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Boiler inspection in the EU: Achievements and challenges for the future

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Energy Efficiency in Buildings

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1 INTRODUCTION

In the European Union several policy measures have been introduced to assure the development of modern domestic boilers with a high useful efficiency (1). In this context the application of the CE mark with **laboratory efficiency** requirements for oil and gas fired boilers has been a milestone.

In practice however this high quality level may deteriorate when the working conditions of the boiler are unfavourable. Moreover, if end-users are not informed about the advantages to replace their old boilers, the penetration of new efficient techniques will be slowed down.

Therefore a consistent energy policy programme also needs to guarantee that the advantages of a high development and production quality are preserved on-site. In other words, the "**on-site efficiency**" has to be optimized as well. This means that not only the technical characteristics of the heating system play an important role, but also the activities of heating installers and the user behaviour.

"**Regular boiler inspection**" is an essential tool to keep the on-site efficiency at an acceptable level and to act when necessary.

The aim of this contribution is to give a brief summary of the recent status of boiler inspection in the EU, to point out some existing barriers and to define specific needs for the near future.

2 BOILER INSPECTION IN THE EU

2.1 SAVE context

In the Council Directive 93/76/EEC (2) the European Commission proposes a policy with particular attention for the "on-site" situation of heating systems. This is formulated in Article 6:
"*Member States shall draw up and implement programmes on regular inspection of heating installations of an effective rated output of more than 15 kW with the aim of improving operating conditions from the point of view of energy consumption and of limiting carbon dioxide emissions*".

Boiler inspection in this context can very broadly be defined as the regular check-up of the heating installation or parts of this installation to verify the energy efficient working.

Furthermore it is clear that in the SAVE strategy "boiler inspection" is not a stand-alone topic. It forms the essential part of a larger approach to optimize CO_2 reduction in the heating sector. Apart from a primary reduction of the heat demand, this approach mainly consists of three elements:

- o High efficiency of new boilers being introduced on the market by CE marking to assure good initial quality;
- o Regular inspection of existing heating systems to keep the quality at a high level in function of time and replace or adjust when necessary;
- o Motivated choice of new efficient heating systems.

In the SAVE II programme several projects have been supported by the European Commission to work out this strategy. In this contribution especially the aspect boiler inspection will be treated but the links with boiler replacement and choice of new efficient systems will be stressed.

2.2 Available data

First of all it has to be mentioned that it requires a considerable effort to gather consistent data on the activities concerning boiler inspection in the different Member States. This is amongst others because different actors are involved: government, installers, chimney sweeps, boiler and burner manufacturers, energy companies, education centres, end-users,…

The summary given below is mainly based on the results of a SAVE project (3). This SAVE project started in January 1995 and was finished by the end of 1996. Although some small changes have occurred during the last three years, the main conclusions of this project are still valid for the new millenium.

The SAVE project as mentioned above consisted of 2 phases: a detailed research on boiler inspection in Flanders (Belgium) and a general research in the European Union. In this last phase an information-exchange was set up between heating experts of different European countries. About 35 experts from 16 countries (all Member States + Switzerland) participated to the information-exchange.
Both professional organisations of boiler manufacturers, installers and chimney sweeps, consumer organisations, research institutes, energy companies and governmental institutions contributed to this phase. Both gas and oil experts were represented.
The information-exchange resulted in amongst others in:
o a comparison of the existing legislations and guidelines in the Member States with respect to boiler inspection. Several aspects were analysed: official control of the application, education of heating technicians, technical inspection requirements, the application area of the legislation,...
o barriers and attitudes of end-users and heating technicians.

2.3 Existing legislations and guidelines for boiler inspection

The information below refers to boiler inspection in the residential sector. For larger heating plants a separate legislation is mostly applied focussing on emission reduction.

Most of the Member States have a legislation or define voluntary guidelines to stimulate maintenance and inspection of smaller central heating boilers. The specific contents however differ significantly from one country to another.

Legal status and application area

Most, but not all, of the countries have an obligatory maintenance and/or inspection for oil fired boilers. For gas fired boilers on the contrary maintenance and inspection is obligatory in only 7 countries. A legislation on inspection of coal fired boilers and decentral heating equipment is even less frequent.

General requirements

The inspection procedure of a boiler may consist of several activities:
o cleaning: boiler, chimney,...
o safety checkings: tightness of fittings,...
o flue gas measurements:
  energy aspects: flue gas losses,...
  environmental aspects: emissions of soot, NO_x,...
  safety aspects: CO-emission,...
o adjusting the burner settings
o setting of the control system,...

