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BSI Standards Publication

Cleanroom energy – Code of practice for improving energy efficiency in cleanrooms and clean air devices

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 March 2013. It was prepared by Technical Committee LBI/30, *Cleanroom technology*. A list of organizations represented on this committee can be obtained on request to its secretary.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this British Standard is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this standard are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

Cleanroom cleanliness can be classified by the concentration of specific contaminants in the air or on surfaces in the cleanroom. Cleanrooms use a considerable amount of energy to provide large amounts of filtered and conditioned air to achieve the specified levels of cleanliness. A considerable amount of energy is also used to achieve:

- a) the necessary temperature and relative humidity for the process in the cleanroom and for personnel comfort;
- b) the necessary pressurization of the space; and
- c) in some cases, the necessary airflow volume flow rate for unidirectional airflow and to a reduced extent non-unidirectional airflow.

Some firms using cleanrooms report that heating and ventilating systems consume up to 80% of the total energy used in their manufacturing facility simply to deliver clean, conditioned air to critical operations. This energy is consumed by heating, cooling, humidification and fan power. Of this, fans required to move air can account for 35% to 50%, much of this being due to the extra energy required to overcome the high pressure differential required for the high efficiency filters and other ventilation components used in cleanrooms. There is therefore a significant potential for energy saving by diligent design in the installation of new cleanrooms, and by retrofit improvements and upgrades to existing facilities.

This British Standard lists and explains measures that can be taken to reduce energy consumption in cleanrooms and applies to the whole range of “cleanroom technology”, from cleanrooms to clean air devices, including isolators, glove boxes and mini-environments as described in BS EN 14644-7. Cleanroom technology is used by organizations within the life-sciences, micro-electronics, aerospace and nuclear fields. The life-sciences sector includes hospital, pharmaceutical and medical device activities.

This British Standard does not address related production processes such as water treatment, oven, autoclave and stress cycling operations that can also create significant energy demands.

1 Scope

This British Standard gives recommendations on reducing energy consumption and maintaining energy efficiency in new and existing cleanrooms and clean air devices, classified by BS EN ISO 14644-1.

The standard is not applicable to the energy efficiency of process equipment, except where it affects the cleanroom environment.

NOTE 1 Further guidance on the use of energy management systems is given in BS EN ISO 50001.

NOTE 2 Energy saving opportunities are listed in Annex A and detailed in Annex B.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 1886, *Ventilation for buildings – Air handling units – Mechanical performance*

BS EN 14799, *Air filters for general air cleaning – Terminology*

BS EN ISO 14644-4, *Cleanrooms and associated controlled environments – Part 4: Design, construction and start-up*

BS EN ISO 14644-5:2004, *Cleanrooms and associated controlled environments – Part 5: Cleanroom operations*

BS EN ISO 14644-6:2007, *Cleanrooms and associated environments – Part 6: Vocabulary*

BS EN ISO 50001, *Energy management systems – Requirements with guidance for use*

Other publications

[N1] HEATING AND VENTILATING CONTRACTORS' ASSOCIATION. *Specification for sheet metal ductwork: low, medium and high pressure/velocity air systems*. DW144. Cumbria, 1998. ISBN: 0 903783 27 4.

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 air handling unit (AHU)

unit or plant, comprising fan, filtration, heating, cooling and mixing of fresh air and recirculated air, that delivers conditioned air to a room or facility

3.2 clean air device

stand-alone equipment for treating and distributing clean air to achieve defined environmental conditions

[SOURCE: BS EN ISO 14644-6:2007, 2.31]

NOTE Clean air devices include certain separate devices as defined in BS EN ISO 14644-7, for example, clean air hoods, containment enclosures, gloveboxes, isolators and mini-environments.

3.3 cleanroom

room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimize the introduction, generation, and retention of particles inside the room, and in which other relevant parameters, e.g. temperature, humidity and pressure, are controlled as necessary

[SOURCE: BS EN ISO 14644-6:2007, 2.33]

3.4 colony forming units (CFUs)

single micro-organism or a single small mass of micro-organisms that when deposited on a microbiological growth medium grows to form a single visible colony that can be counted

NOTE One colony forming unit is expressed as 1 CFU.

3.5 combined heat and power

electrical generation by internal combustion engine or gas turbine with the waste heat from this process being used to generate hot water or steam

3.6 controlled environment

defined zone in which sources of contamination are controlled by specified means

[SOURCE: BS EN ISO 14644-6:2007, 2.45]

3.7 critical zone

area where the product is exposed to the potential deposition of airborne contamination

3.8 final filter

last high efficiency filter in the system before the air enters the cleanroom

NOTE This may be in the AHU or it may be a terminal filter (see 3.12).

