INTERNATIONAL STANDARD

ISO 11011

First edition
2013-09-15

Compressed air — Energy efficiency — Assessment

Air comprimé — Efficacité énergétique — Évaluation

Reference number
ISO 11011:2013(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2. www.iso.org/directives

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The committee responsible for this document is ISO/TC 118, *Compressors and pneumatic tools, machines and equipment*, Subcommittee SC 6, *Air compressors and compressed air systems*.

Introduction

This International Standard has been developed with reference to available documentation[1] (see Bibliography) relating to energy assessment of compressed air systems.

This International Standard is produced to support the objectives of energy management for those organisations utilizing compressed air and wishing to improve the energy efficiency of such systems. Remembering the words of Lord Kelvin who said in 1883, "If you cannot measure it, you cannot improve it", this International Standard aims to assist with measurement and provide the knowledge to enable improvement.

The prime consideration for any compressed air system is the ability to generate air with the least amount of energy. Having done this, the next consideration is to transmit energy from the point of generation to the point of use with the least loss. The final consideration is to eliminate waste and use the least amount of air for the production process.

This International Standard uses speciality terms which relate the needs of assessment activities to those of compressed air systems. Many terms will appear new to the users of this International Standard who are familiar with general compressed air terms.

A general introduction to energy assessment is given in Annex A.

1) Extracts from ASME EA-4-2010 were used with permission from ASME. The core elements used are from Scope and Introduction, Organizing the Assessment, Analysis of Data From the Assessment, Reporting and Documentation, and Mandatory Appendices — I, Preliminary Data Collection Matrix.

Compressed air — Energy efficiency — Assessment

WARNING — Users of this International Standard are advised that energy-related judgements should not compromise safety issues.

1 Scope

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

This International Standard considers compressed air systems as three functional subsystems:

— supply which includes the conversion of primary energy resource to compressed air energy;

— transmission which includes movement of compressed air energy from where it is generated to where it is used;

— demand which includes the total of all compressed air consumers, including productive end-use applications and various forms of compressed air waste.

This International Standard sets requirements for

— analysing the data from the assessment,

— reporting and documentation of assessment findings, and

— identification of an estimate of energy saving resulting from the assessment process.

This International Standard identifies the roles and responsibilities of those involved in the assessment activity.

This International Standard provides indicative information in Annexes B, C, D, and E of the type of data to be collected to assist in a successful assessment. The information provided is not exhaustive and therefore is not intended to restrict the inclusion of other data. The form and presentation of the information given in the annexes is also not intended to restrict the manner of presentation of the reporting to the client.

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.

ISO 1217, *Displacement compressors — Acceptance tests*

ISO 5598, *Fluid power systems and components — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 1217 and ISO 5598 and the following apply.

3.1 General

3.1.1
air treatment
any process provided for the purpose of separation and purification of the compressed air

3.1.2
artificial demand
excess air consumed by a system's unregulated or poorly regulated uses due to operating at a pressure in excess of actual requirements

3.1.3
assessment team
authority to fulfil roles and responsibility of the assessment having appropriate functions and knowledge

3.1.4
baseline
set of typical operating period, work conditions, and performance parameters revealed by assessment and used for comparison of efficiency of measures recommended as a result of energy efficiency assessment procedures

3.1.5
compressed air point of use
components using the pneumatic energy for physical or chemical actions

3.1.6
compressed air systems

group of subsystems comprising integrated sets of components, including air compressors, treatment equipment, controls, piping, pneumatic tools, pneumatically powered machinery, and process applications utilizing compressed air

3.1.7
compressed air system assessment
activity which considers all components and functions, from energy inputs (SUPPLY SIDE) to the work performed (DEMAND SIDE) as the result of these inputs; undertaken to observe, measure, and document energy reduction and performance improvement opportunities in a compressed air system

3.1.8
data logging
measurement of physical parameters while tabulating a periodic log (record) of their numerical value using time-aligned data frames for the plurality of recorded parameters