Considerable differences can be noticed between the Member States. In some countries the inspection job is limited to the cleaning part (chimney and/or boiler). In France for instance no specific legislation exists and inspection generally consists of the sweeping of the chimney. In Sweden the legislation does not prescribe a flue gas measurement (only cleaning of boiler and chimney).

In other countries the legislation prescribes an inspection service with several aspects: cleaning of chimney, of the boiler, adjustment of the burner, flue gas measurements and safety checks (eg. Germany).

The inspection however is mostly limited to the boiler, burner and chimney. The other parts of the heating system: distribution ducts, control system, radiator system are in most cases not included in the inspection.

Technical requirements

There are large differences concerning the technical requirements in the different countries. Moreover in several countries the technical requirements are not in accordance with the current status of technology.

For oil fired boilers:

- o Maintenance interval: The maintenance interval for oil fired boilers is mostly 1 year.
- o CO_2: The CO_2 content in the flue gases is not always an obligatory requirement. Some countries only have a requirement for the flue gas losses which is the combination of a requirement for the CO_2 content and for the flue gas temperature. The CO_2 requirement varies between 8,5 and 12 volume%.
- o Flue gas temperature: Similar to CO_2, the flue gas temperature is not always an obligatory requirement. Maximum values in the existing legislations vary between 210 and 320°C.
- o Flue gas losses: Minimum requirements for flue gas efficiency for oil fired boilers vary between 78 and 92%. Sometimes different values are used depending on the heating capacity or on the age of the boiler.
- o Soot number: A maximum soot number is mostly required for oil fired boilers. Values vary between 1 and 3 Bacharach.
- o NO_x and CO: In the existing legislations requirements concerning NO_x and CO generally do not occur. Boilers with higher capacities (>100 kW) on the contrary mostly have to comply with minimum requirements for these types of emissions. Denmark forms an exception with CO requirements (<500 ppm 0% O_2 for installations with blue flame burners). Belgium and Italy require a maximum CO-emission of 1000 ppm (0% O_2).
- o Others: In some countries it is required that no oil residu may be found on the filter paper used for testing the soot number.

For gas fired boilers:

Time intervals for maintenance vary between 1 and 3 years. Requirements for CO_2, flue gas temperature and flue gas losses are not common. Typical flue gas losses vary between 10 and 15% depending on the boiler age and capacity. Not many countries require maximum values for other emissions. In some cases (eg. Denmark, Luxembourg) measurement of the chimney pressure is regarded as useful.

For coal fired boilers:

Few information is available on the technical requirements for coal fired boilers.

Heating technicians and education

In most of the countries maintenance and inspection is carried out by "qualified" heating technicians. A qualified heating technician generally needs to have an education certificate and has to prove experience. Only in a limited number of countries the qualification of the technician is limited in time (3 to 5 years).

The type of education for the qualified technicians may differ from one country to another:

- o The time of the training courses is or is not specified. When specified it may vary between 60 hours and elaborated courses of 3x280 hours.
- o Some countries provide refresher courses (eg. Austria, Belgium, Denmark).
- o Germany has a very specific structure concerning heating inspection and education which is based on the "Bezirksschornsteinfegermeister".

Inspection certificate

In several countries an inspection certificate is obligatory. The certificate mostly contains information on the checkings made by the technicians and on the results of the flue gas measurements. Advice is rarely added. The type of this certificate may be different from one country to another: booklet, leaflet, label,...

Control on the application of boiler maintenance

Control actions can be taken on different levels:

o education level: control on the activities of the education centres
o technician level: control on the qualification of the technicians (updated lists)
control on the quality of the maintenance job (competence)
o end-user level: control of the presence/completeness of a maintenance certificate
control of the flue gas parameters (measurement check).

In most of the countries the control actions are limited to the education level and the control of the qualification of the heating technicians. Some legislations foresee control procedures and penalties on end-user level. The control procedures however are often not applied effectively. The presence of control procedures on end-user and technician level however appears to have clearly a positive effect. Countries with a high application efficiency generally have extended control procedures on all levels.

2.4 Barriers for an effective and efficient boiler inspection

Legislative level

On legislative level the barriers are mentioned in the previous paragraph. These can be summarised as follows:

o No uniform and sometimes no updated technical inspection requirements;
o Application area mostly limited to oil fired central heating boilers;
o Inspection in a very limited sense: only chimney, boiler or burner, not heating system as a whole, nor efficiency;
o No control on effective application of the existing legislations.

