BS EN ISO 14414:2015+A1:2016

BSI Standards Publication

Pump system energy assessment (ISO/ASME 14414:2015)

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National foreword

This British Standard is the UK implementation of EN ISO 14414:2015+A1:2016. It is identical to ISO/ASME 14414:2015, incorporating amendment 1:2016. It supersedes BS EN ISO 14414:2015 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MCE/6, Pumps and pump testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

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NORME EUROPÉENNE

EUROPÄISCHE NORM

EN ISO 14414:2015+A1

April 2016

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English Version

Pump system energy assessment (ISO/ASME 14414:2015)

Evaluation énergétique des systèmes de pompage
(ISO/ASME 14414:2015)

Energetische Bewertung von Pumpensystemen
(ISO/ASME 14414:2015)

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Introduction

Pumping systems account for a significant portion of a facility's energy consumption in many industries. In the majority of pumping systems the energy added to the working liquid by the pump is much greater than is required by the process. The excess energy added to the system (e.g. due to throttled control valve) increases heat, noise and vibration but also can bring the system's maintenance costs. The addition of excessive energy to the system often results in over-sizing piping system components such as pumps, process components, and control valves, resulting in an increase in capital costs.

This International Standard provides a method to assess pump systems, to identify and quantify pump system energy consumption reduction opportunities and reliability improvement opportunities. It gives a common definition for what constitutes an assessment for both users and providers of assessment services. Its objective is to provide clarity for these types of services which have been variously described as energy assessments, energy audits, energy surveys and energy studies.

In all cases, systems (energy-using logical groups of equipment organized to perform a specific function) are analysed through various techniques such as measurement, resulting in identification, documentation and prioritization of energy performance improvement opportunities.

When contracting for assessment services, facility personnel may use this International Standard to define and communicate their desired scope of assessment activity to third party contractors or consultants.

This International Standard is expected to contribute to decreased energy consumption and consequently to decreased carbon footprint.

This International Standard includes the required assessment report content in Annex A. It gives examples of efficient system operation and energy reduction opportunities in Annex B, information on competencies and experiences welcomed to perform audit in Annex C, guidelines for analysis software in Annex D, a typical example of pre-screening worksheet in Annex E, information on specific energy in Annex F, information on the concept of parasitic power in Annex G and examples of pumping system efficiency indicator in Annex H.

This International Standard is developed within the framework of ISO 50001, ISO 50002 and ISO 50003.

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Pump system energy assessment

1 Scope

This International Standard sets the requirements for conducting and reporting the results of a pumping system energy assessment (hereafter referenced as "assessment") that considers the entire pumping system, from energy inputs to the work performed as the result of these inputs.

The objective of a pumping system energy assessment is to determine the current energy consumption of an existing system and identify ways to improve system efficiency.

These requirements consist of

— organizing and conducting an assessment,

— analysing the data from the assessment, and

— reporting and documenting assessment findings.

This International Standard is designed to be applied, to open and closed loop pumping systems typically used at industrial, institutional, commercial, and municipal facilities, when requested.

This International Standard is focused on assessing electrically-driven pumping systems, which are dominant in most facilities, but is applicable with other types of drivers, such as steam turbines and engines, and drives such as belt.

The International Standard does not

a) specify how to design a pumping system,

b) give detailed qualifications and expertise required of the person using the International Standard although provides a list of body of knowledge in Annex C,

c) address the training or certification of persons,

d) specify how to implement the recommendations developed during the assessment, but does include requirements for an action plan,

e) specify how to measure and validate the energy savings that result from implementing assessment recommendations,

f) specify how to make measurements and how to calibrate test equipment used during the assessment,

g) specify how to estimate the implementation cost or conduct financial analysis for recommendations developed during the assessment,

h) specify specific steps required for safe operation of equipment during the assessment. The facility personnel in charge of normal operation of the equipment are responsible for ensuring that it is operated safely during the data collection phase of the assessment,

i) address issues of intellectual property, security, confidentiality, and safety.

2 Normative references

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

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ISO 17769-1, *Liquid pumps and installation — General terms, definitions, quantities, letter symbols and units — Part 1: Liquid pumps*

ISO 17769-2, *Liquid pumps and installation — General terms, definitions, quantities, letter symbols and units — Part 2: Pumping system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 17769-1 and ISO 17769-2, and the following apply.

3.1
system energy demand
minimum amount of energy which a pumping system in a specified process requires

3.2
components
individual items of equipment within a system

EXAMPLE Pump, motor, drive, valve, heat exchanger.

