Designation: C 1129 – 89 (Reapproved 2001)

# Standard Practice for Estimation of Heat Savings by Adding Thermal Insulation to Bare Valves and Flanges[1]

This standard is issued under the fixed designation C 1129; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 The mathematical methods included in this practice provide a calculational procedure for estimating heat loss or heat savings when thermal insulation is added to bare valves and flanges.

1.2 Questions of applicability to real systems should be resolved by qualified personnel familiar with insulation systems design and analysis.

1.3 Estimated accuracy is limited by the following:

1.3.1 The range and quality of the physical property data for the insulation materials and system,

1.3.2 The accuracy of the methodology used in calculation of the bare valve and insulation surface areas, and

1.3.3 The quality of workmanship, fabrication, and installation.

1.4 This procedure is considered applicable both for conventional-type insulation systems and for removable/reuseable covers. In both cases, for purposes of heat transfer calculations, the insulation system is assumed to be homogenous.

1.5 This practice does not intend to establish the criteria required in the design of the equipment over which thermal insulation is used, nor does this practice establish or recommend the applicability of thermal insulation over all surfaces.

1.6 The values stated in inch-pound units are to be regarded as the standard. The SI units in parentheses are provided for information only.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

C 168 Terminology Relating to Thermal Insulation[2]

C 450 Practice for Prefabrication and Field Fabrication of Thermal Insulation Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments[2]

C 680 Practice for Determination of Heat Gain or Loss and the Surface Temperatures of Insulated Pipe and Equipment Systems by the Use of a Computer Program[2]

C 1094 Guide for Removable Insulation Covers[2]

2.2 *American National Standards Institute Standard:*

ANSI B16.5 Fittings, Flanges, and Valves[3]

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology C 168.

3.2 *Symbols:*—The following symbols are used in the development of the equations for this practice. Other symbols will be introduced and defined in the detailed description of the development. See Figs.1 and 2.

$A_B$ = outer surface area of the bare valve or flange (does not include the wheel and stem of the valve), ft$^2$ (m$^2$).
$A_I$ = surface area of the insulation cover over the valve or flange, ft$^2$ (m$^2$).
$C$ = distance from the center-line axis of the pipe (to which the valve is attached) to the uppermost position of the valve that is to be insulated (recommended to be below the gland seal), ft (m).
$D_F$ = the valve flange and the bonnet flange outer diameter (assumed equal), ft (m).
$D_P$ = the actual diameter of the pipe, ft (m).
$L_V$ = overall length of the valve, flange to flange, ft (m).
$T$ = thickness of the valve flange and of the bonnet flange, ft (m).
$q_B$ = time rate of heat loss per unit area from the bare valve or flange surface, Btu/h·ft$^2$ (W/m$^2$).
$q_I$ = time rate of heat loss per unit area from the insulation surface, Btu/h·ft$^2$) (W/m$^2$).
$Q_B$ = time rate of heat loss from the bare valve or flange surface, Btu/h (W).
$Q_I$ = time rate of heat loss from the insulated surface, Btu/h (W).

[1] This practice is under the jurisdiction of Committee C16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurement.
Current edition approved June 30, 1989. Published August 1989.

[2] *Annual Book of ASTM Standards*, Vol 04.06.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

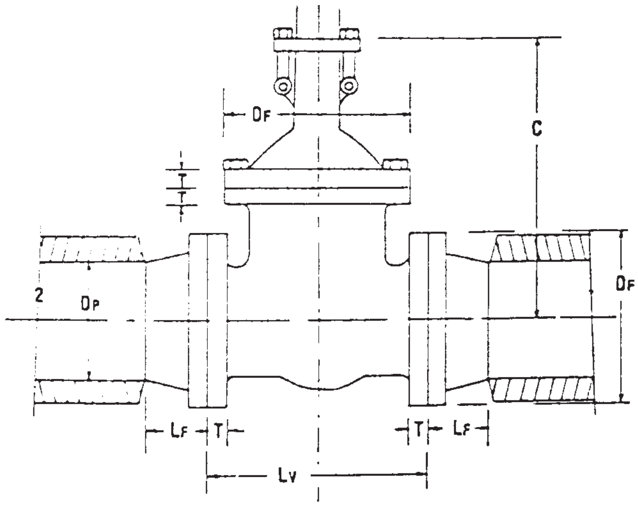


**FIG. 1 Equation 1 for a Bare Valve, $A_{B_V} = [D_P (L_V + 2L_F + (C - D_P/2) - 6T) + 1.5(D_F^2 - D_P^2) + 6 D_F T] \pi$**

