Pascal KALUZNY
21 Juin 2011

TECHNOLOGIES EXPERTISES
RECHERCHES ANALYTIQUES EN ENVIRONNEMENT

Towards the standardization of protocol for the characterization of intrinsic performances of air cleaners

FiMea
Fédération interprofessionnelle des métiers de l'environnement atmosphérique

TERA environnement

Atmos'fair

Air Intérieur –Emissions Industrielles
21-22 juin 2011 - Paris

TERA Environnement

TERA Environnement

Limited Liability Company with a capital of 20 000 €
created in June 2001 (spin-off of a research laboratory of the Grenoble University: the GRECA)

Turnover 2010: 2,2 M€ **Net 2010**: 171 k€

2.5 employees in the creation - 25 employees in June 2011

2 Locations in the SE of France : **Crolles** (38, near Grenoble) et **Fuveau** (13, near Aix-en-Provence)

TERA environnement

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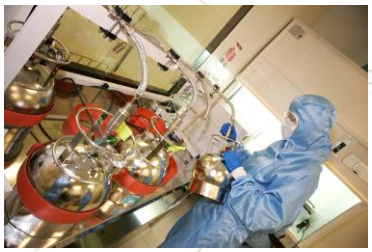

The job: 3 activities

- analysis (the heart of the business of TERA environment)
- development (R&D)
- design and manufacture of equipment related to air sampling

The facilities:

- 325 m^2 of clean rooms (ISO 5 -7)
- 150 m^2 of laboratories
- Analytical equipments (GC-MS, ICP, HPLC, IC…)

Strong involvement in research and innovation projects and standardization work:

- 6 running project (PASS, AXELERA, SCS)
- 5 Theses (2 are still running)

- AFNOR X44B - Cleanroom Technology - since 2005
- AFNOR B44A - Photocatalysis - since 2007
- CEN TC 386 – Photocatalysis – since 2008

Chairman: P.KALUZNY

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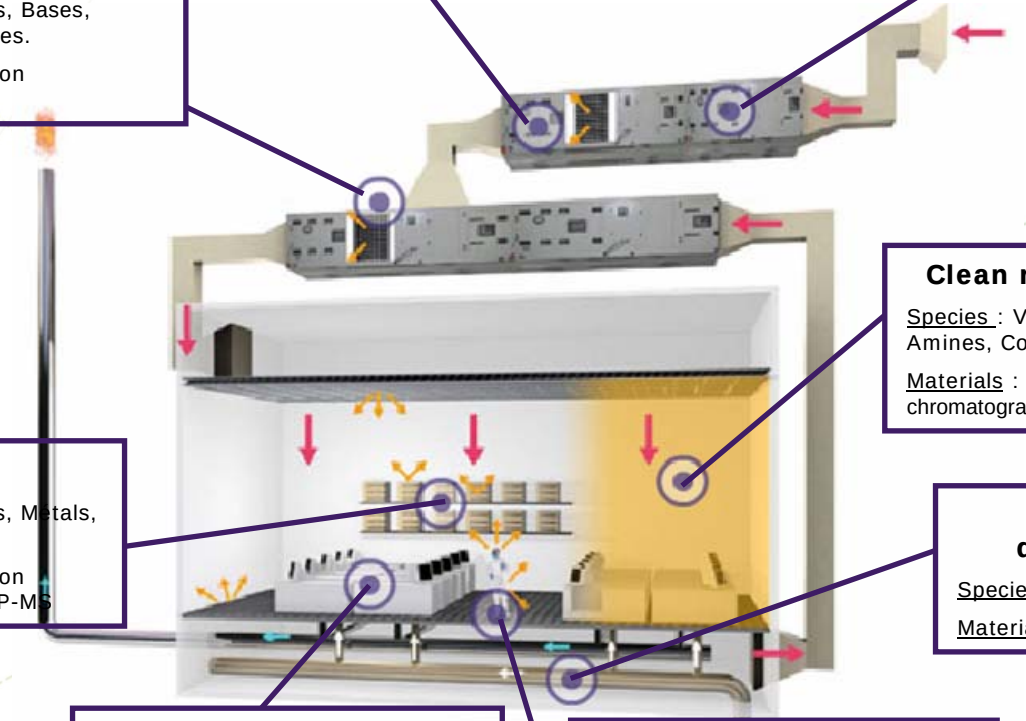
The business sectors: Monitoring of « controlled environments »



Filters release

Species : VOC, Acids, Bases, Boron

Materials : GC-MS, ion chromatography, ICP-MS

Filters established

Species : VOC, Acids, Bases, Amines, Siloxanes, Boron

Materials : GC-MS, ion chromatography, ICP-MS

Filters monitoring

Species : VOC, Acids, Bases, Amines, Condensables.

Materials : GC-MS, ion chromatography

Clean room monitoring

Species : VOC, Acids, Bases, Amines, Condensables, Siloxanes

Materials : GC-MS, ion chromatography

Boxes

Species : VOC, Acids, Métals, Condensables.

