ANSI/ASHRAE Standard 150-2000 (RA 2004)
Reaffirmation of ANSI/ASHRAE Standard 150-2000

ASHRAE STANDARD

Method of Testing the Performance of Cool Storage Systems

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NOTE

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(This foreword is not a part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process.)

FOREWORD

This standard was developed to provide a uniform method for evaluating the performance of cool storage systems installed in buildings or central plants and is intended to be used by owners, operators, consultants, and others. The test method provided in this standard will eliminate the need to develop a specific test procedure for each individual project.

Hereinafter in this foreword, "system" means "cool storage system" unless noted otherwise.

This standard provides a method of determining the cooling performance of a given installation at the time of turnover to the owner or at any time during its useful life. The standard includes options for testing a system at times when less than the peak load is available. A method is given for defining test loads that enable the user to determine if the cool storage system would perform as expected when subjected to the actual peak load.

The standard can also be used to determine the maximum performance of a new or existing system. This information may be desired to optimize the system or to determine the system's current capability prior to an increase in load or other changes to the system.

It is recognized that field testing is costly, and this standard may not provide sufficient benefit to warrant its use at every cool storage installation. Some packaged or modular systems can be provided with sufficient data to establish their expected or design performance without field testing. However, the user still may elect to carry out a field evaluation to help ensure that the system will perform under peak design conditions or to qualify for utility or government incentives.

Many cool storage installations are completely or partially dependent upon field assembly of components that cannot be pre-rated or tested prior to assembly. For these systems, field testing is the only way to ensure that the installed system meets the specified performance requirements.

In other cases, it may be in the best interest of owners, contractors, manufacturers, and designers to establish the system's level of performance at the time of installation. This could prevent costly disagreements or litigation after the system has been accepted and operated for a period of time, possibly under different load conditions.

The test methods provided in this standard are intended to establish cool storage system performance but not to diagnose system operation. These test methods specifically enable the user to economically determine the available capacity of the storage device, the capacity available to meet a load, and the efficiency of the system in meeting the load. They can also be used to characterize the cooling loads for a specific building or cooling system. Users are encouraged to utilize additional instruments and take additional measurements beyond those required by the standard to aid in system diagnosis and optimization.

Test method results represent the actual field performance and capacity under the load profile defined for the test, not the manufacturer's nominal rating. The results may not correspond to ratings based on other conditions.

This standard does not specify how test results will be used. Interpretation of the data obtained from the test is the responsibility of the user.

The committee initially set out to produce separate test methods for different cool storage technologies. As the test methods were developed, it became evident that the basic steps of the test procedure are the same for any technology. The differences among cool storage technologies are addressed in the definitions of the test conditions.

Subsection 5.3 of the standard requires that the user provide certain information about the system necessary to define the test conditions and requirements. This information includes:

1. *The load profile against which the storage device or system must be tested. The user should note that the usable storage capacity of a given storage device or system will vary depending on the load profile.*
2. *The tests that are to be performed. Users may elect to perform any number of the individual tests defined in the standard.*
3. *System parameters such as maximum usable discharge temperature, maximum usable cooling supply temperature, and criteria for determining the fully charged and fully discharged conditions.*
4. *For the Cool Storage System Capacity Test, the boundaries of the system or the portion of the system that is under test.*

This standard may be referenced in project specifications requiring performance testing of newly installed systems. Users of the standard should note that any specification requiring testing under this standard must also include the information required by 5.3.

This standard does not specifically address testing of chillers as components. The scope of the standard does include the performance of chillers or refrigeration machines as parts of a larger system. Users may want to test chiller performance concurrent with performing the tests specified in this standard, since much of the required instrumentation may already be in place.

In keeping with common international practice, the standard uses the unit of kWh, instead of the standard SI unit of MJ, to measure cooling energy stored or delivered. The standard uses the subscripted units kWh_T and kWh_E to differentiate thermal and electrical energy. As MJ becomes accepted in common practice, the standard should be revised to use units of MJ for cooling energy.

