TIN CANS - are they made of steel?

Science content

Properties and uses of materials (steel, aluminium, tin), strength, density, electrical conductivity, rusting, gas pressure, recycling.

Science curriculum links
AT 1 Exploration of science
AT 5 Human influences on the Earth
AT 6 Types and uses of materials
AT 7 Making new materials

Syllabus links
- GCSE Science, Chemistry, Physics,
- Technology

Cross-curricular themes
- Environment
- Citizenship
- Economic Awareness

Lesson time
2 hours
(some homework possible)

Links with other SATIS materials
103 Controlling Rust
604 Metals as Resources
1004 Materials to Repair Teeth

NERIS
Search on
RECYCLING and CANS

SUMMARY

The unit is based upon a practical investigation of food and drink cans and leads students to consider how the materials and methods chosen for can making are related to the contents of the can. Lastly, students are asked to consider the problems involved in recycling cans.

AIMS

- ☐ To link work on the physical and chemical properties of aluminium, iron (steel) and tin to the design of food and drink cans
- ☐ To collect, record and make a critical evaluation of data
- ☐ To illustrate the recycling of aluminium, tin and ferrous metals
- ☐ To provide an opportunity for discussion of social, environmental and economic issues concerned with recycling

STUDENT ACTIVITIES

- ☐ Part A Canning and food preservation, tinplate and aluminium.
- ☐ Part B Investigation, use of a key and data collection about types of can. Follow-up information and questions.
- ☐ Part C Information and questions about recycling. Group discussion problem.

USE

- ☐ The unit builds on prior work on the physical and chemical properties of metals and on work about food preservation.
- ☐ Part B, the investigation, requires students to follow a key and is suitable for practical assessment.
- ☐ Work might be extended to investigate the corrosive effect of acid on samples of can material.

REQUIREMENTS FOR STUDENT PRACTICAL WORK

Each pupil or group of pupils will require

- ☐ access to a collection of food and drink cans and samples of iron, tin and aluminium. These should be checked for sharp edges.
- ☐ magnet
- ☐ simple conductivity test apparatus (e.g. battery, lamp, 3 connecting leads) or multimeter
- ☐ micrometer screw gauge (optional)

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Teaching notes

Cans are best supplied empty with lids/ring pulls removed. (Please check them for sharp edges.) Some can openers fold sharp edges so they are safer. If new cans are used, remove the paper labels and note the contents on the can with a marker pen.

Micrometer screw gauges are sensitive instruments reading to 0.01 mm. Students may need to be shown how to use them correctly – holding by the ratchet. The ratchet will slip when the grip of the jaws is just tight enough. Students should be able to measure the thickness of cans without splitting the wall as long as the side is slightly flattened.

Answers to the questions

Part A

Q1 *Heating kills any bacteria present in the food. The seal prevents further contamination.*

Q2 *Food will not decay but may break down and lose its flavour. Cans are best stored in a cool dry place. Cans will keep more than a year.*

Q3 *Tinplate is cheaper than other packaging metals. Tin protects steel externally, preventing rusting and iron dissolution internally. Aluminium is fairly cheap for packaging, does not corrode externally (but needs to be lacquered internally).*

Q4 *Steel is more expensive. (Aluminium £2,632 per* m^3*, tinplate £3,900 per* m^3*).*

Q5 *Cans with thinner walls are cheaper on raw materials (and lighter to carry).*

Q6 *Food cans are steel. About half all drinks cans are steel, the remainder are aluminium. In Britain steel drinks cans with captive ring pulls have aluminium tops.*

Q7 *Lacquering protects the metal can from chemical attack by the contents, especially from acidic foods and drinks.*

Q8 *Round shape, thick bases, shaped bases and necking, beading. (You can demonstrate the effect of beading by pleating a sheet of paper.)*

Q9 *Cooked foods.*

Q10 *Higher pressure inside than outside due to gas dissolved under pressure. Liquids are fairly incompressible.*

Q11 *Suggestions such as*

(a) strong enough to be resistant to damage during manufacture and transportation, easy to seal after filling, attractive, easy to open, resistant to corrosion by the drink etc.

(b) withstands high pressures during cooking, resistant to attack by contents, inexpensive, etc. The gas pressure from fizzy drinks helps to withstand external pressure.

