

4

PRACTICAL ARITHMETIC FOR THE PROTECTIVE COATINGS INSPECTOR

Coatings inspectors frequently need to apply basic arithmetic to everyday inspections. This module provides a review of common calculations associated with coatings inspection, including: averaging values; converting percentages to decimal format; calculating area (square feet and square meters); calculating volume and converting from milliliters/liter (ounces/gallon) to percentage of thinner addition; converting VOC values into other units; converting temperatures between fahrenheit and celcius; and converting units of measurement for surface profile depth and paint thickness (mils to microns and back). A special session on calculating coating material quantities required for a project based on theoretical and practical coverage rates is also described in this module. Calculating wet film thickness based on the target dry film thickness, volume solids content and thinner addition will be described in Module 5. The intent of this module is to cover basic mathematical procedures that are used in various coatings inspection check points described later in the course.

Learning Outcome

Successful completion of Module 4 will enable the participants to apply practical arithmetic to coatings inspection activities.

Introduction

Arithmetic can be one of the more challenging aspects of coatings inspection that an inspector must employ on a project. Those challenged by math may simply throw up their hands and give up, rather than working through the formulas to generate the correct value(s), or they may rely on others to perform calculations for them. This module helps inspectors to become more comfortable with arithmetic, and describes the steps necessary to perform basic calculations. SSPC publication 03-05, “Practical Math For The Protective Coatings Industry” is an excellent resource that can be used as an aid in helping with calculations.

An inspector should always be equipped with a working calculator to make the calculations easier and faster, and to avoid making simple errors. Recognize however, that if an incorrect value (or the incorrect form of a value) is inadvertently entered into the calculator, the answer will be wrong despite using the correct formula. So take your time and double check all entries. The old phrase says “practice makes perfect.” And replication helps. If you are unfamiliar with any of the procedures described in this module, practice the examples over and over. You can even substitute your own numbers in the examples to help gain confidence in application of the formulas. Finally, recognize that there is always more than one way to arrive at the correct answer. This module describes commonly used methods, but other methods or procedures may be used, as long as the final answer is the same. You will have an opportunity to practice the skills covered in this module during the Module 4 Workshop.

Averaging a Set of Values

Coatings inspectors oftentimes need to evaluate multiple readings through averaging in order to determine if the specification is met. For example, multiple surface profile measurements and dry film thickness readings are typically averaged. Averaging a set of values is one of the simplest mathematical skills that can be applied to the coatings industry. To obtain the average of a set of values, simply add all of the values together to generate a total (a “sum”), then divide the sum by the number of values in the set. Here are several examples of “averaging.”

**Example 1: Averaging Surface Profile Measurements
(in microns)**

Area 1: Measurement (1) 65 microns
Measurement (2) 75 microns
Measurement (3) 50 microns

Step 1: Calculate the Sum $(65 + 75 + 50) = 190$ microns

Step 2: Divide the Sum (190) by the number of values in the set (3)
 $190 \div 3 = 63.3$ microns

Step 3: Since each measurement contains only 2 significant figures, the average value should contain the same number of significant figures. It should be rounded down to 63 microns.

**Example 2: Averaging Surface Profile Measurements
(in mils)**

Area 1: Measurement (1) 2.3 mils
Measurement (2) 3 mils
Measurement (3) 2 mils
Measurement (4) 2.8 mils

Step 1: Calculate the Sum $(2.3 + 3 + 2 + 2.8) = 10.1$ mils

Step 2: Divide the Sum (10.1) by the number of values in the set (4)
 $10.1 \div 4 = 2.5$ mils

**Example 3: Averaging Dry Film Thickness Measurements
(in microns)**

Spot 1: Measurement (1) 100 microns
Measurement (2) 125 microns
Measurement (3) 137 microns

Step 1: Calculate the Sum $(100 + 125 + 137) = 362$ microns

Step 2: Divide the Sum (362) by the number of values in the set (3)
 $362 \div 3 = 120.7$ microns

Step 3: Since each measurement contains only 3 significant figures, the average value should contain the same number of significant figures. It should be rounded up to 121 microns.

**Example 4: Averaging Dry Film Thickness Measurements
(in mils)**

Spot 1:	Measurement (1)	5.6 mils
	Measurement (2)	6.2 mils
	Measurement (3)	4.9 mils

Step 1: Calculate the Sum $(5.6 + 6.2 + 4.9) = 16.7$ mils

Step 2: Divide the Sum (16.7) by the number of values in the set (3)
 $16.7 \div 3 = 5.6$ mils

Converting Percentages to Decimal Format

There are a number of occasions where it may be necessary to convert percentages to decimal format in order to make calculations. Examples include converting the percentage of volume solids of the coating and thinning. The volume solids content of a coating (the volume of resin and pigment in a coating) is expressed by the coating manufacturer as a percentage of the total volume of the coating (the volume of resin, pigment and solvent in a coating). The volume solids (volume of solid materials in a coating) is used to calculate the coverage rate (in square meters/liter; or square feet/gallon) and the target wet film thickness (in microns or mils). However, prior to using the volume solids content value in a formula, it must be converted to “decimal format.” Additionally, the amount of thinner that can be added to a coating to reduce its viscosity is expressed as a percent (e.g., add 15% thinner to the mixed volume). Prior to calculating the amount of thinner that can be added, the percentage value must be converted to decimal format. Both of these are described below.

The volume solids content of a coating is expressed as a percentage, for example 67% solids by volume, which means that 67% of the total volume of the coating is resin and pigment which will remain on the surface after application. The remaining 33% represents the solvents, which will evaporate from the coating film. To convert “67%” to a decimal, simply place a decimal point after the value, then move it two places to the left, and drop the percent symbol (%).

Example 5: Volume Solids Content is 67%

Step 1: 67.%

Step 2: 0.67

So 67% in decimal form is 0.67

Example 6: Volume Solids Content is 84%

Step 1: 84.%

Step 2: 0.84

So 84% in decimal form is 0.84

Example 7: Reduce (thin) the mixed volume of 40 liters of coating using 15% thinner. How much thinner do you add?

Step 1: 15.%

Step 2: 0.15

So 15% in decimal form is 0.15

Step 3: 40 liters of mixed coating x 0.15 = 6 liters of thinner

Example 8: Reduce (thin) the mixed volume of 15 gallons of coating using 5% thinner. How much thinner do you add?

Step 1: 5.%

Step 2: 0.05

So 5% in decimal form is 0.05

Step 3: 15 gallons of mixed coating x 0.05 = 0.75 gallons of thinner

Note: Converting percentages to decimal format can also be illustrated using the United States monetary system. A US dollar is expressed as \$1.00. A dime is 10% of a dollar. It is expressed in decimal format as \$.10. Similarly, a quarter is 25% of a dollar. It is expressed in decimal format as \$.25.

Calculating Area

The coating inspector may need to calculate the surface area prepared and/or coated to determine the number of surface profile or coating thickness measurements to take, or to record the daily progress of the contractor regarding the total area prepared or coated. The coatings inspector may also be required to verify that there is a sufficient

quantity of each coating on the project site to complete the work. In all of these cases, the area must be either known or calculated. If the area cannot be obtained from contract drawings or other sources, then it must be calculated. The formula used to calculate area is based on the shape of the surface. There are hundreds of shapes of items that could be prepared and coated, but this section will focus on three basic shapes: plate, I-beams, and pipe or cylinders.

Calculating the Area of Plate

The area of a plate or wall section is perhaps the easiest shape to calculate. The basic formula is:

Area (in square meters or square feet) = Length x Width

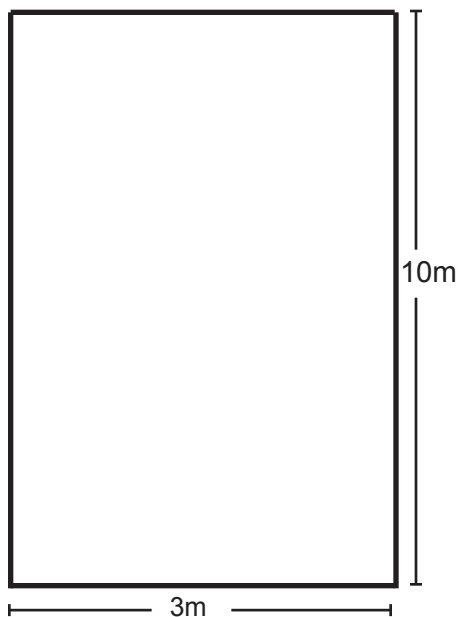


Figure 1

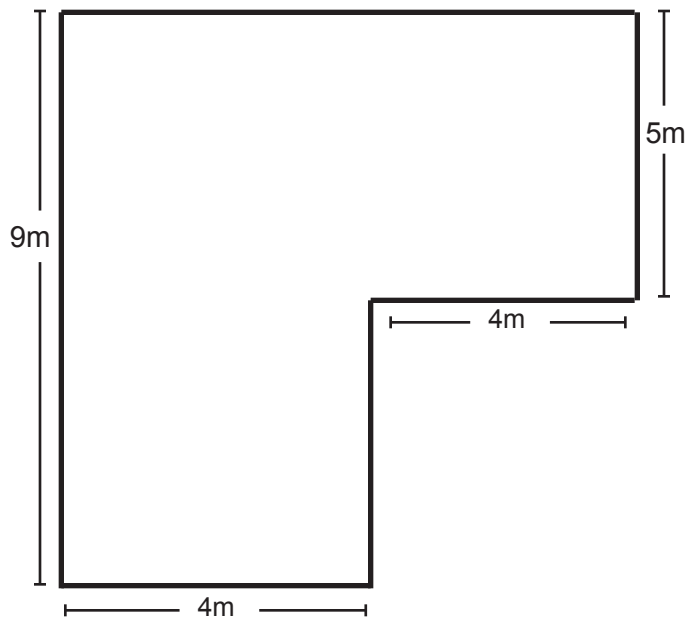


Figure 2

If the surface illustrated as Figure 1 is 10 meters (33 feet) long and 3 meters (9.8 feet) wide, the area can be determined by multiplying the length (10 meters) by the width (3 meters). 10 meters x 3 meters = 30 square meters. The area can also be determined in square feet (33 feet x 9.8 feet = 323.4 square feet). Note that if both sides of the surface are to be prepared and coated, then the area must be doubled. In this case, both sides of the surface shown in Figure 1 add up to 60 square meters (or 646.8 square feet).

The surface illustrated as Figure 2 must be divided into two separate shapes or areas in order to calculate the total area, as shown below in Figures 2a and 2b. Once the area of each of the separate shapes is calculated, they are added together in order to calculate the total area of the entire surface, as shown below.