3.3
hydraulic power
water horsepower
power imparted to the liquid by the pump

3.4
electrical power input
power required to support the pumping system operation

3.5
specific energy
energy consumed to move a certain volume of liquid through the system

3.6
parasitic power
power imparted to the shaft of a pump and not used to move the fluid through the system

4 Identification of the assessment team, authority and functions

4.1 Identification of assessment team functions

The assessment team composed of knowledgeable personnel shall have members that are assigned responsibility and authority to carry out the following functions:

— resource allocation, in order to:

  — allocate funding and resources necessary to plan and execute the assessment,

  — exercise final decision making authority on resources,

  — oversee the eventual participation of non-facility personnel including contracts, scheduling, confidentiality agreements, and statement of work.

— coordination, logistics and communications, in order to:

  — obtain necessary support from facility personnel and other individuals and organizations during the assessment,

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— participate in organizing the assessment team and coordinate access to relevant personnel, systems, and equipment,

— organize, schedule activities and manage the assessment.

4.2 Assessment team structure, leadership and competency

The assessment team should comprise of personnel from cross functional backgrounds. It shall include:

— an assessor who has the pump system analysis competencies as described in Annex C;

— the host organization representative who has overall responsibility and ownership for the assessment;

— experts on the processes and the function of the system;

— experts on the maintenance practises of the pumping system;

— experts who can provide the team with cost data.

The assessment team may be from the host organization or enhanced by using outsourced specialists particularly considering the competence of the assessor

The host organization shall appoint the assessment team leader. This person may be a host facility employee or an external assessor. In small organisations, the team leader may be the competent assessor.

4.3 Facility management support

Facility management shall understand and support the purpose of the assessment.

Facility management shall allow assessment team members from the facility to participate in the assessment to the extent necessary.

The assessment team shall gain written support of facility management prior to conducting the assessment, as follows:

— commit the necessary funding, personnel, and resources to support the assessment;

— communicate to facility personnel the assessment's importance to the organization.

4.4 Communications

Lines of communication required for the assessment shall be established.

The assessment team shall provide clear guidance to facilitate communications among members of the assessment team so all necessary information and data can be communicated in a timely manner. This shall include administrative data, logistics information, as well as operational and maintenance data.

4.5 Access to facilities, personnel and information

The assessment team shall have access to:

— facility areas and pump systems required to conduct the assessment,

— facility personnel (engineering, operations, maintenance, …), their equipment vendors, contractors and others, to collect information pertinent and useful to the assessment activities and analysis of data used for preparation of the report,

— other information sources such as drawings, manuals, data sheet, maintenance records, test reports, historical utility bill information, computer monitoring and control data, electrical equipment panels, and calibration records.

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All data initially identified as essential to the assessment shall be obtained in discussions with knowledgeable facility staff.

4.6 Assessment objectives, scope and boundaries

The overall objectives and scope of the assessment including portion(s) of the facility and boundaries of the system(s) that are to be assessed shall be discussed and agreed upon at an early stage by the assessment team.

The assessment team shall develop a list of site specific objectives for each pumping system, such as performance improvement targets.

4.7 Action plan

4.7.1 General

An action plan for the assessment shall be developed and agreed upon by the assessment team and system owners in order to facilitate the assessment and to make it clear to all assessment team members how the assessment shall be conducted.

The plan shall be flexible and should accommodate various outcomes depending on findings during the assessment, among others:

a) establish information objectives, in particular:

— determine system boundaries (see 5.4);

— review information that has been collected before the start of the assessment;

— identify how much is known about the systems and what information has to be obtained;

— start with a level 1 assessment (see 5.1.2);

b) identify informational objectives for the assessment (see 5.1):

— determine how extensive the assessment is;

— identify the systems that are included in the assessment;

— identify what information is available and what is necessary to collect;

— identify information that is available on paper records (such as logs) or in the facility computer systems and what system parameters are necessary to measure;

— identify who is going to be involved and responsible for the collection of necessary data;

c) establish measurement requirements (see 5.6) in particular:

— identify whether a snapshot of the conditions is sufficient (level 2 according to Table 1) or if it is necessary to collect information during an extended period of time (level 3 according to Table 2);

— identify if permanently installed measurement equipment is available and trustworthy;

d) identify additional informational objectives and in particular true process demands (see 5.4);

e) identify the methods required to meet assessment informational objectives:

— identify how the data are going to be analysed, taking into account the recommendations from Annex B;

— identify tools/software programs that are going to be used;

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f) identify content of the report and responsibilities.

