

ER-93

Occupational Contact Dermatitis in UV-Curable and Vat-Photopolymerisation Workflows: Exposure Routes, Sensitisation, Diagnosis and Prevention

From liquid-resin contact to airborne exposure: why worker protection depends on task, material state and barrier performance

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Statement of Significance

The occupational hazard of a photo-curable formulation is not exhausted by its SDS classification or by the properties of the finished cured article. Workers handle liquid resin, contaminated tools, partially cured parts, wash fluids and waste, and may encounter droplets, contaminated surfaces or other task-specific contact routes. The literature now includes direct reports of occupational allergic contact dermatitis associated with 3D-printing resins, alongside a much longer record from dentistry and UV-curing inks. ER-93 converts that evidence into a worker-protection architecture that separates irritant dermatitis from allergic sensitisation, distinguishes exposure from intrinsic hazard, and treats glove performance, diagnosis and source attribution as evidence-dependent rather than assumed.

Abstract

Occupational contact dermatitis is a practical failure mode in workflows that handle uncured photo-curable materials. Direct 3D-printing case reports now document allergic contact dermatitis associated with (meth)acrylate-containing printing resins and with epoxy-resin chemistry, while recent UV-printing evidence also demonstrates an airborne allergic-contact-dermatitis route. Historical occupational studies in dental personnel and printing workers show that acrylic monomers can become clinically relevant sensitisers and that safety data sheets may not reveal the compounds implicated by patch testing or chemical analysis. Barrier protection is likewise not a binary property: controlled studies show that methacrylate-containing materials can permeate some medical gloves and that breakthrough time varies strongly with glove, monomer and test system. ER-93 therefore treats prevention as a task-specific control problem: identify the handled material state and credible contact route, minimise uncontrolled contact using the hierarchy of controls, select barriers for the actual chemical/task combination, maintain contamination and hygiene controls, and refer suspected occupational disease for professional diagnosis. Patch testing and interpretation of clinical relevance remain clinical procedures; this review does not prescribe self-testing. The paper is deliberately separated from ER-91 evidence-density/SDS interpretation, ER-92 impurity and residual-composition attribution, ER-94 intrinsic monomer structure-hazard relationships, ER-95 photoinitiator substitution, and ER-06/ER-86 finished-device biological and extractables/leachables qualification.

1. Scope and controlling boundaries

ER-93 asks what evidence and controls are required when workers may contact uncured or incompletely cured photo-curable materials and occupational dermatitis is a credible outcome. It is about workplace exposure, disease attribution and prevention, not about ranking commercial resins or recommending a medical treatment.

ER-91 controls evidence-density and SDS-expression asymmetry; ER-93 uses SDS only as one exposure-information input and does not infer hazard ranking from its wording. ER-92 controls impurities, residual reactants and composition-state attribution; ER-93 requires composition evidence when it matters to worker exposure but does not assign causation to an impurity without analytical support. ER-94 controls intrinsic monomer structure-hazard relationships; ER-93 treats structure only as context for exposure control and clinical attribution. ER-95 controls photoinitiator

migration/substitution. ER-06 and ER-86 control finished-device biological response and extractables/leachables, respectively; worker dermatitis from handling a resin is a different endpoint and evidence chain.

2. Irritant and allergic dermatitis are different control problems

Irritant contact dermatitis (ICD) can result from direct chemical irritation, repeated wet work, solvents, detergents and mechanical or physical stress. Allergic contact dermatitis (ACD) requires sensitisation to a substance and can then recur at low subsequent exposure. HSE's COSHH Essentials sheet for UV-curable inks and coatings states that acrylate inks may cause skin allergies, and separately that frequent contact with solvent-based printing substances can cause dermatitis [G2]. HSE's printing-industry dermatitis guidance identifies UV varnishes and inks among substances that generally aggravate skin conditions and UV-cured ink use among printing processes with a high occurrence of skin problems [G1]. The engineering implication is that redness or hand eczema cannot be assigned to one monomer from appearance alone.

For suspected ACD, causal attribution requires a clinical history, exposure reconstruction and specialist testing. The 2026 European Society of Contact Dermatitis guideline treats diagnostic patch testing as a controlled clinical procedure and emphasises appropriate test selection and interpretation [10]. ER-93 therefore prohibits informal workplace patch testing with neat resin or improvised concentrations.

Question	Evidence needed	Unsafe shortcut
Is dermatitis irritant or allergic?	Clinical evaluation, temporal pattern, exposure history; patch testing when clinically indicated.	Assume every resin-related rash is allergy.
Which substance is relevant?	SDS plus product composition information, targeted analysis where needed, clinically interpreted patch-test results.	Assign causation to the most familiar ingredient.
Is the glove protective?	Chemical-specific barrier data or a justified task-specific selection; change frequency and contamination control.	Treat nitrile, latex or another glove material as universally impermeable.
Is a cured part equivalent to liquid resin?	Material-state definition and actual handling step.	Use cured-part safety information to infer liquid-resin handling safety.