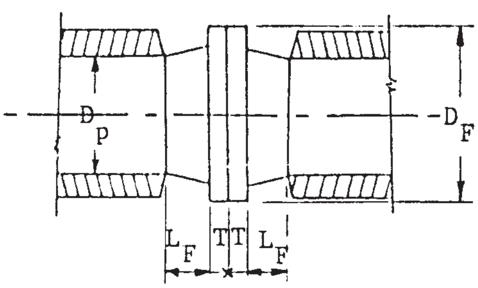


**FIG. 2 Equation 2 for a Bare Flange, $A_{B_F} = [D_P (L_V + 2L_F - 4T) + (D_F^2 - D_P^2) + 4 D_F T] \pi$**

## 4. Summary of Practice

4.1 The procedures for estimating heat loss used in this practice are based upon standard steady-state heat transfer theory as outlined in Practice C 680 (or programs conforming to it). This practice is used to estimate the heat loss per unit surface area for the particular conditions and for all configurations.

4.2 The procedures for estimating surface areas used in this practice are based on standard geometric logic: for a bare valve or flange, the contours of the metal surface are considered. For an insulated valve or flange, the fabricated shape of the finished insulation system is considered.

4.3 *Data Input*:

4.3.1 Total bare surface area and total insulation surface area of the bare valve or flange,

4.3.2 Service and ambient temperatures,

4.3.3 Wind speed,

4.3.4 Surface emittances,

4.3.5 Insulation thickness and type, and

4.3.6 Number of service hours per year.

4.4 *System Description*—Insulation thickness, insulation type, bare valve or flange surface emittance, insulation surface emittance.

4.5 *Analysis*—Once input data is entered, the program calculates the surface coefficients (if not entered directly), the insulation resistance, the bare metal heat loss per unit area, and the insulation surface heat loss per unit area. The rate of heat loss per unit area is computed by Practice C 680 for the appropriate diameter. For bare gate valves, the particular surface area can be taken from a look-up table. Table 1 gives these areas for typical (ANSI Class 150, 300, 600, and 900) flanged gate valves and flanges. If these valves are not considered sufficiently accurate, they can be calculated using Eq 1 (see Fig. 1) and Eq 2 (see Fig. 2). Similar equations can be developed for other types of valves and flanges. For the insulation, the outer surface area may be obtained from the insulation fabricator or contractor.

## 5. Significance and Use

5.1 Manufacturers of thermal insulation for valves typically express the performance of their products in charts and tables showing heat loss per valve. These data are presented for both bare and insulated valves of different pipe sizes, ANSI classes, insulation types, insulation thicknesses, and service temperatures. Additional information on effects of wind velocity, jacket emittance, bare valve emittance, and ambient conditions may also be required to properly select an insulation system. Due to the infinite combination of pipe sizes, ANSI classes, insulation

