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Test Protocol for Livestock Housing and Management Systems

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Foreword

To meet the environmental challenges within the livestock production new technologies are developed within the EU member states and elsewhere. They are developed for different parts of the livestock production chain and enhance the eco-efficiency by reducing material inputs, emission of pollutants, energy consumption, recover valuable by-products and minimize waste disposal problems. These technologies are here and elsewhere referred to as environmental technologies.

However, central stakeholders, such as farmers and authorities only have limited information on their performance which hampers the diffusion of these environmental technologies in the livestock production. Therefore, the Dutch Ministry of Environment, the German Ministry of Agriculture and the Danish Ministry of Environment decided in cooperation with experts from Wageningen University & Research Centre in the Netherlands, the German Association for Technology and Structures in Agriculture (KTBL), University of Hohenheim in Germany, University of Aarhus in Denmark, the Danish Institute for Agro Technology and Food Innovation (AgroTech) and the Danish Pig Production to develop common test-protocols for test and verification of a number of these environmental technologies for livestock production. The work on the different test-protocols was initiated in October 2008 and was finalised in April 2009.

These standardized test-protocols are designed to test and verify the environmental performance and operational stability of different environmental technologies for livestock production. Basically, the test-protocols can therefore be used to provide reliable and comparable information on the performance of new technologies to farmers, authorities and other stakeholder and thereby prepare the ground for that these technologies to a higher extent are used in meeting the environmental challenges of the livestock production within the EU.

1. *Introduction*

The sustainability of livestock production can be improved by stimulating the use of newly developed technology and equipment designed for better ecological, i.e. eco-efficient performance. The eco-efficiency of the production is enhanced by reducing material inputs, emission of pollutants, energy consumption, recover valuable by-products and minimize waste disposal problems. These environmental technologies have been developed or are in development that can be implemented in different parts of the livestock production chain, like techniques to be applied in animal houses or techniques to storage, manure processing or application.

In order to facilitate the diffusion of environmental technologies for agricultural production it is central that these technologies' environmental performance and operational stability is thoroughly tested, making use of test protocols that incorporate the most recent knowledge on measurement methods.

Therefore, in a joint initiative of parties from Denmark, the Netherlands and Germany test protocols have been developed to test and verify different types of environmental technologies for agricultural production. This paper defines the test protocol for new environmental technologies in livestock housing and management systems.

The objective of this protocol is to specify the test procedure for the eco-efficiency of livestock housing and management systems and includes definitions, requirements and conditions for parties involved in the test, measurement and sampling methods, processing and interpretation of measurement results, and reporting.

In this protocol livestock housing and management system is defined as an entity with the primary function of providing housing for a specified animal category, and with a specific design, equipment and management that determines its eco-efficiency. In principle, all elements in an animal house that affect the external environment may be included in a definition of such a system. In practice, the major effect of animal housings on the environment are represented by emissions of ammonia, odour, dust and greenhouse gases, and systems can be characterized by their ability to lower one or more of these emissions. Systems to lower emission may be defined in such a way that they include a specified description of one of the following factors:

- housing design including design of pen, and manure storage and removal system;
- bedding material and other rooting materials;
- additional indoor technical installations and management;
- treatment of indoor air and indoor climate;
- manure treatment, including additives and management;
- feed composition, including additives and management;
- general management.

From the 1990's several systems have been developed with the aim to lower the emission of ammonia from livestock housings. In general these systems are based on standard housing systems with pen and manure storage modifications to reduce emitting surfaces, or manure management systems for quick removal or quick drying. In the BREF-guide for intensive livestock operations an overview is given of available systems for pig and poultry. Besides ammonia, odour and dust (PM10) emission have become important issues in areas with high animal densities. This had led to

the development and introduction of air cleaning technologies in Northern Europe. However, in many cases new livestock housings and management systems may also be an attractive option for farmers to meet the environmental goals.

It is important that the scope and performance statements of the international verification system are defined such that its information can be optimally used by different stakeholders in the member states. This implies that the test protocol should provide a broad array of reliable information that can be analyzed and summarized during the verification in such a way that it can be directly or indirectly used by the different national users as widely as possible.

However, for reasons of costs and time, test protocols have restrictions in the number of parameters to be evaluated and applied methods. The starting point in the design of the present test protocol therefore was to create an optimal balance between reliable information that meets the demands of the different users, and costs in terms of time and budgets to carry out the test procedure.

This protocol describes the requirements for testing livestock housing and management systems during a defined testing period. The test period and the number of sampling days are determined by the requirements for a statistically adequate evaluation of the removal performance. During the testing period the operational stability and deviations from normal operational functioning shall be observed and registered, and the observations reported in the test and evaluation report. Specific test parameters for the assessment of long term operational reliability and durability will, however, not be included in this protocol.

2. Scope

This protocol specifies the information that is needed as basis for an environmental verification of livestock housing systems, manure and feed additives, and associated management, defined as 'livestock housing and management systems' as described in the introduction. In the following livestock housing and management systems are termed "system" unless specification is required.

The specified information includes

- a comprehensive system description, user manual;
- the technical performance of the system based on data that are collected during the test period. The protocol specifies requirements for test parameters, measurement methods, sampling strategy, data collection and handling, calculation methods, reporting;
- evaluation parameters to assess the eco-efficiency of the tested system.

This protocol describes the requirements for verifying the effect on gaseous emissions from animal housing as affected by the physical design and management of a livestock housing system, and application of feed and manure additives during a defined testing period. The length of the testing period is based on the time span required for a statistically adequate evaluation of the performance. Animal productivity, animal health and welfare, working environment, and external environment observed during the testing period will be addressed in the evaluation report.

3. Terms and definitions¹

Additive to manure

A substance that is applied to livestock manure with the intention of changing the characteristics of the manure in such a way that the emission potential of various defined parameters such as ammonia, odour, hydrogen sulphide, methane, and nitrous oxide is alleviated.

The types of additives include:

1. Acidifying agents.
2. Oxidizing agents.
3. Disinfectants.
4. Urease inhibitors.
5. Adsorbents.

Application methods include:

1. Directly to the slurry.
2. Recirculation of slurry to the house.

Ammonia (NH₃)

A gas derived from urea (uric acid) excreted by livestock (poultry) and implicated in acidification and nitrogen enrichment of sensitive ecosystems.

Animal category

Different types of animals according to their species (pigs, cattle, chicken, ducks and turkeys etc.), sex, age and scope of production (breeding, rearing, growing and finishing for meat, milk or egg production).

Animal housing system

A housing system is defined by the way a certain animal category is stocked (floor and pen design), the system for the management and internal storing of manures produced, the ventilation system to control indoor climate and the type and regime to feed and water the animals.

Animal place (AP)

Space provided per animal in a housing system according to animal welfare regulations. Depending on the animal category and the management the number of animals produced on an animal place per year is different.

Animal unit

One animal unit is equal to 100 kg N in the manure storage tank.

Background concentration

Concentration of aerial pollutants in the incoming air.

¹ A number of terms and definitions can be found in *Glossary of terms on livestock manure management 2003* from RAMIRAN Recycling Agricultural, Municipal and Industrial Residues in Agriculture Network - A network in the framework of the European System of Cooperative Research Networks in Agriculture (ESCORENA)
<http://www.ramiran.net/DOC/Glossary2003.pdf>

Bedding material

Bedding material is used in housing systems with solid or partly slatted floors. It should be added in such an amount, that urine and moisture is absorbed. In addition it gives some comfort to the animals.

Building construction

An animal housing can be constructed as a closed or an open building, that could be thermally insulated or not.

Compartment, section

Separate part of an animal housing that can individually be ventilated.

Cooling system

Cooling of a housing system can be done by water fogging of the inlet air, water fogging of the roof, and cooling the inlet air by heat exchanger.

Downtime

The period of time when the system tested is not operating as a result of malfunctions.

Dust

See Particulate matter.

Emission factor

The rate of release of gases or particulates from animal housings to the atmosphere. It can be expressed as the integrated emitted mass per time interval and animal place (e. g. $\text{kg a}^{-1} \text{AP}^{-1}$) or livestock unit (e. g. $\text{OU s}^{-1} \text{LU}^{-1}$). In the case of ammonia it also can be expressed as a percentage of total ammoniacal nitrogen or total nitrogen excreted by the animals.

Norm emission factor

This describes an emission factor for a standard housing system.

Feed additives

Feed additives are substances that are applied to animals with feed or water in order to change the characteristics of the manure in such a way that the emission potential of various defined parameters such as ammonia, odour, hydrogen sulphide, methane, and nitrous oxide is alleviated.

The types of additives include:

1. Digestive additives (bacteria/enzymatic preparations).
2. Plant extracts.

Feed composition

Feeding stuff and nutrients of the feed for animals.