3.9 high efficiency air filter

air filter conforming to BS EN 1822 (all parts), covering the range of efficient particulate air filters (EPA): E 10 – E 12, high efficiency particulate air filters (HEPA): H 13 – H 14 and ultra low penetration air filters (ULPA): U 15 – U 17

3.10 microbe-carrying particle (MCP)

particle on which a micro-organism is carried; it is normally dispersed into room air by personnel as a skin cell, or fragment of skin cell, on which a skin microbe(s) is carried

3.11 non-unidirectional airflow (non-UDAF)

air distribution where the supply air entering the clean zone mixes with the internal air by means of induction

[SOURCE: BS EN ISO 14644-6:2007, 2.95]

3.12 terminal filter

high efficiency air filter located at the point where the air enters the cleanroom

3.13 tri-generation

electrical generation that is integrated with both heat and chilled water generation

3.14 turn down

controlled reduction of airflow velocity in UDAF cleanrooms and clean air devices and airflow rates in non-UDAF cleanrooms in order to save energy during periods when the cleanroom is not in operation

3.15 unidirectional airflow (UDAF)

controlled airflow through the entire cross-section of a clean zone with a steady velocity and approximately parallel airstreams

NOTE This type of airflow results in a directed transport of particles from the clean zone.

[SOURCE: BS EN ISO 14644-6:2007, 2.138, modified - Note 2 has been deleted.]

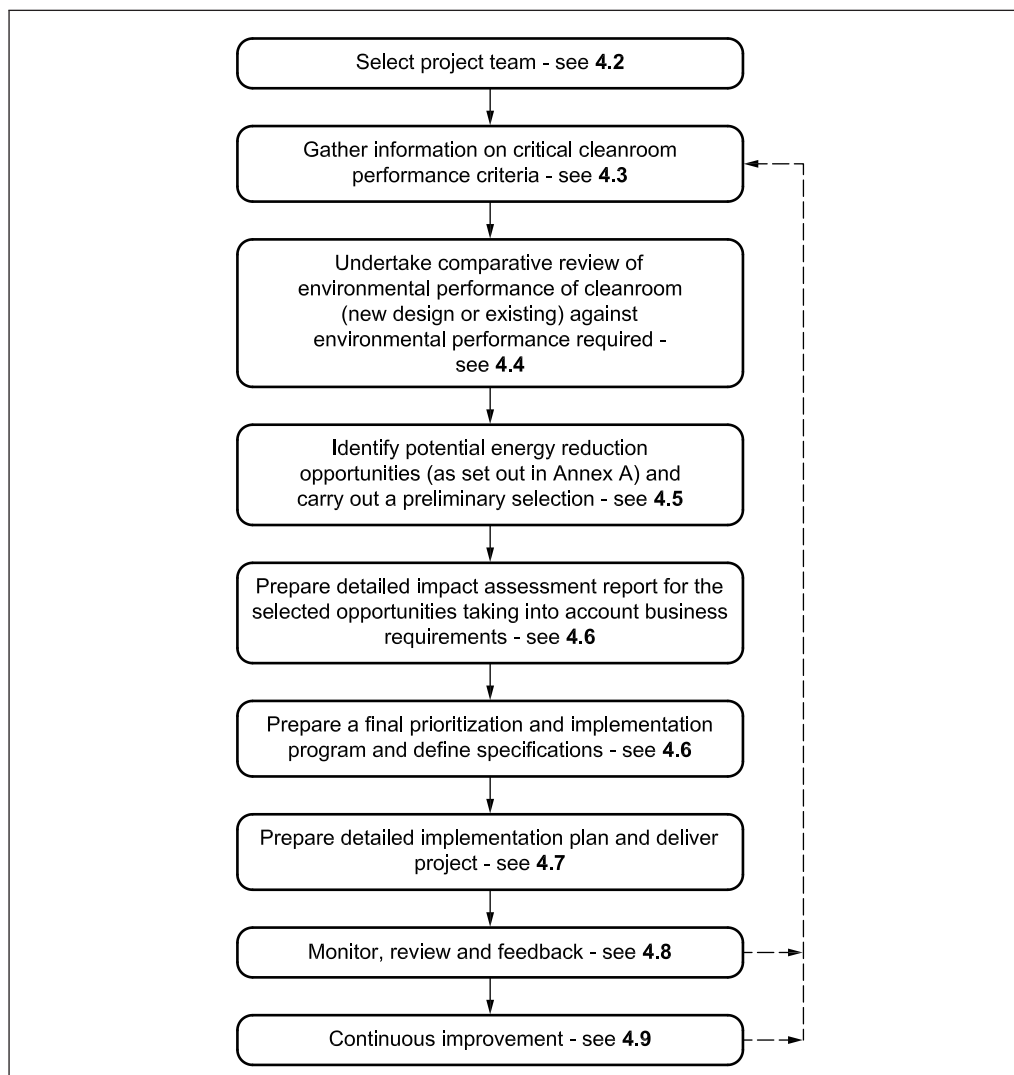
4 The energy evaluation and implementation process

4.1 General

Energy reduction in new and existing cleanrooms and separative devices should be carried out in accordance with the process described in this clause and summarized as a flowchart in Figure 1.