**TABLE 1 Calculated Surface Areas of Bare Valves**

| NPS, in. | ANSI Class | | | |
|---|---|---|---|---|
| | 150 | 300 | 600 | 900 |
| | $ft^2(m^2)$ | $ft^2(m^2)$ | $ft^2(m^2)$ | $ft^2(m^2)$ |
| 2 | 2.21 (0.205) | 2.94 (0.273) | 2.94 (0.273) | 5.20 (0.483) |
| 2½ | 2.97 (0.276) | 3.51 (0.326) | 3.91 (0.363) | 6.60 (0.613) |
| 3 | 3.37 (0.313) | 4.39 (0.408) | 4.69 (0.436) | 6.50 (0.604) |
| 4 | 4.68 (0.435) | 6.06 (0.563) | 7.64 (0.710) | 9.37 (0.870) |
| 6 | 7.03 (0.653) | 9.71 (0.902) | 13.03 (1.210) | 15.80 (1.468) |
| 8 | 10.30 (0.957) | 13.50 (1.254) | 18.40 (1.709) | 23.80 (2.211) |
| 10 | 13.80 (1.284) | 18.00 (1.672) | 26.50 (2.462) | 32.10 (2.982) |
| 12 | 16.10 (1.496) | 24.10 (2.239) | 31.90 (2.964) | 41.90 (3.893) |
| 14 | 22.80 (2.118) | 32.50 (3.019) | 39.70 (3.688) | 48.20 (4.978) |
| 16 | 27.60 (2.564) | 39.30 (3.651) | 50.50 (4.691) | 57.00 (5.295) |
| 18 | 31.70 (2.945) | 49.40 (4.589) | 59.80 (5.555) | 69.70 (6.475) |
| 20 | 37.70 (3.502) | 59.10 (5.490) | 71.30 (6.624) | . . . . . . |
| 24 | 49.10 (4.561) | 83.50 (7.757) | 95.10 (8.835) | . . . . . . |
| 30 | 72.20 (6.707) | 123.30 (11.46) | 141.70 (13.6) | . . . . . . |
| 36 | 107.30 (9.968) | 164.00 (15.24) | 199.00 (18.49) | . . . . . . |

types and thicknesses, service temperatures, insulation cover geometries, surface emittances, and ambient conditions, it is not possible to publish data for each possible case.

5.2 Users of thermal insulation for piping systems faced with the problem of designing large systems of insulated piping, encounter substantial engineering costs to obtain the required thermal information. This cost can be substantially reduced by both the use of accurate engineering data tables, or by the use of available computer analysis tools, or both.

5.3 The use of this practice by the manufacturer, contractor, and users of thermal insulation for valves and flanges will provide standardized engineering data of sufficient accuracy and consistency for predicting the savings in heating energy use by insulating bare valves and flanges.

5.4 Computers are now readily available to most producers and consumers of thermal insulation to permit use of this practice.

5.5 The computer program in Practice C 680 has been developed to calculate the heat loss per unit length, or per unit surface area, of both bare and insulated pipe. With values for bare valve or flange surface areas, heat loss can be estimated. By estimating the outer insulation surface area from an insulation manufacturer's or contractor's drawings, the heat loss from the insulation surface can likewise be calculated by taking the product of heat loss per unit area (from programs conforming to Practice C 680) and the valve or flange insulation surface area. The area of the uninsulated surfaces may also need to be considered.

5.6 The use of this practice requires that the valve or flange insulation system meets Guide C 1094 and Practice C 450, where applicable.

## 6. Calculation

6.1 This calculation of heat gain or loss requires the following:

6.1.1 The thermal insulation shall be assumed to be homogenous as outlined by the definition of thermal conductivity in Terminology C 168.

6.1.2 The valve or flange size and operating temperature shall be known.

6.1.3 The insulation thickness shall be known.

6.1.4 Values of wind speed and surface emittance shall be available to estimate the surface coefficients for both the bare surface and for the insulation.

6.1.5 The surface temperature in each case shall be assumed to be uniform.

6.1.6 The bare surface dimensions or area shall be known.

6.1.7 The outer surface area of the insulation cover can be estimated from drawings or field measurements.

6.1.8 Practice C 680 or other comparable methodology shall be used to estimate the heat loss from both bare and insulated surfaces.

6.2 *Estimation of Rate of Heat Loss from the Bare Surface*—Since Practice C 680 needs to perform iterations in calculating heat flow across an insulation surface, an uninsulated surface must be simulated. To do this, select a thin insulation (with a thickness of 0.02 in. (0.5 mm)) and a thermal curve giving a high thermal conductivity. It is recommended that Type 1 be selected for which the following constants are assigned: $a$ = 10 Btu·in./h·ft$^2$·F (1.44 W/m·c), $b$ = 0, and $c$ = 0.

