

PART X

Forensic Science

Chapters 25–27

Drug Testing

Five biological matrices, five different windows onto methamphetamine use — and the principle that the right test depends on the question being asked.

Testing a person for methamphetamine is not a single procedure but a family of them, each reading a different biological compartment and therefore a different span of time. The analytical foundation was laid in Chapter 6: a two-tier logic of sensitive screening followed by specific confirmation, with the important wrinkle that methamphetamine is metabolized to amphetamine, so both commonly appear together in a positive result. What changes from test to test is the *matrix* — urine, blood, hair, oral fluid, or sweat — and with it the detection window. Choosing among them is a matter of matching the matrix to the purpose, whether that purpose is to detect very recent use, to gauge current impairment, or to reconstruct a long-term pattern.

Urine

Urine is the most common and cost-effective testing matrix, and it is particularly well suited to methamphetamine because a substantial fraction of the drug is excreted unchanged, making it readily detectable. Methamphetamine appears in urine within roughly one to two hours of use; for an occasional user it typically remains detectable for about one to four days, while a chronic or heavy user may test positive for seven to ten days.¹ As Chapter 9 explained, urinary pH modulates this window — acidic urine shortens it, alkaline urine lengthens it — and in chronic users negative specimens can be interspersed with positive ones. Workplace testing operates against the defined cutoff concentrations described in Chapter 6.

Blood

Blood testing offers the most accurate measure of the drug actually circulating at the moment of collection, and it is therefore the matrix of choice where current concentration or recent use is the question — in medical emergencies, accident

investigations, and impaired-driving cases. Because the body clears methamphetamine relatively quickly from the bloodstream, the detection window is short, generally on the order of one to three days (often 24–48 hours), and the procedure is more invasive than the alternatives.¹ Its value lies in precision and its correlation with recent exposure rather than in a long look-back.

Hair

Hair testing provides the longest detection window of any standard method. As hair grows, methamphetamine and amphetamine carried in the bloodstream are incorporated into the hair shaft, creating a durable record; a sampling of roughly the proximal 1.5 inches of hair can reflect use over approximately the preceding ninety days.¹ Because incorporation depends on growth rather than on rapid metabolism, hair is comparatively insensitive to individual differences in clearance, and segmental analysis can even sketch a rough timeline of use. Its weakness is the mirror image of its strength: hair testing is suited to detecting chronic or long-term use and will not reliably capture a single recent exposure.

Saliva (oral fluid)

Oral fluid testing has grown popular for roadside and workplace screening because collection is simple, can be directly observed, and is difficult to adulterate. Methamphetamine enters saliva by diffusion from blood, and — because saliva is typically more acidic than plasma, favoring ion-trapping of this weak base — salivary concentrations can actually exceed plasma concentrations.² The drug appears in oral fluid very quickly, within roughly five to thirty minutes, and remains detectable for about one to two days (in some studies up to around fifty hours), a window broadly comparable to but generally shorter than urine.^{1,2} Its rapid onset makes it especially useful where recent use and possible impairment are the concern.

Sweat

Sweat testing is the least common of the five and works on a different temporal principle. A sweat patch is applied to the skin and worn continuously, typically for

about a week, accumulating drug excreted in sweat over the entire wear period; methamphetamine can appear in sweat within about two hours of use, and the effective detection window is essentially the duration the patch is worn, on the order of one to two weeks.¹ This cumulative, tamper-evident character makes sweat patches useful for monitoring over time, as in probation or treatment programs.

Matrix	Approx. detection window	Best suited to
Urine	~1–4 days (chronic: up to 7–10)	Routine, cost-effective screening
Blood	~24–48 h (up to 2–3 days)	Recent use / current concentration; emergencies, DUI
Hair	~90 days (per ~1.5-inch segment)	Chronic/long-term pattern of use
Oral fluid (saliva)	~1–2 days (to ~50 h)	Recent use; roadside/observed collection
Sweat (patch)	~1–2 weeks (patch wear period)	Continuous monitoring over time

As Chapter 6 stressed, a screening result is presumptive and must be confirmed; the enantiomer question (distinguishing illicit d-methamphetamine from the l-methamphetamine of some decongestants) is resolved by chiral analysis; and incidental environmental exposure — relevant to the contamination of Chapter 27 — generally does not by itself produce a positive test, though it is a documented route of systemic absorption in heavily contaminated settings.

