UNITED NATIONS INTERNATIONAL DRUG CONTROL PROGRAMME

SCIENTIFIC AND TECHNICAL NOTES	SCITEC/18 DECEMBER 2001

RAPID ON-SITE SCREENING OF DRUGS OF ABUSE

A summary of commercially available products and their applications: guidance for the selection of suitable products

Part I

Biological specimens

prepared by

Scientific Section
Division for Operations and Analysis

Preface

Rapid and simple, non-instrumental drug testing (screening) is gaining popularity in law enforcement, criminal justice and emergency and health care systems alike. A wide variety of such on-site screening devices is already marketed to test both seized materials and biological specimens, and the number of available products is increasing continuously, both in application and sophistication.

This SCITEC publication is aimed at assisting in the selection of suitable on-site drug testing devices, responding also to an increasing number of enquiries from Member States for such assistance. The present Part I is devoted to products for the screening of biological samples; Part II will deal with similar devices for on-site testing of seized materials. Criteria for the characterization of on-site drug testing products are discussed, such as screening matrix (urine, sweat, saliva, etc.), number of drugs to be tested, types of tests available, sensitivity, specificity, ease of use / training requirements, cross-reactivity, storage conditions, etc.. Evaluation studies comparing commercial on-site devices with laboratory results, if available, are also referenced. In view of the rapidly growing market for non-instrumental drug screening devices and their applications, and the fact that many products are available from a large number of different distributors, it is clear that any attempt to compile a list of commercially available products can never be comprehensive. Therefore, focus is laid on the significance of the relevant criteria for comparative purposes. Selected examples for individual product groups are given to provide some guidance.

The information in this SCITEC publication is based on the findings of the European Commission funded ROSITA (Roadside Testing Assessment) project, supplemented by relevant information from the scientific literature, Internet and commercial brochures. The final reports of the relevant studies under the ROSITA project, which were aimed at the inventarization and practical performance evaluation of roadside drug testing devices, were published in June 1999 and December 2000, respectively (ROSITA, 1999/2000), and provide further details on individual products.

Table of contents

1. Introduction

The prevalence and use of many drugs of abuse in the general population continue to increase. Recreational use and abuse of licit and illicit preparations has led to an increased awareness of their effect on society. This concern in turn has led to an increased interest in detection methods.

Testing for drugs of abuse in biological samples (e.g., urine, sweat, saliva) may include on-site screens or comprehensive toxicological analysis in a laboratory setting. On-site or point-of-care (POC) tests for drugs of abuse may be used in a variety of applications. These include workplace drug screens, roadside testing, the emergency room and various forensic and outpatient applications: rehabilitation facilities, probation and drug counselling services.

Primarily, on-site screening eliminates the specimens/individuals who test negative for certain drugs such that the more complex and time-consuming confirmation process is not overburdened. However, in the emergency room, screening also serves to identify drugs, which may be useful in patient management.

Drug rehabilitation programs and justice departments use on-site screening devices to immediately verify compliance; employers randomly screen employees to curtail workplace accidents and absenteeism. To serve these purposes, on-site drug screening devices, when used, need to be reliable and rapid. They must also be cost effective, and simple to use, because individuals with little training may perform the testing.

Workplace and forensic screening for drugs of abuse is usually performed for medico-legal purposes. It includes forensic (search) and monitoring (control) operations or routine checks, providing a fast indication, or supporting a suspicion, for the abuse or the presence of illicit drugs. A positive result from a screening device is considered to be a ***presumptive*** result based on a selected cut-off concentration of a drug. Results are intended to separate presumptive positives from true negatives. In other words, when something in a biological specimen has reacted with the test, results provided by these devices indicate whether a drug or drug metabolite *may* be present. A final (evidential) detection of the presence of a drug of abuse requires appropriate laboratory procedures and approved analytical techniques. Only those samples that are positive by both screening and confirmatory methods should be reported as positive. The reasons for this are clear, since the consequences of a positive test result are often grave, involving corrective / punitive action, loss of a job, or even criminal proceedings.

In contrast, *clinical applications of drug screening* for diagnostic, treatment or rehabilitation purposes are performed for the benefit of the patient, and therefore do not necessarily require confirmation. Their objective is medical care. A positive result would not necessarily involve legal proceedings, but may serve as a basis for future medical treatment of the sample donor. False positive results, although undesirable, rarely jeopardise the patient. In these scenarios, on-site drug screening avoids the lengthy turnaround time required for confirmation that usually limits clinical usefulness.

A number of manufacturers produce devices for on-site drugs-of-abuse-screening, and the range of products continues to grow. Available products include devices to detect single drugs of abuse (single-parameter tests), and panel tests that identify several drugs at the same time, either in fixed combinations or, increasingly, in a customized form. Drugs or drug classes that can be identified with available devices include amphetamines, cocaine, opiates, cannabis products, phencyclidine, benzodiazepines, barbiturates, and methadone. Other abused substances such as LSD and psilocybin, or ketamine, gamma-hydroxybutyrate, and volatile substances, cannot be tested with on-site devices. An increasing number of on-site devices, in particular those from European manufacturers, are sensitive enough to cross-react with several amphetamine-type stimulants (ATS) such as ecstasy-type substances, and methoxyamphetamines. However, on-site devices to

specifically detect and differentiate between those substances are currently not available, despite increasing prevalence of ATS abuse.

It is the purpose of this publication to assist in the selection of suitable products for use in different on-site applications. To this end, relevant background information is provided in the next sections. General information on biological testing in different matrices by chemical analysis can be found in a number of other publications issued by, for example, the Scientific Section (United Nations, 1999a, 1999b, 1997, and 1995).

2. Principles of on-site immunoassay devices

Typically, on-site screening devices for biological specimens are immunoassays, using immunochromatographic methods. Most of these tests are based on competitive technology. In these assays, drug (or drug metabolite) that may be present in the test sample competes with a drug conjugate for antibody binding sites.

There are different types of integrated devices providing for the necessary reagents, i.e., drug-conjugate and antibodies, in slightly different configurations. Most currently available on-site immunoassays rely on at least one reagent bound to a solid support.

'Direct competition' technology

In the first type of tests, immobilized drug conjugate competes with drug/metabolite for a limited amount of chemically labelled antibody. In the absence of a sufficient amount of drug or drug metabolite in the sample, unbound antibodies migrate to the detection zone (test window) and bind there to the immobilized, membrane-bound drug conjugate. This results in the formation of a visible line in the test window (negative result).

Conversely, if sufficient amount of drug or drug metabolite is present in the sample, the drug/metabolite saturates the binding sites of the antibodies. This prevents the antibodies from migrating and binding to the immobilized drug conjugate in the test window, and no line forms (positive result).

To confirm that the test is working properly, regardless of the level of drug/metabolite in the sample, a (separate) coloured line will appear in the control window. It is produced by a parallel immunochemical reaction, and indicates that the sample has moved to the detection zone, that antibodies have been recognized, and that the reagents are chemically active.

Displacement technology

Other tests work by displacement of a chemically labelled drug conjugate already bound to an equal amount of a test antibody. If drug/metabolite is present, part of the chemically labelled drug conjugate is displaced from the antibody, allowing it to migrate to the detection zone. There, it binds to immobilized antibody, resulting in a coloured line (positive result). In the absence of drug/metabolite in the sample, all labelled drug conjugate remains bound to the antibody; it will not migrate, resulting in no reaction with the immobilized antibodies in the test window (negative result).

A modification of this principle is the "immunosensor" technology: a fluorescent drug tracer, displaced from immobilized antibody by drug/metabolite present in the test sample, is measured spectrometrically. The intensity of fluorescence correlates with the amount of drug/metabolite present in the sample (LifePoint, 2001).

'Trapping' technology

Finally, a third type of tests uses the colour of dye-labelled antibodies that migrate, in the form of a mobile drug/metabolite-antibody complex, to the detection window to indicate the presence of drug/metabolite in the test sample. In the absence of a sufficient concentration of drug/metabolite, unreacted labelled antibody is trapped by immobilized drug conjugate and thus prevented from reaching the detection window (negative result). In such tests, the intensity of the colour correlates with the drug/metabolite concentration, thus allowing for semi-quantitative results. However, the lack of a control line and the need for comparison with a colour scale limit the practical usefulness of such products.

