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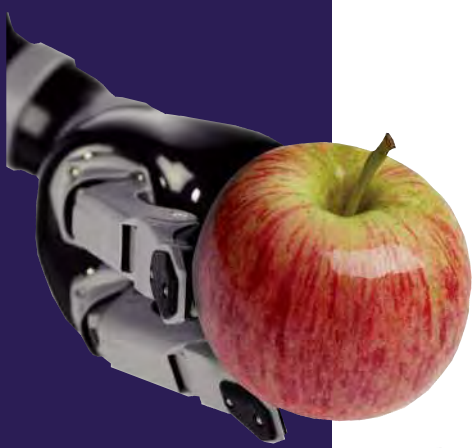
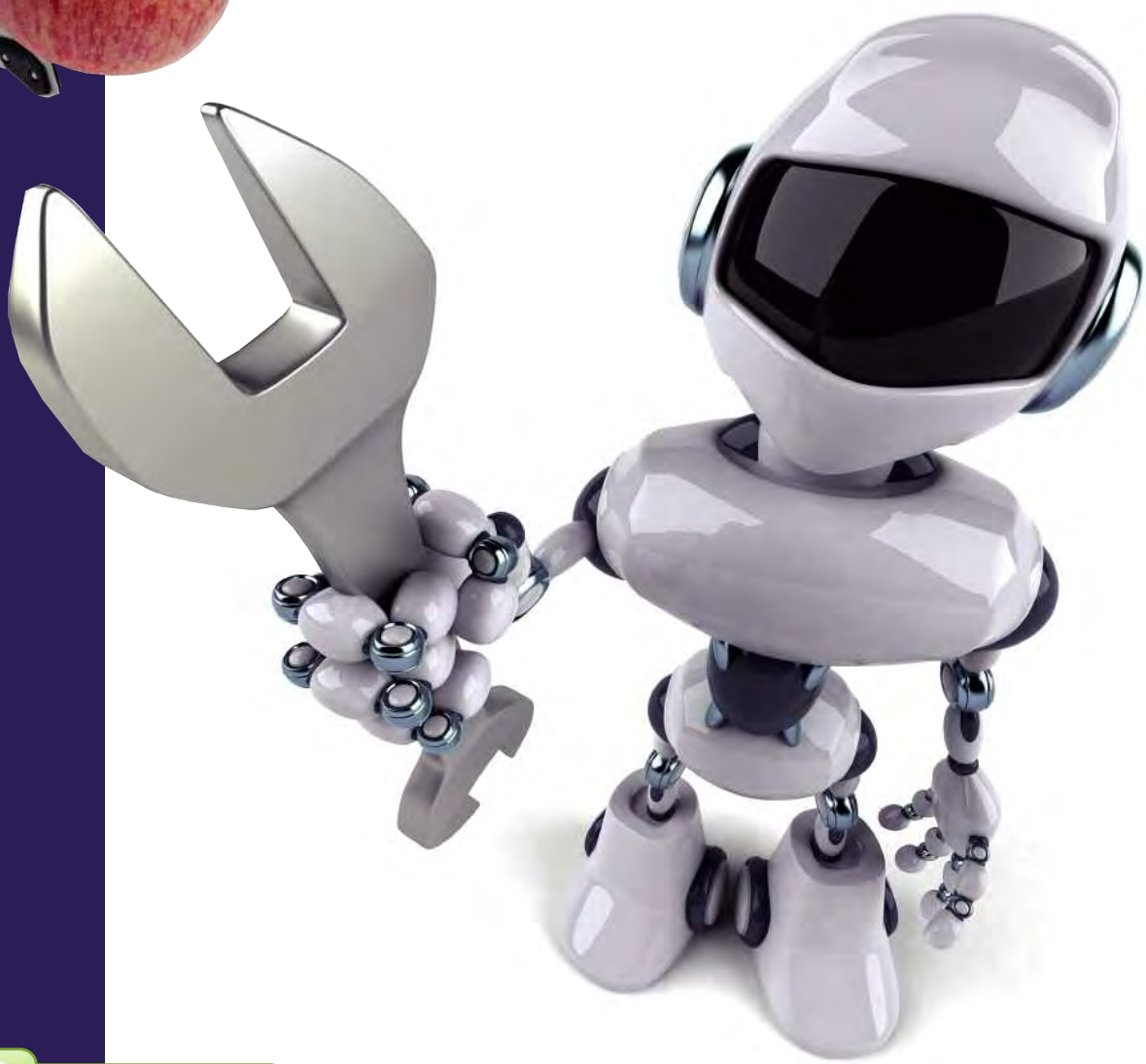
ESP
English for Specific Purposes