Q12 *6%*

Q13 *Steel may be picked out by a magnet.*

Q14 *Save money on transporting waste to landfill and on landfill sites. After recouping capital costs of recycling plant, make money by selling the reclaimed metals.*

Discussion

Many developed countries, under pressure from environmental lobbyists or due to a shortage of landfill sites, operate comprehensive recycling schemes. Similar pressures are beginning to act in the UK. News items and a survey of local facilities may provide useful background to the discussion.

A video, *Steel – The Environmentally Attractive Metal* deals with the recycling of steel cans and is available on free loan from John May, British Steel Tinplate, PO Box 101, Velindre, Swansea SA5 5WW.

Acknowledgements

The author would like to thank Mr L. R. Beard and Ms C. M. McKernan, Research and Development, British Steel Tinplate, for their generous help in the preparation of this unit.

Mr P. Rogers, fellow of the Institute of Metallurgy read and commented on the trial version.

TIN CANS – are they made of steel?

Part A – Preservation and packaging

The canning of food was invented about 200 years ago.

Heating food to a high temperature kills bacteria; and, as long as the can remains airtight, the food will not decay.

Cans came to be called 'tins', because they were always made of **tinplate**, that is steel coated with tin. Aluminium is now being used for cans too.

Q1 *Why does canning preserve food?*

Q2 *How long do you think canned food will remain in good condition?*

Q3 *Suggest why tin-plated steel and aluminium are used for cans.*

Cans are made in millions every day. So very small details of design can help manufacturers keep their costs down and improve the product for the consumer. For example, can makers are trying to use thinner metal. The walls of steel cans for fizzy drinks have been reduced in stages from a thickness of 0.10 mm to 0.095 mm and to 0.09 mm. The aim is for a can wall as thin as 0.08 mm or even 0.07 mm! And with the customer and the environment in mind, drinks cans are now made with captive ring pulls.

	Aluminium	**Tinplate**
cost per tonne	£940	£500
density in tonnes/m^3	2.8	7.8
strength	moderate	very strong
corrosion	attacked by salt acids and alkalis	outside may rust, inside attacked by some foods

Part A Canning for preservation and packaging.

Part B A practical investigation of the structure and materials used for can making.

Part C Recycling

- How are steel cans recycled?
- What are the economic and environmental benefits?
- How to encourage recycling – a problem for discussion.

Q4 *Which is more expensive, a cubic metre of aluminium or tinplate?*

Q5 *What are the benefits of making cans with thinner walls?*

Part B – The technology of tin cans

What are 'tin cans' made of? – an investigation

You will need
- empty food and drink cans *(beware of sharp edges, try to keep part of their labels on them to identify their contents and make sure they are clean)*
- a magnet
- apparatus to test if a can conducts electricity
- samples of the metals iron/steel, aluminium and tin for comparison
- a micrometer screw gauge (optional)

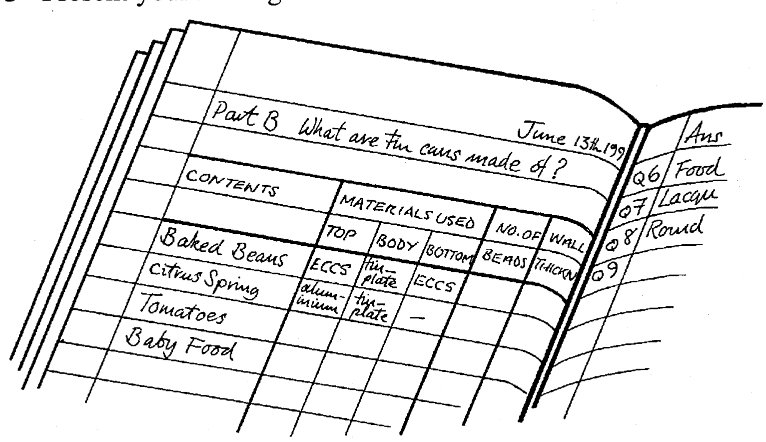
1 Collect together all you need for this investigation.

2 Examine the cans carefully. Be careful of sharp edges. Find out as much as possible about what materials they are made of and how they are constructed.

