MAYO CLINIC
Mayo Medical Laboratories

Drug Testing

An Overview of Mayo Clinic Tests Designed for Detecting Drug Abuse

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Limits of Detection (LOD) Table -

Prescription and OTC Drugs

Last Updated November 2015

The limits of detections (LODs) listed below reflect the concentrations at which the specific drugs can be reliably detected. If the drug is detected at a level below the listed LOD, it will be reported only if it meets laboratory quality criteria for identification.

Drugs other than those listed below may be detected by GC-MS library matching and will be reported if they meet laboratory quality criteria for identification.

Note: Submission of less than the minimum sample volume requires increasing the limit of detection.

Generic Name	LOD (mcg/mL)	Notes	Urine	Serum
Acetaminophen	10.0			
Amitriptyline	1.0		Variability in the LOD	
Amobarbital	1.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Bupropion	1.0			
Butabarbital	1.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Butalbital	10.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Caffeine	15.0			
Carbamazepine	2.0			
Carisoprodol	5.0			
Chlordiazepoxide	5.0	Preferred test for detection of benzodiazepines is a specific request; see Specific Drug Group Confirmation	Variability in the LOD	
Chlorpheniramine	1.0			
Chlorpromazine	5.0			
Chlorpropamide	5.0			
Citalopram	1.0	Unable to differentiate between R- and S-citalopram, reported as citalopram.	Variability in the LOD	

Generic Name	LOD (mcg/mL)	Notes	Urine	Serum
Clomipramine	1.0		Variability in the LOD	
Clozapine	1.0			
Cyclobenzaprine	1.0			
Desipramine	5.0		Variability in the LOD	Variability in the LOD
Dextromethorphan	5.0			
Diazepam	0.5	Preferred test for detection of benzodiazepines is a specific request; see Specific Drug Group Confirmation		
Diltiazem	1.0			
Diphenhydramine	0.5			
Doxepin	1.0		Variability in the LOD	
Doxylamine	5.0			
EDDP (methadone metabolite)	2.5	Preferred test for detection of methadone and metabolite is a specific request; see Specific Drug Group Confirmation		Only detected in urine
Ethosuximide	5.0			
Etomidate	1.0			
Felbamate	5.0			
Fentanyl	1.0	Preferred test for detection of fentanyl is a specific request; see Specific Drug Group Confirmation		
Fluconazole	5.0			
Fluoxetine	4.0			
Gemfibrozil	5.0			
Hydrocodone	5.0	Preferred test for detection of opiates is a specific request; see Specific Drug Group Confirmation	Variability in the LOD	
Hydroxyzine	5.0		Variability in the LOD	
Ibuprofen	25.0		Variability in the LOD	
Imipramine	0.5		Variability in the LOD	
Lamotrigine	25.0		Variability in the LOD	

Generic Name	LOD (mcg/mL)	Notes	Urine	Serum
Lidocaine	1.0			
Lorazepam	5.0	Preferred test for detection of benzodiazepines is a specific request; see Specific Drug Group Confirmation	Variability in the LOD	
Meperidine	1.0		Variability in the LOD	
Mephobarbital	1.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Meprobamate	5.0			
Metaxalone	1.0			
Methadone	1.0	Preferred test for detection of methadone is a specific request; see Specific Drug Group Confirmation	Variability in the LOD	
Methocarbamol	2.5		Variability in the LOD	
Methsuximide	1.0			
Methylphenidate	10.0			
Metronidazole	5.0			
Midazolam	1.0	Preferred test for detection of benzodiazepines is a specific request; see Specific Drug Group Confirmation		
Mirtazapine	1.0			
Naproxen	30.0			
Nordiazepam	1.0			
Normethsuximide	10.0			
Norpropoxyphene	10.0	Preferred test for detection of propoxyphene is a specific request; see Specific Drug Group Confirmation		
Nortriptyline	1.0		Variability in the LOD	
Oxcarbazepine Metabolite	5.0			
Paroxetine	20.0		Variability in the LOD	Variability in the LOD
Pentazocine	5.0			
Pentobarbital	5.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Pentoxifylline	1.0			

