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SENSITIVITY OF THE HOUSE PRESSURE TEST FOR DUCT LEAKAGE TO VARIATIONS IN THE DISTRIBUTION OF AIR LEAKAGE IN THE HOUSE ENVELOPE

John W. Andrews

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Prepared for:
Office of Building Equipment
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Energy Efficiency and
Conservation Division

DEPARTMENT OF APPLIED SCIENCE

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ABSTRACT

The house pressure test for air leakage in ducts calculates the signed difference between the supply and return leakage from the response of the air pressure in the house to operation of the system fan. The currently accepted version of this calculation was based on particular assumptions about how the house envelope leakage is distributed between the walls, ceiling, and floor. This report generalizes the equation to account for an arbitrary distribution of envelope leakage. It concludes that the currently accepted equation is usually accurate to within ±5%, but in a small proportion of cases the results may diverge by 50% or more.

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INTRODUCTION

The purpose of this report is to derive a version of the equations that are used in the house pressure test for duct leakage to determine the signed difference between the supply and return leakage rates to/from outside. The house pressure test, which is one of two tests for duct leakage given as options in ASHRAE Standard 152P (ASHRAE 1998), indirectly measures the air leakage rates in duct systems. The leakage rates from the supply ducts to the outside and to the return ducts from the outside are determined as solutions to equations that have as inputs measured values of the pressure difference between the house and the attic under conditions of system fan off, system fan on, and system fan on with the return register(s) partially blocked. Pressure measurements within the supply and return ducts are also required.

A critical step in deriving the house pressure test protocol involves a formula for the air leakage rate to the outside from the supply ducts minus the air leakage rate from the outside to the return ducts. This equation was first derived by Mark Modera of the Lawrence Berkeley National Laboratory. (His derivation is as yet unpublished, but a descriptive treatment is given in Modera and Byrne 1997.) Modera's equation has since been incorporated in the draft version of Standard 152P (Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems), which is being developed by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).

The physical basis for the equation is that any unbalance in duct leakage will manifest itself as a change in the air pressure in the house when the system fan is turned on. For example, if leakage from outside to the return ducts exceeds that from the supply ducts to the outside, then the duct system is taking in a net amount of air from the outside, which it delivers to the building. This will cause the house pressure to go up when the fan comes on. Conversely, if supply leakage dominates, the house pressure will go down on fan startup. This phenomenon has been used for some time (under the name "dominant duct leakage test") to determine which side of the duct system leaks more than the other. Modera's addition was to show how the leakage flow coefficient of the building envelope could be used as a standard against which the duct leakage could be quantified, so that not only the sign but also the magnitude of the net leakage (supply minus return) could be estimated.

Modera's formula was derived under the assumption that the leakage flow coefficient of the envelope is divided into two equal parts, one relating to the ceiling and the other to the floor. No leakage through the wall was assumed. Although this might seem grossly unrealistic, since much air leakage usually occurs through cracks around windows and doors, it can be argued that what really was done was to apportion the leakage into roughly equal high and low components.

Recently, the degree to which these simplifying assumptions are immune to error in the results has come to be questioned. This report is an attempt to shed light on this issue by deriving an equation that allows for more generality in what is assumed about the envelope leakage distribution.

PRESSURE DISTRIBUTION WITHIN THE ENVELOPE

Our first task is to describe the difference between the assumptions used by Modera in deriving the house-pressure-test formula in ASHRAE 1998 and those employed here. As stated above, Modera's formula was derived under the simplifying assumption that the envelope leakage flow coefficient was divided equally between floor and ceiling leakage, with no leakage attributed to the wall. Although this is likely to be quite unrealistic in many if not most single-family dwellings, it was felt that the results would not be highly dependent on these assumptions.

In an effort to determine how sensitive the house pressure test might be to the details of the envelope leakage distribution, this report modifies these assumptions in the following way:

1. The floor, ceiling, and walls are allowed to embody arbitrary fractions of the total envelope flow coefficient.

2. The pressure in the house is a function of vertical height only. That is, the pressure at any given height above the floor is the same regardless of the location within the house.

3. The pressure difference between the inside and outside varies linearly with height.

4. The flow coefficient for the wall is uniformly distributed over its vertical extent.

The first of these points represents the broadest possible generalization. This is then restricted somewhat by points 2, 3, and 4, which are intended to make the calculation tractable. Although the real pressure and flow distributions may sometimes differ significantly from those implied by these latter points, particularly in windy conditions, the situation outlined above does represent a significant relaxation of the assumptions embodied in Modera's formula, and it should prove valuable to determine what impact variations of the leakage coefficients of the floor, ceiling, and walls will have on the results. If the impact is minimal, then we can with greater confidence use the Modera formula. If the impact is significant, then the modified formula may have to be substituted even if it is more complex.

Using the above assumptions, let us now represent the pressure difference between the inside and the outside of the house as a function of the vertical height y, with y=0 at the floor and y=h at the ceiling. (For multistory housing, floor means the floor of the lowest conditioned story, and ceiling means the ceiling of the highest conditioned story. A flat floor and a flat ceiling are assumed.)

With the system fan off, the house pressure test requires a measurement of the pressure difference of the house with respect to the attic and calls this ΔP_{off}. This pressure difference across the ceiling is representative of the pressure difference across the envelope at $y = h$. With the assumption of a linear relationship of the inside-to-outside pressure difference as a function of y, we may write:

$$P(y) = \Delta P_{off} + k(y-h) \qquad (1)$$

with k constant. The following relationships must hold:

- If $\Delta P_{off} > 0$, then $kh > \Delta P_{off} > 0$
- If $\Delta P_{off} < 0$, then $kh < \Delta P_{off} < 0$.

These are necessary so that P(y) will have a zero somewhere in the range $0 < y < h$. This zero, called the neutral level, means that air infiltrates below this level and exfiltrates above it (or vice versa) allowing a zero net infiltration of air.

INTEGRAL OF A SPECIAL FUNCTION

Functions of the form $sign(x)\ |x|^n$ will appear quite often in what follows, because this is the form that the air flow across the envelope will take as a function of pressure difference. It will sometimes be necessary to integrate this function over a range that includes zero. This could be done by splitting the interval into two parts and treating each separately, but it will be more convenient to have a general formula, particularly because sometimes in the general case it will not be known whether or not the interval includes zero. By treating the cases $x_0 < x_1 < 0$, $x_0 < 0 < x_1$, and $0 < x_0 < x_1$ separately, it is easy to show that

$$\int_{x_0}^{x_1} sign(x)\ |x|^n\ dx = \frac{|x_1|^{n+1} - |x_0|^{n+1}}{n+1} \qquad (2)$$

regardless of whether x_0 and x_1 are of the same or opposite sign.

ENVELOPE LEAKAGE FLOW WITH SYSTEM FAN OFF

The first step in the derivation is to consider the case when the system fan is off. The procedure here is to write an equation for the net envelope leakage in terms of the leakage through the floor, ceiling, and walls, and then to note that with the fan off, this net leakage must equal zero. In writing this equation, we will use the pressure notation introduced above, together with the following terminology for the flow coefficients:

C_{tot} = total envelope flow coefficient
C_f = envelope flow coefficient for the floor
C_c = envelope flow coefficient for the ceiling
C_w = envelope flow coefficient for the walls
n_{env} = exponent in the pressure-flow relation $Q=C\Delta P^n$, assumed to be the same for all three envelope surfaces. (Typically n_{env} is in the range 0.55 - 0.75.)
(Note that $C_{tot} = C_f + C_c + C_w$.)

We then may write:

$$0 = C_f\, sign(\Delta P_{off}-kh)\ |\Delta P_{off}-kh|^{n_{env}} + C_c\, sign(\Delta P_{off})\ |\Delta P_{off}|^{n_{env}} + \frac{C_w}{h}\int_0^h sign(\Delta P_{off}-kh+ky)\ |\Delta P_{off}-kh+ky|^{n_{env}}\, dy \qquad (3)$$

Letting $u = \Delta P_{off} - kh + ky$ and noting that $dy = (1/k)\, du$:

$$0 = C_f\, sign(\Delta P_{off}-kh)\ |\Delta P_{off}-kh|^{n_{env}} + C_c\, sign(\Delta P_{off})\ |\Delta P_{off}|^{n_{env}} + \frac{C_w}{kh}\int_{\Delta P_{off}-kh}^{\Delta P_{off}} sign(u)\ |u|^{n_{env}}\, du \qquad (4)$$

which, upon performing the integral, becomes:

$$0 = C_f\, sign(\Delta P_{off}-kh)\ |\Delta P_{off}-kh|^{n_{env}} + C_c\, sign(\Delta P_{off})\ |\Delta P_{off}|^{n_{env}} + \frac{C_w}{kh(n_{env}+1)}\left(-|\Delta P_{off}-kh|^{n_{env}+1} + |\Delta P_{off}|^{n_{env}+1}\right) \qquad (5)$$

It will now be convenient to simplify the form of Equation 5 without adding any additional restrictive assumptions. We note that the signs of $\Delta P_{off} - kh$ and of ΔP_{off} must be opposite in order for there to be zero net air inflow, i.e., zero must be between these two values. For the same reason, the sign of k must be the same as that of ΔP_{off}. It is therefore possible to get rid of the references to "sign" in Equation 5 by letting the signs of the first two terms on the right-hand side be opposite and noting that $|kh| = sign(\Delta P_{off})\, kh$:

$$0 = -C_f\,|\Delta P_{off} - kh|^{n_{env}} + C_c\,|\Delta P_{off}|^{n_{env}} + \frac{C_w}{|kh|\,(n_{env}+1)}\left(-|\Delta P_{off} - kh|^{n_{env}+1} + |\Delta P_{off}|^{n_{env}+1}\right) \qquad (6)$$

We continue to simplify the form of the equation by defining $z = \Delta P_{off}/(kh)$ [with $0 < z < 1$ because of $|kh| > |\Delta P_{off}|$ and sign (kh) = sign (ΔP_{off})] and then (noting that $|a/b| = |a|/|b|$) dividing each term by $|kh|^{n_{env}}$:

$$0 = -C_f\,(1-z)^{n_{env}} + C_c\,z^{n_{env}} + \frac{C_w}{(n_{env}+1)}\left[-(1-z)^{n_{env}+1} + z^{n_{env}+1}\right] \qquad (7)$$

The physical interpretation of z is the distance from the ceiling to the neutral level as a fraction of the distance from the ceiling to the floor.

Because n_{env} is not an integer, Equation 7 is without a closed-form solution (at least in terms of common functions). The value of z is, however, a necessary input to the solution. We have devised an iterative solution that converges adequately in one step (in all cases tested) so that it is amenable to use with a spreadsheet. It is worth noting, however, that for the Modera assumption $C_f = C_c$ and $C_w=0$, Equation 7 is easily solved and $z = 1/2$.

So as not to interrupt the flow of the argument, consideration of the solution method will be deferred until later, with the reader being asked at this point to accept that a solution for z has been found.

ENVELOPE LEAKAGE FLOW WITH SYSTEM FAN ON

When the system fan is turned on, any imbalance in duct leakage is expected to have an effect on the pressure distribution in the house. If the return leakage (from outside) exceeds supply leakage (to outside), a net amount of air is taken up from the outside by the duct system and delivered to the house. This increases the pressures in the house. If supply leakage dominates, the house pressures are expected to decrease. In the house pressure test, the pressure difference across the ceiling (house with respect to attic) is measured with the system fan on and denoted ΔP_{on}. Assuming that turning the system fan on does not change the indoor-outdoor temperature difference significantly, i.e., assuming the equipment cycles frequently enough to maintain small indoor-air temperature swings, the relative distribution of pressures should not change. In particular, the value of k--which is equal to $\Delta P_{off}/(zh)$--should be the same. The pressure distribution in the house as a function of vertical height y with the system fan on is then given by:

$$P'(y) = \Delta P_{on} + k(y-h) \qquad (8)$$

So we can write an equation for the net inflow of air from the duct system, and knowing z (and hence k) we can use it to solve for $Q_{sleak+rleak}$, which is the ASHRAE Standard 152P nomenclature for the signed difference between supply and return leakage rates. It must equal in magnitude the net inflow of air to the living space from the duct system. If we write an equation for the net *outflow*, in line with others' practice, then we have to make sure we include the proper minus sign:

$$Q_{sleak+rleak} = -C_f\, sign(\Delta P_{on}-kh)\ |\Delta P_{on}-kh|^{n_{env}} - C_c\, sign(\Delta P_{on})\ |\Delta P_{on}|^{n_{env}}$$
$$- \frac{C_w}{h} \int_0^h sign(\Delta P_{on}-kh+ky)\ |\Delta P_{on}-kh+ky|^{n_{env}}\, dy \qquad (9)$$

In a similar manner to what was done in the fan-off case, one lets $u = \Delta P_{on} - kh + ky$ and notes that $dy = (1/k)\, du$:

$$Q_{sleak+rleak} = -C_f\, sign(\Delta P_{on}-kh)\ |\Delta P_{on}-kh|^{n_{env}} - C_c\, sign(\Delta P_{on})\ |\Delta P_{on}|^{n_{env}}$$
$$- \frac{C_w}{kh} \int_{\Delta P_{on}-kh}^{\Delta P_{on}} sign(u)\ |u|^{n_{env}}\, du \qquad (10)$$

which, upon performing the integral, becomes:

$$Q_{sleak+rleak} = -C_f\, sign(\Delta P_{on}-kh)\ |\Delta P_{on}-kh|^{n_{env}} - C_c\, sign(\Delta P_{on})\ |\Delta P_{on}|^{n_{env}}$$
$$- \frac{C_w}{kh(n_{env}+1)} \left(|\Delta P_{on}|^{n_{env}+1} - |\Delta P_{on}-kh|^{n_{env}+1}\right) \qquad (11)$$

We now express k in terms of measured values by inserting $kh = \Delta P_{off} / z$:

$$Q_{sleak+rleak} = -C_f\, sign(\Delta P_{on}-\Delta P_{off}/z)\ |\Delta P_{on}-\Delta P_{off}/z|^{n_{env}} - C_c\, sign(\Delta P_{on})\ |\Delta P_{on}|^{n_{env}}$$
$$- \frac{C_w\, z}{\Delta P_{off}\,(n_{env}+1)} \left(|\Delta P_{on}|^{n_{env}+1} - |\Delta P_{on}-\Delta P_{off}/z|^{n_{env}+1}\right) \qquad (12)$$

We first note that if $C_f = C_c = C_{tot} / 2$ (implying $C_w = 0$) and $z = 0.5$, which are the Modera assumptions, Equation 12 reduces to:

$$Q_{sleak+rleak} = \frac{1}{2} C_{tot} [-sign(\Delta P_{on} - 2\Delta P_{off}) \, |\Delta P_{on} - 2\Delta P_{off}|^{n_{env}} - sign(\Delta P_{on}) \, |\Delta P_{on}|^{n_{env}}] \quad (13)$$

which is equivalent to:

$$Q_{sleak+rleak} = \frac{1}{2} C_{tot} [sign(2\Delta P_{off} - \Delta P_{on}) \, |2\Delta P_{off} - \Delta P_{on}|^{n_{env}} - sign(\Delta P_{on}) \, |\Delta P_{on}|^{n_{env}}] \quad (14)$$

This is the formula (due to Modera) that is in ASHRAE Standard 152P.

The careful reader will also note the ΔP_{off} in the denominator of the third term of Equation 12. This would appear troublesome, since it is quite possible for ΔP_{off} to equal zero. Won't this cause the expression to "blow up"? The answer is no, because in the limit as $\Delta P_{off} \rightarrow 0$, the numerator also approaches zero in such a way that the whole term has a finite limit.

SOLUTION FOR PARAMETER "Z"

We are now ready to pursue the project of comparing the values of $Q_{sleak+rleak}$ obtained from Equation 12 with those from ASHRAE Standard 152 (Equation 14). The only roadblock yet to be cleared is that we have to determine how to solve Equation 7 for the parameter "z", which appears in Equation 12. Ideally, the method of solution should be one that can be readily incorporated into a spreadsheet. This would facilitate the use of Equation 12 in practical applications, should the results show that Equation 14 is, in some circumstances at least, inadequate.

We begin by noting that for the special case $C_w = 0$, Equation 7 can be readily solved, not just for Modera's $C_f = C_c = C_{tot}/2$, but for any C_f and C_c:

$$z = \frac{1}{1 + \left(\frac{C_c}{C_f}\right)^{\frac{1}{n_{env}}}} \quad (15)$$

The first step in generalizing to $C_w \neq 0$ is to note that for any value of z (and remembering that $C_w = C_{tot} - C_c - C_f$), Equation 7 is linear in C_c and C_f. We should therefore be able to graph lines of constant z in the C_c - C_f plane to get an idea of how this parameter behaves. Indeed, if we define $c_c = C_c / C_{tot}$, $c_f = C_f / C_{tot}$, and $c_w = C_w / C_{tot}$, so that $c_c + c_f + c_w = 1$, a universal plot can be constructed that is valid for any C_{tot}. Additionally, when three quantities always add to unity, they can be plotted in a very illuminating way as respective distances from the sides of an equilateral triangle each of whose sides has length $\sqrt{5}/2$. Somewhat more conveniently, they can be represented on a right triangle with legs of unit length. In this case, c_f and c_c are the perpendicular distances from their respective legs, while c_w is $\sqrt{2}$ times the distance from the hypotenuse.

Figure 1 shows such a plot. The horizontal and vertical axes represent c_c and c_f, respectively, while c_w is proportional to the perpendicular distance from the hypotenuse. The diagonal dotted lines on the plot represent constant c_w, in 0.2 increments.

Loci of constant z are shown as solid lines. It can be seen that these are almost, but not quite, perpendicular to the side of the triangle representing $c_w = 0$ (except for the line $z = 0.5$, which is exactly perpendicular). This fact then serves as the starting point for an iterative process. For each line of constant z, draw a dashed line that is exactly perpendicular to the hypotenuse and that intersects the solid line at the hypotenuse. Such a line will define a constant parameter z_0 that is equal to z where the dashed and solid lines intersect at the hypotenuse. Then z_0 will be equal to:

$$z_0 = \frac{1}{1 + \left(\frac{c_c + c_w/2}{c_f + c_w/2}\right)^{\frac{1}{n_{env}}}} \qquad (16)$$

Here the small c's are shown, although Equation 16 is valid with either the C's or the c's.

The approach to iteration is shown in Figure 2. Equation 7 is rewritten in the form f(z)=g(z), where

$$f(z) = c_c\, z^{n_{env}} + \left(\frac{c_w}{n_{env}+1}\right) z^{n_{env}+1}$$

$$g(z) = c_f\, (1-z)^{n_{env}} + \left(\frac{c_w}{n_{env}+1}\right) (1-z)^{n_{env}+1} \qquad (17)$$

The functions f(z) and g(z) are plotted separately. The point where they cross defines the desired value of z. The initial value z_0, calculated according to Equation 16, is shown as a vertical line defining $f(z_0)$ and $g(z_0)$. Straight lines tangent to f(z) and g(z) at $z=z_0$ are next drawn, and their intersection is taken as an approximation to the intersection of f and g. The value of z at which this intersection occurs is the next approximation to the solution, which we call z_1.

The equations of these lines are given, respectively, by:

$$y = f(z_0) + f'(z_0)(z-z_0)$$

$$y = g(z_0) + g'(z_0)(z-z_0) \qquad (18)$$

Solving for z_1, the intersection point, yields the equation:

$$z_1 = z_0 + \frac{f(z_0) - g(z_0)}{g'(z_0) - f'(z_0)} \qquad (19)$$

Using f and g from Equation 17, one obtains

$$z_1 = z_0 + \frac{c_f\,(1-z_0)^{n_{env}} - c_c z_0^{\,n_{env}} + \dfrac{c_w}{n_{env}+1}[(1-z_0)^{n_{env}+1} - z_0^{\,n_{env}+1}]}{n_{env} c_c z_0^{\,n_{env}-1} + n_{env} c_f\,(1-z_0)^{n_{env}-1} + c_w[z_0^{\,n_{env}} + (1-z_0)^{n_{env}}]} \qquad (20)$$

Needless to say, this process can be repeated if necessary to calculate a second iterative value of z, to be called z_2, with z_1 taking the role of z_0 in Equation 20. However, one iteration is generally sufficient.

IS THE STANDARD 152P EQUATION ACCURATE ENOUGH?

The appendix to this report contains spreadsheets in which Equation 12, which was developed here, is compared with Equation 14, which is in ASHRAE Standard 152P. A value of C_{tot}, 157.29 cfm/Pa$^{.65}$, was chosen to correspond to an envelope leakage in cfm at 50 Pa (CFM50) of 2000 with an exponent of 0.65 in the pressure-flow equation, representative of reasonably tight, but not supertight, average-size single-family housing. Each page represents values of the fractions of the envelope leakage flow coefficient in the floor, wall, and ceiling at 0.25 increments.

