Hidex Wipe Testing

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INTRODUCTION

Wipe tests, also called swipe or smear tests, are a crucial method for monitoring surface contamination in environments where radioactive materials are handled. By using a moistened, absorbent material to wipe surfaces, this technique helps detect traces of radioactive contamination that may not be visible. The collected samples are then analysed using radiation detectors, such as liquid scintillation counters or gamma counters, to quantify the level of contamination. Wipe tests play a vital role in maintaining safety standards, ensuring regulatory compliance, and protecting personnel and the environment from potential exposure to harmful radiation.

Radioactive contamination refers to unwanted radioactive material on a surface or within a volume, often referred to as "radioactive dirt". Even small amounts of contamination can be hazardous, particularly if radioactive substances are on surfaces where they can enter the body through contact. This exposure can occur through ingestion, inhalation, or absorption through the skin. The only reliable methods for ruling out contamination are direct surface measurements using suitable meters or analysing wipe samples in a laboratory.

These measurements are routinely performed in laboratories and facilities that handle radioactive materials, with documented results. Typically, wipe tests are used to monitor contamination from low-energy beta-emitting radionuclides such as tritium (^{3}H), carbon-14 (^{14}C), and sulfur-35 (^{35}S), but they can also be employed to detect alpha contamination. For weak beta-emitters like tritium, wipe testing followed by liquid scintillation counting (LSC) is often the only practical option for monitoring their presence. Hidex offers several instruments suitable for measuring alpha, beta and gamma radionuclides in various wipe test applications.