What should you look for? Here are some suggestions.

- ☐ What food or drink did the can contain?
- ☐ Identify the materials used to make *each part* of the can. You might use the key on page 3.
- ☐ Is the inside of the can **lacquered?** (Lacquer is often clear or golden coloured) You can find out by doing a simple electrical conductivity test – lacquers are non-conductors.
- ☐ How is the structure of the can made strong? Does it have a 'necked-in' shape? Does it have 'beads' in the body of the can? If so, count the number of beads. ['Beading' is the term used by the can-maker for the ringed or corrugated effect around some cans. (See the picture on page 4.)]
- ☐ How thin is the can wall? Flatten the can slightly and measure it if you have a micrometer screw gauge.
- ☐ How was the can put together?

3 Present your findings in a table.

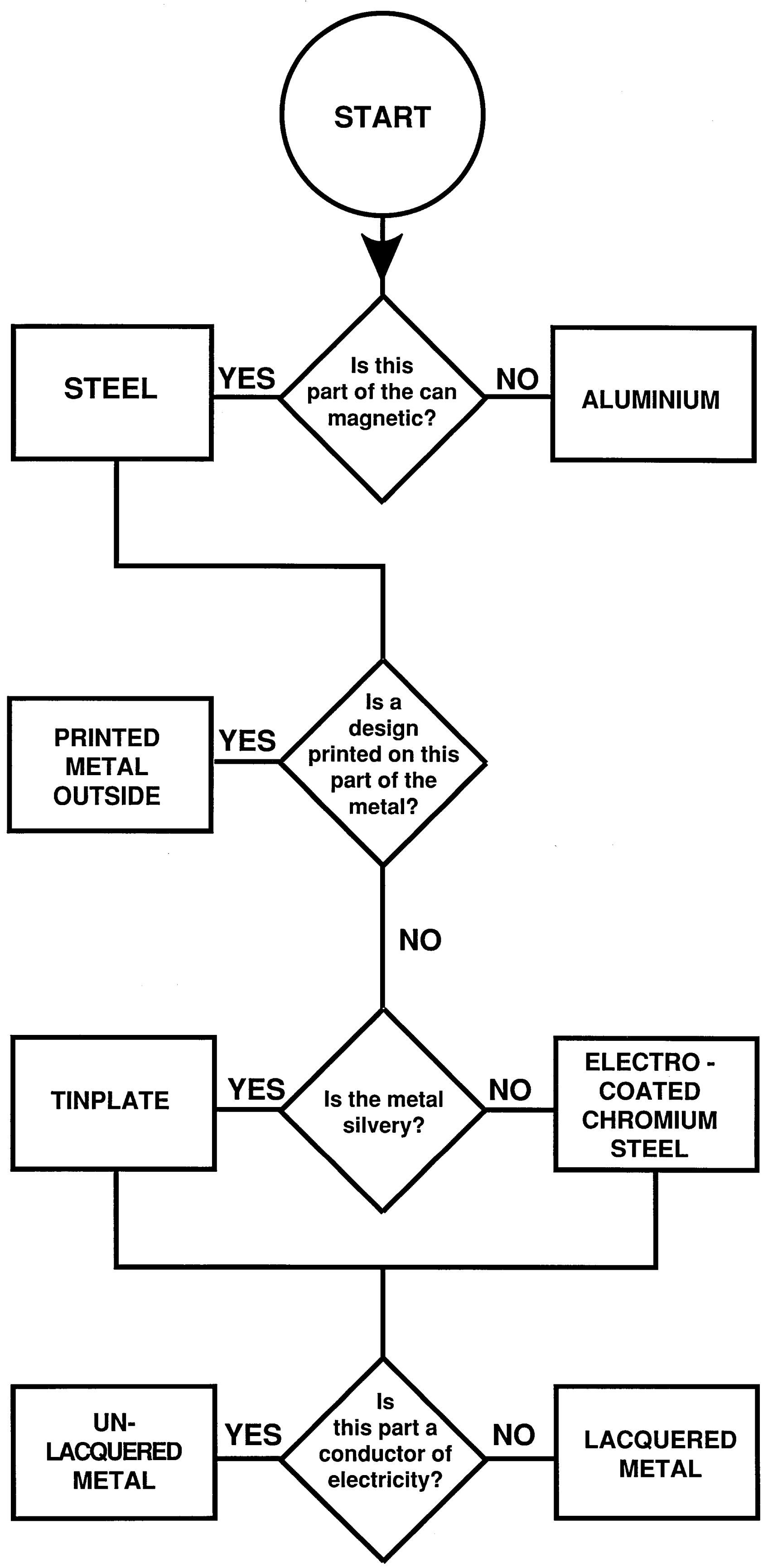


Q6 *What sort of cans (tinplate and/or aluminium) are used for*
(a) food cans,
(b) drinks cans?

Q7 *Suggest why the insides of cans are often lacquered.*

Q8 *What design details are used to make cans strong?*

Key for identification of metals in food and drink cans



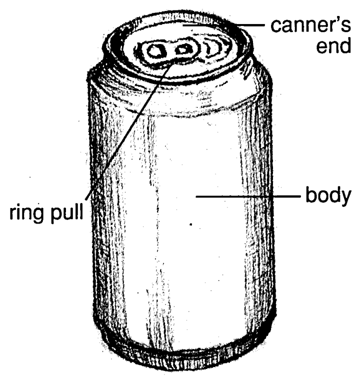


Figure 1 A seamless two-piece can

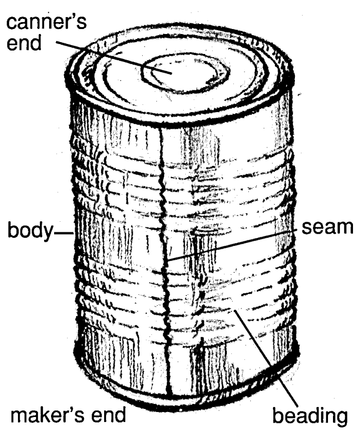


Figure 2 A three-piece can

The energy needed to make a 440 ml drinks can is

	MJ
Steel	5.0
Steel with aluminium end	5.6
Aluminium	5.1

An important use of steel

Tinplate is the major raw material for making virtually all food and petfood cans and about half of all drinks cans. In simple terms, it is a strip steel which is coated on both sides with a thin layer of tin. The tin is applied electrolytically.

Making tinplate is a long-established part of the steel industry in South Wales. There are plants at both Llanelli and Ebbw Vale.

The tinplate producer sells coils or flat plate to a can maker. The can maker produces an open top can for food or drink.

The cans together with their ends are sold to the cannery, where they are filled. The end is seamed on. The food sealed inside the cans is cooked. Cans have to withstand high pressures from inside at this stage and lower pressures inside after cooling. That is why many food cans are beaded to make them stiffer.

Fizzy drinks cans have a higher pressure inside than the atmospheric pressure outside.

> ***Q9** What are 'beaded' cans used for storing ?*
>
> ***Q10** Explain why it is difficult to crush a drinks can before it has been opened but easy when it is empty.*

The material can makers use does not depend on cost per tonne alone. Tinplate was originally used for making cans because it was easy to solder. Today, tinplate cans are almost all welded. Tinplate is stronger than aluminium and tinplate cans are relatively cheap to mass produce. Aluminium cannot be welded and is used for seamless cans only. They are expensive to produce in low numbers. Aluminium is attacked by all food and drink and all aluminium cans must be protected by lacquering inside.

Although most foods are packaged in tinplate cans, about half the drinks cans used in Britain are aluminium. Even the steel cans have aluminium ring-pull ends.