Designers of cool storage systems that will be tested under this standard should specify in their design documents the appropriate instrumentation and system configuration as defined in this standard. The specification should include sufficient detail for the selected sensor(s) to perform as required.

The committee could not find existing flow measurement standards that address field installation and calibration and that encompass the broad range of currently available tech-

nologies and sensors. Consequently, detailed guidance is provided in Annex A.

The instrument accuracy requirements in this standard were selected to provide 10% or better uncertainty in the overall calculation of capacity for most systems. The standard recommends that users who have stricter requirements conduct an uncertainty analysis prior to testing to aid in the selection of instrument types and the measurement method. The uncertainty analysis helps confirm that the selected instruments will provide the desired accuracy in the test results. A similar uncertainty analysis should also be completed after testing, using measured data to determine the uncertainty interval in the test results. Annex B discusses the issues addressed in an uncertainty analysis

1. PURPOSE

This standard prescribes a uniform set of testing procedures for determining the cooling capacities and efficiencies of cool storage systems.

2. SCOPE

2.1 This standard covers cool storage systems composed of chillers, storage medium, storage device or vessel, heat sink equipment or heat sink systems, and other auxiliary equipment required to provide a complete and working system.

2.2 This standard includes the following:

a. a uniform method of testing,
b. identification of test equipment for performing such tests,
c. identification of data required and calculations to be used, and
d. definitions and terminology.

2.3 This standard does not cover testing of the air side distribution.

3. DEFINITIONS

accuracy: the ability of an instrument to indicate the true value of a measured quantity.[1]

capacity: see *thermal storage capacity*, *cool storage system capacity.*

cool storage system: a system that uses a thermal storage device to meet all or part of a cooling or refrigeration load. A cool storage system is composed of chillers, thermal storage medium, thermal storage device or vessel, heat sink equipment or heat sink systems, and other auxiliary equipment and may be a part or subset of a larger cooling system.

cool storage system capacity: the maximum amount of cooling energy that can be supplied by a cool storage system in response to a particular load profile, as determined by the Cool Storage System Capacity Test.

cycle: see *storage cycle*.

critical discharge point: the point in the load profile at which the combination of the required discharge rate and the current storage inventory causes the discharge temperature from the thermal storage device to rise to its highest value.

efficiency:

cycle-specific energy use: ratio of the total energy input in kWh_E or kWh_T (kWh_E or Btu) to the total energy in kWh_T (ton-hour) removed from the load over one or more complete storage cycles. Total energy input includes the energy input to all waterside components that are part of the system under test.

storage efficiency: discharge capacity divided by charge capacity.[1]

fully charged condition: the state of a thermal storage device at which, according to the design, no more heat is to be removed from the thermal storage device. This state is generally reached when the control system stops the charge cycle as part of its normal control sequence.

fully discharged condition: the state of a thermal storage device at which no more usable cooling energy can be recovered from the storage device.

load profile: summary of thermal loads over a period of time. For the purposes of this standard, the load profile specifies thermal loads for each hour of the period, encompassing at least one complete storage cycle. The load profile indicates each hour's total load, the cooling output of the chiller(s) and the thermal storage device, and the state of charge of the thermal storage device. The load profile also shows the corresponding inlet temperature, outlet temperature, and flow rate for each hour's load. Tables 1 and 2 illustrate complete data for two example load profiles.

specified load profile: the load profile that the cool storage system is expected to meet. This may be the load profile used to design the cool storage system and size the equipment or it may be based on actual or expected loads.

maximum allowable charging period: the period of time within which charging of the thermal storage device must be completed. This period is typically determined by the utility rate structure, the building operating schedule, and the design operating strategy.

maximum usable cooling supply temperature: the maximum fluid supply temperature at which the cooling load can be met.

maximum usable discharge temperature: the maximum fluid temperature at which usable cooling can be obtained from the thermal storage device. This temperature may be selected to suit the specific needs of the test.

- For systems configured with the chiller upstream of storage, it is generally equal to the maximum usable cooling supply temperature.
- For systems configured with the chiller downstream of storage, it is generally determined as the highest temper-