What does science have to do with *steel?*

GET REAL SCIENCE!

Company Background
Alliance Laundry Systems invents, designs and produces products for commercial laundry systems. They lead the world in commercial laundry sales, product range, reach and R&D investment. They have five respected brands that are sold and supported by a global network of select distributors. Alliance Laundry Systems is located in Ripon, WI.

Get Real Science Video Link: What does science have to do with steel? or
YouTube: https://youtu.be/EjsdQX3CZho

Teacher Note
This lesson is written to accompany the above video. It is recommended that you watch the entire video in advance. This will help you to anticipate student misconceptions and questions and prepare ways to support their sense making.

If this is the first time that you are using the system models and modeling with your students, take the time to review the Next Generation Science Appendix F section on developing and using models for appropriate grade level expectations.

Lesson Summary
In this lesson students will investigate the strength of alloys using a hands-on activity along with graphical analysis and interpretation of results obtained in the lab.

Standards Alignment
Next Generation Science Standards Performance Expectations

MS-ETS1-4 Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models	ETS1.B: Developing Possible Solutions ETS1.C: Optimizing the Design Solution	Structure and Function

Materials

Play-Doh or modeling clay	½” strips of paper	whiteboard (student size)
½” strips of cardboard	popsicle sticks	whiteboard markers

Procedure

1) Show students the Get Real Science Video from Alliance Laundry. This presentation also includes some resources for this lesson.
   a) Break 1 (0:42) What is steel? - Have students list characteristics of steel as a large group discussion. Try to ask follow-up questions to their responses. Ex: “Steel is strong.” “Do you know what makes it strong?” which may prompt more responses.
   b) Continue the video.
   c) Break 2 (1:28)
      i) In the video, they state the steel is an *alloy.* Define the term alloy as a class (slide 2 of presentation). Show slide 3 (for fun!)
      ii) What is the difference between steel and stainless steel? Show different examples of steel and stainless steel in presentation (slide 4). Create a T-chart to document student responses. Some questions to encourage responses include: What physical differences do you notice? Where are each of these used?
   d) Finish showing students the video.

2) Creating an alloy
   a) Explain to your students that they are going to make a model to demonstrate the structure of an alloy. Be certain that they understand that true alloys combine at the molecular level.
   b) Arrange students into groups of 4. Hand out Play-Doh or modeling clay to each group.
   c) Ask students to build a house out of the clay. Once they are finished, have them place a book on top of the house and observe how the house holds up the book.
   d) Provide strips of cardboard, popsicle sticks and paper. Have them combine these materials with the modeling clay to build a similar house.
   e) Once the class is finished with their second design, have them place the same book on top of the house and observe how it holds up the book.
   f) Have each group report out their new design and how it compares to the strength of the first house.
   g) Ask students which house held the book the best. Did one material or more than one material work best? How did the additional materials assist in the strength of their house?
   h) Finally, ask students to identify how this model of an alloy is similar and different from the real steel alloy.

3) Graphical analysis
   a) Display slide 5. Explain that mPa is a measure of strength and that X content % is the amount of additional material/elements used in the metal.
   b) Using whiteboards, have each group produce one observation and one question they have about the graph.
   c) Ask students to then make a ***claim*** about how the X content % effects the strength of the material.
   d) Ask them to include at least two data points as ***evidence*** to support their claim.
   e) Discuss as a whole class the ***reasoning*** behind the change in the strength. They should be able to use their models from the previous activity to support their understanding.
   f) Finally, hand out the conclusion questions. Have students complete in small groups.

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Conclusion Questions - Steel

1. Today you built a house using different materials. Explain how this experience compares to the graph your teacher displayed. Which materials were “X content”?

2. A class tested the strength of various alloys. View the results below and answer the corresponding questions.

Sample Alloy Type	Chemical Composition	UTS (MPa)	Density (kg/m^3)	Specific Strength $Pa/(kg/m^3)$
6061 aluminum	Aluminum, chromium, copper, iron, magnesium, manganese, silicon, titanium, zinc	310	**2720**	**0.11**
464 brass	Copper, tin, zinc	379	**8430**	**0.04**
220 bronze	Copper, zinc	265	**8900**	**0.03**
101 copper	Arsenic, copper, oxygen, phosphorus, antimony, tellurium	241	**8940**	**0.03**
625 nickel	(mostly) nickel, chromium, molybdenum, niobium	827	**8908**	**0.09**
304 stainless steel	Iron, chromium, nickel, silicon, copper, manganese, phosphorus, sulfur	586	**7680**	**0.08**
EN 988 zinc	Zinc, copper (less than 1%)	150	**7135**	**0.02**

Source: teachengineering.org

a. Compare brass, bronze and zinc alloys. Can you determine a relationship between the specific strength of the alloys and their chemical composition?

b. What can you conclude about the strongest alloy and weakest alloy?

3. What are the three characteristics of steel that make it useful for construction of a washing machine? List each structural characteristic and explain how its structure matches its function. Use the chart below to organize your thoughts.

Structural characteristics	Function

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Conclusion Questions - Steel KEY

1. Today you built a house using different materials. Explain how this experience compares to the graph your teacher displayed. Which materials were "X content"?

   X content % is the amount of additional material/elements used in the metal. The material other than the modeling clay would be considered X content %. The graph shows that the metal strengthens as the X material % increases. This compares to our house building experience because as we added additional material such as popsicle sticks and cardboard, the strength of the house increased.

2. A class tested the strength of various alloys. View the results below to answer the questions.

Sample Alloy Type	Chemical Composition	UTS (MPa)	Density (kg/m^3)	Specific Strength $Pa/(kg/m^3)$
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Source: teachengineering.org

c. Compare brass, bronze and zinc alloys. Can you determine a relationship between the specific strength of the alloys and their chemical composition?

   The strength of these alloys increases as additional material is added to the metal. The zinc alloy includes two materials: zinc and a small amount of copper; strength = 0.02. The bronze alloy includes the same two materials as the zinc alloy but a greater amount of copper: strength = 0.03. The brass alloy has the greatest strength of 0.04 and includes the most added materials - copper, tin, zinc.

d. What can you conclude about the strongest alloy and weakest alloy?

   The strongest alloy is aluminum and the weakest alloy is zinc. Aluminum has 9 different chemicals and zinc only has 2.

3. What are the three characteristics of steel that make it useful for construction of a washing machine? List each structural characteristic and explain how its structure matches its function. Use the chart below to organize your thoughts.

Structural characteristics	Function
Strong	Heavy objects spin during a washing machine cycle. The walls of the machine need to be strong to hold in the items. If steel were not strong, the washing machine could not adequately clean the clothes.
Water resistant	Washing machines use water - the inside of the machine needs to be water resistant to avoid damage to the material. If steel were not water resistant, it would not last long.
Flexible	Large objects can sometimes be placed in a washing machine. If an object were to hit the side of the machine, it needs to withstand that force. If steel were not flexible, it would most likely break if force impacted it.