NOTE Attention is drawn to the European Commission Energy Performance of the Buildings Directive [1], the Energy Act 2011 [2] and the Building Regulations 2010 [3].

Figure 1 Process flowchart



4.2 Selecting a project team

A project team should be set up to include representatives from the key business functions such as quality, validation, production, planning, finance, engineering, maintenance and cleanroom energy experts.

NOTE Additional expertise can be provided by internal or external consultants.

4.3 Gathering information

4.3.1 General

Documents, including drawings and specifications, and information that define the cleanroom performance criteria should be collated; this might take the form of existing quality risk assessments or facility operational assessments.

NOTE The objective is to identify criteria that affect performance and to consider the direct and indirect impacts of possible energy reduction actions.

A survey of the facilities should be carried out and reviewed to identify all the energy saving opportunities, see Annex A.

4.3.2 Existing cleanrooms

For existing cleanrooms the survey should include:

- a) identifying the cleanroom performance criteria to meet the requirements of the process, the products and personnel comfort;
- b) a profile of energy use; this should cover lighting, air handling, comfort heating, cooling and any other significant energy use. The information should come from monitoring or, where this is not possible, from professionally derived estimates;
- c) the current cleanliness performance (from classification and monitoring – particles, chemical species, micro-organisms);
- d) airflow volume flow rate, airflow velocity and pressurization;
- e) practical issues related to onsite operations, e.g. reliability and control, layout, age, condition, function, maintenance;
- f) the results of any benchmarking exercise; this should compare the existing design with best practice energy use with respect to energy cost and carbon emissions;
- g) life cycle costs and optimization studies if possible.

4.3.3 New cleanrooms

For new cleanrooms the survey should include:

- a) identifying the cleanroom performance criteria to meet the requirements of the process, the products and personnel comfort;
- b) the best estimates of projected energy use; this should cover lighting, air handling, heating, cooling and any other significant energy use;
- c) the design performance (in classification terms: cleanliness, microbial, etc.);
- d) the results of any benchmarking exercise; this should confirm that the new design complies with best practice energy use with respect to energy cost and carbon emissions.

NOTE The consideration of life cycle costs and optimization studies can also be included in the exercise.

4.4 Comparative review

A comparative review should be undertaken, to compare the environmental performance of the designed (new) cleanroom or redesigned (existing) cleanroom with the environmental performance requirements (of the process, the products and personnel comfort), to avoid overdesigning, e.g. specifying cleanliness classifications that are lower (cleaner) than necessary or clean spaces that are larger than necessary.

NOTE Significant energy savings can be identified by carrying out such a review.

4.5 Improvement opportunities

The project team should analyse the results of the comparative review, identify potential energy reduction opportunities and carry out a preliminary selection; this can be done using the checklist given in Annex A, Table A.1. Once the preliminary selection has been made using Table A.1, the selection should be assessed and documented as part of the decision-making process, and the reasons why an opportunity is chosen, or not, should be recorded.

4.6 Impact assessment and prioritization

Once the potential energy saving opportunities have been identified from Table A.1 and a preliminary selection carried out, a detailed impact assessment report should be produced, covering all of the potential opportunities identified and taking into account the corresponding recommendations given in Annex B as well as the following business requirements:

- feasibility;
- process compatibility;
- risk;
- safety;
- cost;
- return on investment;
- incentives (e.g. government);
- implementation timeline/programme;
- implementation resources;
- business continuity.

This report identifies which energy reduction opportunities have become less viable or more challenging; these should be reprioritized behind those that can be easily and effectively delivered. A final prioritization and implementation programme should then be prepared.

Specifications and scopes of work should be defined for those opportunities that are to be implemented.

Where industries have standards or guidelines that specify performance requirements, all the situations where one or more performance requirements are in conflict with a particular proposed energy reduction measure should be identified.

NOTE Such performance requirements might include air quality (in terms of particle and microbial concentration), filter efficiency, unidirectional airflow velocity, room air change rate (by varying the air supply rate), recovery time and pressure differentials between adjacent rooms of different grades.

When these situations have been identified, the project team (see 4.2) should formulate a detailed justification to demonstrate that product quality is not affected by the proposed measure. Agreement from any authority concerned prior to implementation should then be obtained.

4.7 Implementation

The project team, now including the selected contractors and suppliers, should produce a detailed implementation plan and undertake the work. The implementation plan should include the expected outcomes for all the selected elements.

4.8 Monitor, review and feedback

On completion of the project and thereafter at regular intervals, for each selected element, the expected outcome defined in the implementation plan should be monitored and reviewed to ensure that the changes remain effective. The associated energy reductions should be monitored, recorded and analysed. The information gathered should be used as feedback for continuous improvement.

4.9 Continuous improvement

Using the feedback, it should be determined if any further changes are needed and then these should be implemented.

Where improvements might be applicable to other similar facilities in the organization, they should be assessed and applied.