6.2.1 Run Practice C 680 for either a horizontal or a vertical pipe of the appropriate diameter, inputing the ambient air temperature, wind speed, and bare valve surface emittance. Unless information is available for estimating the bare valve surface emittance, it is suggested that a value of 0.9 be selected. Select output in units of heat loss per unit surface area. This value of heat loss per unit bare surface area is designated $q_B$.

6.3 *Use of Practice C 680 for the Insulated Valve or Flange*—Since Practice C 680 is designed to calculate heat loss for insulated flat surfaces and for pipes, it is necessary to treat the insulated valve as an insulated pipe. It is recommended that the diameter of the pipe, to which the valve fits, or the diameter of the flanges be selected for the calculation. Input the same ambient air temperature and wind speed as in 6.1 and estimate the insulation surface emittance. For a removable insulation cover, this would be the emittance of the fabric or metal jacket. For conventional insulation, this is either the emittance of that material or of the jacketing, if jacketing is used. The value of heat loss per unit insulation surface area is designated $q_I$.

6.4 *Surface Area of the Bare Valve or Flange*—Fig. 1 gives a diagram of a gate valve with the dimensions $D_P$, $L_V$, $T$, $L_F$, $D_F$, and $C$ as indicated. Eq 1 (see Fig. 1) gives a method for estimating the surface area of valves, and Eq 2 (see Fig. 2) gives a method for estimating the surface area of flanges. Table 1 gives the results of calculating the surface area for 2-in. through 36-in. NPS gate valves for ANSI classes of 150, 300, 600 and 900. The value of a bare valve or flange is designated $A_B$.

6.5 *Surface Area of the Insulated Valve or Flange*—The estimation of the outer insulation surface area is best performed by the manufacturer or the insulation contractor. This surface area will depend on the dimensions of the valve or flange being insulated, the thickness of the insulation, and the extent of coverage to either side of the valve or flange. This practice does not recommend a specific method for arriving at this area, which would be designated as $A_I$.

6.6 *Calculation of Bare Valve or Flange Heat Loss*—This value is determined by taking the product of the bare valve or flange heat loss per unit surface area and of the bare surface area. It will be designated as $Q_B$:

$$Q_B = q_B A_B \quad (1)$$

6.7 *Calculation of Insulated Valve or Flange Heat Loss*—This value is determined by taking the product of the insulated valve or flange heat loss per unit surface area and of the insulation outer surface area. It would be designated as $Q_I$:

$$Q_I = q_I A_I \quad (2)$$

6.8 *Calculation of Heat Loss Savings*—This value is determined by taking the difference between the values of heat loss for the bare and the insulated valve or flange. It would be designated as $Q_{B\text{-}I}$:

$$Q_{B-I} = Q_B - Q_I \quad (3)$$

## 7. Report

7.1 The results of calculations performed in accordance with this practice may be used to estimate heat loss savings for specific job conditions, or may be used in general form to present the effectiveness of insulating valves or flanges for a particular product or system. For the purpose of decision making, it is recommended that reference be made to the specific constants used in the calculations. These references should include:

7.1.1 Name and identification of insulation products or components and the valve or flange products.

7.1.2 Identification of the NPS valve or flange sizes and their ANSI class ratings.

7.1.3 The surface temperatures of the piping system.

7.1.4 The estimated surface emittance used in the calculations.

7.1.5 The equations and constants selected for the thermal conductivity versus mean temperature relationship.

7.1.6 The insulation thickness used for the calculations.

7.1.7 The ambient temperature and the wind speed (or surface coefficient).

7.1.8 The estimate for the outer surface area of the valve or flange insulation system.

7.1.9 The calculated values of $Q_B$ and $Q_I$.

7.1.10 The estimation of heat loss savings, $Q_{B-I}$.

7.1.11 Either tabular or graphical representation of the results of the calculations may be used. No attempt is made to recommend the format of this presentation of results.

