AS 2872—1988

Australian Standard®

ATMOSPHERIC HEATING OF VESSELS CONTAINING FLUIDS—ESTIMATION OF MAXIMUM TEMPERATURE

This Australian Standard was prepared by Committee ME/1, Boilers and Unfired Pressure Vessels. It was approved on behalf of the Council of the Standards Association of Australia on 4 February 1988 and published on 9 May 1988.

The following interests are represented on Committee ME/1:

Aluminium Development Council
Australasian Institute of Metals
Australian Compressed Air Institute
Australian Institute for Non-destructive Testing
Australian Institute of Energy
Australian Institute of Petroleum Limited
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PREFACE

This Standard was prepared by the Association's Committee on Boilers and Unfired Pressure Vessels. Acknowledgement is gratefully made of the considerable assistance provided by ICI Australia Engineering Pty Ltd, which included technical investigation and the development of the data and calculation methods presented in the Standard.

The Standard evolved out of consideration of a proposed revision of Appendix Q of AS 1210—1982, SAA *Unfired Pressure Vessels Code.* In reviewing the Appendix, the committee decided to expand its contents by considering individual gases and by introducing variables that would allow designers to investigate specific situations or conditions of atmospherically heated vessels storing liquefied gases under different configurations and exposure conditions. The result of the review was a document of such volume, technical content, and general interest that it was decided to publish it as a separate Standard.

The method of calculating maximum service temperatures and the related pressures in the hottest month of the year has been checked against Appendix Q and against the information used as basis for Appendix Q which in turn had been previously considered and surveyed by both the Committee on Boilers and Unfired Pressure Vessels, and the Committee on Gas Cylinders. Whereas Appendix Q presented values for containers without distinction between gases, or the many physical or atmospheric conditions that may apply, this Standard allows all significant variables to be investigated.

Although the method was primarily intended for uninsulated compressed liquefied gas containers, it became apparent during its development that the method is so general that it may be used for permanent gases and non-pressurized liquids, provided that they are free-flowing (upper absolute viscosity limit approximately 1 Pa.s). It may also be used for above-ground pipelines.

The atmospheric data presented is believed to be conservatively realistic, but provision has been made for departure from the data where for a particular location, more accurate historical data are available.

The theoretical background for the method given in this Standard will be outlined in a technical paper titled 'Atmospheric Heating of Vessels' to be presented by Messrs P. McGowan and I. Mirovics to the Sixth International Conference on Pressure Vessel Technology in Beijing in 1988.

This method of estimation should be an aid to investigators concerned with—

(a) the prediction of maximum temperatures and pressures in vessels;

(b) estimation of ullage requirements;

(c) assessment of maintenance requirements; and

(d) writing of application codes and regulations.

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ATMOSPHERIC HEATING OF VESSELS CONTAINING FLUIDS— ESTIMATION OF MAXIMUM TEMPERATURE

1 SCOPE. This Standard sets out a method for calculating temperatures and the corresponding pressures of fluids in vessels subject to atmospheric heating in the hottest month of the year in various locations around Australia. It is primarily intended for compressed liquefied gases stored in steel containers, and is equally applicable to stationary as well as transport vessels. Because the method is quite general it may also be used for permanent gases and liquids, provided that the liquids are not too viscous (upper limit approximately 1 Pa.s). It may also be used for above-ground pipelines.

NOTE: Some characteristic properties of a number of fluids are shown graphically in Appendix A. Sample calculations are shown in Appendix B.

2 NOTATION AND CALCULATION PARAMETERS. For the purposes of this Standard, the following notation applies:

A = total surface area, in square metres

A_S = daily mean projected area exposed to sun, in square metres
= 0 if vessel is shaded or under cover

a = absorptivity of surface
= 0.30 for clean white painted surface
= 0.50 for aluminium and stainless surface
= 0.60 for coloured painted surface
= 0.75 for heavily rusted surface
= 0.95 for matt black surface

NOTE: For painted surfaces that are dusty or degraded, use an intermediate value between the relevant value above and 0.75 (heavily rusted surface).

b = $\frac{a}{h}\left(\frac{A_s}{A}\right)$, in square metre kelvins per watt

where

$\left(\frac{A_s}{A}\right)$ = 0.25 for spheres
= value determined from Figure 2 for cylinders

c = isochoric (constant volume) heat capacity of vessel contents per unit volume evaluated at mean temperature T, in joules per cubic metre kelvin
= c' when vessel is nearly full (for sealed vessels)
= c'' when vessel is nearly empty (for sealed vessels)
= c_v/ν for permanent gases and liquids (for sealed vessels)
= c_p/ν for vented (atmospheric) vessels

c' = isochoric heat capacity of boiling saturated liquid per unit volume, in joules per cubic metre kelvin (see Appendix A)

c'' = isochoric heat capacity of condensing saturated vapour per unit volume, in joules per cubic metre kelvin (see Appendix A)

c_v = isochoric specific heat capacity of vessel contents, in joules per kilogram kelvin

c_p = isobaric specific heat capacity of vessel contents, in joules per kilogram kelvin

c_t = specific heat of vessel material, in joules per kilogram kelvin
= 900 J/kg.K for aluminium
= 462 J/kg.K for steel

D = diameter of vessel, in metres

d = thickness of insulation layer, in metres

F = parameter from Figure 1

h = outside surface heat transfer coefficient, in watts per square metre kelvin
= 9.0 $W/m^2.K$ for painted surface
= 6.0 $W/m^2.K$ for aluminium or stainless steel surface

m_t = mass of empty vessel without insulation, in kilograms

p_v = vapour pressure (absolute), in megapascals (see Appendix A)

R = mean daily total global radiation for hottest month, in megajoules per day square metre (see Clause 3 and Figure 3)

r = fractional increase in global radiation due to reflection from surroundings, Typical values are—
= 0.25 for flat clean concrete paving
= 0.5 for reflection from walls on 2 sides plus concrete paving
= 0 for open grassed areas

t_A = mean monthly air temperature for hottest month, in degrees Celsius (see Clause 3 and Figure 4)

t_{Amax} = maximum air temperature, in degrees Celsius (see Clause 3 and Figure 5)

t_F = mean temperature of fluid during hottest month, in degrees Celsius (see Clause 4)

t_{Fmax} = maximum fluid temperature for appropriate condition in Table 1, in degrees Celsius (see Clause 4)

V = effective fluid volume of vessel for calculation purposes, in cubic metres (see Table 1)

ν = specific volume of contents, in cubic metres per kilogram

λ = conductivity of insulation material, in watts per metre kelvin

τ = time constant, in seconds

$$= \left(\frac{cV + m_t c_t}{A}\right)\left(\frac{1}{h} + \frac{d}{\lambda}\right)$$