Materials : GC-MS, ion chromatography, ICP-MS

Gaz line qualification

Species : VOC

Materials : GC-MS

Equipments

Species : VOC, Acids, Bases, Amines, Condensables, Siloxanes

Materials : GC-MS, ion chromatography

Consumables qualification

Species : VOC, Acids, Bases, Métals

Materials : GC-MS, ion chromatography, ICP-MS

TERA environnement

The business sectors: Analyses in the Environment

Industrials waste

Species Sulphate, spin of emission (Acids, Bases, Métals, VOC's, sulfur oxides

Materials : : GC-MS, ion chromatography

Biogenic emissions

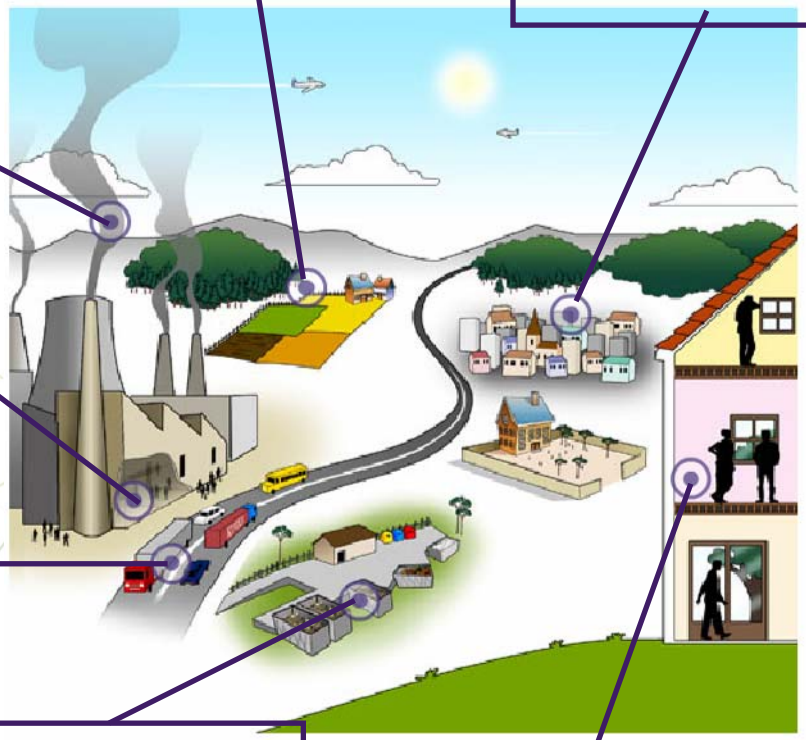
Species : VOC, ammoniac, carboxylic acids

Materials : GC-MS, HPLC, ion chromatography

Air quality / Air Pollution

Species : VOC, PAH, Nitrogen dioxide, Sulfur oxide, Aldehydes

Materials : : GC-MS, HPLC, ion chromatography



Working atmosphere

Species : Hydrogen sulphide, BTEX, aldehydes, Solvents, Acids, metals particles

Materials : GC-MS, HPLC, ICP-MS, ICP-OES

Automotives emissions

Species : BTEX, VOC, PAH

Materials : GC-MS, HPLC, ion chromatography, Spectro UV-visible

Fragrant emissions

Species VOC, carboxylic acids, carbonyl derivatives, sulfurs, Hydrogen sulphide

Materials : GC-MS, HPLC, ion chromatography, Spectro UV-visible

Indoor air quality

Species VOC (whose BTEX, Formaldehyde, Ozone)

Materials : GC-MS, HPLC, ion chromatography, Spectro UV-visible

TERA environnement

Towards the standardization of Air Cleaner Performances

The issue of IAQ (Indoor Air Quality)

➔ The context

We spend nearly 90% of the time in indoor environments

The concentrations are of 2 to 10 times higher inside than outside

➔ How to approach the problem?

EcoLogicSense

Network of sensors

1/ Chemical characterization of the atmosphere

- Sampling, passive or dynamic
- Automated Air Sampling
- Analyses performed in laboratory

Diagnostic Kit

2/ Characterization of the materials

- Outgassing determination in the laboratory
- "in situ" outgassing determination
- Measurement of the adsorption of materials

PhD thesis: in situ formaldehyde color sensor

3/ Characterization of the performance of air cleaners

- The on-site measurements
- Current projects
- Standardization

Projects: EPURATEURS 1 and 2, NORMA-CAT

Standards: XP B44A-13 and -200

EPURATEUR 1 and 2

➔ EPURTEUR 1:
- Study of the air cleaner market
- Analysis of the different technologies
- definition of a protocol to test the performance of air cleaner

➔EPURATEUR 2:
- To design and to built a test rig
- To validate the test rig and the measurement apparatus
- To test 2 different air cleaners with pollutants representative of :
  - Particles : latex (PSL)
  - Gases : toluene
  - Microorganisms : *Bacillus subtilis* (bacteria) and *Aspergillus niger* (fungi)
  - Allergens : cat allergens
- To propose this test method for a standardization work

The funders

ADEME

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RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE LA SANTÉ, DE LA JEUNESSE, DES SPORTS ET DE LA VIE ASSOCIATIVE

The partners

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Les Hôpitaux Universitaires de STRASBOURG

TERA environnement

NORMA-CAT project

TERA Environnement Laboratory
www.tera-environnement.com

Zoom avant

NORMA-CAT PROJECT

Development of new materials and systems for "photocatalytic" air treatment : standardization of methods for characterization and performance tests.