## 8. Precision and Bias

8.1 This practice is intended as a method of estimated heat loss savings, not of predicting those savings. As such, it is designed to be used as a decision-making tool. With no standardized test procedure for measuring heat loss from valves or flanges, either bare or insulated, the precision of this methodology is not known.

8.2 There are a number of factors which influence the estimation of heat loss savings, however. The result of a savings estimate is far more dependent upon the calculated heat loss from the bare surface than from the insulated surface. The calculated heat loss from the bare surface, in turn, is highly dependent on the values of valve or flange service temperature, ambient temperature, wind speed, and surface area, with a lesser dependence on surface emissivity.

8.3 Since the service temperature should be reasonably well known, the person performing this estimation is advised to perform Practice C 680 calculations on the bare surface under extreme environmental conditions. This may not be necessary if the piping system is located indoors in a controlled environment, but it is strongly advised if located outdoors. For example, the greatest heat loss savings would occur for a cold ambient temperature with a strong wind; the least savings would occur for a hot ambient temperature with no wind. Use of these calculations, along with a calculation based on design conditions, will give maximum and minimum values of heat loss savings.

8.4 *Example 1 of Calculations for Extreme Conditions*—For Example 1 in Appendix X1, the standard environmental conditions were given as 40°F ambient temperature with a 5 mph wind. Let us assume that the design winter conditions are − 10°F with a 15 mph wind and that the design summer conditions are 100°F with no wind. Under these conditions, we can perform new sets of calculations and compare these to those given in the original problem (see Table 2). Based on these calculations, the estimated savings might be expected to vary by ±37 % with variations in environmental conditions.

8.5 The estimate of bare valve or flange surface area may also not be accurately known since it may be difficult to obtain dimensions from the manufacturer. Flange surface areas, however, should be relatively simple to calculate by knowing the flange diameter, flange thickness, and flange spacing and using Eq 2 (see Fig. 2). For valves which have dimensions varying with manufacturer, NPS, ANSI Class, and type, the surface area can vary considerably. If no specific information is available on the valves being considered, it is recommended that the valve surface areas on Table 1 be used. If dimensions are known, Eq 1 (see Fig. 1) may be used to estimate the bare valve surface area.

8.6 Statements made in Practice C 680 regarding precision and bias are also applicable to this practice.

## 9. Keywords

9.1 calculated energy savings; heat loss from pipes; pipe systems

**TABLE 2 Example of Calculations for Extreme Conditions**

| | Winter Conditions, Btu/h | Standard Conditions, Btu/h | Summer Conditions, Btu/h |
|---|---|---|---|
| $q_B$ | 5 266 (+ 35 %) | 3 903 (0 %) | 2 502 (−36 %) |
| $q_I$ | 97.3 (+ 6 %) | 92.2 (0 %) | 85.2 (−8 %) |
| $Q_B$ | 71 091 | 52 691 | 33 777 |
| $Q_I$ | 2 043 | 1 936 | 1 789 |
| $Q_{B-I}$ | 69 047 (+ 36 %) | 50 754 (0 %) | 31 988 (−37 %) |

## APPENDIX

**(Nonmandatory Information)**

### X1. EXAMPLES

X1.1 *General:*

X1.1.1 Two examples are presented to illustrate the utility of this method of estimating heat loss savings by insulating valves or flanges. It is assumed that the estimator has access to a computer with the Practice C 680 program and with appropriate thermal performance curves for the insulation products being considered.

X1.1.2 Sample thermal conductivity versus mean temperature data for the insulating materials being used in the examples are given. The curves contained herein are for illustration purposes only and are not intended to reflect any actual product currently being produced.

X1.2 *Example 1:*

X1.2.1 Consider an ANSI Class 300 valve on an 8-in. NPS pipe line. The service temperature is 600°F and, for the purposes of the calculations, we are given a standard outdoor temperature of 40°F and a wind speed of 5 mph. The valve has a dark, low reflectance surface. We are to insulate the valve with a removable cover that is 2 in. thick, completely and uniformly covers the valve body, and has an insulation media whose thermal curve has been characterized by the following values of a Type 2 insulation:

$$a = -1.62 \quad \text{(X1.1)}$$

$$b = 0.00213$$

X1.2.1.1 The manufacturer of the removable cover gives us an outer surface area for this product of 21 $ft^2$. What is the approximate rate of heat loss savings from insulating the valve with the removable cover?