Generic Name	LOD (mcg/mL)	Notes	Urine	Serum
Phencyclidine	1.0	Preferred test for detection of PCP is a specific request; see Specific Drug Group Confirmation		
Phenobarbital	5.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Phenytoin	5.0			
Primidone	5.0			
Promethazine	1.0			
Propofol	5.0			
Quetiapine	5.0		Variability in the LOD	Variability in the LOD
Quinidine	5.0		Variability in the LOD	
Salicylate	5.0			
Secobarbital	1.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Sertraline	1.0		Variability in the LOD	Variability in the LOD
Temazepam	1.0	Preferred test for detection of benzodiazepines is a specific request; see Specific Drug Group Confirmation	Variability in the LOD	
Theophylline	5.0			
Thiopental	1.0	Preferred test for detection of barbiturates is a specific request; see Specific Drug Group Confirmation		
Thioridazine	1.0			
Ticlopidine	1.0			
Topiramate	5.0			
Tramadol	5.0			
Trazodone	2.0			
Trimipramine	1.0			
Valproic Acid	5.0			
Venlafaxine	2.0			
Verapamil	1.0			

Generic Name	LOD (mcg/mL)	Notes	Urine	Serum
Zolpidem	1.0			

Approximate Detection Times

All Specific Drug Groups

Last Updated November 2015

	LOQ (ng/mL)	Detection time* up to
Amphetamine-Type Stimulants		
Amphetamine	25	3 days
Methamphetamine	25	3 days
3,4-Methylenedioxyamphetamine (MDA)	25	2 days
3,4-Methylenedioxymethamphetamine (MDMA)	25	2 days
Phentermine	25	
Ephedrine/pseudoephedrine	25	5 days
Barbiturates		
Long-Acting		
Phenobarbital	100	15 days
Intermediate-Acting		
Butalbital	100	7 days
Amobarbital	100	3 days
Short-Acting		
Pentobarbital	100	3 days
Secobarbital	100	3 days
Benzodiazepines		
Long-Acting		10 days
Diazepam	100	
Nordiazepam	100	
Intermediate-Acting		5 days
Alprazolam	100	
Lorazepam	100	
Oxazepam	100	
Temazepam	100	
Chlordiazepoxide	100	
Clonazepam	100	
Flunitrazepam	50	
Short-Acting		2 days
Triazolam	100	
Flurazepam	100	

	LOQ (ng/mL)	Detection time* up to
Buprenorphine		
Buprenorphine	0.5	7 days
Norbuprenorphine	0.5	7 days
Cocaine & Metabolite		
Cocaine	50	<1 day
Benzoylecgonine	50	5 days
Fentanyl		
Fentanyl	0.2	3 days
Norfentanyl	1.0	3 days
Ketamine		
Ketamine	25	2 days
Norketamine	25	2 days
Lysergic Acid Diethylamide (LSD)		
LSD	0.5	<1 day
2-Oxo-3-hydroxy-LSD	5	5 days
Marijuana/Cannabis (THC-COOH)		
Single Use	3	3 days
Moderate Use (4 times per week)		5 days
Heavy Use (daily)		10 days
Chronic Heavy Use		30 days
Methadone		
Methadone	100	7 days
EDDP (methadone metabolite)	100	7 days
Opiates		
6-MAM	5	1 day
Morphine	100	3 days
Codeine	100	3 days
Hydrocodone	100	3 days
Hydromorphone	100	3 days
Oxycodone	100	3 days
Oxymorphone	100	3 days

	LOQ (ng/mL)	Detection time* up to
Phencyclidine		
Phencyclidine	25	8 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Note: These tests do not differentiate between dextro (+) amphetamine (dexamphetamine) and racemic mixtures of dextro (+) and levo (-) isomers that are present in "street" amphetamine. These tests do not differentiate between ephedrine and pseudoephedrine.

Alcohol

Ethanol is cleared at an approximate rate of 15 mL per hour (healthy, nonalcoholic adults will clear 1 drink per hour).

1 standard bar drink (1.5 ounces of 80 proof liquor) = 1 standard glass of wine = 1 bottle of regular (4.5%) beer.

- Alcoholics clear ethanol faster than normal.
- Alcohol concentration is performed by headspace gas chromatography with flame ionization detection (GC-FID) (reference method to demonstrate intoxication potential in blood).
    - Serum may be submitted, but is not preferred.
    - Urine alcohol concentration is not a good indicator of intoxication.

      Note: Urine alcohol concentration depends on a number of alcoholic drinks consumed, fluid intake, and number of hours since last voiding.