4.7.2 Assessment scheduling

The dates of the assessment, and dates and times of key meetings shall be designated in advance of beginning the assessment.

The assessment meetings shall include:

— kick-off meeting. It shall occur just prior to the commencement of the assessment. The purpose of this meeting is to review information to be collected in the initial data collection and evaluation (see 4.8) and establish the work schedule. At this meeting, the assessment team should discuss the safety protocols, tools, methods, measurement, metering and diagnostic equipment required;

— daily schedule(s) for the on-site assessment;

— periodic reporting to facility managers in the form of debriefings should occur as agreed-upon by the assessment team;

— wrap-up meeting at the conclusion of the onsite activities. It is designed to outline the assessment investigations and initial recommendations (see 5.8).

The assessment team shall determine corrective courses of action for irregularities that may or do occur during an assessment (e.g. the failure of a computerized records system).

4.8 Initial Data Collection and Evaluation

4.8.1 General

Before the start of the assessment, the initial data collection shall be made. To expedite the process, precollection data are optional.

NOTE This information is used in all assessment phases.

4.8.2 Initial facility specialist interviews

The assessment team shall collect information on operating practices and any specific operating considerations that affect energy use for the equipment through contact with personnel and specialists.

The assessment team shall also have access to facilities personnel who understand connected systems that will be influenced by changes made to the pumping system.

4.8.3 Energy project history

The assessment team shall collect and review information on energy saving projects, assessments, audits, baselines, or benchmarking already conducted for the pumping systems being assessed.

4.8.4 Energy cost

The assessment team shall collect cost data including electricity cost per kWh, or other similar terms, considering all charges such as demand charges, peak rates, time-of-the-day rate and any other costs up to the point of use. Where necessary, appropriate costs should be assigned to onsite generated electricity. These costs should be used in subsequent analyses. If electricity is generated on site the avoided cost or potential sales cost of the energy should be used.

The assessment team shall agree on the period during which the costs are considered valid.

The assessment team should also consider issues such as demand charges and trends to identify situations not made obvious by the use of average values.

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From this information, the assessment team shall determine an average annual energy cost per kWh over the previous 12 months.

If a facility has established a marginal cost for energy, it may be used in the energy cost saving calculation

4.8.5 Initial system data

The assessment team shall:

— define the functional needs of the system(s);

— identify high energy consumption equipment;

— identify control method(s);

— identify throttle control systems;

— identify high, low or negative static head systems;

— identify inefficient devices (obvious signs of disrepair or incorrect operation);

— identify lower mean time before failure (MTBF) pump systems, which generally indicate poor efficiency operation (see Annexes F and H).

4.9 Objective check

Prior to conducting the assessment, the assessment team shall ensure that the action plan meets the stated assessment objectives.

The action plan of assessment and the objectives shall be reviewed for relevance, cost-effectiveness, and capacity to produce the desired results.

5 Conducting the Assessment

5.1 Assessment Levels

5.1.1 General

Depending on the needs of the host organization, one or more of the levels of assessment given in Table 1 shall be selected.

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Table 1 — Assessment Level Overview

Activities	Level 1 assessment	Level 2 assessment	Level 3 assessment
Pre-screening opportunities	Required	Required	Required
Walk through	Optional	Required	Required
Identify systems with potential saving opportunities	Required	Required	Required
Evaluate systems with potential saving opportunities	Optional	Required	Required
Measurement of operating data for a typical single operating point	Optional	Required	Required
Measurement/data logging of systems with variable operating conditions	Not Applicable	Not Applicable	Required

NOTE 1 A level 1 assessment is a qualitative review with possible quantitative elements intended to determine the potential for significant energy savings based on further assessments and to identify specific systems that merit a greater level of attention.

NOTE 2 A level 2 assessment is a quantitative review intended to determine energy consumption and potential savings based on measurement of a single steady-state operating condition requiring a single set of measurements.

NOTE 3 A level 3 assessment is a quantitative review that takes varying system demands into account by monitoring the system over a time span long enough to capture the various operating conditions which require their own set of measurements.

Depending on the level of assessment, data shall be collected in accordance with Table 2.

5.1.2 Level 1 assessments

Level 1 assessment shall include gathering of system information for pumping systems considered for evaluation within the scope of the assessment.

Level 1 assessment shall start with the pre-screening.

During the pre-screening, the control methods for the different systems shall be noted. It shall be determined which systems are best suited for a closer evaluation. It should also be noted if changes to the pump system will affect other systems, thereby introducing constraints on potential optimization strategies for the pump system.