The entries on each page show values of ΔP_{off} in 0.5 Pa increments from -3 to +3 (with 0.01 instead of 0.00 to avoid division of zero by zero), and ΔP_{on} values in 1 Pa increments from 0 to 5. (Negative values of ΔP_{on} are included if one realizes that changing the sign of both ΔP_{off} and ΔP_{on} produces a $Q_{sleak+rleak}$ that is the same in magnitude and opposite in sign from the one in the table. (This has been checked using the spreadsheet, but since the values are redundant they are not reproduced here.)

The columns of the spreadsheet are described as follows:

Column 1: The current value of ΔP_{off}.
Column 2: The current value of ΔP_{on}.
Column 3: The value of z_0 calculated according to Equation 16.
Column 4: The value of z_1, resulting from the first iteration using Equation 20.
Column 5: The value of z_2, the second iteration of Equation 20.
Column 6: The value of $\Delta P_{off}/z_1 - \Delta P_{on}$.
Column 7: The value of $\Delta P_{off}/z_2 - \Delta P_{on}$.
Column 8: $Q_{sleak+rleak}$ using z_1 in Equation 12.
Column 9: $Q_{sleak+rleak}$ using z_2 in Equation 12.
Column 10: $Q_{sleak+rleak}$ using Equation 14, the ASHRAE Standard 152P formula.
Column 11: The difference between the absolute values of Column 9 and Column 10.
Column 12: The percent difference between the above.

The first thing to notice is that Equation 12 and Equation 14 always give the same sign for $Q_{sleak+rleak}$. That is, both equations always agree on which side of the duct system, supply or return, has more leakage.

Nevertheless, a quick perusal of these spreadsheets can be disquieting. It is not hard to find cases where the percent difference exceeds 50%. A closer look, however, provides quite a bit of reassurance. Most of the time, the percentage deviation between the two values is quite small. Part of the reason for this is that there are certain cases for which the results are "pinned" to be equal. One obvious such case is when the actual leakage distribution is the same as that assumed in developing Equation 14 (the one in ASHRAE Standard 152P). Another occurs when the house pressure with the fan off is near zero. In real-world testing, this condition is often approximated, especially during calm weather in the spring and fall, when wind and stack effect are small.

Moreover, it is possible to identify "danger flags" whose absence makes it all but certain that the two values are within 5% of each other. These are discussed further below.

In analyzing the results further, we distinguished between slab-on-grade housing and houses with an open foundation (basement or crawl space). In slab housing one would expect that the fraction of leakage through the floor will be very close to zero, whereas with an open foundation one would generally expect significant leakage at the floor level. We therefore grouped the spreadsheets into three categories:

- Slab Cases: $c_f = 0$ and $c_c = 0$, 0.25, or 0.50 (three cases).
- Open-Foundation Cases: $c_f = 0.25$ and $c_c = 0$, 0.25, or 0.50
  $c_f = 0.50$ and $c_c = 0$ or 0.25
  $c_f = 0.75$ and $c_c = 0$ (six cases)
- "Unlikely" Cases: these are cases with no leakage through the walls or with ceiling leakage of 75% or more of the total.

Figure 3 is a histogram for the slab cases showing the relative frequencies of various ranges of percentage deviations between $Q_{sleak+rleak}$ as calculated according to Equation 14 (Standard 152P) and Equation 12 (this report). The deviations are between absolute values, so the bias toward positive numbers indicates that Equation 12 tends to show somewhat greater leakage imbalance than does Equation 14. The data points are divided into two categories, those for which $|\Delta P_{off}|$ is relatively small (≤ 1 Pa) and those for which $|\Delta P_{off}|$ exceeds 1 Pa. For the latter set, the number of outliers (cases where the difference is greater than 5%) is more than 40% of the total, and a small but significant number of these are extreme, i.e., greater than 35% deviation. When $|\Delta P_{off}| \leq 1$ Pa, however, the picture brightens considerably. Now almost 80% of the cases agree within 5% and there are no extreme disagreements. Additionally, inspection of the spreadsheets reveals that nearly all of the moderate-disagreement cases, i.e., 6% to 25% deviation, occur when $\Delta P_{on} \approx 0$ or when ΔP_{off} is roughly half of ΔP_{on}. These conditions correspond to cases where the pressure difference across the ceiling or the floor is close to zero with the system fan on. The possibility exists, therefore, of developing a correction factor to be used when the house pressures lie within certain designated ranges.

The open-foundation cases, shown in Figure 4, are very similar. This was something of a surprise to the author, who expected the slab cases to deviate from Equation 14 more than the open-foundation cases, because the constraint of zero floor leakage is so clearly at variance with the assumptions behind that equation.

It should be mentioned that the cases where the ceiling has most of the leakage are somewhat more problematic, with greater and more frequent deviations from Equation 14. It should also be noted that the case where floor and ceiling leakage each account for half of the total, with none through the walls, that the deviation is always exactly zero. If that weren't so it would be cause for worry, since this is precisely the assumption on which Equation 14 is based.

HOW DO ERRORS IN Qsleak+rleak TRANSLATE INTO ERRORS IN THE SEPARATE SUPPLY AND RETURN LEAKAGE VALUES?

An important next step is to investigate how errors in $Q_{sleak+rleak}$ stemming from leakage distribution in the envelope translate into errors in the separate values of supply and return leakage (Q_{sleak} and Q_{rleak}) as calculated according to the house pressure test algorithm. That step is beyond the scope of this report, but two observations bearing on its resolution should be made.

1. In addition to $Q_{sleak+rleak}$ as defined above, the house pressure test also makes use of a signed difference in leakage rates when the return register is blocked, which is called $Q_{sleak+rleakRB}$. The same mathematics used to analyze the unblocked-register case can be used when the register is blocked. The percentage deviations for the two Q's, in any given case, will generally differ, however, because the house pressure with the system fan on is different. Thus, the general analysis is expected to be somewhat complicated.

2. If the percent deviations for $Q_{sleak+rleak}$ and $Q_{sleak+rleakRB}$ are both small, as will often be the case, then the error in the individual leakage rates due to such errors will also be small.

3. Conditions where significant deviations are to be expected can be identified on the basis of the values of ΔP_{on} and ΔP_{off}, and sufficiently accurate correction factors might be developed for use even in the cases where deviation is expected.

CONCLUSIONS

This report shows how an equation for the signed difference (algebraic sum) $Q_{sleak+rleak}$ of the duct leakage rates from the supply side to outside (taken as +) and to the return side from outside (taken as -) is expected to depend on the detailed distribution of the leakage in the building envelope. ASHRAE Standard 152P uses an equation that is based on a specific assumption about this distribution, namely half the leakage flow coefficient due to the floor, half to the ceiling, and none to the walls. In most cases, the more-detailed equation yields results that are within 5% of the Standard 152P equation, but cases of >50% deviation are not hard to find. The following conclusions are drawn from the work reported:

- For "realistic" cases, the Standard 152P value of $Q_{sleak+rleak}$ will differ from that produced by the more general formula by 5% or less about 80% of the time, when the absolute value of the house pressure with the system fan off is less than 1 Pa.

- Conditions where greater deviation is found are largely restricted to those where the house pressure across the ceiling or the floor, with the system fan on, is close to zero. It would be useful to develop a correction factor applying to those cases that would improve agreement without requiring detailed knowledge of the leakage distribution in the envelope.

- Cases to beware of include those with very leaky ceilings (which might be identifiable by inspection) and those with large stack and wind effect, leading to values of the fan-off house pressure ΔP_{off} in excess of 1 Pa.

REFERENCES

1. ASHRAE 1998. Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems. Draft. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA.

2. Modera, M. and J. Byrne. Can a New Duct Test Take the Pressure? Home Energy, January/February 1997, p. 29.

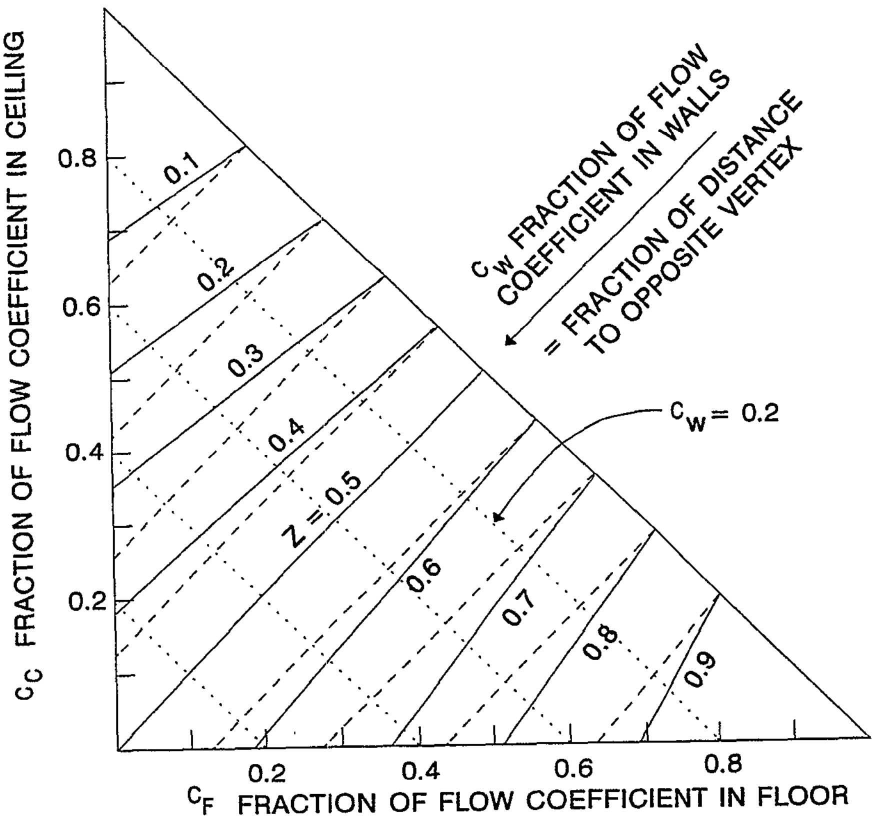

Figure 1. Dependence of Parameter "z" on the Distribution of Air Leakage Within the Envelope

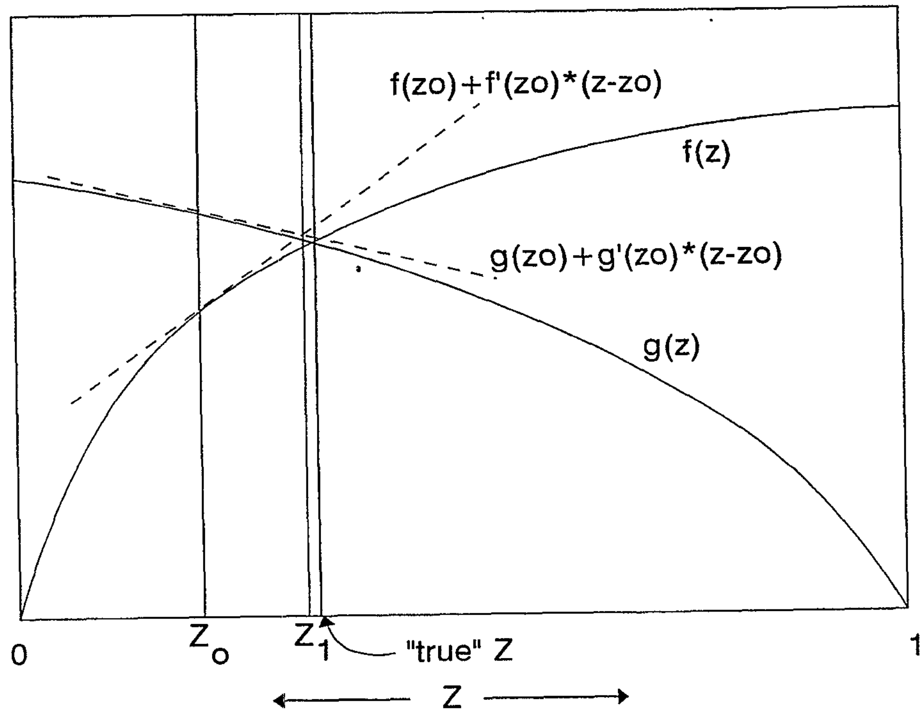

Figure 2. Iterative Solution for Parameter "z"

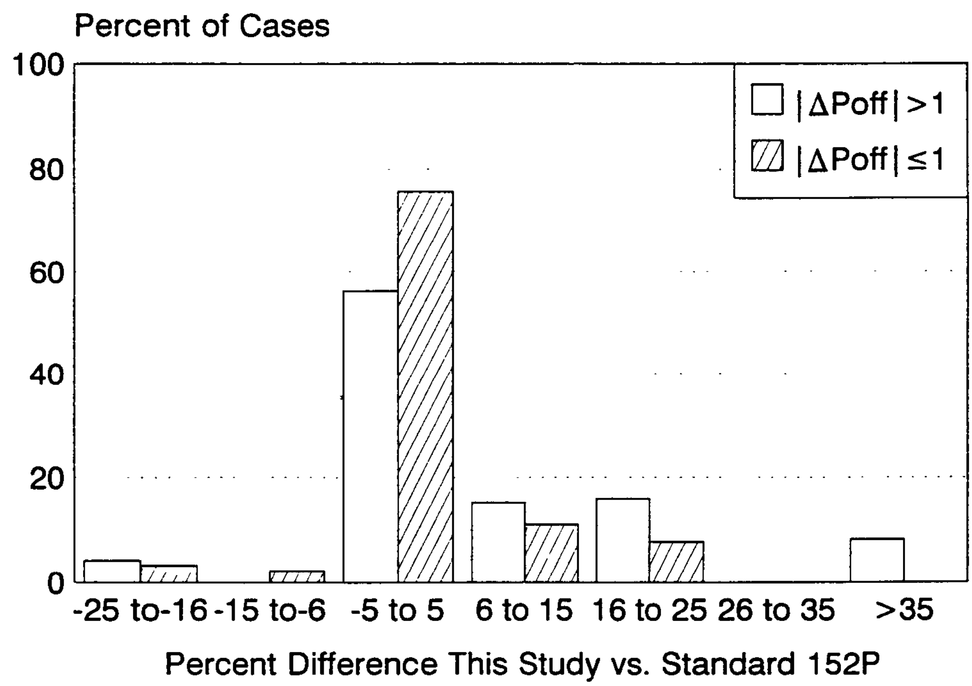

Figure 3. Frequency Histogram of Discrepancy in $Q_{sleak+rleak}$ Between This Study and Standard 152P, for Slab-on-Grade Homes (Floor Leakage Assumed Equal to Zero)

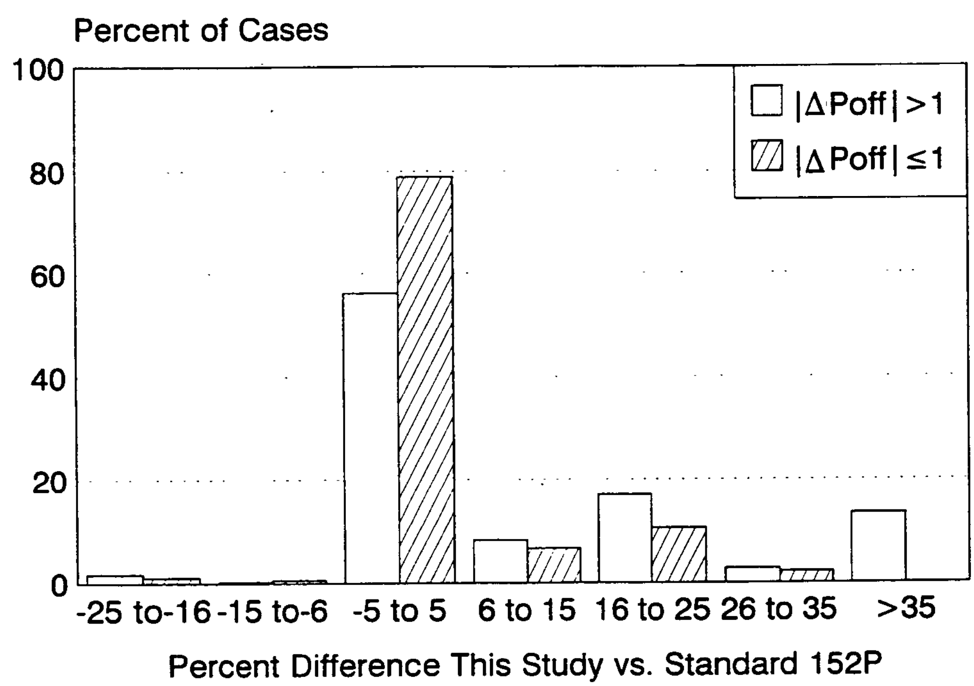

Figure 4. Frequency Histogram of Discrepancy in $Q_{sleak+rleak}$ Between This Study and Standard 152P, for Homes with Open Foundations (Floor Leakage ≥ 25% of the Total)

APPENDIX: SPREADSHEET CALCULATIONS OF Qsleak+rleak

The following spreadsheets show the calculated values of Qsleak+rleak for various input values. The columns are described as follows:

Column 1: The current value of ΔP_{off}.
Column 2: The current value of ΔP_{on}.
Column 3: The value of z_0 calculated according to Equation 16.
Column 4: The value of z_1, resulting from the first iteration using Equation 20.
Column 5: The value of z_2, the second iteration of Equation 20.
Column 6: The value of $\Delta P_{off}/z_1 - \Delta P_{on}$.
Column 7: The value of $\Delta P_{off}/z_2 - \Delta P_{on}$.
Column 8: $Q_{sleak+rleak}$ using z_1 in Equation 12.
Column 9: $Q_{sleak+rleak}$ using z_2 in Equation 12.
Column 10: $Q_{sleak+rleak}$ using Equation 14, the ASHRAE Standard 152P formula.
Column 11: The difference between Standard 152 (Eq. 14) and this report (Eq. 12) (absolute value of Column 9 minus absolute value of Column 10).
Column 12: The percent difference between the above.