Widmark Equation

The Widmark Equation is a useful tool for:

- Predicting Blood Alcohol Concentration (BAC).
- Predicting time elapsed since the last drink.
- Estimating how many drinks were consumed if the time of the last drink and BAC are known.

Amphetamine-Type Stimulants (ATS)

Alias: Amfetamine

Interpretation

- The presence of ATS >LOQ indicates exposure within a 2- to 3-day interval preceding specimen collection.

Metabolites

- Methamphetamine is metabolized to amphetamine; both can be present in urine after methamphetamine use.

  Methamphetamine > **Amphetamine**

- Selegiline, femprofazone, and benzphetamine are all metabolized to methamphetamine and amphetamine.
- Clobenzorex is metabolized to amphetamine.
- Amphetamine is not metabolized to methamphetamine; absence of methamphetamine in the presence of amphetamine indicates the primary drug of use is amphetamine.

- 3,4-Methylenedioxymethamphetamine (Ecstasy, MDMA) is metabolized to 3,4-methylenedioxyamphetamine (MDA).

  3,4-Methylenedioxymethamphetamine >3,4-methylenedioxy-amphetamine

Approximate Detection Times

Amphetamine-Type Stimulants	LOQ (ng/mL)	Detection Time* up to
Amphetamine	25	3 days
Methamphetamine	25	3 days
3,4-Methylenedioxyamphetamine (MDA)	25	2 days
3,4-Methylenedioxymethamphetamine (MDMA)	25	2 days
Phentermine	25	
Ephedrine/pseudoephedrine	25	5 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Note: These tests do not differentiate between dextro (+) amphetamines (eg, dexamphetamine) and racemic mixtures of dextro (+) and levo (-) isomers that are present in "street" amphetamines. These tests do not differentiate between ephedrine and pseudoephedrine.

Barbiturates

Interpretation

- **If there is a question as to a patient's therapeutic compliance**, a serum test request for the specific drug of interest may be of help.

Metabolites

- Mephobarbital is metabolized to phenobarbital.

Mephobarbital > **Phenobarbital**

Approximate Detection Times

Barbiturates	LOQ (ng/mL)	Detection Time* up to
Long-Acting		
Phenobarbital	100	15 days
Intermediate-Acting		
Butalbital	100	7 days
Amobarbital	100	3 days
Short-Acting		
Pentobarbital	100	3 days
Secobarbital	100	3 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Benzodiazepines

Interpretation

- **If there is a question as to a patient's therapeutic compliance**, a serum test request for the specific drug of interest may be of help.

Metabolites

- Benzodiazepines are extensively metabolized, and the parent compounds are not detected in urine.
- Diazepam is metabolized to nordiazepam, oxazepam, and temazepam; all may be detected after diazepam use.

  Diazepam > **Nordiazepam, Oxazepam, and Temazepam**

- Chlordiazepoxide is metabolized to nordiazepam and oxazepam; all may be detected after chlordiazepoxide use.

  Chlordiazepoxide > **Nordiazepam and Oxazepam**

- Alprazolam is detected as the metabolite alpha-hydroxyalprazolam.
- Triazolam is detected as the metabolite alpha-hydroxytriazolam
- Clonazepam is detected as the metabolite 7-aminoclonazepam.
- Flunitrazepam is detected as the metabolite 7-aminoflunitrazepam.
- Flurazepam is detected as the metabolite hydroxyethyl-flurazepam.

Approximate Detection Times

Benzodiazepines	LOQ (ng/mL)	Detection Time* up to
Long-Acting		10 days
Diazepam as metabolites	100	
Nordiazepam	100	
Intermediate-Acting		5 days
Alprazolam as metabolite	100	
Lorazepam	100	
Oxazepam	100	
Temazepam	100	
Chlordiazepoxide as metabolite	100	
Clonazepam as metabolite	100	
Flunitrazepam as metabolite	50	

Benzodiazepines	LOQ (ng/mL)	Detection Time* up to
Short-Acting		2 days
Triazolam as metabolite	100	
Flurazepam as metabolite	100	

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Buprenorphine

Interpretation

- The elimination half-lives have ranged from 1.2 to 7.2 hours after intravenous injection; elimination half-lives after sublingual or transdermal use are longer and may range from 20 to 36 hours or more.
- Buprenorphine is metabolized through N-dealkylation to the pharmacologically active metabolite N-dealkylbuprenorphine (norbuprenorphine) through cytochrome P450 3A4 and by conjugation to glucuronide metabolites.
- The presence of buprenorphine or norbuprenorphine >LOQ indicates exposure to buprenorphine within 7 days.

