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

**Video Link:** [**https://youtu.be/09f4SnyhFRY**](https://youtu.be/09f4SnyhFRY)

**Lesson Plan**

**Teacher Note:** Please preview the entire video and pre-work the questions in order to anticipate students’ needs, misconceptions, and materials unique to your classroom. It is also recommended to review the video and lesson plan titled “What does a surge tank have to do with math?” The molasses lesson is a continuation of the surge tank video and may require the context that was provided by the initial surge tank lesson.

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.

* Using ratios and percentages to understand and solve problems
* Describing pressure per square inch
* Understanding units of measure for electrical current; milliamps in this case

**Common Core Mathematical Content Standards**

* **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.

**Note:** Although the mathematics done in this lesson meet 6th and 7th grade standards, the topic and the context of the material discussed is at a higher grade level.

**Common Core Mathematical Practice Standards**

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

 2. Reason abstractly and quantitatively.

 3. Attend to precision.

**Company Information**

At Werner Electric Supply, our story is defined by progress. From our modest beginnings in 1948, we have grown to serve the needs of our loyal customers and valued partners. While 400+ employees now provide diverse, high quality products and services for businesses throughout the entire state of Wisconsin, Michigan’s Upper Peninsula, and North Dakota, it all started with just one man in a small shop in Neenah Wisconsin.

Today, we offer over $30-million in inventory made up of 24,000 SKUs in our state-of-the-art, 250,000-square-foot warehouse and offices. As a key partner to our customers in all areas of business, Werner Electric strives to provide service that goes above and beyond expectations from 13 locations and counting. With growth based on the needs of our customers and partners, we are dedicated to long-term growth as an independent B2B distributor with customizable solutions that make a difference for those with whom we work.

**Summary**

Companies that work with fluids such as beverages and syrups require a large number of automated processes that aid in quality, safety, efficiency, and cost. The development of a new bottling line, for instance, often involves consultation with a process engineer who will advise them. This involves understanding a complex system and the various measurements involved in the process. In this video we will work from the engineer’s point of view to understand how the surge tank level will be monitored. This requires calibrating a level transmitter for the surge tank in question.

**Differentiation**

* The questions on the student handout are scaffolded to meet the needs of students who may need extra support.
* Extension questions have been provided for stronger students who may need to go beyond the video
* Students may also benefit from working with others while investigating the problem.

**Pre-Activity Discussion**

* This video is a continuation of the Werner Electric Supply video “What does a surge tank have to do with math.” The previous lesson discusses a surge tank for a bottling line. Systems like these have a variety of components and variables to understand. Pipe length, pipe diameter, pump pressure, liquid pressure, temperature, liquid level, air pressure, flow rate, and tank size are several of these. The current lesson involves determining the electrical output as related to inches of water column in the surge tank. Additionally, the tank will hold molasses which has a different specific gravity as compared to water. The tank will have a level transmitter that must be calibrated to take this into account.
* Using the provided vocabulary discuss the purpose of a surge tank.
* Students should discuss possible ways that the level of fluid in the surge tank could be determined. Keep in mind that it is not reasonable to physically measure the fluid level as it needs to continually adjust based on information at hand. They could do this through group discussions and/or drawings.
* It may be necessary to discuss the units of Amperes and Milliamperes.
* **Vocabulary**
* **Surge Tank** – A holding vessel between the point where fluid is distributed and the point where the fluid is filled into containers. When fluids are in motion and a process needs to change or stop, the fluids will continue to move for a time. A surge tank allows for fluids to have a place to go as the dynamics of the system change. The level in the tank will vary, but with careful monitoring can be maintained at a pre-determined level.
* **Setpoint** – This is the liquid level that will be maintained in the surge tank. This is often given as a percentage and is determined by the needs of the system with the help of an engineer. It is common to maintain the level at 50% of the tank capacity.
* **Ampere** – The base unit of electric current or the rate of flow of electricity. Usually written as Amps for short.
* **Milliampere** – Represents one thousandth of an ampere. This is used to describe very small electrical currents. Usually abbreviated mA.
* **Inches of Water Column** – Liquid in the tank exerts pressure based on the number of inches of liquid present. This is referred to as ‘Inches of Water Column’ or IWL. A column of water with a base that is one square inch and 27.78 inches tall will exert one pound of pressure. That is to say, 27.78 inches of water will exert pressure equal to 1 pound per square inch.
* **Level Transmitter** – Electrical component connected to the tank which converts the pressure exerted by the liquid into an electrical signal. The transmitter must be calibrated based on the height of the tank when full as well as the type of liquid used.