Crime Laboratories

How seized material becomes court-admissible evidence — through standardized identification, rigorous documentation, and an unbroken chain of custody.

Where Chapter 25 concerned the testing of people, this chapter concerns the testing of *things*: the seized powders, crystals, tablets, and residues that a forensic drug chemistry laboratory must identify and, often, weigh. The stakes here are a person's liberty, so the discipline is built around producing conclusions that will withstand legal scrutiny — which means standardized methods, meticulous records, and a documented custodial trail from seizure to courtroom.

Evidence handling

Forensic drug laboratories operate under written standard operating procedures and, to support the credibility of their results, generally maintain accreditation — commonly to the ISO/IEC 17025 standard — and participate in regular proficiency testing.⁶ Beyond identification, the laboratory documents the condition of evidence, determines net weight (often a legally significant quantity, reported with a stated measurement uncertainty), and controls materials handling and storage, instrument calibration, analytical and verification procedures, report writing, and case review.^{4,5} The volume of this work is not trivial: many jurisdictions report that forensic laboratory resources are strained by caseloads — a strain compounded, as the next chapter notes, by the demands of processing clandestine-laboratory evidence.

Identification methods

Identification follows the same two-tier logic introduced in Chapter 6, formalized for the forensic context. Presumptive tests — typically colorimetric spot tests that change color in the presence of a suspected substance — are fast and can support probable cause for arrest and seizure, but they are not definitive. Confirmatory identification relies on instrumental techniques such as gas chromatography—

mass spectrometry and infrared spectroscopy, which separate components and positively identify a compound by its chemical signature — for methamphetamine, the diagnostic mass spectrum described in Chapter 5.⁴ The governing framework is that of the Scientific Working Group for the Analysis of Seized Drugs (SWG-DRUG), which since 1997 has recommended minimum standards and classifies techniques into three categories (A, B, and C) by their discriminating power — mass spectrometry and infrared spectroscopy being high-selectivity Category A methods, color tests low-selectivity Category C.⁵ Crucially, SWGDRUG requires the use of *multiple uncorrelated techniques*, so that an appropriate analytical scheme yields effectively no uncertainty in the reported identification; this consensus-standards effort now proceeds alongside the NIST-sponsored Organization of Scientific Area Committees and standards such as ASTM E2329.⁵

Chain of custody

None of this analytical rigor matters in court without an intact chain of custody — the documented, unbroken record of who handled a piece of evidence, when, and under what conditions, from the moment of seizure through analysis to presentation at trial.⁶ Chain-of-custody documentation exists to guarantee that the material tested is the material seized and that it was not altered or contaminated along the way; gaps or irregularities in that record are among the most common grounds on which forensic drug evidence is challenged. To protect against error, courts frequently permit the defense to obtain independent testing of split or retained samples through an accredited laboratory, provided custody is properly maintained.⁶

Limitations

Forensic identification is powerful but not without limits, and honest practice acknowledges them. Samples may be degraded or contaminated; immunoassay-based presumptive tests carry the cross-reactivity liabilities of Chapter 6; the constant emergence of novel psychoactive substances can outpace reference libraries; and case backlogs can delay confirmatory results by days to weeks.^{5,6} These are the same analytical realities described earlier, here carrying the added

weight of the justice system, which is precisely why the field insists on validated methods, multiple techniques, and documented custody.

Waste and Environmental Impact

The physical legacy that clandestine production — and, increasingly, smoking — leaves behind in the built environment, and the difficult problem of cleaning it up.

Scope of this chapter

Consistent with this book's fixed boundaries, this chapter treats contamination, hazard, and remediation only. It describes what is left behind and the danger it poses to occupants and responders — not how methamphetamine is produced. Chemical hazards documented at raided sites are reported here as environmental-health facts, in the same spirit as any hazardous-materials assessment.