Feeding technique

The feeding technique describes the technical installations for mixing, transportation, and dispensing of the feed to the animals. The feed can be applied in a dry or wet form.

Floor design

The floor of a pen or a housing system can be designed solid (concrete) with the use of bedding material or slatted. The slats can be made of metal, concrete or plastic.

Heating system

Installation for production, transportation and distribution of heat in the housing. Heat can be produced by burning coal, gas or oil or by electrical energy. The heat distribution can be done by zone heating (heating elements in floor or in ceiling, radiating heat onto animal) or room heating (preheating incoming air, convective room heating).

Livestock unit (LU)

1 LU equals to 500 kg live weight of an animal.

Manure system

The manure system describes the collection and removal of slurry or farm yard manure out of the housing system. Gutters and channels are used for slurry removal, for straw based systems the manure is removed by scrapers or small tractors with a mounted scraper.

Manure treatment

Chemical and/or physical manipulation of the livestock manure such as addition of acids or other chemicals, aeration, electrochemical treatment (oligolysis), radiation (e.g. using UV light), ultrasound, etc. in order to change the characteristics of the manure and to reduce gaseous emission.

Odour

Pleasant or unpleasant smell caused by different odorants with very different chemical, physical, and biological properties.

The odour concentration is given in European Odour Units per cubic meter air (OU_E/m^3) and the concentration is measured by olfactometric in accordance with the European CEN-standard (EN 13725).

Particulate Matter (PM)

Particulate matter is also called dust. Any airborne, finely divided solid or liquid matter with a mean aerodynamic diameter is equal to 100 micrometers. PM10: particles with a mean aerodynamic diameter less than 10 micrometers; PM2.5: particles with a mean aerodynamic diameter less than 2.5 micrometers.

Pen design

Structuring of a pen with separated areas for lying, feeding and dunging. Single area pens are unstructured.

Pull and plug systems

The manure is drained from the gutter by gravity to a tank outside the housing unit. A plug is pulled to drain the gutter. The period between draining depends of the design of the pits and type of housing unit.

Standard housing system

The standard housing system describes the national state of the art for animal housing systems.

Summer period

Defined here as the period from May 15 to September 30.

Uptime of the system

The period of time when the system tested is functioning.

Ventilation system

Housings must be ventilated in order to provide the livestock with fresh air and to remove gaseous products of metabolism, heat and moisture. Ventilation can be designed either as a forced or a natural ventilation system.

Ventilation rate

The ventilation rate gives the volume flow of air in $\text{m}^3 \text{hour}^{-1}$ through an animal housing. It can be given for the entire housing unit or per animal (place).

In the case of forced ventilated housings the ventilation rate is controlled either by the difference between outside and inside temperature and/or the concentration of carbon dioxide or ammonia in the air.

The ventilation rate of natural ventilated housings depends on wind flow, wind speed (pressure difference) and thermal lift inside the housing.

The design of the ventilation systems and the ventilation rates are based on national regulations and differ between the states.

4. *System description*

The manufacturer/applicant is responsible for providing a precise and full description of the system before the test starts. The system description shall include all relevant and essential information that is needed:

- to organize and design the test;
- to enable the farmer to operate, to maintain and to monitor the system properly;
- to on-line monitor the system including key parameters needed for the determination of the uptime/downtime of the system,
- to allow the verification authorities to check the system afterwards;
- to give insight in the working mechanism.

In particular the description of the housing system where the technique or system should be applied shall include:

- the animal category (race, genetic, weight range, herd size, total number, space provided per animal);
- a general description of the management of the livestock and the pen design (description of the pen design, drawing will be helpful);
- the construction of the building (capacity, length, wide);
- the ventilation system and its design (capacity, set point values, air inlet/outlet);
- the heating/cooling system;
- the floor type (solid/slats, material of the floor);
- the type of bedding material and amount, management, application;
- the manure system and management, manure treatment;
- the feeding technique and management;
- the feed composition (nutrients and ingredients) and feed additives;
- the kind of drinking system.

The system or the technology to be tested should be described in the following manner:

- a list of the (technical) components needed for application including type (e.g. material and characteristics), technical and functional description and design
- description of the applied technique, and if relevant, type and composition of additives used, their provision including the accuracy of application;
- the system's function in detail and the expected performance of the system with respect to the effect on the pollutants (odour, ammonia, dust);
- illustrations and/or diagrams of the system (top and sectional views, details if necessary);
- a list of the essential design and operational parameters (ranges) that are specific for the system to be tested and that are decisive for proper function and therefore should be controlled during the test (e. g. slurry acidification: pH; minimum amount of additives applied per m²);
- a list of key parameters considered relevant to be electronically or manually logged during operation of the system as part of system surveillance; this list shall include a description on how they are controlled;
- a compilation of the input materials needed and liquids and wastes produced (including amount and relevant chemical composition).

In addition, the description shall include detailed instructions for operation, service and maintenance and surveillance (see chapter 6).

Finally, the manufacturer/applicant shall provide information

- on the environmental, occupational, animal and food safety of the products applied;
- which parameters are essential for the calculation of the uptime/downtime of the system (the test institute is, however, responsible for a professional evaluation of whether this information is reliable and sufficient),
- on the predicted durability of the system and its components;
- on warranty provisions;
- if the technology has already been installed a list on demonstration units already working (animal category, type of housing system, animal weights, ventilation rates in particular).

5. Requirements

This chapter describes the requirements related to the test of livestock housing and management systems. The requirements described apply to the organization of the test activities, test facilities and test organization, as well as requirements for the framework and contents of the test plan.

In addition the chapter describes the measurement parameters to be included in the test and a specification of the methods to be used. Finally the chapter includes requirements to ensure representative feeding and management conditions on the test facility, and requirements related to the impact of the system on occupational health and safety as well as animal health and welfare and food safety.

5.1 Requirements for the organization of the test activities

The test of a new technology, housing or management system involves various actors:

1. The applicant which intent to have a technology or system tested.
2. The test organization which will conduct the required tests.
3. The farmer(s) which own the facilities where the tests are conducted.

Test Plan

It is required that the applicant or the test organization writes (in local I language) the test plan based on the template in Annex A and that all questions of the template have to be answered. To reduce the risk that the test results at the end are rejected because they have not been produced in accordance with the test protocol it is advised to confer the relevant verification authorities in case of uncertainties about how to prepare the test plan.

The applicant or the test organization can decide whether the test plan shall be handled as confidential.

Prior to start a full-scale test on e.g. a new design of a livestock housing unit or the effect of adding a chemical agent or a physical manipulation, an evaluation of the potential risks on normal and potential unintentional use of the product shall be performed in relation to:

1. Food stuff security (residues in meat or other products).
2. Animal health and welfare (corrosive burns, allergic reactions, infections, etc.).
3. Working environment (corrosive burns, allergic reactions, infections, etc.).
4. External environment (emission of undesirable agents and residues in the manure etc.).

Full system description of the technology tested

Prior to the test activities starts a full description of the system or the technology to be tested shall be available, cf. chapter 4. The description shall include detailed instructions for operation, service and maintenance and surveillance.

During the test period

During operation the applicant/manufacture of the system is responsible for electronic logging of a number of key parameters to ensure the operation of the system. This logging shall include those parameters essential for the calculation of the uptime/downtime of the system, cf. chapter 4.

During the test period the applicant/manufacture of the system or technology is not allowed to visit the farm unless they are contacted by the farm owner due to operational problems. In this case the operational problems should be dated and described in the test log-book by the farmer or the test organization. In addition it should be dated when and how the problem is solved and signed by the farmer and the applicant/manufacture when repairs have been finalised.

During operation of the system, the applicant/manufacture of the system or technology is responsible for electronic logging of a number of key parameters to ensure the operation of the system as described in chapter 4.

If the applicant/manufacture has conducted tests on earlier models of the system/technology, all the test reports must be enclosed including a description of the differences between the models.

The test organisation is responsible for coordinating and implementing the test plan and for drawing up all the necessary data record tables. Furthermore, the test organisation is responsible for the calculation of the uptime/downtime of the system tested.

In addition, the test organisation must ensure that the log-book is kept in the right place in the housing unit.

The farmer is responsible for recording the production conditions in accordance with the test plan. The farmer must also record the time spent on operational problems and maintenance of the system or technology.

5.2 Requirements for the test facility and the test organization

The livestock housing and management system shall be tested under farm conditions that are representative for the standard practices of the animal categories for which the system or technology is intended for use. This implies that requirements need to be defined to ensure that both the lay-out of the test facility and the management conditions during the test period are representative for the applied categories.