Project leader : Pascal KALUZNY, Chairman of CEN TC 386 Photocatalysis (TERA Environnement)

Term : 3 years **Budget :** 2 million Euros funded by the FUI

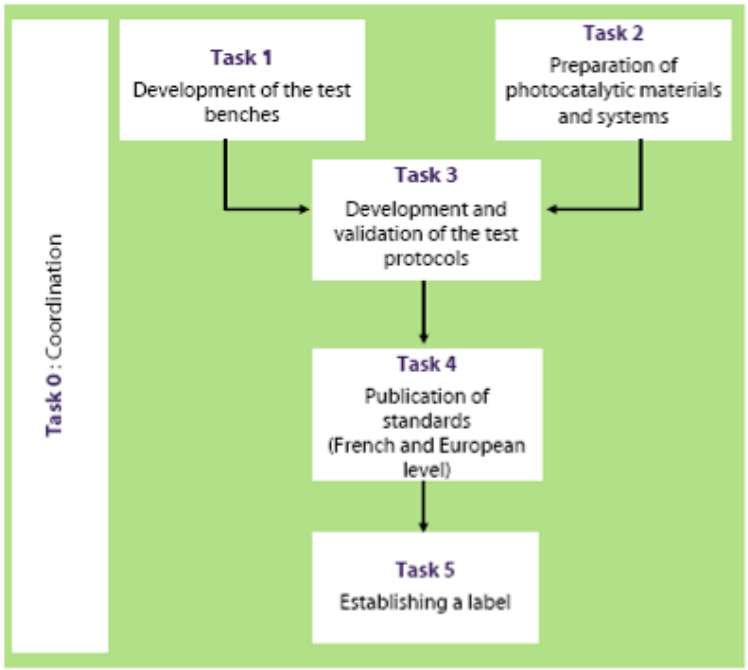
Keywords : photocatalysis materials, standard, air treatment, VOC, odours

THE OBJECTIVES OF THE PROJECT

- To develop new photocatalytic materials
- To develop test to assess :
  - intrinsic efficiencies of the active phase of materials
  - efficiencies of photocatalytic systems under conditions close to the application
- To validate the protocols developed with AFNOR on various photocatalytic media and systems
- To publish AFNOR standards at the national level
- To submit AFNOR standards as New Work Items (NWI) at the European level and facilitate future technical committee

NORMA-CAT Project

SUMMARY OF THE TASKS



CHALLENGES

SCIENTIFIC

- New products
- Intrinsic activity of the material
- Control of the performance in the visible
- Analytical methods

(detection of CO and CO_2 at trace level)

ECONOMIC

- Emerging market, generating employment
- Promotion of the methods and results at the European level through standardization (CEN/TC 386)

ENVIRONMENTAL

- Destruction of pollutants without a transfer of the pollution
- Possible air pollution impact
- To improve security
- Reduction of discharges of pollutants

HEALTH

- To decrease in concentrations of pollutants in indoor environments
- To measure possible by-products