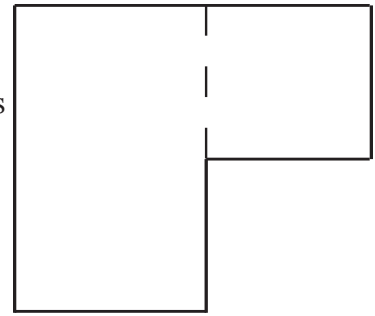


Figure 2

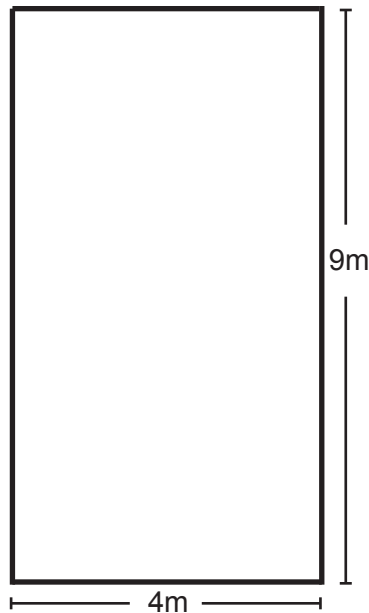


Figure 2a

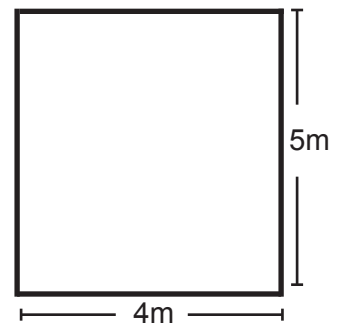


Figure 2b

Dimensions of surface illustrated in Figure 2a: 9 meters long x 4 meters wide

Dimensions of surface illustrated in Figure 2b: 5 meters long x 4 meters wide

The area of the surface illustrated in Figure 2a is 36 square meters (9 meters x 4 meters)

The area of the surface illustrated in Figure 2b is 20 square meters (5 meters x 4 meters)

The total area of the surface illustrated in Figure 2 (Figures 2a and 2b combined) is 56 square meters (36 meters + 20 meters)

If both sides are to be prepared and coated, then the area must be doubled. In this case, both sides of Figure 2 would total 112 square meters.

The area of the surface in Figure 2 can also be calculated in square feet:

Dimensions of surface illustrated in Figure 2a: 29.5 feet long x 13.1 feet wide

Dimensions of surface illustrated in Figure 2b: 16.4 feet long x 13.1 feet wide

The area of the surface illustrated in Figure 2a is 386.5 square feet (29.5 feet x 13.1 feet)

The area of the surface illustrated in Figure 2b is 214.8 square feet (16.4 feet x 13.1 feet)

The total area of the surface illustrated in Figure 2 is 601.3 square feet (386.5 feet + 214.8 feet)

If both sides are to be prepared and coated, then the area must be doubled. In this case, both sides of Figure 2 would total 1,202.6 square feet.

Calculating the Area of I-beams

A steel I-beam is used for this example, but I-beams can also be constructed of concrete. The same approach is used to calculate surface area, whether concrete or steel are involved. A steel I-beam is essentially three steel plates joined (welded) together to create the shape. The beam may have “stiffeners,” but these are also steel plate sections. Therefore, we can use the same formula (length x width) to calculate the area of a steel I- beam.

An I-beam has top and bottom plates that are positioned horizontally. These are called “flanges.” The vertical steel plate that connects the top and bottom flanges is called the “web.” Stiffeners are vertical plates that are connected to the top and bottom flanges and to the web. They are located on either side of the web. An I-beam (without stiffeners) is shown in Figure 3. A photograph of an I-beam with stiffeners in place is also shown.

To determine the total area of the I-beam, follow these 8 basic steps:

Step 1: Measure the length and width of one of the flanges and calculate the area of one of the surfaces by multiplying the length times the width.

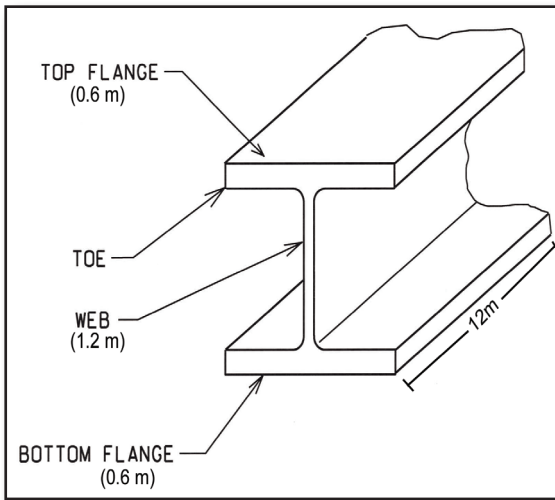


Figure 3



I-Beam

- Step 2: Multiply the area determined in Step 1 by four, since both flanges will be coated on both sides. Note that the edges of the flanges will also be coated, but this surface area will typically not have a significant affect on the total area. However, if the thickness of the flange is significant, the area of the edges can also be calculated by multiplying the width (thickness in this case) times the length of one of the edges and multiplying by 4 to account for all 4 edges. For the purpose of this example, the edges are not included in the calculations.
- Step 3: Measure the length and width of the web and calculate the area by multiplying the length times the width.
- Step 4: Multiply the area in Step 3 by two, since the web will be coated on both sides.
- Step 5: Measure the length and width of a stiffener (again ignore the thickness for this example), and calculate the area of one of the sides by multiplying the length times the width.
- Step 6: Multiply the area in Step 5 by two, since the stiffener will be coated on both sides.
- Step 7: Multiply the area in Step 6 by the total number of stiffeners.
- Step 8: Add the total surface area of the flanges, web and stiffeners together to determine the total area of the I-beam

Example 9 (metric)

A 12 meter long I-beam has a 1.2 meter web, 0.6 meter flanges and eight (8) - 0.15 meter wide by 1.2 meters long stiffeners.

Step 1: 12 meters (length) x 0.6 meter (width)
 $(12 \times 0.6) = 7.2$ square meters

Step 2: 7.2 square meters x 4 = 28.8 square meters

Step 3: 12 meters (length) x 1.2 meters (width) = 14.4 square meters

Step 4: 14.4 square meters x 2 = 28.8 square meters

Step 5: 1.2 meters (length) x 0.15 meter (width) = 0.18 square meter

Step 6: $0.18 \times 2 = 0.36$ square meter

Step 7: 0.36 square meter x 8 stiffeners = 2.9 square meters

Step 8: 28.8 square meters (flanges) + 28.8 square meters (web) + 2.9 square meters (stiffeners) = 60.5 square meters

Example 10 (US standard):

A 40 foot long I-beam has a 4 foot web, 2 foot flanges and eight (8) - 3 inch wide by 4 foot long stiffeners.

Step 1: 40 feet (length) x 2 feet (width)
 $(40 \times 2) = 80$ square feet

Step 2: 80 square feet x 4 = 320 square feet

Step 3: 40 feet (length) x 4 feet (width) = 160 square feet

Step 4: 160 square feet x 2 = 320 square feet

Step 5: 4 feet (length) x 0.25 foot (width) = 1 square foot

Step 6: 1 square foot x 2 = 2 square feet

Step 7: 2 square feet x 8 stiffeners = 16 square feet

Step 8: 320 square feet (flanges) + 320 square feet (web) + 16 square feet (stiffeners) = 656 square feet

Calculating the Area of a Cylinder (i.e., tank)



The area of a cylinder or tank can be calculated if the circumference of one end (e.g., the roof) can be determined and if the area of the side walls can be calculated. Note that the side walls of a tank are created by bending flat steel sheets to create a circle. So the formula to calculate the area of the side walls is the same as the formula to calculate the area of plate, described earlier in this module.

Example 11 (metric)

This first example uses the metric system. The tank in this example is ground storage tank 40 meters high with a roof diameter of 30 meters.

The circumference (C) of the roof (or the bottom) of a tank is calculated using the formula:

$C = \pi \times d$, where π (pi) = 3.14 and d = diameter of the roof

If the diameter of the roof is 30 meters, the circumference is 3.14×30 meters, or 94.2 meters.

To determine the radius (r) of the roof, divide the diameter by 2.

$$r = 30 \div 2 = 15 \text{ meters}$$

To determine the area (A) of the roof, use the formula: $A = \pi \times r^2$

$$A = 3.14 \times (15 \text{ meters})^2 = 3.14 \times (225) = 706.5 \text{ square meters}$$

If the tank bottom was the same diameter as the roof, then the total area of the tank bottom is the same as the area of the roof (706.5 square meters in this example).

The surface area of the shell is determined by multiplying the height of the tank shell by the circumference: 40 meters $\times$ 94.2 meters = 3,768 square meters.

If the entire exterior of the tank is being coated, the surface area is the sum of the areas of the roof and shell (706.5 square meters + 3,768 square meters = 4,474.5 square meters).

Example 12 (US standard)

This second example uses the US standard system. In this example the ground storage tank is 50 feet high with a roof diameter of 100 feet:

The circumference (C) of the roof and/or the bottom of a tank is calculated using the formula:

$$C = \pi \times d, \text{ where } \pi (\text{pi}) = 3.14 \text{ and } d = \text{diameter of the roof or floor}$$

If the diameter of the roof is 100 feet, the circumference is 3.14×100 , or 314 feet.

To determine the radius of the roof, divide the feet diameter by 2

$$100 \text{ feet} \div 2 = 50 \text{ feet}$$

To determine the area of the roof, use the formula: $A = \pi \times r^2$

$$A = 3.14 \times (50 \text{ feet})^2 = 3.14 \times (2500) = 7,850 \text{ square feet}$$

If the tank bottom was the same diameter as the roof, then the total area of the tank bottom is the same as the area of the roof (7,850 square feet in this example).

The surface area of the shell is determined by multiplying the height of the tank shell by the circumference: $50 \text{ feet} \times 314 \text{ feet} = 15,700 \text{ square feet}$

If the entire interior of the tank is being coated, the surface area is the sum of the areas of the roof, floor, and shell ($7,850 \text{ square feet} + 7,850 \text{ square feet} + 15,700 \text{ square feet} = 31,400 \text{ square feet}$)

Calculating the Surface Area of a Pipe



The surface area of a pipe can be calculated by knowing the circumference of the pipe (calculated using the same formula used to determine the circumference of a circle) and the length of the pipe. The circumference is multiplied by the length of the pipe to determine the total area (in square meters or square feet). If the inside diameter (ID) and outside diameter (OD) of the pipe are significantly different (due to pipe wall thickness), the total interior surface area may be significantly less than the total exterior surface area of the pipe.