3. Exposure state must be mapped across the workflow

A VPP workflow changes material state repeatedly. The highest direct-contact potential generally occurs before full cure, but a defensible assessment should map the actual tasks rather than infer risk from a generic label. The relevant unit of analysis is task x material state x contact route x frequency/duration x control measure.

Workflow state	Credible occupational contact points	Minimum control record
Liquid resin / refill	Pouring, mixing, spills, contaminated exterior surfaces and tools.	Material identity/version, transfer method, splash/contact controls, glove selection, spill procedure.
Printer operation	Vat access, failed prints, build-platform handling, uncured residue.	Closed/open handling steps, access frequency, cleaning method, contaminated-touch surfaces.
Washing / cleaning	Resin-contaminated wash fluid, tools, wipes and containers; solvent or detergent irritation may coexist.	Cleaning fluid identity, ventilation/containment as relevant, glove compatibility, waste handling.
Part removal / pre-post-cure	Tacky or incompletely cured surfaces, supports and residue.	Defined cure state before handling, tools, no-touch/limited-touch method where feasible.

Workflow state	Credible occupational contact points	Minimum control record
Maintenance / waste	Vat-film changes, filters, waste resin, absorbents and contaminated PPE.	Decontamination sequence, waste containment, replacement PPE and hand-hygiene procedure.

4. Direct evidence from 3D-printing work

Fenech et al. reported a dental technician with occupational allergic contact dermatitis in the setting of 3D printing and (meth)acrylate exposure [1]. This is direct evidence that additive-manufacturing adoption can create a new occupational exposure pathway in a trade already familiar with methacrylates. It does not establish a universal incidence rate or implicate every resin composition.

Doré et al. subsequently reported allergic contact dermatitis due to a 3D-printing resin containing methacrylates [2]. Creytens et al. documented a different chemical class: occupational allergic contact dermatitis associated with epoxy resins in the 3D-printing industry [3]. Together, these reports are a useful guard against the shorthand "3D-printing dermatitis = acrylate allergy". The causal substance must be demonstrated, not inferred from process name.

5. Historical occupational evidence supplies mechanism and control context

Dental personnel provide a long-standing occupational comparison because they handle reactive acrylic materials directly. Aalto-Korte et al. reviewed dental personnel with acrylic-monomer allergy and found exposure-specific patterns involving 2-HEMA, TREGDMA, bis-GMA, MMA, EGDMA and other monomers [5]. The study supports exposure-specific diagnostic reasoning, not a universal ranking of these chemicals.

Aalto-Korte and Suuronen later reviewed 55 patients with acrylic-compound allergy in an occupational dermatology clinic. Chemical analyses were often performed when SDS did not reveal the acrylic compounds associated with positive tests, and the authors concluded that anaerobic-sealant SDS often lacked sensitisation warnings despite sensitising methacrylates [6]. ER-93 uses this source consistently with ER-91 and ER-92: SDS is essential hazard communication, but source attribution may require more evidence.

UV-curing printing remains another directly relevant occupational analogue. Coco-Viloin et al. reported occupational airborne allergic contact dermatitis from UV-curing printing varnish [4]. This demonstrates that direct hand contact is not the only possible presentation in UV-curing work, but ER-93 does not infer that airborne exposure occurs in every VPP printer or every resin workflow.

6. Diagnosis and source attribution belong to a clinical evidence chain

The 2026 ESCD guideline updates best practice for diagnostic patch testing [10]. In occupational cases, the engineering role is to provide the clinician with a credible exposure inventory and retrievable material information; the clinical role is to select and interpret tests. Workplace staff should not improvise patch tests with raw printing resin, wash solution or other process chemicals.

A positive reaction to one (meth)acrylate does not automatically identify the original workplace sensitiser. De Groot and Rustemeyer review cross- and co-sensitisation around HEMA and related (meth)acrylates [7]. Therefore, relevance requires reconciliation of test results with actual product composition, exposure history and, when necessary, chemical analysis. ER-94 owns the structure/cross-reactivity interpretation; ER-93 owns the occupational relevance chain.

7. Gloves are a chemical-barrier system, not a material name

Sananez et al. investigated clinical reactions associated with dental bonding material handled through nitrile gloves and experimentally examined monomer permeation. Permeation times varied widely, with lower-molecular-weight monomers passing faster in that test system; the authors identified HEMA as the probable causative agent in the reported cases [8]. This is evidence against treating "nitrile" as a universal zero-permeation category.

Lönnroth and Ruyter measured breakthrough times for mono- and dimethacrylate mixtures across fourteen medical gloves and observed values from minutes to more than two hours for four monomers with molecular mass below 300 [9]. Some tested nitrile, synthetic-rubber and PVC products gave longer protection in that study. These data are formulation-, glove- and method-specific and cannot be converted into a universal glove-change interval for VPP resins.