As much information as practical should be collected during the level 1 assessment.

The availability at the facility of some types of data (see 5.5) should also be reported during the level 1 assessment even if it is not collected.

A pre-screening worksheet shall be used to assist in this pre-screening exercise. A typical example of worksheet to aid in the data collection process is given in Annex E.

In general, the steps taken during the pre-screening shall include the following:

a) sort by driver size, annual operating hours, and estimated energy cost;

b) focus on centrifugal pumps operating at fixed speed;

c) focus on pumping systems that throttle and recirculate for flow control;

d) look for energy-waste symptoms such as large difference in supply and demand, commonly achieved through valve throttling and by-pass flows (see 5.5.5);

e) identify inefficient pumping systems via maintenance and operational staff interviews and review of maintenance records;

f) select for assessment those systems that appear most likely to exhibit savings potential.

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From this information the assessment team shall make estimates regarding the potential for energy savings in each system and shall select the pumping systems that meet the criteria for level 2 or level 3 assessments.

5.1.3 Level 2 assessments

Level 2 assessments shall be performed when it is clear that the observed operating conditions are representative for the operation of the systems and the changes in operating condition are small or non-existent.

Level 2 assessments shall be performed using data taken from the facility information systems, in paper or electronic format, or by using portable measuring devices. The measurements shall cover a limited amount of time, thus giving a snapshot of the operating conditions at the time of measurement.

5.1.4 Level 3 Assessments

Level 3 assessments shall be made on pumps systems where conditions vary substantially over time. For such systems, the assessment team shall record the system performance data over the time period or capture data at the extreme duty points. This activity shall be associated with more extensive use of *in situ* monitoring to ensure that the operating conditions can be accurately determined at the various duty points (i.e. design point, normal, rated, maximum and minimum flow rates). The monitoring shall be made by connecting transducers to data logging equipment and recording the sensor output, or in some facilities, where historical information is stored, the relevant information should be downloaded from the facility information system.

Table 2 — Required and optional data for assessment level 1, 2 and 3

System information	Level 1 assessment	Level 2 assessment	Level 3 assessment
Description of the facility	Required	Required	Required
Pumping system inventory (provided prior to assessment start) for systems that meet pre-screening criteria - List of pumps - Pump description (including pumped media) - Pump type - Pump application - Physical location of pump - Installed motor data (rated nameplate power, voltage, full load amperage, and frequency) - Annual operational hours (or % operation) - Control method e.g. control valve, variable speed drive (VSD), bypass	Required	Required	Required
Operating parameters (including flow and pressure)	Optional	Required	Required
Pump curve(s)	Optional	Required	Required
Design point	Optional	Required	Required
Cavitation at pump or in system	Optional	Required	Required
Maintenance level (low, medium, high)	Optional	Required	Required
Equipment information (service type, time in service, shared duty, voltage)	Optional	Required	Required
Typical flow rates and variations thereof	Optional	Required	Required
Duration diagrams	Optional	Required	Required
Histograms	Optional	Required	Required

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Table 2 *(continued)*

System information	Level 1 assessment	Level 2 assessment	Level 3 assessment
Maintenance costs	Optional	Required	Required
Process and instrument diagrams (PID)/Digital control system (DCS) screen-shots	Optional	Required	Required
Rating of any other drive system (e.g. steam turbine drive)	Optional	Required	Required

5.2 Walk Through

A walk through is required for level 2 and 3 assessments and may be required for some pumping systems undergoing a level 1 assessment.

The walk through shall entail examination throughout ensuring that the information provided to the assessment team reflects the configuration of the existing systems.

For the pumping systems undergoing level 2 and 3 assessments, after the walk through is completed, the information listed in 5.5 shall be collected using the methodologies specified in 5.6.

All components of the system shall be considered and pertinent information such as valve locations, locations of available pressure taps, flow meters, valve positions etc. should be noted.

During the walk through, information about the control methods for the different systems such as valve settings should be noted.

The assessment team shall also identify any existing conditions that are often associated with inefficient pumping system operation.