PARTNERS

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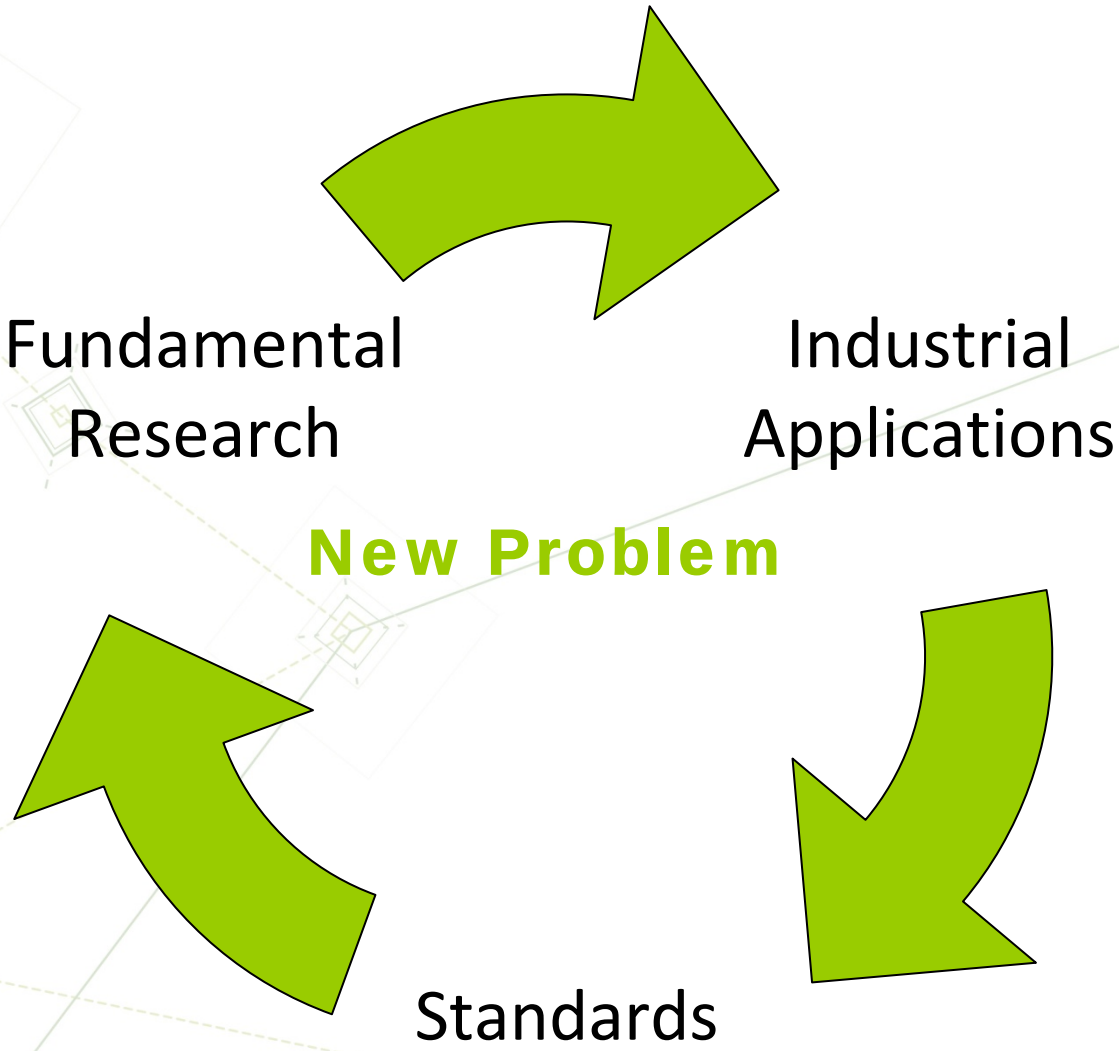
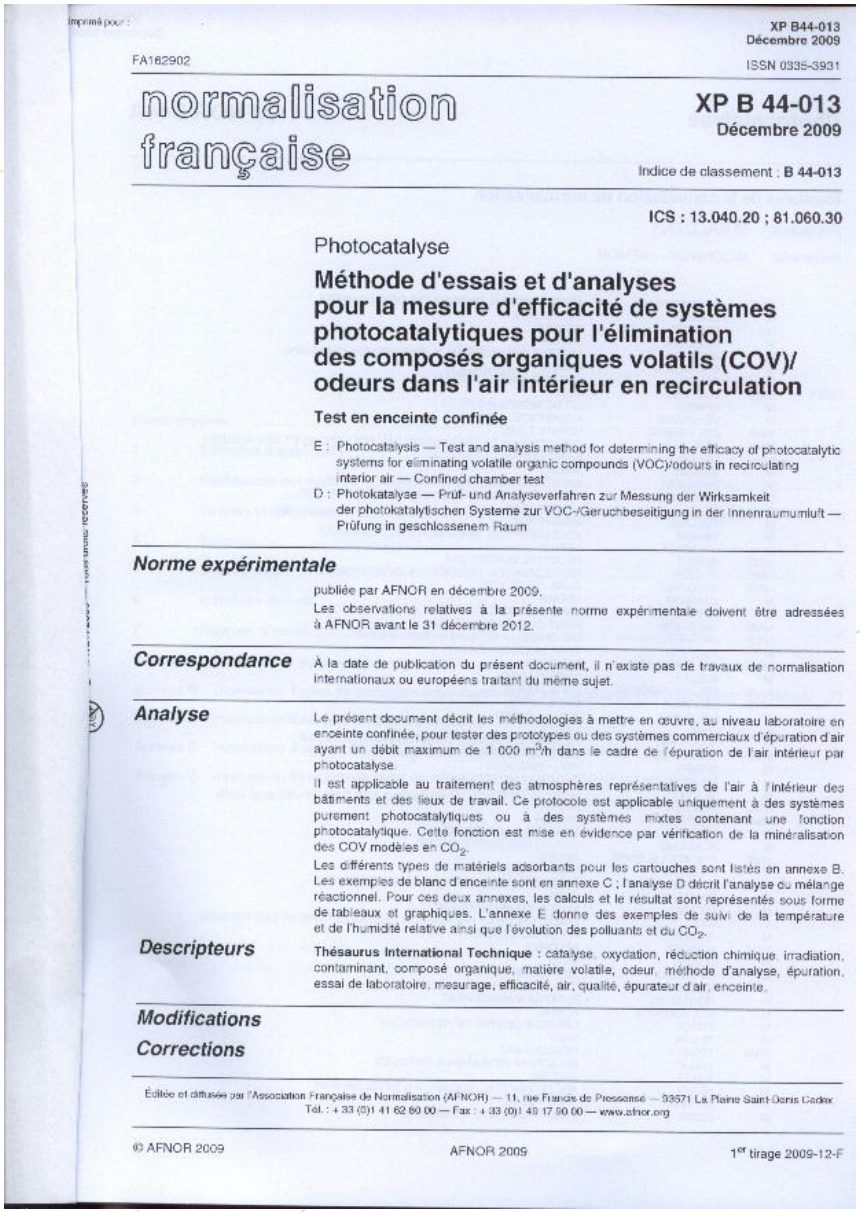

Fundamental Research
Industrial Applications
New Problem
Standards

The XP B44-13 standard



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Décembre 2009

ISSN 0335-3931

normalisation française

XP B 44-013
Décembre 2009

Indice de classement : B 44-013

ICS : 13.040.20 ; 81.060.30

Photocatalyse

Méthode d'essais et d'analyses pour la mesure d'efficacité de systèmes photocatalytiques pour l'élimination des composés organiques volatils (COV)/ odeurs dans l'air intérieur en recirculation

Test en enceinte confinée

E : Photocatalysis — Test and analysis method for determining the efficacy of photocatalytic systems for eliminating volatile organic compounds (VOC)/odours in recirculating interior air — Confined chamber test

D : Photokatalyse — Prüf- und Analyseverfahren zur Messung der Wirksamkeit der photokatalytischen Systeme zur VOC-/Geruchbeseitigung in der Innenraumumluft — Prüfung in geschlossenem Raum

Norme expérimentale

publiée par AFNOR en décembre 2009.

Les observations relatives à la présente norme expérimentale doivent être adressées à AFNOR avant le 31 décembre 2012.

Correspondance

À la date de publication du présent document, il n'existe pas de travaux de normalisation internationaux ou européens traitant du même sujet.

