A Quality Assurance System for Indoor Environment and Energy Use

Å. Wahlström, T. Törnström and S. Ruud

Department of Energy Technology, SP Swedish National Testing and Research Institute, Box 857, SE-501 15 Borås, Sweden

ABSTRACT

To achieve the intended results of building, managing and using a property requires knowledge, continuity and communication, which can be assured by a dynamic and flexible quality assurance (QA) system. Such a system, intended to ensure high-quality indoor environmental conditions, has been developed and successfully applied over the last ten years. However, although clients have been very satisfied with the QA system and its results, the pressure for energy efficiency improvement has increased. Concentration solely on either good indoor environment or energy efficiency might cause mutual adverse effects, and it is important to avoid this. Specialist researchers, property owners, builders and building managers have therefore together developed the existing QA system so that it now also includes consideration of energy use. The new QA rules have now been agreed by a representative committee consisting of private and municipality property owners, and have been tested in a school building in the spring of 2006. The main target group of the end results is the occupants. It means a lot to know, that the house one should live in or in other ways use, has a healthy indoor environment with minimal use of energy.

KEYWORDS

Quality assurance system, energy efficiency, management system, healthy building.

INTRODUCTION

The building process unfortunately provides many opportunities - right from the initial order, through design, construction and up to and including operation - for errors, misunderstandings and compromises that can result in poor indoor environmental conditions and/or inefficient use of energy. Failure to use available knowledge, or quality breakdowns, are often due to the client failing first to provide, and then to require, sufficiently detailed requirements for design, construction and/or maintenance. This may be because the client is unable to quantify, or does not consider, the benefits of improved indoor environment or reduced energy use resulting from better design, construction and/or maintenance. Such improvements involve a higher investment but will lead to reduced costs during operation, and will therefore be profitable in the long run.

A quality assurance system concentrating on achieving a high-quality indoor environment was developed during the 1990s and has been successfully applied to schools, offices and dwellings (Samuelson [2000]). Clients have been very satisfied with the QA system and its results in terms of an improved indoor environment, with fewer complaints from the building users (Emami and Forseaus [2004], Cedås and Hilmarsson [2006]), but the new emphasis on energy conservation (such as in the European Energy Performance in Buildings Directive [EPBD, 2002/91/EC]), has added new demands for energy improvements as well. However, a reduction of energy use is appropriate only if it does not adversely affect the indoor environment. In order to avoid a one-sided focus on either good indoor environment or energy efficiency that might result in mutually adverse effects, the building sector requested that the QA system should be extended to consider energy use as well.

Specialist researchers, property owners, builders and building managers have therefore jointly developed the QA system with the objective of including energy efficiency assurance (Wahlström and Ekstrand-Tobin, 2005). To ensure that the system's rules are accepted, and that they are needed by the building sector, the system has been approved by a committee consisting of representatives of private and municipality property owners. The new QA-system for both indoor environment and energy use is now ready to be applied in practice.

The system covers the planning, design, construction, commissioning and operation phases, and it would be natural to perform a performance analysis of all phases of the extended system. However, to do so, considering both the indoor environment and energy use, would have required a very long test period. In order to obtain a first relatively quick evaluation, the extended system was applied to the Sjöbo School, which formed a special case in that its indoor environment had already been certified with the QA-system in 2003, so that it needed only the additional element of QA of its energy system.

DESCRIPTION OF THE QUALITY ASSURANCE SYSTEM

The primary objective of quality assurance is to work towards continuing improvements and to encourage clients, builders, architects, administrators and occupants to perform measures that otherwise would not have been considered. This requires quantified and measurable goals, action plans for measures and management systems during operation.

Cooperation between all parties, from scientists and public authorities to designers, contractors, managers and users, is important for the end results. All need to listen to, and to learn from, each other. Good indoor environment and efficient use of energy can be achieved by creativity, planning and layout design, choice of materials, technical designs and systems for heating, ventilation, electricity and water supply. This QA system makes sure that the requirements set out in legislation, standards or common codes of practice are fulfilled as intended. An independent third party supervises, evaluates and checks that the requirements are fulfilled. Measurements show that the performance requirements have been met. Occupants' perceptions of the indoor environment are evaluated with the help of questionnaires, while energy use is evaluated with energy measurements or energy bills. The QA system includes new building and reconstruction work, as well as improvements of existing buildings, and covers the entire process, from planning and design, through the construction stage to final use and operation. The certification is based on ISO 9000 procedures, is illustrated in Figure 1 and described in SPCR 114E (2006).