This chapter describes the requirements that farms have to meet in order to be used as test facilities. To ensure adequate quality of all activities related to the test measurements and reporting, general requirements for the test organization are specified as well in this chapter.

The test facilities must represent farm characteristics that can be considered representative for standard practices in the country in question. The following items have to be considered:

1. Size of the livestock units involved in the test, minimum/maximum size.
2. Stock density, fulfillment of welfare requirements.
3. Pen design.
4. Manure removal system.
5. Ventilation system and management lay-out and dimensioning in relation to number of animals, air quality thresholds (ammonia, carbon dioxide).
6. Feeding system and ration, representative protein and energy ranges.
7. Production level, representative performance ranges.
8. Health management, medicine use.
9. Applicability to other housing systems and animal categories (cf. annex I).

Standard practices may differ between countries.

During the test a number of farm parameters related to these requirements have to be registered to verify standard practice. They are listed in chapter 5.4 as conditional measurement parameters.

The following requirements are specified for the test organization and involved laboratories:

1. The test organization has to fulfil the general requirements of ISO 9001 *Quality management*¹.
2. Sampling and measuring of all test parameters shall be performed by laboratories fulfilling the general requirements of the ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories*.
3. For specific measurement parameters, as defined in chapter 5.4, laboratories have to fulfil the specific requirements of the indicated quality standard. Especially attentions should be drawn to the requirements of the EN 15259:2007: *Air quality - Measurement of stationary source emissions - Requirements for measurement sections and sites and for the measurement objective, plan and report*.
4. The test organization and involved laboratories must demonstrate relevant experience and expertise. The relevant experience should include measurement experience in livestock production in general and more specific experience in measuring emissions from animal categories that are involved in the test. The involved technicians and researchers should have a thorough understanding of livestock production systems and its management. The test organization must demonstrate its ability to combine measurement experience and livestock production expertise into data collection, handling, analysis, interpretation and reporting that meet the standards of sound research.
5. The test organization has to show their independency from involved actors and the results of the test evaluation.

5.3 Test design and sampling strategy

The emissions of ammonia, odour and total and fine dust (PM10 and PM2.5) are the primary parameters that are used to assess the eco-efficiency of livestock housing

¹ The aim is within a short time period to strengthen this requirement to a certified ISO 9001 quality management system.

and management systems that are subject of the test. The design of the test and its sampling strategy is based on providing the following information:

1. The effect of the system on the yearly averaged ammonia emission both expressed in terms of the relative effect against a reference system and expressed in absolute emission units.
2. The effect of the system on the yearly averaged odour emission, similarly as for ammonia expressed in relative and absolute terms. In addition also the effect of the system on the odour emission during the summer period, in relative and absolute terms.
3. The effect of the system on the yearly averaged PM10 and PM2.5 emission, similarly as for ammonia expressed in relative and absolute terms.

The test design is based on the case-control approach. If for compelling reasons the case-control approach is not feasible, as will be specified below, alternatively the test design will be based on a multiple location test without control. Both approaches will be described separately in the next sections.

Case-control test design (within a farm)

In this approach the emissions of animal compartments equipped with the investigated system (case) and animal compartments with standard equipment (control) are directly compared by carrying out simultaneous measurements. Animal compartments are located on the same farm.

The lay-out and equipment of the control compartment is based on what is considered common practice in the test country (e.g. standard housing system). All relevant non-system factors that affect emissions (temperature, ventilation rate, animal age, feed etc.) are kept as equal as possible between case and control compartments. This approach has been adopted for two reasons:

- A case-control set-up is effective in terms of creating an optimal ratio between statistical accuracy and costs. In this set-up the disturbing effects of non-system factors that similarly in both case and control compartment at the same time, are eliminated by observing the differences between case and control compartments.
- Transfer of results across nations can be eased by relating the observed relative effects to the national standard housing systems. A table with emission factors (measured and possible legal/allowable limits) for different animal categories is found in Annex C for Ammonia, in Annex D for odour and in Annex E for dust.

The case-control study design can be applied to housing units that are sectioned into compartments, as can be found in pig production (farrowing sows, weaners, and growing/finishing pigs). In cases where housing units are not sectioned, comparison may take place between equally designed housing units at the same farm location. For example in poultry production, broiler farms may have two or more identical barns that can be used for this purpose. The sampling strategy is outlined in Table 1.

Table 1. Sampling strategy for testing livestock housing and management systems: case-control within a farm.

Parameter	Requirement
Number of compartments/housing units for sampling	Minimum of two different farm locations, each farm location having at least one case and one control compartment/housing unit.
Minimum size of units for sampling	The unit size shall be representative for farms in the participating states (cf. 5.2).
Measurement periods	At each farm location: Ammonia, odour and dust (for yearly average): <ul style="list-style-type: none"> • Six days of measurements randomly distributed in one year. Approximately one measurement day each second month. Maximum one half of the measurement days shall be located during the first half of the growth cycle. Odour (for worst case during the summer): <ul style="list-style-type: none"> • Six extra days during the summer period¹ with outdoor temperature above 16°C (during sampling).
Sampling sites	Simultaneously sampling in the case and the control compartments/housing units.

The case-control setup provides data that express the difference in emission between the investigated system and the reference. The effect of the system can be estimated as the overall mean difference. The statistical significance of the system effect (i.e. differing from 0) can be verified by applying a paired t-test, and confidence intervals for the system effect can be calculated from the pooled variance of differences.

Variance levels may differ among emission components and animal categories. It is advised to check before the test starts if the minimum number of observations (Table 1) should be increased to improve the distinguishing power of the test.

For the generalization of results it is of importance to investigate the existence of possible interactive effects of farm location on the system effect. Interactive effects of farm location can be investigated by testing (t-test) whether the mean system effects of both farms differ from each other. In case farm location interactions occur, as a worst case approach, the results from the lowest effect will be considered to represent the system effect.

Other test designs

When a case-control within a farm study design is not possible an alternative approach could be applied. Naturally ventilated livestock housing systems like dairy

¹ Summer period defined here as May 15th to September 30th.

farms may, for example, not be suitable for case-control studies within a farm, as in most cases only one dairy house is situated on each site, and sectioning of dairy houses may not be applicable.

In such cases at least 4 test farms equipped with the system should be monitored during the required test period and the emission factors calculated accordingly.

For reference two options are available:

- Comparison with norm emission factors.
- Comparison with a representative number of minimum 4 reference farms.

The latter will increase the transfer of the test results to other countries.

Table 2. *Sampling strategy for test of livestock housing systems in cases where case-control within a farm is not possible*

Parameter	Requirement
Number of test farms	Minimum of four different farm locations
Minimum size of units for sampling	The unit size shall be representative for farms in the participating states.
Measurement periods	At each farm location: Ammonia, odour and dust (for yearly average): <ul style="list-style-type: none"> • Six days of measurements randomly distributed in one year. Approximately one measurement day each second month. Maximum one half of the measurement days shall be located during the first half of the growth cycle. Odour (for worst case during the summer): <ul style="list-style-type: none"> • Six extra days during the summer period¹ with outdoor temperature above 16°C (during sampling).

Emission measurements require the measurement of ventilation rates. In naturally ventilated building, ventilation rates cannot be measured by fans and have to be estimated by using tracer gas methods.

In certain cases this approach cannot be applied because naturally ventilated buildings are too open to allow a proper mixing of tracer gas and the investigated components, which is a prerequisite to apply this method. Currently, no adequate methods exist to investigate systems in case of very open buildings. Given the developments in open animal housings in cattle production there is a need for developing new measurement methods for open buildings.

¹ Summer period defined here as May 15th to September 30th.

5.4 Measurement parameters

Two lists of measurement parameters are shown in the two tables below: a list of primary measurement parameters and a list of conditional measurement parameters.

Table 3 shows the primary measurement parameters consisting of the primary environmental pollutants emitted from the livestock housing unit and which are the primary targets of the environmental technologies for livestock production.

As seen in Table 3 the primary measurement parameters are ammonia, odour, and dust.

Table 4 shows the conditional measurement parameters, which include parameters that may influence the emission level of the primary environmental pollutants or which are relevant reference values. In addition the table includes other – secondary - environmental pollutants.

Some of the conditional parameters are mandatory while others are optional. In the table the mandatory and optional measurement parameter are marked with “M” or “O”, respectively. In both tables it is mainly referred to measuring principles.

The measurement parameters specified in this protocol is based on existing national guidelines etc., but there is a need to develop international common measurement standards and a international reference guide.

For each measurement parameter the necessary units expressing the results are given. This is to ensure the highest possible comparability of the results and a sufficient informative basis for recalculating, reproducing, conversion and relating of values.

The emission has to be expressed per animal place and per time unit or per livestock unit and time unit.