**Information Needed to Solve:**

* Diagram of the surge tank which is a cylinder connected to a cone.
* Specific gravity of fluids
* Specific gravity of water = 1
* Specific gravity of molasses = 1.4
* 27.78 inches of water column exerts 1 pound per square inch

**Part 1 (0:00 – 1:04)**

BREAK 1

* A full tank of water would output a reading of 20 mA, while an empty tank would read 4 mA. Discuss possible reasons why the industry would not use 0 mA.
* Students should determine number of milliamps that the transmitter will output when the tank is 50%?

**Part 2 (1:06 – 1:44)**

BREAK 2

* Have students discuss the effect molasses would have on the milliamp output if there were no adjustments made? What are the implications of mistakenly calibrating the transmitter for water rather than molasses?
* Because the molasses has 1.4 times the specific gravity we cannot let 72 inches be equal to 20 mA. Students should determine the number of inches of water column that should be entered to represent 20 mA.

**Part 3 (1:45 – 3:02)**

BREAK 3

* Students should determine the output in milliamps and the percentage the operator of the system sees on their monitor assuming there are 54 inches of fluid in the surge tank.
* An alarm is set to alert the operator if the tank reaches 85% capacity. Have students determine whether a transmitter output of 17.7 mA will trigger the alarm?

**Extension**

* What would the level gauge read when the level is at 5 inches?
* Find out the specific gravity of some other fluids. Answer the questions from part two of the lesson using the new specific gravity for another fluid.
* Use what you have learned about inches of water column to research water pressure in other situations such as a local water tower. Create a short presentation for your class.

**Student Handout – What does molasses have to do with math?** Name(s):

**Pre-Activity Discussion:** *Notes on necessary background information.*

**Problem:** *Find the milliamp output of a level transmitter based on the fluid in a surge tank.*

**Break 1**

* A full tank of water would output a reading of 20 mA, while an empty tank would read 4 mA. Discuss possible reasons why the industry would not use 0 mA.

* Use the diagram of the surge tank as needed.
* Determine number of milliamps that the transmitter will output when the tank is 50% full.

**Break 2**

* Discuss the effect molasses would have on the milliamp output if there were no adjustments made? What are the implications of mistakenly calibrating the transmitter for water rather than molasses?
* Because the molasses has 1.4 times the specific gravity we cannot let 72 inches be equal to 20 mA. Determine the number of inches of water column that should be entered to represent 20 mA.

**Break 3**

* Determine the output in milliamps and the percentage the operator of the system sees on their monitor assuming there are 54 inches of fluid in the surge tank.
* An alarm is set to alert the operator if the tank reaches 85% capacity. Determine whether a transmitter output of 17.7 mA will trigger the alarm?

**Surge Tank**



**Answer Key – What does molasses have to do with math?**

**Pre-Activity Discussion:** *Notes on necessary background information.*

**Problem:** *Find the milliamp output of a level transmitter based on the fluid in a surge tank.*

**Break 1**

* A full tank of water would output a reading of 20 mA, while an empty tank would read 4 mA. Discuss possible reasons why the industry would not use 0 mA.

**Answers vary:**

 **This is an industry standard. One thought is that using 0 mA would make it so that a**

 **technician would not be able to tell if the tank were empty or if something were broken.**

* Use the diagram of the surge tank as needed.
* Determine number of milliamps that the transmitter will output when the tank is 50% full.

**Min. = 4 mA and Max. = 20 mA which is a range of 16 mA**

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**Break 2**

* Discuss the effect molasses would have on the milliamp output if there were no adjustments made? What are the implications of mistakenly calibrating the transmitter for water rather than molasses?

**Answers Vary:**

**The transmitter would output a larger mA reading than it should. This could cause the operator to think that the level in the tank is much higher than it actually is. It is possible that significant damage could be done if the tank empties unexpectedly.**

* Because the molasses has 1.4 times the specific gravity we cannot let 72 inches be equal to 20 mA. Determine the number of inches of water column that should be entered to represent 20 mA.



**Break 3**

* Determine the output in milliamps and the percentage the operator of the system sees on their monitor assuming there are 54 inches of fluid in the surge tank.

  **The operator sees 75%**

* An alarm is set to alert the operator if the tank reaches 85% capacity. Determine whether a transmitter output of 17.7 mA will trigger the alarm?

 

**This is approximately 85.6%. Since the alarm triggers at 85% we would expect an alarm when the output is 17.7 mA.**

**Surge Tank**