3. Purpose and intended use of on-site drug screening

The selection of an on-site drug-screening device is strongly affected by a number of considerations, above all, by the purpose for which the drug screen will be carried out: deterrence of drug use, drug-free proof at time of testing, monitoring of treatment progress, investigations into the cause of an accident, assessment of the level of impairment, etc.. Drug-testing devices must meet slightly different requirements for each of the different applications.

In most cases, national drug legislation will also provide the framework for on-site drug screening in different applications (e.g., SAMHSA, 2001; Wennig, 2000). These laws will normally regulate all steps involved, including the circumstances where drug testing can be performed, the authority to collect different sample specimens and the collection process, and actions that can be taken on the basis of positive test results. Legislation may, however, vary considerably from one country to another. A summary of legislative approaches in 20 countries covering the use of alternative matrices for drug testing is provided by Cone (Cone, 2001).

Currently, on-site testing for drugs of abuse is being carried out, to varying extents, in the following applications:

- Workplace surveillance programmes (including pre-employment, random / periodic, "reasonable suspicion", post-accident, and return-to-duty/follow-up testing), including testing of military and personnel in other safety-sensitive jobs,
- Roadside drug testing programmes,
- Crime investigations and legal proceedings,
- Drug treatment and rehabilitation programmes,
- Parole / probation programmes (including so-called "drug courts"[a]),
- Hospital emergency room examinations,
- Insurance assessments.

Intertwined with the context and purpose of drug screening are a number of other considerations that form an integral part of the choice of a final product. They include the type and range of drugs to be detected, the time window to be covered, sample collection and handling, implications of the test results, and performance characteristics of the device itself, including any built-in quality control, i.e., provisions to limit potential errors due to operator performance.

An understanding of certain critical aspects related to the functioning of on-site screening devices and the interpretation of results is therefore useful to help relate the advertised

[a] Drug courts, which began in the United States in 1989,are aimed at providing an alternative to prison for first time drug offenders. The concept of drug courts can now be found in an increasing number of countries, including Canada, Australia and Ireland. In the US, for example, in 2001, there were over 70,000 enrolees in more than 600 drug court programmes. With an average testing of twice weekly, an estimated 7.8 million tests is performed annually (LifePoint, 2001).

performance characteristics of a device to its appropriateness for an intended application. To this end, the next sections will briefly discuss the following areas, and their relevance for on-site screening:

- Sample specimen (matrix)
- Cross-reactivity
- Cut-off value / concentration
- Analytical performance characteristics of on-site screening devices
- Stability of on-site devices, and
- Other considerations, such as types of device (product design), "read-out" of results, range of drugs/classes to be tested, time required to perform a test, documentation of results, and costs.

4. Criteria for comparison of on-site devices

4.1. Sample specimen (matrix)

There are a variety of biological specimens suitable for on-site drug screening, including urine, sweat and saliva (blood and hair/nails, although used in some of the applications mentioned above, are not discussed here as they are not amenable to on-site screening in the strict sense). The choice of a specimen for analysis depends on the purpose of the testing, and may be affected by concerns about sample collection, transport, handling, and assurance of sample integrity between the collection site and point of analysis. Most commonly, on-site devices focus on the detection of illicit drugs in urine.

Urine

Urine is the preferred specimen for on-site drug testing, and it has a long history of use in a variety of applications, in particular workplace drug testing. There is an extensive scientific basis for urine testing methodology, and uniform testing criteria have been established. As a consequence, urine-testing results are frequently accepted in court (Caplan and Goldberger, 2001). In addition, urine samples can be easily acquired; and they are stable and typically available in sufficient amounts.

However, urine samples can be relatively easily substituted, or adulterated. Among the most popular manipulations is dilution of the sample, for example, by excessive drinking or use of diuretics, or simply by adding water. Furthermore, the patterns of drug excretion are dependent on the pH value of the urine and are thus influenced by diet. Deliberate changes of the pH of the urine can be effected by the addition of pH-modifying agents (e.g., vinegar, ascorbic acid, lemon juice). Similarly, addition of oxidizing (sodium hypochlorite) and surface-active (e.g., detergents, soap) agents, certain medicaments, and even sweeteners (saccharin) or table salt (sodium chloride), may also lead to false results.

Therefore, to ensure the integrity of the sample it may be necessary to observe directly the collection of urine, i.e., urine testing can be invasive of privacy.

Finally, because detection times in urine are relatively long (in the order of days) for most drugs (see Table 1), urine testing can only indicate recent exposure to drugs. It is not possible to draw conclusions on the amount of drug used (i.e., there is no clear relationship between dose and urine concentration), the time since the last dose, or the level of impairment. If the purpose of drug testing is to relate concentrations to impairment or other toxicological / pharmacological responses, *blood* is generally the specimen of choice, as blood drug concentrations are most closely related to concentrations at receptor sites.[b]

[b] Note, however, that the ability to predict the presence of drugs in blood from analysis of other body fluids depends on the timing of sampling relative to the last intake. If a drug was taken very recently, it is possible

However, to perform a blood test, a laboratory setting is required. Other alternative matrices that may be useful to relate concentrations with impairment are sweat and, particularly, saliva.

Table 1: DRUG DETECTION TIMES IN URINE

The following table should be used as a guide only (individual differences in the metabolism and excretion of drugs and their metabolites may affect specific detection times).

DRUG type *	INFREQUENT USER	FREQUENT USER	CHRONIC USER
Amphetamine	1-3 days	2-6 days	Several weeks
Methamphetamine	1-3 days	2-6 days	Several weeks
Cocaine	12-48 hours	1-4 days	Up to several weeks
Morphine	12-48 hours	2-6 days	Up to several weeks
Codeine	1-3 days	2-5 days	Up to several weeks
Cannabis products	2-5 days	4-14 days	Up to 2-3 months
Phencylidine (PCP)	1-3 days	3-7 days	Up to about a month
Benzodiazepines	2-5 days	4-14 days	Up to about a month
Secobarbital	2-4 days	4-8 days	Several weeks
Phenobarbital and other barbiturates	4-8 days	5-15 days	A month or more
Methadone	1-4 days	2-10 days	Up to several weeks
Pethidine (Meperidine)	6-24 hours	1-3 days	Up to a week

* Note: Drug detection times actually refer to the urinary metabolites of most of the drugs listed.

Source: 1-Step Detect Associates

Sweat and saliva[c]

Compared to urine, sweat and saliva have a relatively short history in drug testing, in particular in on-site drug screening. Their value as alternative specimens has only been recognized recently as more reliable, easy-to-use, on-the-spot collection devices have become available, and performance tests have begun to indicate the suitability of these specimens in selected applications. Distinct advantages of sweat and saliva compared to urine are the facts that they are less invasive, and cause less concern about violation of privacy and adulteration of samples. In addition, both can be used to detect recent use, and test results may have potential for correlation with performance impairment (Liu and Gadzala, 1997).

Unlike urine, the major component found in sweat and saliva is the parent drug; drug concentrations are generally much lower than in urine. Both aspects are important, since the nature of the target analyte (parent drug or metabolite) and its concentration, relate to the specificity and sensitivity, respectively (see definitions below), of on-site screening tests, and thus determine their reliability. The differences between sweat/saliva and urine in terms of target analyte and concentration also means that devices designed for use with urine cannot easily be used for saliva or sweat testing (Hamilton and Drummer, 2000).

While there may be less interference from endogenous compounds than with urine, both sweat and saliva are susceptible to external contamination. It has been reported, for example, that *saliva* samples collected early (<8h) after oral or nasal ingestion of cocaine

---

that it can only be found in blood (and saliva), but not yet in urine. If a drug was taken a longer time ago, it is possible that it is not detectable any more in blood, but only in urine (and possibly in sweat) (ROSITA, 1999/2000: D4). An example of the latter is cannabis: the urine detection window for cannabis metabolites is considerably longer than the presence of THC in blood, resulting in a poor predictability of blood concentrations of the pharmacologically active component from urine concentrations (ROSITA, 1999/2000: D4).