Approximate Detection Times

Buprenorphine	LOQ (ng/mL)	Detection Time* up to
Buprenorphine	0.5	7 days
Norbuprenorphine	0.5	7 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Cocaine and Metabolite

Interpretation

- The presence of cocaine >LOQ indicates exposure to cocaine within 1 day prior to specimen collection.
- The presence of benzoylecgonine >LOQ indicates exposure to cocaine within 5 days prior to specimen collection.

Metabolites

- Cocaine is metabolized to several inactive metabolites, the predominant one being benzoylecgonine.

Cocaine > **Benzoylecgonine**

Approximate Detection Times

Cocaine & Metabolite	LOQ (ng/mL)	Detection Time* up to
Cocaine	50	<1 day
Benzoylecgonine	50	5 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Fentanyl

Interpretation

- The presence of fentanyl or norfentanyl >LOQ indicates exposure to fentanyl within 3 days.

Metabolites

- Fentanyl is metabolized primarily by oxidative N-dealkylation to norfentanyl.

Fentanyl > **Norfentanyl**

Approximate Detection Times

Fentanyl	LOQ (ng/mL)	Detection Time* up to
Fentanyl	0.2	3 days
Norfentanyl	1.0	3 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Ketamine

Interpretation

- The presence of ketamine or norketamine >LOQ indicates exposure to ketamine within 2 days.

Metabolites

- Ketamine is metabolized by N-demethylation to the active metabolite norketamine.

Ketamine > **Norketamine**

Approximate Detection Times

Ketamine	LOQ (ng/mL)	Detection Time* up to
Ketamine	25	2 days
Norketamine	25	2 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Lysergic Acid Diethylamide (LSD)

Interpretation

- The clearance half-life of LSD averages 3 hours, while the clearance half-life of LSD metabolite averages 12 hours.
- The presence of LSD >LOQ indicates exposure to LSD within 1 day.
- The presence of 2-oxo-3-hydroxy-LSD >LOQ indicates exposure to LSD within 2 to 5 days.

Metabolites

- LSD is metabolized to 2-oxo-3-hydroxy-LSD.

LSD > **2-oxo-3-hydroxy-LSD**

Approximate Detection Times

Lysergic Acid Diethylamide (LSD)	LOQ (ng/mL)	Detection Time* up to
LSD	0.5	<1 day
2-Oxo-3-hydroxy-LSD	5	5 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Marijuana delta^{9}-Tetrahydrocannabinol (THC)

Interpretation

The parent drug, delta^{9}-tetrahydrocannabinol (THC), has a clearance half-life of less than 30 minutes and is not detectable in urine. Following a dose of THC, the metabolite typically appears in the urine within 60 minutes, but can take as long as 4 hours.

Note: The presence of the major THC-COOH >LOQ indicates exposure to THC within 3 days after a single use, to approximately 30 days in heavy chronic users.

Metabolites

- The major metabolite is tetrahydrocannabinol carboxylic acid (THC-COOH). THC-COOH is inactive and very lipid soluble.

delta^{9}-tetrahydrocannabinol (THC) > tetrahydrocannabinol carboxylic acid (THC-COOH)

Approximate Detection Times

Marijuana/Cannabis (THC-COOH)	LOQ (ng/mL)	Detection Time* up to
Single Use	3	3 days
Moderate Use (4 times per week)		5 days
Heavy Use (daily)		10 days
Chronic Heavy Use		30 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Methadone

Interpretation

- The clearance half-life of methadone averages 30 hours. Urinary methadone excretion is pH dependent; excretion is decreased with increased urinary pH.
- Patients who are taking methadone for therapeutic purposes excrete both parent methadone and metabolite in their urine.
- The absolute concentration found in a patient's urine sample can be highly variable; however, patients who are known to be compliant with their methadone therapy have ratios of EDDP:methadone >0.60.
- If there is a question as to a patient's therapeutic compliance, a serum test request for the specific drug of interest may be of help.
- The presence of methadone >LOQ indicates exposure to methadone within 6 to 7 days prior to specimen collection.

Metabolites

- Methadone is metabolized to an inactive metabolite, 2-ethylidene-1,5-dimethyl-3,3- diphenylpyrrolidine (EDDP).