Analyse

Le présent document décrit les méthodologies à mettre en œuvre, au niveau laboratoire en enceinte confinée, pour tester des prototypes ou des systèmes commerciaux d'épuration d'air ayant un débit maximum de 1 000 m^3/h dans le cadre de l'épuration de l'air intérieur par photocatalyse.

Il est applicable au traitement des atmosphères représentatives de l'air à l'intérieur des bâtiments et des lieux de travail. Ce protocole est applicable uniquement à des systèmes purement photocatalytiques ou à des systèmes mixtes contenant une fonction photocatalytique. Cette fonction est mise en évidence par vérification de la minéralisation des COV modèles en CO_2.

Les différents types de matériels adsorbants pour les cartouches sont listés en annexe B. Les exemples de blanc d'enceinte sont en annexe C ; l'analyse D décrit l'analyse du mélange réactionnel. Pour ces deux annexes, les calculs et le résultat sont représentés sous forme de tableaux et graphiques. L'annexe E donne des exemples de suivi de la température et de l'humidité relative ainsi que l'évolution des polluants et du CO_2.

Descripteurs

Thésaurus International Technique : catalyse, oxydation, réduction chimique, irradiation, contaminant, composé organique, matière volatile, odeur, méthode d'analyse, épuration, essai de laboratoire, mesurage, efficacité, air, qualité, épurateur d'air, enceinte.

Modifications

Corrections

Éditée et diffusée par l'Association Française de Normalisation (AFNOR) — 11, rue Francis de Pressensé — 93571 La Plaine Saint-Denis Cedex
Tél. : + 33 (0)1 41 62 80 00 — Fax : + 33 (0)1 49 17 90 00 — www.afnor.org

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➔ Title:
Photocatalysis – Test method for determining the efficacy of photocatalytic systems for eliminating volatile organic compounds (VOC) / odours in recirculating interior air – Confined chamber test

➔ a French standard

➔ XP status

➔ Publication in December 2009

➔ XP B44 - 13

➔ Proposed at the European level:
Photocatalysis – Batch mode test methods – Part 1 Measurement of efficiency of photocatalytic devices used for the elimination of VOC and odour in indoor air, in active mode

The XP B 44 -13 standard

➔ The scope

- to test prototype or commercial air cleaner systems with a maximum flow rate of 1,000 m^3/h used for the indoor air remediation.
- It applies to the treatment of atmospheres that are representative of the air inside buildings and workplaces.
- for photocatalytic systems alone or combined systems that include a photocatalytic function.
- Demonstration of the photocatalytic function by verifying the mineralisation (CO_2)

➔ The principle

The system is placed inside an air tight chamber and exposed to a model VOC mixture. Changes in pollutant concentrations due to operation of the system, as well as the production of CO2 and the appearance of by-products, are measured against time.

➔Test conditions

- A mixture: Acetone, acetaldehyde, heptane and toluene.
- 2 concentrations:

test with search for reaction by-products

250 ppbv ± 10% per compound at 22 °C 1Patm

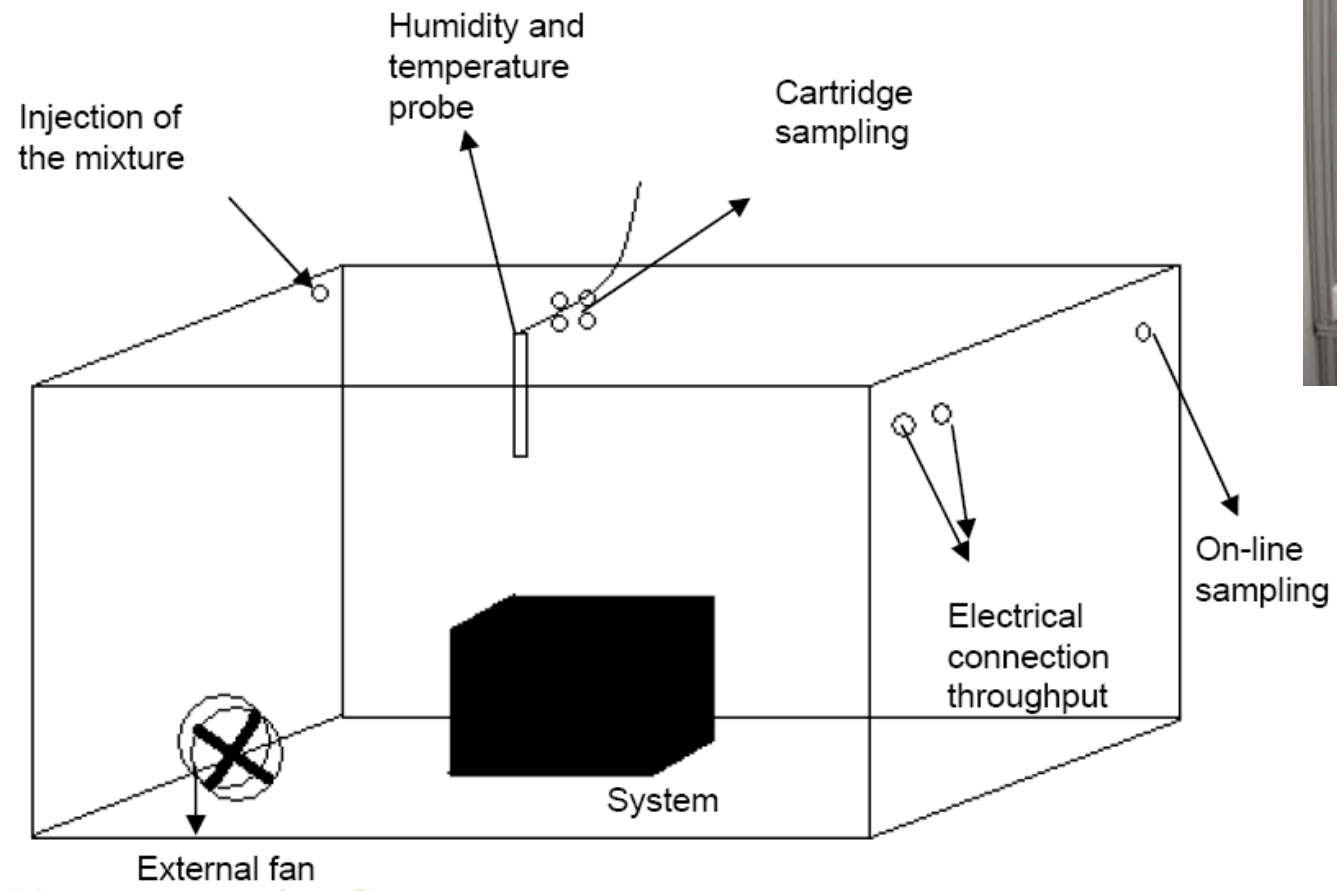
test used to demonstrate the photocatalytic activity (monitoring of CO2)