Maria Letizia Faggiani • Margherita Robba

# New Mechways

English for Mechanics, Mechatronics and Energy





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# New Mechways

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# PRESENTAZIONE

## L'ARGOMENTO

***New Mechways*** è rivolto agli studenti dei Nuovi Istituti:

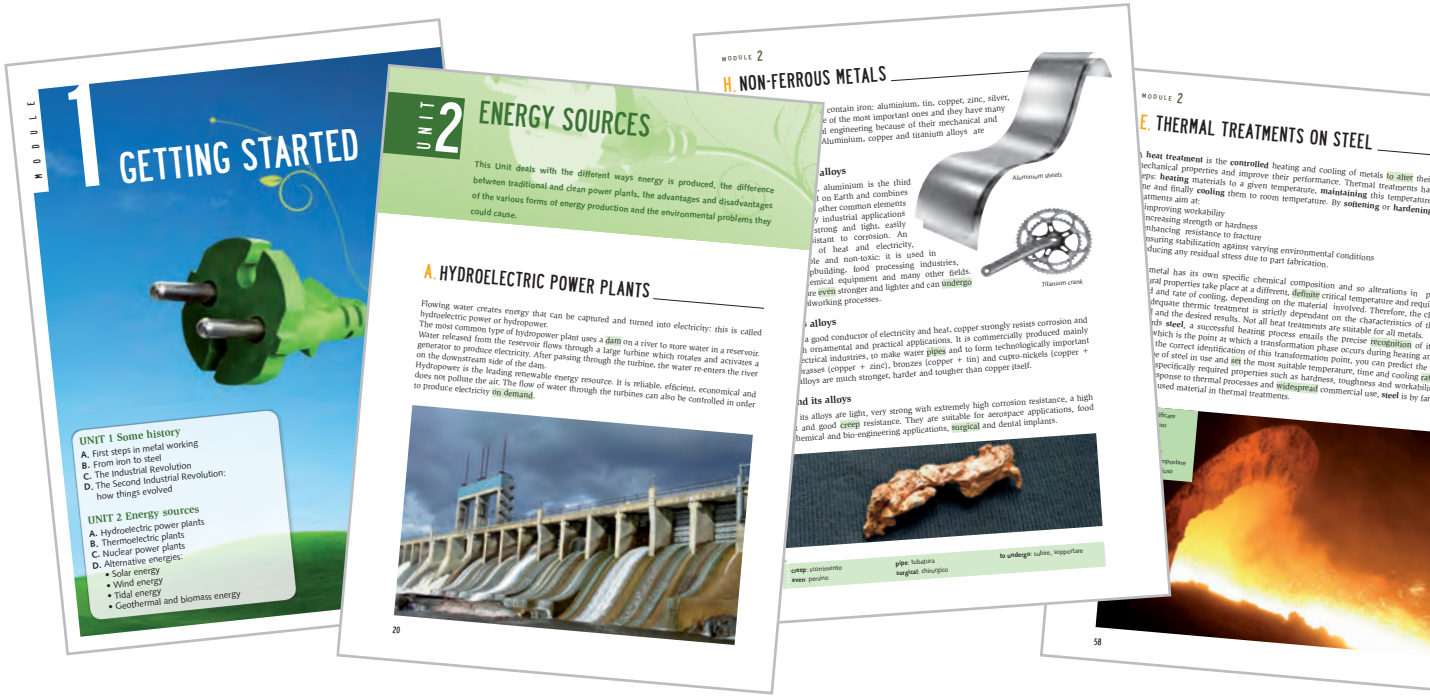
- **Tecnici** ad indirizzo Meccanica, Meccatronica ed Energia e le sue omonime aree opzionali di approfondimento
- **Professionali** ad indirizzo Industria ed Artigianato e in generale, a coloro che hanno l'esigenza di utilizzare la lingua inglese come strumento di studio e/o lavoro in campo **meccanico**.