[c] For simplicity, the term “saliva” is used in this publication, even though the oral fluid used as sample specimen for “saliva testing” is not technically “saliva”.

may show higher cocaine concentrations due to nasal cavity or mouth residues (Liu and Gadzala, 1997). The same applies to residues of THC after cannabis smoking. This may be useful if evidence of recent exposure to a drug is required, although it is important to recognize that there is large individual variability in oral cavity contamination, and that in such cases there can be no correlation with plasma concentrations (Hamilton and Drummer, 2000). External contamination may also lead to incorrect results in *sweat* testing. Another practical complication in the interpretation of results from sweat tests is the large variation in sweat production, depending on ambient temperature and physical activity. For *saliva*, dry mouth as a consequence of drug use may render it difficult to obtain amounts of saliva sufficient for testing (ROSITA, 1999/2000: D4).

With regard to deliberate adulterations and interferences in sweat and saliva testing, there is still little information available to-date. However, as with urine, the dilution of *saliva* with water and other fluids, the deliberate contamination with solid materials, or the use of certain drugs or chemicals to alter fluid production or change the saliva pH can all theoretically affect a saliva-based test (Hamilton and Drummer, 2000). Similar considerations also apply to *sweat* testing.

For *saliva*, practical experience to-date seems to indicate the usefulness of testing this specimen for amphetamines and opiates, but not yet for benzodiazepines and cannabinoids (Grönholm and Lillsunde, 2001). Results from practical performance evaluation studies in the framework of the ROSITA project indicate that saliva is preferred as specimen for on-site testing in most European countries, mainly due to the low invasiveness and the simplicity of sample collection. Nevertheless, *sweat* is considered an acceptable alternative specimen. (p.47, Deliverable D3)

A comparison of different biological specimens (matrices), urine, sweat and saliva, is provided in Table 2.

Table 2: Comparison of biological specimens for drug testing with on-site screening devices
Note that this comparison does not consider applications of the specimen in other than ON-SITE situations. It does, therefore, not consider sweat testing in the form of sweat patches, which (because worn for several days) are a cumulative measure of drug excretion, thus allowing to monitor drug intake for a period of days to weeks.

Criteria for comparison	**Urine**	**Sweat**	**Saliva**
History of use/ experiences with specimens	Long history of use; uniform testing criteria established	Relatively new approach; performance testing under development; more R&D required	Relatively new approach; performance testing under development; more R&D required
Sample acquisition (note: practicalities of sampling depend on the facilities at the sampling sites)	Easy (but less practical, for example, at the roadside)	Easy, but sensitivity might be a problem	Easy; but existing collection devices may still need improving for practical use in *on-site* situations
Privacy	Invasive	Non-invasive	Non-invasive
Target analyte	Metabolite(s)	Parent drug (and metabolites)	Parent drug (and metabolites)
Analyte concentration	High	Low	Low
Detection time	Relatively long	Relatively short	Relatively short
Adulteration, substitution and contamination	Easily adulterated / substituted	Adulteration possible but difficult; external contamination possible	Adulteration possible, but difficult
Result	Indicates prior exposure in past few days	“Current-status” / “real time” results	“Current-status” / “real time” results
Correlation with impairment	No	Usually not	Yes

4.2. Cross-reactivity

Some drugs may interfere, i.e., they show "cross-reactivity", in the analysis of others. For example, drugs and drug metabolites with significant structural similarities to the target analyte may cross-react with target analyte-specific antibodies, producing false positive results. Cross-reactivity is expressed as a percent figure, with 100% cross-reactivity for the target analyte. More generally, it is the degree to which any substrate other than the target substrate interacts with an antibody.

In this connection it is important to know that some immunoassays are class-specific only. They cannot be used therefore to identify, specifically, individual drugs within a class. Examples are tests for amphetamines, benzodiazepines, barbiturates, and opiates. Class-specificity does therefore not imply that all drugs in the same drug class have the same cross-reactivities, and that detection limits (and cut-off concentrations; see below) are the same for each drug within a class. Information on individual cross-reactivities for the different substances in a drug class is usually stated in the package insert.

The optimal / desirable degree of cross-reactivity of a test depends on the intended use. While in some applications highly specific immunoassays may be desirable to allow the presumptive *identification of an individual drug*, in other situations it may be sufficient to know that any drug from a given class of related substances might be present. However, there are clearly also technical limitations in the production of antibodies with a defined specificity.

Manufacturers test for cross-reactivity by spiking test samples and documenting test results. This is the information that is found in package inserts. However, the cross-reactivity lists provided by most manufacturers have been found to be far from complete (Grönholm and Lillsunde, 2001). Moreover, since these data are not obtained from actual ingestion of drug, the reported concentrations are not necessarily physiologic and may not give information about possible interference of drug metabolites. It is also highly possible that some cross-reacting compounds may not have been tested, and are therefore not listed. Lists of compounds, which have been tested and found not to cross-react, are therefore equally informative to obtain a more comprehensive picture of possible interferences.

The issue of cross-reactivity is particularly relevant in the context of amphetamine-type stimulants (ATS), because of the large number of closely related substances, including ecstasy-type "designer" analogues (such as MDMA, MDA, MDE, MBDB), with different control status. Although amphetamine class tests are usually designed to cross-react with ecstasy and other illicit ATS, degrees of cross-reactivity may vary considerably from one substance to another. Even for amphetamine and methamphetamine, the "parent" analytes, degrees of cross-reactivity in amphetamine class tests may differ, depending on the manufacturer of the specific test.[d] On-site screening devices that specifically detect and allow differentiation of individual ATS are not yet widely available, despite the high and increasing prevalence of ATS abuse worldwide. Some manufacturers, e.g., Microgenics, claim to have developed high specificity antibodies for the detection of ecstasy-type drugs.

Another problem that is particularly relevant in the context of tests for amphetamines, but also for opiates, is the fact that certain prescription drugs may lead to a positive test, either because of direct cross-reactivity of some of their ingredients, or because their main urinary metabolites are the target drugs tested. For amphetamine tests, examples include certain nasal decongestants and anorectics (e.g., ephedrine, phenylpropanolamine, phentermine), and the anti-parkinsonian drug selegiline, which is metabolized to amphetamine (a list of 'metabolic' precursors is provided in (United Nations, 1995)).

[d] Note that in the European context, a test for "amphetamines" is designed to cross-react with amphetamine, MDA, MDMA, MDE, and MBDB (ROSITA 1999/2000, D3); for US approved tests, (+)-methamphetamine is the target analyte, and tests must in the future also cross-react with MDMA, MDA, MDE at levels of 50-150% cross-reactivity (SAMHSA, 2001).

In addition, other typical cross-reactions in urine tests include (ROSITA, 1999/2000):

Opiate-type tests:

Most opiate assays are designed to detect morphine. Heroin use causes a positive opiate test result because its predominant urinary metabolite is morphine. A number of cough suppressants, such as codeine, some analgesics, and morphine agonists and antagonists cross-react to a high extent with opiate-type tests. False positive results may also be produced from the ingestion of food containing poppy seeds. In contrast, the ability to detect the use of synthetic opioids, such as hydromorphone, hydrocodone, oxycodone and oxymorphone varies among immunoassays from different manufacturers.

Cocaine tests:

Benzoylecgonine, one of the major urinary metabolites of cocaine, is the target analyte for cocaine tests. However, most tests also cross-react to a variable extent with other metabolites and cocaine itself.

Cannabis tests:

In addition to 11-nor-delta-9-THC-COOH, the major urinary metabolite of cannabis products, most cannabis tests also cross-react with other metabolites and delta-9-THC, the active principle itself.

Benzodiazepine tests:

Oxaprozin an anti-inflammatory drug, amongst others, interferes with some urine benzodiazepine immunoassays.

4.3. Cut-off value / concentration

The cut-off value of an assay is the specific concentration of a drug, or drug metabolite, in the sample that is chosen as a limit to distinguish a presumptive positive from a negative test result. Samples with concentrations at or above the cut-off level are considered presumptive positive and results below are considered negative. This definition of cut-off values implies that two methods with different cut-off values do not produce the same results: samples with analyte concentrations very close to the cut-off values may be negative by one method and positive by another. The cut-off concentration is therefore not an analytical concept alone, but it also takes medico-legal and political considerations into account, with the ultimate aim of applying a uniform standard for fair, objective practice.

