Rail expansion and contraction

Key Learning Area	Unit or lesson title and main focus questions	Most appropriate level and suggested number of lessons
Science	**Rail expansion and contraction** How do engineers allow for expansion and contraction of railway tracks?	**Stage 4** 1–2 lessons

Teacher briefing

Students learn about why steel expands or contracts when it rises or falls in temperature and design an experiment to observe this expansion and contraction. This experiment is placed in the context of the 15 kilometre of track inside Sydney Metro Northwest tunnels where the temperature is controlled, and the remainder of the track exposed to more extreme Sydney temperature changes.

Requirements for these lessons

Students plan a laboratory experiment. Teachers must be satisfied that their investigation can be performed safely.

Key terms and vocabulary

Temperature range, temperature fluctuations, expansion, contraction, continuously welded track, slab track and fasteners, the effect of adding or removing heat on different states of matter.

Background information

- Most of the existing Sydney rail network runs on surface tracks. These tracks are exposed to the full range of climatic elements. The temperature range in Greater Sydney can be significant. Air temperature can vary over the year from -3 degrees Centigrade to up around 46 degrees Centigrade
- The railway tracks exposed to these temperature fluctuations are made of steel and will undergo expansion and contraction. Allowances must be made to cater for this expansion and contraction
- These allowances are made during the construction of the railway tracks
- Steel used in railway tracks either expands or contracts as a coefficient temperature change
- For steel, the coefficient of thermal expansion is 13×10^{-6} per degree Centigrade. That amount is really small. A metre of steel railway track only expands/contracts 0.013 mm for every degree of temperature change
- Over 100 metres of track, however, this represents 1.3 mm expansion or contraction for every degree Centigrade of temperature change

- When train wheels contact joints in railway track, this produces noise. To enable smoother running, the tracks on Sydney Metro Northwest will be continuously welded. This means they do not have many expansion/contraction joints
- Sydney Metro Northwest will connect the North West region to the Greater Sydney rail network through 15 km twin tunnels and the existing 13 km Epping to Chatswood Rail Link
- Inside the tunnels, the temperature range will be naturally below that experienced by tracks exposed to the elements. The temperature in the tunnels can also be more reliably predicted than surface track sections exposed to the elements
- The amount of expansion and contraction of the steel rail track can be easily calculated if the temperature range is known
- Modern welded track design usually means the steel track is heated to the midrange temperature point that it will be exposed to. It is then laid in around 100 m lengths on slab track in the floor of the tunnel.

Web links

An imaginative demonstration of the expansion and contraction of a steel bar

https://www.youtube.com/watch?v=kDktat01G_E

A photograph of extreme rail expansion in a Melbourne heat wave illustrates expansion to the class in a dramatic manner

http://www.telegraph.co.uk/news/picturegalleries/worldnews/4360255/Heatwave-in-Melbourne-plays-havoc-with-the-Australian-Open.html

Syllabus links

Science 7–10

SC4-16CW describes the observed properties and behaviour of matter, using scientific models and theories about the motion and arrangement of particles.

(CW1) The properties of the different states of matter can be explained in terms of the motion and arrangement of particles.

Students:

- (b) relate an increase or decrease in the amount of heat energy possessed by particles to changes in particle movement
- (c) use a simple particle model to predict the effect of adding or removing heat on different states of matter.

Learning experiences

Activity 1

Discuss the information about the tunnel and rail track in Background information (page 160–161) with students and ask them to answer the following questions:

- Describe why steel expands or contracts when it rises or falls in temperature. In your answer make sure you refer to the behaviour of the particles that make up steel
- The length of new track in the tunnels of Sydney Metro Northwest west of Epping is 15 km. If the temperature in the tunnels changed by 2.5 degrees Centigrade, how much would the length of track expand if left to do so?
- Modern welded track design usually means the track is heated to the midrange temperature point the steel could be expected to be exposed to 100 m lengths of track are then laid on concrete slab track and held in place to the floor of the tunnel by rail fasteners. Identify the advantages of this technique as a means of minimising the effect of expansion or contraction
- Assume the lengths of track not in a tunnel are exposed to the full range of temperatures typical for the North West region of Sydney. What is the maximum difference in length a 1000 m length of steel railway track could experience due to expansion and contraction assuming a minimum temperature of 2.5 degrees Centigrade and a maximum temperature of 45.5 degrees Centigrade?

Activity 2

Students design their own experiment that will enable them to observe expansion and contraction of steel in their school laboratory. Hint: A retort stand bar makes a good model for a steel railway track.

View the Youtube clip below to see an imaginative way of demonstrating the expansion and contraction of a steel bar.

https://www.youtube.com/watch?v=kDktat01G_E

The metal bar in the video expands when heated by a bunsen burner and contracts when tap water is poured on it. The rotation of the white straw amplifies the expansion of the metal bar. (Published 25 October 2012.)

Important: Ensure that students describe their planned experiment to you in some detail first. You must be satisfied that their investigation can be performed safely.

The final track laid on Sydney Metro, April 2018.