Grazie alla ricchezza del materiale proposto, ***New Mechways*** – concepito per promuovere un apprendimento attivo basato sui contenuti (*content-based learning*) – offre la possibilità di scegliere gli argomenti sia in base ai programmi delle materie tecnico-scientifiche di indirizzo, sia in base agli interessi e al livello di competenza linguistica degli studenti.
I contenuti sono stati ordinati secondo criteri di graduale complessità concettuale e linguistica e vengono esplorati utilizzando le quattro abilità in modo omogeneo ed integrato. I brani offrono un assortimento di stili, registri e livelli di difficoltà e sono tratti da fonti diverse: giornali e riviste specializzate, testi scolastici inglesi e americani, materiale promozionale, manuali tecnici e siti Internet.

## GLI OBIETTIVI

***New Mechways*** si propone di:

- far acquisire le competenze necessarie per leggere e comprendere testi che presentano termini, espressioni, strutture sintattiche e modalità discorsive specifiche del linguaggio scientifico e tecnologico settoriale;
- migliorare le capacità di ricezione e produzione, orale e scritta;
- arricchire il patrimonio lessicale;
- consolidare abitudini grammaticali corrette o approfondire alcune strutture già note agli studenti;
- stimolare l'interesse e la partecipazione attiva degli studenti, dando spazio alla loro esperienza personale e a problematiche di attualità.

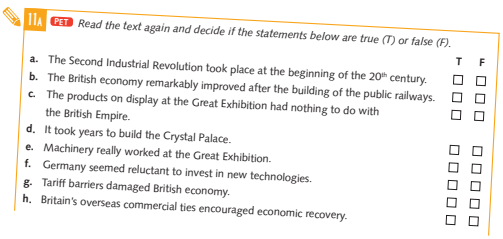


## LA STRUTTURA

***New Mechways*** è diviso in **sette Moduli**, ognuno dei quali è ripartito in 3 sezioni:

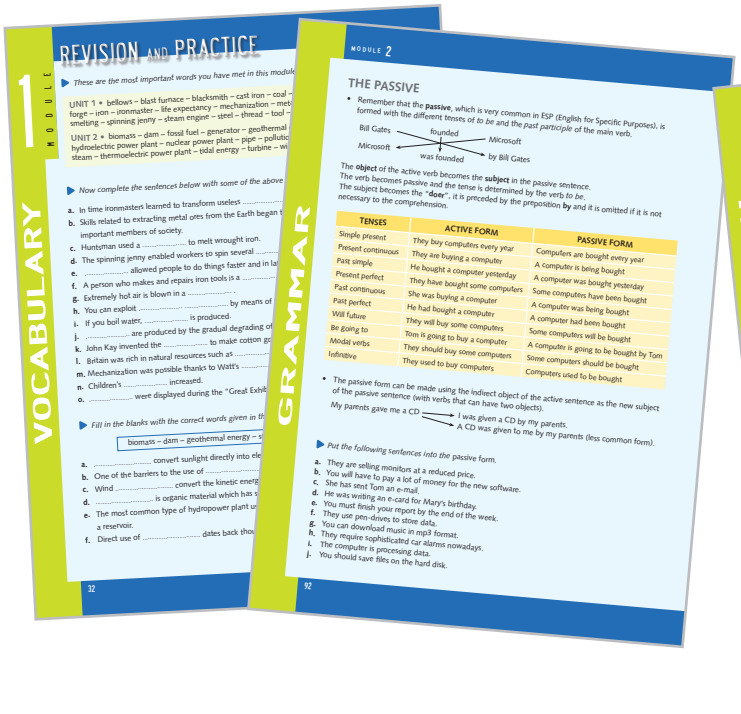
**1 Contents Section** – Divisa in Unità, contiene testi e attività che riguardano i contenuti specifici della specializzazione già affrontati in L1. Ogni Unità è suddivisa in **Capitoli** per favorire non solo uno studio più parcellizzato, ma anche la scelta antologica da parte dell'insegnante. I testi vengono affrontati in modo graduale, attraverso esercizi di *Before reading*, *While reading*, esplorazione del lessico tecnico, comprensione scritta e/o orale, globale e specifica. Brevi "box" di approfondimento, denominati *Moving Deeper*, permettono di ampliare le conoscenze sull'argomento. Alcune attività sono contrassegnate dal simbolo PET, poiché sono modellate sui test d'esame Cambridge English.