Barrier statement	Permitted interpretation	Not permitted
A glove material performed well in one published test.	Evidence that a specific glove/chemical/test combination can delay permeation.	Universal compatibility with all photo-curable resins.
A manufacturer publishes permeation data for a chemical.	Input to task-specific glove selection if chemical, thickness and test method are relevant.	Assume same performance for an untested mixture or contaminated glove.
No visible resin reached the skin.	No gross visible contact was observed.	Proof of zero molecular permeation.

8. Prevention: hierarchy first, PPE last line

HSE guidance for printing identifies UV-cured ink use as a skin-risk activity and recommends avoiding contact, protecting skin and controlling chemical-handling tasks [G1]. Its COSHH essentials sheet for UV-curable inks and coatings emphasises preventing or adequately controlling exposure [G2]. The transferable principle for VPP is the hierarchy of controls: remove unnecessary contact opportunities, contain transfer and cleaning steps where practicable, standardise handling, then use task-appropriate PPE as the remaining barrier.

- Design transfers and maintenance so hands do not become the primary handling tool.
- Keep resin-contaminated tools, wipes, printer touch points and waste within a defined contamination-control system.
- Separate clean and contaminated gloves/tasks; replace contaminated gloves rather than spreading resin to controls, keyboards or doors.
- Select glove and protective clothing using chemical/task evidence where available; do not infer universal protection from polymer type alone.
- Train workers to recognise early skin symptoms and to report them before repeated exposure makes attribution more difficult.
- For suspected occupational dermatitis, provide clinicians with SDS, process description, material identities and exposure chronology.

9. Minimum occupational reporting set

Domain	Minimum disclosure
Material	Exact resin/chemical identity and version; known hazardous constituents from current documentation; relevant cleaning agents.
Task	Transfer, printing access, part removal, cleaning, maintenance, waste or finishing; open/closed handling.
Material state	Liquid, contaminated wash fluid, tacky/partially cured, fully post-cured, waste/residue.
Contact route	Direct skin contact, contaminated surface, splash/droplet, or documented airborne route; do not infer an unobserved route.
Controls	Containment/engineering controls, work practice, glove/clothing identity, change criteria, hygiene.
Health event	Timing relative to work, body site, recurrence, work/non-work pattern; medical findings only when professionally established.
Attribution	Clinical testing and chemical analysis locators where applicable; distinguish confirmed cause from suspected association.

10. Prohibited shortcuts

- Do not diagnose ACD from a photograph, symptom description or SDS alone.

- Do not treat a positive patch test to one monomer as proof that the same monomer was present in the workplace material.
- Do not assume that fully cured-part qualification describes the hazard of uncured-resin handling.
- Do not publish a universal glove material, breakthrough time or change interval without chemical- and product-specific evidence.
- Do not infer that all VPP dermatitis is caused by (meth)acrylates; epoxy-resin evidence demonstrates chemical-class alternatives.
- Do not convert occupational case reports into population incidence estimates.

11. Research and standardisation gaps

The direct 3D-printing occupational dermatitis literature remains case-dominated. Priority work includes task-resolved exposure studies in VPP workplaces, chemical analysis of contaminated surfaces and PPE, permeation testing on representative commercial resin mixtures, and prospective surveillance that distinguishes irritant disease from confirmed sensitisation. Better source attribution is also needed when SDS and marketed ingredient descriptions do not disclose the species associated with clinical reactions.

12. Conclusions

Occupational dermatitis in photo-curable workflows is a material-state and task problem, not a simple property of the finished polymer. Direct 3D-printing cases now establish that occupational ACD can occur with both (meth)acrylate-containing and epoxy-resin systems, while older dental and UV-printing evidence supplies stronger mechanistic and prevention context. A defensible control programme maps where uncured chemistry is handled, reduces contact by design, treats glove protection as chemical-specific, preserves contamination control, and routes suspected disease into professional clinical diagnosis and source attribution. The central non-equivalences are decisive: SDS completeness is not exposure completeness; glove use is not zero permeation; a positive patch test is not product-composition proof; and cured-part qualification is not uncured-resin worker protection.

Limitations

This review is a literature-based occupational engineering synthesis, not medical advice and not a treatment guideline. Case reports demonstrate possibility and causal pathways but do not establish incidence. Glove-permeation studies are product- and method-specific. Regulatory and occupational-control obligations vary by jurisdiction; the current SDS and applicable workplace regulations remain controlling for each site.

Author contributions

Juan Segurola: conceptualisation, literature synthesis, engineering framework, writing and critical review.

Competing interests

The author is founder, CEO and CTO of 3Dresyns by Resyner Technologies S.L. No proprietary formulation, supplier, concentration or internal compatibility window is disclosed in this review.

Data availability

No new experimental dataset was generated. Statements derive from the cited peer-reviewed literature and public occupational guidance.

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