MATERIALS AND METHODS

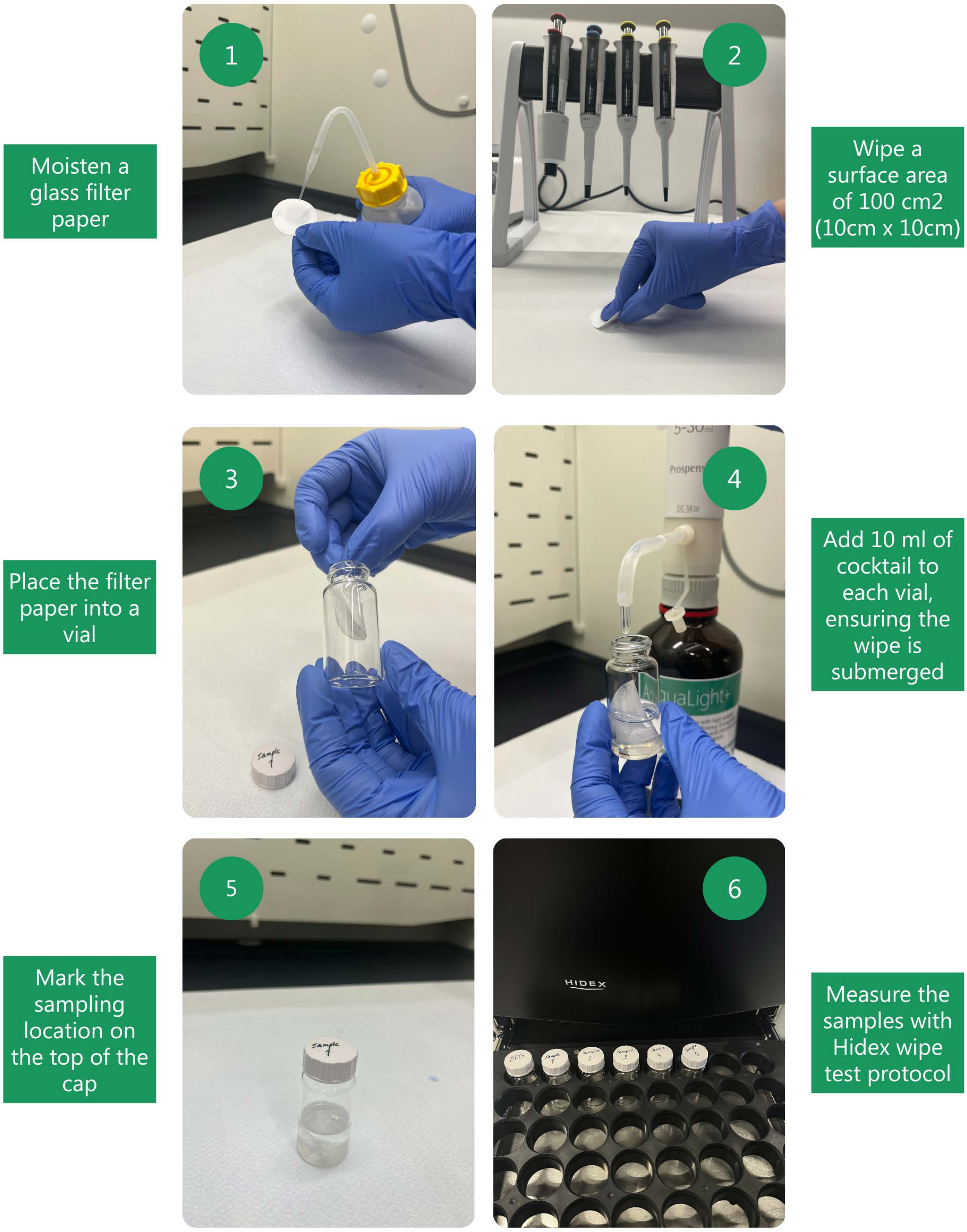


Figure 1. Step-by-step photo instructions of performing wipe testing

Sample preparation

Wipe Materials: Filter papers are commonly used due to their high absorption capacity, cost-effectiveness, and compatibility with various radiation analysis methods. Glass fiber filters are excellent wipe materials for both alpha and beta contamination, offering high collection efficiency and reliable activity recovery. They also become transparent when immersed in liquid scintillation cocktail, which aids the detection process. Cotton swabs, also called wad sticks, are useful for wiping cavities and small spots as well as for uneven or rough surfaces, as their shape allows for better contact with these areas.

Pre-moistened or Dry Wipes: Wipes can be used either dry or pre-moistened, often with distilled water or a mild detergent, depending on the type of contamination and surface characteristics. Pre-moistened wipes typically improve pick-up efficiency, especially for non-fixed contaminants, by loosening particles adhered to the surface. When conducting wipe tests for alpha isotopes, however, it’s generally recommended to use dry filters. This helps ensure that the alpha-emitting material remains on the surface of the wipe, making the alpha particles more accessible for detection. If wet wipes are used for alpha contamination, a dilute acid solution is recommended as the wetting agent, as this can improve particle recovery without significantly interfering with detection.

Conventional wiping materials and wetting agents are listed in Table 1.

Assay	Wipe material	Wetting agent
Beta	Glass fiber filter Paper filter Cotton swab	Water or water/alcohol Dry
Alpha	Glass fiber filter Paper filter	Dry Dilute acid Water or water/alcohol
Gamma	Glass fiber filter Paper filter Cotton swab	Water or water/alcohol Dry

Table 1. Wipe materials and wetting agents in order of preference for beta, alpha and gamma assays.

Sampling: Moisten or use dry filter paper, depending on your preference. Wipe approximately 100 cm^2 of the surface (10 cm x 10 cm). For example, follow a zigzag pattern from left to right and then continue sampling in a perpendicular direction (see figure 1). It is important to cover the entire sampling area. Place the filter paper into a 20 ml plastic vial and mark the sampling location on the top of the cap. Perform a wipe test on all designated areas using a new filter paper for each location. Prepare background sample the same way without sampling.