If it is known that the type of environmental technology tested does not reduce a specific parameter or has only marginal effect on it the manufacturer/applicant can decide to specify the pollution reduction for this specific parameter as zero without making measurements.

Table 3. Primary measurement parameters

Parameter/ Units	Sample conditions (where, how and how often)	Measuring method (reference to the method)
Odour [OU/m ³]	<ul style="list-style-type: none"> • Minimum number and distribution of sampling days (refer to chapter 5.3). • Minimum three samples per sampling day. • Sampling between 9 am and 4 pm. • Sampling time: Between 30 and 120 minutes. • Sampling equipment: Nalophan, 30 litres bags (minimum size). • Sampling location: Cross section of air outlets, preferably mixed sample. 	EN 13725/AC:2006 Air quality – Determination of odour concentration by dynamic olfactometry Methods that are in compliance with this CEN standard.
Ammonia [mg/m ³]	<ul style="list-style-type: none"> • Minimum number and distribution of sampling days (refer to chapter 5.3). 	Photo-acoustic monitor (NDIR), FTIR spectrometer,

	<ul style="list-style-type: none"> • Sampling time: 24 hours. • Continuous measuring methods: based on hourly values (24 samples). • Sampling location: Air inlet and air outlet. • Correction of background concentration. 	NOx-chemoluminescence monitor, impinger system
Dust - PM10 - PM2.5 - Total [mg/m ³]	<ul style="list-style-type: none"> • Minimum number and distribution of sampling days (cf. chapter 5.3). • Continuous measuring methods: based on hourly values (24 samples). • Sampling time: 24 hours for PM10/2.5. • Sampling location: Air inlet and air outlet. 	Standards for outdoor measurements exists ¹ : EN 13284-1:2001 EN 13284-2:2004 EN 15259:2007 Also other instruments can be used e.g. Impactor, optical (light scattering) instruments, mircobalancing

General recommendations

- Avoid absorption, adsorption, diffusion, condensation, leakages, and blockages during sampling.
- Consider scavenging time and dead time of sampling tubes; rising time resp. dying out time of measuring instrument.
- Consider potential cross sensitivities of measuring instruments.
- Measuring range of instruments or methods should fit to effective range of expected values; avoid measuring close to the lower or upper detection limit.
- Calibration and maintenance of instruments and methods is mandatory.

Table 4. Conditional measurement parameters

Parameter/Unit M: Mandatory O: Optional	Sample conditions (where, how and how often)	Measuring method (reference to the method)
Ventilation rate (M) [m ³ /h]	Ventilation rate through all air outlets.	Mechanical ventilation: Fan wheel anemometer covering the whole outlet. In case of naturally ventilated housings ² : Tracer gas method (when sufficient amount of air mixing). ³
CO ₂ (M) [mg/m ³]	cf. Table 3 "Ammonia" and "General recommendations" above	
CH ₄ (O) [mg/m ³]	cf. Table 3 "Ammonia" and "General recommendations" above	

¹ A new, validated standard for measuring the emission of dust from livestock houses is needed.

² For a number of open housing units there are no ventilation rate methods available.

³ It is recommended in advance to ask for approval of the experimental layout.

H ₂ S (O/M in case of increased concentrations) [mg/m ³]	Combine with odour sampling	Electrical resistance of thin gold film
N ₂ O (O) [mg/m ³]	Combine with odour sampling	GC-ECD
Number and weight of animals in the housing unit (M) [kg]	Date, number and weight of animals when they are inserted and taken out of the housing unit and during the sampling days, service times.	Weighing
Amount of products (milk, eggs etc.) [O]		Documentation
Floor space per animal (M) [m ²] Air volume per animal (M) [m ³]	Type of floors (material, perforation, condition)	Documentation
Temperature (M) [°C]	<ul style="list-style-type: none"> • Minimum Sampling time: 24 hours (sampling days). • Continuous measuring methods: based on hourly values (24 samples). • Sampling location: Air inlet and air outlet. 	<p>Termo couples.</p> <p>Adequate measuring range, sensitivity, detection limit</p> <p>Consider undesired effects on measuring device through e.g. contaminations, wind or direct sunshine.</p>
Humidity (M) Relative humidity [%]	<ul style="list-style-type: none"> • Minimum sampling time: 24 hours (sampling days) together with particles else simultaneously with odour measurements. • Sampling location: Air inlet and air outlet. 	<p>Capacity sensor.</p> <p>Adequate measuring range, sensitivity, detection limit</p> <p>Consider undesired effects on measuring device through e.g. contaminations, wind, water or direct sunshine, frost.</p>
Wind (M: natural ventilation) <ul style="list-style-type: none"> • direction [°] • - speed [m/s] 	<ul style="list-style-type: none"> • Minimum Sampling time: 24 hours (sampling days) • Continuous measuring methods: based on hourly values (24 samples) • Sampling location: Luv side • Measuring height: 2.5 and 5 m 	<p>Ultrasonic anemometer Wind vane Cup anemometer Propeller anemometer</p> <p>Adequate measuring range, sensitivity, detection limit, free approaching flow</p> <p>Consider undesired effects on measuring device through e.g. contaminations or wind shadows, frost</p>
Global radiation (O) [W/m ²] Duration Intensity	<ul style="list-style-type: none"> • Minimum Sampling time: 24 hours (sampling days) • Continuous measuring methods: based on hourly values (24 samples) 	Solarimeter
Manure parameters (M) <ul style="list-style-type: none"> • Amount [kg] [m³] • pH • DM [%] • Organic DM [%] • N [%] [g/kg] 	<p>Minimum samples of sampling days</p> <p>Samples must be inactivated chemical and biological. (Immediately after sampling</p>	Laboratory methods

<ul style="list-style-type: none"> • TAN [%] [g/kg] • C:N • P, K • Additives/residues 	the samples must be stored in a cooled box and within 5 hours the samples must be located in a freezer).	
Registration of the dates of emptying the pits or manure channels (M)		
Cleaning of animal house and dunging behaviour	<p>Description of cleaning procedure.</p> <p>Registration of dunging behaviour in each pen on days with odour sampling</p>	
Fouling /pollution of surfaces (pen and animals)	Investigation during sampling days	Measurement Assessment / Rating
<p>Feed amount and composition</p> <p>[kg]</p> <p>DM [%]</p> <p>ME [MJ /kg]</p> <p>C</p> <p>XP</p> <p>XF</p> <p>Lysine</p> <p>P. K</p> <p>Additives</p> <p>Feeding strategy and frequency</p>	<p>Samples of charge</p> <p>Samples during sampling days near trough</p> <p>During the testing period the dietary protein contents should be within specific ranges for different pig categories and poultry. See Annex F</p> <p>In case of feed additives the correct amount/dose shall be verified.</p>	<p>Laboratory methods</p> <p>Documentation</p>
Pressure loss (O) [Pa]		Manemometer, electronic micro manemometer (difference pressure across membrane)
Noise (O)	Outdoor 1-2 m from ventilation outlet.	Noise level meter ISO 3746
<p>Consumption of electricity (M)</p> <p>[Kwh]</p> <p>Related to time</p>	Continuous measurement of electricity consumption by ventilation in general and potentially by the environmental technology	
<p>Consumption of water (M)</p> <p>[l]</p> <p>[m³]</p> <p>Related to time</p>	Continuous measurement	
<p>Consumption of chemicals /additives (e.g. acid) (M)</p> <p>[mg or kg] mass</p> <p>[l or m³] volume</p> <p>Each related to space and animals</p> <p>[m²]</p> <p>[AP]</p> <p>[LU]</p>	Continuous measurement	
Operational function and stability (M), Activities, special events (M)	Documentation	

The tests shall be performed taking the following conditions into consideration:

The ammonia emission factor shall be calculated in kg NH₃ animal place⁻¹ year⁻¹ as well as in kg NH₃-N kg⁻¹ total ammoniacal nitrogen (TAN) in the manure. The latter shall take into account that the emission of ammonia from a livestock housing system is not only affected by the housing design and management but also by the manure composition. The latter is a dynamic factor and will change over time due to development in feed composition and strategy, animal genetics, animal productivity, etc.

The TAN content can be estimated using the procedure of the Danish normative system¹. Based on the collection of the following factors the excretion of N, P, and K can be estimated with good approximation:

1. Amount of feed uptake in the test period (kg, feed units).
2. Feed composition (N, P, K, dry matter).
3. Amount of product in the test period (kg meat, milk, egg).
4. Product composition (g N, P, K).
5. Digestibility coefficients of the feed ingredients (N, P, K, dry matter).

5.5 Occupational health and safety requirements

In general, technical installations in livestock housing - as all industrial machinery and equipment – must comply with the Machinery Directive (Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)). They must be designed and constructed in such a way that they can be used, adjusted and maintained throughout all phases of their life without putting persons at risk.

