

Printed Analytical Labware and Sample-Handling Devices: Contamination, Sorption, Cleanliness and Measurement Bias

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Abstract

Printed Analytical Labware and Sample-Handling Devices is evaluated as the bounded decision of whether printed analytical hardware changes the composition or measured response of the sample it is meant to handle. The controlled state comprises resin and lot, print/wash/cure state, internal surface, solvent/sample chemistry, contact time, temperature, cleaning history and analytical method. For ER-282, the three cited sources are used only for the evidence roles stated below and only within their demonstrated scope. ER-282 defines measurements, transfer logic, failure modes and release gates specific to this subject; no universal process window, product recipe or compliance conclusion is inferred.

Keywords: analytical labware; sample handling; contamination; sorption; leaching; cleanliness; measurement bias; SLA

1. Significance, scope and ownership

ER-282 owns whether printed analytical hardware changes the composition or measured response of the sample it is meant to handle. The review is organised around the decision-specific evidence chain and leaves neighbouring ownership intact.

1.1. Corpus boundary

The object under review is the analytical path, not the chemistry assay itself. ER-86 retains extractables/leachables methodology and ER-281 retains reactor hydrodynamics. ER-282 asks whether the printed holder, channel, cartridge or extraction device changes the sample or signal enough to bias the intended measurement.

2. Subject-specific state model and causal chain

For ER-282, causal interpretation begins by freezing resin and lot, print/wash/cure state, internal surface, solvent/sample chemistry, contact time, temperature, cleaning history and analytical method. Any change in contact area, polymer surface, cleaning history or sample matrix can shift recovery or background; the printed device must therefore be carried inside the analytical uncertainty model.

3. Direct evidence and point-of-use source map

Cocovi-Solberg and co-workers demonstrated SLA-printed lab-on-valve platforms for automated assays, while Cocovi-Solberg and Miró explicitly identified solvent compatibility and leaching of incompletely cured resin species as issues for printed extraction devices. ER-282 treats the printed device as part of the measurement system rather than inert labware by assumption. Reference [1] is used for printed lab-on-valve analytical feasibility and device-state effects. Reference [2] is used for printed extraction-device solvent/leaching compatibility. Reference [3] is used for the incumbent analytical extractables/leachables scope.

4. Measurement architecture

The measurement architecture for ER-282 is built around procedural blanks, spike recovery, adsorption/desorption, carry-over, extractables, dimensional/channel verification, optical background and method-specific bias versus an established reference device. Blank contamination, spike recovery, carry-over and matrix dependence are evaluated against a reference path so that the device contribution can be separated from assay variability.

5. Qualification and transfer

A device is bridged to a new assay only after challenging the matrix, analyte concentration, contact history and cleaning sequence most likely to change sorption, leaching or carry-over. Geometric similarity alone cannot establish analytical neutrality.

6. Failure modes and interpretation traps

The central interpretation trap in ER-282 is that a successful fluid transfer or extraction is taken as proof of analytical neutrality; blank contamination or analyte loss is not measured. Blank, recovery, carry-over, extractables and geometry gates prevent a successful assay result from being used retrospectively as proof that the printed device was analytically inert.

7. Non-compensatory release gates

Gate	Minimum evidence	Blocking failure
Device state	Final resin/wash/cure/cleaning state fixed	Uncontrolled labware state
Blank	Material/process blanks below decision need	Background not measured
Recovery/sorption	Spike recovery across range/matrix	Analyte loss unquantified
Carry-over	Sequence challenge and washout measured	Prior sample ignored
Extractables	Interference/leachables checked where relevant	Printed path assumed inert
Geometry	Channels/dead volumes verified	Nominal CAD used
Cleaning life	Declared cleaning cycles represented	First-use result generalized
Method bias	Comparison to reference path with uncertainty	Successful assay called unbiased

8. Minimum verification experiment

Run material blanks and process blanks through the final device, challenge low/high analyte concentrations and representative interferents, compare recovery and carry-over against a reference path, and repeat after declared cleaning cycles. Any bias that changes with sample matrix or contact history must remain in the uncertainty budget.

9. Knowledge boundary

Printed analytical hardware is feasible, but the literature does not establish one photopolymer as analytically inert across analytes, solvents and cleaning histories. Low-concentration adsorption and long-cycle carry-over remain application-specific.

10. Conclusions

ER-282 treats printed analytical hardware as part of the measurement system and requires direct evidence that contamination, sorption, carry-over and cleaning do not invalidate the intended result.

References

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