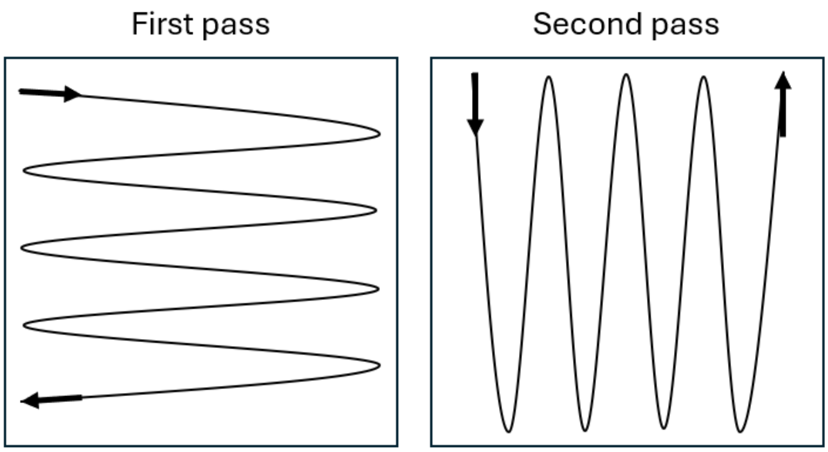


Figure 2. Wipe test sampling is performed using a zigzag pattern from left to right (first pass) and then continue sampling in a perpendicular direction (second pass).

Typically, the standard area for a wipe test is 100 cm^2. This is commonly used in regulatory guidelines, including those from the IAEA, NRC, and ISO 7503-2, for assessing removable surface contamination. However, in practical applications, the wipe area can vary depending on the surface being tested and the contamination risk. Some protocols may specify different areas, especially in cases where smaller or larger surfaces are being monitored.

Instruments

LSC measurement:

- Hidex automatic TDCR liquid scintillation counter
    - 300 SL, 600 SL or ULLA
- Triathler
    - LSC or Multilabel Tester
- Hidex Sense Beta

Gamma measurement:

- Hidex Automatic Gamma Counter AMG
- Triathler
    - Gamma Counter, NaI System or Multilabel Tester

Materials

- Gloves
- Glass microfiber filters, Whatman GF/A, Ø 37 mm
- Cotton swabs
- Plastic vials, 20 ml or 7 ml
- Microcentrifuge tubes, Eppendorf®
- Eppendorf® tube adapter
- Liquid scintillation cocktail:
    - AquaLight+
        - Water-dissolving DIN cocktail for general beta counting and α/β separation applications
    - AquaLight+ NPE Free
        - Water-dissolving DIN cocktail for general beta counting
        - Contains no Nonyl Phenyl Ethoxylates (NPEs)
    - MaxiLight+
        - Lipophilic, unquenched, NPE-free, DIN based cocktail with highest counting efficiency for organic and non-aqueous samples
        - Excellent α/β-counting properties
        - Suitable only for dried filters

LSC measurements

FILTER PAPER METHOD A

1. Moisten or use dry glass filter paper, depending on your preference.
2. Wipe approximately 100 cm^2 of the surface (10 cm x 10 cm). For example, follow a zigzag pattern from left to right and then continue sampling in a perpendicular direction (see figure 1). It is important to cover the entire sampling area.
3. Place the filter paper into a 20 ml plastic vial and mark the sampling location on the top of the cap.
4. Perform a wipe test on all designated areas using a new filter paper for each location.
5. Prepare background sample the same way without sampling.
6. Once all samples have been taken, add 1 ml of water to each vial and shake gently.
7. Add 10 ml AquaLight+ cocktail to each vial and shake gently. Make sure that the entire wipe is below the liquid surface. Use 1 ml water and 5 ml AquaLight+ cocktail with small vials (7ml).
8. Measure the samples with Hidex wipe test protocol. Place the background sample in the first position and then the rest of vials.

NOTES
- This method is especially practical with moistened wipes.
- The role of water (step 6.) is to facilitate elution of radioactivity from the filter paper to cocktail. If water is omitted, radioactivity may reside in the filter yielding to poor counting efficiency.