Note 1 to entry: Two types of data logging are:

a) dynamics: data logging while creating a sufficiently high frequency periodic log (record) so as to investigate the time-based variation of measured physical parameters

b) trending: data logging during an extended duration of time for the purpose of investigating regularities, irregularities, or both in the measured physical parameters throughout time

3.1.9
demand
total of all compressed air consumers, including productive end-use applications and various forms of compressed air waste

3.1.10
drawdown
circumstance observed in a compressed air system that is characterized by continual pressure decay arising from a compressed air system event whereby air demand exceeds the capacity of supply

3.1.11
operating period
group of typical time periods that share similar compressed air energy and compressed air demand profiles

Note 1 to entry: See 3.1.15.

3.1.12
spot check measurement
measurement of physical parameters creating a log (record) of their numerical value that is carried out at random time intervals or limited to a few instances

3.1.13
supply
conversion of primary energy resource to compressed air energy

3.1.14
transmission
movement of compressed air energy from where it is generated to where it is used

3.1.15
typical operating period
time period that represents a period of typical plant operation

3.2 Flow

3.2.1
demand flow rate
total airflow rate of demand-side consumption

Note 1 to entry: Demand-side consumption includes productive consumers, inappropriate usage, artificial demand, and demand-side waste. This takes into account supply flow plus or minus the compressed air supplied to system demand from secondary storage as system pressure decreases. This can also account for the airflow entering secondary storage as system pressure increases.

3.2.2
flow dynamic application
end use wherein the peak airflow rate and minimum pressure occur simultaneously

3.2.3
flow static application
end uses characterized when peak airflow rate and minimum pressure required do not occur simultaneously

3.2.4
generation flow rate
airflow rate of compressed air generated by the air compressor(s) before any air treatment equipment air use and supply-side waste

3.2.5
peak airflow
maximum value of the airflow during the daily or other periodic operating cycle

3.2.6
storage flow rate
airflow rate entering the storage volume as pressure increases or the airflow rate exiting the storage volume as pressure decreases

Note 1 to entry: The airflow can be either entering or exiting the system or the primary or secondary storage.

3.2.7
supply flow rate
net airflow rate leaving the supply side of the system

3.3 Pressure

3.3.1
compressor inlet pressure
pressure of the aspirated air at the standard inlet point of the compressor which varies with compressor design and type

Note 1 to entry: The pressure is at the inlet flange for bare compressors or ambient air entry point into the package for packaged compressors.

3.3.2
drawdown pressure
total pressure decay in compressed air system pressure that occurs during a particular drawdown event

3.3.3
pressure loss
reduction in compressed air pressure resulting from the interaction of airflow through the fixed resistance associated with a component of the air system

Note 1 to entry: See 3.3.8.

3.3.4
pressure signature
pressure profile of a repeated event that is correlated with a specific end-use or production activity

3.3.5
minimum system pressure
lowest possible air pressure a system can reach before adversely affecting the process

3.3.6 Operating pressure

3.3.6.1
user operating pressure
prescribed air pressure at the inlet point of the particular compressed air user equipment according to its specifications

3.3.6.2
system operating pressure
air pressure at the entry point into the network of the compressed air users

3.3.7
pressure gradient
rate of pressure change with respect to distance in the direction of maximum change

Note 1 to entry: In fluid mechanics, the change in pressure, P, along the length and distance, d, of a fluid conduit. It is represented by $\Delta P/\Delta d$.

Note 2 to entry: The air velocity in a pipeline depends on the magnitude of the gradient and resistance of the pipeline.

Note 3 to entry: Without gradient, there is no airflow. In a compressed air system, air moves from high-pressure toward low-pressure areas.