In detail the installations must satisfy the essential safety requirements contained in Annex I of the Directive, a correct conformity assessment must be carried out and a “Declaration of Conformity” must be given.

It is the responsibility of the manufacturer, importer or end supplier of the equipment to ensure that equipment supplied is in conformity with the Directive. In addition, Council Directive 89/655/EEC of 30 November 1989 concerns the minimum safety and health requirements for the use of work equipment by workers at work (amended 2007/30/EC) and places obligations on businesses and employers to take into account potential dangers to operators and other persons using or affected by machines and equipment.

In general terms, the directive requires that all equipment provided for use at work is: Suitable for the intended use; safe for use, maintained in a safe condition and, in certain circumstances, inspected to ensure this remains the case; used only by people who have received adequate information, instruction and training; and

¹ Poulsen, H.D. & V.F. Kristensen, 1998. Standard values for farm manure. A reevaluation of the Danish standard values concerning the nitrogen, phosphorus and potassium content of manure. Ministry of Food, Agriculture and Fisheries, Danish Institute of Agricultural Sciences, DIAS report no 7, Animal Husbandry, 160 pp.

accompanied by suitable safety measures, e.g. protective devices, markings, warnings.

In addition, ISO 12100-2:2003 (Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles) defines technical principles to help designers in achieving safety in the design of machinery.

The safety instructions must be documented in a safety data sheet and must be observed carefully.

Before the beginning of any work, the installation must always be shut down.

5.6 Animal welfare

In general, technical installations in livestock housing must comply with

- the Council Directive 2001/88/EC (of 23 October 2001 amending Directive 91/630/EEC) laying down minimum standards for the protection of pigs;
- the Commission Directive 2001/93/EC (of November 2001 amending Directive 91/630/EEC) laying down minimum standards for the protection of pigs;
- the Council Directive 1999/74/EC (of July 1999) laying down minimum standards for the protection of laying hens;
- the Council directive 2007/43/EC (of June 2007) laying down minimum rules for the protection of chickens kept for meat production;
- the Council Directive of 19 November 1991 laying down minimum standards for the protection of calves (91/629/EEC).

They must be designed and constructed in such a way that they can be used, adjusted and maintained throughout all phases of their life without putting the animals at risk.

The main important factors are listed in the regulations in Annex G.

Furthermore the national legislation must be considered which describes the paragraphs often in more detail and imply higher requirements.

Animal health and welfare can be affected by different technical installations of a housing system. For example, the space provided per animal and the floor design in a pen has an effect on animal welfare. The higher or lower risk for some diseases is caused by different technical installations (e. g. manure system, access to a yard). The results of the BAT-Support project (link to the literature will be added) show in detail the influence of different technical modules on the animal welfare and the risk for animal health for pigs and poultry.

5.7 Food safety

The use of feedstuffs and feed additives shall be in compliance with the safety requirements in the European legislation, European Parliament and Council Regulation (EC) No. 1831/2003.

The aim of this regulation is to ensure:

- The use of safe feedstuffs and additives in livestock.
- Food safety (no residues of unwanted substances).
- The use of healthy food in relation to health and welfare of the consumers.
- Environmental protection.

Specific European directives specify limits and define whereby the use of feed additives is regulated to guarantee food safety when livestock products are used for human consumption.

The register on feed and feed additives (European Parliament and Council Regulation (EC) No. 1831/2003) is available at the link

http://ec.europa.eu/food/food/animalnutrition/feedadditives/legisl_en.htm

In addition, the community register contains a list of the accepted feed additives and current updated modifications pursuant to the Regulation (EC) No. 1831/2003. This list is available at the link

http://ec.europa.eu/comm/food/food/animalnutrition/feedadditives/registeradditives_en.htm.6

6. *User manuals*

In general, user manuals shall be written in a local language and in consideration of EN 62079:2003 (Preparation of instructions - Structuring, content and presentation) that provides general principles and detailed requirements for the design and formulation of all types of instructions.

The manual shall include the information provided with the system description according to chapter 4. In particular, it should bear instructions for

- the operation of the system and the technical installations;
- the prevention of and dealing with incidents (environmental safety);
- operational health and safety measures (see chapter 5.5);
- service and maintenance;
- surveillance of the installations.

7. Test report and evaluation

This paragraph describes the requirements to the test report including data handling, statistical analysis etc.

The test report shall be written in English and, if necessary, in the local language. The report shall include chapters on the below mentioned subheadings. The following text gives a description of the contents which must be included in the chapters.

Foreword

The foreword should include a description of the three parties that have been involved in the test - the applicant, the test organisation and the farmers.

The period in which the test has been performed must also be mentioned with specific dates.

The foreword must end with the date and signatures of the person(s) who have been responsible for the test. The signature must be accompanied by the name and address of the test organisation.

Introduction

The introduction may include a general description of, for example, the odour, and ammonia and dust problems in the agricultural sector and the need for new technology.

In addition, the introduction shall include a description of the applicant/manufacture involved in the test and give a general description of the housing and management system and technology. If the applicant/manufacture has performed previous tests, these shall be specified, and references shall be provided.

Materials and Methods

The materials and methods section shall include a description of:

- the farms involved in the test;
- the housing and management system and technology;
- the measurement method;
- calculation and statistical methods.

The housing unit in which the test is performed shall be described. The description shall include the

- animal category;
- the dimensions of the sections and pens;
- the number of pens per section;
- the number of animals per section.

In addition, the type of floor, dunging system, feed system and ventilation system shall be described. Photos taken inside the sections and photos of the housing unit shall be included in the test report.

The test design shall be described including the dimensioning of the test and the measurement methods with a specification of the measurement instruments used,

the measurement points, and the measurement frequency and calibration procedures.

Furthermore the test report shall include a description of the statistical data processing method, including used models and the statistical software package.

Results

The description of the results starts with a specification of the measured odour, ammonia and dust concentrations, which are the primary targets of the test. The individual raw data shall be shown first in graphs and subsequently the processed data shall be given in tables with median, average and 95 percentiles, and tests on the significance of the applied treatment effects.

After the presentation of the raw data a discussion of the results shall be given.

The average and standard deviation of the conditional measurement parameters (Table 4) shall be shown in tables and commented on in the text.

An evaluation of the operating stability of the system shall be given. This evaluation shall be based on observations made during the entire testing period and shall include all recorded data describing the stability of the system or technology.

The uptime of the system/technology during the test period shall be calculated as well as the efficiency of the technology corrected by the uptime factor.¹

Furthermore, the test report shall include an evaluation of the potential risks which may be related to the use of the system including potential impact on

- the welfare of the animals;
- the occupational health and safety;
- the total (external) environmental;
- food safety of e.g. feed additives.

These evaluations shall include situations with normal operation of the system/technology and any unforeseen use and problem.

The test report shall include advice to the verification authorities on how to inspect the system.

Finally the test report shall include an evaluation of how the results can be applied to other types of animal housing units or other animal categories.

Discussion and conclusion

The conclusion describes and discusses the test results and validates the housing and management system and technology in general. The results will be discussed in relation to aspects of the working principle of the system, plausibility of the results, and to findings in related research reports. The conclusion chapter shall include aspect only which can be justified in the results chapter in the test report.

¹ If, for example, the measured efficiency of a technology to reduce emission of ammonia is 90% and the uptime is 80% the corrected efficiency of the technology is 72%.

References

Relevant references to be specified.

Annexes

Annexes can be added if relevant.

8. Bibliography

EN 481:1994 *Workplace atmospheres - Size fraction definitions for measurement of airborne particles.*

EN 62079:2003 *Preparation of instructions - Structuring, content and presentation.*

EN 13725 *Air quality – Determination of odour concentration by dynamic olfactometry*

EN 13284-1:2001 *Stationary source emissions - Determination of low range mass concentration of dust - Part 1: Manual gravimetric method.*

EN 13284-2:2004 *Stationary source emissions - Determination of low range mass concentration of dust - Part 2: Automated measuring systems.*

EN 15259:2007 *Air quality - Measurement of stationary source emissions - Requirements for measurement sections and sites and for the measurement objective, plan and report.*

ISO 3746 *Acoustics - Determination of sound power levels of noise sources - Survey method*

ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories*

ISO 12100-2:2003 *Safety of machinery - Basic concepts, general principles for design - Part 2: Technical principles*

Annexes

Annex A (informative) Template for a test plan

NAME OF TEST INSTITUTE

TEST PLAN FOR [technology/system]

[name of technology/system] **delivered from** [name of manufacturer/applicant]

CONTACT DATA ETC.:

Farmer / Chr. No.:	
Address of housing unit (if different from the address of the heard owner):	
Health status:	
Visiting rules:	
Start of test of test (dd/mm/yy):	
End of test (dd/mm/yy):	
Responsible technician:	
Technician(s):	
Consultant(s) from the test institute:	
Local advisor/veterinarian:	
Contact person from the company financing the test:	
Service technician(s) from the supplier of the technology/system:	
File:	

BACKGROUND AND AIM [maximum of one page]

A description of the technology/system can be seen in Annex x. The development process of the technology/system and any previous tests shall be specified (references shall be mentioned in the reference list at the end of the test plan).