In this connection, it should be remembered that a clear correlation between the cut-off concentration and the level of impairment has not been established for any of the sample specimens. In fact, a definition of thresholds for impairment (similar to blood-alcohol levels) may be dangerous, since blood levels only correlate with the acute phase of drug use, if at all. At the same time, blood levels may be low during withdrawal, but it is exactly this phase that is characterized by the highest level of distress in the user, which may also cause some type of ‘impairment’. Moreover, any attempt to correlate test results with impairment has to carefully consider these pharmacokinetic / metabolic aspects for individual drugs and how they are reflected in concentration profiles in different sample specimens.

Table 3 provides cut-off values as currently recommended for urine drug screening in the European Union, Australia and the US. Cut-off values differ for some drug classes (e.g., amphetamines and opiates) because they are usually established based on epidemiological information, i.e., they reflect, to a certain extent, the prevalence of, and the importance attached to the abuse of certain drugs or drug classes in different countries. It is important to be aware that recommended cut-off values are not cast in stone, but they may be changed in response to technology advances or to changes in user demand or drug

prevalence rates. In the US, for example, the SAMHSA[e] recommended cut-off concentrations have already been revised several times since the inception of the US workplace-testing programme in 1988, and they continue to evolve, with the latest proposed cut-off concentrations having been published in September 2001. The European cut-off values as recommended by the "Barcelona Group" in 1996 are currently also being revised. Although necessary to account for advances in research, the practice of adjusting cut-off values may result in situations where the specific values for some devices may not always be in concurrence with recommended limits.

Table 3: Workplace drug screening cut-offs in urine (ng/mL)

Drug type	Europe	Australia	US
Amphetamines*	300 (300)	300	1000 (500)
Cannabis metabolites	50 (50)	50	50 (50)
Cocaine metabolites	300 (300)	300	300 (150)
Opiates	300 (300)	300	2000 (2000)
Phencyclidine (PCP)	- (25)	-	25 (25)
Barbiturates	300 (200)		300
Benzodiazepines	200 (200)		300
Methadone or metabolites	300 (300)		300

* See footnote (d) on cross-reactivities, p.10, above.

Note:

- Values in brackets refer to the amended cut-off concentrations proposed for application in the European Union and the US, respectively.
- The last three drug classes are not commonly tested for in the US Workplace testing programmes ("SAMHSA-5").

Sources: Verstraete and Pierce, 2000; SAMHSA, 2001

For urine, most manufacturers use the recommended cut-offs for their on-site drug screening devices. However, some use lower cut-offs for some drugs, which may result in an increase in the number of reported positives. In general, a wide variability in the performance of on-site devices around the claimed cut-off has been found, especially with visually read tests, resulting in both false positive and false negative results. For sweat and saliva, official cut-off values have only recently been published (SAMHSA, 2001), subsequent to the use of these alternative specimens for workplace drug screening purposes gaining in acceptance.

4.4. Analytical performance characteristics of on-site screening devices

The performance of on-site screening devices is usually assessed in terms of *sensitivity*, which is the percentage of true positive, and *specificity* or percentage of true negative results. These analytical measures therefore indicate the ability of the on-site device to identify, at a given cut-off concentration, those samples that truly contain the target analyte (sensitivity) or are truly drug-free (specificity). [f]

In analytical performance studies, sensitivity and specificity are expressed as percentage of results confirmed by another method such as instrumental (laboratory-based) immunoassays or gas chromatography-mass spectrometry (GC/MS). The specimens identified as positive by the on-site screening device but later confirmed as negative are called *false positive*. And specimens identified as negative by the device but confirmed positive are called *false negative*. (Note: in some papers, instead of sensitivity and specificity, the percentages of false positives and false negatives, respectively, are used to characterize the performance of screening tests).

[e] SAMHSA is the US Substance Abuse and Mental Health Services Administration, which succeeds NIDA in responsibility for US Federal drug testing standards.

[f] Note that the definitions of sensitivity, specificity and efficiency/accuracy in this context are more closely related to those used in medicine and differ from those used in analytical chemistry.

While the number of false positive test results, by definition (equation 1), does not change the sensitivity value of a test, it does alter its specificity (equation 2). As a consequence, a test with a high degree of specificity is desirable whenever the occurrence of false positives test results can lead to serious action against the tested individual. By contrast, if it is desirable to detect all positive samples, even on the condition that also some false positives may be detected, high sensitivity is important (ROSITA, 1999/2000: D4).

The overall performance of a test is often expressed by the term *efficiency* (sometimes called accuracy), which is defined as the percentage of all true (correct) results, whether positive or negative (equation 3). High efficiency is desired when both false positives and false negatives can have equally serious consequences for the tested individual.

$$\text{Sensitivity} = \frac{TP}{TP + FN} \times 100 \qquad \text{(equation 1)}$$

$$\text{Specificity} = \frac{TN}{TN + FP} \times 100 \qquad \text{(equation 2)}$$

$$\text{Efficiency} = \frac{(TP + TN)}{N} \times 100 \qquad \text{(equation 3)}$$

Where
TP = number of true positives
FP = number of false positives
TN = number of true negatives
FN = number of false negatives
N = total number of tests performed (= TP + TN + FP + FN)

Sometimes, the terms “aggressive test” and “conservative test” are used to characterize tests based on the ratio of false positive and false negative results. While an aggressive test is considered to be a test that results in more false positives than false negatives, a conservative test results in more false negatives than false positives (ROSITA, 1999/2000: D4).

The relevance and implications of false positive and false negative results depend on the purpose and context of the drug test being carried out. For the successful introduction of on-site tests into routine police practice for roadside testing, for example, i.e., to screen drivers on-the-spot for possible drug use, before potential drug users are then required to provide blood samples for confirmation testing, the absence of false negatives is critical. Such tests, which are designed to eliminate the possibility of a false negative result, are sometimes called ‘negative specific’ tests (PharmChem, 2001).

The following analytical criteria are recommended for a good screening test (ROSITA, 1999/2000: D4):

Sensitivity ≥ 90%
Specificity ≥ 90%
Efficiency ≥ 95%

Another concept that allows the characterization of the analytical performance of on-site screening devices is the overall probability that a test result is a correct result, e.g., the percentage of correctly identified positive results out of all (true and false) positive results. *Positive Predictive Value (PPV)* and *Negative Predictive Value (NPV)* are the analytical

measures of the probability of obtaining a correct positive and negative result, respectively (see equations 4 and 5). A high PPV indicates a high probability that a specimen identified as positive by the device will be confirmed as positive by the reference laboratory method. Similarly, the NPV characterizes the probability that a negative test result is a correct negative result.

$$PPV = \frac{TP}{TP + FP} \times 100 \qquad \text{(equation 4)}$$

$$NPV = \frac{TN}{TN + FN} \times 100 \qquad \text{(equation 5)}$$

For on-site screening devices, in addition to the measurable performance indicators, it is equally important to evaluate the device's operator dependency, and any potential for obtaining incorrect results. ROSITA has placed emphasis on this issue, and its findings, complemented with information from other sources, are integrated into the comparative Table 4 below.

4.5. Stability of on-site devices

Commercial products may differ in their ability to resist certain conditions that may affect their performance, including temperature and humidity. They may also differ in shelf life, i.e., the length of storage during which accurate performance is ensured by the manufacturer.

Temperature / Humidity
Since on-site drug screening devices are based on immunoassay technology, i.e., an antigen-antibody reaction, the ambient temperature and humidity during both storage and testing is critical. Inappropriate storage conditions may degrade the viability of the reagents. Most devices can be stored at room temperature (15-28°C); refrigeration is possible but not necessary. A minority of devices must be stored in the refrigerator (2-8°C). Generally, if stored in the refrigerator, devices should be allowed to reach room temperature before use. To minimize the impact of humidity, devices should only be removed from their package immediately before use. Most disposable on-site devices, especially if they provide for a built-in validity check, appear to operate satisfactorily over reasonable, defined ranges of temperature (ROSITA, 1999/2000) and relative humidity.