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0	cc=	0	cw=	1	1/nenv=	1.538462	
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF	
-3.00	0.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-306	-306	-252	53	19	
-2.50	0.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-271	-271	-224	47	19	
-2.00	0.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-235	-235	-194	41	19	
-1.50	0.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-195	-195	-161	34	19	
-1.00	0.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-150	-150	-123	26	19	
-0.50	0.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-95	-95	-79	17	19	
0.01	0.00	0.5000	0.5000	0.5000	0.0200	0.0200	7	7	6	1	19	
0.50	0.00	0.5000	0.5000	0.5000	1.0000	1.0000	95	95	79	17	19	
1.00	0.00	0.5000	0.5000	0.5000	2.0000	2.0000	150	150	123	26	19	
1.50	0.00	0.5000	0.5000	0.5000	3.0000	3.0000	195	195	161	34	19	
2.00	0.00	0.5000	0.5000	0.5000	4.0000	4.0000	235	235	194	41	19	
2.50	0.00	0.5000	0.5000	0.5000	5.0000	5.0000	271	271	224	47	19	
3.00	0.00	0.5000	0.5000	0.5000	6.0000	6.0000	306	306	252	53	19	
-3.00	1.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-378	-378	-357	21	6	
-2.50	1.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-348	-348	-331	17	5	
-2.00	1.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-315	-315	-303	13	4	
-1.50	1.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-281	-281	-272	9	3	
-1.00	1.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-244	-244	-239	5	2	
-0.50	1.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-204	-204	-202	2	1	
0.01	1.00	0.5000	0.5000	0.5000	-0.9800	-0.9800	-156	-156	-156	0	0	
0.50	1.00	0.5000	0.5000	0.5000	0.0000	0.0000	-95	-95	-79	17	19	
1.00	1.00	0.5000	0.5000	0.5000	1.0000	1.0000	0	0	0	0	0	
1.50	1.00	0.5000	0.5000	0.5000	2.0000	2.0000	68	68	45	23	41	
2.00	1.00	0.5000	0.5000	0.5000	3.0000	3.0000	122	122	82	40	39	
2.50	1.00	0.5000	0.5000	0.5000	4.0000	4.0000	169	169	115	54	38	
3.00	1.00	0.5000	0.5000	0.5000	5.0000	5.0000	210	210	145	65	37	
-3.00	2.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-441	-441	-427	14	3	
-2.50	2.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-413	-413	-402	11	3	
-2.00	2.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-383	-383	-375	8	2	
-1.50	2.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-353	-353	-347	5	2	
-1.00	2.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-320	-320	-317	3	1	
-0.50	2.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-285	-285	-284	1	0	
0.01	2.00	0.5000	0.5000	0.5000	-1.9800	-1.9800	-246	-246	-246	0	0	
0.50	2.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-204	-204	-202	2	1	
1.00	2.00	0.5000	0.5000	0.5000	0.0000	0.0000	-150	-150	-123	26	19	
1.50	2.00	0.5000	0.5000	0.5000	1.0000	1.0000	-68	-68	-45	23	41	
2.00	2.00	0.5000	0.5000	0.5000	2.0000	2.0000	0	0	0	0	0	
2.50	2.00	0.5000	0.5000	0.5000	3.0000	3.0000	57	57	37	20	42	
3.00	2.00	0.5000	0.5000	0.5000	4.0000	4.0000	107	107	70	36	41	
-3.00	3.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-499	-499	-489	10	2	
-2.50	3.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-472	-472	-464	8	2	
-2.00	3.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-445	-445	-439	6	1	
-1.50	3.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-416	-416	-413	4	1	
-1.00	3.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-386	-386	-384	2	0	
-0.50	3.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-355	-355	-354	1	0	
0.01	3.00	0.5000	0.5000	0.5000	-2.9800	-2.9800	-321	-321	-321	0	0	
0.50	3.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-285	-285	-284	1	0	
1.00	3.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-244	-244	-239	5	2	
1.50	3.00	0.5000	0.5000	0.5000	0.0000	0.0000	-195	-195	-161	34	19	
2.00	3.00	0.5000	0.5000	0.5000	1.0000	1.0000	-122	-122	-82	40	39	
2.50	3.00	0.5000	0.5000	0.5000	2.0000	2.0000	-57	-57	-37	20	42	
3.00	3.00	0.5000	0.5000	0.5000	3.0000	3.0000	0	0	0	0	0	
-3.00	4.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-553	-553	-545	8	2	
-2.50	4.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-528	-528	-522	6	1	
-2.00	4.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-502	-502	-498	4	1	
-1.50	4.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-475	-475	-472	3	1	
-1.00	4.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-447	-447	-446	1	0	
-0.50	4.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-418	-418	-418	0	0	
0.01	4.00	0.5000	0.5000	0.5000	-3.9800	-3.9800	-387	-387	-387	0	0	
0.50	4.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-355	-355	-354	1	0	
1.00	4.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-320	-320	-317	3	1	
1.50	4.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-281	-281	-272	9	3	
2.00	4.00	0.5000	0.5000	0.5000	0.0000	0.0000	-235	-235	-194	41	19	
2.50	4.00	0.5000	0.5000	0.5000	1.0000	1.0000	-169	-169	-115	54	38	
3.00	4.00	0.5000	0.5000	0.5000	2.0000	2.0000	-107	-107	-70	36	41	
-3.00	5.00	0.5000	0.5000	0.5000	-11.0000	-11.0000	-604	-604	-598	7	1	
-2.50	5.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-580	-580	-575	5	1	
-2.00	5.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-555	-555	-552	4	1	
-1.50	5.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-530	-530	-528	2	0	
-1.00	5.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-504	-504	-502	1	0	
-0.50	5.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-476	-476	-476	0	0	
0.01	5.00	0.5000	0.5000	0.5000	-4.9800	-4.9800	-447	-447	-447	0	0	
0.50	5.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-418	-418	-418	0	0	
1.00	5.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-386	-386	-384	2	0	
1.50	5.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-353	-353	-347	5	2	
2.00	5.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-315	-315	-303	13	4	
2.50	5.00	0.5000	0.5000	0.5000	0.0000	0.0000	-271	-271	-224	47	19	
3.00	5.00	0.5000	0.5000	0.5000	1.0000	1.0000	-210	-210	-145	65	37	

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0	cc=	0.25	cw=	0.75	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.3131	0.3639	0.3640	-8.2438	-8.2414	-282	-282	-252	30	11
-2.50	0.00	0.3131	0.3639	0.3640	-6.8698	-6.8678	-250	-250	-224	26	11
-2.00	0.00	0.3131	0.3639	0.3640	-5.4958	-5.4942	-216	-216	-194	23	11
-1.50	0.00	0.3131	0.3639	0.3640	-4.1219	-4.1207	-180	-179	-161	19	11
-1.00	0.00	0.3131	0.3639	0.3640	-2.7479	-2.7471	-138	-138	-123	14	11
-0.50	0.00	0.3131	0.3639	0.3640	-1.3740	-1.3736	-88	-88	-79	9	11
0.01	0.00	0.3131	0.3639	0.3640	0.0275	0.0275	7	7	6	1	11
0.50	0.00	0.3131	0.3639	0.3640	1.3740	1.3736	88	88	79	9	11
1.00	0.00	0.3131	0.3639	0.3640	2.7479	2.7471	138	138	123	14	11
1.50	0.00	0.3131	0.3639	0.3640	4.1219	4.1207	180	179	161	19	11
2.00	0.00	0.3131	0.3639	0.3640	5.4958	5.4942	216	216	194	23	11
2.50	0.00	0.3131	0.3639	0.3640	6.8698	6.8678	250	250	224	26	11
3.00	0.00	0.3131	0.3639	0.3640	8.2438	8.2414	282	282	252	30	11
-3.00	1.00	0.3131	0.3639	0.3640	-9.2438	-9.2414	-371	-371	-357	14	4
-2.50	1.00	0.3131	0.3639	0.3640	-7.8698	-7.8678	-342	-342	-331	11	3
-2.00	1.00	0.3131	0.3639	0.3640	-6.4958	-6.4942	-311	-311	-303	9	3
-1.50	1.00	0.3131	0.3639	0.3640	-5.1219	-5.1207	-279	-279	-272	7	2
-1.00	1.00	0.3131	0.3639	0.3640	-3.7479	-3.7471	-243	-243	-239	4	2
-0.50	1.00	0.3131	0.3639	0.3640	-2.3740	-2.3736	-204	-204	-202	2	1
0.01	1.00	0.3131	0.3639	0.3640	-0.9725	-0.9725	-156	-156	-156	-0	-0
0.50	1.00	0.3131	0.3639	0.3640	0.3740	0.3736	-81	-81	-79	2	3
1.00	1.00	0.3131	0.3639	0.3640	1.7479	1.7471	0	0	0	0	0
1.50	1.00	0.3131	0.3639	0.3640	3.1219	3.1207	57	57	45	12	24
2.00	1.00	0.3131	0.3639	0.3640	4.4958	4.4942	103	103	82	21	23
2.50	1.00	0.3131	0.3639	0.3640	5.8698	5.8678	143	143	115	28	22
3.00	1.00	0.3131	0.3639	0.3640	7.2438	7.2414	180	180	145	34	21
-3.00	2.00	0.3131	0.3639	0.3640	-10.2438	-10.2414	-438	-438	-427	10	2
-2.50	2.00	0.3131	0.3639	0.3640	-8.8698	-8.8678	-410	-410	-402	8	2
-2.00	2.00	0.3131	0.3639	0.3640	-7.4958	-7.4942	-382	-382	-375	7	2
-1.50	2.00	0.3131	0.3639	0.3640	-6.1219	-6.1207	-352	-352	-347	5	1
-1.00	2.00	0.3131	0.3639	0.3640	-4.7479	-4.7471	-320	-320	-317	3	1
-0.50	2.00	0.3131	0.3639	0.3640	-3.3740	-3.3736	-285	-285	-284	1	0
0.01	2.00	0.3131	0.3639	0.3640	-1.9725	-1.9725	-246	-246	-246	-0	-0
0.50	2.00	0.3131	0.3639	0.3640	-0.6260	-0.6264	-201	-201	-202	-1	-1
1.00	2.00	0.3131	0.3639	0.3640	0.7479	0.7471	-127	-127	-123	4	3
1.50	2.00	0.3131	0.3639	0.3640	2.1219	2.1207	-56	-56	-45	11	23
2.00	2.00	0.3131	0.3639	0.3640	3.4958	3.4942	0	0	0	0	0
2.50	2.00	0.3131	0.3639	0.3640	4.8698	4.8678	47	47	37	10	24
3.00	2.00	0.3131	0.3639	0.3640	6.2438	6.2414	89	89	70	19	24
-3.00	3.00	0.3131	0.3639	0.3640	-11.2438	-11.2414	-497	-497	-489	9	2
-2.50	3.00	0.3131	0.3639	0.3640	-9.8698	-9.8678	-471	-471	-464	7	1
-2.00	3.00	0.3131	0.3639	0.3640	-8.4958	-8.4942	-445	-445	-439	5	1
-1.50	3.00	0.3131	0.3639	0.3640	-7.1219	-7.1207	-417	-417	-413	4	1
-1.00	3.00	0.3131	0.3639	0.3640	-5.7479	-5.7471	-387	-387	-384	2	1
-0.50	3.00	0.3131	0.3639	0.3640	-4.3740	-4.3736	-355	-355	-354	1	0
0.01	3.00	0.3131	0.3639	0.3640	-2.9725	-2.9725	-321	-321	-321	-0	-0
0.50	3.00	0.3131	0.3639	0.3640	-1.6260	-1.6264	-283	-283	-284	-1	-0
1.00	3.00	0.3131	0.3639	0.3640	-0.2521	-0.2529	-237	-237	-239	-2	-1
1.50	3.00	0.3131	0.3639	0.3640	1.1219	1.1207	-166	-166	-161	5	3
2.00	3.00	0.3131	0.3639	0.3640	2.4958	2.4942	-101	-101	-82	19	21
2.50	3.00	0.3131	0.3639	0.3640	3.8698	3.8678	-47	-47	-37	10	23
3.00	3.00	0.3131	0.3639	0.3640	5.2438	5.2414	0	0	0	0	0
-3.00	4.00	0.3131	0.3639	0.3640	-12.2438	-12.2414	-552	-552	-545	7	1
-2.50	4.00	0.3131	0.3639	0.3640	-10.8698	-10.8678	-528	-528	-522	6	1
-2.00	4.00	0.3131	0.3639	0.3640	-9.4958	-9.4942	-502	-502	-498	5	1
-1.50	4.00	0.3131	0.3639	0.3640	-8.1219	-8.1207	-476	-476	-472	3	1
-1.00	4.00	0.3131	0.3639	0.3640	-6.7479	-6.7471	-448	-448	-446	2	0
-0.50	4.00	0.3131	0.3639	0.3640	-5.3740	-5.3736	-419	-419	-418	1	0
0.01	4.00	0.3131	0.3639	0.3640	-3.9725	-3.9725	-387	-387	-387	-0	-0
0.50	4.00	0.3131	0.3639	0.3640	-2.6260	-2.6264	-353	-353	-354	-1	-0
1.00	4.00	0.3131	0.3639	0.3640	-1.2521	-1.2529	-315	-315	-317	-2	-1
1.50	4.00	0.3131	0.3639	0.3640	0.1219	0.1207	-267	-267	-272	-5	-2
2.00	4.00	0.3131	0.3639	0.3640	1.4958	1.4942	-200	-200	-194	6	3
2.50	4.00	0.3131	0.3639	0.3640	2.8698	2.8678	-140	-140	-115	25	20
3.00	4.00	0.3131	0.3639	0.3640	4.2438	4.2414	-88	-88	-70	18	23
-3.00	5.00	0.3131	0.3639	0.3640	-13.2438	-13.2414	-604	-604	-598	7	1
-2.50	5.00	0.3131	0.3639	0.3640	-11.8698	-11.8678	-581	-581	-575	5	1
-2.00	5.00	0.3131	0.3639	0.3640	-10.4958	-10.4942	-556	-556	-552	4	1
-1.50	5.00	0.3131	0.3639	0.3640	-9.1219	-9.1207	-531	-531	-528	3	1
-1.00	5.00	0.3131	0.3639	0.3640	-7.7479	-7.7471	-504	-504	-502	2	0
-0.50	5.00	0.3131	0.3639	0.3640	-6.3740	-6.3736	-477	-477	-476	1	0
0.01	5.00	0.3131	0.3639	0.3640	-4.9725	-4.9725	-447	-447	-447	-0	-0
0.50	5.00	0.3131	0.3639	0.3640	-3.6260	-3.6264	-417	-417	-418	-1	-0
1.00	5.00	0.3131	0.3639	0.3640	-2.2521	-2.2529	-383	-383	-384	-2	-0
1.50	5.00	0.3131	0.3639	0.3640	-0.8781	-0.8793	-345	-345	-347	-2	-1
2.00	5.00	0.3131	0.3639	0.3640	0.4958	0.4942	-293	-293	-303	-9	-3
2.50	5.00	0.3131	0.3639	0.3640	1.8698	1.8678	-231	-231	-224	7	3
3.00	5.00	0.3131	0.3639	0.3640	3.2438	3.2414	-175	-175	-145	30	19

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0	cc=	0.5	cw=	0.5	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.1558	0.2097	0.2109	-14.3089	-14.2276	-269	-268	-252	16	6
-2.50	0.00	0.1558	0.2097	0.2109	-11.9240	-11.8564	-239	-238	-224	14	6
-2.00	0.00	0.1558	0.2097	0.2109	-9.5392	-9.4851	-206	-206	-194	12	6
-1.50	0.00	0.1558	0.2097	0.2109	-7.1544	-7.1138	-171	-171	-161	10	6
-1.00	0.00	0.1558	0.2097	0.2109	-4.7696	-4.7425	-132	-131	-123	8	6
-0.50	0.00	0.1558	0.2097	0.2109	-2.3848	-2.3713	-84	-84	-79	5	6
0.01	0.00	0.1558	0.2097	0.2109	0.0477	0.0474	7	7	6	0	6
0.50	0.00	0.1558	0.2097	0.2109	2.3848	2.3713	84	84	79	5	6
1.00	0.00	0.1558	0.2097	0.2109	4.7696	4.7425	132	131	123	8	6
1.50	0.00	0.1558	0.2097	0.2109	7.1544	7.1138	171	171	161	10	6
2.00	0.00	0.1558	0.2097	0.2109	9.5392	9.4851	206	206	194	12	6
2.50	0.00	0.1558	0.2097	0.2109	11.9240	11.8564	239	238	224	14	6
3.00	0.00	0.1558	0.2097	0.2109	14.3089	14.2276	269	268	252	16	6
-3.00	1.00	0.1558	0.2097	0.2109	-15.3089	-15.2276	-376	-375	-357	18	5
-2.50	1.00	0.1558	0.2097	0.2109	-12.9240	-12.8564	-347	-346	-331	16	5
-2.00	1.00	0.1558	0.2097	0.2109	-10.5392	-10.4851	-317	-316	-303	14	4
-1.50	1.00	0.1558	0.2097	0.2109	-8.1544	-8.1138	-285	-284	-272	12	4
-1.00	1.00	0.1558	0.2097	0.2109	-5.7696	-5.7425	-249	-248	-239	9	4
-0.50	1.00	0.1558	0.2097	0.2109	-3.3848	-3.3713	-208	-208	-202	6	3
0.01	1.00	0.1558	0.2097	0.2109	-0.9523	-0.9526	-156	-156	-156	-0	-0
0.50	1.00	0.1558	0.2097	0.2109	1.3848	1.3713	-64	-65	-79	-14	-19
1.00	1.00	0.1558	0.2097	0.2109	3.7696	3.7425	1	0	0	0	0
1.50	1.00	0.1558	0.2097	0.2109	6.1544	6.1138	48	48	45	3	6
2.00	1.00	0.1558	0.2097	0.2109	8.5392	8.4851	88	88	82	6	7
2.50	1.00	0.1558	0.2097	0.2109	10.9240	10.8564	124	123	115	8	7
3.00	1.00	0.1558	0.2097	0.2109	13.3089	13.2276	156	155	145	10	7
-3.00	2.00	0.1558	0.2097	0.2109	-16.3089	-16.2276	-446	-446	-427	18	4
-2.50	2.00	0.1558	0.2097	0.2109	-13.9240	-13.8564	-419	-418	-402	16	4
-2.00	2.00	0.1558	0.2097	0.2109	-11.5392	-11.4851	-390	-390	-375	14	4
-1.50	2.00	0.1558	0.2097	0.2109	-9.1544	-9.1138	-360	-359	-347	12	3
-1.00	2.00	0.1558	0.2097	0.2109	-6.7696	-6.7425	-327	-326	-317	9	3
-0.50	2.00	0.1558	0.2097	0.2109	-4.3848	-4.3713	-290	-290	-284	5	2
0.01	2.00	0.1558	0.2097	0.2109	-1.9523	-1.9526	-246	-246	-246	-0	-0
0.50	2.00	0.1558	0.2097	0.2109	0.3848	0.3713	-182	-183	-202	-19	-10
1.00	2.00	0.1558	0.2097	0.2109	2.7696	2.7425	-101	-102	-123	-22	-19
1.50	2.00	0.1558	0.2097	0.2109	5.1544	5.1138	-45	-45	-45	1	2
2.00	2.00	0.1558	0.2097	0.2109	7.5392	7.4851	1	0	0	0	1
2.50	2.00	0.1558	0.2097	0.2109	9.9240	9.8564	40	39	37	2	5
3.00	2.00	0.1558	0.2097	0.2109	12.3089	12.2276	76	75	70	4	6
-3.00	3.00	0.1558	0.2097	0.2109	-17.3089	-17.2276	-508	-507	-489	19	4
-2.50	3.00	0.1558	0.2097	0.2109	-14.9240	-14.8564	-482	-481	-464	17	4
-2.00	3.00	0.1558	0.2097	0.2109	-12.5392	-12.4851	-454	-454	-439	14	3
-1.50	3.00	0.1558	0.2097	0.2109	-10.1544	-10.1138	-425	-424	-413	12	3
-1.00	3.00	0.1558	0.2097	0.2109	-7.7696	-7.7425	-394	-393	-384	9	2
-0.50	3.00	0.1558	0.2097	0.2109	-5.3848	-5.3713	-360	-359	-354	5	1
0.01	3.00	0.1558	0.2097	0.2109	-2.9523	-2.9526	-320	-320	-321	-0	-0
0.50	3.00	0.1558	0.2097	0.2109	-0.6152	-0.6287	-274	-274	-284	-10	-3
1.00	3.00	0.1558	0.2097	0.2109	1.7696	1.7425	-196	-197	-239	-42	-19
1.50	3.00	0.1558	0.2097	0.2109	4.1544	4.1138	-132	-133	-161	-28	-19
2.00	3.00	0.1558	0.2097	0.2109	6.5392	6.4851	-80	-82	-82	-0	-1
2.50	3.00	0.1558	0.2097	0.2109	8.9240	8.8564	-37	-38	-37	1	3
3.00	3.00	0.1558	0.2097	0.2109	11.3089	11.2276	1	0	0	0	1
-3.00	4.00	0.1558	0.2097	0.2109	-18.3089	-18.2276	-564	-564	-545	19	3
-2.50	4.00	0.1558	0.2097	0.2109	-15.9240	-15.8564	-539	-538	-522	17	3
-2.00	4.00	0.1558	0.2097	0.2109	-13.5392	-13.4851	-512	-512	-498	14	3
-1.50	4.00	0.1558	0.2097	0.2109	-11.1544	-11.1138	-484	-484	-472	12	2
-1.00	4.00	0.1558	0.2097	0.2109	-8.7696	-8.7425	-455	-454	-446	9	2
-0.50	4.00	0.1558	0.2097	0.2109	-6.3848	-6.3713	-423	-422	-418	5	1
0.01	4.00	0.1558	0.2097	0.2109	-3.9523	-3.9526	-387	-387	-387	-0	-0
0.50	4.00	0.1558	0.2097	0.2109	-1.6152	-1.6287	-346	-347	-354	-8	-2
1.00	4.00	0.1558	0.2097	0.2109	0.7696	0.7425	-286	-286	-317	-31	-10
1.50	4.00	0.1558	0.2097	0.2109	3.1544	3.1138	-215	-216	-272	-56	-23
2.00	4.00	0.1558	0.2097	0.2109	5.5392	5.4851	-159	-160	-194	-34	-19
2.50	4.00	0.1558	0.2097	0.2109	7.9240	7.8564	-111	-113	-115	-2	-2
3.00	4.00	0.1558	0.2097	0.2109	10.3089	10.2276	-70	-71	-70	1	2
-3.00	5.00	0.1558	0.2097	0.2109	-19.3089	-19.2276	-617	-616	-598	19	3
-2.50	5.00	0.1558	0.2097	0.2109	-16.9240	-16.8564	-592	-592	-575	16	3
-2.00	5.00	0.1558	0.2097	0.2109	-14.5392	-14.4851	-567	-566	-552	14	3
-1.50	5.00	0.1558	0.2097	0.2109	-12.1544	-12.1138	-540	-539	-528	11	2
-1.00	5.00	0.1558	0.2097	0.2109	-9.7696	-9.7425	-511	-511	-502	8	2
-0.50	5.00	0.1558	0.2097	0.2109	-7.3848	-7.3713	-481	-481	-476	5	1
0.01	5.00	0.1558	0.2097	0.2109	-4.9523	-4.9526	-447	-447	-447	-0	-0
0.50	5.00	0.1558	0.2097	0.2109	-2.6152	-2.6287	-411	-411	-418	-7	-2
1.00	5.00	0.1558	0.2097	0.2109	-0.2304	-0.2575	-365	-366	-384	-19	-5
1.50	5.00	0.1558	0.2097	0.2109	2.1544	2.1138	-295	-296	-347	-51	-16
2.00	5.00	0.1558	0.2097	0.2109	4.5392	4.4851	-234	-236	-303	-67	-25
2.50	5.00	0.1558	0.2097	0.2109	6.9240	6.8564	-183	-185	-224	-39	-19
3.00	5.00	0.1558	0.2097	0.2109	9.3089	9.2276	-139	-140	-145	-5	-3