Example 13 (metric)

This first example uses the metric system. The pipe has a 0.6 meter outside diameter and is 12 meters long:

$$C = \pi \times d, \text{ where } \pi (\text{pi}) = 3.14 \text{ and } d = \text{diameter of the pipe}$$

If the diameter of the pipe is 0.6 meter, the circumference is (3.14×0.6) , or 1.9 meters.

To determine the surface area of the exterior of the pipe, multiply the length by the circumference:

$$12 \text{ meters} \times 1.9 \text{ meters} = 22.80 \text{ square meters}$$

Example 14 (US standard)

This second example uses the US standard system. The pipe is 2 feet in outside diameter and 40 feet in length:

$$C = \pi \times d, \text{ where } \pi (\text{pi}) = 3.14 \text{ and } d = \text{diameter of the pipe}$$

If the diameter of the pipe is 2 feet, the circumference is (3.14×2) , or 6.3 feet.

To determine the surface area of the exterior of the pipe, multiply the length by the circumference:

$$40 \text{ feet} \times 6.3 \text{ feet} = 252 \text{ square feet}$$

Calculating Volume

A coatings inspector may be required to estimate the total volume of liquid that a tank or vessel can hold. The formulas for calculating volume are shown below. It is more likely that a coatings inspector will need to calculate the volume of mixed coating and the volume of thinner that can be added to the coating and still conform to the coating manufacturers instructions, as well as Volatile Organic Compound (VOC) regulations. Examples of these types of calculations are also provided in this section.

Example 15

The volume of a box is calculated using the formula:

$V = l \times w \times h$, where

l = length

w = width

h = height

If the box is 3 feet long, 2 feet wide, and 4 feet high, the volume inside the box is:

$$3 \text{ feet} \times 2 \text{ feet} \times 4 \text{ feet} = 24 \text{ cubic feet}$$

Example 16

The volume (V) of a cylinder (i.e., a tank) can be calculated by determining the surface area of the roof and multiplying by the height. Note this is the same approach for the box above because in the formula above, the surface area of one end of the box is determined (3 feet x 2 feet) and multiplied by the height (4 feet). In the case of the cylinder, the surface area of the roof is determined by the formula $\pi \times r^2$ as discussed earlier in the module, with this result multiplied by the height of the tank. The formula for the volume of a tank is therefore:

$V = \pi \times r^2 \times h$, where

$\pi = 3.14$

r = radius of the tank

h = height of the tank

If the radius of the tank is calculated to be 9 meters and the height of the tank is 10 meters, the volume that the tank will hold (in liters) is calculated as:

$$3.14 \times (9 \text{ meters})^2 \times 10 \text{ meters} = 2,543 \text{ cubic meters.}$$

To convert cubic meters to liters, multiply by 1,000. Therefore, the volume that the tank can hold is 2,543,000 liters.

Example 17

If the radius of the tank is calculated to be 30 feet and the height of the tank is 50 feet, the volume that the tank will hold (in gallons) is calculated as:

$$3.14 \times (30 \text{ feet})^2 \times (50 \text{ feet}) = 141,300 \text{ cubic feet}$$

To convert cubic feet to gallons, multiply by 7.48 since there are 7.48 gallons in a cubic foot. Therefore, the volume that the tank can hold is 141,300 cubic feet x 7.48 gallons per cubic foot = 1,056,924 gallons

While the information above may be useful to an inspector, it is perhaps more useful to be able to calculate the volume of mixed coating and the volume of thinner that can be added to the mixed coating.

To calculate the volume of mixed coating and thinner, some basic conversion factors may be needed.

1. There are 3.79 liters in 1 US Gallon
2. There are 29.6 milliliters in 1 ounce
3. There are 1000 milliliters in 1 liter
4. There are 128 ounces in 1 US gallon

Example 18 (metric)

Step 1: A container holding 4 liters of Part A is combined with a container holding 1 liter of Part B. The total mixed volume will be 5 liters.

Step 2: If the coating in Step 1 is to be thinned 5%, the total volume of coating (5 liters) is multiplied by 0.05, which equates to 0.25 liter (5 liters x 0.05 = 0.25 liter).

Step 3: Convert 0.25 liter to milliliters for more accuracy. There are 1000 milliliters in a liter.

Multiply 0.25×1000 milliliters = 250 milliliters. If 250 milliliters of thinner are added to 5 liters of mixed coating, the coating will have been thinned 5% by volume.

Example 19 (US standard)

Step 1: A container holding 4 gallons of Part A is combined with a container holding 1 gallon of Part B. The total mixed volume will be 5 gallons.

Step 2: If the coating in Step 1 is to be thinned 5%, the total volume of coating (5 gallons) is multiplied by 0.05, which equates to 0.25 gallon (5 gallons x 0.05 = 0.25 gallon).

Step 3: Convert 0.25 gallon to ounces for more accuracy. There are 128 ounces in a gallon.

Multiply $128 \text{ ounces} \times 0.25 = 32$ ounces. If 32 ounces (1 US quart) of thinner are added to 5 gallons of mixed coating, then the coating will have been thinned 5% by volume.

Converting Milliliters/Liter to Percentage

If the coating manufacturer or prevailing conditions require the mixed material (liters) to be reduced (thinned) using a given amount of thinner (e.g., milliliters or liters of thinner), the amount of thinner added will have to be converted to a percentage, so that the applied wet film thickness can be increased to provide the desired dry film thickness. The formula for adjusting the wet film thickness (based on percentage of thinner addition) will be described in Module 5. The example below shows how to convert a given volume of added thinner to a percentage of thinner added.

If the coating manufacturer requires the coating to be thinned 30 milliliters/liter, the first step is to convert the liter to milliliters (there are 1000 milliliters in a liter). Next, divide the amount of thinner added by the volume of paint being thinned. In this example 30 milliliters of thinner is divided by 1000 milliliters of paint ($30 \div 1000 = 0.03$). By moving the decimal two places to the right, the percentage of thinner that can be added to the coating and conform to the manufacturers instructions is 3% of the total volume of coating mixed.

Converting Ounces/Gallon to Percentage

If the manufacturer requires the coating to be thinned 8 ounces/gallon, the first step is to convert gallons to ounces (there are 128 ounces in a gallon). Using the same formula as discussed above, 8 ounces of thinner is divided by 128 ounces of coating to determine the percentage of thinner added ($8 \div 128 = 0.06$). By moving the decimal two places to the right, the percentage of thinner that can be added to the coating and conform to the manufacturers instructions is 6% of the total volume of coating mixed.

Converting Volatile Organic Compound (VOC) Content Values

The Volatile Organic Compound (VOC) content of a coating represents any compound of carbon that evaporates from a coating and photochemically reacts with solar radiation (sunlight) and contributes to air pollution. Note that not all solvents are addressed under the air pollution regulations. There are “exempt” solvents in paints that are not included in the VOC content value because they do not undergo very significant photochemical reactions in sunlight. Water is one example of an exempt solvent, as water does not contribute to poor air quality upon evaporation. The VOC content of a coating is listed on a coating manufacturer’s product data sheet. Most manufacturers also list the adjusted VOC content when a specific type and amount of thinner is added to the coating for purposes of application. More information on VOC content in industrial coatings is provided in Module 6 of this course.

The VOC content of a coating may be expressed using the metric system or standard US system. The coatings inspector may be required to convert from one form to another.

If the VOC content of a coating material is expressed in grams/liter (g/L) and the inspector must convert it to pounds/gallon to verify conformance to the project specification, the value in g/L is divided by 119.8. If the VOC content of a coating material is expressed in pounds/gallon (lbs./gal) and the inspector must convert it to g/L to verify conformance to the project specification, the value in lbs./gal is multiplied by 119.8. An example of each of these conversions is shown below.

Example 20

Converting grams/liter (g/L) to pounds/gallon (lbs./gal.)

The coating contains 343 grams/liter of non-exempt solvents.

$$343 \text{ g/L} \div 119.8 = 2.86 \text{ lbs./gal.}$$

Example 21

Converting pounds/gallon (lbs./gal.) to grams/liter (g/L)

The coating contains 3.4 pounds/gallon of non-exempt solvents.

$$3.4 \text{ lbs/gal} \times 119.8 = 407.3 \text{ g/L}$$

Converting Temperature

Temperature can be expressed in degrees Fahrenheit (°F) or in degrees Celsius (°C). The Fahrenheit scale is the scale where the boiling point of water is 212° and the freezing point of water is 32° under standard atmospheric conditions. It is the primary scale used in the US to report temperature. The Celsius scale is the metric version of the Fahrenheit scale where the boiling point of water is 100° and the freezing point of water is 0° under standard atmospheric conditions. You may hear it referred to as a “centigrade” scale, although this term is no longer used.

A coatings inspector may need to convert from °F to °C, or from °C to °F to meet specification requirements. There are many conversion charts that convert one temperature unit to another at a glance. However, if no conversion table is readily available, the temperatures can be converted from one to another using two simple formulas shown below. A conversion chart is appended to this module.

If the temperature in °F is known, and needs to be converted to °C, the following formula can be used:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32 ^{\circ}\text{F}) \div 1.8$$

If the temperature in °C is known, and needs to be converted to °F, the following formula can be used:

$$^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32 ^{\circ}\text{F}$$

Example 22: Converting from Fahrenheit to Celsius

The temperature is 83°F

$$^{\circ}\text{C} = (83 ^{\circ}\text{F} - 32 ^{\circ}\text{F}) \div 1.8 = (51 ^{\circ}\text{F}) \div 1.8 = 28.3 ^{\circ}\text{C}$$

Example 23: Converting from Celsius to Fahrenheit

The temperature is 5 °C

$$^{\circ}\text{F} = (1.8 \times 5 ^{\circ}\text{C}) + 32 ^{\circ}\text{F} = (9) + 32 ^{\circ}\text{F} = 41 ^{\circ}\text{F}$$

Converting Units Used to Express Coating Thickness and Surface Profile Depth

Surface profile depth (described in Module 3) and coating thickness (described in Module 5) can be expressed in either mils or micrometers. One mil is equivalent to 0.001 inch; One micrometer is equivalent to 0.001 millimeter. Oftentimes the term micrometer is abbreviated as “micron.” The symbol for micrometer or micron is μm . There are 25.4 microns in a mil.

A coatings inspector may need to convert from one unit to another to verify conformance to a project specification and/or the coating manufacturer’s instructions. For example, if the surface profile is expressed in micrometers (μm) or microns, but the inspection equipment used to measure the surface profile depth displays the value in mils, then the inspector will need to convert from mils to microns to verify conformance. Conversely, if the coating thickness is displayed from the gage in microns and the project specification lists the specified coating thickness in mils, the inspector will need to convert

from microns to mils to verify conformance. To convert from mils to microns, the value in mils is multiplied by 25.4; to convert from microns to mils, the value in microns is divided by 25.4. An example of each of these situations is provided below.

