Air sampling is the primary tool in the industrial hygiene toolbox for evaluating chemical exposures in the workplace. The science of air sampling is well developed with published methods for hundreds of chemicals and occupational exposure limits for comparison with sampling results. But hygienists are well advised to take a fresh look at surface and dermal sampling when the science warrants.

There are several compelling reasons to add surface and dermal sampling to your toolbox.

- **NIOSH** estimates that more than 13 million workers in the U.S. are potentially exposed to chemicals that can be absorbed through the skin.

- OSHA notes in Section II of its *Technical Manual* that the number of cases and the rate of skin disorders exceed recordable respiratory conditions.

- Approximately 60 percent of all regulated chemicals carry a skin notation.

- Dermal exposure is often the primary exposure route for nonvolatile chemicals such as aromatic isocyanates and will contribute significantly to overall exposure.

- The August 2019 *Synergist* article “*Sampling for Drugs in Uncontrolled Environments*” notes that surface residual sampling has application in controlling exposures to opioids in pharmacy compounding, clinical environments, first-response, and law enforcement.
OSHA has not set surface limits for individual chemicals as enforceable standards. However, OSHA inspectors may perform wipe sampling for toxic metals and other compounds during worksite inspections. These results help support findings of violations of the housekeeping requirements in standards such as that for hexavalent chromium. OSHA may also wipe the inside of respirators using colorimetric indicators or other sample media to document the absence of an effective respiratory protection program. Finally, colorimetric devices that indicate permeation may be used inside gloves to support violations of the OSHA PPE standard.

EPA has established federal limits for lead in dust on floors and windowsills in houses built before 1978 and in childcare facilities. Wipe sampling of surfaces is performed to ensure compliance with the new limits that will go into effect in January 2020, including 10 µg/ft² of lead dust on floors and 100 µg/ft² on windowsills.

U.S. states have promulgated regulations on reoccupancy of a structure previously contaminated by methamphetamine. In California, for example, methamphetamine residue on any indoor surface must be less than or equal to 1.5 μg/100 cm².

ACGIH has taken a big step in the 2019 TLVs and BEIs book, by introducing TLVs as surface limits (SL). One of the first two TLV-SLs from ACGIH is for o-Phthalaldehyde (OPA) with a TLV-SL of 25 µg/100 cm². OPA is used as a disinfectant for medical instruments.

Evaluating and Controlling Surface and Dermal Hazards

Industrial hygienists may need to use a multifaceted approach to adequately protect workers from surface and dermal hazards. Rather than just a sampling program, think of it as a dermal exposure reduction program consisting of:

- detection of skin and surface contaminants
- protection through the proper selection and changing frequency of PPE, such as gloves
- decontamination of skin, work surfaces, tools, and equipment
- determination of program effectiveness through biological monitoring

Let’s take a look at the elements of a dermal exposure reduction program.

Detection

A logical first question is, “Why should I sample surface and dermal hazards, since there are few regulatory standards or exposure limits?” There are several reasons, including:

1. ensuring a comprehensive assessment of all exposure routes
2. confirming you have selected the proper PPE, particularly hand protection, and that it is worn properly as required by the OSHA PPE standard
3. evaluating the effectiveness of decontamination or housekeeping procedures as required by the housekeeping provision in designated OSHA standards
4. making sure there is no contamination of uncontrolled work areas such as break rooms
5. safeguarding against take-home toxins on worker equipment, clothing, shoes, etc.

The next question is “How do I sample surface and dermal hazards?” Following are some options:
**Wipe sampling.** Most hygienists are familiar with wipe sampling using a filter, gauze pad, or other material that is used dry or wetted with a liquid or solvent specified in the procedure. OSHA methods for wipe samples include OSHA W4001 for hexavalent chromium using PVC or quartz filters and OSHA Method ID-125G for metals using Smear Tabs and Ghost Wipes.

- Quantitative wipe sampling is done on flat surfaces such as tabletops or floors to precisely measure the amount of contaminant in a defined area using a template to wipe a consistent size area.

- Qualitative wipe sampling on irregular surfaces such as doorknobs, drinking fountains, keyboards, and respirators can also provide the hygienist with valuable information by indicating the presence of the contaminant in an uncontrolled area.

(IH trivia: Do you know why hygienists normally wipe an area of 100 cm²? The *OSHA Technical Manual* states that this is the typical surface area of a worker’s palm.)

**Microvacuum sampling** uses a cassette loaded with a specified filter and a short length of tubing on the cassette inlet that serves as a nozzle. When attached to a pump at high flows, the cassette nozzle vacuums contaminants from surfaces, including mold spores from deep-pile carpets. ASTM D5755, *Standard Test Method for Microvacuum Sampling and Indirect Analysis of Dust by Transmission Electron Microscopy for Asbestos Structure Number Surface Loading*, specifies a carbon-filled black polypropylene cassette with cowl loaded with an MCE or polycarbonate filter and a short length of tubing on the inlet to sample asbestos on surfaces.