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0	cc=	0.75	cw=	0.25	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.0477	0.0684	0.0696	-43.8596	-43.1128	-278	-275	-252	23	9
-2.50	0.00	0.0477	0.0684	0.0696	-36.5497	-35.9273	-247	-244	-224	21	9
-2.00	0.00	0.0477	0.0684	0.0696	-29.2398	-28.7418	-214	-211	-194	18	9
-1.50	0.00	0.0477	0.0684	0.0696	-21.9298	-21.5564	-177	-175	-161	15	9
-1.00	0.00	0.0477	0.0684	0.0696	-14.6199	-14.3709	-136	-135	-123	11	9
-0.50	0.00	0.0477	0.0684	0.0696	-7.3099	-7.1855	-87	-86	-79	7	9
0.01	0.00	0.0477	0.0684	0.0696	0.1462	0.1437	7	7	6	1	9
0.50	0.00	0.0477	0.0684	0.0696	7.3099	7.1855	87	86	79	7	9
1.00	0.00	0.0477	0.0684	0.0696	14.6199	14.3709	136	135	123	11	9
1.50	0.00	0.0477	0.0684	0.0696	21.9298	21.5564	177	175	161	15	9
2.00	0.00	0.0477	0.0684	0.0696	29.2398	28.7418	214	211	194	18	9
2.50	0.00	0.0477	0.0684	0.0696	36.5497	35.9273	247	244	224	21	9
3.00	0.00	0.0477	0.0684	0.0696	43.8596	43.1128	278	275	252	23	9
-3.00	1.00	0.0477	0.0684	0.0696	-44.8596	-44.1128	-406	-403	-357	46	12
-2.50	1.00	0.0477	0.0684	0.0696	-37.5497	-36.9273	-376	-373	-331	42	12
-2.00	1.00	0.0477	0.0684	0.0696	-30.2398	-29.7418	-343	-341	-303	38	12
-1.50	1.00	0.0477	0.0684	0.0696	-22.9298	-22.5564	-308	-306	-272	34	12
-1.00	1.00	0.0477	0.0684	0.0696	-15.6199	-15.3709	-268	-267	-239	28	11
-0.50	1.00	0.0477	0.0684	0.0696	-8.3099	-8.1855	-222	-221	-202	19	9
0.01	1.00	0.0477	0.0684	0.0696	-0.8538	-0.8563	-155	-155	-156	-1	-1
0.50	1.00	0.0477	0.0684	0.0696	6.3099	6.1855	-53	-54	-79	-24	-37
1.00	1.00	0.0477	0.0684	0.0696	13.6199	13.3709	2	0	0	0	7
1.50	1.00	0.0477	0.0684	0.0696	20.9298	20.5564	45	43	45	-2	-4
2.00	1.00	0.0477	0.0684	0.0696	28.2398	27.7418	83	81	82	-1	-2
2.50	1.00	0.0477	0.0684	0.0696	35.5497	34.9273	118	115	115	-0	-0
3.00	1.00	0.0477	0.0684	0.0696	42.8596	42.1128	149	146	145	1	1
-3.00	2.00	0.0477	0.0684	0.0696	-45.8596	-45.1128	-483	-480	-427	53	12
-2.50	2.00	0.0477	0.0684	0.0696	-38.5497	-37.9273	-453	-450	-402	48	11
-2.00	2.00	0.0477	0.0684	0.0696	-31.2398	-30.7418	-421	-419	-375	43	11
-1.50	2.00	0.0477	0.0684	0.0696	-23.9298	-23.5564	-387	-385	-347	37	10
-1.00	2.00	0.0477	0.0684	0.0696	-16.6199	-16.3709	-348	-347	-317	30	9
-0.50	2.00	0.0477	0.0684	0.0696	-9.3099	-9.1855	-304	-303	-284	19	7
0.01	2.00	0.0477	0.0684	0.0696	-1.8538	-1.8563	-245	-245	-246	-1	-0
0.50	2.00	0.0477	0.0684	0.0696	5.3099	5.1855	-144	-145	-202	-57	-33
1.00	2.00	0.0477	0.0684	0.0696	12.6199	12.3709	-83	-85	-123	-38	-37
1.50	2.00	0.0477	0.0684	0.0696	19.9298	19.5564	-37	-39	-45	-6	-13
2.00	2.00	0.0477	0.0684	0.0696	27.2398	26.7418	3	0	0	0	11
2.50	2.00	0.0477	0.0684	0.0696	34.5497	33.9273	38	35	37	-2	-6
3.00	2.00	0.0477	0.0684	0.0696	41.8596	41.1128	71	68	70	-3	-4
-3.00	3.00	0.0477	0.0684	0.0696	-46.8596	-46.1128	-548	-545	-489	56	11
-2.50	3.00	0.0477	0.0684	0.0696	-39.5497	-38.9273	-518	-516	-464	51	10
-2.00	3.00	0.0477	0.0684	0.0696	-32.2398	-31.7418	-487	-485	-439	46	10
-1.50	3.00	0.0477	0.0684	0.0696	-24.9298	-24.5564	-453	-452	-413	39	9
-1.00	3.00	0.0477	0.0684	0.0696	-17.6199	-17.3709	-416	-415	-384	31	8
-0.50	3.00	0.0477	0.0684	0.0696	-10.3099	-10.1855	-374	-373	-354	19	5
0.01	3.00	0.0477	0.0684	0.0696	-2.8538	-2.8563	-320	-320	-321	-1	-0
0.50	3.00	0.0477	0.0684	0.0696	4.3099	4.1855	-225	-226	-284	-58	-23
1.00	3.00	0.0477	0.0684	0.0696	11.6199	11.3709	-158	-160	-239	-80	-40
1.50	3.00	0.0477	0.0684	0.0696	18.9298	18.5564	-108	-111	-161	-50	-37
2.00	3.00	0.0477	0.0684	0.0696	26.2398	25.7418	-67	-70	-82	-12	-16
2.50	3.00	0.0477	0.0684	0.0696	33.5497	32.9273	-30	-33	-37	-4	-11
3.00	3.00	0.0477	0.0684	0.0696	40.8596	40.1128	3	0	0	0	14
-3.00	4.00	0.0477	0.0684	0.0696	-47.8596	-47.1128	-607	-604	-545	59	10
-2.50	4.00	0.0477	0.0684	0.0696	-40.5497	-39.9273	-577	-575	-522	53	10
-2.00	4.00	0.0477	0.0684	0.0696	-33.2398	-32.7418	-547	-544	-498	47	9
-1.50	4.00	0.0477	0.0684	0.0696	-25.9298	-25.5564	-514	-512	-472	40	8
-1.00	4.00	0.0477	0.0684	0.0696	-18.6199	-18.3709	-477	-476	-446	31	7
-0.50	4.00	0.0477	0.0684	0.0696	-11.3099	-11.1855	-437	-436	-418	19	4
0.01	4.00	0.0477	0.0684	0.0696	-3.8538	-3.8563	-386	-386	-387	-1	-0
0.50	4.00	0.0477	0.0684	0.0696	3.3099	3.1855	-299	-301	-354	-54	-16
1.00	4.00	0.0477	0.0684	0.0696	10.6199	10.3709	-226	-228	-317	-89	-33
1.50	4.00	0.0477	0.0684	0.0696	17.9298	17.5564	-174	-176	-272	-96	-43
2.00	4.00	0.0477	0.0684	0.0696	25.2398	24.7418	-131	-134	-194	-60	-37
2.50	4.00	0.0477	0.0684	0.0696	32.5497	31.9273	-93	-96	-115	-19	-18
3.00	4.00	0.0477	0.0684	0.0696	39.8596	39.1128	-58	-62	-70	-9	-13
-3.00	5.00	0.0477	0.0684	0.0696	-48.8596	-48.1128	-661	-658	-598	60	10
-2.50	5.00	0.0477	0.0684	0.0696	-41.5497	-40.9273	-632	-629	-575	54	9
-2.00	5.00	0.0477	0.0684	0.0696	-34.2398	-33.7418	-602	-600	-552	48	8
-1.50	5.00	0.0477	0.0684	0.0696	-26.9298	-26.5564	-569	-568	-528	40	7
-1.00	5.00	0.0477	0.0684	0.0696	-19.6199	-19.3709	-534	-533	-502	30	6
-0.50	5.00	0.0477	0.0684	0.0696	-12.3099	-12.1855	-495	-494	-476	18	4
0.01	5.00	0.0477	0.0684	0.0696	-4.8538	-4.8563	-447	-447	-447	-0	-0
0.50	5.00	0.0477	0.0684	0.0696	2.3099	2.1855	-369	-371	-418	-47	-12
1.00	5.00	0.0477	0.0684	0.0696	9.6199	9.3709	-291	-293	-384	-92	-27
1.50	5.00	0.0477	0.0684	0.0696	16.9298	16.5564	-236	-238	-347	-109	-37
2.00	5.00	0.0477	0.0684	0.0696	24.2398	23.7418	-190	-193	-303	-109	-44
2.50	5.00	0.0477	0.0684	0.0696	31.5497	30.9273	-151	-154	-224	-70	-37
3.00	5.00	0.0477	0.0684	0.0696	38.8596	38.1128	-116	-119	-145	-26	-20

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0	cc=	0.95	cw=	0.05	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.0036	0.0048	0.0049	***********	***********	-311	-308	-252	56	20
-2.50	0.00	0.0036	0.0048	0.0049	***********	***********	-276	-273	-224	49	20
-2.00	0.00	0.0036	0.0048	0.0049	***********	***********	-239	-236	-194	43	20
-1.50	0.00	0.0036	0.0048	0.0049	***********	***********	-198	-196	-161	35	20
-1.00	0.00	0.0036	0.0048	0.0049	***********	***********	-152	-151	-123	27	20
-0.50	0.00	0.0036	0.0048	0.0049	***********	***********	-97	-96	-79	17	20
0.01	0.00	0.0036	0.0048	0.0049	2.0627	2.0299	8	8	6	1	20
0.50	0.00	0.0036	0.0048	0.0049	103.1371	101.4946	97	96	79	17	20
1.00	0.00	0.0036	0.0048	0.0049	206.2742	202.9892	152	151	123	27	20
1.50	0.00	0.0036	0.0048	0.0049	309.4113	304.4838	198	196	161	35	20
2.00	0.00	0.0036	0.0048	0.0049	412.5484	405.9784	239	236	194	43	20
2.50	0.00	0.0036	0.0048	0.0049	515.6855	507.4730	276	273	224	49	20
3.00	0.00	0.0036	0.0048	0.0049	618.8226	608.9675	311	308	252	56	20
-3.00	1.00	0.0036	0.0048	0.0049	***********	***********	-461	-458	-357	101	25
-2.50	1.00	0.0036	0.0048	0.0049	***********	***********	-427	-424	-331	93	25
-2.00	1.00	0.0036	0.0048	0.0049	***********	***********	-389	-387	-303	84	24
-1.50	1.00	0.0036	0.0048	0.0049	***********	***********	-349	-347	-272	74	24
-1.00	1.00	0.0036	0.0048	0.0049	***********	***********	-303	-301	-239	62	23
-0.50	1.00	0.0036	0.0048	0.0049	***********	***********	-248	-247	-202	45	20
0.01	1.00	0.0036	0.0048	0.0049	1.0627	1.0299	-149	-149	-156	-7	-5
0.50	1.00	0.0036	0.0048	0.0049	102.1371	100.4946	-54	-55	-79	-24	-35
1.00	1.00	0.0036	0.0048	0.0049	205.2742	201.9892	2	0	0	0	8
1.50	1.00	0.0036	0.0048	0.0049	308.4113	303.4838	48	46	45	1	2
2.00	1.00	0.0036	0.0048	0.0049	411.5484	404.9784	89	86	82	4	5
2.50	1.00	0.0036	0.0048	0.0049	514.6855	506.4730	126	123	115	8	7
3.00	1.00	0.0036	0.0048	0.0049	617.8226	607.9675	161	157	145	12	8
-3.00	2.00	0.0036	0.0048	0.0049	***********	***********	-547	-544	-427	117	24
-2.50	2.00	0.0036	0.0048	0.0049	***********	***********	-512	-510	-402	108	24
-2.00	2.00	0.0036	0.0048	0.0049	***********	***********	-475	-473	-375	97	23
-1.50	2.00	0.0036	0.0048	0.0049	***********	***********	-435	-433	-347	85	22
-1.00	2.00	0.0036	0.0048	0.0049	***********	***********	-389	-388	-317	70	20
-0.50	2.00	0.0036	0.0048	0.0049	***********	***********	-334	-333	-284	49	16
0.01	2.00	0.0036	0.0048	0.0049	0.0627	0.0299	-242	-242	-246	-4	-2
0.50	2.00	0.0036	0.0048	0.0049	101.1371	99.4946	-141	-142	-202	-60	-35
1.00	2.00	0.0036	0.0048	0.0049	204.2742	200.9892	-85	-86	-123	-37	-35
1.50	2.00	0.0036	0.0048	0.0049	307.4113	302.4838	-38	-41	-45	-4	-10
2.00	2.00	0.0036	0.0048	0.0049	410.5484	403.9784	2	0	0	0	13
2.50	2.00	0.0036	0.0048	0.0049	513.6855	505.4730	40	37	37	-0	-0
3.00	2.00	0.0036	0.0048	0.0049	616.8226	606.9675	75	72	70	1	2
-3.00	3.00	0.0036	0.0048	0.0049	***********	***********	-619	-615	-489	127	23
-2.50	3.00	0.0036	0.0048	0.0049	***********	***********	-584	-581	-464	117	22
-2.00	3.00	0.0036	0.0048	0.0049	***********	***********	-547	-544	-439	105	21
-1.50	3.00	0.0036	0.0048	0.0049	***********	***********	-506	-504	-413	92	20
-1.00	3.00	0.0036	0.0048	0.0049	***********	***********	-461	-459	-384	75	18
-0.50	3.00	0.0036	0.0048	0.0049	***********	***********	-407	-406	-354	51	14
0.01	3.00	0.0036	0.0048	0.0049	-0.9373	-0.9701	-317	-317	-321	-3	-1
0.50	3.00	0.0036	0.0048	0.0049	100.1371	98.4946	-213	-214	-284	-70	-28
1.00	3.00	0.0036	0.0048	0.0049	203.2742	199.9892	-157	-158	-239	-81	-41
1.50	3.00	0.0036	0.0048	0.0049	306.4113	301.4838	-110	-112	-161	-48	-35
2.00	3.00	0.0036	0.0048	0.0049	409.5484	402.9784	-69	-72	-82	-10	-13
2.50	3.00	0.0036	0.0048	0.0049	512.6855	504.4730	-32	-35	-37	-3	-7
3.00	3.00	0.0036	0.0048	0.0049	615.8226	605.9675	3	0	0	0	16
-3.00	4.00	0.0036	0.0048	0.0049	***********	***********	-682	-679	-545	134	22
-2.50	4.00	0.0036	0.0048	0.0049	***********	***********	-648	-645	-522	123	21
-2.00	4.00	0.0036	0.0048	0.0049	***********	***********	-611	-608	-498	111	20
-1.50	4.00	0.0036	0.0048	0.0049	***********	***********	-570	-568	-472	96	18
-1.00	4.00	0.0036	0.0048	0.0049	***********	***********	-525	-523	-446	78	16
-0.50	4.00	0.0036	0.0048	0.0049	***********	***********	-471	-470	-418	52	12
0.01	4.00	0.0036	0.0048	0.0049	-1.9373	-1.9701	-384	-384	-387	-3	-1
0.50	4.00	0.0036	0.0048	0.0049	99.1371	97.4946	-277	-279	-354	-76	-24
1.00	4.00	0.0036	0.0048	0.0049	202.2742	198.9892	-221	-222	-317	-95	-35
1.50	4.00	0.0036	0.0048	0.0049	305.4113	300.4838	-174	-176	-272	-96	-43
2.00	4.00	0.0036	0.0048	0.0049	408.5484	401.9784	-133	-135	-194	-58	-35
2.50	4.00	0.0036	0.0048	0.0049	511.6855	503.4730	-95	-98	-115	-17	-16
3.00	4.00	0.0036	0.0048	0.0049	614.8226	604.9675	-60	-64	-70	-7	-10
-3.00	5.00	0.0036	0.0048	0.0049	***********	***********	-740	-737	-598	140	21
-2.50	5.00	0.0036	0.0048	0.0049	***********	***********	-706	-703	-575	128	20
-2.00	5.00	0.0036	0.0048	0.0049	***********	***********	-669	-666	-552	115	19
-1.50	5.00	0.0036	0.0048	0.0049	***********	***********	-629	-627	-528	99	17
-1.00	5.00	0.0036	0.0048	0.0049	***********	***********	-583	-582	-502	79	15
-0.50	5.00	0.0036	0.0048	0.0049	***********	***********	-530	-529	-476	53	10
0.01	5.00	0.0036	0.0048	0.0049	-2.9373	-2.9701	-445	-445	-447	-3	-1
0.50	5.00	0.0036	0.0048	0.0049	98.1371	96.4946	-337	-338	-418	-80	-21
1.00	5.00	0.0036	0.0048	0.0049	201.2742	197.9892	-279	-281	-384	-103	-31
1.50	5.00	0.0036	0.0048	0.0049	304.4113	299.4838	-233	-235	-347	-113	-39
2.00	5.00	0.0036	0.0048	0.0049	407.5484	400.9784	-191	-194	-303	-109	-44
2.50	5.00	0.0036	0.0048	0.0049	510.6855	502.4730	-154	-157	-224	-67	-35
3.00	5.00	0.0036	0.0048	0.0049	613.8226	603.9675	-119	-122	-145	-23	-17