Shelf life (length of storage)
The biological nature of immunoassay reagents also results in a limited shelf life for such products. Currently, most manufacturers guarantee shelf lives for their products between 12 and 18 months when stored at room temperature. The expiry date should be printed on the package of each device.

4.6. Other considerations [g]

Types of device
In terms of product design, there are three main types of integrated on-site immunoassay devices for urine testing [h]:

1. **'Pipette and read' devices**
   These devices take the form of a test cassette or test card (i.e., a credit card-like solid support). A dropper pipette is enclosed for the addition of sample into the reaction well(s). A few drops of sample are sufficient to do the test.

2. **'Dip and read' devices**
   These devices take the form of test strips or test cards, which are dipped into the sample for a few seconds.

3. **'Cup principle'**
   In the cup design, the testing device is built in the side or the top of a complex disposable plastic unit that only requires addition of sample. This restricts the number of manipulations, and the tester is not handling biological samples at any time (provided that there is no leaking of the container). The cup always includes a temperature check (ROSITA, 1999/2000).

A fourth principle uses the **immunosensor technology**. These instruments consist of a small cell through which sample is passed, and an optical unit for measuring the resulting signal. They are portable test systems suitable for on-site applications. Sample collection and data processing are fully automated (LifePoint, 2001). Immunosensors thus combine the simplicity of on-site screening devices with performance characteristics and quantitative results of laboratory based methods.

"Read-out" of results
Drug screening devices typically provide for qualitative, colorimetric detection of the presence of drugs/metabolites. Different principles are used in commercially available on-site drug screening devices to evaluate the result. 90% of the commercially available devices always show a control line to indicate the validity of the test. The presence of a second line, in the test window, indicates a negative result, while absence of the line indicates a positive result.

A minority of tests does not have a control line, and the appearance of a single coloured line indicates a positive result. By comparing the intensity of the colour with a colour scale, such tests may provide semi-quantitative results. However, they can also lead to subjective interpretation, and a clear distinction between positive and negative results usually requires some training before routine testing can be carried out.

An important practical aspect for consideration is the readability of the results (line) under varying light conditions. This may be particularly relevant for roadside testing (ROSITA, 1999/2000).

Some manufacturers sell instruments that provide digital read-outs for visually read tests. One manufacturer offers a fully automated collection, processing and analyzing system that employs spectrometric detection and reporting of quantitative results.

---

[g] For further information, the recommendations from ROSITA, i.e., an assessment of on-site devices for roadside applications, are attached in full in Annex I.

[h] For sweat and saliva testing, commercially available devices are usually of the "pipette and read" and "dip and read" type.

Range of drugs/classes to be tested: single-parameter versus panel tests
In terms of costs, single-parameter tests are cheaper in use than panel test devices, but the use of single-tests requires that the operator be able to pre-select target drugs. In practice, therefore, multi-tests may be preferred as they provide a more comprehensive picture with the same input. The combined use of single tests for low probability drugs and double or triple tests for high frequency drugs is considered a practical compromise (ROSITA, 1999/2000: D3).

Time requirements to perform a test
Typically, on-site tests can be performed in only a few minutes. Tests that require an incubation period may take longer, up to 15-20 minutes, also depending on the skills of the operator. Low temperatures may prolong the time required to perform tests (ROSITA, 1999/2000: D4). Results from practical performance evaluation studies at the roadside indicate that short measurement times (2-5 minutes) are preferred; more than 10 minutes are generally considered unacceptably long for on-site examination processes (ROSITA, 1999/2000: D3)

Documentation / storage of results
Storage of results cannot be accomplished easily with most on-site screening devices. In some cases, results can be stored electronically, either directly by the device or by an electronic result reader that has to be purchased separately. For some devices, the results in the detection window will not change with time, and storage of the device thus allows storage of results. In other cases, photocopying of the results is possible, but this procedure may not be an option for certain applications, e.g., roadside testing.

Costs
Costs for urine testing devices vary between approximately US$2-5 for single-parameter tests and US$10-20 for five-parameter panel test. For saliva and sweat testing devices, because of the still limited market size, costs are generally slightly higher and lie between US$5-15 for one to five parameters (ROSITA, 1999/2000: D3).

Costs for on-site devices that were found acceptable for roadside testing by police officers participating in the study were less than US$5 for single-parameter devices and about US$15 (range: approximately US$4-25) for 4-parameter devices (ROSITA, 1999/2000: D3).

References

Barrett C, Good C and Moore C (2001), Comparison of point-of-collection screening of drugs of abuse in oral fluid with a laboratory-based urine screen, *Forensic Sci. Int.*, 122: 163-166.

Beck O, et al. (2000), Frontline immunochromatographic device for on-site urine testing of amphetamines: laboratory validation using authentic specimens, *Annals of Clin. Biochem.*, 37 (2), 199-204.

Caplan YH and Goldberger BA (2001), Alternative specimens for workplace drug testing, *J. Anal. Toxicol.*, 25: 396-399.

Cone EJ (2001), Legal, workplace, and treatment drug testing with alternate biological matrices on a global scale, *Forensic Sci. Int.*, 121: 7-15.

Grönholm M and Lillsunde P (2001), A comparison between on-site immunoassay drug-testing devices and laboratory results, *Forensic Sci. Int.*, 121: 37-46.

Hamilton W and Drummer OH (2000), Issues associated with testing for drugs in oral fluids, *Bulletin of the International Association of Forensic Toxicologists*, 30 (3): 8-9.

Hofbauer BM et al. (1998), Comparison of immunochromatic rapid tests for screening of benzodiazepines, amphetamine, and its derivate (ecstasy) in urine, *poster presented at the TIAFT/SOFT Joint Congress*, 1998, Albuquerque, Mexico.

Iten PX (1994), *Fahren unter Drogen- oder Medikamenteneinfluss, Forensische Interpretation und Begutachtung*, Institute of Forensic Medicine, University Zürich.

Jehanli A, et al. (2001), Blind trials of an onsite saliva drug test for marijuana and opiates, *J. Forensic Sci.*, 46 (5): 1214-1220.

Kadehjian LJ (2001), Performance of five non-instrumented urine drug-testing devices with challenging near-cutoff specimens, *J. Anal. Toxicol.*, 25: 670-679.

Levisky JA, et al. (2001), Comparison of urine to sweat patch test results in court ordered testing, *Forensic Sci. Int.*, 122: 65-68.

LifePoint Inc. (2001), Manufacturer's brochure.

Liu RH and Gadzala DE (1997), Nature of Abused Drugs and Sample Characteristics, in: *Handbook of Drug Analysis. Applications in Forensic and Clinical Laboratories*. Washington, DC: American Chemical Society, pp. 3-33.

Moore L, et al. (2001), Gas chromatography-mass spectrometry confirmation of Cozart RapiScan saliva methadone and opiates tests, *J. Anal. Toxicol.*, 25: 520-524.

Niedbala RS, et al. (2001), Laboratory analysis of remotely collected oral fluid specimens for opiates by immunoassay, *J. Anal. Toxicol.*, 25: 310-315.

PharmChem (2001), *www.pharmchem.com*

Peace MR, et al. (2000), Performance evaluation of four on-site drug-testing devices for detection of drugs of abuse in urine, *J. Anal. Toxicol.*, 24: 589-594.

Price CP, et al. (1997), Disposable integrated immunoassay devices, in: Price CP and Newman DJ (Editors), *Principles and Practice of Immunoassay*, Second edition, London, Macmillan Reference Ltd, pp. 579-603.

ROSITA (1999, 2000), Roadside Testing Assessment, Project funded by the European Commission under the Transport RTD Programme of the 4th Framework Programme (*www.rosita.com)*: Deliverables D1, D2, D3, D4 and D5.

SAMHSA (2001), Substance Abuse and Mental Health Services Administration, Center for Substance Abuse Prevention, Division of Workplace Programs: *Mandatory Guidelines for Federal Workplace Drug Testing Programs*, Draft 4, September 2001 (*workplace.samhsa.gov/ResourceCenter/DT/FA/GuidelinesDraft4.htm).*

SAMHSA (1999), Substance Abuse and Mental Health Services Administration, Center for Substance Abuse Prevention, Division of Workplace Programs: *An evaluation of non-instrumented drug test devices* (*www.health.org/workplace/summary.htm).*

Taylor EH, et al. (1999), Accuracy of five on-site immunoassay drugs-of-abuse testing devices, *J. Anal. Toxicol.*, 23: 119-124.