3.3.8 Pressure profile

3.3.8.1
cyclic pressure profile
timely function of the compressed air pressure variations in daily or other periodical operation cycles at a particular point of the compressed air system caused by combination of different air consumption cycles of several end users

3.3.8.2
distance pressure profile
function of pressure degradation along the compressed air transmission and distribution system at a certain typical period of operation cycle caused by pressure loss in its components

Note 1 to entry: Components such as air treatment facilities, fittings, air transmission pipes, branch pressure take-offs, etc.

3.3.9 Pressure differential

3.3.9.1
available pressure differential
compressed air pressure difference between the inlet and outlet of a component, which represents a variable resistance to airflow

Note 1 to entry: The available compressed air energy represented by the upstream volume and greater pressure that is available to the system.

Note 2 to entry: See 3.3.3.

3.3.9.2
storage pressure differential
difference between pressure in a storage volume and the desired target pressure of the connected system or sector

3.3.10
target pressure
compressed air pressure that is desired to be consistently supplied to a compressed air system or sector of a compressed air system at a specific point

EXAMPLE A specific point may include the main header downstream of supply, air treatment equipment, upstream of a system control valve, downstream of a system control valve, etc.

Note 1 to entry: See 3.3.5.

3.4 Storage

3.4.1
primary storage
compressed air storage system that is located on the generation side (supply) of a compressed air system

3.4.2
secondary storage
auxiliary storage vessel installed close to the end-user equipment by heavy intermittent air consumption and use of long and small transmission lines with the purpose of elimination of overloading the main air transmission line and excessive pressure losses

3.5 Volume

3.5.1
effective volume
internal volume of a single storage component or sector of a compressed air system reflecting its capability to store compressed air energy

3.5.2
geometrical volume
mechanical volume
calculated by adding all of the geometric volumes in the system based on the observed sizes of those volumes

3.5.3
system volume
internal volume of the compressed air system reflecting its capability to store compressed air energy and to suppress air pressure pulsations

4 Roles and responsibilities

4.1 Identification of assessment team members

The functions and knowledge required to accomplish an assessment are listed in 4.1.1. The assessment team shall have members that have responsibility and authority to carry out these functions.

4.1.1 Required functions and personnel

4.1.1.1 Resource allocation

a) Determine availability of on-site, as well as other off-site participants.

b) Allocation of funding and resources necessary to plan and execute the assessment.

c) Exercise final decision-making authority on resources.

d) Oversee participation of outside personnel, including items such as contracts, scheduling, confidentiality agreements, statement of work, and/or other items.

4.1.1.2 Coordination, logistics, and communications

a) Obtain necessary support from plant personnel and other individuals and organizations during the assessment.

b) Participate in organizing the assessment team and coordinate access to relevant personnel, systems, and equipment.

c) Organize and schedule assessment activities.

4.1.1.3 Compressed air systems knowledge

a) Have background, experience, and recognized abilities to perform the assessment activities, data analysis, and report preparation.

b) Be familiar with operating and maintenance practices for compressed air systems.

c) Have experience applying the systems approach in assessments.

4.1.1.4 Competency

Assessment personnel shall have the knowledge and skills necessary to perform assessments. Those personnel can also require formal documentation in order to meet some national requirements.

In the absence of national requirements, those leading the assessment shall provide evidence of familiarity with and understanding of, compressed air technology basics through recognized qualifications, as well as a relevant period of experience in assessment activities. See Annex F for further information.

Information on other assessment team members is identified in 4.6.

4.2 Site management support

Site management support is essential for the successful outcome of the assessment. Site management understanding and support of the purpose of the assessment shall be secured. The site personnel shall be engaged in the assessment to the extent necessary. The support of site management shall be gained prior to conducting the assessment as follows:

a) Commit the necessary funding, personnel, and resources to support the assessment.

b) Communicate to site personnel the assessment's importance to the organization.

4.3 Communications

Lines of communication required for the assessment shall be established. Clear guidance shall be provided to facilitate communications among members of the assessment team so all necessary information and data can be communicated in a timely manner. This includes administrative data and logistics information, as well as operational and maintenance data.

