replaced. Cured foam will not degrade under the slab.

- **Noninvasive** – PolyLevel installation equipment allows placement in tight and limited access areas. There is less mess than mudjacking and smaller holes required for installation. The liquid PolyLevel components are delivered beneath the slab through drilled ⅜-inch to ¾-inch holes.

- **Fast Cure Time** – PolyLevel foam cures quickly to typically allow treated areas to be reopened for use immediately after holes are patched. Cure time depends upon the placed thickness of the material, however, it is generally considered to be 90 percent cured within 30 minutes. Using the PolyLevel foam solution will dramatically decrease lane downtime and inconvenience to commuters on roadway projects.

5.4 Products

The standard PolyLevel product line includes one (1) single-part nonexpanding resin and three (3) two-part expanding foams. Brief general descriptions and product uses are included below. Additional product descriptions and properties are included on the Technical Information sheets in *Appendix 5A*.

- **PolyLevel® Trench Breaker (PL220TB)** – Used as a ditch block or trench break material due to its low exothermic reaction temperature and quick dissipation of heat.

- **PolyLevel® 250 Hydrophobic (PL250H)** – Nominal 2.5 pcf density in a free-rise state. Hydrophobic material allows for use in applications where water is likely present beneath the slabs or pavement. Used mainly in residential and low load applications.

- **PolyLevel® 400 Hydrophobic (PL400H)** - Nominal 4 pcf density in a free-rise state. Hydrophobic material allows for use in applications where water is likely present beneath the slabs or pavement. Used in commercial, roadwork, and moderate to high load applications.

- **PolyLevel® Soil Improvement (PLSI400H)** – Used to fill subsurface voids and improve weak native and fill soils.

Model specifications for PL250H, PL400H, and PLSI400H are available at *www.OnStableGround.com*.

5.5 Installation Process

5.5.1 Equipment

Figure 5.15 Truck-mounted installation unit

PolyLevel foam is installed with custom-built installation rigs (*Figure 5.15*). The basic components of the system include material storage tanks, a generator, an air compressor, pumps, a proportioner, and applicator(s)/gun(s). The proportioner includes a material heater, pressure regulator, stroke counter, and insulated and heated hoses. This ensures that both materials are delivered to the applicator at a consistent pressure and temperature.

5.5.2 Installation Steps – PL250H and PL400H

The following installation steps provide a broad overview of PL250H and PL400H injection beneath a concrete slab or pavement. Intermediate steps, installation equipment and tools used, and considerations for unusual conditions or applications are not addressed.

Step 1

Access/application holes are drilled at strategic locations in the slab (*Figure 5.16*). In general, the holes are spaced 5 feet apart and 3 feet from the edges of the slab. Locations and spacing are often modified in the field to achieve the desired result.

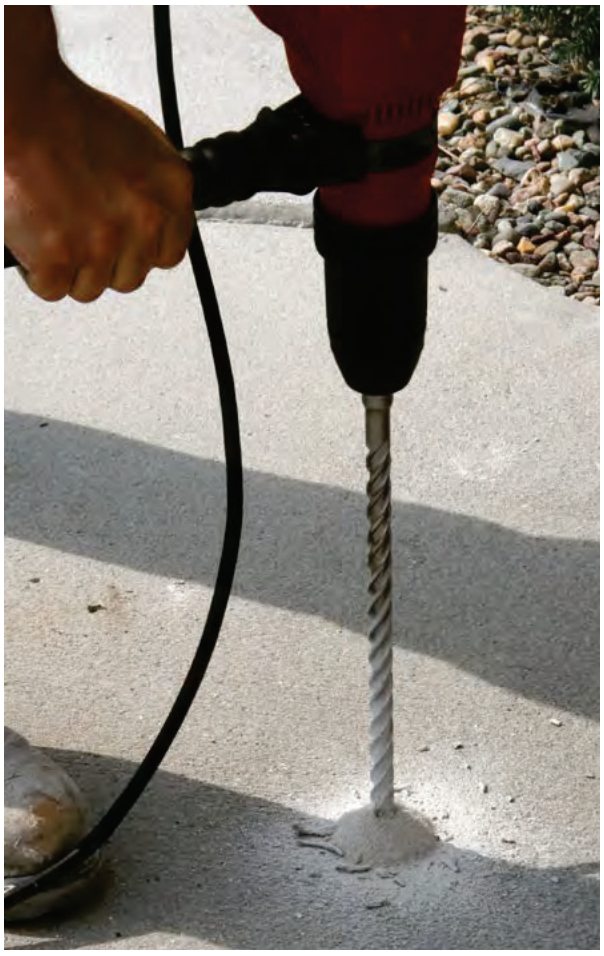

Figure 5.16 Concrete slab drilled to provide access holes

Step 2

PolyLevel foam is injected to fill voids and allow for lifting (*Figure 5.17*). Lift may be monitored with survey equipment or string lines (refer back to *Figure 5.13* and *Figure 5.14*).

Figure 5.17 PolyLevel foam injected below the slab

Step 3

When the injection is completed, the holes are patched with mortar mix, NexusPro® silicone joint sealant, or epoxy sealant (*Figure 5.18*).

Figure 5.18 Patching the injection hole

5.5.3 Installation Steps –PLSI400H

PolyLevel can also be injected into the soil to densify and strengthen weak soils below the surface. Supportworks' custom Soil Improvement blend (PLSI400H) has a slower reaction than blends PL250H and PL400H. The extended reaction time allows the foam to migrate further through the soil, providing better coverage. Below are general installation steps for using PolyLevel for soil improvement applications.

