Calculations for Spa Volumes

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A common difficulty in the treatment of spas lies in calculating the volume of water contained in the vessel. The correct figure is available, of course, on the manufacturer's specification sheets, but they are frequently not available. Two of the most common causes of incorrect calculations are addressed, with methods for avoiding these errors.

Introduction

In the chemical treatment of portable or self–contained spas it is often difficult to accurately calculate the correct volume of water to be treated, and the correct information from the manufacturer is often unavailable. Miscalculation in such a relatively small volume of water can lead to grossly inaccurate dosing of chemicals, leading to water chemistry conditions ranging from inconvenient to damaging.

Methods exist for the calculation of swimming pool volumes, which can be useful when swimming pools or spas are arranged in convenient geometric shapes. However, the "rounding off" to the nearest foot, which is common and acceptable in pool volume calculation, can lead to larger errors in a small spa. The varied shapes of footwells, irregular shapes for arm rests, seating, areas for reclining, sitting, steps and other contoured angles with numerous radiused corners in most spas also lead to difficulties when using formulas designed for uniform geometric shapes.

In order to deal with these two areas of difficulty, two strategies have been developed. The first strategy corrects for rounding errors, and the second attempts to address irregular shapes.

Rounding Errors in Geometric Shapes

As an example of rounding errors, consider the spa owner who reports to his chemical retailer a spa volume of 650 gallons. When asked for the dimensions, the spa owner reports that the spa is 5' • 7' • 32". Such a spa, of course, would not exist without steps, benches, etc. But in the interest of illustrating the errors derived from rounding, this spa calculates to 87.5 cubic feet, which, multiplied by 7.5 (gallons per cubic foot) in a uniform rectangular shape equals 656.25 gallons.

5' • 7' • 2½' • 7.5 = 656.25

If, however, the actual dimensions of the spa are 4'9" • 6'11" • 27" the actual volume would equal approximately 554.68 gallons.

4.75 • 6.92 • 2.25 • 7.5 = 554.68125

Rounding errors alone in this spa constitute an error of approximately 15.5%.

In a swimming pool calculation, similar rounding would only constitute an error of approximately 6%:

Rounded: 18 • 32 • 5.5 • 7.5 = 23,760

Actual: 17'9" • 31'11" • 5'3" • 7.5 or

17.75 • 31.92 • 5.25 • 7.5 = 22,309

Table 1 may be used as a convenience in converting inches to decimal fractions. For the calculation of volume in spas that are geometric in shape (or are combinations of geometric shapes) Figure 2 (round) and Figure 3 (square or rectangular) may be used.

Non–geometric Shapes

Compounding the inaccuracies resulting from rounding are errors resulting from irregular shapes. Unfortunately, this problem doesn't lend itself to such a simple correction as fine–tuning the rounded feet to inches and the inches to decimal fractions. In fact, because of the infinite variations of footwells, arm rests, benches, recliners, and steps, along with infinite variations of contoured angles and radiused corners, exact calculation is impossible.

In order to obtain the correct volume, a collection of approximately 500 – 600 manufacturer specification sheets was assembled, which listed the length, width, overall depth, and gallon capacity. The dimen-

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sions were first converted to feet, and the inches were converted to decimal equivalents and added to the feet. The figures were put into the equation:

L • W • D • (X) = gallonage

After over 500 repetitions of solving for X, the values for X were averaged, with the result being 2.5. The capacity of the spas was the recalculated using the formula:

L • W • D • 2.5 = gallonage

In over 95% of the examples the resulting gallonage was within 5 gallons of the manufacturers stated capacity. This formula, with the 2.5 factor, compensates for the irregular features of spas in a statistically significant percentage of spas. In the absence of a more precise method of calculation, this formula has proven useful when the manufacturer's specifications are unavailable.

When applying this information to the spa used in the above example, taking into account the fact that the spa is not a uniform rectangle but rather contains numerous benches, steps, and other variations in interior configuration, we find that:

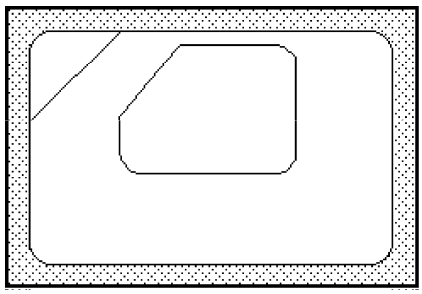
4.75 • 6.92 • 2.25 • 2.5 ≅ 185

Although rounding alone contributes to a 15.5% overstatement of the content of this spa, the assumption that no irregular shapes protrude into the area contributes an additional 56.5% error, for a total overstatement of 471.25 gallons, or a 72% error.

Of course, if the average depth, instead of the total depth were used in the first formula, the percentage of error would be somewhat less, but average depth in today's freeform spas can be extremely difficult to estimate. Using the 2.5 factor in the modified "Complex Spa" formula accounts for all of these factors in the vast majority of such spas.