Un ricco **apparato iconografico** (con funzioni esplicative, non solo esornative) correda i brani di lettura, per ognuno dei quali è previsto un esauriente glossario.

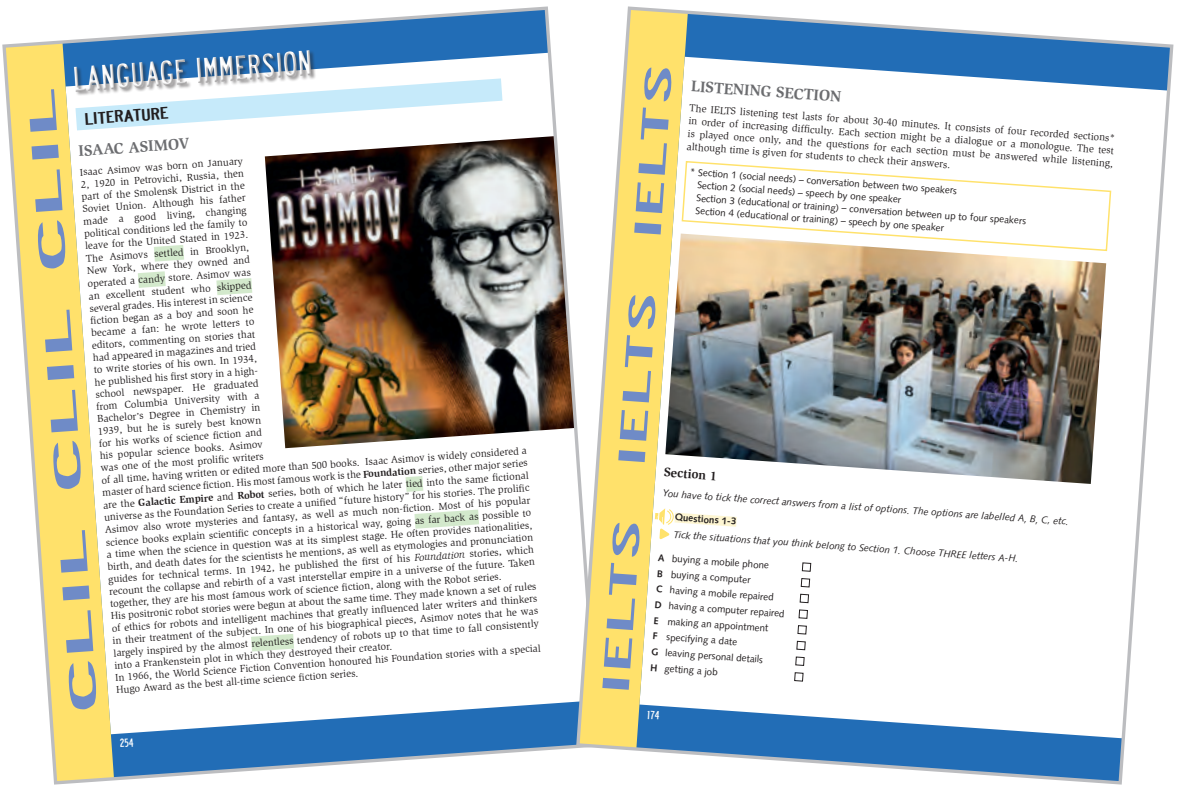

**2 Revision and Practice** – Si occupa di contenuti inerenti alla disciplina ponendo particolare attenzione all'arricchimento lessicale, strutturale e allo sviluppo delle quattro abilità linguistiche. Presenta le seguenti ripartizioni:

- **Vocabulary**. Comprende specifiche attività per il conseguimento del lessico tecnico più importante del Modulo. Costituisce anche uno strumento che gli studenti possono utilizzare come rinforzo e ripasso degli argomenti del modulo.
- **Grammar**. Propone il rinforzo delle strutture morfo-sintattiche più ricorrenti nel linguaggio tecnico.
- **Communication**. Offre testi e attività di consolidamento dei contenuti appresi per sviluppare le *quattro abilità linguistiche*: **Reading – Listening – Speaking – Writing**.