United Nations (1999a), Guidelines for testing drugs under international control in hair, sweat and saliva, manual for use by national laboratories, ST/NAR/30/Rev.1.

United Nations (1999b), Recommended methods for the detection and assay of lysergide (LSD), phencyclidine (PCP), psilocybin and methaqualone in biological specimens, manual for use by national laboratories, ST/NAR/31.

United Nations (1997), Recommended methods for the detection and assay of barbiturates and benzodiazepines in biological specimens, manual for use by national laboratories, ST/NAR/28.

United Nations (1995), Recommended methods for the detection and assay of heroin, cannabinoids, cocaine, amphetamine, methamphetamine and ring-substituted amphetamine derivatives in biological specimens, manual for use by national laboratories, ST/NAR/27.

Vertstraete AG and Pierce A (2001), Workplace drug testing in Europe, *Forensic Sci. Int.*, 121: 2-6.

Wennig R (2000), Threshold values in toxicology – useful or not?, *Forensic Sci. Int.*, 113: 323-330.

Yang JM and Lewandrowski KB (2001), Urine drugs of abuse testing at the point of care: clinical interpretation and programmatic considerations with specific reference to the Syva Rapid Test (SRT), *Clinica Chimica Acta*, 307, 27-32.

Annex I

Assessment of on-site devices for roadside applications: General conclusions and recommendations

Roadside Testing Assessment (ROSITA) Deliverable D5 (19 December 2000)

These conclusions and recommendations are abstracted from the report of an evaluation of roadside testing devices carried out under the Roadside Testing Assessment (ROSITA) project, commissioned by the European Commission.

The Rosita project studied 2968 subjects and compared 15 different urine on-site drug tests and 3 on-site saliva tests (one of which was used on sweat as well) in 8 countries.

From this experience, the following conclusions can be drawn:

Place/Status/Significance/Role of roadside drug tests in EU Traffic Safety

- There is a need for roadside drug tests.
- Roadside drug tests are useful under both types of legislation: impairment type and *per se* type.
- Roadside drug tests will increase the confidence of police officers when prosecuting drugged driving. Without an on-site tool to confirm the suspicion, a police officer will be more reluctant to prosecute.
- Roadside drug tests can save time and simplify the enforcement procedure, e.g. by avoiding the need to take the subject to a police station or health care facility for testing.
- Roadside drug tests can save money, by excluding a drug as cause of the impairment and thus avoiding more expensive laboratory analysis. In addition, they can help to reduce the inconvenience experienced by people who did not take drugs by allowing them to continue on their way more rapidly.
- Subjects are impressed by the result (even more so if the procedure was complex or if the result is read electronically) and often confess when confronted with a positive result, sometimes after a long and vehement denial before the test result.
- Roadside tests and the publicity made around them can have a deterrent effect, because the subjective risk of being caught increases
- The use of on-site tests will be more targeted and economical if it is based on a suspicion by a trained police officer. Training in recognition of recent drug use or impairment is also essential to an effective enforcement of drug-driving laws.
- Users of on-site tests have shown great creativity in overcoming some of the encountered problems.
- The need for on-site tests is so great that in some countries, police officers would rather use an imperfect device than wait for a more suitable one.
- Roadside tests are, and should always remain, preliminary tests, that allow the police officer to take immediate measures on-site. A legal sanction should only be based on the result of a reference method in a certified laboratory and/or on the signs of impairment of the subject (depending on the type of legislation in force).
- Those countries which do not permit roadside testing at present (e.g. the UK, apart from alcohol) should consider legislative changes which would in future permit the use of on-site tests of proven validity.

Choice of the sample to be tested

- In all countries, blood is considered the best fluid for confirmation analysis, because the presence of drugs in blood corresponds best with recent use and impairment. On the basis of the

comparison between the results of reference analysis in blood, urine, oral fluid and sweat, the following fluids seem suitable for on-site analysis (i.e. there is a good agreement between the results in this fluid and in blood).

  - Amphetamines: excellent agreement between urine, oral fluid and blood; for sweat, the low numbers of samples do not allow a conclusion;
  - Benzodiazepines : urine gives moderately good results, for oral fluid, the sensitivity needs to be improved and sweat was not tested;
  - Cannabinoids: better agreement with oral fluid than with urine. Urine has a better sensitivity, but not a good specificity. Oral fluid has a sensitivity and specificity of approximately 90 %;
  - Cocaine: excellent for urine and oral fluid; for sweat, the low numbers of samples do not allow a conclusion;
  - Opiates: slightly better agreement with oral fluid than with urine. Urine has a better sensitivity (97%), but a lower specificity (85%). Oral fluid has a sensitivity and specificity of approximately 90%;
- When the necessary facilities are available (e.g. a sanitary van), urine can be obtained relatively easily at the roadside.
- When the facilities are not available, obtaining a urine sample is a problem and it can be time-consuming if the driver has to be brought to a suitable facility.
- In some cases, the volume of urine obtained is low, and tests should require a small sample volume.
- Some countries clearly stated that sampling urine at the roadside was unacceptable.
- A clear majority of countries prefer oral fluid as the matrix for roadside testing, while one country favoured sweat and one favoured urine.
- The methods for obtaining saliva need further improvements. Wiping over the tongue seems to be a well-accepted technique, but in this case the analytical detection technique needs to be very sensitive. Sampling oral fluid with dedicated devices gave the following problems:
- It was sometimes messy;
- It was sometimes uncomfortable for the subject;
- In some cases it took a long time;
- The co-operation of the subject was needed (in some cases, intentionally or not, the subject swallowed the collection device);
- Oral fluid is sometimes viscous, which can give problems with some devices;
- Literature data have shown variable oral fluid concentrations for codeine, according to the sampling method used (with or without stimulation, …) with spitting giving the highest concentrations;
- There are indications that tetrahydrocannabinol (THC) binds to the material of some sampling devices;
- Dry mouth is a frequently encountered problem in drug users. Sampling is then more difficult and time-consuming, but in the evaluation it was possible to obtain oral fluid in nearly all cases.
- In all, sweat and saliva sampling seemed very well accepted by the subjects, much better than urine or blood sampling.

Evaluation of the on-site urine drug tests

- For each type of drug, several urine drug tests satisfied our analytical criteria for a good test (accuracy > 95%, sensitivity > 90%, specificity > 90%, when compared with a reference method in urine), but none scored highly for all the drug categories.
- In general, on-site tests for methamphetamine have a better sensitivity for XTC and related compounds. However their sensitivity for samples that only contained amphetamine was much lower.
- Use of a combination of an amphetamine test with a methamphetamine test gave very good results in the detection of amphetamine and ecstasy.
- On-site urine tests are relatively easy to use after some training.
- Appropriate training in the use and reading of on-site tests is essential.
- There is no clear majority for dip- or pipette-type devices. Cup-type devices would be preferred if they did not leak and required less sample.
- A preference exists for blue lines (easier to read at night under street-lighting) and multi-analyte tests.
- In some countries, ‘aggressive’ tests (more false positives than false negatives) are preferred.

Evaluation of the on-site oral fluid and sweat tests

- With possibly one exception, the presently available on-site devices for oral fluid are too complex, and take too much time.
- The present-generation of on-site tests for oral fluids are insufficiently sensitive and/or specific to give reliable results for most classes of drugs.
- There are several new versions of the evaluated tests and new on-site tests for oral fluid, some of which look very promising in terms of sensitivity, which should be evaluated when they become available.
- On-site tests for oral fluid should be targeted to the parent molecule and not to the urinary metabolite, e.g. to THC, 6-acetylmorphine, cocaine.
- The significance of the much higher concentrations of THC found when extracting a Salivette®, compared to the concentrations in liquid saliva, needs further study.
- One device for testing sweat was evaluated. Sweat as a roadside specimen looks promising but needs further evaluation and dedicated studies

Optimal cut-offs for oral fluid

- Our evaluation was performed on a too limited set of samples to permit firm recommendations for the cut-offs to be used in oral fluid. Some data are given in WP4, but they need further validation.