Methadone > **2-Ethylidene-1,5-dimethyl-3,3- diphenylpyrrolidine (EDDP)**

Approximate Detection Times

Methadone	LOQ (ng/mL)	Detection Time* up to
Methadone	100	7 days
EDDP (methadone metabolite)	100	7 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Opiates

Interpretation

- Opiates are the natural or synthetic drugs that have a morphine-like pharmacological action. Medically, opiates are used primarily for relief of pain. Opiates include morphine and drugs structurally similar to morphine (eg, codeine, hydrocodone, hydromorphone, oxycodone).
- Heroin (diacetylmorphine) is a synthetic opiate made from morphine and is rarely detectable in body fluids. It has a half-life of a few minutes. Illicit heroin often contains small amounts of acetylcodeine. The presence of both codeine and morphine in urine does not rule out the use of heroin; however, the ratio of morphine to codeine can be helpful in discriminating between heroin and codeine use.
- Ingestion of bakery products containing poppy seeds can also cause morphine to be excreted in urine. If excessively large amounts are consumed, this can result in urine morphine concentrations up to 2000 ng/mL for a period of 6 to 12 hours after ingestion. Due to first-pass metabolism, no pharmacologic effect is experienced from poppy seed ingestion.
- **If there is a question as to a patient's therapeutic compliance**, a serum test request for the specific drug of interest may be of help.
- The presence of an opiate >LOQ indicates exposure to that opiate within 2 to 3 days prior to specimen collection.
- The presence of 6-MAM is conclusive evidence of prior heroin use. However, due to its short half-life, it is only detectable in urine for about 8 hours after administration.

Metabolites

- Heroin (diacetylmorphine) is metabolized to morphine. Heroin undergoes rapid deacetylation to 6-monoacetylmorphine (6-MAM), which is about 6 times more potent than morphine. 6-MAM is further deacetylated to morphine. The effects of heroin are attributed to the combined effect of heroin, 6-MAM, and morphine.

  Diacetylmorphine > **6-monoacetylmorphine (6-MAM)** > **Morphine**

- Codeine is metabolized to morphine. The presence of morphine in urine can indicate exposure to morphine, heroin, or codeine.

  Codeine > **Morphine**

- Hydromorphone is a minor metabolite of morphine and may be excreted in urine at concentrations up to 2.5% of the morphine concentration. Consequently, the detection of minor amounts of hydromorphone in urine containing high concentrations of codeine should not be interpreted as evidence of hydromorphone use.

- Hydrocodone is a minor metabolite of codeine that is metabolized to hydromorphone and may be excreted in urine at concentrations up to 11% of the codeine concentration. Consequently, the detection of minor amounts of hydrocodone in urine containing high concentrations of codeine should not be interpreted as evidence of hydrocodone use.

Hydrocodone > **Hydromorphone**

- Oxycodone is metabolized to oxymorphone.

Oxycodone > **Oxymorphone**

Approximate Detection Times

Opiates	**LOQ (ng/mL)**	**Detection Time* up to**
6-MAM	5	<1 day
Morphine	100	3 days
Codeine	100	3 days
Hydrocodone	100	3 days
Hydromorphone	100	3 days
Oxycodone	100	3 days
Oxymorphone	100	3 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Phencyclidine (PCP)

Interpretation

- The clearance half-life of PCP averages 15 hours.
- The presence of PCP >LOQ indicates exposure to PCP within 2 to 8 days prior to specimen collection.

Approximate Detection Times

Phencyclidine	LOQ (ng/mL)	Detection Time* up to
Phencyclidine	25	8 days

*These are approximate detection times for the drug or metabolites in urine. The actual detection time depends on dose, frequency of use, and individual metabolism.

Masking Agents/Adulterants

Drug of abuse tests performed in the Toxicology and Drug Monitoring Laboratory are used to monitor compliance with treatment programs and should be utilized in a clinical setting where test results can be definitively used to make a diagnosis. Specimen adulteration can have a significant, potentially damaging, effect on treatment decisions. For this reason, the Toxicology and Drug Monitoring Laboratory utilizes a multistep process to evaluate specimens for adulteration.

The specimen adulteration evaluation involves the following tests: creatinine, specific gravity, pH, and oxidants. When one or more of these results are outside the normal reference value, an adulterant comment is added to the final report that identifies the specific adulterant found.

View the **Adulterant Survey Algorithm**.