



Australian Government

Office of the Renewable Energy Regulator

HEAT LOSS TEST PROCEDURE FOR SOLAR WATER HEATERS WITH A HOT WATER STORAGE TANK GREATER THAN 630L

1.1 SCOPE

This document sets out the test conditions, equipment and configuration to be used for heat loss tests of hot water tanks that exceed the upper volume limit of 630L set in AS1056.1.

The procedure specified in this document closely follows the procedure defined in AS1056.1-2003 for tanks of less than 630L volume except the procedure has been modified to accommodate differing requirements for mounting of large tanks and relaxation of the requirements to control ambient temperature. The test procedure in this document was developed to allow large tanks to be tested without the requirement to mount the tank in a special test chamber. As very large tanks cannot be easily transported and mounted in a test chamber the modified test requirements allow testing in a simplified enclosure that could be readily constructed at the place of manufacture or at most installation sites.

1.2 TEST CONDITIONS

1.2.1 TEST ENCLOSURE AND AIR TEMPERATURE

The tank shall be mounted in a ventilated test space that has insulated walls to minimise heating and cooling from the surroundings other than by the controlled air circulation around the tank. The horizontal and vertical dimensions of the test space shall be greater than two times the corresponding dimensions of the tank under test. An ambient temperature sensor shall be used to measure the air temperature upstream of the tank. The ambient temperature probe shall be located approximately mid-tank height and not less than 1.5 m from the water heater. Air circulation around the tank shall be controlled such that the vertical temperature gradient from the base of the tank to the top of the tank shall not exceed 1K/m. The air temperature variation during the test shall be monitored at one minute intervals. The analysis procedure (section 1.6) accounts for the influence of the variation of both air temperature and tank temperature during the test. Ambient humidity control is not required for this test.

1.2.2 AIR MOVEMENT

The air speed at the position where the tank is to be mounted at a height of 1000 mm \pm 100 mm from the mounting platform shall be between 0.25 m/s and 0.5 m/s. When operating under the same air flow conditions after the installation of the water heater, a point approximately 1 metre from the water heater and 1 metre from the platform shall be selected that has an air speed that falls within the range 0.25 m/s and 0.5 m/s. The air speeds during subsequent tests shall be maintained at this measured air speed \pm 0.1 m/s in this position.

1.2.3 RADIANT HEAT SOURCES

The water heater under test shall not be exposed to any radiant heat sources during the test. The test room walls and ceilings shall be insulated to ensure that the inside wall and ceiling surface temperatures in the room are within 2K of the air temperature. Where the temperature difference between any test room equipment and the test room ambient temperature is greater than 5K, the appliance under test shall be shielded against direct radiation from the relevant equipment. The container should not be in view of any hot surfaces associated with the test room temperature regulation system or any other equipment. External windows, where incorporated in a test room, shall be provided with radiation shields.

1.3 EQUIPMENT AND SET UP

1.3.1 CONTAINER HOT WATER TEMPERATURE MEASUREMENT POSITION

A single temperature-sensing device, located as near as is practicable to the centre of gravity of the stored water in the container, shall be used to measure the container hot water temperature. The method of installation shall be such that it will not cause an increase in heat loss. The fitting used to hold the core temperature sensor shall be lagged to the same level of insulation as the tank near the sensor mounting.

1.3.2 CONTAINER HOT WATER TEMPERATURE DETERMINATION

To minimise the influence of convection currents from the electric element, the container hot water temperature at the temperature control cut-out is defined as the average temperature over a 5 minute period starting 3 minutes after the temperature control cut-out.

1.3.3 CONTAINER INSTALLATION

The water heater shall be set up and connected for the tests in accordance with the installation diagrams and instructions supplied by the manufacturer, except where these conflict with the requirements of this test. Where the manufacturer recommends alternative methods of connection, one of these methods may be used at the discretion of the testing laboratory. The test setup and method used shall be fully described in the test report.

All control valves, non return valves, pressure reducing and relief valves, and any other devices normally fitted in the cold water supply to the water heater or to the feed tank shall be connected during the test. Fittings supplied with the unit shall be used for the test. Fittings that are required but which are not supplied shall be supplied by the test laboratory. A description of all fittings and their origin shall be included in the test report. If the water heater is not supplied with mounting legs then it shall be mounted on a platform of particleboard, medium density fibreboard, plywood or equivalent timber board of not less than 20 mm to 30 mm thickness, with the top of the platform between 300 mm and 400 mm above the floor. The platform shall extend to not less 300 mm from the base of the water heater in each direction. The space underneath the platform shall be open on all sides to allow free circulation of air.

1.3.4 ELECTRICAL CONNECTIONS

Only the bottom (main) heating unit shall be energised as in normal operation.

1.4 MEASUREMENT ACCURACY AND INSTRUMENTATION

1.4.1 TEMPERATURE

Measurements of temperature shall be made using devices with an uncertainty of measurement of less than $\pm 0.2\text{K}$ at the 95% confidence level. Temperature measurement instruments shall have a resolution of at least 0.1K .

The ambient temperature sensor shall have a time constant of less than two minutes when exposed to an air flow of 0.5 m/s . The sensor shall be shielded from radiation heat transfer from the test product and from the equipment in the room.

Note: Time constant of a temperature sensor is defined as the time it takes to reach $(1 - 1/e)$ (63.2%) of the temperature change when subjected to a step change in temperature.

1.4.2 ELECTRICAL ENERGY CONSUMPTION

Measurements of energy consumption shall be made with an uncertainty of not greater than 2% at the 95% confidence level and a resolution of 10 Wh or better.

Note: To meet an uncertainty of 2% at the 95% confidence level, it is usually necessary to have measuring instruments with an accuracy of 1% or better.