Clandestine methamphetamine production causes three broad categories of harm: acute physical injury from fires, explosions, chemical burns, and toxic fumes; environmental hazard; and child endangerment.⁷ This chapter concerns the second and, through it, the third — the persistent contamination that outlasts the activity itself and turns a building into a lingering public-health problem.

Environmental contamination

Unlike controlled pharmaceutical manufacture, clandestine production involves the uncontrolled storage, use, generation, and disposal of a range of chemicals, together with the deposition of methamphetamine residue onto indoor surfaces — and these residues have been shown to persist on household surfaces and materials for months or even years.^{8,9} The contamination can be severe and highly variable: sampling at production sites has found residual surface methamphetamine ranging from around 0.1 microgram per 100 square centimeters to extraordinarily high levels, and airborne methamphetamine concentrations during activity spanning from a few to several thousand micrograms per cubic meter, accompanied by hazardous gases such as phosphine and hydrogen chloride.⁸ Importantly, contamination is no longer understood to arise from production alone: controlled stud-

ies show that *smoking* methamphetamine also deposits measurable residue on surfaces, extending the problem well beyond former "labs" to any dwelling where the drug has been heavily smoked.⁹

Cleanup challenges

Remediating a contaminated property is genuinely difficult, and for much of the drug's history there were few established standards for what "clean" even meant.⁷ The pioneering benchmark came from Washington State, which set a post-remediation cleanup level of 0.5 microgram per 100 square centimeters (5 micrograms per square foot) — a threshold based not on a precise health calculation but on a judgment about what level was reasonable and achievable; a comparable guideline is used in Australia.^{9,10} Remediation itself typically requires gross removal of contaminated chemicals followed by decontamination — often the removal of carpets, countertops, and fixtures along with repeated cleaning of surfaces — and then verification sampling to demonstrate that the standard has been met.¹⁰ Because thorough remediation is costly, it is frequently not undertaken; some owners abandon contaminated property rather than pay for it, responsibility and cost remain legally unsettled, and public-health and environmental authorities, rather than police, generally must lead the effort.⁷

Public safety

The public-safety stakes fall hardest on unsuspecting occupants, and especially on children. Studies of "third-hand" exposure — people unknowingly living in contaminated homes — have documented a range of health effects including behavioral and sleep disturbances, respiratory effects, skin and eye irritation, and headaches, with methamphetamine detectable in the hair of residents, children among them, even at contamination levels near the common 0.5 microgram per 100 square centimeter guideline.⁹ A well-documented public-health report describes a family of five who moved into a former clandestine laboratory in Australia: all developed adverse health effects, hair testing confirmed systemic absorption of methamphetamine from the environment, and the effects were most pronounced in the youngest child, whose hair showed the highest levels — plausi-

bly from repeated hand-to-surface contact during play combined with less frequent handwashing.⁹ These findings drive the core public-safety responses: identifying and properly managing former production and heavy-use sites, enforcing remediation before reoccupation, and — critically — preventing the sale or rental of contaminated homes to unwitting buyers and tenants through disclosure and regulation. The same concerns increasingly extend to shelters and transient housing, where authorities now address methamphetamine (and fentanyl) residue as an occupational and occupant hazard.¹⁰

Dimension	Key facts
Sources of residue	Clandestine production and smoking; persist months–years on surfaces
Contamination range	Surface ~0.1 to thousands of $\mu\text{g}/100\text{ cm}^2$; airborne $\mu\text{g}/\text{m}^3$ plus toxic gases at active sites
Remediation standard	e.g., $0.5\text{ }\mu\text{g}/100\text{ cm}^2$ (Washington; similar in Australia); not strictly health-derived
Remediation process	Gross chemical removal → decontamination (remove fixtures, clean) → verification sampling
Public-safety risk	Third-hand exposure, especially children; health effects; disclosure/sale controls needed

References — Part X

Listed in order of first citation within Part X. Numbering restarts each installment; the apparatus is to be consolidated on final assembly. Sources current as of 2026.