These conditions may be identified through the following potential indicators:

a) pumping systems where significant throttling takes place[1)]

b) pumping systems with recirculation of flow used as a control scheme;

c) pumping systems with large flow or pressure variations;

d) systems with multiple pumps where the number of operated pumps is not adjusted in response to changing conditions;

e) systems serving multiple end uses where a minor user sets the pressure requirements[1)];

f) cavitating equipment[1)];

g) high vibration and/or noisy pumps, motors or piping[1)];

h) equipment with high maintenance requirements (low MTBF) [1)],

i) systems for which the functional requirements have changed with time, but the pumps have not;

j) worn, eroded, corroded, distorted or broken impellers/diffusers/vanes or wear rings and casings (if available, this information can be provided by facility staff);

k) clogged pipelines or pumps (usually requires historical data to be discovered);

l) systems which have a low pumping system efficiency indicator (for information, see Annex H);

m) seized valves or leaking recirculation valves;

n) sealing systems, especially high temperature, requiring cooling (see B.4.3);

1) Possible indication of excessive parasitic power level (see Annex H).

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o) lack of proper inlet screening, where appropriate.

5.3 Understanding system functional requirements

The assessment team shall determine what are the normal operating conditions as well as operation under extreme and abnormal conditions, knowing the limits within which the system is designed to operate and how the operating conditions are distributed overtime.

If accurate records are not available and the facility personnel may be unable to supply the needed information, the assessment team shall monitor the system over some period of time in order to establish the demands on the system.

5.4 Determining system boundaries and system energy demand

The assessment team shall determine the system boundaries and system energy demand of each pumping system undergoing a level 2 or 3 assessment.

A pumping system assessment shall consider the overall efficiency of the existing system.

NOTE If the subsystems are part of a larger facility system, the system boundary is complex and the boundary is determined prior to any measurements and calculations

5.5 Information needed to assess the efficiency of a pumping system

5.5.1 General

After the decision is taken on which pumping systems require further investigation, the following information from 5.5.2 to 5.5.6 shall be gathered.

The assessment team shall determine the data collection needs for each system being evaluated.

The assessment team shall maintain quality assurance in the design and execution of a measurement plan as a consistent, repeatable, and reproducible process.

The measurement plan shall adhere to principles of safety, transparency, and reliability.

The measurement plan shall include the measurements required to develop an annual energy consumption baseline for the pumping system. This is typically done by taking instantaneous flow, pressure and electrical measurements and determining operating hours at varying system conditions.

Cross-checking should be done to ensure the data are correct.

5.5.2 Electrical motor/drive information

Initial motor/drive information to be collected from the nameplate (if available) or manufacturer's data sheets shall include:

a) line frequency;

b) motor size (rated power);

c) motor rated speed;

d) motor rated voltage;

e) motor full load amps (FLA) - the current to the motor when operating at rated power;

f) motor power rating information;

g) nominal efficiency or efficiency class (if provided);

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h) motor type and characteristics;

i) type of drive (e.g. variable frequency drive, belt, gear, direct);

j) motor history (e.g. original, rewound, replaced).

5.5.3 Pump information

5.5.3.1 Rotodynamic pumps

This information should be obtained from the pump nameplate (if available) and any records that may be kept on file for the pump.

If the information from the nameplate and records differ, this should be noted and addressed later in the assessment of the system. Pump information required (when available) shall include:

a) type of pump and model;

b) manufacturer name;

c) serial number;

d) customer tag number;

e) number of stages;

f) type of drive;

g) nominal speed – (r/min);

h) design point (flowrate and head);

i) impeller diameter (installed and maximum);

j) pump performance curves, if available, including rated total head, flow, power, efficiency and net positive suction required (NPSHR),

k) maintenance records;

l) pump cavitation or recirculation problems;

m) sealing system data.

5.5.3.2 Positive displacement (PD) Pumps

This information should be obtained from the pump nameplate (if available) and any records that may be kept on file for the pump.

If the information from the nameplate and records differ, this should be noted and addressed later in the assessment of the system. Pump information required (when available) shall include:

a) type of pump and model;

b) manufacturer name;

c) serial number;

d) customer tag number;

e) pump description/model number;

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f) rated data:

— speed (r/min);

— pressure;

— temperature;

— power;

g) system data (operating conditions);

h) relief valve setting;

i) pump performance curves;

j) maintenance records;

k) pump cavitation, recirculation line, or other operational problems;

l) sealing system.

5.5.4 Liquid properties information

Required liquid information shall include:

a) name of the liquid;

b) dynamic viscosity;

c) temperature;

d) density;

e) presence of solids and their characterization;

f) vapour pressure at running pressure and temperature conditions;

g) free gas percentage, when applicable;

h) hazards,

i) inflammability.

5.5.5 Detailed system data

Required systems data information shall include:

a) system layout,

b) unusual operating conditions;

c) PID diagrams,

d) pump control method:

— variable speed drive (VSD);

— throttled (valve percentage open if available);

— by-pass/recirculation;

— on/off;

— pumps in series or in parallel, or split duty;

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