X1.2.2 For the bare valve, assume the surface emittance is 0.95 since its surface is dark and of low reflectance. For the given conditions on an 8-in. NPS pipe, Practice C 680 predicts a heat loss per unit area, for a bare surface (see 6.2 of Practice C 680): $q_B$ = 3903 Btu/h·$ft^2$.

X1.2.3 For the insulated valve, the outer insulation surface is a gray, rubberized fabric. An emittance of 0.9 would represent a reasonable value for this material. Again, using Practice C 680 with 2 in. of the given insulation material and the given conditions, the insulated heat loss per unit outer surface area can be calculated:

$$q_I = 92.2 \text{ Btu/h}\cdot \text{ft}^2 \quad \text{(X1.2)}$$

X1.2.4 Using Table 1, we can obtain an estimate for the surface area of the bare 8-in. NPS valve that is of a 300 ANSI class:

$$A_B = 13.50 \text{ ft}^2 \quad \text{(X1.3)}$$

X1.2.5 The insulation cover supplier gave us an estimate for the outer surface area of the cover:

$$A_I = 21.0 \text{ ft}^2 \quad \text{(X1.4)}$$

X1.2.6 We are now ready to perform the calculations by the methodology described in 6.6-6.8:

$$Q_B = q_B A_B = 52\,691 \text{ Btu/h} \quad \text{(X1.5)}$$

$$Q_I = q_I A_I = 1\,936 \text{ Btu/h}$$

$$Q_B - I = Q_B - Q_I = 50\,754 \text{ Btu/h}$$

X1.3 *Example 2:*

X1.3.1 An engineer is trying to decide whether to insulate a large number of ANSI Class 300 valves on a 4-in. NPS pipe line. This is a high-temperature (1000°F) line where the rest of the piping is covered with 3 in. of a premolded type of insulation. The bare piping is shiny stainless steel; the insulation is jacketed with aluminum. If we assume a 55°F ambient temperature and a 10 mph wind, approximately what energy savings could be realized by insulating the bare valves? The insulation thermal performance can be approximated by a Type 1 material thermal curve where:

$$a = 0.40 \quad \text{(X1.6)}$$

$$b = 0.105 \times 10^{-3}$$

$$c = 0.286 \times 10^{-6}$$

X1.3.2 For the bare stainless steel valve, assume an emittance of 0.2. For the given conditions on a bare 4-in. NPS pipe, we use Practice C 680 to compute the heat loss per unit area from the bare valve surface:

$$q_B = 7\,271 \text{ Btu/h} \cdot \text{ft}^2 \quad \text{(X1.7)}$$

X1.3.3 For the insulated valve, assume a jacketing surface emittance of 0.5. Again, using Practice C 680 but this time for a 4-in. pipe covered with 3 in. of the premolded insulation, we can estimate the heat loss per unit outer insulation surface area:

$$q_I = 105.8 \text{ Btu/h}\cdot\text{ft}^2 \quad \text{(X1.8)}$$

X1.3.4 Referencing Table 1 in this practice, we can approximate the surface area of the bare valve:

$$A_B = 6.06 \text{ ft}^2 \quad \text{(X1.9)}$$

X1.3.5 The insulation contractor has estimated the outer surface area of the insulation:

$$A_I = 13.60 \text{ ft}^2 \quad \text{(X1.10)}$$

X1.3.6 With these values of heat loss per unit area and of surface areas, we are now ready to estimate heat loss savings by the methodology of 6.6-6.8 in this practice:

$$Q_B = q_B A_B = 44\,062 \text{ Btu/h} \quad \text{(X1.11)}$$

$$Q_I = q_I A_I = 1\,439 \text{ Btu/h}$$

$$Q_{B-I} = Q_B - Q_I = 42\,623 \text{ Btu/h}$$