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**What does Safety have to do with math?**

**VIDEO:** [**https://youtu.be/PBZ0AX0RbXg**](https://youtu.be/PBZ0AX0RbXg)

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the questions in order to anticipate students’ needs, misconceptions and other situations that may be unique to your classroom.

You will also need to determine the background knowledge of your students regarding the following topics and decide the best method for providing that background in order to support the conceptual understanding of the mathematics shown in the video.

* + Definition of pi ($π$)
	+ Volume of 3-D solids, specifically a cylinder
	+ Unit rates
	+ Unit conversion

**Common Core Mathematical Content Standards**

* 6.G.A Solve real-world and mathematical problems involving area, surface area, and volume.
* 7.G.A Draw, construct and describe geometrical figures and describe the relationships between them.
* 7.G.B Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.
* 6.RP Understand ratio concepts and use ratio reasoning to solve problems.
* 7.RP. Analyze proportional relationships and use them to solve real-world and mathematical problems.
* 8.G.C Solve real-world and mathematical problems involving volume of cylinders, cones and spheres.
* G-GMD Geometric measurement and dimension
* High School Mathematical Modeling Standard

**Common Core Mathematical Practice Standards**

1. Make sense of problems and persevere in solving them.

2. Reason abstractly and quantitatively

3. Construct viable arguments and critique the reasoning of others.

4. Model with mathematics

6. Attend to precision

**Company Information**

With approximately 300 facilities across North America, South America and Europe, Georgia-Pacific is one of the world's leading manufacturers and marketers of bath tissue, paper towels and napkins, tableware, paper-based packaging, office papers, cellulose, specialty fibers, nonwoven fabrics, building products and related chemicals. In Northeastern Wisconsin, its Green Bay facilities make nationally-known products (Quilted Northern®, Angel Soft® and Compact® bath tissue; enMotion® and SofPul® paper towels; and Vanity Fair® and Mardi Gras® napkins) and packaging is produced in Sheboygan and Oshkosh. Each year, GP's Ecosourceä facility in Green Bay recycles nearly 100,000 tons of wastepaper - equal to 1.7 million trees - and saves 5 million cubic feet of landfill space. In addition, its Neenah-based research and development laboratory, iNNOVATION institute®, constantly develops creative and innovative products, and tests them in Green Bay using the latest technology available. For more information, visit: gp.com.

**Summary**

Employee safety is a high priority for manufacturers. When designing a product, many prototypes are created and research is conducted to determine if the product is safe for customers. In the case of furniture, stability is a critical area to test. This video shows how mathematics can help determine if the air quality in a storage tank is safe for Georgia Pacific employees.

**Pre-Activity Discussion:**

* Why would storage tanks be used in a manufacturing environment?
* What are some common shapes that are used for storage tanks?
* **Vocabulary**
	+ Air exchanges - how many times the air within a defined space is replaced.

**Differentiation:**

* The questions on the student handout are scaffolded to meet the needs of middle school students who may need extra support.
* Eliminating some of the added questions and/or just posing the question(s) from the video would be a possible differentiation strategy for students who do not need the extra support.
* Students may also benefit by working with others as part of a partner/group investigation of this problem.

**Summary of Information needed and the problems posed in the video:**

* The storage tank is a cylinder that is 70ft tall and 55ft in diameter
* 1 hour = 60 minutes
* Video solutions use exact value by using the $π$ calculator key.
* 1 cubic foot = 7.48052 gallons
* How many minutes will it take to clear the air in the storage tank?
* How many fans do need?
* If only 5 fans are able to be used, what would be the air flow rate needed for each of them?
* The question at the end of the video regarding a storage tank of a different shape is provided in the extension section of the lesson plan.

**Part 1: (0:00 – 1:01)**

* Have students label diagram of tank with the measurements given in the video.
* Discuss the problem that we are being asked to solve. *(How could we figure out if we have all the bad air out of the tank, and all the good air in the tank?)*
* What are the things we need to figure out? Do we have all the information we need? If not, what else do we need?