International co-operation

- The ROSITA project has shown that there is a strong desire amongst forensic scientists, police officers and manufacturers in the EU to co-operate in technical developments in the field of traffic safety. This should be encouraged by the EU, perhaps by setting up an EU-wide technical review committee to keep a watching brief on emergent technology and developments in other regions (for example the USA) which might be adopted within the EU. Some of the principal aims of this committee might be to harmonise technical procedures and produce EU guidelines for roadside tests, including impairment tests by police officers, and laboratory confirmatory methods used subsequent to impairment tests and/or on-site drug tests.
- It would be desirable if a move could be made within the EU to a single set of regulations for driving under the influence, given the removal of barriers to movement within the EU. The committee could perhaps work on this also. We accept that this is likely to be a long-term aim, but at least the trend would be determined on a scientific rather than a political basis.

Annex II

Comparative table of selected examples for commercially available product groups

The Table below is an attempt to organize available information in a user-friendly way, i.e., to allow comparison of selected products. Products found to be similar in the ROSITA study are grouped together. Further details on available drug combinations in a panel test, cross-reactivities and cut-off values of individual tests, etc. can also be found in the evaluation studies listed as references, as well as from manufacturers (see Annex III).

No one type of test is consistently superior to the others in identifying presumptive positive and negative specimens. It is therefore recommended to visit drug screening programmes or institutions that use the devices under consideration and question about the level of satisfaction.

Comparative table of selected commercially available product groups

Note: This table is not comprehensive. The market of on-site immunoassay screening devices, and the availability of new or improved products, is growing continuously.

Type of test	**Drug** AMP (Amphetamines) PCP (Phencyclidine) mAMP (Methamphetamines) BNZ (Benzodiazepines) COC (Cocaine) BRB (Barbiturates) OPI (Opiates) MDN (Methadone) CAN (Cannabis products)	**No. of parameters per device**	**Ease of use**[#]	FDA approval [##] (for one or more of the products available)	**Product Name** (see Annex III for details of manufacturers / distributors)	**Analytical performance evaluation studies (parameters that have been evaluated)**
	URINE TESTS					
Dip	AMP, COC, OPI, CAN, BNZ	1	+	yes	(OnTrak) Frontline	Beck (AMP); ROSITA:D2 (AMP, COC, OPI, CAN)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1		?	InstaStick	
Dip	mAMP, COC, OPI, CAN	1 (2-4)		yes	Rapid One (Rapid Tec)	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 5, 10		?	DrugScreen	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB	1 or 3	+++	yes	(OnTrak) TesTstik	Grönholm (AMP, OPI, CAN, BNZ); ROSITA:D2 (AMP, COC, OPI, CAN); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1 or 5		?	Dbest One Step	
Dip	AMP, mAMP, COC, OPI, CAN, BNZ, BRB, MDN	1 or 6	+	yes	ToxiQUICK	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-2		?	QuikStrip	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-6	+++	yes	Dip Drugscan-one step	Grönholm (AMP, OPI, CAN, BNZ)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9		?	One step…Rapidip InstaTest	ROSITA:D2 (AMP, COC, OPI, CAN)
Dip	mAMP, COC, OPI, CAN, PCP	1-5		yes	RediScreen	

Type of test	Drug AMP (Amphetamines) PCP (Phencyclidine) mAMP (Methamphetamines) BNZ (Benzodiazepines) COC (Cocaine) BRB (Barbiturates) OPI (Opiates) MDN (Methadone) CAN (Cannabis products)	No. of parameters per device	Ease of use[#]	FDA approval [##] (for one or more of the products available)	Product Name (see Annex III for details of manufacturers / distributors)	Analytical performance evaluation studies (parameters that have been evaluated)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-3, 5, 8, 9	+++	Yes	Rapid Drug Screen	Peace (AMP, COC, OPI, CAN, PCP, BNZ, BRB); ROSITA:D2 (AMP, mAMP, COC, OPI, CAN); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP); Taylor (AMP, COC, OPI, CAN, PCP)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 4, 5 or 10		?	FirstStep	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9		yes	Acon One Step Test	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9	+	yes	QuickScreen	Peace (AMP, COC, OPI, CAN, PCP, BNZ, BRB); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-6, 9		yes	Surescreen	Grönholm (AMP, OPI, CAN, BNZ)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 2, 4, 5, 9	++	yes	PharmScreen	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP); Taylor (AMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 5 or 9		?	SureStep Drug Screen Card	
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 5 or 10		?	Dipro Drugscreen	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
	mAMP, COC, OPI, CAN, PCP	5		?	Assurance Drug Screen Card	
	mAMP, COC, OPI, CAN, PCP	5		?	Clinistrip Drug Check Card	
	AMP, COC, OPI, CAN, BNZ	5		?	Rapitest	Grönholm (AMP, OPI, CAN, BNZ); ROSITA:D2 (AMP, COC, OPI, CAN)
	mAMP, COC, OPI, CAN, PCP	5		?	Ultimed Surestick Drug Screen Card	
Dip	mAMP, COC, OPI, CAN	2-4		?	Fastix	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	2-5		?	AccuStik	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	2-5		?	Status Stik	
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB	2-6, 8		?	MicroLINE	Kadehjian (AMP, COC, OPI, CAN, PCP)
Dip	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	2-10		?	Accutest	
Pipette	AMP, mAMP, COC, OPI, CAN, BNZ, BRB, MDN	1		?	Accutest	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1		yes	Acon One Step Test	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1 or 5		?	DBest One Step	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 5 or 10		?	DrugScreen	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-4	++	yes	First Check (Home Drug Test Kit)	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-6		?	Quikpac (mono tests) QuikScreen (panel tests)	

Type of test	Drug AMP (Amphetamines) PCP (Phencyclidine) mAMP (Methamphetamines) BNZ (Benzodiazepines) COC (Cocaine) BRB (Barbiturates) OPI (Opiates) MDN (Methadone) CAN (Cannabis products)	No. of parameters per device	Ease of use[#]	FDA approval [##] (for one or more of the products available)	Product Name (see Annex III for details of manufacturers / distributors)	Analytical performance evaluation studies (parameters that have been evaluated)
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-5, 8 or 9	++	yes	AccuSign DOA	Taylor (COC, CAN)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9			Dako	
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 2, 4 or 9		yes	Mahsan	
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-5, 7-9			Status DS	Grönholm (AMP, OPI, CAN); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP); Taylor (AMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9		?	Syva Rapid Test	Grönholm (AMP, OPI, CAN); Kadehjian (AMP, COC, OPI, CAN, PCP); Peace (AMP, COC, OPI, CAN, PCP, BNZ, BRB); ROSITA:D2 (AMP, mAMP, COC, OPI, CAN); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP); Yang (AMP, COC, OPI, CAN, PCP, BNZ, BRB)
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9		?	TOX/See	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-6	++	yes	DTx	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9		?	InstaCheck	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9	++	yes	SunLine	
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 5 or 9		yes	VisuaLine II	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9	+	yes	QuickScreen	Peace (AMP, COC, OPI, CAN, PCP, BNZ, BRB); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-6, 9		yes	Surescreen	Grönholm (AMP, OPI, CAN, BNZ)
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1, 2, 4, 6-9		?	OneStep…Rapicard InstaTest	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-3, 5		?	A-Sure	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-5, 7	++	yes	Verdict-II	
	AMP, COC, OPI, CAN, PCP	5, 7		yes	Profile-II; Profile-II A (A…adulteration panel)[###]	
Pipette	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB	2-5		?	Monitect; Monitect…A (A…adulteration panel)[###]	
Pipette	AMP, COC, OPI, CAN, PCP, BNZ, BRB	5, 7 or 8	-	yes	Triage DOA Panel	Grönholm (AMP, OPI, CAN, BNZ); Kadehjian (AMP, COC, OPI, CAN, PCP); Peace (AMP, COC, OPI, CAN, PCP, BNZ, BRB)
Pipette	AMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	8	++	yes	Profile-II ER	
Cup	AMP, mAMP, COC, OPI, CAN, PCP	1, 2, 5	+	yes	Drugstop	
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB	4-6		yes	DrugCheck	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
Cup	AMP, COC, OPI, CAN, PCP, BNZ, BRB	4 or 5	++	yes	(OnTrak) TesTcup	Grönholm (AMP, OPI, CAN, BNZ); Kadehjian (AMP, COC, OPI, Can, PCP); ROSITA:D2 (AMP, COC, OPI, CAN); SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP); Taylor (AMP, COC, OPI, CAN, PCP)
Cup	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	5		yes	First Check (Home Drug Test Kit)	