4.4 Access to equipment, resources, and information

For the performance of a complete and comprehensive assessment of a facility's compressed air system, it is necessary to physically inspect and make selected measurements on the system components. Therefore, access shall be required to

a) plant areas and compressed air system components required to conduct the assessment,

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

c) other information sources such as drawings, manuals, test reports, historical utility bill information, computer monitoring and control data, electrical equipment panels, and calibration records necessary to conduct the assessment.

4.5 Assessment objectives and scope

The overall goals and scope of the assessment shall be discussed and agreed upon at an early stage by the assessment team. The overall objectives of the assessment shall include identification of performance improvement opportunities in the compressed air system being assessed using a systems approach. The scope of the assessment shall define the area(s) of the facility to be assessed.

4.6 Identification of other assessment team members

The assessment considers the entire system from energy inputs to the work performed as a result of those inputs. As a result of facility specialists interviews, certain manufacturing equipment or processes that use compressed air may be identified for detailed study requiring the participation of individuals with specialized knowledge related to these applications.

4.7 Objective check

Prior to conducting the assessment, the plan of action shall be reviewed to establish that it meets the stated assessment objectives. The assessment plan of action shall be reviewed for relevance, cost effectiveness, and capacity to produce the desired results.

5 Assessment methodology

5.1 General

Assessments involve collecting and analysing system design, operation, energy inputs, energy use, and performance data and identifying energy performance improvement opportunities for system optimization. An assessment can also include additional information, such as recommendations for improving resource utilization, reducing per unit production cost, reducing lifecycle costs, and improving environmental performance related to the assessed system(s).

The methodologies to be applied in performing the assessment shall include one or more of the following techniques:

a) observation and research;

b) spot-check measurements;

c) data logging, including dynamics and trend.

5.2 Systems engineering methods

This International Standard utilizes systems engineering methods applied to a compressed air system assessment. It is necessary to:

a) Understand compressed air point of use as it supports critical plant production functions.

b) Correct existing poor performing applications and those that upset system operation.

c) Eliminate wasteful practices, leaks, artificial demand, and inappropriate use.

d) Create and maintain an energy balance between supply and demand.

e) Optimize compressed air energy storage and air compressor control.

Application of a systems approach to a compressed air system assessment directs the focus toward total system performance rather than individual component efficiency.

NOTE Systems engineering focuses on defining client needs and required system functionality early in the development cycle, documenting system requirements, and then proceeding with system design while considering the entire system.

5.3 Systems engineering process

The systems engineering process is described in 10 steps:

a) Identify what needs to be accomplished.

b) Identify what needs to be evaluated.

c) Get organized, identify the assessment team, and get plant background information.

d) Define the present system.

e) State site-specific system assessment goals.

f) Design the system assessment (what, how, when).

g) Test the assessment's design for relevance, completeness, and cost effectiveness.

h) Do the assessment and gather facts and data.

i) Analyse the facts and data to develop solutions and estimate cost and savings.

j) Report and document recommendations and findings.

NOTE 1 Compressed air systems engineering is an iterative process including requirements definition, the assessment process, and evaluation of outcomes and results. It is a fluid process whereby outcomes and results can achieve defined goals or can result in new or revised requirements definition.

NOTE 2 There are many compressed air system integration factors where decisions related to one component or subsystem impact other components or subsystems. Concept alternatives should be proposed and analysed before final conclusions are reached.

5.4 System assessment process

5.4.1 General

The assessment should document issues and concerns about compressed air use, critical production functions, and poor compressed air system performance. The assessment should identify and quantify energy waste, compressed air supply-and-demand balance, energy use, and total compressed air demand. These generalizations should be used to guide the selection of objectives and action items for preliminary data collection.

5.4.2 Relationships in the system assessment process

The relationships of those involved in the assessment and the assessment process are shown in Figure 1.