FILTER PAPER METHOD B
Alternative method with minimum amount of cocktail

1. Moisten or use dry glass filter paper, depending on your preference.
2. Wipe approximately 100 cm^2 of the surface (10 cm x 10 cm). For example, follow a zigzag pattern from left to right and then continue sampling in a perpendicular direction (see figure 1). It is important to cover the entire sampling area.
3. Place the filter paper into a 20 ml plastic vial against the inside wall and mark the sampling location on the top of the cap.
4. Perform a wipe test on all designated areas using a new filter paper for each location.
5. Prepare background sample the same way without sampling.
6. Once all samples have been taken, add 1 ml of liquid scintillation cocktail to each vial and tilt the vial so that the cocktail wets the filter and adheres it to the wall (see figure 2). Note! Use always dry filters with MaxiLight+ cocktail or dry the filter after sampling.
7. Measure the samples with Hidex wipe test protocol. Place the background sample in the first position and then the rest of vials. Triathler: Insert the vial in counting adapter, the filter paper facing the detection opening.

Figure 3. The filter is wetted with liquid scintillation cocktail so that it adheres to the wall of the counting vial.

NOTES

- This method is the most sensitive, but it requires glass fiber filter papers. Radioactivity stays in the filter. Glass fibers form an ideal microenvironment for detection.
    - Best counting efficiency compared to other materials (paper, cotton swabs etc.).
- Only small amount of cocktail is needed. This helps in minimizing background and cutting costs.
- Minimum yield of radioactive waste.

COTTON SWAB METHOD

1. Depending on your preference, wipe the target with a dry or moistened swab.
2. Cut the stick so that it fits in a plastic vial and drop in. Small vials are recommended.
3. Prepare background sample the same way without sampling.
4. Add 1 ml of water in the vial and shake.
5. Add 5 ml of AquaLight+ cocktail and shake vigorously.
6. Measure the samples with Hidex wipe test protocol. Place the background sample in the first position and then the rest of vials. Triathler: Insert the vial in counting adapter and measure.

NOTES

- The role of shaking (step 5.) is to ensure that the cocktail can efficiently reach the possible radioactive contamination.