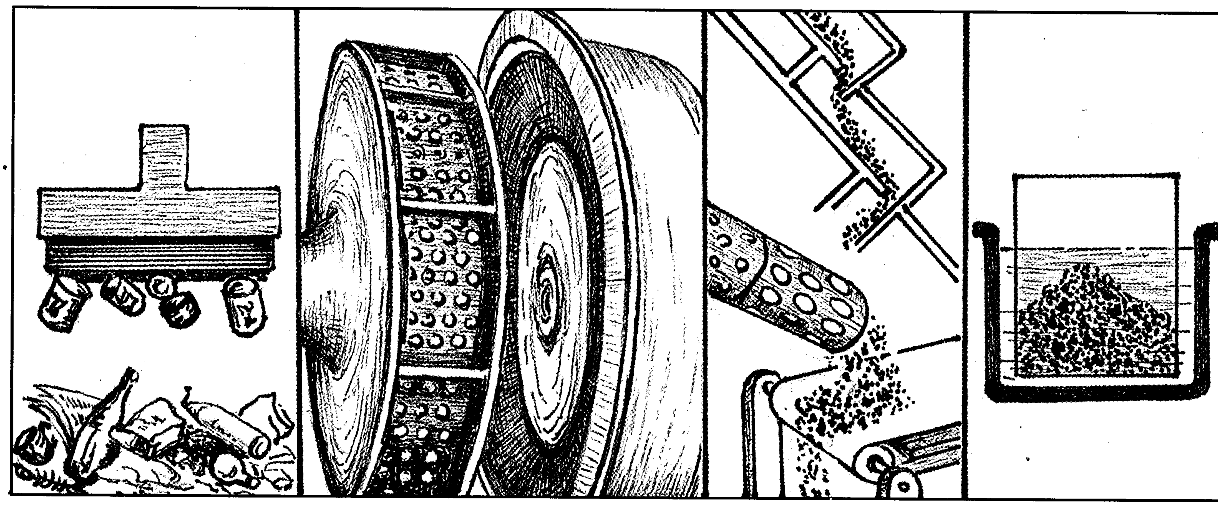
> ***Q11** Imagine you are working for a food and drink manufacturer. You are about to launch two new brands. What sort of can would you choose to hold*
> *(a) a fizzy peppermint drink,*
> *(b) cheese and onion-flavoured baked beans?*

Part C – Recycling cans

In Britain about 15 billion cans are used each year. Most are made of steel. In 1989 only 1050 million steel cans were recycled. (The proportion of aluminium cans recycled is much lower.)

Steel cans reclaimed from domestic rubbish are processed by the method outlined here. Local authorities who build recycling plants can sell the metal they reclaim. Land for rubbish tips is expensive and local authorities can save money by tipping less waste.

The steel recycling process



Step 1 – Magnetic Extraction
Steel cans are extracted from waste by a magnet.

Step 2 – Shredding
Cans are shredded to remove food scraps, labels, lacquers and aluminium ends from beverage cans.

Step 3 – Removing Contaminants
An air blast removes the lighter materials and a magnet separates steel from the rest of the waste.

Step 4 – Detinning
Contaminant-free steel (mostly tinplate) from step 3 is immersed in a strongly alkaline detinning solution. Tin is then separated from the steel in the tinplate by an electrolytic process.

Figure 3 Recyling steel cans

Steel which has to be detinned first has a value of about £35 per tonne and is sold for use as scrap in the charge of a steel-making furnace. Although there is only a small amount of tin on tinplate, tin is an expensive metal and that recovered by detinning is re-sold.

Aluminium is a good conductor of electricity and can be removed from rubbish using a linear motor to induce eddy currents in it. It throws itself off the conveyor belt. However, this technology is not yet widely used. Aluminium can be sent straight for remelting. It fetches around £700 per tonne.

Q12 What percentage of cans were recycled in 1989?

Q13 Why is steel easier to recycle from mixed household rubbish than other metals?

Q14 What are the economic arguments for recycling cans?

Organising the discussion

- Work in a small group.
- Appoint someone to chair the group and to report back to the class if required.
- Note down the answers you decide on.

A problem for discussion

How should people be encouraged to recycle all kinds of cans?

The following ideas have been used successfully in other countries.

- ☐ A deposit on all drink cans (and bottles). This is paid back on return to any food shop. The food shop sorts them for return and recycling. Sorting is often a part-time job for students.
- ☐ A law requiring local authorities to separate all empty cans from rubbish collections for recycling.
- ☐ An agreement for householders to sort out different kinds of cans and return them to a collecting point.

Try to add more ideas to this list.

a *What are the advantages and disadvantages of these ideas?*

b *Which scheme, or combination of schemes do you think should be used in the UK?*

c *How could you try to get your ideas adopted by other people?*

Answers to the questions are in the *Teachers' Notes.*