

# End-of-Life Decision Hierarchies for Photopolymer Products: Reuse, Repair, Recycling, Recovery and Disposal

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## Abstract

End-of-Life Decision Hierarchies for Photopolymer Products is evaluated as the bounded decision of which end-of-life route should remain open for a specific photopolymer article once technical feasibility, legal status and evidence of retained function are separated. The controlled state comprises article identity, contamination, service history, damage, remaining function, separability, material recovery route, jurisdiction and receiving process. The evidence base [1] [2] [3] [4] is used only within its demonstrated scope. ER-280 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:** end of life; reuse; repair; recycling; recovery; disposal; circular economy; waste hierarchy

## 1. Significance, scope and ownership

ER-280 owns which end-of-life route should remain open for a specific photopolymer article once technical feasibility, legal status and evidence of retained function are separated. The review is organised around the decision-specific evidence chain and leaves neighbouring ownership intact.

### 1.1. Corpus boundary

The hierarchy here orders decision questions, not environmental outcomes. ER-17 retains comparative life-cycle conclusions, ER-178 retains legal waste disposition, ER-183 retains mechanical recycling, and ER-198 retains material-loop evidence. ER-280 stops at choosing which routes remain technically and evidentially open for the specific article.

## 2. Subject-specific state model and causal chain

For ER-280, causal interpretation begins by freezing article identity, contamination, service history, damage, remaining function, separability, material recovery route, jurisdiction and receiving process. A route can remain technically feasible yet still fail because the article has insufficient remaining function, no accepted downstream destination, or an unresolved legal status.

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

The EU Waste Framework Directive places prevention, preparing for reuse, recycling, other recovery and disposal in a priority order while allowing justified departures based on life-cycle thinking. ISO 59004:2024 provides circular-economy vocabulary and implementation guidance. ER-280 translates those architectures into a photopolymer decision tree without claiming that the highest nominal route is always technically or environmentally superior. Reference [1] is used for the statutory waste-hierarchy architecture. Reference [2] is used for circular-economy vocabulary and implementation principles. Reference [3] is used for material-loop closure and recovered-feedstock evidence boundaries. Reference [4] is used for mechanical recycling/reincorporation boundaries.

## 4. Measurement architecture

The measurement architecture for ER-280 is built around remaining-use inspection, repair verification, recovered-feedstock identity, recycling yield, secondary-output accounting, applicable waste classification and life-cycle evidence when a comparative environmental claim is made. The evidence set must preserve losses, fresh inputs and downstream acceptance so that a nominally preferred route cannot hide unresolved outputs.

## 5. Qualification and transfer

Transfer to another product or jurisdiction starts by rebuilding the feasible-route set; prior rankings are not inherited. Reuse or repair evidence can transfer only when function and damage state are comparable, while recycling or disposal routes require their own receiving-process and legal checks.

## 6. Failure modes and interpretation traps

The central interpretation trap in ER-280 is that a technically possible route is called preferable without demonstrating retained function, destination acceptance, recovered-material quality or overall environmental outcome. The gates force function, destination, legal status and environmental comparison to remain separate; a circularity label cannot compensate for a failed route-specific condition.

## 7. Non-compensatory release gates

| Gate                     | Minimum evidence                               | Blocking failure                           |
|--------------------------|------------------------------------------------|--------------------------------------------|
| Article state            | Identity, contamination, service history fixed | Route chosen for generic material          |
| Reuse                    | Remaining function verified                    | Visual appearance substitutes for function |
| Repair                   | Repair restores defined function and integrity | Repair feasibility called qualification    |
| Recycling/recovery       | Recovered output identity/yield measured       | Recovered mass alone called circularity    |
| Destination              | Receiving process acceptance demonstrated      | No downstream acceptance                   |
| Legal status             | Jurisdiction/classification decision recorded  | Hierarchy substituted for law              |
| Environmental comparison | Bounded LCA when superiority claimed           | Higher hierarchy called greener            |
| Disposition record       | Losses, fresh inputs and final route traceable | Unresolved outputs disappear               |

## 8. Minimum verification experiment

For one end-of-life article, enumerate feasible routes before testing. For each route state the required evidence, losses, fresh inputs and downstream destination. Reject routes that fail safety, function, legal acceptance or material-quality gates. If ranking routes environmentally, perform a separate bounded life-cycle comparison rather than using the hierarchy label as the result.

## 9. Knowledge boundary

The hierarchy does not supply product-specific technical feasibility, environmental superiority or legal acceptance. Comparative environmental ranking still needs bounded life-cycle evidence, while destination and jurisdiction can change the permitted route.

## 10. Conclusions

ER-280 provides a defensible route-selection hierarchy for a specific end-of-life article while preserving separate gates for function, destination, legal acceptance and any comparative environmental claim.

## References

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