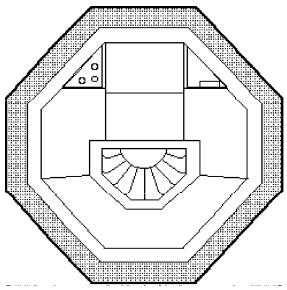
About the Author

Robert W. Lowry is the owner of Lowry Consulting, a Woodstock, Georgia–based chemical, technical, and business resource for the pool and spa industry. Mr. Lowry is a chemist, educator, author, and businessman. He has spent more than 20 years in the pool and spa industry. He has co–owned two specialty chemical manufacturing companies and an industry newspaper.



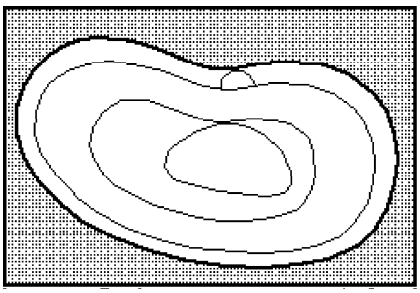
4'9" • 6'11" • 27"

4.75 • 6.92 • 2.25 • 2.5 = 185



7'1" • 7'1" • 34"

7.08 • 7.08 • 2.83 • 2.5 = 354



5'5" • 8' • 27"

5.42 • 8.0 • 2.25 • 2.5 = 244

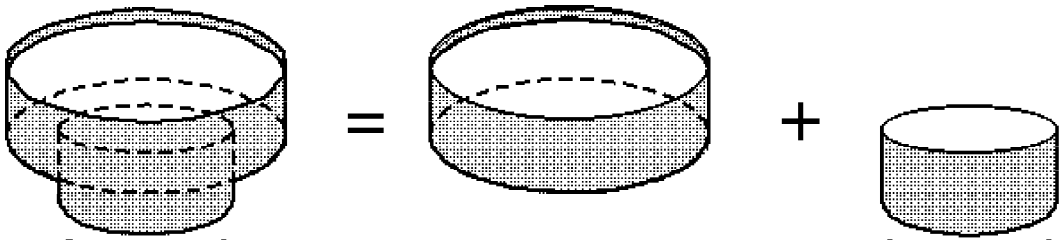
Figure 1 – Sample Equations for Complex Spas

Inches	Decimal	Inches	Decimal
1	0.08	7	0.58
2	0.17	8	0.67
3	0.25	9	0.75
4	0.33	10	0.83
5	0.42	11	0.92
6	0.50	12	1.00

Table 1 – Inch to Decimal Conversion

Rectangular:
Length ÅWidth ÅAverage Depth Å7.5 = Gallons
Oval:
Length ÅWidth ÅAverage Depth Å5.9 = Gallons
Round:
Diameter ÅDiameter ÅAverage Depth Å5.9 = Gallons
Complex Spas:
Length ÅWidth ÅOverall Depth Å2.5 = Gallons

Table 2 – Volume Formulas



Spas may be combinations of basic geometric shapes without a significant number of variations complicating the configuration. It is easy then to calculate the volume or gallonage of the basic shapes and add them together. The spa shown here is a combination of 2 cylinders – a smaller cylinder with a larger one stacked on top.

Formula:

Diameter • Diameter • Average Depth • 5.9 = Gallons

Example:

Part 1 – 7 foot diameter and 18 inches deep to bench seat level

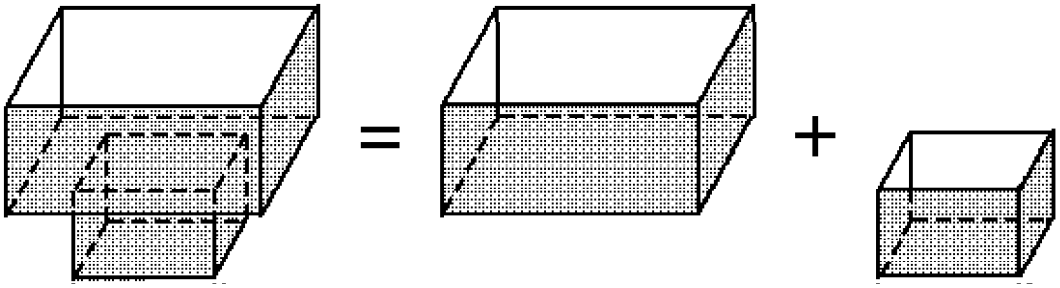
7 • 7 • 1.5 • 5.9 = 434 gallons

Part 2 – 4 foot diameter and 18 inches deep to bottom

4 • 4 • 1.5 • 5.9 = 142 gallons

Add Part 1 and Part 2 together: 434 + 142 = 576 total gallons

Figure 2 – Sample Equation for Round Geometric Spa



The spa shown here is a combination of 2 rectangles – a smaller rectangle with a larger one stacked on top.

Formula:

Length • Width • Average Depth • 7.5 = Gallons

Example:

Part 1 – 7 foot length, 6 foot width and 18 inches deep to bench seat level

7 • 6 • 1.5 • 7.5 = 472.5 gallons

Part 2 – 4 foot length, 3 foot width and 18 inches deep to bottom

4 • 3 • 1.5 • 7.5 = 135 gallons

Add Part 1 and Part 2 together: 472.5 + 135 = 607.5 total gallons

Figure 3 – Sample Equation for Rectangular Geometric Spa