1. Methamphetamine detection windows by matrix — urine (~1–4 days; chronic use up to 7–10 days), blood (~24–48 h, up to 2–3 days), hair (~90 days per ~1.5-inch segment), oral fluid (~1–2 days, up to ~50 h), sweat patch (~1–2 weeks, per wear period). (Verstraete AG. Detection times of drugs of abuse in blood, urine, and oral fluid. *Ther Drug Monit.* 2004; SAMHSA, *Clinical Drug Testing in Primary Care*, TAP 32; Methamphetamine Toxicity, StatPearls NBK430895; clinical toxicology summaries.)
2. Scheidweiler KB, Huestis MA, et al. Methamphetamine disposition in oral fluid, plasma, and urine — oral-fluid pharmacology (ion-trapping producing salivary concentrations exceeding plasma; detection window similar to urine; ease of collection). (PMC2709797.)
3. Methamphetamine metabolism to amphetamine (~43–50% excreted unchanged), with both analytes commonly detected on testing. (See Part IV references; oral-fluid/urine disposition literature.)
4. Forensic drug chemistry — analysis of seized material; presumptive (colorimetric spot) versus confirmatory (GC-MS, infrared) testing; net-weight determination. (NIST / National Forensic Science Technology Center, *A Simplified Guide to Forensic Drug Chemistry*; ForensicSciencesSimplified.org.)
5. Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG) Recommendations (since 1997) — Category A/B/C technique classification by discriminating power; requirement for multiple uncorrelated techniques; Code of Professional Practice, Education/Training, Methods of Analysis, and Quality Assurance. NIST-sponsored OSAC seized-drug standards; ASTM E2329-17. (swgdrug.org; NIST SP 1500-24; ScienceDirect S2468170924000122.)
6. Forensic drug testing, admissibility, and chain of custody — written SOPs, ISO/IEC 17025 accreditation, proficiency testing; presumptive versus confirmatory evidence for criminal liability; chain-of-custody requirements and defense challenges; independent/split-sample testing; laboratory backlogs. (Overview of forensic drug testing in criminal cases; NIST SP 1500-24.)
7. Clandestine methamphetamine laboratories — three harm categories (physical injury; environmental hazard; child endangerment); remediation challenges, cost, unsettled responsibility, and the leading role of public-health/environmental authorities; scarcity of established contamination standards historically. (Arizona State University Center for Problem-Oriented Policing, *Clandestine Methamphetamine Labs*, 2nd ed.)
8. Martyny JW, et al. (National Jewish Medical and Research Center) — surface methamphetamine contamination from a single production event (~0.1 to as high as ~16,000 µg/100 cm²) and airborne methamphetamine (2.6–5,500 µg/m³) with hazardous gases (phosphine, hydrogen chloride, iodine), as reviewed in *Remediation of Manufactured Methamphetamine in Clandestine Laboratories: A Literature Review* (PMC6262873).
9. Environmental methamphetamine exposure and third-hand health effects — 25-case-study analysis (behavioral, sleep, respiratory, skin/eye effects, headaches; meth-

amphetamine in hair including children; effects near the 0.5 µg/100 cm² guideline), PM-C7560285; simulated-smoking surface-contamination study (0.23–15.44 µg/100 cm²), *ACS Chemical Health & Safety* / ScienceDirect; CDC MMWR, "Adverse Health Effects Associated with Living in a Former Methamphetamine Drug Laboratory — Victoria, Australia, 2015" (mm6552a3) — family of five, systemic absorption, effects most pronounced in the youngest child.

10. Remediation cleanup standards — Washington State post-remediation level of 0.5 µg/100 cm² (5 µg/ft²), not strictly health-derived; state regulation of clandestine-lab decontamination (e.g., Washington Chapters 246-205 WAC and 64.44 RCW; Arkansas ADEQ clandestine-lab cleanup standards); decontamination procedures (fixture removal, surface cleaning, verification sampling); Washington State Department of Health guidance on methamphetamine and fentanyl residue in shelters and housing.

End of Part X — Forensic Science (Chapters 25–27)

*Part XI — Sociology (Chapters 28–30: Why People Use Meth; Homelessness and Meth; Stigma)
continues the volume.*