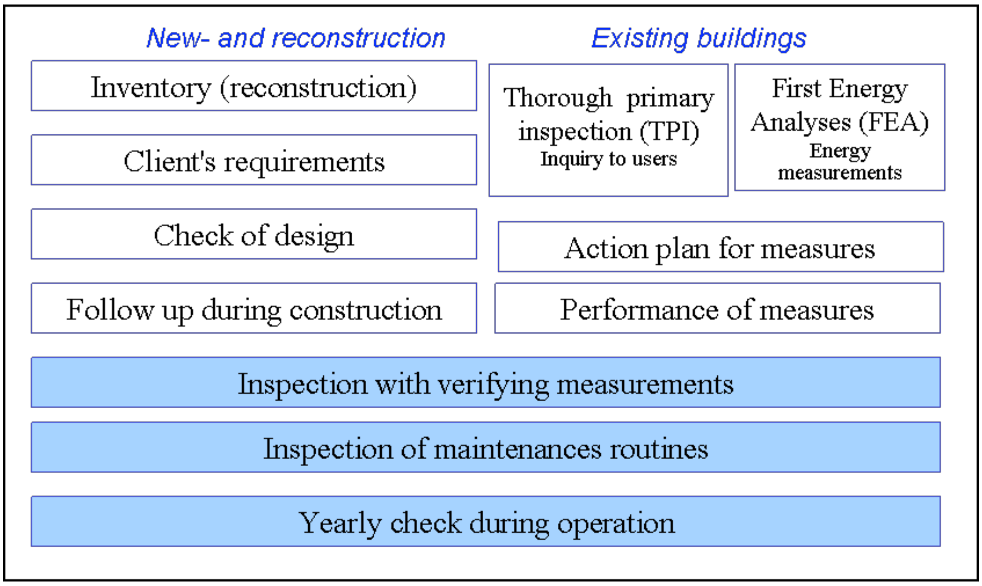

Figure 1: Illustration of procedures for quality assurance of indoor environment and energy use.

Additional elements for energy use

Certification work for existing buildings begins with a first energy analysis (FEA), which consists of an inventory of the actual property with its actual energy status, energy aspects and energy performance (Wahlström, 2005). This can be done by examining construction drawings, operational follow-up programs, control systems or other documentation; inspections, interviews with staff and additional measurements. It is recommended that this should be done in conjunction with the TPI (Thorough Primary Inspection) of the indoor environment, particularly with respect to visual inspection and interviews with staff.

The results of the FEA are then used to set objectives to be achieved, including a performance measurement specification of how the comprehensive targets should be measured and checked. The QA system considers the fact that each building project is unique, and therefore the annual energy use target will be set on the basis of the building's current condition and its related limitations, rather than on the basis of a specific predefined figure. For new construction, or major reconstruction, the primary limitations relate to building use and climate, while minor reconstruction and existing buildings also have limitations due to design.

The next step is to draw up an action plan for measures and perform them in order to reach the set targets. Experience shows that successful energy efficiency in a building will be maintained only if the building is efficiently managed, operated and maintained, with all parties steadily improving their performance and with the results regularly monitored. This means that the energy target must be regularly monitored and reviewed, and the QA system is therefore based on a management system modelled on a Swedish standard (SS 627750, [2003]). The standard includes comprehensive routines for energy management applied for any organisation and has therefore been refined and customised to fit the building sector.

PILOT PROJECT OF THE ADDITIONAL ENERGY USE QA

The main classroom building of Sjöbo School (originally built in 1959) was reconstructed in 2001 and 2002, complemented by new building of the gymnasium, kindergarten, teachers' staff rooms etc. In total, the school consists of six buildings, with a floor area of 6673 m^2. The indoor environment element of the QA system was employed during the planning, design, construction and commissioning stages, and after some months of operation the school indoor environment was certified. As far as energy use is concerned, the school should perform quite well since all buildings were reconstructed or newly built with new building envelopes and HVAC systems, with the focus of this project being to introduce the extended QA system in order to ensure retention of good building performance rather than (primarily) to improve energy use.

Method of working

In order to make all parties aware of, and involved in, the coming work, the project started with an introductory meeting consisting of:

- staff at the school (principal, maintain staff, cleaner and safety representative),
- the building owner (local authority building manager and indoor environment and energy use manager),
- the third party company (responsible for introduction of the QA system and certification body) and
- two consultants for performing measures.

If one of these functions fails actively to play its intended part, the whole project will probably fail. The project group therefore had regular meetings during the introduction of the extended QA system. The actual work began with a first energy analysis (FEA) in order to determine the reference status of the school and to identify scope for improvements. The annual energy use was 121 kWh/m^2 of district heating, and electricity 59 kWh/m^2 of electricity.

Targets and measures

The targets were set after considering the result from the FEA, reference values from the statistics (152 kWh/m^2 for heating, SCB [2005]), the municipality's energy policy and the fact that district heating is supplied from mainly renewable sources: district heating use was to be reduced by 10 % within one year and by 15 % after two years, while the use of electricity should not exceed the previous level.

In order to reach the target the project group agreed on the following measures:

- A document data base should be created with all construction drawings, maintenance instructions, operating instructions, check lists etc. on the municipality Intranet computer system. This meant that all parties concerned could easily access the documentation, which would also be unaffected (= would not be lost) as a result of any personnel changes. The Sjöbo School data base will serve as template for other buildings.
- A meeting to be held every third month between occupants' representatives, staff at the school and the building owners, in order to discuss departures from indoor environment or energy use performance. The minutes from these meetings to be kept in the document data base.