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.25 cc= 0 cw= 0.75 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.6869	0.6361	0.6360	-4.7163	-4.7171	-304	-304	-252	52	19
-2.50	0.00	0.6869	0.6361	0.6360	-3.9303	-3.9309	-270	-270	-224	46	19
-2.00	0.00	0.6869	0.6361	0.6360	-3.1442	-3.1447	-233	-233	-194	40	19
-1.50	0.00	0.6869	0.6361	0.6360	-2.3582	-2.3586	-194	-194	-161	33	19
-1.00	0.00	0.6869	0.6361	0.6360	-1.5721	-1.5724	-149	-149	-123	25	19
-0.50	0.00	0.6869	0.6361	0.6360	-0.7861	-0.7862	-95	-95	-79	16	19
0.01	0.00	0.6869	0.6361	0.6360	0.0157	0.0157	7	7	6	1	18
0.50	0.00	0.6869	0.6361	0.6360	0.7861	0.7862	95	95	79	16	19
1.00	0.00	0.6869	0.6361	0.6360	1.5721	1.5724	149	149	123	25	19
1.50	0.00	0.6869	0.6361	0.6360	2.3582	2.3586	194	194	161	33	19
2.00	0.00	0.6869	0.6361	0.6360	3.1442	3.1447	233	233	194	40	19
2.50	0.00	0.6869	0.6361	0.6360	3.9303	3.9309	270	270	224	46	19
3.00	0.00	0.6869	0.6361	0.6360	4.7163	4.7171	304	304	252	52	19
-3.00	1.00	0.6869	0.6361	0.6360	-5.7163	-5.7171	-376	-376	-357	19	5
-2.50	1.00	0.6869	0.6361	0.6360	-4.9303	-4.9309	-346	-346	-331	15	4
-2.00	1.00	0.6869	0.6361	0.6360	-4.1442	-4.1447	-314	-314	-303	11	4
-1.50	1.00	0.6869	0.6361	0.6360	-3.3582	-3.3586	-280	-280	-272	8	3
-1.00	1.00	0.6869	0.6361	0.6360	-2.5721	-2.5724	-243	-243	-239	4	2
-0.50	1.00	0.6869	0.6361	0.6360	-1.7861	-1.7862	-203	-203	-202	1	1
0.01	1.00	0.6869	0.6361	0.6360	-0.9843	-0.9843	-156	-156	-156	0	0
0.50	1.00	0.6869	0.6361	0.6360	-0.2139	-0.2138	-98	-98	-79	20	22
1.00	1.00	0.6869	0.6361	0.6360	0.5721	0.5724	-0	-0	0	0	0
1.50	1.00	0.6869	0.6361	0.6360	1.3582	1.3586	68	68	45	23	41
2.00	1.00	0.6869	0.6361	0.6360	2.1442	2.1447	122	122	82	40	39
2.50	1.00	0.6869	0.6361	0.6360	2.9303	2.9309	168	168	115	53	38
3.00	1.00	0.6869	0.6361	0.6360	3.7163	3.7171	209	209	145	64	36
-3.00	2.00	0.6869	0.6361	0.6360	-6.7163	-6.7171	-439	-439	-427	12	3
-2.50	2.00	0.6869	0.6361	0.6360	-5.9303	-5.9309	-411	-411	-402	9	2
-2.00	2.00	0.6869	0.6361	0.6360	-5.1442	-5.1447	-382	-382	-375	6	2
-1.50	2.00	0.6869	0.6361	0.6360	-4.3582	-4.3586	-351	-351	-347	4	1
-1.00	2.00	0.6869	0.6361	0.6360	-3.5721	-3.5724	-319	-319	-317	2	1
-0.50	2.00	0.6869	0.6361	0.6360	-2.7861	-2.7862	-284	-284	-284	0	0
0.01	2.00	0.6869	0.6361	0.6360	-1.9843	-1.9843	-246	-246	-246	0	0
0.50	2.00	0.6869	0.6361	0.6360	-1.2139	-1.2138	-205	-205	-202	3	1
1.00	2.00	0.6869	0.6361	0.6360	-0.4279	-0.4276	-154	-154	-123	31	22
1.50	2.00	0.6869	0.6361	0.6360	0.3582	0.3586	-69	-69	-45	25	43
2.00	2.00	0.6869	0.6361	0.6360	1.1442	1.1447	-0	-0	0	0	0
2.50	2.00	0.6869	0.6361	0.6360	1.9303	1.9309	57	57	37	20	42
3.00	2.00	0.6869	0.6361	0.6360	2.7163	2.7171	107	107	70	36	41
-3.00	3.00	0.6869	0.6361	0.6360	-7.7163	-7.7171	-497	-497	-489	8	2
-2.50	3.00	0.6869	0.6361	0.6360	-6.9303	-6.9309	-471	-471	-464	6	1
-2.00	3.00	0.6869	0.6361	0.6360	-6.1442	-6.1447	-443	-443	-439	4	1
-1.50	3.00	0.6869	0.6361	0.6360	-5.3582	-5.3586	-415	-415	-413	2	1
-1.00	3.00	0.6869	0.6361	0.6360	-4.5721	-4.5724	-385	-385	-384	1	0
-0.50	3.00	0.6869	0.6361	0.6360	-3.7861	-3.7862	-354	-354	-354	0	0
0.01	3.00	0.6869	0.6361	0.6360	-2.9843	-2.9843	-321	-321	-321	0	0
0.50	3.00	0.6869	0.6361	0.6360	-2.2139	-2.2138	-286	-286	-284	2	1
1.00	3.00	0.6869	0.6361	0.6360	-1.4279	-1.4276	-246	-246	-239	7	3
1.50	3.00	0.6869	0.6361	0.6360	-0.6418	-0.6414	-201	-201	-161	40	22
2.00	3.00	0.6869	0.6361	0.6360	0.1442	0.1447	-127	-127	-82	45	43
2.50	3.00	0.6869	0.6361	0.6360	0.9303	0.9309	-58	-58	-37	21	43
3.00	3.00	0.6869	0.6361	0.6360	1.7163	1.7171	-0	-0	0	0	0
-3.00	4.00	0.6869	0.6361	0.6360	-8.7163	-8.7171	-551	-551	-545	6	1
-2.50	4.00	0.6869	0.6361	0.6360	-7.9303	-7.9309	-526	-526	-522	4	1
-2.00	4.00	0.6869	0.6361	0.6360	-7.1442	-7.1447	-500	-500	-498	3	1
-1.50	4.00	0.6869	0.6361	0.6360	-6.3582	-6.3586	-474	-474	-472	2	0
-1.00	4.00	0.6869	0.6361	0.6360	-5.5721	-5.5724	-446	-446	-446	0	0
-0.50	4.00	0.6869	0.6361	0.6360	-4.7861	-4.7862	-417	-417	-418	-0	-0
0.01	4.00	0.6869	0.6361	0.6360	-3.9843	-3.9843	-387	-387	-387	0	0
0.50	4.00	0.6869	0.6361	0.6360	-3.2139	-3.2138	-355	-355	-354	1	0
1.00	4.00	0.6869	0.6361	0.6360	-2.4279	-2.4276	-321	-321	-317	4	1
1.50	4.00	0.6869	0.6361	0.6360	-1.6418	-1.6414	-284	-284	-272	12	4
2.00	4.00	0.6869	0.6361	0.6360	-0.8558	-0.8553	-242	-242	-194	48	22
2.50	4.00	0.6869	0.6361	0.6360	-0.0697	-0.0691	-186	-186	-115	71	47
3.00	4.00	0.6869	0.6361	0.6360	0.7163	0.7171	-109	-109	-70	39	43
-3.00	5.00	0.6869	0.6361	0.6360	-9.7163	-9.7171	-602	-602	-598	5	1
-2.50	5.00	0.6869	0.6361	0.6360	-8.9303	-8.9309	-578	-578	-575	3	1
-2.00	5.00	0.6869	0.6361	0.6360	-8.1442	-8.1447	-554	-554	-552	2	0
-1.50	5.00	0.6869	0.6361	0.6360	-7.3582	-7.3586	-529	-529	-528	1	0
-1.00	5.00	0.6869	0.6361	0.6360	-6.5721	-6.5724	-503	-503	-502	0	0
-0.50	5.00	0.6869	0.6361	0.6360	-5.7861	-5.7862	-476	-476	-476	-0	-0
0.01	5.00	0.6869	0.6361	0.6360	-4.9843	-4.9843	-447	-447	-447	0	0
0.50	5.00	0.6869	0.6361	0.6360	-4.2139	-4.2138	-418	-418	-418	1	0
1.00	5.00	0.6869	0.6361	0.6360	-3.4279	-3.4276	-388	-388	-384	3	1
1.50	5.00	0.6869	0.6361	0.6360	-2.6418	-2.6414	-355	-355	-347	8	2
2.00	5.00	0.6869	0.6361	0.6360	-1.8558	-1.8553	-319	-319	-303	17	5
2.50	5.00	0.6869	0.6361	0.6360	-1.0697	-1.0691	-280	-280	-224	56	22
3.00	5.00	0.6869	0.6361	0.6360	-0.2837	-0.2829	-231	-231	-145	86	46

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0.25		cc=	0.25	cw=	0.5	1/nenv= 1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-279	-279	-252	27	10
-2.50	0.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-248	-248	-224	24	10
-2.00	0.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-214	-214	-194	21	10
-1.50	0.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-178	-178	-161	17	10
-1.00	0.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-136	-136	-123	13	10
-0.50	0.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-87	-87	-79	8	10
0.01	0.00	0.5000	0.5000	0.5000	0.0200	0.0200	7	7	6	1	10
0.50	0.00	0.5000	0.5000	0.5000	1.0000	1.0000	87	87	79	8	10
1.00	0.00	0.5000	0.5000	0.5000	2.0000	2.0000	136	136	123	13	10
1.50	0.00	0.5000	0.5000	0.5000	3.0000	3.0000	178	178	161	17	10
2.00	0.00	0.5000	0.5000	0.5000	4.0000	4.0000	214	214	194	21	10
2.50	0.00	0.5000	0.5000	0.5000	5.0000	5.0000	248	248	224	24	10
3.00	0.00	0.5000	0.5000	0.5000	6.0000	6.0000	279	279	252	27	10
-3.00	1.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-368	-368	-357	10	3
-2.50	1.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-339	-339	-331	8	3
-2.00	1.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-309	-309	-303	6	2
-1.50	1.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-277	-277	-272	4	2
-1.00	1.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-242	-242	-239	3	1
-0.50	1.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-203	-203	-202	1	0
0.01	1.00	0.5000	0.5000	0.5000	-0.9800	-0.9800	-156	-156	-156	0	0
0.50	1.00	0.5000	0.5000	0.5000	0.0000	0.0000	-87	-87	-79	8	10
1.00	1.00	0.5000	0.5000	0.5000	1.0000	1.0000	0	0	0	0	0
1.50	1.00	0.5000	0.5000	0.5000	2.0000	2.0000	56	56	45	12	23
2.00	1.00	0.5000	0.5000	0.5000	3.0000	3.0000	102	102	82	20	22
2.50	1.00	0.5000	0.5000	0.5000	4.0000	4.0000	142	142	115	27	21
3.00	1.00	0.5000	0.5000	0.5000	5.0000	5.0000	178	178	145	33	20
-3.00	2.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-434	-434	-427	7	2
-2.50	2.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-407	-407	-402	5	1
-2.00	2.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-379	-379	-375	4	1
-1.50	2.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-350	-350	-347	3	1
-1.00	2.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-318	-318	-317	1	0
-0.50	2.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-284	-284	-284	0	0
0.01	2.00	0.5000	0.5000	0.5000	-1.9800	-1.9800	-246	-246	-246	0	0
0.50	2.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-203	-203	-202	1	0
1.00	2.00	0.5000	0.5000	0.5000	0.0000	0.0000	-136	-136	-123	13	10
1.50	2.00	0.5000	0.5000	0.5000	1.0000	1.0000	-56	-56	-45	12	23
2.00	2.00	0.5000	0.5000	0.5000	2.0000	2.0000	0	0	0	0	0
2.50	2.00	0.5000	0.5000	0.5000	3.0000	3.0000	47	47	37	10	23
3.00	2.00	0.5000	0.5000	0.5000	4.0000	4.0000	88	88	70	18	23
-3.00	3.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-494	-494	-489	5	1
-2.50	3.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-468	-468	-464	4	1
-2.00	3.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-442	-442	-439	3	1
-1.50	3.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-414	-414	-413	2	0
-1.00	3.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-385	-385	-384	1	0
-0.50	3.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-355	-355	-354	0	0
0.01	3.00	0.5000	0.5000	0.5000	-2.9800	-2.9800	-321	-321	-321	0	0
0.50	3.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-284	-284	-284	0	0
1.00	3.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-242	-242	-239	3	1
1.50	3.00	0.5000	0.5000	0.5000	0.0000	0.0000	-178	-178	-161	17	10
2.00	3.00	0.5000	0.5000	0.5000	1.0000	1.0000	-102	-102	-82	20	22
2.50	3.00	0.5000	0.5000	0.5000	2.0000	2.0000	-47	-47	-37	10	23
3.00	3.00	0.5000	0.5000	0.5000	3.0000	3.0000	0	0	0	0	0
-3.00	4.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-549	-549	-545	4	1
-2.50	4.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-525	-525	-522	3	1
-2.00	4.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-500	-500	-498	2	0
-1.50	4.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-474	-474	-472	1	0
-1.00	4.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-446	-446	-446	1	0
-0.50	4.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-418	-418	-418	0	0
0.01	4.00	0.5000	0.5000	0.5000	-3.9800	-3.9800	-387	-387	-387	0	0
0.50	4.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-355	-355	-354	0	0
1.00	4.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-318	-318	-317	1	0
1.50	4.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-277	-277	-272	4	2
2.00	4.00	0.5000	0.5000	0.5000	0.0000	0.0000	-214	-214	-194	21	10
2.50	4.00	0.5000	0.5000	0.5000	1.0000	1.0000	-142	-142	-115	27	21
3.00	4.00	0.5000	0.5000	0.5000	2.0000	2.0000	-88	-88	-70	18	23
-3.00	5.00	0.5000	0.5000	0.5000	-11.0000	-11.0000	-601	-601	-598	3	1
-2.50	5.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-578	-578	-575	3	0
-2.00	5.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-554	-554	-552	2	0
-1.50	5.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-529	-529	-528	1	0
-1.00	5.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-503	-503	-502	1	0
-0.50	5.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-476	-476	-476	0	0
0.01	5.00	0.5000	0.5000	0.5000	-4.9800	-4.9800	-447	-447	-447	0	0
0.50	5.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-418	-418	-418	0	0
1.00	5.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-385	-385	-384	1	0
1.50	5.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-350	-350	-347	3	1
2.00	5.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-309	-309	-303	6	2
2.50	5.00	0.5000	0.5000	0.5000	0.0000	0.0000	-248	-248	-224	24	10
3.00	5.00	0.5000	0.5000	0.5000	1.0000	1.0000	-178	-178	-145	33	20

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.25 cc= 0.5 cw= 0.25 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.3131	0.3334	0.3335	-8.9983	-8.9961	-263	-263	-252	11	4
-2.50	0.00	0.3131	0.3334	0.3335	-7.4985	-7.4968	-234	-234	-224	10	4
-2.00	0.00	0.3131	0.3334	0.3335	-5.9988	-5.9974	-202	-202	-194	9	4
-1.50	0.00	0.3131	0.3334	0.3335	-4.4991	-4.4981	-168	-168	-161	7	4
-1.00	0.00	0.3131	0.3334	0.3335	-2.9994	-2.9987	-129	-129	-123	6	4
-0.50	0.00	0.3131	0.3334	0.3335	-1.4997	-1.4994	-82	-82	-79	4	4
0.01	0.00	0.3131	0.3334	0.3335	0.0300	0.0300	6	6	6	0	4
0.50	0.00	0.3131	0.3334	0.3335	1.4997	1.4994	82	82	79	4	4
1.00	0.00	0.3131	0.3334	0.3335	2.9994	2.9987	129	129	123	6	4
1.50	0.00	0.3131	0.3334	0.3335	4.4991	4.4981	168	168	161	7	4
2.00	0.00	0.3131	0.3334	0.3335	5.9988	5.9974	202	202	194	9	4
2.50	0.00	0.3131	0.3334	0.3335	7.4985	7.4968	234	234	224	10	4
3.00	0.00	0.3131	0.3334	0.3335	8.9983	8.9961	263	263	252	11	4
-3.00	1.00	0.3131	0.3334	0.3335	-9.9983	-9.9961	-370	-370	-357	13	3
-2.50	1.00	0.3131	0.3334	0.3335	-8.4985	-8.4968	-342	-342	-331	11	3
-2.00	1.00	0.3131	0.3334	0.3335	-6.9988	-6.9974	-312	-312	-303	10	3
-1.50	1.00	0.3131	0.3334	0.3335	-5.4991	-5.4981	-281	-281	-272	8	3
-1.00	1.00	0.3131	0.3334	0.3335	-3.9994	-3.9987	-246	-246	-239	6	3
-0.50	1.00	0.3131	0.3334	0.3335	-2.4997	-2.4994	-206	-206	-202	4	2
0.01	1.00	0.3131	0.3334	0.3335	-0.9700	-0.9700	-156	-156	-156	-0	-0
0.50	1.00	0.3131	0.3334	0.3335	0.4997	0.4994	-64	-64	-79	-14	-20
1.00	1.00	0.3131	0.3334	0.3335	1.9994	1.9987	0	0	0	0	0
1.50	1.00	0.3131	0.3334	0.3335	3.4991	3.4981	47	47	45	2	4
2.00	1.00	0.3131	0.3334	0.3335	4.9988	4.9974	86	86	82	4	5
2.50	1.00	0.3131	0.3334	0.3335	6.4985	6.4968	121	121	115	6	5
3.00	1.00	0.3131	0.3334	0.3335	7.9983	7.9961	152	152	145	7	5
-3.00	2.00	0.3131	0.3334	0.3335	-10.9983	-10.9961	-440	-440	-427	13	3
-2.50	2.00	0.3131	0.3334	0.3335	-9.4985	-9.4968	-414	-414	-402	12	3
-2.00	2.00	0.3131	0.3334	0.3335	-7.9988	-7.9974	-386	-386	-375	10	3
-1.50	2.00	0.3131	0.3334	0.3335	-6.4991	-6.4981	-356	-356	-347	8	2
-1.00	2.00	0.3131	0.3334	0.3335	-4.9994	-4.9987	-323	-323	-317	6	2
-0.50	2.00	0.3131	0.3334	0.3335	-3.4997	-3.4994	-288	-288	-284	4	1
0.01	2.00	0.3131	0.3334	0.3335	-1.9700	-1.9700	-246	-246	-246	-0	-0
0.50	2.00	0.3131	0.3334	0.3335	-0.5003	-0.5006	-193	-193	-202	-9	-4
1.00	2.00	0.3131	0.3334	0.3335	0.9994	0.9987	-101	-101	-123	-22	-20
1.50	2.00	0.3131	0.3334	0.3335	2.4991	2.4981	-45	-45	-45	-0	-0
2.00	2.00	0.3131	0.3334	0.3335	3.9988	3.9974	0	0	0	0	0
2.50	2.00	0.3131	0.3334	0.3335	5.4985	5.4968	39	39	37	1	4
3.00	2.00	0.3131	0.3334	0.3335	6.9983	6.9961	73	73	70	3	4
-3.00	3.00	0.3131	0.3334	0.3335	-11.9983	-11.9961	-502	-502	-489	13	3
-2.50	3.00	0.3131	0.3334	0.3335	-10.4985	-10.4968	-476	-476	-464	12	2
-2.00	3.00	0.3131	0.3334	0.3335	-8.9988	-8.9974	-449	-449	-439	10	2
-1.50	3.00	0.3131	0.3334	0.3335	-7.4991	-7.4981	-421	-421	-413	8	2
-1.00	3.00	0.3131	0.3334	0.3335	-5.9994	-5.9987	-391	-391	-384	6	2
-0.50	3.00	0.3131	0.3334	0.3335	-4.4997	-4.4994	-358	-358	-354	4	1
0.01	3.00	0.3131	0.3334	0.3335	-2.9700	-2.9700	-320	-320	-321	-0	-0
0.50	3.00	0.3131	0.3334	0.3335	-1.5003	-1.5006	-278	-278	-284	-6	-2
1.00	3.00	0.3131	0.3334	0.3335	-0.0006	-0.0013	-210	-210	-239	-29	-13
1.50	3.00	0.3131	0.3334	0.3335	1.4991	1.4981	-132	-132	-161	-29	-20
2.00	3.00	0.3131	0.3334	0.3335	2.9988	2.9974	-80	-80	-82	-2	-2
2.50	3.00	0.3131	0.3334	0.3335	4.4985	4.4968	-38	-38	-37	0	1
3.00	3.00	0.3131	0.3334	0.3335	5.9983	5.9961	0	0	0	0	0
-3.00	4.00	0.3131	0.3334	0.3335	-12.9983	-12.9961	-558	-558	-545	13	2
-2.50	4.00	0.3131	0.3334	0.3335	-11.4985	-11.4968	-533	-533	-522	12	2
-2.00	4.00	0.3131	0.3334	0.3335	-9.9988	-9.9974	-508	-508	-498	10	2
-1.50	4.00	0.3131	0.3334	0.3335	-8.4991	-8.4981	-480	-480	-472	8	2
-1.00	4.00	0.3131	0.3334	0.3335	-6.9994	-6.9987	-452	-452	-446	6	1
-0.50	4.00	0.3131	0.3334	0.3335	-5.4997	-5.4994	-421	-421	-418	3	1
0.01	4.00	0.3131	0.3334	0.3335	-3.9700	-3.9700	-387	-387	-387	-0	-0
0.50	4.00	0.3131	0.3334	0.3335	-2.5003	-2.5006	-349	-349	-354	-5	-1
1.00	4.00	0.3131	0.3334	0.3335	-1.0006	-1.0013	-303	-303	-317	-14	-4
1.50	4.00	0.3131	0.3334	0.3335	0.4991	0.4981	-219	-219	-272	-53	-22
2.00	4.00	0.3131	0.3334	0.3335	1.9988	1.9974	-159	-159	-194	-35	-20
2.50	4.00	0.3131	0.3334	0.3335	3.4985	3.4968	-111	-111	-115	-4	-3
3.00	4.00	0.3131	0.3334	0.3335	4.9983	4.9961	-70	-70	-70	-0	-0
-3.00	5.00	0.3131	0.3334	0.3335	-13.9983	-13.9961	-611	-611	-598	13	2
-2.50	5.00	0.3131	0.3334	0.3335	-12.4985	-12.4968	-587	-587	-575	12	2
-2.00	5.00	0.3131	0.3334	0.3335	-10.9988	-10.9974	-562	-562	-552	10	2
-1.50	5.00	0.3131	0.3334	0.3335	-9.4991	-9.4981	-536	-536	-528	8	1
-1.00	5.00	0.3131	0.3334	0.3335	-7.9994	-7.9987	-508	-508	-502	6	1
-0.50	5.00	0.3131	0.3334	0.3335	-6.4997	-6.4994	-479	-479	-476	3	1
0.01	5.00	0.3131	0.3334	0.3335	-4.9700	-4.9700	-447	-447	-447	-0	-0
0.50	5.00	0.3131	0.3334	0.3335	-3.5003	-3.5006	-413	-413	-418	-4	-1
1.00	5.00	0.3131	0.3334	0.3335	-2.0006	-2.0013	-374	-374	-384	-11	-3
1.50	5.00	0.3131	0.3334	0.3335	-0.5009	-0.5019	-323	-323	-347	-25	-7
2.00	5.00	0.3131	0.3334	0.3335	0.9988	0.9974	-237	-237	-303	-65	-24
2.50	5.00	0.3131	0.3334	0.3335	2.4985	2.4968	-183	-183	-224	-40	-20
3.00	5.00	0.3131	0.3334	0.3335	3.9983	3.9961	-139	-139	-145	-6	-5