End-user level

The conducted surveys showed that on end-user side the motivation is not obvious. For end-users "a boiler" unlike "a car" is an object they would like to see and be seen as few as possible. It does not matter to most of them whether the efficiency is high, as long as their comfort is guaranteed. Boiler and burner replacement are only considered when the equipment breaks down.
It is therefore clear that the motivation to replace old boilers is low in almost all countries. The average age of the oil fired boilers when being replaced sometimes amounts to 30 years and the percentage of boilers older than 20 years exceeds 35%. For gas fired boilers the average replacement age is slightly lower: 15-25 years. Also the estimated amount of old boilers is relatively smaller: 5-20%. This relatively low percentage is partly due to the change from city gas to natural gas.

Installer/heating technician level

Installers and heating technicians are ideal intermediaries to inform and influence the end-users in a positive and fair way. In some cases this may be limited by following barriers:

o Due to the an incorrect legislative context (no control on the application of inspection) no fair competition between experts is possible. This leads to a situation where an end-user will prefer a person (even not qualified) who will certify that his/her installation works correctly although it does not.
o Installers mostly do not dispose of the correct tools to inform end-users on an individual basis about the benefits of inspection and resulting measures.
o There still is a serious problem of oversizing of the boiler capacity. According to the experts, the sizing of the boiler capacity appears to be a problem not only for the old boilers but also for the new ones. On-site surveys in Belgium (4) for instance showed that the average annual load of domestic boilers amounts to 10%. The difference in annual load between new and older boilers was limited.

3 CHALLENGES FOR THE FUTURE

It is clear that:
- o a considerable energy saving and CO_2 reduction potential still exists for the residential heating sector (3,5);
- o the application of inspection can be improved significantly in order to use this potential;
- o tools and successful applications (e.g. German Schornsteinfegerhandwerk, Danish OR-scheme) are available in the EU to serve as example and a basis for improvement. Several of these elements have been developed in the SAVE II programme.

Below some of the main elements for improvement are summarized.

3.1 Integrated approach of inspection

Inspection of residential heating systems up till now is limited to:
- o a regular flue gas sided inspection
- o the burner, boiler and chimney.

The possibilities of regular inspection with respect to energy saving are bigger than this. For the future the concept of on-site inspection could be defined as:
- o a unique and initial inspection for each new installation or a renovated installation;
- o a regular inspection on flue gas efficiency (boiler, burner, chimney);
- o a unique inspection for all heating installation with boilers older than e.g. 20 years; different aspects should be investigated: energy saving potential, sizing,…

The approach is also summarized in scheme 1. The topics indicated in "grey" show how "inspection" has mostly been defined up till now.

The new approach is firstly based on the principle of **combining different types of inspections** at different moments in the lifetime of the boiler. The regular inspection is a limited but frequent check-up while the initial and replacement inspection are unique but more detailed. Each inspection type has its own objective corresponding to the life stage of the installation. The replacement inspection is to be considered as an information service towards the end-user.

Secondly the approach tries to extend the current "boiler/burner/chimney" inspections to other aspects of the **heating system** as: distribution ducts, control systems, boiler sizing,… The term "boiler inspection" could in the future even be extended to the larger application of "inpsection of the heating, **cooling and hot tap water system**".

Initial inspection	
objective	Assure good initial working conditions of new+renovated installations
when?	New installation
	Renovated installation (e.g. burner or boiler replacement)
what?	Flue gas efficiency
	Air inlet, chimney
	Sizing of boiler capacity
	Settings control system
	Insulation of distribution ducts
Regular inspection	
objective	Assure good flue gas conditions in function of time
when?	All installations, oil fired: 1/year, gas fired: depening on type 1/year to 1/3year
what?	Flue gas efficiency
	Chimney
	Settings control system
	Changes in heat demand, e.g. insulation (with respect to boiler sizing)
Replacement inspection	
objective	Stimulate replacement of old inefficient types
when?	All boilers older than 20 years
what?	Annual efficiency, saving potential
	Economical consequences of boiler/burner replacement
	Also distribution losses, control system, chimney (condensation problems)

Scheme 1: Integrated approach of "heating system inspection"

Some countries are already going in the direction of this type of approach (e.g. German legislation, Danish inspection legislation + voluntary actions on replacement, new proposal for legislation in Flemish part of Belgium).

Tools for estimation the annual efficiency and evaluation of the energy saving by replacement were developed or are under development in the SAVE II programme (6, 7).