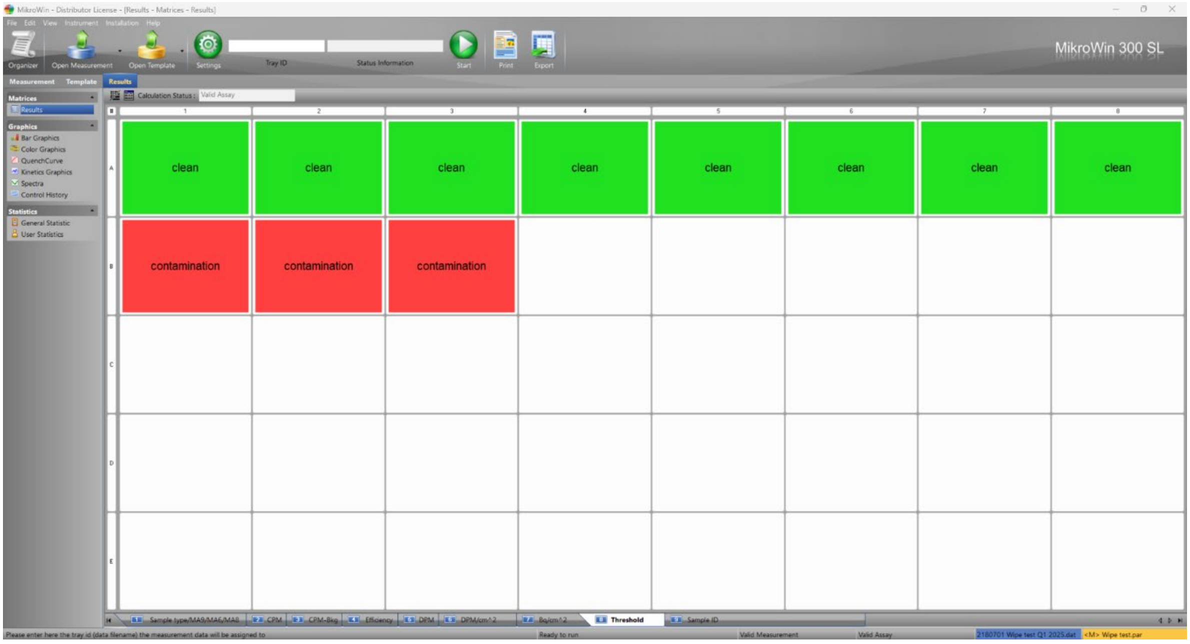


Figure 4. Wipe test results view in the MikroWin LSC software.

H-3 and C-14 wipe test recovery

Recovery of ^{3}H and ^{14}C was studied using wipe test methods A and B, described in detail in LSC measurements section. A known activity of ^{3}H- or ^{14}C-glucose in water (~10 000 DPM) was deposited on moistened glass fiber filter paper.
In method A, the filter paper was transferred to a 20 ml plastic vial, where 1 ml water and 10 ml AquaLight+ cocktail was added. For smaller vials (7 ml) used in Triathler measurements, 1 ml of water and 5 ml of AquaLight+ cocktail were used.
In method B, the filter paper was placed in a 20 ml plastic vial and fully wetted with 1 ml of AquaLight+ or MaxiLight+ cocktail. When using MaxiLight+, the filter papers were dried overnight before adding the cocktail.
Samples were counted immediately after preparation. Method A samples were remeasured 24 hours later using Hidex 300 SL counter, but no significant differences were observed between the measurements.

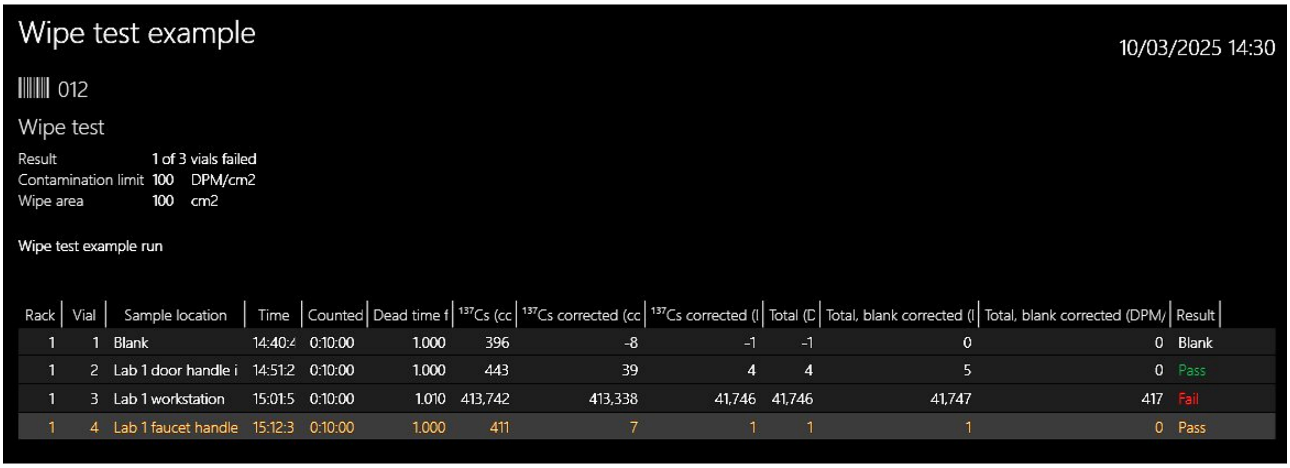
Wipe test recovery %				
Assay	Method	Cocktail	300 SL	Triathler
H-3	A	AquaLight+	52 (53)	14*
	B	AquaLight+	47	12
	B	MaxiLight+	49	21
C-14	A	AquaLight+	96 (96)	71*
	B	AquaLight+	87	69
	B	MaxiLight+	94	80

Table 2. Recovery (in percent) of ^{3}H and ^{14}C deposited on glass fiber filter using wipe test method A and B, described in LSC measurements section. Wipe test samples were measured with Hidex 300 SL Super Low Level and Triathler LSC counters. The recovery in parenthesis is the result after 24h. *Samples in small vials (7ml).