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0.25	cc=	0.75	cw=	0	1/nenv=	1.538462	
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF	
-3.00	0.00	0.1558	0.1558	0.1558	-19.2613	-19.2613	-269	-269	-252	17	6	
-2.50	0.00	0.1558	0.1558	0.1558	-16.0510	-16.0510	-239	-239	-224	15	6	
-2.00	0.00	0.1558	0.1558	0.1558	-12.8408	-12.8408	-207	-207	-194	13	6	
-1.50	0.00	0.1558	0.1558	0.1558	-9.6306	-9.6306	-171	-171	-161	11	6	
-1.00	0.00	0.1558	0.1558	0.1558	-6.4204	-6.4204	-132	-132	-123	8	6	
-0.50	0.00	0.1558	0.1558	0.1558	-3.2102	-3.2102	-84	-84	-79	5	6	
0.01	0.00	0.1558	0.1558	0.1558	0.0642	0.0642	7	7	6	0	6	
0.50	0.00	0.1558	0.1558	0.1558	3.2102	3.2102	84	84	79	5	6	
1.00	0.00	0.1558	0.1558	0.1558	6.4204	6.4204	132	132	123	8	6	
1.50	0.00	0.1558	0.1558	0.1558	9.6306	9.6306	171	171	161	11	6	
2.00	0.00	0.1558	0.1558	0.1558	12.8408	12.8408	207	207	194	13	6	
2.50	0.00	0.1558	0.1558	0.1558	16.0510	16.0510	239	239	224	15	6	
3.00	0.00	0.1558	0.1558	0.1558	19.2613	19.2613	269	269	252	17	6	
-3.00	1.00	0.1558	0.1558	0.1558	-20.2613	-20.2613	-396	-396	-357	39	10	
-2.50	1.00	0.1558	0.1558	0.1558	-17.0510	-17.0510	-366	-366	-331	36	10	
-2.00	1.00	0.1558	0.1558	0.1558	-13.8408	-13.8408	-335	-335	-303	32	10	
-1.50	1.00	0.1558	0.1558	0.1558	-10.6306	-10.6306	-301	-301	-272	28	10	
-1.00	1.00	0.1558	0.1558	0.1558	-7.4204	-7.4204	-263	-263	-239	23	9	
-0.50	1.00	0.1558	0.1558	0.1558	-4.2102	-4.2102	-218	-218	-202	16	8	
0.01	1.00	0.1558	0.1558	0.1558	-0.9358	-0.9358	-156	-156	-156	-1	-0	
0.50	1.00	0.1558	0.1558	0.1558	2.2102	2.2102	-52	-52	-79	-27	-41	
1.00	1.00	0.1558	0.1558	0.1558	5.4204	5.4204	0	0	0	0	0	
1.50	1.00	0.1558	0.1558	0.1558	8.6306	8.6306	42	42	45	-3	-7	
2.00	1.00	0.1558	0.1558	0.1558	11.8408	11.8408	78	78	82	-4	-5	
2.50	1.00	0.1558	0.1558	0.1558	15.0510	15.0510	111	111	115	-4	-3	
3.00	1.00	0.1558	0.1558	0.1558	18.2613	18.2613	142	142	145	-3	-2	
-3.00	2.00	0.1558	0.1558	0.1558	-21.2613	-21.2613	-472	-472	-427	45	10	
-2.50	2.00	0.1558	0.1558	0.1558	-18.0510	-18.0510	-443	-443	-402	41	10	
-2.00	2.00	0.1558	0.1558	0.1558	-14.8408	-14.8408	-412	-412	-375	37	9	
-1.50	2.00	0.1558	0.1558	0.1558	-11.6306	-11.6306	-379	-379	-347	32	9	
-1.00	2.00	0.1558	0.1558	0.1558	-8.4204	-8.4204	-342	-342	-317	25	8	
-0.50	2.00	0.1558	0.1558	0.1558	-5.2102	-5.2102	-300	-300	-284	16	5	
0.01	2.00	0.1558	0.1558	0.1558	-1.9358	-1.9358	-246	-246	-246	-0	-0	
0.50	2.00	0.1558	0.1558	0.1558	1.2102	1.2102	-141	-141	-202	-61	-36	
1.00	2.00	0.1558	0.1558	0.1558	4.4204	4.4204	-82	-82	-123	-42	-41	
1.50	2.00	0.1558	0.1558	0.1558	7.6306	7.6306	-38	-38	-45	-7	-17	
2.00	2.00	0.1558	0.1558	0.1558	10.8408	10.8408	0	0	0	0	0	
2.50	2.00	0.1558	0.1558	0.1558	14.0510	14.0510	34	34	37	-3	-9	
3.00	2.00	0.1558	0.1558	0.1558	17.2613	17.2613	65	65	70	-5	-7	
-3.00	3.00	0.1558	0.1558	0.1558	-22.2613	-22.2613	-536	-536	-489	48	9	
-2.50	3.00	0.1558	0.1558	0.1558	-19.0510	-19.0510	-508	-508	-464	43	9	
-2.00	3.00	0.1558	0.1558	0.1558	-15.8408	-15.8408	-478	-478	-439	39	8	
-1.50	3.00	0.1558	0.1558	0.1558	-12.6306	-12.6306	-445	-445	-413	33	8	
-1.00	3.00	0.1558	0.1558	0.1558	-9.4204	-9.4204	-410	-410	-384	25	6	
-0.50	3.00	0.1558	0.1558	0.1558	-6.2102	-6.2102	-370	-370	-354	16	4	
0.01	3.00	0.1558	0.1558	0.1558	-2.9358	-2.9358	-320	-320	-321	-0	-0	
0.50	3.00	0.1558	0.1558	0.1558	0.2102	0.2102	-227	-227	-284	-57	-22	
1.00	3.00	0.1558	0.1558	0.1558	3.4204	3.4204	-153	-153	-239	-86	-44	
1.50	3.00	0.1558	0.1558	0.1558	6.6306	6.6306	-106	-106	-161	-54	-41	
2.00	3.00	0.1558	0.1558	0.1558	9.8408	9.8408	-67	-67	-82	-15	-20	
2.50	3.00	0.1558	0.1558	0.1558	13.0510	13.0510	-32	-32	-37	-5	-15	
3.00	3.00	0.1558	0.1558	0.1558	16.2613	16.2613	0	0	0	0	0	
-3.00	4.00	0.1558	0.1558	0.1558	-23.2613	-23.2613	-595	-595	-545	50	9	
-2.50	4.00	0.1558	0.1558	0.1558	-20.0510	-20.0510	-567	-567	-522	45	8	
-2.00	4.00	0.1558	0.1558	0.1558	-16.8408	-16.8408	-537	-537	-498	39	8	
-1.50	4.00	0.1558	0.1558	0.1558	-13.6306	-13.6306	-505	-505	-472	33	7	
-1.00	4.00	0.1558	0.1558	0.1558	-10.4204	-10.4204	-471	-471	-446	25	5	
-0.50	4.00	0.1558	0.1558	0.1558	-7.2102	-7.2102	-432	-432	-418	15	4	
0.01	4.00	0.1558	0.1558	0.1558	-3.9358	-3.9358	-386	-386	-387	-0	-0	
0.50	4.00	0.1558	0.1558	0.1558	-0.7898	-0.7898	-324	-324	-354	-30	-9	
1.00	4.00	0.1558	0.1558	0.1558	2.4204	2.4204	-221	-221	-317	-96	-36	
1.50	4.00	0.1558	0.1558	0.1558	5.6306	5.6306	-170	-170	-272	-103	-46	
2.00	4.00	0.1558	0.1558	0.1558	8.8408	8.8408	-128	-128	-194	-65	-41	
2.50	4.00	0.1558	0.1558	0.1558	12.0510	12.0510	-92	-92	-115	-23	-22	
3.00	4.00	0.1558	0.1558	0.1558	15.2613	15.2613	-59	-59	-70	-11	-17	
-3.00	5.00	0.1558	0.1558	0.1558	-24.2613	-24.2613	-648	-648	-598	51	8	
-2.50	5.00	0.1558	0.1558	0.1558	-21.0510	-21.0510	-621	-621	-575	46	8	
-2.00	5.00	0.1558	0.1558	0.1558	-17.8408	-17.8408	-592	-592	-552	40	7	
-1.50	5.00	0.1558	0.1558	0.1558	-14.6306	-14.6306	-561	-561	-528	33	6	
-1.00	5.00	0.1558	0.1558	0.1558	-11.4204	-11.4204	-527	-527	-502	25	5	
-0.50	5.00	0.1558	0.1558	0.1558	-8.2102	-8.2102	-490	-490	-476	14	3	
0.01	5.00	0.1558	0.1558	0.1558	-4.9358	-4.9358	-447	-447	-447	-0	-0	
0.50	5.00	0.1558	0.1558	0.1558	-1.7898	-1.7898	-393	-393	-418	-24	-6	
1.00	5.00	0.1558	0.1558	0.1558	1.4204	1.4204	-286	-286	-384	-98	-29	
1.50	5.00	0.1558	0.1558	0.1558	4.6306	4.6306	-229	-229	-347	-118	-41	
2.00	5.00	0.1558	0.1558	0.1558	7.8408	7.8408	-186	-186	-303	-117	-48	
2.50	5.00	0.1558	0.1558	0.1558	11.0510	11.0510	-148	-148	-224	-75	-41	
3.00	5.00	0.1558	0.1558	0.1558	14.2613	14.2613	-115	-115	-145	-31	-24	

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0.5	cc=	0	cw=	0.5	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.8442	0.7903	0.7891	-3.7958	-3.8016	-301	-301	-252	49	18
-2.50	0.00	0.8442	0.7903	0.7891	-3.1632	-3.1680	-267	-267	-224	43	18
-2.00	0.00	0.8442	0.7903	0.7891	-2.5306	-2.5344	-231	-231	-194	38	18
-1.50	0.00	0.8442	0.7903	0.7891	-1.8979	-1.9008	-192	-192	-161	31	18
-1.00	0.00	0.8442	0.7903	0.7891	-1.2653	-1.2672	-147	-147	-123	24	18
-0.50	0.00	0.8442	0.7903	0.7891	-0.6326	-0.6336	-94	-94	-79	15	18
0.01	0.00	0.8442	0.7903	0.7891	0.0127	0.0127	7	7	6	1	18
0.50	0.00	0.8442	0.7903	0.7891	0.6326	0.6336	94	94	79	15	18
1.00	0.00	0.8442	0.7903	0.7891	1.2653	1.2672	147	147	123	24	18
1.50	0.00	0.8442	0.7903	0.7891	1.8979	1.9008	192	192	161	31	18
2.00	0.00	0.8442	0.7903	0.7891	2.5306	2.5344	231	231	194	38	18
2.50	0.00	0.8442	0.7903	0.7891	3.1632	3.1680	267	267	224	43	18
3.00	0.00	0.8442	0.7903	0.7891	3.7958	3.8016	301	301	252	49	18
-3.00	1.00	0.8442	0.7903	0.7891	-4.7958	-4.8016	-372	-372	-357	15	4
-2.50	1.00	0.8442	0.7903	0.7891	-4.1632	-4.1680	-342	-342	-331	12	3
-2.00	1.00	0.8442	0.7903	0.7891	-3.5306	-3.5344	-311	-311	-303	8	3
-1.50	1.00	0.8442	0.7903	0.7891	-2.8979	-2.9008	-277	-277	-272	5	2
-1.00	1.00	0.8442	0.7903	0.7891	-2.2653	-2.2672	-241	-241	-239	2	1
-0.50	1.00	0.8442	0.7903	0.7891	-1.6326	-1.6336	-202	-202	-202	-0	-0
0.01	1.00	0.8442	0.7903	0.7891	-0.9873	-0.9873	-156	-156	-156	0	0
0.50	1.00	0.8442	0.7903	0.7891	-0.3674	-0.3664	-102	-102	-79	23	26
1.00	1.00	0.8442	0.7903	0.7891	0.2653	0.2672	-0	-0	0	0	0
1.50	1.00	0.8442	0.7903	0.7891	0.8979	0.9008	69	70	45	25	43
2.00	1.00	0.8442	0.7903	0.7891	1.5306	1.5344	123	123	82	41	40
2.50	1.00	0.8442	0.7903	0.7891	2.1632	2.1680	169	169	115	54	38
3.00	1.00	0.8442	0.7903	0.7891	2.7958	2.8016	209	210	145	64	36
-3.00	2.00	0.8442	0.7903	0.7891	-5.7958	-5.8016	-435	-435	-427	8	2
-2.50	2.00	0.8442	0.7903	0.7891	-5.1632	-5.1680	-407	-408	-402	6	1
-2.00	2.00	0.8442	0.7903	0.7891	-4.5306	-4.5344	-379	-379	-375	3	1
-1.50	2.00	0.8442	0.7903	0.7891	-3.8979	-3.9008	-349	-349	-347	1	0
-1.00	2.00	0.8442	0.7903	0.7891	-3.2653	-3.2672	-317	-317	-317	-0	-0
-0.50	2.00	0.8442	0.7903	0.7891	-2.6326	-2.6336	-283	-283	-284	-1	-0
0.01	2.00	0.8442	0.7903	0.7891	-1.9873	-1.9873	-246	-246	-246	0	0
0.50	2.00	0.8442	0.7903	0.7891	-1.3674	-1.3664	-207	-207	-202	4	2
1.00	2.00	0.8442	0.7903	0.7891	-0.7347	-0.7328	-160	-160	-123	36	26
1.50	2.00	0.8442	0.7903	0.7891	-0.1021	-0.0992	-96	-96	-45	51	72
2.00	2.00	0.8442	0.7903	0.7891	0.5306	0.5344	-0	-0	0	0	0
2.50	2.00	0.8442	0.7903	0.7891	1.1632	1.1680	59	59	37	22	46
3.00	2.00	0.8442	0.7903	0.7891	1.7958	1.8016	109	109	70	39	43
-3.00	3.00	0.8442	0.7903	0.7891	-6.7958	-6.8016	-493	-493	-489	4	1
-2.50	3.00	0.8442	0.7903	0.7891	-6.1632	-6.1680	-467	-467	-464	3	1
-2.00	3.00	0.8442	0.7903	0.7891	-5.5306	-5.5344	-440	-440	-439	1	0
-1.50	3.00	0.8442	0.7903	0.7891	-4.8979	-4.9008	-413	-413	-413	-0	-0
-1.00	3.00	0.8442	0.7903	0.7891	-4.2653	-4.2672	-384	-384	-384	-1	-0
-0.50	3.00	0.8442	0.7903	0.7891	-3.6326	-3.6336	-353	-353	-354	-1	-0
0.01	3.00	0.8442	0.7903	0.7891	-2.9873	-2.9873	-321	-321	-321	0	0
0.50	3.00	0.8442	0.7903	0.7891	-2.3674	-2.3664	-287	-287	-284	3	1
1.00	3.00	0.8442	0.7903	0.7891	-1.7347	-1.7328	-250	-250	-239	10	4
1.50	3.00	0.8442	0.7903	0.7891	-1.1021	-1.0992	-208	-208	-161	47	26
2.00	3.00	0.8442	0.7903	0.7891	-0.4694	-0.4656	-158	-158	-82	76	63
2.50	3.00	0.8442	0.7903	0.7891	0.1632	0.1680	-67	-67	-37	30	57
3.00	3.00	0.8442	0.7903	0.7891	0.7958	0.8016	-1	-0	0	0	0
-3.00	4.00	0.8442	0.7903	0.7891	-7.7958	-7.8016	-547	-547	-545	2	0
-2.50	4.00	0.8442	0.7903	0.7891	-7.1632	-7.1680	-523	-523	-522	1	0
-2.00	4.00	0.8442	0.7903	0.7891	-6.5306	-6.5344	-497	-497	-498	-0	-0
-1.50	4.00	0.8442	0.7903	0.7891	-5.8979	-5.9008	-471	-471	-472	-1	-0
-1.00	4.00	0.8442	0.7903	0.7891	-5.2653	-5.2672	-444	-444	-446	-1	-0
-0.50	4.00	0.8442	0.7903	0.7891	-4.6326	-4.6336	-416	-417	-418	-1	-0
0.01	4.00	0.8442	0.7903	0.7891	-3.9873	-3.9873	-387	-387	-387	0	0
0.50	4.00	0.8442	0.7903	0.7891	-3.3674	-3.3664	-357	-357	-354	2	1
1.00	4.00	0.8442	0.7903	0.7891	-2.7347	-2.7328	-324	-324	-317	7	2
1.50	4.00	0.8442	0.7903	0.7891	-2.1021	-2.0992	-289	-289	-272	17	6
2.00	4.00	0.8442	0.7903	0.7891	-1.4694	-1.4656	-251	-251	-194	57	26
2.50	4.00	0.8442	0.7903	0.7891	-0.8368	-0.8320	-207	-207	-115	92	57
3.00	4.00	0.8442	0.7903	0.7891	-0.2042	-0.1984	-151	-150	-70	80	72
-3.00	5.00	0.8442	0.7903	0.7891	-8.7958	-8.8016	-598	-599	-598	1	0
-2.50	5.00	0.8442	0.7903	0.7891	-8.1632	-8.1680	-575	-575	-575	-0	-0
-2.00	5.00	0.8442	0.7903	0.7891	-7.5306	-7.5344	-551	-551	-552	-1	-0
-1.50	5.00	0.8442	0.7903	0.7891	-6.8979	-6.9008	-526	-526	-528	-1	-0
-1.00	5.00	0.8442	0.7903	0.7891	-6.2653	-6.2672	-501	-501	-502	-1	-0
-0.50	5.00	0.8442	0.7903	0.7891	-5.6326	-5.6336	-475	-475	-476	-1	-0
0.01	5.00	0.8442	0.7903	0.7891	-4.9873	-4.9873	-447	-447	-447	0	0
0.50	5.00	0.8442	0.7903	0.7891	-4.3674	-4.3664	-420	-420	-418	2	0
1.00	5.00	0.8442	0.7903	0.7891	-3.7347	-3.7328	-390	-390	-384	5	1
1.50	5.00	0.8442	0.7903	0.7891	-3.1021	-3.0992	-359	-359	-347	12	3
2.00	5.00	0.8442	0.7903	0.7891	-2.4694	-2.4656	-326	-326	-303	23	7
2.50	5.00	0.8442	0.7903	0.7891	-1.8368	-1.8320	-290	-290	-224	66	26
3.00	5.00	0.8442	0.7903	0.7891	-1.2042	-1.1984	-250	-250	-145	105	53