The section shall include a precise description of the aim of the test and a specification of the primary test parameters.

TEST PROCEDURE

The description of the test procedure shall include the following items:

- Description of the herd and the housing system/technology where the test is conducted. (Previous description of the individual components in the system/technology shall be specified in an appendix to the test plan. The verification authorities can then check that the applied system/technology is identical to the tested system/technology).
- Specification of the primary measurement parameters, e.g. odour and ammonia (see Table 3).
- Specification of the secondary measurement parameters (see Table 4).
- Description of the location of measurement points, instruments and how they are calibrated.
- Description of the work procedures in the housing unit and how the animal production parameters shall be recorded (see Table 4).
- Timetable for the entire test period.
- Logbook (location of logbook and description of parameters that shall be recorded).

DATA RECORDING

The tables to be used shall be stated.

ALLOCATION OF RESPONSIBILITY

The allocation of responsibility shall include all work processes, so the technician can use the list when instructing the stockmen.

A list should be drawn up for each section and for each air cleaner.

What needs to be done	When	By who

PROCESSING OF RESULTS

Raw data shall be presented in tables, which shall be included in appendices in the final test report. The raw data shall also be presented in graphs, which shall be included in the results section in the final test report.

The primary measurement parameters shall then be analysed in accordance with the specifications given in the test protocol.

For example, the ammonia concentration and the logarithmically transformed odour concentration can be processed with an analysis of variance in the MIXED Procedure in SAS (SAS Inst. Inc., Cary, NC). Both the median and the 95 percentiles shall be calculated for odour concentration and odour emission. For the other primary parameters, the average shall be calculated instead of the median.

The average and the standard deviation shall be calculated for the secondary parameters.

COMPENSATION

The farmer is provided with compensation in connection with the test. The farmer is paid DKK/Euro XXX per hour for any extra work.

APPENDICES

The appendices shall include all data recording tables, e.g. tables for

- Odour recordings.
- Ammonia recordings.
- Dunging behaviour.
- Production data.

UPDATINGS OF THE TEST PLAN

The test plan shall be up dated every time changes are made. It is not enough to list the changes in the logbook. For each update, the date for the changes shall be noted and the test plan shall be given a new version no.

Example:

1st version: DD/MM/YY initials 1 / initials 2

2nd version: DD/MM/YY initials 1 / initials 2

Annex B (informative) Example of a contract

CONTRACT

BETWEEN [name of the company financing the test]

AND [name of the test organisation]

AND [name of the farmer(s)]

ABOUT Test of the technology/system called [name of technology/system]
delivered from [name of manufacturer/applicant]

1. AIM

1.1. The aim is to test the technology/system called [name of technology/system] according to the test protocol called [name of test protocol].

2. SCOPE AND TEST PROCEDURE

2.1. The test includes the system/technology in a unit for sows/weaners/finishers weighing between xx and yy kg.

2.2. The enclosed test protocol states how the test shall be conducted and specifies which data recordings and analyses shall be performed.

2.3. The animals included in the trial shall be housed in accordance with EU and national legislation.

2.4. The farmer, the company financing the test and the manufacturer/applicant shall agree that all results shall remain confidential during the test period and until the final test report is published.

2.5. Data recordings and analyses can be conducted by other institutes, provided that this is specified in the contract.

2.6. The service contracts shall be drawn up before the test starts and shall not be changed during the test period.

3. REQUIREMENTS

3.1. Requirements for checking feed and production specified in the working plan

shall be met by the farmer.

- 3.2. All production-related data shall be available, including receipts for purchases and sales of animals and receipts for feed.
- 3.3. Animals shall only be moved in accordance with the guidelines laid down by the test institute.
- 3.4. Changes to the housing unit (system/technology) and/or the production shall not be made without an agreement with the test institute.
- 3.5. The results of the test shall not be manipulated to benefit the farmer or anyone else.
- 3.6. During the contract period, the farmer shall not conduct tests together with other parties other than the test institute.
- 3.7. The farmer shall agree to inform the herd veterinarian and production consultant that the test is being conducted.

4. HERD VISITS / INFORMATION / ANALYSIS

- 4.1. As required, a technician from the test institute shall conduct an inspection of the herd and the relevant system/technology. The technician collects data and provides the farmer with data recording tables. Further details of the visits are described in the enclosed test protocol.
- 4.2. The results of the test shall remain confidential until the results have been published.
- 4.3. Analyses of the feed content shall be performed in accordance with the test plan.

5. TERMINATION OF THE CONTRACT

- 5.1. The contract runs until DD/MM/YY.
- 5.2. The contract is irrevocable for the farmer, the test institute and the manufacturer/applicant until DD/MM/YY.
- 5.3. In case of unforeseen problems with the animal production or the system/technology, the contract and test protocol can be reconsidered. If it is not possible to find a solution, the farmer, the test institute and/or the manufacturer/applicant may terminate the test with one month's notice.

6. VISITING RULES

- 6.1. When the farmer signs the contract, he shall declare that the health status of the herd is _____. The test institute shall be informed immediately of any disease outbreaks where the health status of the herd is at risk.

-
- 6.2. In order to disseminate the knowledge of the new technology, the farmer shall agree to receive visits when contacted by the test institute.
 - 6.3. During herd visits, the farmer shall agree to observe the general visiting rules, i.e. quarantine period of at least 12 hours after contact with livestock with a lower health status than that of the farmer's livestock. Quarantine is not required after visits on farms with livestock with a higher health status or the same health status.

If the farmer has established his own visiting rules, these rules shall also be complied with.

7. COMPENSATION

- 7.1. Compensation is paid for extra work carried out during the test period. The farmer is paid DKK/Euro XXX,- per hour for extra work.

This point shall include any agreements made by the three parties regarding the amount of compensation and what the compensation covers.

8. RESPONSIBILITY

- 8.1.
- 8.2.

9. RECONSTRUCTION COSTS

- 9.1. Costs relating to changes or installations that can be attributed to a specific test are covered by the test institute or the manufacturer/applicant.
- 9.2. Equipment and material purchased by the test institute or the manufacturer/applicant belong to these parties, unless otherwise agreed.
- 9.3. Ownership after completion of the test shall be specified.
- 9.4. If the farmer terminates the present contract during the test period (see point 5.3), the test institute and manufacturer/applicant reserve the right to decide what to do with the equipment installed on the farm. The farmer can, by agreement with the test institute, acquire the entire installation at a fixed price.
- 9.5. If the test institute or the manufacturer/applicant terminate the present contract during the test period (see 5.3), the ownership of the installation and equipment is as specified in point 9.3. Furthermore, if the manufacturer/applicant terminates the contract during the test period, they shall pay for the measurements taken so far.
- 9.6. If the farmer goes bankrupt or the farm is put up for sale, the test institute is entitled to reclaim the equipment purchased by the test institute. The same applies to the manufacturer/applicant if the company goes bankrupt or closes

down.

- 9.7. The farmer is responsible for maintaining the equipment and covering the costs of fire insurance for the equipment installed in connection with the test. The farmer is also responsible for ensuring that the equipment is in compliance with the environmental approval.
- 9.8 With regard to test facilities established on the farm in connection with the test, the test institute and the manufacturer/applicant are subject to the legislation of the country in which the test is performed. The test institute is therefore not liable for any operating loss and cannot be held responsible for any indirect loss arising from the test facilities.