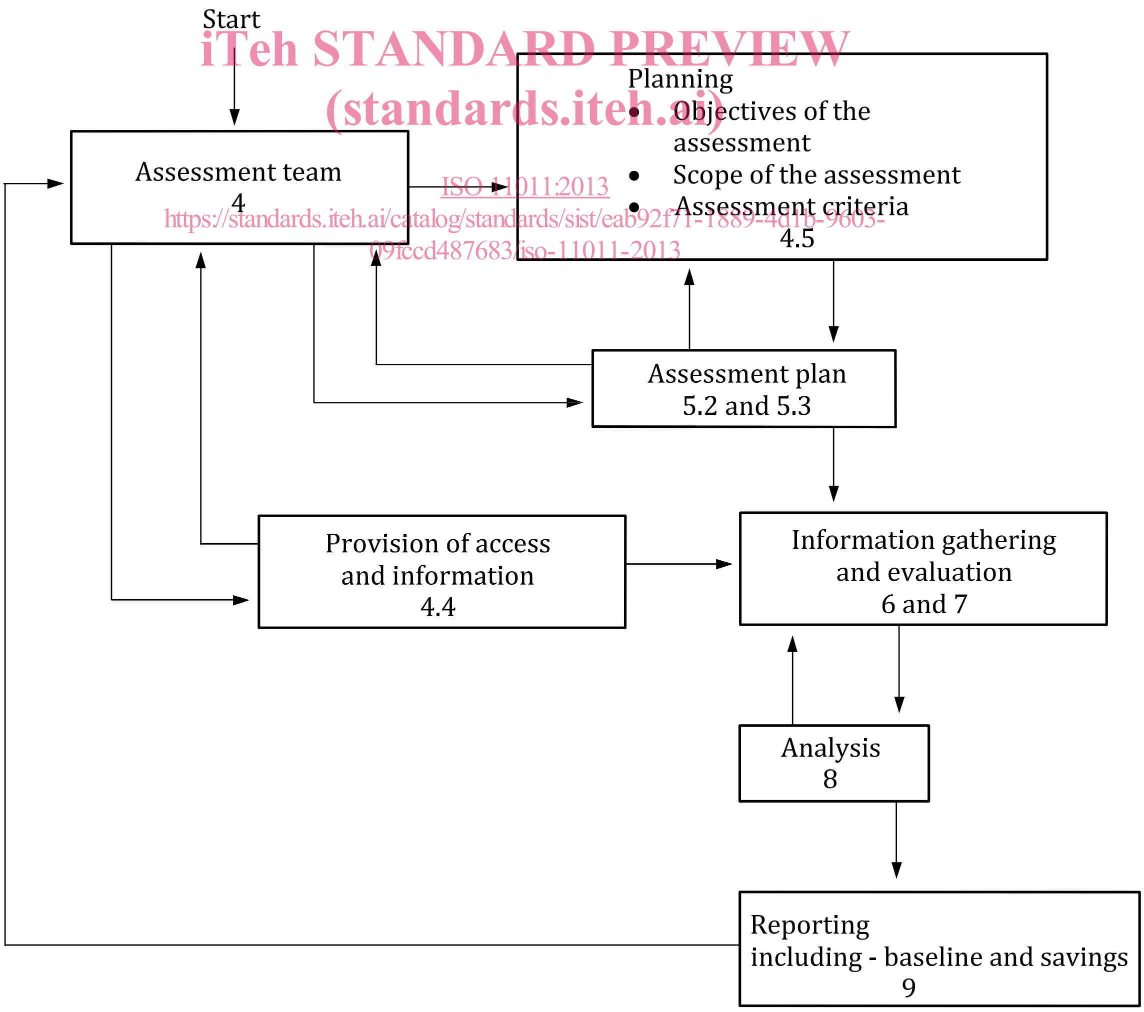

Figure 1 — Process for conducting an energy assessment of a compressed air system