Example 24: Converting from mils to micrometers (microns)

Measured surface profile depth: 3.5 mils
Conversion to microns: $3.5 \text{ mils} \times 25.4 = 88.9 \text{ } \mu\text{m}$

Example 25: Converting from micrometers (microns) to mils

Measured coating thickness: $125 \text{ } \mu\text{m}$
Conversion to mils: $125 \text{ } \mu\text{m} \div 25.4 = 4.9 \text{ mils}$

Calculating Wet Film Thickness

Prior to mixing, thinning and applying the coating, the contractor should determine the target wet film thickness to apply to achieve the specified DFT. Some coating manufacturers list the wet film thickness or “WFT” on the product data sheet (many do not). Even if the target WFT is listed on the PDS, the contractor must ensure that the recommended dry film thickness or “DFT” is the same as the specified DFT for the product. Further, if the coating will be reduced (thinned), the target WFT must be adjusted based on the amount of thinner added, so the manufacturer’s target WFT will no longer be representative. The bottom line is that the contractor and/or the applicator should be knowledgeable in how to calculate a target wet film thickness. In most cases, the inspector is concerned with the dry film thickness and not the wet film thickness. But the contractor must ensure that the proper wet film thickness is applied, in order to comply with the dry film thickness requirements of the specification. If the coating is applied too thin or too thick, then rework is often required.

Calculating the Target Wet Film Thickness

Before you measure the wet film thickness, you will need to calculate the target wet film thickness for the applicator to shoot for by obtaining three values. Without these values, the target wet film thickness (WFT) remains unknown unless it is provided by the coating

manufacturer. Also, attempts to determine the WFT without the help of a calculator can result in mathematical errors, so use your calculator.

Value No. 1: The target dry film thickness (DFT)

Value No. 2: The solids by volume content of the coating material

Value No. 3: The amount of thinner that will be added to the coating

Let's look at each of these a little closer to determine where the three values come from.

Step 1: Determine Value No. 1 – The Target Dry Film Thickness

The target dry film thickness (DFT) is indicated in the project specification. It is typically expressed in mils (0.001") or microns (μm). There are 25.4 μm in 1 mil. If the project specification does not provide the target DFT, then you will need to locate the recommended DFT on the coating manufacturer's application instructions. In either case, write down the target DFT. If the project specification or the manufacturer's instructions provide a range for the DFT rather than a target, then write down the range.

Example: *"The primer coat shall be applied to a dry film thickness (DFT) of 51-102 microns (2-4 mils)."*
Write down: 51-102 microns DFT
(2-4 mils DFT)

Step 2: Determine Value No. 2 – The Solids by Volume Content of the Coating Material

When the solids by volume content is indicated on the coating manufacturer's product data sheet, it is typically expressed as a percent (%). This value represents the non-volatile or non-evaporative content of a coating (e.g., the resin, pigment and additives). Often there is a solids by weight value on the product data sheet as well. Do not use this value in determining WFT requirements.

Example: *Solids by Volume: 47%*

If the solids by volume content is not listed on the coating manufacturer's product data sheet, there are two ways to determine it, depending on whether or not you are working in metric units.

Metric Example

1. Start with the standard rule of coating coverage: One liter of coating that is 100% solids by volume will cover 149 square meters if it is applied exactly 25.4 microns thick.
2. Determine coverage rate at 25.4 microns. Locate the theoretical coverage rate and dry film thickness that the coverage rate is based on using the coating manufacturer's product data sheet. Multiply the two numbers together to determine the coverage rate at 25.4 microns.

Example: *The theoretical coverage rate is
37 square meters per liter at 76 microns.
 $76 \div 25.4 = 3$
 $37 \times 3 = 111$ square meters per liter at
25.4 microns dry film thickness*

3. Calculate the solids by volume content. Divide the theoretical coverage rate at 25.4 microns by 149.

Example: *The theoretical coverage rate is
111 square meters per liter at 25.4 microns.
 $111 \div 149 = 0.74$*

4. Convert the solids content to a percentage. Multiply the volume solids value by 100.

Example: *$0.74 \times 100 = 74\%$ solids by volume*

U.S. Customary Units Example

You can use the value for the “theoretical coverage rate at 1 mil” on the product data sheet to estimate the solids by volume content of the coating. This can be a little more challenging, so you’ll need to follow these next few steps carefully and you’ll need to use your calculator.

1. **Start with the standard rule of coating coverage:** One US gallon of coating that is 100% solids by volume will cover 1,604 square feet if it is applied exactly 1 mil thick.
2. **Determine coverage rate at 1 mil.** Locate the theoretical coverage rate and the dry film thickness that the coverage rate is based on using the coating manufacturer's product data sheet. Multiply the two numbers together to determine the coverage rate at 1 mil.

Example: *The theoretical coverage rate is 401 square feet per gallon at 3 mils. $401 \times 3 = 1203$ square feet per gallon at 1 mil dry film thickness.*

3. **Calculate the solids by volume content.** Divide the theoretical coverage rate at 1 mil by 1,604.

Example: *The theoretical coverage rate is 1,203 square feet per gallon at 1 mil.*
 $1203 \div 1604 = 0.75$

4. **Convert the solids content to a percentage.** Multiply the volume solids value by 100.

Example: *$0.75 \times 100 = 75\%$ solids by volume*

Step 3: Determine Value No. 3 – The Amount of Thinner that will be added to the Coating

Most industrial coatings do not require thinning unless a low temperature increases the viscosity of the coating. Unnecessary thinning should be avoided. Over thinning a coating may violate air pollution regulations.

If the project specification and the coating manufacturer permit thinner to be added to the coating, the amount of thinner that will be added must be taken into consideration when calculating a target wet film thickness. This is because the thinner is part of the wet film that is applied to the surface, but is not part of the dry film that remains on the surface (the thinner will evaporate into the air).

Coating manufacturers typically communicate the amount of thinner to add based on a percentage of the total volume of coating mixed for application (e.g., 15%), or based on a certain volume (1 pint per gallon). Ultimately, you will need a “percent thinner” value for your calculation. If the coating manufacturer provides the percentage of thinner to add, then no further work is required. If the coating manufacturer indicates thinner addition by volume, then you will need to calculate the percentage using some very basic units of measurement.

- a) There are 4 quarts in 1 US gallon. A quart is 25% (1/4) of 1 US Gallon

- b) There are 8 pints in 1 US gallon. A pint is 12.5% (1/8) of 1 US Gallon

Example: *The coating was thinned 1 pint per gallon, or 12.5%*

Now that we have all three values (target DFT, percent solids by volume and percent thinner), we can calculate the target WFT.

Step 4: Select a Formula

There are two formulas. Select only one of the two formulas when calculating a wet film thickness. The formula you should select is based on whether or not the coating was thinned prior to use. Here are the two formulas. Formula A is one step, while Formula B requires two steps.

Formula A (NO thinner addition)

$\text{DFT} \div \% \text{ solids by volume} = \text{WFT}$

Formula B (WITH thinner addition)

Step 1: $\% \text{ solids by volume} \div (100\% + \% \text{ thinner added}) =$
adjusted volume solids content

Step 2: $\text{DFT} \div \text{adjusted volume solids content} = \text{WFT}$

Step 5: Enter the Values into the Formula Selected in Step 4

Once you select a formula, enter the values into the formula to arrive at the wet film thickness range. Remember, ALL percentage values must be converted to decimal format, simply by moving the decimal point two places to the left. For example, 75% is 0.75

Example 1 – DFT range of 51-102 microns (2-4 mils) with no thinner added. The solids by volume is 75%. Use Formula A:

*51 microns (2 mils) $\text{DFT} \div 0.75 \text{ solids by volume} =$
68 microns (2.7 mils) WFT*

*102 microns (4 mils DFT) $\div 0.75 \text{ solids by volume} = 135 \text{ microns}$
(5.3 mils WFT)*

Therefore, the applicator should strive to apply the coating within a range of 63-140 microns (2.5-5.5 mils) WFT.

Example 2 – DFT range of 51-102 micrometers (2-4 mils) with 12.5% thinner added. Use Formula B:

(75% solids by volume ÷ 112.5%) = 67% adjusted volume solids content

51 microns (2 mils) DFT ÷ 0.67 solids by volume =

76 microns (3.0 mils) WFT

102 microns (4 mils) DFT ÷ 0.67 solids by volume =

152 microns (6.0 mils) WFT

Therefore, the applicator should strive to apply the coating within a range of 76-152 microns (3-6 mils) WFT. Even with the addition of 12.5% thinner, the coating should “shrink” to 51 to 102 microns (2-4 mils) DFT.

The percentage of solids by volume content of a coating remains a key component in the calculation of the wet film thickness. Unfortunately, the published value may be “theoretical” and based on the formulation. Therefore, the contractor may choose to apply a test area of the coating (thinned if appropriate), measure the wet film thickness, then after the coating dries on the test area, measure the dry film thickness. This will provide the applicators with a “practical” wet film target. If the resulting dry film thickness meets the requirements of the specification, the actual volume solids content of the coating material becomes a moot point. Conversely, if the resulting dry film thickness is too low or too high, the actual percentage of volume solids can be calculated as long as the wet film and dry film thickness is known. Then the revised target wet film thickness can be calculated. This is demonstrated below. Concurrently, the applied coating film can be evaluated for flow characteristics, resistance to sag, etc.

Target DFT (from the specification): 127 microns (5 mils)

Calculated Target WFT (based on 67% solids by volume):
203 microns (8 mils)

Actual WFT (measured): 203 microns (8 mils)

Actual DFT (measured): Only 102 microns (4 mils)

$(\text{Actual DFT} / \text{Actual WFT}) \times 100 = \text{Adjusted Percent Volume Solids Content}$

$102 \div 203 \text{ microns } (4 \div 8 \text{ mils}) \times 100 = .50 \text{ or } 50\%$

Revised Target WFT = $127 \text{ microns } (5 \text{ mils DFT}) \div 0.50 =$
254 microns (10 mils)WFT

Calculating Coating Coverage Rates and Estimating Material Quantities

The coatings inspector is not responsible for ordering coating materials and thinners for a project. That responsibility lies with the facility owner or the contractor. However, the inspector may be required to verify that there is an adequate amount of each coating material and thinner on-site, in order to prevent project delays associated with material shortages.

