

**ANSI/ASHRAE Standard 94.1-2010**

**(Supersedes ANSI/ASHRAE Standard 94.1-2002 [RA 2006])**



# ASHRAE STANDARD

## Method of Testing Active Latent-Heat Storage Devices Based on Thermal Performance

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#### NOTE

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## FOREWORD

*This is a revision of Standard 94.1-2002 (RA 2006). This standard was prepared under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It may be used, in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform standards throughout the industry.*

*The changes made for the 2010 revision include the following:*

- *The references were updated.*
- *The normative references were separated from the bibliography.*
- *Informative Annex B (Bibliography) was added.*
- *The Table of Contents was updated.*
- *The numbering of the standards referenced in the body were updated to be consistent with the references and bibliography sections.*
- *The figures were enlarged for easier reading.*
- *Other minor editorial corrections were made.*

## 1. PURPOSE

The purpose of this standard is to provide a standard procedure for determining the thermal performance of latent heat thermal energy storage devices used in heating, air-conditioning, and service hot water systems.

## 2. SCOPE

**2.1** This standard applies to latent heat thermal energy storage devices in which a transfer fluid enters the device through a single inlet and leaves the device through a single outlet. This standard is not applicable to those configurations in which there is simultaneous flow into the storage device through more than one inlet or simultaneous flow out of the storage device through more than one outlet. The transfer fluid can be either a liquid or a noncondensing gas.

**2.2** This standard does not include factors relating to cost, life, or reliability. It anticipates a variety of energy sources but does not consider the interfacing requirements of any specific heating or cooling system. In particular, the five cycles prior to testing specified in Section 5.1 are not intended as a measure of phase-change material degradation.

**2.3** The test procedure and equipment outlined in this standard are most easily adaptable to devices used to store thermal energy on the order of  $10^7$  Btu ( $10^{10}$  J) or less.

**2.4** This standard permits testing of a storage device containing a source of internal heating, such as a stirring pump or

an electric immersion heater, provided that less than 10% of the charge capacity in a test is supplied by the internal heating. If such a source of internal heating is used, the internal heat input must be measured and Equations 2 and 5 must be appropriately modified.

## 3. DEFINITIONS

The following definitions are stipulated for this document:

**ambient air:** the air in the space surrounding the thermal energy storage device.

**charge capacity:** the amount of heat that can be transferred into the storage device at a specified rate for a specific set of values for the initial temperature of the storage device, the temperature rise of the exiting fluid, and the mass flow rate of fluid through the storage system.

**charge test time:** the duration of a single transient test in which energy is added to the storage device.

**cycling (latent-heat-type storage device):** a process in which heat is applied to and removed from the storage device in a cyclic manner and the phase of the storage medium is changed twice in each cycle.

**discharge capacity:** the amount of heat that can be removed from the storage device at a specified rate and for a specific set of values for the initial temperature of the storage device, the temperature decrease of the exiting fluid, and the mass flow rate of fluid through the storage system.

**discharge test time:** the duration of a single transient test in which energy is removed from the storage device.

**heat loss coefficient:** the rate at which heat is lost from the storage device per degree temperature difference between the average storage medium temperature and the average ambient air temperature (or ground temperature, if the storage device is buried).

**standard air:** air weighing  $0.075 \text{ lb/ft}^3$  ( $1.2 \text{ kg/m}^3$ ), which approximates dry air at a temperature of  $70^\circ\text{F}$  ( $21.1^\circ\text{C}$ ) and a barometric pressure of  $29.92 \text{ in. Hg}$  ( $101.3 \text{ kPa}$ ).

**standard barometric pressure:** the barometric pressure of  $29.92 \text{ in. Hg}$  ( $101.3 \text{ kPa}$ ) at  $32^\circ\text{F}$  ( $0^\circ\text{C}$ ).

**storage device:** the container(s) plus all contents of the container(s) used for storing thermal energy. The transfer fluid and accessories, such as heat exchangers, flow-switching devices, valves, and baffles, which are integral with the thermal storage container(s), are considered part of the storage device.

**storage medium:** the material in the storage device, independent of the containing structure, in which the major portion of the energy is stored.

**transfer fluid:** the fluid that carries energy in and out of the storage device.

**storage efficiency:** discharge capacity divided by charge capacity.