Gamma measurements

Gamma-emitting radionuclides can be measured from wipe samples using Hidex AMG automatic or Triathler gamma counters. Gamma measurement requires no additional sample preparation beyond collecting the wipe.
Hidex AMG software includes an easy-to-use built-in wipe test assay, allowing users to easily configure parameters such as the acceptance levels and the use of a blank sample. When samples are analysed using this assay, the results are clearly marked as "passed" or "failed" based on the predefined limits.

1. Moisten or use dry glass filter paper, depending on your preference.
2. Wipe approximately 100 cm^2 of the surface (10 cm x 10 cm). For example, follow a zigzag pattern from left to right and then continue sampling in a perpendicular direction (see figure 1). It is important to cover the entire sampling area.
3. Place the filter paper into a 20 ml plastic vial.
4. Perform a wipe test on all designated areas using a new filter paper for each location.
5. Prepare background sample the same way without sampling.
6. Hidex AMG: Location information can be brought in results in 2 ways: as a sample metadata file addition to the template (as seen in Fig. 4) or as a 2D code on top of the vial (2D reader is an optional feature) resulting sample location details added to the result directly. Triathler: Mark the sampling location on the top of the cap.
7. Hidex AMG: Place the vials into the vial holders on a large rack. Triathler: Insert the vial into a corresponding adapter.
8. Hidex AMG: Using Hidex AMG software, use ready wipe test assay and define radiation limits and areas. Blank sample can be used if so desired. Software will give results directly as pass or fail based on the limits given by the user. Triathler: Use H-3 or C-14 protocols under similarly labelled buttons.


Wipe test example
10/03/2025 14:30
012
Wipe test
Result 1 of 3 vials failed
Contamination limit 100 DPM/cm2
Wipe area 100 cm2

Wipe test example run

Rack	Vial	Sample location	Time	Counted	Dead time f	^{137}Cs (cc	^{137}Cs corrected (cc	^{137}Cs corrected (I	Total (D	Total, blank corrected (I	Total, blank corrected (DPM/	Result
1	1	Blank	14:40:4	0:10:00	1.000	396	-8	-1	-1	0	0	Blank
1	2	Lab 1 door handle i	14:51:2	0:10:00	1.000	443	39	4	4	5	0	Pass
1	3	Lab 1 workstation	15:01:5	0:10:00	1.010	413,742	413,338	41,746	41,746	41,747	417	Fail
1	4	Lab 1 faucet handle	15:12:3	0:10:00	1.000	411	7	1	1	1	0	Pass

Figure 5. Result view of the Wipe test assay in the Hidex AMG software.

Microplate reader

Wipe test measurements can also be performed with Hidex Sense Beta microplate reader using an Eppendorf® tube adapter. For best results, it is recommended to use MaxiLight+ cocktail to enhance counting efficiency.

1. Moisten glass filter paper.
2. Wipe approximately 100 cm^2 of the surface (10 cm x 10 cm). For example, follow a zigzag pattern from left to right and then continue sampling in a perpendicular direction (see figure 1). It is important to cover the entire sampling area.
3. Dry the sample for ~15 minutes at 60°C or overnight at room temperature.
4. Place the filter paper into a 1.5 ml microcentrifuge tube and label the tube with the corresponding sampling location.
5. Perform a wipe test on all designated areas using a new filter paper for each location.
6. Prepare background sample the same way without sampling.
7. Add 0.5-1 ml of MaxiLight+ to each tube and mix by inverting. Ensure the entire wipe is submerged in the liquid.
8. Place the tubes in the Hidex Eppendorf® adapter and count the samples for 60 seconds using a ready-made Eppendorf® Adapter template for the relevant isotopes.