Coating manufacturers frequently provide a rate of coverage (square meters per liter, or square feet per gallon) on their product data sheets. However, this rate is theoretical (does not include any material losses) and is based on their recommended coating thickness (in microns or mils), which may or may not be the same as that required by the project specification. The theoretical coverage rate (based on the specified coating thickness) can be calculated using the information below.

All coating manufacturers calculate the theoretical coverage rates of their products based on one of two standard formulas.

“Four liters of 100% volume solids paint will cover 149 square meters of smooth surface, when applied 25 microns thick,” or

“One gallon of 100% volume solids paint will cover 1,604 square feet of smooth surface, when applied 1 mil thick.”

Based on the actual volume solids (from the coating manufacturers' product data sheet) and target coating thickness (from the project specification), the theoretical coverage rate can be calculated, as illustrated below.

For example, assume that the project specification requires that the coating be applied 100-150 microns (4-6 mils) thick (dry), and that the volume solids content of the coating is 65%. The theoretical coverage rate can be calculated as:

Example 26 – Metric Coverage Rates

149 square meters/4 liters $\div$ 6 (which is $150 \div 25$) = 25 square meters/4 liters (with no losses) if the coating is 100% solids. Since the coating is less than 100%, the coverage rate is reduced by multiplying the theoretical coverage by the percent solids by volume of the coating material:

25 square meters/4 liters $\times$ 0.65 = 16.3 square meters/4 liters when applied at the specified 150 microns dry film thickness. Note that the coverage rate would be further reduced by material losses during application.

Example 27 - US Standard Coverage Rates

1604 square feet/gallon $\div$ 6 mils = 267 square feet/gallon of coverage (with no losses) if the coating is 100% solids. Since the coating is less than 100%, the coverage rate is reduced by multiplying the theoretical coverage by the percent solids by volume of the coating material:

267 square feet/gallon $\times$ 0.65 = 174 square feet per gallon when applied at the specified 6 mils dry film thickness. Note that the coverage rate would be further reduced by material losses during application.

Example 28 (metric) Total Amount of Coating Required Without Consideration of Losses

If the project encompassed 4,000 square meters of smooth structural steel, a minimum of 246 4-liter containers of primer will be required without any consideration for material losses ($4,000 \text{ square meters} \div 16.3 \text{ square meters/4 liters} = 246 \text{ 4-liter containers}$).

Example 29 (US standard) Total Amount of Coating Required Without Consideration of Losses

If the project encompassed 35,000 square feet of smooth structural steel, a minimum of 202 gallons of primer will be required without any consideration for material losses (35,000 square feet ÷ 174 square feet per gallon = 202 gallons).

As indicated above, this assumes that every drop of paint that is mixed will be transferred to the surface. This is not possible due to mixing and application losses. Quantifying these losses can be challenging, and is dependent on the transfer efficiency of the application method, as well as other factors such as the size of kits available (e.g., if all kits are 5 gallons or larger, a few gallons may have to be discarded at end of each day after all prepared surfaces have been coated). And coating manufacturers do not provide any specific written guidance on their data sheets, other than a statement like, “Allow for losses due to mixing and application.”

In order to calculate a practical coverage rate, an estimation of the transfer efficiency must be made, and is based on the porosity of the substrate, the complexity of the structure being coated, the method of application, etc. For example, brush and roller application to large, flat surfaces will generate a very high transfer efficiency rating, while spray application to intricate parts will typically generate a lower transfer efficiency rating. It is up to the contractor or material estimator to generate a transfer efficiency rating based on the specifics of the project. For illustration purposes, we will assume a 20% loss, or an 80% “transfer efficiency.” The “practical” coverage rate is calculated by multiplying the theoretical coverage rate (above) by the transfer efficiency, as shown below:

Example 30 (metric) Coverage Considering Transfer Efficiency

16.3 square meters/4 liters x 0.80 = 13.0 square meters/4 liters

Example 31 (US standard) Coverage Considering Transfer Efficiency

174 square feet per gallon x 0.80 = 139 square feet per gallon.

Based on this practical coverage rate, the number of 4-liter containers of paint required to coat 4,000 square meters of smooth steel increases from 231 to 290 (4,000 square meters ÷ 13.0 square meters per 4 liters). The number of gallons of paint required to coat 35,000 square feet of smooth steel increases from 202 gallons to 252 gallons (35,000 square feet ÷ 139 square feet per gallon).

The final factor that has an impact on the amount of *primer* to order includes the surface profile. For example, if the primer is applied to a blast cleaned surface with a nominal surface profile of say 75 µm (3 mils), the contractor should figure on using as much as 25% of the primer to fill the anchor pattern before building up the thickness that is measured, since dry film thickness is measured from the tops of the peaks (the actual percentage used depends on the thickness of the primer). Imparting a surface profile into a steel surface effectively increases surface area. It makes sense then that the larger the surface (more surface area), the more coating that will be required.

So our practical coverage rate of 13.0 square meters/4 liters (139 square feet per gallon) will not be accurate for the primer coat applied to an abrasive blast cleaned surface with a 75 µm (3 mil) anchor pattern. The coverage rate for the primer must be adjusted as shown below (based on 25% loss in the anchor pattern):

Example 32 (metric) Revised Coverage Rates Considering Material Requirements to Fill Profile

13.0 square meters/4 liters x 0.75 = 9.8 square meters/4 liters

Example 33 (US standard) Revised Coverage Rates Considering Material Requirements to Fill Profile

139 square feet per gallon x 0.75 = 105 square feet per gallon

Note that this step is only required for estimating the amount of primer required, since subsequent coats will be applied to a relatively smooth surface.

Example 34 (metric) Total Amount of Coating Required With Consideration of Losses

4000 square meters ÷ 9.8 square meters/4 liters = 408-4 liter containers

Example 35 (US standard) Total Amount of Coating Required With Consideration of Losses

35,000 square feet ÷ 105 square feet per gallon = 334 gallons

Example 36 Metric Example Summary

Remember we started with a theoretical coverage rate of 16.3 square meters per 4-liters and a 246 4-liter material (primer) order. After estimating material losses and surface roughness, we ended with a practical coverage rate of 9.8 square meters/4-liters and a 408-4 liter material order to coat 4,000 square meters with primer. If material losses and surface profile consumption were not accounted for, the contractor would have been short 162-4 liter containers of primer.

Example 37 US Standard Example Summary

Remember we started with a theoretical coverage rate of 174 square feet/gallon and a 202 gallon material (primer) order. After estimating material losses and surface roughness, we ended with a practical coverage rate of 105 square feet/gallon and a 334 gallon material order to coat 35,000 square feet with primer. If material losses and surface profile consumption were not accounted for, the contractor would have been short 132 gallons of primer.

If the contractor plans to thin every mixed lot of coating by 15%, then the total quantity of coating must be multiplied by 15% to obtain the quantity of thinner that must be ordered. Note that this does not include clean-up solvent; only thinner to reduce the viscosity of the coating. Remember to convert 15% to decimal format, as shown below.

Example 38 (metric) Example for Thinner Requirements

385-4 liter containers of primer x 0.15 = 58-4 liter containers of thinner

Example 39 (US standard) Example for Thinner Requirements

334 gallons of primer x 0.15 = 50 gallons of thinner

Summary

This module provided a review of common arithmetic that a coatings inspector may use during basic coatings inspection, including: averaging of values; converting percentages to decimal format; calculating area (square foot and square meters); calculating volume and converting from milliliters/liter (ounces/gallon) to percentage of thinner addition; converting VOC values; converting temperatures; and converting units of measurement for surface profile depth and paint thickness (microns/mils). The procedures used to calculate coating material quantities based on theoretical and practical coverage rates was also described in this module.

	Module Four
	Practical Arithmetic for the Protective Coatings Inspector

	Module Four Learning Outcomes
	Comprehension of Module Four will enable the participant to: ■ Apply practical arithmetic to calculations relating to everyday coatings inspection activities

	Introduction
■ Arithmetic can be challenging ■ Coatings inspectors use basic arithmetic skills daily ■ SSPC "Practical Math for the Protective Coatings Industry" ■ Use a calculator ■ "Practice makes perfect"	

	Introduction, con't.
	■ Averaging values ■ Converting percentages to decimal format ■ Calculating area ■ Calculating volume ■ Converting mL/L to % ■ Converting VOC content values ■ Converting temperatures ■ Converting units of measurement (for surface profile and coating thickness) ■ Calculating coating material and thinner quantities ■ Calculating WFT

	Averaging a Set of Values
	■ Applies to surface profile measurements and coating thickness measurements ■ Sum all values in the data set, then divide by the number of values in the data set.

	Averaging a Set of Values
	Example 1: Averaging Surface Profile Measurements (in microns) Area 1: Measurement (1) 65 microns Measurement (2) 75 microns Measurement (3) 50 microns Step 1: Calculate the Sum $(65 + 75 + 50) = 190$ microns Step 2: Divide the Sum (190) by the number of values in the set (3) $190 \div 3 = 63.3$ microns Step 3: Round to 63 microns, since measurements only contain 2 significant figures

Averaging a Set of Values

*Example 3:
Averaging Dry Film Thickness Measurements (in microns)*

Spot 1: Measurement (1) 100 microns
Measurement (2) 125 microns
Measurement (3) 137 microns

Step 1: Calculate the Sum ($100 + 125 + 137 = 362$ microns)

Step 2: Divide the Sum (362) by the number of values in the set (3) $362 \div 3 = 120.7$ microns

Step 3: Round to 121 microns, since measurements only contain 3 significant figures

Converting Percentages to Decimal Format

- Volume solids content of coatings and allowable thinner addition often expressed as percentages
- Percentage must be converted to decimal format for use in calculations
- To convert percent value to decimal format, move decimal 2 places left & remove "%" sign

Converting Percentages to Decimal Format

*Example 5:
Volume Solids Content is 67%*

Step 1: 67, %

Step 2: 0.67

So 67% in decimal format is 0.67

Converting Percentages to Decimal Format

*Example 7:
Reduce (thin) the mixed volume of 40 liters of coating using 15% thinner*

Step 1: ↑ 15, %

Step 2: ↑ 0.15

So 15% in decimal form is 0.15

Step 3: 40 liters of mixed coating $\times 0.15 = 6$ liters of thinner

Calculating Area

- Useful for:
 - Determining no. of coating thickness measurements (per SSPC PA2, described in Module 5)
 - Reporting daily progress
 - Verifying sufficient coating quantities
 - Focus on 3 shapes: steel plate, I-beams and pipe/cylinders