Step 1

Drive injection tubes into the soil at the specified locations and depths (*Figure 5.19)*. In general, injection locations are spaced 3 to 5 feet apart laterally and about 3 to 4 feet apart vertically, if multiple injection depths are required at one location.

After the tubes are at the appropriate depths, retract the tubes a few inches to dislodge the tube caps and create a pathway for the foam to flow.

Figure 5.19 Driving injection tube

Step 2

Attach the PolyLevel gun to the injection tube and inject foam into the soil (*Figure 5.20)*. Inject until the specified volume of foam has been injected, until the desired amount of lift has been achieved, or as instructed by the project engineer. Particular attention should be given to back pressure. Pressure build-up and surface movement are indicators to stop injecting at that injection tube.

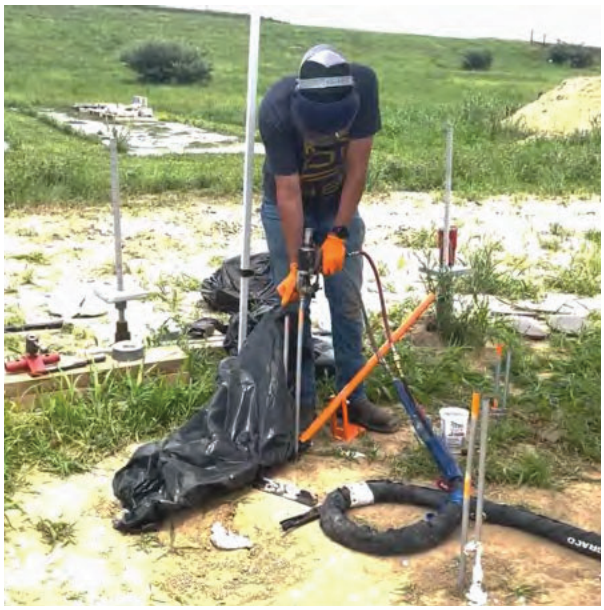

Figure 5.20 Injecting PolyLevel Soil Improvement foam into soil

Step 3

After the injections are completed, remove or cut off the injection tubes below grade as required.

5.6 Product Use Considerations

5.6.1 Installation Considerations

- PolyLevel PL250H and PL400H expanding foams are intended for use beneath rigid concrete slabs and pavements with some spanning capability. The products should not be used beneath flexible pavements, e.g., asphalt, brick pavers, cobble stone, or highly deteriorated and broken concrete.

- When the A and R-side chemicals are combined, heat is produced relative to the amount of material mixed. Because closed-cell polyurethane is an effective insulator, the generated heat dissipates very slowly. Installing too much material at one time can start a fire, char or smoke the foam, and damage the integrity and effectiveness of the installation. To reduce the risk of heat damage:

    - Do not install foam in layers more than 5 inches thick; if subsequent lifts are needed, allow time for the injected foam to cool.

    - For large voids, install a predetermined amount of PolyLevel foam at every other injection location, then circle back around and install at the unfilled locations. After all locations are filled with the first layer, inject a second layer of foam using the same procedure. In most cases, this approach allows the PolyLevel to spread out and cool before more is added.

- Care should be taken by the installer not to overlift the slab or pavement sections. Should an overlift situation occur, slight adjustments may be possible in the elevations of adjacent sections. Otherwise, sections may have to be ground down or removed and replaced.

- Releveling slabs and pavements by injecting PolyLevel PL250H or PL400H foams at the interface of the concrete and subgrade soils will not address deep-seated problems such as consolidation of fill or native soils, erosion, or sinkhole development. Experience has shown that deep consolidation of fill or native soils is often the cause of dips and sags in roadway sections and settlement of approach slabs. For these types of applications, PolyLevel PLSI400H foam is injected into the subsoils to strengthen and densify the consolidating soils. PolyLevel PL250H or PL400H can then be injected beneath the concrete slabs to lift the slabs, if necessary.

5.6.2 Safety Considerations

- Both the A and R-side materials pose potential health risks such as irritation and sensitization to the respiratory system, skin, and eyes. Symptoms can become progressively worse or persistent with continued exposure. Remove sensitized people from potential exposure activities and always wear the proper Personal Protective Equipment (PPE) when working with PolyLevel.

- The chemical reaction generates off-gasses. Fortunately, most applications are outside or within large open and/or well-ventilated areas. The gasses are mostly contained under the slab and dissipate slowly causing no adverse effect. However, in poorly ventilated areas, the gasses can displace or reduce breathing air. Long term exposure can cause an allergic-like sensitivity to the product. It is imperative to avoid breathing fumes generated by polyurethane as it can cause serious issues with the lungs including allergy-like symptoms, asthma, and sensitization. To avoid negative side effects:

    - Wear a fitted, NIOSH-approved, P100 particulate filtering facepiece respirator or a supplied air respirator during any amount of exposure.

    - In poorly ventilated areas, provide mechanical ventilation and use a supplied air respirator. Remove anyone who is not wearing the appropriate respiratory protection.

    - Perform test sprays away from the work area. Although the spray should be observed, do not hover over the test foam for risk of inhaling fumes.

    - Do not break open an actively curing bulb of foam. This will dramatically increase off-gassing and risk of inhalation.

- The cured polyurethane foam that forms from the reaction of the A and R-side chemicals is considered inert and nonhazardous when properly installed. Avoid exposing cured polyurethane foam to extreme heat (>200°F) or open flame as it is a flammable substance.

- While seldom an issue, PolyLevel that is exposed to UV light should be covered to prevent degradation.