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot=	157.29	nenv=	0.65	cf=	0.5	cc=	0.25	cw=	0.25	1/nenv=	1.538462
DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.6869	0.6666	0.6665	-4.5004	-4.5010	-272	-272	-252	20	8
-2.50	0.00	0.6869	0.6666	0.6665	-3.7504	-3.7508	-242	-242	-224	18	8
-2.00	0.00	0.6869	0.6666	0.6665	-3.0003	-3.0007	-209	-209	-194	16	8
-1.50	0.00	0.6869	0.6666	0.6665	-2.2502	-2.2505	-174	-174	-161	13	8
-1.00	0.00	0.6869	0.6666	0.6665	-1.5001	-1.5003	-133	-133	-123	10	8
-0.50	0.00	0.6869	0.6666	0.6665	-0.7501	-0.7502	-85	-85	-79	6	8
0.01	0.00	0.6869	0.6666	0.6665	0.0150	0.0150	7	7	6	1	8
0.50	0.00	0.6869	0.6666	0.6665	0.7501	0.7502	85	85	79	6	8
1.00	0.00	0.6869	0.6666	0.6665	1.5001	1.5003	133	133	123	10	8
1.50	0.00	0.6869	0.6666	0.6665	2.2502	2.2505	174	174	161	13	8
2.00	0.00	0.6869	0.6666	0.6665	3.0003	3.0007	209	209	194	16	8
2.50	0.00	0.6869	0.6666	0.6665	3.7504	3.7508	242	242	224	18	8
3.00	0.00	0.6869	0.6666	0.6665	4.5004	4.5010	272	272	252	20	8
-3.00	1.00	0.6869	0.6666	0.6665	-5.5004	-5.5010	-360	-360	-357	3	1
-2.50	1.00	0.6869	0.6666	0.6665	-4.7504	-4.7508	-333	-333	-331	2	1
-2.00	1.00	0.6869	0.6666	0.6665	-4.0003	-4.0007	-303	-303	-303	1	0
-1.50	1.00	0.6869	0.6666	0.6665	-3.2502	-3.2505	-272	-272	-272	-0	-0
-1.00	1.00	0.6869	0.6666	0.6665	-2.5001	-2.5003	-238	-238	-239	-1	-0
-0.50	1.00	0.6869	0.6666	0.6665	-1.7501	-1.7502	-201	-201	-202	-1	-1
0.01	1.00	0.6869	0.6666	0.6665	-0.9850	-0.9850	-156	-156	-156	0	0
0.50	1.00	0.6869	0.6666	0.6665	-0.2499	-0.2498	-100	-100	-79	21	24
1.00	1.00	0.6869	0.6666	0.6665	0.5001	0.5003	-0	-0	0	0	0
1.50	1.00	0.6869	0.6666	0.6665	1.2502	1.2505	56	56	45	12	23
2.00	1.00	0.6869	0.6666	0.6665	2.0003	2.0007	101	101	82	19	21
2.50	1.00	0.6869	0.6666	0.6665	2.7504	2.7508	140	140	115	25	20
3.00	1.00	0.6869	0.6666	0.6665	3.5004	3.5010	175	175	145	30	18
-3.00	2.00	0.6869	0.6666	0.6665	-6.5004	-6.5010	-427	-427	-427	-0	-0
-2.50	2.00	0.6869	0.6666	0.6665	-5.7504	-5.7508	-401	-401	-402	-1	-0
-2.00	2.00	0.6869	0.6666	0.6665	-5.0003	-5.0007	-374	-374	-375	-2	-0
-1.50	2.00	0.6869	0.6666	0.6665	-4.2502	-4.2505	-345	-345	-347	-2	-1
-1.00	2.00	0.6869	0.6666	0.6665	-3.5001	-3.5003	-315	-315	-317	-2	-1
-0.50	2.00	0.6869	0.6666	0.6665	-2.7501	-2.7502	-282	-282	-284	-2	-1
0.01	2.00	0.6869	0.6666	0.6665	-1.9850	-1.9850	-246	-246	-246	0	0
0.50	2.00	0.6869	0.6666	0.6665	-1.2499	-1.2498	-206	-206	-202	4	2
1.00	2.00	0.6869	0.6666	0.6665	-0.4999	-0.4997	-157	-157	-123	33	24
1.50	2.00	0.6869	0.6666	0.6665	0.2502	0.2505	-62	-62	-45	17	32
2.00	2.00	0.6869	0.6666	0.6665	1.0003	1.0007	-0	-0	0	0	0
2.50	2.00	0.6869	0.6666	0.6665	1.7504	1.7508	48	48	37	10	24
3.00	2.00	0.6869	0.6666	0.6665	2.5004	2.5010	88	88	70	18	23
-3.00	3.00	0.6869	0.6666	0.6665	-7.5004	-7.5010	-486	-486	-489	-2	-0
-2.50	3.00	0.6869	0.6666	0.6665	-6.7504	-6.7508	-462	-462	-464	-3	-1
-2.00	3.00	0.6869	0.6666	0.6665	-6.0003	-6.0007	-436	-436	-439	-3	-1
-1.50	3.00	0.6869	0.6666	0.6665	-5.2502	-5.2505	-410	-410	-413	-3	-1
-1.00	3.00	0.6869	0.6666	0.6665	-4.5001	-4.5003	-382	-382	-384	-2	-1
-0.50	3.00	0.6869	0.6666	0.6665	-3.7501	-3.7502	-353	-353	-354	-2	-0
0.01	3.00	0.6869	0.6666	0.6665	-2.9850	-2.9850	-321	-321	-321	0	0
0.50	3.00	0.6869	0.6666	0.6665	-2.2499	-2.2498	-287	-287	-284	3	1
1.00	3.00	0.6869	0.6666	0.6665	-1.4999	-1.4997	-249	-249	-239	10	4
1.50	3.00	0.6869	0.6666	0.6665	-0.7498	-0.7495	-204	-204	-161	43	24
2.00	3.00	0.6869	0.6666	0.6665	0.0003	0.0007	-129	-128	-82	46	44
2.50	3.00	0.6869	0.6666	0.6665	0.7504	0.7508	-50	-50	-37	13	29
3.00	3.00	0.6869	0.6666	0.6665	1.5004	1.5010	-0	-0	0	0	0
-3.00	4.00	0.6869	0.6666	0.6665	-8.5004	-8.5010	-542	-542	-545	-3	-1
-2.50	4.00	0.6869	0.6666	0.6665	-7.7504	-7.7508	-518	-518	-522	-3	-1
-2.00	4.00	0.6869	0.6666	0.6665	-7.0003	-7.0007	-494	-494	-498	-3	-1
-1.50	4.00	0.6869	0.6666	0.6665	-6.2502	-6.2505	-469	-469	-472	-3	-1
-1.00	4.00	0.6869	0.6666	0.6665	-5.5001	-5.5003	-443	-443	-446	-3	-1
-0.50	4.00	0.6869	0.6666	0.6665	-4.7501	-4.7502	-416	-416	-418	-2	-0
0.01	4.00	0.6869	0.6666	0.6665	-3.9850	-3.9850	-387	-387	-387	0	0
0.50	4.00	0.6869	0.6666	0.6665	-3.2499	-3.2498	-357	-357	-354	3	1
1.00	4.00	0.6869	0.6666	0.6665	-2.4999	-2.4997	-324	-324	-317	7	2
1.50	4.00	0.6869	0.6666	0.6665	-1.7498	-1.7495	-288	-288	-272	15	5
2.00	4.00	0.6869	0.6666	0.6665	-0.9997	-0.9993	-246	-246	-194	52	24
2.50	4.00	0.6869	0.6666	0.6665	-0.2496	-0.2492	-191	-191	-115	76	49
3.00	4.00	0.6869	0.6666	0.6665	0.5004	0.5010	-97	-97	-70	27	32
-3.00	5.00	0.6869	0.6666	0.6665	-9.5004	-9.5010	-594	-594	-598	-4	-1
-2.50	5.00	0.6869	0.6666	0.6665	-8.7504	-8.7508	-571	-571	-575	-4	-1
-2.00	5.00	0.6869	0.6666	0.6665	-8.0003	-8.0007	-548	-548	-552	-4	-1
-1.50	5.00	0.6869	0.6666	0.6665	-7.2502	-7.2505	-525	-525	-528	-3	-1
-1.00	5.00	0.6869	0.6666	0.6665	-6.5001	-6.5003	-500	-500	-502	-3	-1
-0.50	5.00	0.6869	0.6666	0.6665	-5.7501	-5.7502	-474	-474	-476	-2	-0
0.01	5.00	0.6869	0.6666	0.6665	-4.9850	-4.9850	-447	-447	-447	0	0
0.50	5.00	0.6869	0.6666	0.6665	-4.2499	-4.2498	-420	-420	-418	2	1
1.00	5.00	0.6869	0.6666	0.6665	-3.4999	-3.4997	-390	-390	-384	6	1
1.50	5.00	0.6869	0.6666	0.6665	-2.7498	-2.7495	-358	-358	-347	11	3
2.00	5.00	0.6869	0.6666	0.6665	-1.9997	-1.9993	-323	-323	-303	21	7
2.50	5.00	0.6869	0.6666	0.6665	-1.2496	-1.2492	-284	-284	-224	60	24
3.00	5.00	0.6869	0.6666	0.6665	-0.4996	-0.4990	-236	-236	-145	90	47

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.5 cc= 0.5 cw= 0 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-252	-252	-252	0	0
-2.50	0.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-224	-224	-224	0	0
-2.00	0.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-194	-194	-194	0	0
-1.50	0.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-161	-161	-161	0	0
-1.00	0.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-123	-123	-123	0	0
-0.50	0.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-79	-79	-79	0	0
0.01	0.00	0.5000	0.5000	0.5000	0.0200	0.0200	6	6	6	0	0
0.50	0.00	0.5000	0.5000	0.5000	1.0000	1.0000	79	79	79	0	0
1.00	0.00	0.5000	0.5000	0.5000	2.0000	2.0000	123	123	123	0	0
1.50	0.00	0.5000	0.5000	0.5000	3.0000	3.0000	161	161	161	0	0
2.00	0.00	0.5000	0.5000	0.5000	4.0000	4.0000	194	194	194	0	0
2.50	0.00	0.5000	0.5000	0.5000	5.0000	5.0000	224	224	224	0	0
3.00	0.00	0.5000	0.5000	0.5000	6.0000	6.0000	252	252	252	0	0
-3.00	1.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-357	-357	-357	0	0
-2.50	1.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-331	-331	-331	0	0
-2.00	1.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-303	-303	-303	0	0
-1.50	1.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-272	-272	-272	0	0
-1.00	1.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-239	-239	-239	0	0
-0.50	1.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-202	-202	-202	0	0
0.01	1.00	0.5000	0.5000	0.5000	-0.9800	-0.9800	-156	-156	-156	0	0
0.50	1.00	0.5000	0.5000	0.5000	0.0000	0.0000	-79	-79	-79	0	0
1.00	1.00	0.5000	0.5000	0.5000	1.0000	1.0000	0	0	0	0	0
1.50	1.00	0.5000	0.5000	0.5000	2.0000	2.0000	45	45	45	0	0
2.00	1.00	0.5000	0.5000	0.5000	3.0000	3.0000	82	82	82	0	0
2.50	1.00	0.5000	0.5000	0.5000	4.0000	4.0000	115	115	115	0	0
3.00	1.00	0.5000	0.5000	0.5000	5.0000	5.0000	145	145	145	0	0
-3.00	2.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-427	-427	-427	0	0
-2.50	2.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-402	-402	-402	0	0
-2.00	2.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-375	-375	-375	0	0
-1.50	2.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-347	-347	-347	0	0
-1.00	2.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-317	-317	-317	0	0
-0.50	2.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-284	-284	-284	0	0
0.01	2.00	0.5000	0.5000	0.5000	-1.9800	-1.9800	-246	-246	-246	0	0
0.50	2.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-202	-202	-202	0	0
1.00	2.00	0.5000	0.5000	0.5000	0.0000	0.0000	-123	-123	-123	0	0
1.50	2.00	0.5000	0.5000	0.5000	1.0000	1.0000	-45	-45	-45	0	0
2.00	2.00	0.5000	0.5000	0.5000	2.0000	2.0000	0	0	0	0	0
2.50	2.00	0.5000	0.5000	0.5000	3.0000	3.0000	37	37	37	0	0
3.00	2.00	0.5000	0.5000	0.5000	4.0000	4.0000	70	70	70	0	0
-3.00	3.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-489	-489	-489	0	0
-2.50	3.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-464	-464	-464	0	0
-2.00	3.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-439	-439	-439	0	0
-1.50	3.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-413	-413	-413	0	0
-1.00	3.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-384	-384	-384	0	0
-0.50	3.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-354	-354	-354	0	0
0.01	3.00	0.5000	0.5000	0.5000	-2.9800	-2.9800	-321	-321	-321	0	0
0.50	3.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-284	-284	-284	0	0
1.00	3.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-239	-239	-239	0	0
1.50	3.00	0.5000	0.5000	0.5000	0.0000	0.0000	-161	-161	-161	0	0
2.00	3.00	0.5000	0.5000	0.5000	1.0000	1.0000	-82	-82	-82	0	0
2.50	3.00	0.5000	0.5000	0.5000	2.0000	2.0000	-37	-37	-37	0	0
3.00	3.00	0.5000	0.5000	0.5000	3.0000	3.0000	0	0	0	0	0
-3.00	4.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-545	-545	-545	0	0
-2.50	4.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-522	-522	-522	0	0
-2.00	4.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-498	-498	-498	0	0
-1.50	4.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-472	-472	-472	0	0
-1.00	4.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-446	-446	-446	0	0
-0.50	4.00	0.5000	0.5000	0.5000	-5.0000	-5.0000	-418	-418	-418	0	0
0.01	4.00	0.5000	0.5000	0.5000	-3.9800	-3.9800	-387	-387	-387	0	0
0.50	4.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-354	-354	-354	0	0
1.00	4.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-317	-317	-317	0	0
1.50	4.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-272	-272	-272	0	0
2.00	4.00	0.5000	0.5000	0.5000	0.0000	0.0000	-194	-194	-194	0	0
2.50	4.00	0.5000	0.5000	0.5000	1.0000	1.0000	-115	-115	-115	0	0
3.00	4.00	0.5000	0.5000	0.5000	2.0000	2.0000	-70	-70	-70	0	0
-3.00	5.00	0.5000	0.5000	0.5000	-11.0000	-11.0000	-598	-598	-598	0	0
-2.50	5.00	0.5000	0.5000	0.5000	-10.0000	-10.0000	-575	-575	-575	0	0
-2.00	5.00	0.5000	0.5000	0.5000	-9.0000	-9.0000	-552	-552	-552	0	0
-1.50	5.00	0.5000	0.5000	0.5000	-8.0000	-8.0000	-528	-528	-528	0	0
-1.00	5.00	0.5000	0.5000	0.5000	-7.0000	-7.0000	-502	-502	-502	0	0
-0.50	5.00	0.5000	0.5000	0.5000	-6.0000	-6.0000	-476	-476	-476	0	0
0.01	5.00	0.5000	0.5000	0.5000	-4.9800	-4.9800	-447	-447	-447	0	0
0.50	5.00	0.5000	0.5000	0.5000	-4.0000	-4.0000	-418	-418	-418	0	0
1.00	5.00	0.5000	0.5000	0.5000	-3.0000	-3.0000	-384	-384	-384	0	0
1.50	5.00	0.5000	0.5000	0.5000	-2.0000	-2.0000	-347	-347	-347	0	0
2.00	5.00	0.5000	0.5000	0.5000	-1.0000	-1.0000	-303	-303	-303	0	0
2.50	5.00	0.5000	0.5000	0.5000	0.0000	0.0000	-224	-224	-224	0	0
3.00	5.00	0.5000	0.5000	0.5000	1.0000	1.0000	-145	-145	-145	0	0

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.75 cc= 0 cw= 0.25 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.9523	0.9316	0.9304	-3.2203	-3.2244	-303	-304	-252	51	19
-2.50	0.00	0.9523	0.9316	0.9304	-2.6836	-2.6870	-269	-270	-224	46	19
-2.00	0.00	0.9523	0.9316	0.9304	-2.1468	-2.1496	-233	-233	-194	40	19
-1.50	0.00	0.9523	0.9316	0.9304	-1.6101	-1.6122	-193	-193	-161	33	19
-1.00	0.00	0.9523	0.9316	0.9304	-1.0734	-1.0748	-148	-149	-123	25	19
-0.50	0.00	0.9523	0.9316	0.9304	-0.5367	-0.5374	-95	-95	-79	16	19
0.01	0.00	0.9523	0.9316	0.9304	0.0107	0.0107	7	7	6	1	18
0.50	0.00	0.9523	0.9316	0.9304	0.5367	0.5374	95	95	79	16	19
1.00	0.00	0.9523	0.9316	0.9304	1.0734	1.0748	148	149	123	25	19
1.50	0.00	0.9523	0.9316	0.9304	1.6101	1.6122	193	193	161	33	19
2.00	0.00	0.9523	0.9316	0.9304	2.1468	2.1496	233	233	194	40	19
2.50	0.00	0.9523	0.9316	0.9304	2.6836	2.6870	269	270	224	46	19
3.00	0.00	0.9523	0.9316	0.9304	3.2203	3.2244	303	304	252	51	19
-3.00	1.00	0.9523	0.9316	0.9304	-4.2203	-4.2244	-373	-373	-357	16	4
-2.50	1.00	0.9523	0.9316	0.9304	-3.6836	-3.6870	-343	-343	-331	12	4
-2.00	1.00	0.9523	0.9316	0.9304	-3.1468	-3.1496	-311	-311	-303	9	3
-1.50	1.00	0.9523	0.9316	0.9304	-2.6101	-2.6122	-277	-277	-272	5	2
-1.00	1.00	0.9523	0.9316	0.9304	-2.0734	-2.0748	-241	-241	-239	2	1
-0.50	1.00	0.9523	0.9316	0.9304	-1.5367	-1.5374	-202	-202	-202	-0	-0
0.01	1.00	0.9523	0.9316	0.9304	-0.9893	-0.9893	-156	-156	-156	0	0
0.50	1.00	0.9523	0.9316	0.9304	-0.4633	-0.4626	-103	-103	-79	25	27
1.00	1.00	0.9523	0.9316	0.9304	0.0734	0.0748	-0	-0	0	0	1
1.50	1.00	0.9523	0.9316	0.9304	0.6101	0.6122	77	78	45	33	54
2.00	1.00	0.9523	0.9316	0.9304	1.1468	1.1496	132	132	82	50	47
2.50	1.00	0.9523	0.9316	0.9304	1.6836	1.6870	178	178	115	63	43
3.00	1.00	0.9523	0.9316	0.9304	2.2203	2.2244	218	219	145	73	40
-3.00	2.00	0.9523	0.9316	0.9304	-5.2203	-5.2244	-435	-435	-427	8	2
-2.50	2.00	0.9523	0.9316	0.9304	-4.6836	-4.6870	-407	-408	-402	6	1
-2.00	2.00	0.9523	0.9316	0.9304	-4.1468	-4.1496	-379	-379	-375	3	1
-1.50	2.00	0.9523	0.9316	0.9304	-3.6101	-3.6122	-348	-348	-347	1	0
-1.00	2.00	0.9523	0.9316	0.9304	-3.0734	-3.0748	-317	-317	-317	-0	-0
-0.50	2.00	0.9523	0.9316	0.9304	-2.5367	-2.5374	-283	-283	-284	-1	-0
0.01	2.00	0.9523	0.9316	0.9304	-1.9893	-1.9893	-246	-246	-246	0	0
0.50	2.00	0.9523	0.9316	0.9304	-1.4633	-1.4626	-207	-207	-202	5	3
1.00	2.00	0.9523	0.9316	0.9304	-0.9266	-0.9252	-162	-162	-123	39	27
1.50	2.00	0.9523	0.9316	0.9304	-0.3899	-0.3878	-107	-107	-45	62	82
2.00	2.00	0.9523	0.9316	0.9304	0.1468	0.1496	-0	-0	0	0	2
2.50	2.00	0.9523	0.9316	0.9304	0.6836	0.6870	69	69	37	32	60
3.00	2.00	0.9523	0.9316	0.9304	1.2203	1.2244	121	122	70	51	54
-3.00	3.00	0.9523	0.9316	0.9304	-6.2203	-6.2244	-493	-493	-489	4	1
-2.50	3.00	0.9523	0.9316	0.9304	-5.6836	-5.6870	-467	-467	-464	2	1
-2.00	3.00	0.9523	0.9316	0.9304	-5.1468	-5.1496	-440	-440	-439	1	0
-1.50	3.00	0.9523	0.9316	0.9304	-4.6101	-4.6122	-412	-412	-413	-0	-0
-1.00	3.00	0.9523	0.9316	0.9304	-4.0734	-4.0748	-383	-383	-384	-1	-0
-0.50	3.00	0.9523	0.9316	0.9304	-3.5367	-3.5374	-353	-353	-354	-1	-0
0.01	3.00	0.9523	0.9316	0.9304	-2.9893	-2.9893	-321	-321	-321	0	0
0.50	3.00	0.9523	0.9316	0.9304	-2.4633	-2.4626	-287	-287	-284	3	1
1.00	3.00	0.9523	0.9316	0.9304	-1.9266	-1.9252	-251	-251	-239	12	5
1.50	3.00	0.9523	0.9316	0.9304	-1.3899	-1.3878	-211	-211	-161	51	27
2.00	3.00	0.9523	0.9316	0.9304	-0.8532	-0.8504	-166	-166	-82	84	68
2.50	3.00	0.9523	0.9316	0.9304	-0.3164	-0.3130	-109	-108	-37	71	98
3.00	3.00	0.9523	0.9316	0.9304	0.2203	0.2244	-1	-0	0	0	3
-3.00	4.00	0.9523	0.9316	0.9304	-7.2203	-7.2244	-547	-547	-545	2	0
-2.50	4.00	0.9523	0.9316	0.9304	-6.6836	-6.6870	-522	-522	-522	1	0
-2.00	4.00	0.9523	0.9316	0.9304	-6.1468	-6.1496	-497	-497	-498	-1	-0
-1.50	4.00	0.9523	0.9316	0.9304	-5.6101	-5.6122	-471	-471	-472	-1	-0
-1.00	4.00	0.9523	0.9316	0.9304	-5.0734	-5.0748	-444	-444	-446	-2	-0
-0.50	4.00	0.9523	0.9316	0.9304	-4.5367	-4.5374	-416	-416	-418	-1	-0
0.01	4.00	0.9523	0.9316	0.9304	-3.9893	-3.9893	-387	-387	-387	0	0
0.50	4.00	0.9523	0.9316	0.9304	-3.4633	-3.4626	-357	-357	-354	3	1
1.00	4.00	0.9523	0.9316	0.9304	-2.9266	-2.9252	-325	-325	-317	8	3
1.50	4.00	0.9523	0.9316	0.9304	-2.3899	-2.3878	-291	-291	-272	19	7
2.00	4.00	0.9523	0.9316	0.9304	-1.8532	-1.8504	-255	-255	-194	61	27
2.50	4.00	0.9523	0.9316	0.9304	-1.3164	-1.3130	-215	-214	-115	99	60
3.00	4.00	0.9523	0.9316	0.9304	-0.7797	-0.7756	-168	-168	-70	98	82
-3.00	5.00	0.9523	0.9316	0.9304	-8.2203	-8.2244	-598	-598	-598	0	0
-2.50	5.00	0.9523	0.9316	0.9304	-7.6836	-7.6870	-574	-575	-575	-1	-0
-2.00	5.00	0.9523	0.9316	0.9304	-7.1468	-7.1496	-550	-551	-552	-1	-0
-1.50	5.00	0.9523	0.9316	0.9304	-6.6101	-6.6122	-526	-526	-528	-2	-0
-1.00	5.00	0.9523	0.9316	0.9304	-6.0734	-6.0748	-501	-501	-502	-2	-0
-0.50	5.00	0.9523	0.9316	0.9304	-5.5367	-5.5374	-475	-475	-476	-1	-0
0.01	5.00	0.9523	0.9316	0.9304	-4.9893	-4.9893	-447	-447	-447	0	0
0.50	5.00	0.9523	0.9316	0.9304	-4.4633	-4.4626	-420	-420	-418	2	1
1.00	5.00	0.9523	0.9316	0.9304	-3.9266	-3.9252	-391	-391	-384	6	2
1.50	5.00	0.9523	0.9316	0.9304	-3.3899	-3.3878	-361	-360	-347	13	4
2.00	5.00	0.9523	0.9316	0.9304	-2.8532	-2.8504	-329	-328	-303	26	8
2.50	5.00	0.9523	0.9316	0.9304	-2.3164	-2.3130	-295	-294	-224	70	27
3.00	5.00	0.9523	0.9316	0.9304	-1.7797	-1.7756	-258	-257	-145	112	56