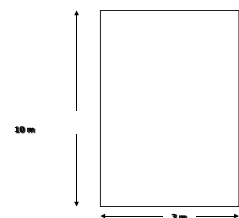
Calculating Area-Plate

- Calculating area of plate or wall section

➢ Area = Length $\times$ Width

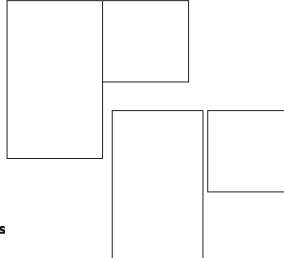
➢ $10 \text{ m} \times 3 \text{ m} = 30$ square meters

➢ If coating both sides, double the area (60 square meters)



Calculating Area-Plate

- Calculating area of irregular plate or wall
 - Area = Length x Width (Divide into separate sections)
 - Section 1: 9 meters x 4 meters
9 x 4 = 36 square meters
 - Section 2: 5 meters x 4 meters
5 x 4 = 20 square meters
 - Section 1 + Section 2
36 + 20 = 56 square meters



Calculating Area-I Beam

- Steel or Concrete "I" Beams
- Area = Length x Width
- Two Flanges (4 sides)
- One Web (2 sides)
- Multiple stiffeners (2 sides)



Calculating Area-I Beam

1. Measure length (L) & width (W) of one flange. $L \times W$ = Area of 1 flange side.
 2. Multiply area of flange x 4 (4 sides), ignoring flange thickness*
- * If edges are included, measure length & thickness of one edge.
 $L \times W$ = Area of 1 flange edge. Multiply area of flange edge x 4 (4 edges).*

Calculating Area-I Beam

3. Measure length (L) & width (W) of web.
 $L \times W$ = Area of 1 web side.
4. Multiply area of web x 2 (2 sides)
5. Measure length (L) & width (W) of stiffener.
 $L \times W$ = Area of 1 stiffener side.
6. Multiply area of stiffener x 2 (2 sides)
7. Multiply area of stiffener by no. of stiffeners
8. Add flange (with or without edges), web and stiffener area together

Calculating Area-I Beam

- *Example 9: A 12 meter long I-beam has a 1.2 meter web, 0.6 meter flanges and eight (8) - 0.15 meter wide by 1.2 meters long stiffeners.*
- Step 1: 12 meters (length) x 0.6 meter (width)
(12 x 0.6) = 7.2 square meters
- Step 2: 7.2 square meters x 4 = 28.8 square meters
- Step 3: 12 meters (length) x 1.2 meters (width) = 14.4 square meters
- Step 4: 14.4 square meters x 2 = 28.8 square meters

Calculating Area-I Beam

- *Example 9, continued*
- Step 5: 1.2 meters (length) x 0.15 meter (width) = 0.18 square meter
- Step 6: 0.18 x 2 = 0.36 square meter
- Step 7: 0.36 square meter x 8 stiffeners = 2.9 square meters
- Step 8: 28.8 square meters (flanges) + 28.8 square meters (web) + 2.9 square meters (stiffeners) = 60.5 square meters

Calculating Area-Tank

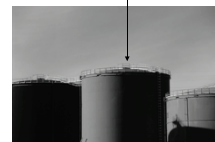
1. Calculate circumference (C) of roof
 $C = \pi \times d$, where (π) = 3.14 and d = diameter of the roof



2. Calculate radius (r) of roof
 $r = \text{roof diameter} \div 2$

Calculating Area-Tank

3. Calculate area of roof
 $A = \pi \times r^2$, where (π) = 3.14 and r^2 = radius of roof squared



4. Repeat 1-3 for floor. If same, double roof area

Calculating Area-Tank

5. Calculate surface area of shell
 (height of tank x circumference)



6. Sum areas [roof and shell (interior and exterior), and floor (interior only)]

Calculating Area-Tank

Example 10: Coat exterior of a ground storage tank 40 meters high with 30 meter diameter roof

1. Calculate circumference (C) of roof
 $C = (\pi) \times d$
 $C = 3.14 \times 30 = 94.2 \text{ meters}$
2. Calculate radius (r) of roof
 $r = \text{roof diameter} \div 2$
 $r = 30 \div 2 = 15 \text{ meters}$

Calculating Area-Tank

Example 10, continued

3. Calculate area of roof
 $A = (\pi) \times r^2$
 $A = 3.14 \times (15 \text{ meters})^2 = 706.5 \text{ square meters}$
4. Calculate area of floor (not included in this example)

Calculating Area-Tank

Example 10, continued

5. Calculate surface area of shell
 $40 \text{ meters} \times 94.2 \text{ meters} = 3,768 \text{ square meters}$
6. Sum areas:
 Roof: 706.5 square meters
 Shell: +3,768.0 square meters
 4,474.5 square meters

Calculating Area-Pipe

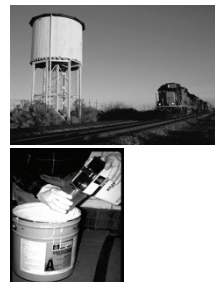
Example 11.
Coat exterior of a pipe 12 meters long and 0.6 meters in diameter

1. Calculate circumference (C) of pipe
 $C = (\pi) \times d$
 $C = 3.14 \times 0.6 = 1.9 \text{ meters}$
2. Area = length of pipe x circumference
 $12 \text{ meters} \times 1.9 \text{ meters} = 22.80 \text{ square meters}$



Calculating Volume

- Used to estimate total volume a tank/vessel can hold
- Used to estimate volume of mixed coating (for thinner addition)



Calculating Volume

Example 12:
Calculating the volume (V) of a tank

$$V = (\pi) \times r^2 \times h$$

$\pi = (3.14)$
 $r = \text{radius of tank}$
 $h = \text{height}$

Tank radius of 9 meters and height of 10 meters
 $3.14 \times (9 \text{ m})^2 \times 10 \text{ m} = 2,543 \text{ cubic meters}$
 $2,543 \text{ cubic meters} \times 1000 = 2,543,000 \text{ liters}$



Calculating Volume

Example 13:

Part A: 4 Liters

Part B: 1 Liter

Total: 5 Liters

5% thinner addition

$$5 \text{ L} \times 0.05 = 0.25 \text{ L}$$

$$0.25 \text{ L} \times 1000 \text{ mL/L} = 250 \text{ mL}$$



Calculating Volume

- Converting Milliliters/Liter to Percent
Example: Manufacturer recommends thinning 30 mL/L

1. Convert liters to milliliters (1000 mL/L)
2. Divide volume of thinner (30 mL) by volume of paint (1000 mL)
3. $30 \div 1000 = 0.03$, or 3%

Converting VOC Content Values

- VOC content in a coating are solvents that react with sunlight and generate poor air quality
- Excludes "exempt" solvents (e.g., water)
- VOC content listed on manufacturers PDS
- VOC content w/ and w/o thinner addition listed
- Expressed in g/L and/or lbs./gal.

Converting VOC Content Values

- **Conversions:**
 - g/L $\longleftrightarrow$ lbs./gal (divide g/L by 119.8)
 - lbs./Gal $\longleftrightarrow$ g/L (multiply lbs./Gal by 119.8)
- **Example 14: Converting to Lbs./Gal**
 - $343 \text{ g/L} \div 119.8 = 2.86 \text{ lbs./gal.}$
- **Example 15: Converting to g/L**
 - $3.4 \text{ lbs./gal.} \times 119.8 = 407.3 \text{ g/L}$

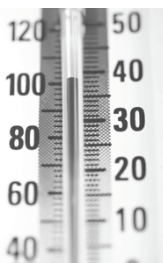
Converting Temperature

- Temperature expressed in Celsius or Fahrenheit
- Celsius
 - Freezing is 0; boiling is 100
- Fahrenheit
 - Freezing is 32; boiling is 212



Converting Temperature

- **Converting from Fahrenheit to Celsius**
 - $^{\circ}\text{C} = (^{\circ}\text{F} - 32^{\circ}\text{F}) \div 1.8$
- **Example 16: Convert 83°F**
 - $(83^{\circ}\text{F} - 32^{\circ}\text{F}) \div 1.8 = 28.3^{\circ}\text{C}$
- **Converting from Celsius to Fahrenheit**
 - $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32^{\circ}\text{F}$
- **Example 17: Convert 5°C**
 - $(1.8 \times 5^{\circ}\text{C}) + 32^{\circ}\text{F} = 41^{\circ}\text{F}$



Converting Units of Coating Thickness and Surface Profile

- Surface profile depth (Module 3) and coating thickness (Module 5) expressed in micrometers (microns, μm) or mils (0.001")
- Conversion
 - $25.4 \mu\text{m} = 1 \text{ mil}$

Converting Units of Coating Thickness and Surface Profile

- **Example 18:**
Converting from mils to microns

- Surface profile: 3.5 mils
 - $3.5 \times 25.4 = 88.9 \mu\text{m}$



Converting Units of Coating Thickness and Surface Profile

- **Example 19:**
Converting from microns to mils

- Coating thickness:
 - $125 \mu\text{m}$
 - $125 \div 25.4 = 4.9 \text{ mils}$

Calculating the Target Wet Film Thickness

- Based on volume solids content of coating
- If volume solids is unknown:
 - Divide theoretical coverage rate into standard coating coverage rate, then convert to a percentage

Calculating a Target Wet Film Thickness

- Calculating Target Wet Film Thickness

$$\text{WFT} = \frac{\text{Target DFT}}{\% \text{ solids by volume}}$$

Example: 127 microns DFT
68% solids by volume (0.68)

Target wet film thickness: 178-203 microns

Calculating a Target Wet Film Thickness

- Effect of Thinner Addition on WFT Target

$$\text{WFT} = \frac{\text{Target DFT}}{\left[\frac{\% \text{ solids by volume}}{100\% + \% \text{ thinner}} \right]}$$

Calculating a Target Wet Film Thickness

- Effect of Thinner Addition, continued

$$\text{WFT} = \frac{127 \text{ microns DFT}}{\left[\frac{68\%}{100\% + 20\% \text{ thinner}} \right]}$$

$$\text{WFT} = \frac{127 \text{ microns DFT}}{68} = 223 \text{ microns}$$

Calculating the Target Wet Film Thickness

- Based on volume solids content of coating
- If volume solids is unknown:
 - Divide theoretical coverage rate into standard coating coverage rate, then convert to a percentage
 - Example:
 - Theoretical coverage rate: 111 sq. meters
 - Standard coverage rate: 149 sq. meters
 - $111 \div 149 = 0.74$ or 74%

Calculating Coating Coverage Rates & Estimating Material Quantities

- Coating inspector may need to verify adequate coating amounts for project
- Theoretical coverage rate on PDS
 - Does not include losses
 - Based on recommended DFT



Calculating Coating Coverage Rates & Estimating Material Quantities
■ Calculating theoretical coverage rates ➢ $m^2/l = \text{Solids by Volume (\%)} \times 10/DFT$ ➢ <i>One gallon of 100% volume solids paint will cover 1,604 square feet of smooth surface, when applied 1 mil thick</i>