**Lift tape sampling** allows surface sampling of mold spores or glass fibers. While it sounds low-tech, packing tape is often used to lift suspect materials from surfaces. The tape with sample is then placed onto a microscope slide for analysis. Newer methods collect surface samples directly onto sticky microscope slides such as Stick-to-Its.

**Colorimetric tests for lead** include the following:

- Lead Check Swabs to detect lead in paint. This test is recognized by EPA for use on painted wood,
metal, drywall, and plaster.

- Full Disclosure to detect lead on skin and surfaces. NIOSH developed this colorimetric kit technology and transferred it to SKC for commercial production. Full Disclosure is not only a detection device but also a behavior modification tool. The kit allows workers to determine if their handwashing has been effective. At the end of a work shift, workers thoroughly clean their hands, use wipes on their hands, and add a few chemicals to the wipes. If these wipes turn red, it indicates that lead is present and the workers need to wash again before leaving the work area and heading home to their families.

**Colorimetric tests for amines, isocyanates, and more.**

Colorimetric Laboratories, Inc. (now CLI by SKC), a long-standing pioneer in the field of dermal and surface sampling, has developed a variety of surface and dermal wipes called SWYPE™ Pads for high-profile contaminants found in the polyurethane foam and other industries. SWYPE Pads are formulated for a specific group of chemicals such as amines, isocyanates, acid/bases, and phenols. The pads change color to provide a qualitative indication of the chemical presence. SWYPE Pads for Aromatic Isocyanates are described on the OSHA website.

**Wipe sampling for methamphetamine residue.** In recent years, industrial hygienists have been called upon to protect the public from the hazards of methamphetamine residue and related contamination in structures. The unique expertise of hygienists is being used in many ways in this public health crisis to:

- protect first-responders and other personnel from the hazards
- develop health and safety plans for decontamination of buildings and the environment
- confirm that appropriate “safe” levels established by individual state regulatory authorities have been met prior to building reoccupancy

NIOSH made a major contribution to this effort by developing a field detection kit for methamphetamine residue. Known commercially as MethChek®, this detection kit can both detect the presence of meth and provide an indication of meth levels. This immunoassay-based detection kit looks and functions like a home pregnancy test. The user wipes the test surface, extracts the meth with a buffer solution, adds a drop of the extract to the test kit, and watches the result develop. Kits are available with limits of identification relevant to cleanup guidelines in designated states ranging from 50 ng/100 cm² to 1500 ng/100 cm².
Protection

An essential part of a dermal exposure reduction program is selecting the most effective protection. Gloves play a large role in protection from contaminants. Permeation detectors from CLI by SKC called PERMEA-TEC™ Sensors can be worn under gloves to indicate areas of breakthrough of chemicals including amines, isocyanates, acids/bases, phenol, and organic solvents. PERMEA-TEC Sensors look like an adhesive bandage with the pad turned outward. If chemicals permeate the glove, the sensor changes color. PERMEA-TEC for Solvents features a charcoal pad that not only changes color, but also can be analyzed by a lab to determine the specific solvent that broke through the glove. These sensors are described on the OSHA website.

Decontamination

When a detection tool indicates the presence of contaminants on skin or surfaces or chemical breakthrough in gloves, a critical step is decontamination. This can best be performed using CLI by SKC chemical-specific solutions. Aqueous-based DECONtamination Solutions for surfaces are biodegradable and specifically formulated for isocyanates or amines. They are safe for all surfaces. D-TAM™ Solution for skin is a nontoxic, gentle, and biodegradable cleanser that contains high molecular weight ingredients that do not enhance chemical absorption into the skin. It removes a broad spectrum of lipophilic chemicals.

Determination

Biological monitoring is the final step in a dermal exposure reduction program that is necessary for some chemicals. The ACGIH Biological Exposure Indices (BEIs) provide guidance on what to test (blood, urine, breath) and acceptable levels for each. The BEI values correspond to the biological uptake that would occur in workers exposed to airborne concentrations at the TLV level. When BEIs are exceeded and airborne levels are below TLV, the dermal route should be investigated as the source of exposures.

Conclusion

Dermal and surface exposures are well worth a fresh look by the industrial hygiene community. Dermal exposure is often the primary exposure route for nonvolatile chemicals that contribute significantly to overall exposure, and there is increased government awareness and adoption of agency skin notations. Today, industrial hygienists can find several innovative technologies for a variety of chemicals with application in many workplaces and in public health. Even qualitative indicators serve a useful purpose in flagging cross-contamination in uncontrolled areas, inadequate housekeeping or worker cleaning, glove permeation, and improper use of respirators. A comprehensive exposure assessment program would not be complete without a dermal exposure reduction program.

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Resources


NIOSH: “Effects of Skin Contact with Chemicals: What a Worker Should Know” (PDF, August 2011).