1000 ppbv ± 10% per compound at 22 °C 1Patm.

TERA environnement

The XP B44A-13 standards: the air tight chamber

Schematic diagram of an air tight chamber



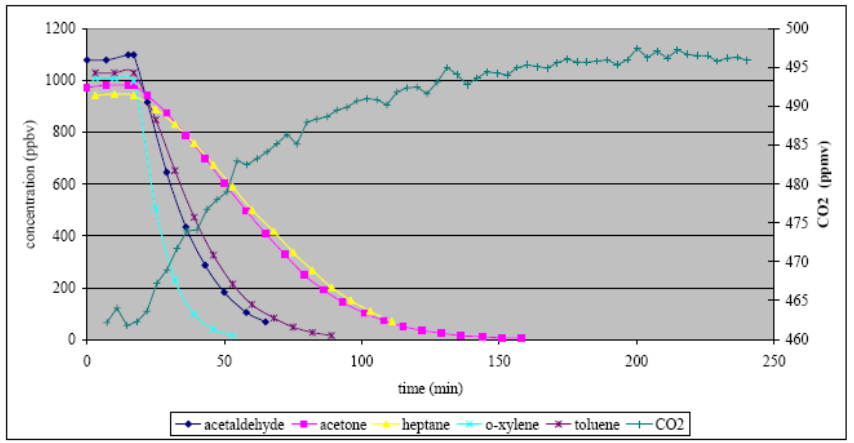
The XP B 44-13 standard: test report

➔ Purpose of the investigation

➔ Methodology: reference to the standard, volume of the chamber, analysis techniques used, pollutant generation, etc.

➔ Results:

- pollutants and CO_2 against time (ppbv and/or µg/m³);
- T °C and % RH against time;
- identified by-products (5 ppbv after subtracting the blank).
- percentage of mineralisation against time
- ozone against time;
- all test observations,
- apparatus quantification and detection limits



- CADR. $$CADR = R_{AC} \times V$$

With V the volume of the chamber

And R_{AC} coming from

$R_{Totale} = R_{Nat}$ test with air cleaner

$R_{Totale} = R_{Nat} + R_{AC}$ test without air cleaner

And

$$C(t) = C_0 e^{-(R_{Nat} + R_{AC}) \times t}$$

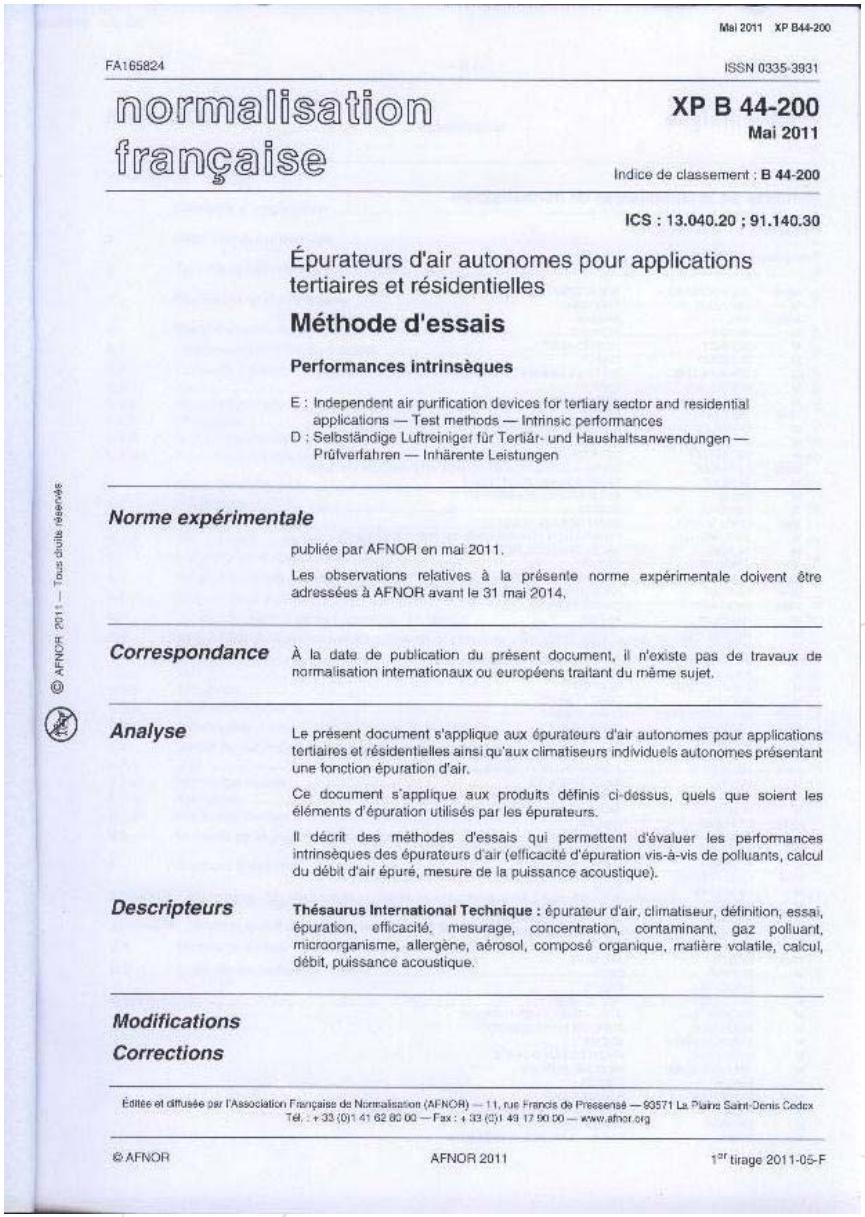
With C0 : the initial pollutant concentration