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Calculating theoretical coverage rates ➢ Calculation based on <i>actual</i> volume solids content of the coating and <i>specified</i> DFT ■ Data for Examples: ➢ Specified dry coating thickness: 100-150 μm ➢ Actual volume solids content: 65%

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Example 20: $65 \times 10 / 125 \text{ microns} = 5.2 \text{ m}^2/l$

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Example 21: ➢ Project is 4,000 square meters ➢ $4,000 \text{ square meters} \div 5.2 \text{ square meters/liter} = 769.23 \text{ liter containers}$

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Quantifying mixing and application losses ➢ Dependent on transfer efficiency (TE), kit sizes available/used, etc. ➢ Manufacturers do not quantify ➢ Must be estimated based on type and size structure, application method, etc. ➢ For Examples: 20% loss (80% TE)

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Example 22: ➢ Project is 4,000 square meters ➢ $5.2 \text{ square meters/liters} \times 0.80 = 4.16 \text{ square meters/liters}$

	Calculating Coating Coverage Rates & Estimating Material Quantities
	■ Quantifying consumption of primer by surface profile ➢ Coverage rate based on smooth surfaces (okay for estimating intermediate or finish coats) ➢ Abrasive blast cleaning increases surface area ➢ Coating thickness measured from peaks ➢ Primer consumption must be estimated based on surface roughness (and primer thickness) ➢ For Examples: 25% loss in profile (75% TE)

	Calculating Coating Coverage Rates & Estimating Material Quantities
	■ Example 23 & 24: ➢ Project is 4,000 square meters ➢ $4.16 \text{ square meters/liters} \times 0.75 = 3.12 \text{ square meters/liters}$ ➢ $4,000 \text{ square meters} \div 3.12 \text{ square meters/liters} = 1282 \text{ liter containers}$

	Calculating Coating Coverage Rates & Estimating Material Quantities
	■ Example 25 (example summary) ➢ Project is 4,000 square meters ➢ Theoretical coverage rate: 5.2 square meters per liter (769.23 liter primer order) ➢ Practical coverage rate: 3.12 square meters per liter ➢ If losses not accounted for, 1282 liter containers, material shortage

	Calculating Coating Coverage Rates & Estimating Material Quantities
	■ Example 26 (thinner estimation) ➢ Project is 4,000 square meters ➢ 1282 liters primer order ➢ Contractor estimates thinning 15% ➢ $1282 \text{ liters primer} \times 0.15 = 192 \text{ liter containers of thinner}$

	Summary
	■ Review of common arithmetic used by a coatings inspector: ➢ Averaging values ➢ Converting percentages to decimal format ➢ Calculating area ➢ Calculating volume ➢ Converting mL/L to % ➢ Converting VOC content values ➢ Converting temperatures ➢ Converting units of measurement (for surface profile and coating thickness) ➢ Calculating coating material and thinner quantities ➢ Calculating WFT

	Module 4 Workshop
	■ Complete "Problem Sets" ■ Use calculator ■ Work independently ■ Answers will be provided to the class by the instructor

	Module Four
	Practical Arithmetic for the Protective Coatings Inspector

	Module Four Learning Outcomes
	Comprehension of Module Four will enable the participant to: ■ Apply practical arithmetic to calculations relating to everyday coatings inspection activities

	Introduction
■ Arithmetic can be challenging ■ Coatings inspectors use basic arithmetic skills daily ■ SSPC "Practical Math for the Protective Coatings Industry" ■ Use a calculator ■ "Practice makes perfect"	

	Introduction, con't.
	■ Averaging values ■ Converting percentages to decimal format ■ Calculating area ■ Calculating volume ■ Converting mL/L and oz./gallon to % ■ Converting VOC content values ■ Converting temperatures ■ Converting units of measurement (for surface profile and coating thickness) ■ Calculating coating material and thinner quantities ■ Calculating WFT

	Averaging a Set of Values
■ Applies to surface profile measurements and coating thickness measurements ■ Sum all values in the data set, then divide by the number of values in the data set.	

	Averaging a Set of Values
	<i>Example 2:</i> <i>Averaging Surface Profile Measurements (in mils)</i> Area 1: Measurement (1) 2.3 mils Measurement (2) 3 mils Measurement (3) 2 mils Measurement (4) 2.8 mils Step 1: Calculate the Sum ($2.3 + 3 + 2 + 2.8$) = 10.1 mils Step 2: Divide the Sum (10.1) by the number of values in the set (4) $10.1 \div 4 = 2.5$ mils

Averaging a Set of Values

Example 4:
Averaging Dry Film Thickness Measurements (in mils)

Spot 1: Measurement (1) 5.6 mils
Measurement (2) 6.2 mils
Measurement (3) 4.9 mils

Step 1: Calculate the Sum $(5.6 + 6.2 + 4.9) = 16.7$ mils

Step 2: Divide the Sum (16.7) by the number of values in the set (3) $16.7 \div 3 = 5.6$ mils

Converting Percentages to Decimal Format

- Volume solids content of coatings and allowable thinner addition often expressed as percentages
- Percentage must be converted to decimal format for use in calculations
- To convert percent value to decimal format, move decimal 2 places left & remove "%" sign

Converting Percentages to Decimal Format

- Illustrated using US Monetary System
 - US Dollar \$1.00 (100%)
 - Quarter is 25% (\$0.25)
 - Dime is 10% (\$0.10)
 - Nickel is 5% (\$0.05)
 - Penny is 1% (\$0.01)



Converting Percentages to Decimal Format

Example 5:
Volume Solids Content is 67%

Step 1: 67%

Step 2: 0.67

So 67% in decimal format is 0.67

Converting Percentages to Decimal Format

Example 7:
Reduce (thin) the mixed volume of 11 gallons of coating using 15% thinner

Step 1: 15%

Step 2: 0.15

So 15% in decimal form is 0.15

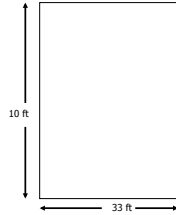
Step 3: 11 gallons of mixed coating $\times 0.15 = 1.65$ gallons of thinner

Calculating Area

- Useful for:
 - Determining no. of coating thickness measurements (per SSPC PA2, described in Module 5)
 - Reporting daily progress
 - Verifying sufficient coating quantities
 - Focus on 3 shapes: steel plate, I-beams and pipe/cylinders

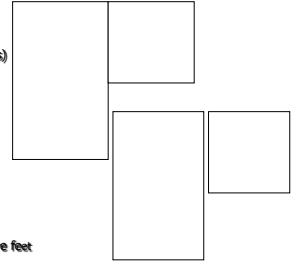
Calculating Area-Plate

- Calculating area of plate or wall section
 - Area = Length x Width
 - 33 feet x 10 feet
 - $33 \times 10 = 330$ square feet
 - If coating both sides, double the area
660 square feet



Calculating Area-Plate

- Calculating area of irregular plate or wall
 - Area = Length x Width
(Divide into separate sections)
 - Section 1:
 $29.5 \text{ feet} \times 13.1 \text{ feet}$
 $29.5 \times 13.1 = 386.5$ square feet
 - Section 2:
 $16.4 \text{ feet} \times 13.1 \text{ feet}$
 $16.4 \times 13.1 = 214.8$ square feet
 - Section 1 + Section 2
 $386.5 + 214.8 = 601.3$ square feet



Calculating Area-I Beam

- Steel or Concrete "I" Beams
- Area = Length x Width
- Two Flanges (4 sides)
- One Web (2 sides)
- Multiple stiffeners (2 sides)



Calculating Area-I Beam

1. Measure length (L) & width (W) of one flange. $L \times W = \text{Area of 1 flange side.}$
2. Multiply area of flange x 4 (4 sides), ignoring flange thickness*

* If edges are included, measure length & thickness of one edge.

$L \times W = \text{Area of 1 flange edge. Multiply area of flange edge} \times 4 \text{ (4 edges).}$

Calculating Area-I Beam

3. Measure length (L) & width (W) of web.
 $L \times W = \text{Area of 1 web side.}$
4. Multiply area of web x 2 (2 sides)
5. Measure length (L) & width (W) of stiffener.
 $L \times W = \text{Area of 1 stiffener side.}$
6. Multiply area of stiffener x 2 (2 sides)
7. Multiply area of stiffener by no. of stiffeners
8. Add flange (with or without edges), web and stiffener area together

Calculating Area-I Beam

- *Example 10: A 40 foot long I-beam has a 4 foot web, 2 foot flanges and eight (8) – 3 inch wide by 4 foot long stiffeners.*

Step 1: 40 feet (length) x 2 feet (width)
 $(40 \times 2) = 80$ square feet

Step 2: 80 square feet x 4 = 320 square feet
(flange area)

Step 3: 40 feet (length) x 4 feet (width) =
160 square feet

Step 4: 160 square feet x 2 = 320 square feet
(web area)

Calculating Area-I Beam

■ *Example 10, continued*

- Step 5: 4 feet (length) x 0.25 foot (width) = 1 square foot
- Step 6: 1 x 2 = 2 square feet (stiffener area)
- Step 7: 2 square feet x 8 stiffeners = 16 square feet
- Step 8: 320 square feet (flanges) + 320 square feet (web) + 16 square feet (stiffeners) = 656 square feet

Calculating Area-Tank

1. Calculate circumference (C) of roof
 $C = \pi \times d$, where (π) = 3.14 and d = diameter of the roof
2. Calculate radius (r) of roof
 $r = \text{roof diameter} \div 2$



Calculating Area-Tank

3. Calculate area of roof
 $A = \pi \times r^2$, where (π) = 3.14 and r^2 = radius of roof squared
4. Repeat 1-3 for floor. If same, double roof area



Calculating Area-Tank

5. Calculate surface area of shell
 (height of tank x circumference)
5. Sum areas [roof and shell (interior and exterior), and floor (interior only)]



Calculating Area-Tank

Example 12: Coat exterior of a ground storage tank 50 feet high with 100 foot diameter roof

1. Calculate circumference (C) of roof
 $C = (\pi) \times d$
 $C = 3.14 \times 100 = 314$ feet
2. Calculate radius (r) of roof
 $r = \text{roof diameter} \div 2$
 $r = 100 \div 2 = 50$ feet

Calculating Area-Tank

Example 12, continued

- Calculate area of roof
 $A = (\pi) \times r^2$
 $A = 3.14 \times (50 \text{ feet})^2 = 7,850$ square feet
4. Calculate area of floor (same as roof)