- Control and adjustment of the heating system and ventilation system.
- Presence detectors for ventilation in the kindergarten and gymnasium. In order not to jeopardise the indoor environment, special rules for how the ventilation system should be operated were set up, as described below.
- Electronic pulse sampling of measuring equipment.
- Include maintenance and control of the ventilation units in the building energy control system
- Training of maintenance staff in operation of the building energy control system.
- Include energy use in the indoor environment management system, with monthly check of changes in energy use.

Rules for intermittent operation of ventilation

The QA system says that unless a particular activity requires a specific ventilation rate, premises shall be ventilated at 0.35 litres/m^2, second for management of the building's emissions and at 7 litres/second and person for hygiene ventilation. The building should always have a base flow to prevent the air flowing in the wrong direction. This means that premises can be demand-controlled ventilated, with a minimum ventilation flow when unoccupied, and with higher flows when occupied, but this was not possible in the Sjöbo School since the existing ventilation system could be operated only at half or full speed (or turned off entirely). Intermittent operation was therefore needed. Since there is very little knowledge of how the indoor environment will be affected by intermittent ventilation operation, some measurements of emission concentrations in the building when ventilated intermittently were made, and the following additional rules were agreed:

- Premises with activities that cause high concentrations of chemicals or air particles, e.g. kitchens, shower rooms, domestic science rooms, handicraft rooms, chemistry laboratories etc, must always have a ventilation base flow that ensures that the air will flow in the intended direction.
- Premises with activities with low risk of causing poor air quality may use intermittent operation, with the ventilation turned off when the areas are unoccupied and the following four points are fulfilled:

1 That there are dampers that prevent reverse air flow in the supply and exhaust duct systems when the ventilation is turned off.

2 Before premise can be used again, after a period of turned-off ventilation, the ventilation system must have been running for a sufficient period of time to have given three air changes of the room volume.
   a. In areas with occupancy control, no extra air change is required if the area has low-emitting materials and the ventilation has been turned off for less than five hours.

3 After all occupants have left the room, and before intermittent operation starts, ventilation shall have continued and changed one room volume of air.

4 When changing from continuous operation to intermittent operation, it is recommended that a questionnaire survey should be held after one year of operation. Other aspects to be followed up via the ordinary complaints procedure.

Results of the pilot project

The extended QA system with energy use has been successfully incorporated in the Sjöbo School and, since the start of the project, energy use of district heating has preliminary decreased by 8 % and that of electricity by 4 %. By following the QA system a significant improvement of energy use control has been reached in the school buildings.

CONCLUSIONS AND FURTHER WORK

New demands for energy improvements might draw attention away from the indoor environment, which should be resisted. The preliminary results from this work show that this can be done by using a practical and flexible quality assurance (QA) system. An existing indoor environment QA system has therefore been extended to cover energy use, and has been successfully tested during operation in a school building with a previously certified indoor environment. The goal of the future is to apply this QA system also for the planning, design, construction and commissioning phase and into more building types, such as offices and residential buildings.

ACKNOWLEDGEMENT

The authors would like to thank Anders Thelin and Jenny Petersson, of the Building Management Department of Borås municipality, and Kjell Ekblad, maintenance technician at Sjöbo School, for valuable input to this work, and FORMAS (the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning) and BIC (the Swedish Construction Sector Innovation Centre) for their financial support.

REFERENCES

Cedås, D., Hilmarsson, E. (2006). P-*marking, Mapping the signification of P-marking in the building process*. Examination work in engineering in building technology, Högskolan i Borås, Ingenjörshögskolan, Nr9/2006. In Swedish.

EPBD (2002). Directive 2002/91/EC of the 16 December 2002, The European Community Official Journal, no. L 001, 04/01/2003 p. 0065-0071.

Emami, K., Forseaus, A. (2004). *Questionnaire in compulsory schools. Comparison of P-marked and non P-marked schools*. Högskolan i Borås, Ingenjörshögskolan. In Swedish.

Samuelson I. (2000). Quality assurance of the indoor environment in schools, offices and dwellings through P-marking, *Proceedings of Healthy Buildings 2000*, Espoo, Finland, August 6-10.

SCB (2005). Energy statistics for premises, multifamily dwellings and dwellings, EN 16 SM 0503, the Statistics Sweden, SCB, 2005, In Swedish.

SPCR 114E (2005). Certification rules for P-marking of the indoor environment and energy use, SP Swedish National testing and Research Institute, December 2005, In Swedish.

SS 627750 (2003). Swedish standard for Energy management -requirement specification. SIS Swedish Standard Institute, 2003.

Wahlström, Å. (2005). *P-marked indoor environment and energy use -Handbook before certification of energy use*, SP Rapport 2005: 41, ISBN 91-85303-73-9, Energiteknik, Borås, December 2005, In Swedish.

Wahlström Å., Ekstrand-Tobin, A. (2005). Quality assurance of indoor environment and energy use. *Proceeding of the 7th Symposium on Building Physics in the Nordic Countries*, page 1041- 1048, Reykjavik, June 13-15, 2005.