3.2 Legislation or guidelines on boiler inspection

An effective legislation or guidelines on boiler inspection could contain following elements:

- o requirements for qualified heating technicians
- o guidelines for a basic education for qualified heating technicians
- o guidelines for an updating course for qualified heating technicians
- o description of an initial inspection procedure/requirements/certificate
- o description of a regular inspection procedure/requirements/certificate (including time interval between 2 inspections)
- o description of a replacement inspection procedure/requirements/certificate
- o a procedure to check the application of the legislation (e.g. in Greece: activities of heating experts being checked on end-user level).

3.3 Application area of inspection

In many countries the application area of "regular" inspection has up till now been limited to oil fired boilers. These boilers indeed require particular attention with respect to flue gas sided adjustments.

There are however some arguments to introduce a regular inspection scheme for gas fired boilers too. Especially for the types with fans or forced draught burners. The inspection requirements and procedures may be different with respect to oil fired boilers. The inspection frequency may also be lower (e.g. every 2 or 3 years).

Examples of guidelines for inspection of gas fired boilers can already be found in some countries (e.g. Germany, Luxemburg, Austria, Italy, Netherlands).

Article 6 of the SAVE directive clearly indicates an application area above 15 kW. This excludes most of the decentral heating equipment as gas, oil or coal fired radiators. A flue gas sided inspection for these types of appliances is indeed not simple, especially from technical point of view (flue gas sampling, measurement accuracy).

3.4 Technical requirements for regular inspection

It was mentioned that the technical requirements for a regular inspection differ a lot between the Member States and that not all of them are updated. It should not be too difficult to define some general requirements for existing heating systems that are acceptable for most of the countries. These can be derived from the gathered data in the SAVE project on boiler inspection in the EU.

In Belgium for instance following recent values were proposed for of oil fired boilers:

Construction date boiler	Soot-index	Flue gas efficiency (%)	Minimum CO2-volume%
<1988	2	85	10
1988-1997	1	88	11
>= 1998	1	90	12

Some countries already have more strict requirements. A typical new approach in this context is to

fix an objective for the future in the legislation. E.g.: x years after introduction of the legislation all boilers need to meet the requirements of the best category (e.g. boilers older than 1998).

Another aspect of the technical requirements is the measurement procedure. There is a clear tendency towards the use of electronic measurement equipment (for flue gas efficiency and emissions). Cost of this equipment is dropping and advantages are clear: more accurate burner settings, time saving operation.

3.5 Education of installers

End-users need to be "triggered" or "motivated" by an external source. Their own motivation (merely avoiding discomfort, defects and unsafe situations) is not sufficient. There are several reasons to assume that the heating technician can fulfill this motivating role.

Therefore to improve the motivation of the end-user following actions are necessary:
- o Heating technicians have to become regular contact persons in as many dwellings as possible. An efficient inspection procedure offers a possibility to achieve this goal.
- o The task of the heating technician has to be reconsidered. Up till now in many cases the activities of heating technicians have been limited to the technical job. Real motivation of the end-user by the heating technician is not common. The role of the heating technician as an "adviser" needs to be promoted.

This requires a specific education of the heating experts. Following items need attention: calculation of boiler capacity and estimation of annual efficiency.

The tools for estimation of the annual efficiency (5, 6) and an energy guidebook for installers (7) are under development in the SAVE II programme. These can be used to work out targeted "energy" educations for installers.

4 CONCLUSIONS

The energy saving and CO_2 reduction possibilities of "inspection" of residential heating systems, have up till now not fully been used. Inspection is mostly limited to the flue gas sided inspection of boiler, burner and chimney. In several countries legislations have a poor application ratio due to lack of control.

Improvements can therefore be made on following aspects:
- o Integrated approach of inspection with 3 types of inspection per boiler lifetime:
  1. a unique initial inspection to assure good starting conditions for a new or renovated installation;
  2. a regular flue gas sided inspection to assure good burner conditions for all installations;
  3. a unique replacement inspection to inform end-users about possible replacement benefits for boiler older than 20 years.
- o Definition of common up to date technical requirements and measurement procedures for regular inspection of both gas and oil fired boilers.
- o Education of heating experts on specific energy topics: boiler choice in function of comfort and energy efficiency, annual efficiency of heating systems.
- o In case of legislation: control on application of legislation.

Projects under the SAVE II programme have developed the necessary tools and have gathered the necessary information to make these challenges achievable within short term.

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