Figure 6. Wipe tests can be measured with Hidex Sense using the Hidex Eppendorf® adapter, which holds up to six samples for measurement.

Leak tests of sealed radiation sources

Wipe testing is a widely used method for detecting leaks in sealed radioactive sources, ensuring they remain intact and do not release radioactive contamination. Leak testing is critical for regulatory compliance, radiation safety, and verifying source integrity.

For example, Nickel-63 (Ni-63) is a low-energy beta-emitting radionuclide commonly used in electron capture detectors (ECDs) for gas chromatography. Since Ni-63 is a sealed radiation source, leak testing is required to ensure that no radioactive material escapes, preventing contamination risks. For low-energy beta particles like Ni-63, liquid scintillation counting is the most effective method for detecting any leaked activity. Leak testing must always be performed according to the manufacturer's guidelines.

General procedure:

1. A wipe material (e.g., glass fiber filter paper or cotton swab) is gently rubbed over the sealed source's surface or its container. Moisten or use dry wipe, depending on your preference. Avoid excessive pressure to prevent damage to the source.
2. The wiped area is typically 100 cm^2, unless the source itself is smaller.
3. The sample is analysed using liquid scintillation counting or gamma spectrometry depending on the radionuclide.

Regulatory standards, such as those from the IAEA, NRC (10 CFR 39.35), and ISO 9978, set limits for leakage. A result exceeding 185 Bq (or 0.005 µCi) is generally considered a failed test, indicating potential leakage. In such cases, the source must be removed from service and the appropriate regulatory authority must be notified.

Calculating surface contamination

Wipe test surface contamination is usually determined in disintegrations per minute (dpm) or becquerels per square centimeter (Bq/cm^2) using the following equation:

$$\text{Surface contamination } (\mathrm{Bq/cm^2}) = \frac{(R - R_b)}{(E \times 60 \times A \times F)}$$

where:

- R = total count rate (counts per minute)
- R_b = count rate of the blank
- E = instrument efficiency for a specific isotope (e.g. 35% means E = 0.35)
- 60 = sec/min (to convert counts per minute to counts per second)
- A = wiped area in cm^2 or area of the detector in direct measurements
- F = pick-up factor for the wipe (e.g. 10% means F = 0.1)

Including the pick-up factor (also called wipe efficiency) in calculations makes the contamination estimate more accurate. The pick-up factor accounts for the fact that wipes do not capture 100% of the contamination present on the surface. It reflects the efficiency of the wipe in collecting radioactive particles, which can depend on various factors, such as the type of wipe material, surface roughness, contamination type, and the wiping technique. The pick-up factor is often determined through experimental calibration and is less than 1 (e.g., 0.1–0.8).

In practice, it is almost impossible to measure the total amount of removable activity on the surface, and in most cases, a value for the wiping efficiency cannot be determined precisely but can only be estimated. Generally, a value between 0.05 to 0.5 is used, depending on the surface smoothness. For example, a value of 0.5 can be used for sampling glass, stainless steel and smooth surface plastics; 0.1 for permeable surfaces like concrete and wood; and 0.05 for other kinds of surfaces.

Note! Pick-up factor is not directly included in the Hidex wipe test protocols as it must be determined onsite.

Surface contamination limits

Surface contamination activity limits vary depending on the type of radioactive material, regulatory body, and application environment (e.g., laboratories, medical facilities, nuclear power plants). These limits are set to ensure safety for workers and the public and are generally expressed in terms of becquerels per square centimeter (Bq/cm²) or disintegrations per minute per square centimeter (dpm/cm²). Here is a summary of some commonly referenced limits:

1. International Standards
   - IAEA (International Atomic Energy Agency): Provides guidelines for acceptable levels of surface contamination for different radionuclides[1,2].
     - Alpha Emitters: 0.04 Bq/cm² (or 240 dpm/100 cm²)
     - Beta/Gamma Emitters: 0.4 Bq/cm² (or 2400 dpm/100 cm²)
   - These limits for unrestricted or public areas often serve as a reference for international regulations, though actual regulatory limits may vary.
   - ISO 7503 Parts 1 and 2: Standards outline general principles for surface contamination and provide a specific method for using wipe samples[3,4].