Date and place

Farmer

Date and place

Applicant/Manufacturer

Date and place

Test organisation

Annex C (informative) Emission factors for ammonia for different animal categories

The table shows ammonia emission coefficients and emission factors for different livestock categories and housing systems in Germany, The Netherlands and Denmark

Live-stock	Housing and floor system	Manure ¹	DE NH ₃ -N kg/kg N ²	DE NH ₃ /(A P a)	NL NH ₃ /A P a) ³	DK
Dairy cows	Slatted (channel, back flushing)	Liquid	0,236	14.6	9.5	0.16
	Pre-manufactured floor	Liquid	No data	-	?	0.08
	Deep litter	Deep litter	0,236	14.6	-	0.06
	Zero grazing, slatted floor	Liquid			11	
Grower/ finishers	Partially slatted (solid 50-75%)	Liquid	0,268	3.6	3.5	0.13
	Partially slatted (solid 25-49%)	Liquid		3.6	-	0.17
	Fully slatted	Liquid	0,268	3.6	4	0.24
	Deep litter	Deep litter	0,384	4.9	-	0.25
Piglets	Two climate housing, partially slatted	Liquid	0,196 ⁴	0.4	0.43	0.10
	Fully slatted	Liquid	0,268	0.5	0.6	0.24
	Deep litter	Deep litter	0,384	No data	-	0.25
Sows, pregnant	Individual, partially slatted	Liquid	0,239 ⁵	7.3	4.2	0.13
	Individual, fully slatted	Liquid			-	0.19
	Deep Litter	Deep litter			2.6	0.25
Sows, lactating	Box, partially slatted	Liquid			8.3	0.13
	Box, fully slatted	Liquid			-	0.26
Broilers	Deep litter	Deep litter	0,138 ⁶	0.05	0.08	0.20
Layers	Free-range, solid manure	Solid	0,351 ⁶	0.32 floor housing, manure pit	0.315	0.40

Sources:

German data: Dämmgen, U. (ed.) (2009): *Calculation of emission from German agriculture – National emission inventory report (NIR)*, vTI Agriculture and Forestry Research, special issue 324.

Dutch data: Infomil, 2009. Information centre for the environment: InfoMil. Regulatory list of ammonia emission factors and system description, in Dutch. Available at: <http://www.infomil.nl/asp/get.aspx?xdl=/views/infomil/xdl/page<mldt=29375&Sitldt=111&Varldt=82>

Accessed at March 2009.

¹ Liquid manure: Based on TAN = total ammoniacal nitrogen (nitrogen in urine)

Deep litter and solid manure: Based on total nitrogen excreted in urine and faeces.

² Related to TAN.

³ For NL only reference housing systems included; minimum levels for BAT-systems are lower.

⁴ Naturally ventilated housing with kennels.

⁵ No differentiation between the housing systems.

⁶ Related to total N.

Annex D (informative) Emission factors for odour for different animal categories

The table shows odour emission coefficients for different livestock categories and housing systems in Germany, The Netherlands and Denmark

Animal type	Housing unit	DE (annual average, OU/(LU s))	NL OU/AP s ⁻¹	DK (5 & 95 percentiles)
Dry sows	Sows kept in individual crates	20	19	16 OU _E /sec./animal (7-39)
	Sows kept loose	-	19	16 OU _E /sec./animal (7-39)
Lactating sows	Sows and piglets kept in crates with partially slatted floor	15	228	72 OU _E /sec./sow (40-125)
	Sows and piglets kept in crates with fully slatted floor	15	28	100 OU _E /sec./sow (56-280)
Weaners	Weaners kept in pens with partially slatted floor	75	8	380 OU _E /sec./1000 kg animal (200-750)
	Weaners kept in pens with fully slatted floor	75	8	380 OU _E /sec./1000 kg animal (200-750)
Finishers	Finishers kept in pens with partially slatted floor	50	23	300 OU _E /sec./1000 kg animal (110-810)
	Finishers kept in pens with fully slatted floor	50	23	450 OU _E /sec./1000 kg animal (190-1200)

Odour emission factors from production units with cattle

Animal type	Housing unit	DE (annual average, OU/(LU s))	NL	DK (5 & 95 percentiles)
	All type of housing units	12		170 OU _E /sec./1000 kg animal
Beef cattle 6-24 month			36	
Veal calves			36	

Odour emission factors from poultry				
Animal type	Housing unit	DE (annual average, OU/(LU s))	NL OU/AP s ⁻¹	DK (5 & 95 percentiles)
Layers	Floor systems	60	0.35	900 OU _E /sec./1000 kg animal
Layers	Cages	20 (aerated manure belt)	0.34	400 OU _E /sec./1000 kg animal
		50 (manure belt, no aeration)		
	Aviary system	30 (aerated belt)	0.34	
		55 (manure belt, no aeration)	0.34	
Broilers	Deep litter	60	0.24	400 OU _E /sec./1000 kg animal

Sources:

Dutch data: Infomil, 2009. Information centre for the environment: InfoMil. Regulatory list of ammonia emission factors and system description, in Dutch. Available at:
<http://www.infomil.nl/asp/get.aspx?xdl=/views/infomil/xdl/page<mldt=29375&Sitldt=111&Varldt=82>
 Accessed at March 2009.

Annex E (informative) Emission factors for dust (PM10) for different animal categories

The table shows dust emission factors for different livestock categories and housing systems in Germany, The Netherlands and Denmark

Livestock	Housing and floor system	Manure	DE kg/ (AP a)	NL	DK
Dairy cows	Slatted (channel, back flushing)	Liquid	1.8	0.3	
	Pre-manufactured floor	Liquid	-	-	
	Deep litter	Deep litter	0.4	-	
Grower/ Finishers	Partially slatted (solid 50-75%)	Liquid	0.24	0.275	
	Partially slatted (solid 25-49%)	Liquid		-	
	Fully slatted	Liquid	0.24	0.275	
	Deep litter	Deep litter	0.32	-	
Piglets	Two climate housing, partially slatted	Liquid	0.08	0.132	
	Fully slatted	Liquid	0.08	0.132	
	Deep litter	Deep litter	-	-	
Sows, pregnant	Individual, partially slatted	Liquid	0.16	0.220	
	Individual, fully slatted	Liquid	0.16	0.220	
	Deep Litter	Deep litter	0.8	-	
Sows, lactating	Box, partially slatted	Liquid	0.16	0.208	
	Box, fully slatted	Liquid	0.16	-	
Broilers	Deep litter	Deep litter	0.015	0.053 ¹	
Layers	Free-range, solid manure	Solid manure	0.24	0.058 ¹	

Sources:

Dutch data: Regulatory list of the ministry of environment:

VROM, 2009:

http://www.vrom.nl/Docs/milieu/2008/bestanden%20per%2020%20mei/Emissies_fijnstof_veeh_210308.xls

Accessed 3-3-2009

¹ Dust emission data for poultry will be revised in March 2009.

Annex F (informative) Feeding parameters

Ranges of dietary protein contents in different pig categories in NL, DK and DE

Fatteners:	Up to 50 kg live weight	15-18% crude protein (DE: 17-19%)
	> 50 kg live weight	14-16.5% crude protein (DE: 15.5-16.5%)
Piglets:	< 20 kg:	18-21% crude protein (DE: 18.5-19%)
	> 20 kg:	17-20% crude protein (DE: 18%)
Sows:	Pregnant	11-14% crude protein (DE: 12-14%)
	Lactating	13-16% crude protein (DE: 16-17.5%)

Dietary protein contents in poultry feeding (approximate values)

DK

Broilers, 1.6-3.0 kg live weight, 30-45 days of age	20-21% crude protein
Outdoor broilers, 2.4 kg live weight, 56 days of age	15% crude protein

Turkeys, females, 10 kg live weight	20% crude protein
Turkeys, males, 20 kg live weight	18% crude protein

Ducks, 4 kg live weight	17% crude protein
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Geese, 7 kg live weight	16% crude protein
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Laying hens	16-18% crude protein
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DE

Laying hens: 18-20 weeks	12-13.5% crude protein
20-42 weeks	15.5-16.5% crude protein
43-63 weeks	15-16.5% crude protein

Broilers:	1-2 weeks	22-23.5% crude protein
	2-5 weeks	22-24.5% crude protein
	> 5 weeks	18-20% crude protein

Turkeys:	Week 1-2	28.5-29.5% crude protein
	Week 3-5	26-27.5% crude protein
	Week 6-9	23-24.5% crude protein
	Week 10-13	21-22.5% crude protein
	Week 14-17	18-19.5% crude protein
	Week 18-22	14-15.5% crude protein

Ducks:	Week 1-2	18-20% crude protein
	>2 weeks	16-18% crude protein

The farmer must be able to document the actual crude protein level in the feed during the test period. If the farmer is not able to deliver this documentation, three feed samples must be taken spread over the measurement period and analysed.