R_{Nat} : the rate of disappearance due to naturel phenomena

R_{AC} : the rate of disappearance due to the air cleaner

TERA environnement

The XP B44A-200 standards



Mai 2011 XP B44-200

FA165824 ISSN 0335-3931

normalisation française

XP B 44-200
Mai 2011

Indice de classement : B 44-200

ICS : 13.040.20 ; 91.140.30

Épurateurs d'air autonomes pour applications tertiaires et résidentielles

Méthode d'essais

Performances intrinsèques

E : Independent air purification devices for tertiary sector and residential applications — Test methods — Intrinsic performances
D : Selbständige Luftreiniger für Tertiär- und Haushaltsanwendungen — Prüfverfahren — Inhärente Leistungen

Norme expérimentale

publiée par AFNOR en mai 2011.

Les observations relatives à la présente norme expérimentale doivent être adressées à AFNOR avant le 31 mai 2014.

Correspondance À la date de publication du présent document, il n'existe pas de travaux de normalisation internationaux ou européens traitant du même sujet.

Analyse

Le présent document s'applique aux épurateurs d'air autonomes pour applications tertiaires et résidentielles ainsi qu'aux climatiseurs individuels autonomes présentant une fonction épuration d'air.

Ce document s'applique aux produits définis ci-dessus, quels que soient les éléments d'épuration utilisés par les épurateurs.

Il décrit des méthodes d'essais qui permettent d'évaluer les performances intrinsèques des épurateurs d'air (efficacité d'épuration vis-à-vis de polluants, calcul du débit d'air épuré, mesure de la puissance acoustique).

Descripteurs **Thésaurus International Technique :** épurateur d'air, climatiseur, définition, essai, épuration, efficacité, mesurage, concentration, contaminant, gaz polluant, microorganisme, allergène, aérosol, composé organique, matière volatile, calcul, débit, puissance acoustique.

Modifications

Corrections

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➔Title:
Independent air purification devices for tertiary sector and residential applications – Test methods – Intrisic performances.

➔a French standard

➔ XP status

➔ Publication in May 2011

➔XP B 44-200

TERA environnement

The XP B 44-200 standard

➔The scope

- to test stand-alone air cleaners for residential and commercial applications
- to evaluate the intrisic performance of the air cleaner
- to determine the effective treatment towards: gas, allergens, inert particles and microorganisms (in informative annex)
- to measure some by products
- to calculate the CADR

➔ The principle

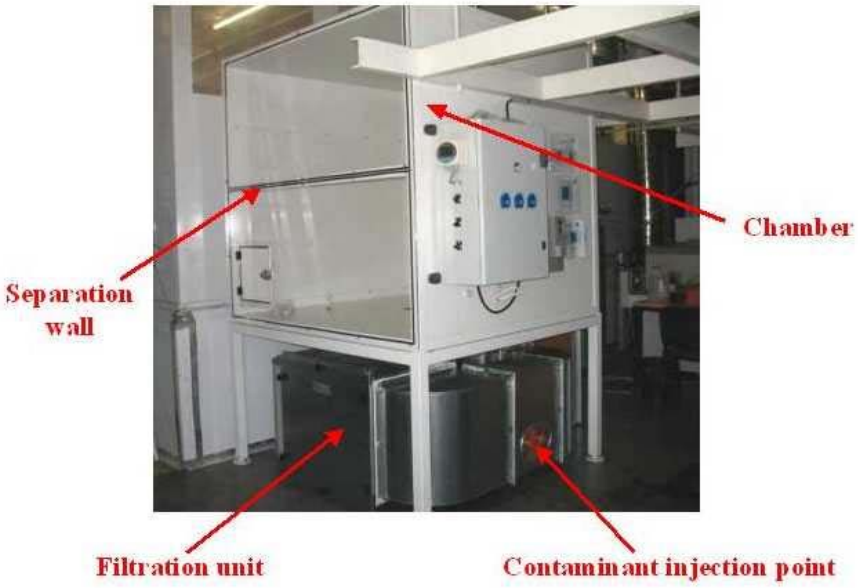
- The system is tightly placed inside a test chamber.
- The pollutants are continuously upstream injected
- Downstream measurement of pollutants are performed.