2. U.S. Standards
   - NRC (Nuclear Regulatory Commission) and DOE (Department of Energy): Have guidelines for contamination limits, often depending on the use and handling of specific radionuclides[5,6,7].
     - Removable Contamination:
       - Alpha Emitters: 200 dpm/100 cm² for unrestricted areas
       - Beta/Gamma Emitters: 1000–5000 dpm/100 cm² for restricted and unrestricted areas
   - EPA (Environmental Protection Agency): For cleanup sites, surface contamination limits can vary based on site-specific assessments and the type of radionuclide involved.

3. European Standards
   - European Commission: Sets limits through directives like the European Basic Safety Standards Directive.
     - Typical guidance aligns with IAEA limits, often requiring contamination levels to be as low as reasonably achievable (ALARA), especially in medical and industrial settings.
     - For public areas, beta/gamma emitters are generally limited to 0.4 Bq/cm².

4. Other Industry-Specific Limits
   - Medical Facilities: Often have stricter limits, especially in patient areas, due to the sensitivity of personnel and patients to radiation exposure.
   - Nuclear Power Plants: May have limits customized for specific isotopes used on-site, especially alpha emitters like plutonium, which have stricter control due to the radiotoxicity if inhaled.

These limits are often regulated and enforced by national agencies based on international guidance but can vary depending on risk assessments and specific application areas. For restricted areas (such as controlled or supervised areas in nuclear facilities), higher contamination levels may sometimes be permitted, subject to local regulations and site-specific risk assessments, provided the necessary protective measures and radiation safety protocols are in place.

CONCLUSIONS

The recovery of radioactivity from a wiped object depends on several factors: the properties of the surface, the radioactive compound, and the characteristics of the wipe material. The pressing force applied during wiping, the level of moistness or dryness of the wipe, and the repeatability of the procedure also influence results. Due to these variables, wipe tests should be regarded as a qualitative rather than quantitative method. However, there is no practical alternative for monitoring weak beta emitters, especially tritium, other than wipe testing followed by liquid scintillation counting. In general, a wipe test result of 200 dpm/100 cm^2 or higher is considered indicative of contamination.

REFERENCES

1. IAEA Safety Standards Series No. GSR Part 3 (2014) - *Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards.*
2. IAEA Safety Standards Series No. TS-R-1 (2019) - *Regulations for the Safe Transport of Radioactive Material.*
3. ISO 7503-1:2016(E) *Measurement of radioactivity – Measurement and evaluation of surface contamination – Part 1. General principles.*
4. ISO 7503-2:2016(E) *Measurement of radioactivity – Measurement and evaluation of surface contamination – Part 2. Test method using wipe-test samples.*
5. The U.S. Nuclear Regulatory Commission (NRC) 10 CFR 20.1501 (1998) *Standards for Protection Against Radiation.*
6. The U.S. Nuclear Regulatory Commission (NRC) 10 CFR 835 (1998) *Occupational Radiation Protection.*
7. The U.S. Nuclear Regulatory Commission (NRC) NUREG-1575 (1997) *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).*

HIDEX DEVICES COMPATIBLE FOR WIPE TESTING

Hidex 300 SL

Hidex AMG

Hidex Triathler

ADDITIONAL PRODUCTS

LSC Cocktails

Standards

Vials

HELPING SCIENTIFIC RESEARCH AND SAFETY OF EVERYDAY LIFE

At Hidex scientific development is at the core of our values. We believe in the scientific advancement and continued improvement of our products. Our passion is to develop and optimise instrument sensitivity, streamline measuring operation, and make usability as smooth as possible.

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