1.4.3 TIME

Measurements of event time shall be made using instruments having an accuracy of better than $\pm 0.01\%$, and a reading resolution of 1 second or better. All event time measurements shall be recorded to the nearest second.

1.5 MEASUREMENT OF STANDING HEAT LOSS

The water heater is installed with all normal fittings connected (except for the hot water outlet pipe and cold water inlet) and insulated and operated at a nominal storage temperature of 75°C for approximately 48 h or 4 temperature control cycles (whichever is longer) without hot water being drawn off so that the unit reaches thermal equilibrium. The heat loss is equal to the measured energy input, corrected to specified conditions of temperature and time, and is expressed in kilowatt hours per 24 h.

1.5.1 HEATER CONFIGURATION

The test procedure only applies to tanks with the electric element in the bottom of the tank. To determine heat loss of tanks normally fitted with a raised electric element (eg horizontal tanks) or with no element (eg heat pumps, some solar systems) shall be tested with a special element that is formed to reach into the bottom of the tank with at least 50% of the active area of the element in the bottom 10% of the tank depth.

Note: If a tank is fitted and tested with a raised electric element (as in horizontal tanks used in solar water heaters) the following procedure may not result in stable operation due to slow conduction down the water in the tank below the electric element.

1.5.2 TEMPERATURE REQUIREMENTS

For this test the container's own temperature control device may be used if it complies with the requirements below. Heat the container to a temperature that will achieve a measured container hot water temperature of $75^{\circ}\text{C} \pm 2\text{K}$ at each temperature control cut-out.

If the water heater's own temperature controller cannot maintain the above temperature condition for 48 h or 4 temperature control cycles (which ever is longer), a suitably calibrated external control shall be used. It is generally preferred that the heating element as supplied with the system is used for the heat loss test. Details of the element used shall be included in the test report.

1.5.3 PROCEDURE

The procedure shall be as follows:

- (a) Add water to the container or via the feed tank to the normal operating level or until full, as appropriate. Ensure all relevant fittings are connected and insulated as specified. Disconnect the hot water outlet and cold water inlet. Ensure that the system has a means of venting pressure as the water expands during heating.
- (b) Energise the water heater and allow the hot water temperature to stabilise for 48 h from the first temperature control cut out or 4 temperature control cycles (which ever is longer), while allowing the water in an unvented container to expand and discharge through the relief valve (where applicable).
- (c) Commence heat loss measurements at a temperature control cut-out after stabilisation and continue the test until a cut-out that occurs not less than 48 hours or four temperature control cycles (which ever is longer) from the commencement of the test. Record container hot water temperature, ambient air temperature and energy consumption at equal intervals of 1 minute or less for the duration of the test.

1.6 ANALYSIS

Numerical corrections for variations in heat loss as a result of core temperature variations during temperature control cycles shall be undertaken on the test data. The two components of this correction are:

- (a) the energy taken to change the storage water temperature to a different cutout temperature (from start to finish temperature of a temperature control cycle – this correction may be positive or negative); and
- (b) the integrated heat loss for the actual air – core water temperature difference during the monitoring period.

Over a test period extending over 4 or more temperature control cycles (minimum test period of 48h) the heat loss, Q_{loss} , is given by:

$$Q_{loss} = UA \left(\overline{T_t - T_a} \right) \Delta t$$

$$= [EL_{in} - (E_2 - E_1)]$$

where EL_{in} is the electrical energy input over test period (kWh)
 E is the thermal energy in the container
 E_1 is the thermal energy at the first temperature control cutout (kWh)
 E_2 is the thermal energy at the last temperature control cutout (kWh)
 Δt is the time interval between temperature control cutouts (hrs)
 T_t is the tank core temperature ($^{\circ}\text{C}$)
 T_a is the air temperature ($^{\circ}\text{C}$)

$\overline{T_t - T_a}$ is the average of the one minute temperature difference readings over the interval between temperature control events

UA is the heat loss rate per unit temperature difference (kWh)/(h K)

Hence

$$UA = \frac{[EL_{in} - (E_2 - E_1)]}{\left(\overline{T_t - T_a} \right) \Delta t}$$

Standard 24-hour standing heat loss, $Q_{loss,55}$, corrected back to a temperature rise of 55K, is therefore:

$$Q_{loss,55} = UA * 55 * 24$$

where EL_{in} , E_1 and E_2 are all in kWh and $Q_{loss,55}$ is in kWh per 24 hours for a 55K temperature difference.

The thermal energy in the container at the start and end of the test (E_1 and E_2) can be approximated to $\pm 0.25\%$ by:

$$E = M C_p T_H$$

$$= \rho V C_p T_H \times 10^{-3} \quad (\text{Joules})$$

$$= \rho V C_p T_H \times 10^{-3} / 3.6 \times 10^6 \quad (\text{kWh})$$

$$= 1.133 \times 10^{-3} \times V \times T_H \quad (\text{kWh})$$

where: E is in kWh

T_H is the hot water temperature in $^{\circ}\text{C}$.

V is the static capacity of the storage water heater in litres

$C_p = 4184 \text{ J}/(\text{K}.\text{kg})$ as a representative specific heat value for the operating range 20°C to 75°C

$\rho = 974.8 \text{ kg/m}^3$ water density for the temperature of 75°C

3.6×10^6 is Joules per kWh

10^{-3} is m^3 per litre

1.6.1 REPORT

The standing heat loss in kWh per 24 hours (to 3 significant figures), shall be reported. Details of the water heater tested, temperature controller and settings, test conditions and equipment used shall also be included in the test report. The number of temperature or temperature/pressure relief valves mounted on hot-water fittings shall also be noted in the report.

1.7 REFERENCES

AS1056.1 -2003 (draft) Storage water heaters – general requirements