Type of test	Drug AMP (Amphetamines) PCP (Phencyclidine) mAMP (Methamphetamines) BNZ (Benzodiazepines) COC (Cocaine) BRB (Barbiturates) OPI (Opiates) MDN (Methadone) CAN (Cannabis products)	No. of parameters per device	Ease of use[#]	FDA approval [##] (for one or more of the products available)	Product Name (see Annex III for details of manufacturers / distributors)	Analytical performance evaluation studies (parameters that have been evaluated)
Cup	AMP, mAMP, COC, OPI, CAN, PCP	3-6	+++	yes	Syva Rapid Cup	Grönholm (OPI, CAN); Kadehjian (AMP, COC, OPI, CAN, PCP)
	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	6		yes	Genie Cup	SAMHSA/1999 (AMP/mAMP, COC, OPI, CAN, PCP)
Cup	AMP, mAMP, COC, OPI, CAN, PCP	5 or 6		?	Accutest	
Cup	AMP, mAMP, COC, OPI, CAN, BNZ, BRB, MDN	4, 5 or 8		?	MicroScreen Cup	
Cup	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB	3-7		?	InstaCup	
Cup	AMP, mAMP, COC, OPI, CAN, PCP	4-6		?	Status DS Cup	
	SALIVA TESTS					
Dip	AMP, mAMP, COC, OPI, CAN, BNZ, BRB, MDN	1 or 6	+	yes	ToxiQUICK	
'Pipette'	mAMP, COC, OPI, CAN	1-3 or 4	+	not FDA approved	ORALscreen	Barrett (mAMP, COC, OPI, CAN)
	COC, OPI, CAN	1-3			Carepoint	
	AMP, COC, OPI, CAN, BNZ, MDN	1, 2, 5	+	not FDA approved	RapiScan[####]	Grönholm (AMP, OPI, CAN, BNZ); Jehanli (OPI, CAN); Moore (OPI, MDN)
Immuno sensor	AMP, mAMP, COC, OPI, CAN, PCP, BNZ, BRB, MDN	1-9	+++		Impact Test System	
	SALIVA / SWEAT TESTS					
Wipe and dip	AMP, COC, OPI, CAN	1	++	not FDA approved	Drugwipe	Grönholm (AMP, OPI)
Wipe and dip	CAN (AMP, COC, OPI under preparation)	1-2	++		Drugwipe II	

[#] Evaluations as reported by ROSITA (ROSITA, 1999/2000: D2):
- \- not acceptable
- \+ acceptable
- ++ good
- +++ very good

[##] Information on FDA approval has been taken from ROSITA (ROSITA, 1999/2000: D2), and dates back to 1999. Only those products that were practically evaluated as part of ROSITA are considered in the table. In addition, since 1999, additional devices may have obtained approval by FDA.

[###] Note: Test includes an integrated adulteration check for different means of adulteration (e.g., pH, glutaraldehyde, sample dilution, nitrites, oxidizing agents (bleach), etc.)

[####] Note: digital reader required (at approximately US$2,500)

Annex III

Products, manufacturers / distributors

Product(s)	Manufacturers / Distributors	Further information at:
AccuSign DOA AccuStik	Princeton BioMeditech	http://www.pbmc.com
Accutest	Jant Pharmacal	http://www.accutest.net
Acon One Step	Access Diagnostic Tests	http://www.drugtest.freeserve.co.uk
Assurance Drug Screen Card	Applied Biotech	
A-Sure	Microgenics	http://www.microgenics.com
Carepoint	Coventry	
Clinistrip Drug Check Card	Clinicare Technologies	
Dako	Veda Lab	
dBest (product line)	AmeriTek	http://www.ameritek.org
Dip Drugscan-one step	Syntron Bioresearch	http://www.syntron.net
Dipro DrugScreen	Dipro Diagnostics	http://www.dipro.co.at
DrugCheck	Drug Free Enterprises Cortez Diagnostics	http://www.drugcheck.com http://www.rapidtest.com
DrugScreen	ulti med Products	http://www.ultimed.de
Drugstop	V-tech	http://www.v-techbiotech.com
Drugwipe	Securetec	http://www.securetec.net
DTx	Forefront Diagnostics 1-Step Detect Associates	 http://www.1stepdtx.com
Fastix	1-Step Detect Associates	http://www.1stepdtx.com
FirstCheck	WorldWide Medical	http://www.wwmed.com
FirstStep	Triad Associates	http://www.triad-assoc.com
(OnTrak) Frontline	Roche Diagnostics	
Genie Cup *(Now traded as Syva RapidCup)*	Point of Care Technologies	http://www.geniecup.com
Impact Test System	LifePoint	http://www.lifepointinc.com
InstaCheck InstaCup InstaStick	Forefront Diagnostics 1-Step Detect Associates	http://www.forefrontdiagostics.com http://www.1stepdtx.com
Mahsan	Mahsan Diagnostika	http://www.mahsan.de

Product(s)	Manufacturers / Distributors	Further information at:
microLINE	Microgenics Casco-Nerl	http://www.microgenics.com http://www.casconerl.com/products/microLINE.html
MicroScreen Cup	Microgenics Forefront Diagnostics	http://www.microgenics.com
Monitect	1-Step Detect Associates	http://www.1stepdtx.com
OneStep … RapiDip InstaTest RapiCard InstaTest	Cortez Diagnostics	http://www.rapidtest.com/listC.htm
OralScreen	Avitar Technologies Surescreen	http://www.avitarinc.com http//:surescreencorp.com
PharmScreen	PharmChem Laboratories American Biomedical	http://www.pharmchem.com
Profile-II Profile-II A Profile-II ER	Medtox Diagnostics	http://www.medtox.com
QuickScreen	Phama Tech Wolfe Data	http://www.phamatech.com http://www.quickscreencup.com
QuikPac QuikScreen QuikStrip	Syntron Bioresearch	http://www.syntron.net
Rapid Drug Screen	American Bio Medica BioScan Screening Systems	http://www.rapiddrugscreen.com http://www.bioscaninc.com
Rapid One Rapid Tec	American Bio Medica BioScan Screening Systems	http://www.rapiddrugscreen.com http://www.bioscaninc.com
RapiScan	Cozart Bioscience	http://www.cozart.co.uk
Rapitest	Morwell Diagnostics	
RediScreen	Redwood Biotech	http://www.onsitedrugtests.com
Status DS Status Stik	LifeSign LLC	http://www.lifesignmed.com
SunLine	Sun Biomedical Laboratories	http://www.sunbiomed.com
Surescreen	Surescreen Diagnostics	http://surescreencorp.com
Surestep	BioChem ImmunoSystems Triad Associates	 http://www.triad-assoc.com
Syva Rapid Cup Syva Rapid Test	Dade Behring	http://www.dadebehring.com

Product(s)	Manufacturers / Distributors	Further information at:
TesTcup TesTstik (OnTrak product line)	Roche Diagnostic Systems	http://www.demapoc.mah.roche.com
ToxiQUICK	Biomar Diagnostic Systems	http://www.biomar.de
TOX/See	Bio-Rad Laboratories	http://www.biorad.com
Ultimed Surestick Drug Screen Card	Applied Biotech	
Triage DOA Panel	Biosite Diagnostics	http://www.biosite.com
Verdict-II	Medtox Diagnostics	http://www.medtox.com
VisuaLine	Sun Biomedical Laboratories	http://www.sunbiomed.com

Note: This list is not comprehensive. The market of on-site immunoassay screening devices, and the availability of new or improved products, is growing continuously. In addition, identical devices may be marketed by a number of different distributors.