Annex G (normative) Animal welfare, EUROPEAN GUIDELINES

Council Directive 2001/88/EC of 23 October 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs

PIGS:

- Unobstructed floor area available for each pig (weaner, rearing pig kept in group)
- Total unobstructed floor area available for each gilt after service and to each sow
- Flooring surface for gilts after service and pregnant sows (solid floor)
- Concrete slatted floor: Max. width openings (piglets, weaners, rearing pigs, gilt after service and sows); Min. slat width (piglets and weaners, rearing pigs, gilts after service and sows)
- Group housing for sows and gilts
- Sows and gilts shall have permanent access to manipulable material
- Sows and gilts kept in groups: fed using a system which ensures that each individual can obtain sufficient food even when competitors for the food are present
- Pregnant sows and gilts: must be given a sufficient quantity of bulky or high-fibre food as well as high-energy food
- "Aggressors" or attacked pigs, sick or injured pigs may temporarily be kept in individual pens (shall allow the animal turn around easily)

Commission Directive 2001/93/EC of November 2001 amending Directive 91/630/EEC laying down minimum standards for the protection of pigs

General Conditions

- Buildings: continuous noise levels as loud as 85dBA shall be avoided
- Light: intensity of at least 40 lux for min 8h/d
- Accommodation:
 - lying area: physically and thermally comfortable as well as adequately drained and clean which allow the animals to lie at the same time
 - Rest and get up normally
 - See other pigs (exception: the week before the expected farrowing time and during farrowing)
- Pigs must have permanent access to a sufficient quantity of material to enable proper investigation and manipulation activities (straw, hay, wood, sawdust, mushroom compost, peat or a mixture of such)
- Floors: smooth but not slippery; so designed, constructed and maintained so as not to cause injury or suffering to pigs; suitable for the size and weight of the pigs; no litter: form a rigid, even and stable surface
- Fed: once a day; fed in groups and not ad libitum or automatic system feeding the animals individually: each pig must have access to the food at the same time as the others in the group
- >2 weeks of age: pigs must have permanent access to a sufficient quantity of fresh water

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- Procedures intended as an intervention carried out for other than therapeutic or diagnostic purposes or for identification (resulting in damage to or the loss of a sensitive part of the body or the alteration of bone structure) shall be prohibited with the following exceptions:
 - ≤ 7 days of life: uniform reduction of corner teeth of piglets
 - docking of a part of the tail
 - castration of male pigs by other means than tearing tissues
 - nose ringing (only: outdoor husbandry systems and in compliance with national legislation)

Specific provisions for various categories of pigs

BOARS:

- Pens. Must allow the boar to turn around, to hear smell and see other pigs; unobstructed floor area

SOWS AND GILTS:

- Measures for minimising aggressions in groups
- If necessary treated against external and internal parasites; farrowing crates: pregnant sows and gilts must be thoroughly cleaned
- Week before the expected farrowing time: must be given suitable nesting material in sufficient quantity unless it is not technically feasible for the slurry system
- Unobstructed area behind the sow or gilt must be available for the ease of natural or assisted farrowing
- Farrowing pens where sows are kept loose: some means of protecting the piglets; farrowing rails

PIGLETS:

- Part of the total floor- sufficient to rest together at the same time- must be solid or covered with a mat, or littered with straw or other suitable material
- Farrowing crate: piglets must have sufficient space to be suckled without difficulty
- Weaning at least 28d- 7 days earlier when moved into specialised housings

WEANER AND REARING PIGS:

- Groups: measures to prevent fighting (beyond normal behaviour)
- Groups: little mixing as possible, mixing at as young an age as possible, provided with opportunities to escape and hide
- Severe fighting: causes shall be investigated and appropriate measures taken (providing straw , other materials), aggressors shall be kept separate
- Tranquillising medicaments: to facilitate mixing shall be limited to exceptional conditions , only after consultation a veterinarian

LAYING HENS:

Council Directive 1999/74/EC of July 1999 laying down minimum standards for the protection of laying hens

Alternative Systems

- Systems must be equipped:
 - feeders, at least 10cm/bird; circular feeders at least 4cm/bird
 - Continuous drinking troughs 2,5 cm/hen; circular drinking troughs 1cm/hen; one nipple drinker or cup for every 10 hens
- One nest for every 7 hens, group nest: at least 1m² of nest space for max. 120 hens
- Perches: without sharp edges, at least 15cm/hen, not mounted above the litter, horizontal distance between perches at least 30cm, horizontal distance between the perch and the wall at least 20cm
- At least 250cm² of littered area/pen, litter occupying at least one third of the ground surface
- Floors of installations: support adequately each of the forward-facing claws of each foot
- Systems (rearing) where laying hens can move freely between different levels: max. 4 levels; headroom between levels at least 45cm; drinking and feeding facilities: equal access for all hens; level arrangement: prevent droppings falling on the levels below
- Open runs: several popholes (35cm high, 40cm wide and extending along the entire length of the building, total opening: 2m/1000hens); equipped with shelter, if necessary drinking troughs
- Stocking density: ≤ 9 hens/m² usable area

Enriched cages:

- At least 750cm²/hen (600cm² usable)
- A nest
- Litter (scratching, pecking)
- Perches (15cm/hen)
- Feed through: 12cm/hen, ad libitum
- Drinking system: appropriate to the size of the group; 2 nipple drinkers or cups within the reach of each hen
- Inspection, installation and depopulation of hens: min. aisle width of 90cm between tiers of cages, min. 35cm between the floor of the building and the bottom tier of cages
- Claw-shortening devices

- Inspection by the owner (once a day)
- Sound level shall be minimised (constant or sudden noise shall be avoided)
- Light levels (sufficient to allow all the hens to see one another and be seen clearly, show normal levels of activity; natural light: light must be distributed evenly; lighting regime: prevent health and behavioural problems)
- Cleaning and disinfection of the parts which are in contact with the hens regularly, in any case before a new batch of hens is brought in
- Droppings must be removed as often as necessary; dead hens every day
- Cages: equipped to prevent hens escaping
- Tiers of cages: must allow inspection of all tiers and facilitate the removal of hens
- Cage door: an adult hen must be removed without injury
- Mutilation shall be prohibited (Member States may authorise beak trimming)

Council directive 2007/43/EC of June 2007 laying down minimum rules for the protection of chickens kept for meat production

- Max. stocking density (33kg/m²)
- Higher stocking density (39kg/m²) if stricter welfare standards are met
- Max. stocking density of 39kg/m² be increased by max. 3kg/m² (monitoring, good management practice, cumulative daily mortality rate)

- Drinkers position
- Feed availability
- Litter: dry and friable on the surface
- Ventilation; sufficient to avoid overheating; in combination with heating systems: remove excessive moisture
- Noise: sound level should be minimised
- Light: at least 20 lux (bird eye level) during the lighting period, lightning before slaughtering
- Inspection: at least twice a day
- Cleaning: thoroughly cleaned and disinfected every time after final depopulation, clean litter must be provided
- Record keeping (number of chickens, useable area, hybrid of chickens...) retained at least for three years
- Surgical interventions: other than therapeutic or diagnostic purposes shall be prohibited (beak trimming may be authorised by Member States)

Council Directive of 19 November 1991 laying down minimum standards for the protection of calves (91/629/EEC) (rearing and fattening)

- No individual pens after an age of eight weeks (exception: veterinarian certifies it)
- Width and length of any individual pens
- Individual pens: no solid walls
- Calves in groups: unobstructed space allowance (depending on the live weight)

- Materials used for the construction (not harmful, capable to clean)
- Electrical circuits and equipment must be installed so as to avoid electric shocks
- Insulation, heating and ventilation: must ensure that air circulation, dust level, temperature, relative air humidity and gas concentration in levels which are harmful
- Automated or mechanical equipment (concerning health and well-being); inspected once daily
- Artificial ventilation system: appropriate back-up system to guarantee sufficient air renewal, alarm system (tested regularly)
- Light: not permanently in darkness; appropriate natural or artificial lightning equivalent to the period of natural light (9 a.m. to 5 p.m.), strong enough for inspection at any time
- Inspection: at least twice daily (housed calves); once daily (calves kept outside)
- Accommodation: allow to lie down, rest, stand up and groom itself without difficulty
- Calves shall not be tethered, exception: group-housed calves, not more than one hour at the time of feeding milk or milk substitute

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- Housing, pens, equipment and utensils must be properly cleaned and disinfected; Faeces, urine and uneaten or split food must be removed as often as necessary
 - Floors: smooth but not slippery; suitable for the size and weight; form a rigid, even and stable surface
 - Lying area: comfortable, clean, adequately drained, not affect the calves; bedding for all calves less than 2 weeks old
 - Diet: appropriate to their age, weight and behavioural and physiological needs; sufficient iron (blood haemoglobin level of at least 4,5 mmol/litre), min. daily ration of fibrous food (> 2 weeks), raising from 50g-250g per day from 8-20 weeks old
 - Calves shall not be muzzled
 - Fed at least twice a day, no ad libitum feeding or automatic feeding system: access to the food at the same time
 - > 2 weeks: sufficient quantity of fresh water or other liquids; hot weather conditions: fresh drinking water at all times
 - Feeding and watering equipment: contamination must be minimized
 - Bovine colostrum: as soon as possible after it is born; in any case within the first 6 hours