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.75 cc= 0.25 cw= 0 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.8442	0.8442	0.8442	-3.5535	-3.5535	-269	-269	-252	17	6
-2.50	0.00	0.8442	0.8442	0.8442	-2.9612	-2.9612	-239	-239	-224	15	6
-2.00	0.00	0.8442	0.8442	0.8442	-2.3690	-2.3690	-207	-207	-194	13	6
-1.50	0.00	0.8442	0.8442	0.8442	-1.7767	-1.7767	-171	-171	-161	11	6
-1.00	0.00	0.8442	0.8442	0.8442	-1.1845	-1.1845	-132	-132	-123	8	6
-0.50	0.00	0.8442	0.8442	0.8442	-0.5922	-0.5922	-84	-84	-79	5	6
0.01	0.00	0.8442	0.8442	0.8442	0.0118	0.0118	7	7	6	0	6
0.50	0.00	0.8442	0.8442	0.8442	0.5922	0.5922	84	84	79	5	6
1.00	0.00	0.8442	0.8442	0.8442	1.1845	1.1845	132	132	123	8	6
1.50	0.00	0.8442	0.8442	0.8442	1.7767	1.7767	171	171	161	11	6
2.00	0.00	0.8442	0.8442	0.8442	2.3690	2.3690	207	207	194	13	6
2.50	0.00	0.8442	0.8442	0.8442	2.9612	2.9612	239	239	224	15	6
3.00	0.00	0.8442	0.8442	0.8442	3.5535	3.5535	269	269	252	17	6
-3.00	1.00	0.8442	0.8442	0.8442	-4.5535	-4.5535	-355	-355	-357	-2	-1
-2.50	1.00	0.8442	0.8442	0.8442	-3.9612	-3.9612	-328	-328	-331	-3	-1
-2.00	1.00	0.8442	0.8442	0.8442	-3.3690	-3.3690	-299	-299	-303	-3	-1
-1.50	1.00	0.8442	0.8442	0.8442	-2.7767	-2.7767	-268	-268	-272	-4	-1
-1.00	1.00	0.8442	0.8442	0.8442	-2.1845	-2.1845	-235	-235	-239	-4	-2
-0.50	1.00	0.8442	0.8442	0.8442	-1.5922	-1.5922	-199	-199	-202	-3	-2
0.01	1.00	0.8442	0.8442	0.8442	-0.9882	-0.9882	-156	-156	-156	0	0
0.50	1.00	0.8442	0.8442	0.8442	-0.4078	-0.4078	-105	-105	-79	27	29
1.00	1.00	0.8442	0.8442	0.8442	0.1845	0.1845	-0	-0	0	0	0
1.50	1.00	0.8442	0.8442	0.8442	0.7767	0.7767	61	61	45	16	30
2.00	1.00	0.8442	0.8442	0.8442	1.3690	1.3690	105	105	82	23	25
2.50	1.00	0.8442	0.8442	0.8442	1.9612	1.9612	143	143	115	28	22
3.00	1.00	0.8442	0.8442	0.8442	2.5535	2.5535	178	178	145	32	20
-3.00	2.00	0.8442	0.8442	0.8442	-5.5535	-5.5535	-421	-421	-427	-6	-1
-2.50	2.00	0.8442	0.8442	0.8442	-4.9612	-4.9612	-396	-396	-402	-6	-2
-2.00	2.00	0.8442	0.8442	0.8442	-4.3690	-4.3690	-369	-369	-375	-6	-2
-1.50	2.00	0.8442	0.8442	0.8442	-3.7767	-3.7767	-342	-342	-347	-6	-2
-1.00	2.00	0.8442	0.8442	0.8442	-3.1845	-3.1845	-312	-312	-317	-5	-2
-0.50	2.00	0.8442	0.8442	0.8442	-2.5922	-2.5922	-281	-281	-284	-3	-1
0.01	2.00	0.8442	0.8442	0.8442	-1.9882	-1.9882	-246	-246	-246	0	0
0.50	2.00	0.8442	0.8442	0.8442	-1.4078	-1.4078	-209	-209	-202	7	3
1.00	2.00	0.8442	0.8442	0.8442	-0.8155	-0.8155	-165	-165	-123	42	29
1.50	2.00	0.8442	0.8442	0.8442	-0.2233	-0.2233	-106	-106	-45	61	81
2.00	2.00	0.8442	0.8442	0.8442	0.3690	0.3690	-0	-0	0	0	0
2.50	2.00	0.8442	0.8442	0.8442	0.9612	0.9612	53	53	37	16	35
3.00	2.00	0.8442	0.8442	0.8442	1.5535	1.5535	95	95	70	25	30
-3.00	3.00	0.8442	0.8442	0.8442	-6.5535	-6.5535	-481	-481	-489	-8	-2
-2.50	3.00	0.8442	0.8442	0.8442	-5.9612	-5.9612	-457	-457	-464	-8	-2
-2.00	3.00	0.8442	0.8442	0.8442	-5.3690	-5.3690	-432	-432	-439	-7	-2
-1.50	3.00	0.8442	0.8442	0.8442	-4.7767	-4.7767	-406	-406	-413	-6	-2
-1.00	3.00	0.8442	0.8442	0.8442	-4.1845	-4.1845	-379	-379	-384	-5	-1
-0.50	3.00	0.8442	0.8442	0.8442	-3.5922	-3.5922	-351	-351	-354	-3	-1
0.01	3.00	0.8442	0.8442	0.8442	-2.9882	-2.9882	-321	-321	-321	0	0
0.50	3.00	0.8442	0.8442	0.8442	-2.4078	-2.4078	-289	-289	-284	5	2
1.00	3.00	0.8442	0.8442	0.8442	-1.8155	-1.8155	-254	-254	-239	15	6
1.50	3.00	0.8442	0.8442	0.8442	-1.2233	-1.2233	-215	-215	-161	54	29
2.00	3.00	0.8442	0.8442	0.8442	-0.6310	-0.6310	-168	-168	-82	86	69
2.50	3.00	0.8442	0.8442	0.8442	-0.0388	-0.0388	-95	-95	-37	57	87
3.00	3.00	0.8442	0.8442	0.8442	0.5535	0.5535	-0	-0	0	0	0
-3.00	4.00	0.8442	0.8442	0.8442	-7.5535	-7.5535	-536	-536	-545	-9	-2
-2.50	4.00	0.8442	0.8442	0.8442	-6.9612	-6.9612	-513	-513	-522	-8	-2
-2.00	4.00	0.8442	0.8442	0.8442	-6.3690	-6.3690	-490	-490	-498	-8	-2
-1.50	4.00	0.8442	0.8442	0.8442	-5.7767	-5.7767	-466	-466	-472	-7	-1
-1.00	4.00	0.8442	0.8442	0.8442	-5.1845	-5.1845	-441	-441	-446	-5	-1
-0.50	4.00	0.8442	0.8442	0.8442	-4.5922	-4.5922	-415	-415	-418	-3	-1
0.01	4.00	0.8442	0.8442	0.8442	-3.9882	-3.9882	-387	-387	-387	0	0
0.50	4.00	0.8442	0.8442	0.8442	-3.4078	-3.4078	-359	-359	-354	4	1
1.00	4.00	0.8442	0.8442	0.8442	-2.8155	-2.8155	-328	-328	-317	11	3
1.50	4.00	0.8442	0.8442	0.8442	-2.2233	-2.2233	-295	-295	-272	23	8
2.00	4.00	0.8442	0.8442	0.8442	-1.6310	-1.6310	-259	-259	-194	65	29
2.50	4.00	0.8442	0.8442	0.8442	-1.0388	-1.0388	-218	-218	-115	103	62
3.00	4.00	0.8442	0.8442	0.8442	-0.4465	-0.4465	-167	-167	-70	96	81
-3.00	5.00	0.8442	0.8442	0.8442	-8.5535	-8.5535	-588	-588	-598	-10	-2
-2.50	5.00	0.8442	0.8442	0.8442	-7.9612	-7.9612	-566	-566	-575	-9	-2
-2.00	5.00	0.8442	0.8442	0.8442	-7.3690	-7.3690	-544	-544	-552	-8	-1
-1.50	5.00	0.8442	0.8442	0.8442	-6.7767	-6.7767	-521	-521	-528	-7	-1
-1.00	5.00	0.8442	0.8442	0.8442	-6.1845	-6.1845	-498	-498	-502	-5	-1
-0.50	5.00	0.8442	0.8442	0.8442	-5.5922	-5.5922	-473	-473	-476	-3	-1
0.01	5.00	0.8442	0.8442	0.8442	-4.9882	-4.9882	-447	-447	-447	0	0
0.50	5.00	0.8442	0.8442	0.8442	-4.4078	-4.4078	-421	-421	-418	4	1
1.00	5.00	0.8442	0.8442	0.8442	-3.8155	-3.8155	-394	-394	-384	9	2
1.50	5.00	0.8442	0.8442	0.8442	-3.2233	-3.2233	-364	-364	-347	17	5
2.00	5.00	0.8442	0.8442	0.8442	-2.6310	-2.6310	-333	-333	-303	31	10
2.50	5.00	0.8442	0.8442	0.8442	-2.0388	-2.0388	-299	-299	-224	75	29
3.00	5.00	0.8442	0.8442	0.8442	-1.4465	-1.4465	-262	-262	-145	117	57

COMPARISON OF Qsr FORMULAS: ASHRAE STANDARD 152P vs. GENERALIZED FORMULA

Ctot= 157.29 nenv= 0.65 cf= 0.95 cc= 0 cw= 0.05 1/nenv= 1.538462

DPoff	DPon	Zo	Z1	Z2	DPoff/Z-DPon		Qsr generalized		Qsr 152	diff	%DIF
-3.00	0.00	0.9964	0.9952	0.9951	-3.0146	-3.0149	-316	-316	-252	64	22
-2.50	0.00	0.9964	0.9952	0.9951	-2.5122	-2.5124	-281	-281	-224	57	22
-2.00	0.00	0.9964	0.9952	0.9951	-2.0097	-2.0099	-243	-243	-194	49	22
-1.50	0.00	0.9964	0.9952	0.9951	-1.5073	-1.5074	-201	-201	-161	41	22
-1.00	0.00	0.9964	0.9952	0.9951	-1.0049	-1.0050	-155	-155	-123	31	22
-0.50	0.00	0.9964	0.9952	0.9951	-0.5024	-0.5025	-99	-99	-79	20	22
0.01	0.00	0.9964	0.9952	0.9951	0.0100	0.0100	8	8	6	2	22
0.50	0.00	0.9964	0.9952	0.9951	0.5024	0.5025	99	99	79	20	22
1.00	0.00	0.9964	0.9952	0.9951	1.0049	1.0050	155	155	123	31	22
1.50	0.00	0.9964	0.9952	0.9951	1.5073	1.5074	201	201	161	41	22
2.00	0.00	0.9964	0.9952	0.9951	2.0097	2.0099	243	243	194	49	22
2.50	0.00	0.9964	0.9952	0.9951	2.5122	2.5124	281	281	224	57	22
3.00	0.00	0.9964	0.9952	0.9951	3.0146	3.0149	316	316	252	64	22
-3.00	1.00	0.9964	0.9952	0.9951	-4.0146	-4.0149	-383	-383	-357	26	7
-2.50	1.00	0.9964	0.9952	0.9951	-3.5122	-3.5124	-351	-351	-331	21	6
-2.00	1.00	0.9964	0.9952	0.9951	-3.0097	-3.0099	-318	-318	-303	16	5
-1.50	1.00	0.9964	0.9952	0.9951	-2.5073	-2.5074	-283	-283	-272	11	4
-1.00	1.00	0.9964	0.9952	0.9951	-2.0049	-2.0050	-245	-245	-239	6	2
-0.50	1.00	0.9964	0.9952	0.9951	-1.5024	-1.5025	-204	-204	-202	2	1
0.01	1.00	0.9964	0.9952	0.9951	-0.9900	-0.9900	-156	-156	-156	0	0
0.50	1.00	0.9964	0.9952	0.9951	-0.4976	-0.4975	-101	-101	-79	23	25
1.00	1.00	0.9964	0.9952	0.9951	0.0049	0.0050	-0	-0	0	0	0
1.50	1.00	0.9964	0.9952	0.9951	0.5073	0.5074	94	94	45	49	71
2.00	1.00	0.9964	0.9952	0.9951	1.0097	1.0099	150	150	82	68	59
2.50	1.00	0.9964	0.9952	0.9951	1.5122	1.5124	197	197	115	82	53
3.00	1.00	0.9964	0.9952	0.9951	2.0146	2.0149	239	239	145	94	49
-3.00	2.00	0.9964	0.9952	0.9951	-5.0146	-5.0149	-444	-444	-427	17	4
-2.50	2.00	0.9964	0.9952	0.9951	-4.5122	-4.5124	-415	-415	-402	13	3
-2.00	2.00	0.9964	0.9952	0.9951	-4.0097	-4.0099	-385	-385	-375	9	2
-1.50	2.00	0.9964	0.9952	0.9951	-3.5073	-3.5074	-353	-353	-347	6	2
-1.00	2.00	0.9964	0.9952	0.9951	-3.0049	-3.0050	-320	-320	-317	3	1
-0.50	2.00	0.9964	0.9952	0.9951	-2.5024	-2.5025	-285	-285	-284	1	0
0.01	2.00	0.9964	0.9952	0.9951	-1.9900	-1.9900	-246	-246	-246	0	0
0.50	2.00	0.9964	0.9952	0.9951	-1.4976	-1.4975	-206	-206	-202	4	2
1.00	2.00	0.9964	0.9952	0.9951	-0.9951	-0.9950	-159	-159	-123	36	25
1.50	2.00	0.9964	0.9952	0.9951	-0.4927	-0.4926	-103	-103	-45	58	79
2.00	2.00	0.9964	0.9952	0.9951	0.0097	0.0099	-0	-0	0	0	0
2.50	2.00	0.9964	0.9952	0.9951	0.5122	0.5124	91	91	37	54	84
3.00	2.00	0.9964	0.9952	0.9951	1.0146	1.0149	147	148	70	77	71
-3.00	3.00	0.9964	0.9952	0.9951	-6.0146	-6.0149	-500	-500	-489	12	2
-2.50	3.00	0.9964	0.9952	0.9951	-5.5122	-5.5124	-473	-473	-464	9	2
-2.00	3.00	0.9964	0.9952	0.9951	-5.0097	-5.0099	-445	-445	-439	6	1
-1.50	3.00	0.9964	0.9952	0.9951	-4.5073	-4.5074	-416	-416	-413	4	1
-1.00	3.00	0.9964	0.9952	0.9951	-4.0049	-4.0050	-386	-386	-384	1	0
-0.50	3.00	0.9964	0.9952	0.9951	-3.5024	-3.5025	-354	-354	-354	0	0
0.01	3.00	0.9964	0.9952	0.9951	-2.9900	-2.9900	-321	-321	-321	0	0
0.50	3.00	0.9964	0.9952	0.9951	-2.4976	-2.4975	-286	-286	-284	2	1
1.00	3.00	0.9964	0.9952	0.9951	-1.9951	-1.9950	-248	-248	-239	9	4
1.50	3.00	0.9964	0.9952	0.9951	-1.4927	-1.4926	-207	-207	-161	46	25
2.00	3.00	0.9964	0.9952	0.9951	-0.9903	-0.9901	-161	-161	-82	79	65
2.50	3.00	0.9964	0.9952	0.9951	-0.4878	-0.4876	-105	-105	-37	68	95
3.00	3.00	0.9964	0.9952	0.9951	0.0146	0.0149	-0	-0	0	0	1
-3.00	4.00	0.9964	0.9952	0.9951	-7.0146	-7.0149	-554	-554	-545	9	2
-2.50	4.00	0.9964	0.9952	0.9951	-6.5122	-6.5124	-528	-528	-522	6	1
-2.00	4.00	0.9964	0.9952	0.9951	-6.0097	-6.0099	-502	-502	-498	4	1
-1.50	4.00	0.9964	0.9952	0.9951	-5.5073	-5.5074	-475	-475	-472	2	0
-1.00	4.00	0.9964	0.9952	0.9951	-5.0049	-5.0050	-447	-447	-446	1	0
-0.50	4.00	0.9964	0.9952	0.9951	-4.5024	-4.5025	-417	-417	-418	-0	-0
0.01	4.00	0.9964	0.9952	0.9951	-3.9900	-3.9900	-387	-387	-387	0	0
0.50	4.00	0.9964	0.9952	0.9951	-3.4976	-3.4975	-356	-356	-354	1	0
1.00	4.00	0.9964	0.9952	0.9951	-2.9951	-2.9950	-323	-323	-317	6	2
1.50	4.00	0.9964	0.9952	0.9951	-2.4927	-2.4926	-287	-287	-272	15	5
2.00	4.00	0.9964	0.9952	0.9951	-1.9903	-1.9901	-250	-250	-194	56	25
2.50	4.00	0.9964	0.9952	0.9951	-1.4878	-1.4876	-208	-208	-115	93	58
3.00	4.00	0.9964	0.9952	0.9951	-0.9854	-0.9851	-162	-162	-70	92	79
-3.00	5.00	0.9964	0.9952	0.9951	-8.0146	-8.0149	-605	-605	-598	7	1
-2.50	5.00	0.9964	0.9952	0.9951	-7.5122	-7.5124	-580	-580	-575	5	1
-2.00	5.00	0.9964	0.9952	0.9951	-7.0097	-7.0099	-555	-555	-552	3	1
-1.50	5.00	0.9964	0.9952	0.9951	-6.5073	-6.5074	-529	-529	-528	2	0
-1.00	5.00	0.9964	0.9952	0.9951	-6.0049	-6.0050	-503	-503	-502	0	0
-0.50	5.00	0.9964	0.9952	0.9951	-5.5024	-5.5025	-476	-476	-476	-0	-0
0.01	5.00	0.9964	0.9952	0.9951	-4.9900	-4.9900	-447	-447	-447	0	0
0.50	5.00	0.9964	0.9952	0.9951	-4.4976	-4.4975	-419	-419	-418	1	0
1.00	5.00	0.9964	0.9952	0.9951	-3.9951	-3.9950	-389	-389	-384	4	1
1.50	5.00	0.9964	0.9952	0.9951	-3.4927	-3.4926	-357	-357	-347	10	3
2.00	5.00	0.9964	0.9952	0.9951	-2.9903	-2.9901	-324	-324	-303	21	7
2.50	5.00	0.9964	0.9952	0.9951	-2.4878	-2.4876	-289	-289	-224	65	25
3.00	5.00	0.9964	0.9952	0.9951	-1.9854	-1.9851	-251	-251	-145	106	53