Calculating Area-Tank

Example 12, continued

5. Calculate surface area of shell
 $50 \text{ feet} \times 314 \text{ feet} = 15,700 \text{ square feet}$
6. Sum areas:
 Roof: 7,850 square feet
 Floor: 7,850 square feet
 Shell: +15,700 square feet
 31,400 square feet

Calculating Area-Pipe

Example 14: Coat exterior of a pipe 40 feet long and 2 feet in diameter

1. Calculate circumference (C) of pipe
 $C = (\pi) \times d$
 $C = 3.14 \times 2 = 6.3 \text{ feet}$
2. Area = length of pipe x circumference
 $40 \text{ feet} \times 6.3 \text{ feet} = 252 \text{ square feet}$



Calculating Volume

- Used to estimate total volume a tank/vessel can hold
- Used to estimate volume of mixed coating (for thinner addition)



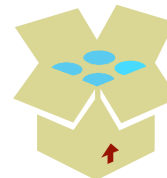
Calculating Volume

Example 15: Calculating the volume (V) of a box

$$V = l \times w \times h$$

l= length
 w= width
 h= height

Box 3' x 2' x 4' = 24 cubic feet



Calculating Volume

Example 17: Calculating the volume (V) of a tank

$$V = (\pi) \times r^2 \times h$$

$$(\pi) = (3.14)$$

r= radius of tank

h=height

Tank radius of 30 feet and height of 50 feet
 $3.14 \times (30 \text{ feet})^2 \times 50 \text{ feet} = 141,300 \text{ cubic feet}$
 $141,300 \text{ cubic feet} \times 7.48 = 1,056,924 \text{ gallons}$



Calculating Volume

- Volumes of mixed coating and thinner

- Conversions:

- 3.79 liters = 1 US Gallon
- 29.6 mL = 1 US Ounce
- 1000 mL = 1 Liter
- 128 Oz. = 1 US Gallon



Calculating Volume

Example 19
Part A: 4 Gallons
Part B: 1 Gallon
Total: 5 Gallons



5% thinner addition
 $5 \text{ Gal} \times 0.05 = 0.25 \text{ Gal}$
 $0.25 \text{ Gal} \times 128 \text{ oz/gal} = 32 \text{ oz (1 US quart)}$

Calculating Volume

- Converting Ounces/Gallon to Percent
Example: Manufacturer recommends thinning 8 oz./gal.
 1. Convert gallons to ounces (128 oz./gal.)
 2. Divide volume of thinner (8 oz) by volume of paint (128 oz)
 3. $8 \div 128 = 0.06$, or 6%

Converting VOC Content Values

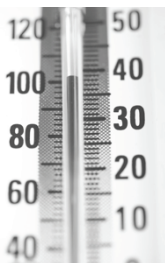
- VOC content in a coating are solvents that react with sunlight and generate poor air quality
- Excludes "exempt" solvents (e.g., water)
- VOC content listed on manufacturers PDS
- VOC content w/ and w/o thinner addition listed
- Expressed in g/L and/or lbs./gal.

Converting VOC Content Values

- Conversions:
 - g/L $\longrightarrow$ lbs./gal (divide g/L by 119.8)
 - lbs./Gal $\longrightarrow$ g/L (multiply lbs./Gal by 119.8)
- Example 20: Converting to Lbs./Gal
- $343 \text{ g/L} \div 119.8 = 2.86 \text{ lbs./gal.}$
- Example 21: Converting to g/L
- $3.4 \text{ lbs./gal.} \times 119.8 = 407.3 \text{ g/L}$

Converting Temperature

- Temperature expressed in Celsius or Fahrenheit
- Celsius
 - Freezing is 0; boiling is 100
- Fahrenheit
 - Freezing is 32; boiling is 212



Converting Temperature

- Converting from Fahrenheit to Celsius
 - > $^{\circ}\text{C} = (^{\circ}\text{F} - 32^{\circ}\text{F}) \div 1.8$
- Example 22: Convert 83°F
> $(83^{\circ}\text{F} - 32^{\circ}\text{F}) \div 1.8 = 28.3^{\circ}\text{C}$
- Converting from Celsius to Fahrenheit
 - > $^{\circ}\text{F} = (1.8 \times ^{\circ}\text{C}) + 32^{\circ}\text{F}$
- Example 23: Convert 5°C
> $(1.8 \times 5^{\circ}\text{C}) + 32^{\circ}\text{F} = 41^{\circ}\text{F}$

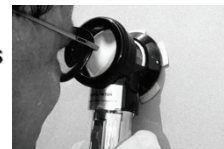


Converting Units of Coating Thickness and Surface Profile

- Surface profile depth (Module 3) and coating thickness (Module 5) expressed in micrometers (microns, μm) or mils (0.001")
- Conversion
 - $25.4 \mu\text{m} = 1 \text{ mil}$

Converting Units of Coating Thickness and Surface Profile

- *Example 24:*
Converting from mils to microns
- Surface profile: 3.5 mils
 - $3.5 \times 25.4 = 88.9 \mu\text{m}$



Converting Units of Coating Thickness and Surface Profile

- *Example 25:*
Converting from microns to mils
- Coating thickness:
 - $125 \mu\text{m}$
 - $125 \div 25.4 = 4.9 \text{ mils}$



Calculating a Target Wet Film Thickness

- Calculating Target Wet Film Thickness

$$\text{WFT} = \frac{\text{Target DFT}}{\% \text{ solids by volume}}$$

$$\text{Example: } \frac{5 \text{ mils DFT}}{68\% \text{ solids by volume (0.68)}}$$

Target wet film thickness: 7-8 mils

Calculating a Target Wet Film Thickness

- Effect of Thinner Addition on WFT Target

$$\text{WFT} = \frac{\text{Target DFT}}{\left[\frac{\% \text{ solids by volume}}{100\% + \% \text{ thinner}} \right]}$$

Calculating a Target Wet Film Thickness

- Effect of Thinner Addition, continued

$$\text{WFT} = \frac{5 \text{ mils DFT}}{\left[\frac{68\%}{100\% + 20\% \text{ thinner}} \right]}$$

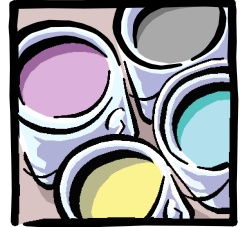
$$\text{WFT} = \frac{5 \text{ mils DFT}}{\left[\frac{68}{120} \right]} = 0.57 = 9 \text{ mils} \quad \frac{5 \text{ mils DFT}}{120}$$

Calculating the Target Wet Film Thickness

- Based on volume solids content of coating
- If volume solids is unknown:
 - Divide theoretical coverage rate into standard coating coverage rate, then convert to a percentage
 - Example:
 - Theoretical coverage rate: 1203 sq. ft./gal
 - Standard coverage rate: 1604 sq. ft./gal
 - $1203 \div 1604 = 0.75$ or 75%

Calculating Coating Coverage Rates & Estimating Material Quantities

- Coating inspector may need to verify adequate coating amounts for project
- Theoretical coverage rate on PDS
 - Does not include losses
 - Based on recommended DFT



Calculating Coating Coverage Rates & Estimating Material Quantities

- Calculating theoretical coverage rates
 - One gallon of 100% volume solids paint will cover 1,604 square feet of smooth surface, when applied 1 mil thick

Calculating Coating Coverage Rates & Estimating Material Quantities

- Calculating theoretical coverage rates
 - Calculation based on *actual* volume solids content of the coating and *specified* DFT
- Data for Examples:
 - Specified dry coating thickness: (4-6 mils)
 - Actual volume solids content: 65%

Calculating Coating Coverage Rates & Estimating Material Quantities

- **Example 27:**
 - 1604 square feet/gallon $\div$ 6 mils = 267 square feet/gallon (@ 100% volume solids, smooth steel and no losses)
 - 267 square feet/gallon $\times$ 0.65 volume solids = 174 square feet/gallon (smooth steel and no losses)

Calculating Coating Coverage Rates & Estimating Material Quantities

- **Example 29:**
 - Project is 35,000 square feet
 - 35,000 square feet $\div$ 174 square feet/gallon = 202 gallons (smooth steel and no losses)

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Quantifying mixing and application losses – Dependent on transfer efficiency (TE), kit sizes available/used, etc. – Manufacturers do not quantify – Must be estimated based on type and size structure, application method, etc. – For Examples: 20% loss (80% TE)

Calculating Coating Coverage Rates & Estimating Material Quantities
■ <i>Example 31:</i> ➢ Project is 35,000 square feet ➢ $174 \text{ square feet/gallon} \times 0.80 \text{ TE} = 139 \text{ square feet/gallon (smooth steel)}$ ➢ $35,000 \text{ square feet} \div 139 \text{ square feet/gallon} = 252 \text{ gallons}$

Calculating Coating Coverage Rates & Estimating Material Quantities
■ Quantifying consumption of primer by surface profile – Coverage rate based on smooth surfaces (okay for estimating intermediate or finish coats) – Abrasive blast cleaning increases surface area – Coating thickness measured from peaks – Primer consumption must be estimated based on surface roughness (and primer thickness) – For Examples: 25% loss in profile (75% TE)

Calculating Coating Coverage Rates & Estimating Material Quantities
■ <i>Example 33 & 35:</i> ➢ Project is 35,000 square feet ➢ $139 \text{ square feet/gallon} \times 0.75 \text{ TE} = 105 \text{ square feet/gallon}$ ➢ $35,000 \text{ square feet} \div 105 \text{ square feet/gallon} = 334 \text{ gallons}$

Calculating Coating Coverage Rates & Estimating Material Quantities
■ <i>Example 37 (example summary)</i> ➢ Project is 35,000 square feet ➢ Theoretical coverage rate: 174 square feet/gallon (202 gallon primer order) ➢ Practical coverage rate: 105 square feet/gallon (334 gallon primer order) ➢ If losses not accounted for, 132 gallon material shortage

Calculating Coating Coverage Rates & Estimating Material Quantities
■ <i>Example 39 (thinner estimation)</i> ➢ Project is 35,000 square feet ➢ 334 gallon primer order ➢ Contractor estimates thinning 15% ➢ $334 \text{ gallons primer} \times 0.15 = 50 \text{ gallons of thinner}$

	Summary
	■ Review of common arithmetic used by a coatings inspector: – Averaging values – Converting percentages to decimal format – Calculating area – Calculating volume – Converting mL/L and oz./gallon to % – Converting VOC content values – Converting temperatures – Converting units of measurement (for surface profile and coating thickness) – Calculating coating material and thinner quantities – Calculating WFT

	Module 4 Workshop
	■ Seventeen “Problem Sets” ■ Use calculator ■ Work independently ■ Use US Std. ■ Answers will be provided to the class by the instructor 