**Part 2: (1:06 – 1:17)**

* New question posed: What is the volume of the storage tank? , then convert that volume into gallons.
* Discuss definition of volume and why it is measured in cubic units.
* Discuss how the answer varies depending on the value of pi used (3.14 vs. 3.1415 vs. $π$). This will be important because the $π$ key on a scientific calculator was used to calculate the answers in the video.
* Could this variation in the calculation of the volume affect the safety of the employees? (See extensions section in lesson plan to explore this further.)
* Discuss why they are being asked to convert cubic feet to gallons.
* Before showing Part 3, have students share their solution methods

**Part 3: (1:22 – 3:14)**

* Solutions are shown
* After showing the solutions, have students reflect on any errors in their thinking and calculations.
* New question posed: If six air exchanges per hour is required, how many fans are needed?
* Discuss why there is a regulation regarding the number of air exchanges per hour.
* Before showing Part 4, have students share their solution methods

**Part 4: (3:21 – 4:25)**

* Solutions are shown
* After showing the solutions, have students reflect on any errors in their thinking and calculations.
* New question posed: Using only 5 fans, how much air would each fan need to move to meet the required six air exchanges per hour?

**Part 5: (4:31 – 5:19)**

* Solutions are shown
* After showing the solutions, have students reflect on any errors in their thinking and calculations

**Extension:**

* Use unit analysis for the given problems to show how the correct units are derived
* Have students work the problems in the video again using different rounded values for pi. Are the differences in the results significant enough to cause a safety concern? Discuss other real world affects that rounding may cause. Is there a common practice that mathematicians, scientists and engineers follow as they use numbers in their daily work?
* Storage tanks are not always cylindrical. Have students investigate other storage tank designs (or create their own) and calculate the volume. By also calculating the surface area of their design, they could determine which has the largest volume, but the smallest surface area. Why would that be important?

**Student Handout - *What does Safety have to do with Math?***  **Name(s):**

**Pre-Video Discussion:**  *Notes on important background information.*

**Break 1:**  How do we know when we have all the bad air out of the tank and only good air in the tank?What are the things we need to figure out? Do we have all the information we need? If not, what else do we need?

**Break 2:** Calculate the volume of the storage tank, then convert that volume into gallons.

(1 cubic foot = 7**.**48052 gallons)

**Break 3:** How long will it take for the fan to replace all the bad air with fresh air in the storage tank? The fan shown in the video clears a volume of 638 cubic feet of air per minute.

**Break 4:** If six air exchanges per hour is required, how many fans are needed?

**Break 5:**  Using only 5 fans, how much air would each fan need to move to meet the required six air exchanges per hour?

**ANSWER KEY – What does Safety have to do with math?**

**Volume = B x h (Area of base x height)**



Area of this circular base = $π $x radius2

 = $π$ **x (27.5 ft)2 = 2375.83 sq ft**

The area of the base needs to be stacked up to reach the top of the cylinder, 70 ft. high

**2375.83 ft2 x 70 ft = 166,308.06 ft3**

**Part 2**

If 1 cubic foot = 7.48052 gallons,

then 166,308.06 cubic feet = \_\_\_ gallons

(166,308.06 ft3) (7.48052 gallons / 1 ft3)

1,244,070 gallons

**Part 3**

The fan clears a volume of 638 cubic feet of air per minute.

How many minutes will it take to clear the air in the storage tank?

166,308 ft3 divided by 628 ft3 per minute = 265 minutes

**Part 4**

How many fans do we need?

 The fan clears a volume of 638 cubic feet of air per minute or (638)(60) cubic feet per hour. Which means one fan clears 37,680 ft3 of air per hour.

The storage tank holds 166,308 ft3 of air. Six air exchanges per hour would require (6)(166,308 ft3) of air to be moved. This is a total of 997,848 ft3 of air to move every hour.

Dividing the total air that needs to be moved every by the fan’s capabilities results in 26.5 or 27 fans.

**Part 5**

Previously we calculated that 997,848 ft3 of air needs to be moved every hour in order to provide six complete air exchanges in the storage tank.

Dividing that total by 5 fans, each fan would need to move 199, 570 ft3 of air per hour.

Fans are rated by cubic feet of air moved per minute. By dividing 199,570 ft3 per hour 60 min per hour we get an air flow rate of 3,327 ft3 per minute needed for each fan if we can only use 5 fans.