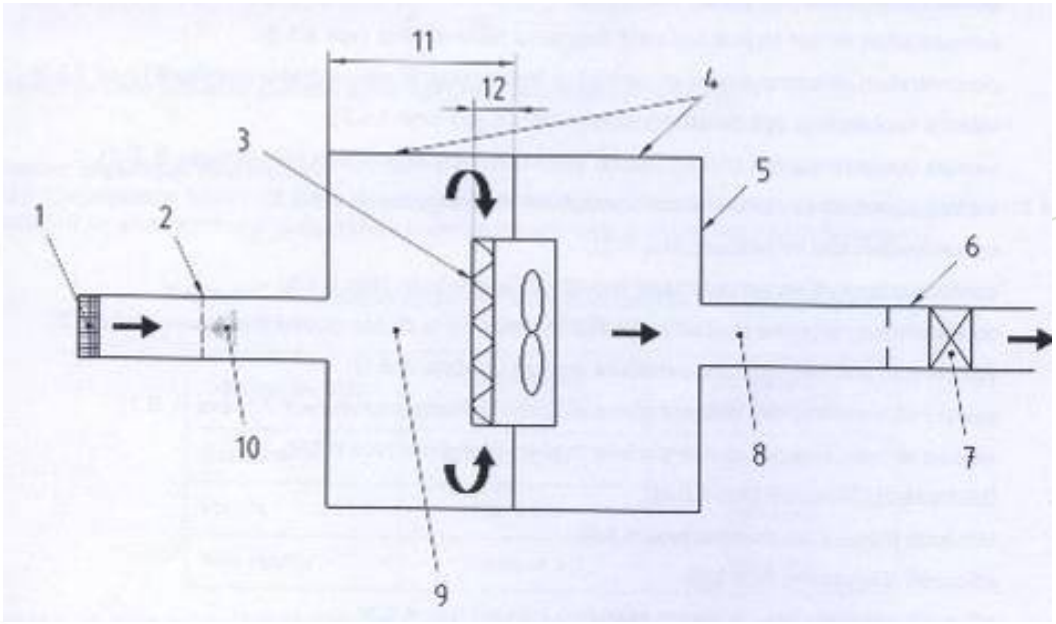
➔Test conditions

For **gas** test	- A mixture: Acetone, acetaldehyde, heptane and toluene. - concentrations: 250 ppbv ± 10% per compound at 22 °C 1Patm
For **allergens**	- Felis domesticus 1 - concentration: between 10 and 20 ng/m3
For **inert particles**	- DEHS
For **microorganisms**	- bacterium: *Staphyloccocus epidermidis* - fungus: Aspergillus niger

TERA environnement

The XP B44A-200 standards: the air tight chamber





1.HEPA filter
2. Grid
3. Air cleaner in test
4. The difference in pressure between the upstream and downstream of the air cleaner is zero
5. Chamber
6.Measuring air flow
7. Fan
8. Downstream sampling
9. Upstream sampling
10. Injection of pollutants
11. Size of the upstream portion of chamber
12.Size of the air cleaner in excess in the upstream part of the chamber

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The XP B 44-200 standard: test report

- Information about used technical materials
- Information about the air cleaner
- T, RH and P
- Fan speeds of the air cleaner during the test
- Air flow of the air cleaner during the test
- By products: identification and concentration

- CADR

CADR = Q x E

where Q is the air flow of the cleaner during the test and E is given by:

$$E = \frac{C_{am} - C_{av}}{C_{am}}$$

where Cam et Cav are the downstream and upstem mesured concentrations

- Average electric power
- Sound power of the air cleaner during the test

TERA environnement

Comparison of XP B44-13 and XP B44-200 standards

	Flow through reactor	Batch reactor
Standards	XP B44-200	XP B44-013
Contaminant injection	Continuous	Punctual
Primary chemical contaminants	Acetaldehyde, acetone, n-heptane, toluene	Acetaldehyde, acetone, n-heptane, toluene
Concentrations	250-500 ppbV*	250 ppbV* 1000 ppbV* for mineralization
Required level for the blank of the chambers	50 ppbV*	50 ppbV*
RH	50% ±5%	50% ±5% at the beginning of the test
Temperature	22°C ±2°C	22°C ±2°C
Sealing	N.A.	Loss < 10% in 8h
Type of samplings	Simultaneous upstream end downstream	1 point during the test
Detection Limits	≤ 25 ppbV*	≤ 20 ppbV*
Possible secondary pollutants	O_3, CO, NO_x, formaldehyde	CO, CO_2, O_3, aldehydes

TERA environnement

Conclusion

Two philosophies to test air cleaners

- XP B44-200: Flow through reactor: the totality of the effluent is forced to pass through the purifier. It can be used to determine the intrinsic performances of the air cleaner towards particles, allergens and chemicals.

-XP B44-013: Batch reactor: contaminants (a mixture of chemicals) are punctually injected.The decay of their concentrations is followed

Each of these protocols presents advantages and drawbacks regarding the representativeness of the air cleaner efficiency measurement, as well as for the search for secondary contaminants possibly produced by the purifier itself.

In each case, the CADR can be determined.

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Thank you

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