**3 Language Immersion** – È volta al potenziamento della lingua tramite materie in inglese e certificazione linguistica.

- **CLIL** (Content and Language Integrated Learning). Alla fine di ogni Modulo è presente un CLIL CORNER che si collega alle tematiche presentate in alcune delle discipline curriculari: *Matematica – Letteratura – Tecnologie meccaniche di processo e di prodotto – Meccanica, macchine ed energia – Disegno, progettazione e organizzazione industriale*. Gli argomenti proposti possono favorire una didattica cross-curricolare, coinvolgendo docenti delle materie citate per eventuali approfondimenti e/o progetti che permetttono concretamente di studiare il medesimo contenuto da diverse prospettive.
- **IELTS** (*International English Language Test System*). Viene data la possibilità di prendere dimestichezza con il più popolare test al mondo per la certificazione del livello di conoscenza della lingua inglese. Il test valuta in modo accurato la capacità di comunicare in inglese considerando situazioni che si verificano nella vita reale e professionale.




RISORSE ONLINE Disponibili sul sito www.edisco.it:

- CD con la registrazione delle attività di ascolto;
- materiali extra per attività di approfondimento e di esercitazione;
- *Teacher's Guide* con soluzioni degli esercizi – *transcripts* delle attività di ascolto – note didattiche – prove di verifica collegate ai singoli Moduli – simulazioni della Terza Prova dell'Esame di Stato.

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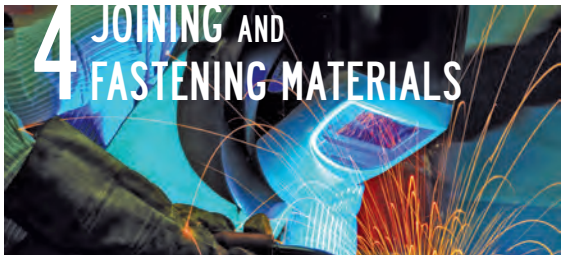

MODULE 5

# 5 TECHNICAL DRAWING

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## UNIT 2 • Computers



## UNIT 3 • Computerized drawing



## REVISION AND PRACTICE



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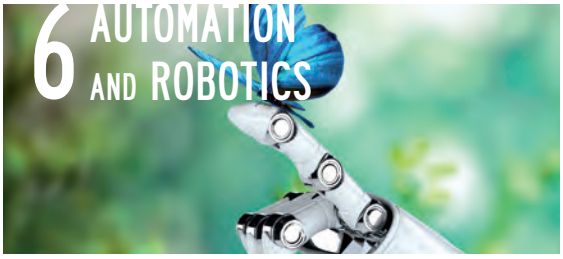

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# MATERIALS

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**B.** Loads and stresses

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**"To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science."**

*Albert Einstein*

- Albert Einstein (1879-1955) was a German-born theoretical physicist who developed the general theory of relativity, one of the two pillars of modern physics. While best known for his mass–energy equivalence formula $E = mc^2$ (which has been dubbed "the world's most famous equation"), he received the 1921 Nobel Prize in Physics for his services to theoretical Physics and especially for his discovery of the law of the photoelectric effect which was pivotal in establishing quantum theory.

## *Why study this Module?*

**In this Module you will examine the properties of engineering materials and the physical changes they undergo. You will also learn about the uses of these materials and you will be given information about some innovative types of materials which play an essential role in our daily life.**

UNIT 1

# PROPERTIES OF MATERIALS

**This Unit looks at the properties of materials that make them suitable for certain uses, the most widely used engineering materials and their applications. You will also learn about more advanced materials and their treatments.**

## A. MECHANICAL PROPERTIES OF MATERIALS

When studying materials and especially when selecting materials for a project/design, it is important to consider their properties, which can be classified in 4 groups:

1. **mechanical** (strength, hardness, toughness, elasticity, plasticity, brittleness, ductility and malleability)
2. **thermal** (conductivity, expansion, melting point)
3. **electrical** (conductivity, magnetism, resistivity)
4. **chemical** (atomic volume, density, corrosion resistance, flammability).

Strength, hardness, toughness, elasticity, plasticity, brittleness, ductility and malleability are **mechanical properties** used as measurements of how materials behave under a load. These properties are described in terms of the types of force or stress that the metal must withstand (see Chapter B).

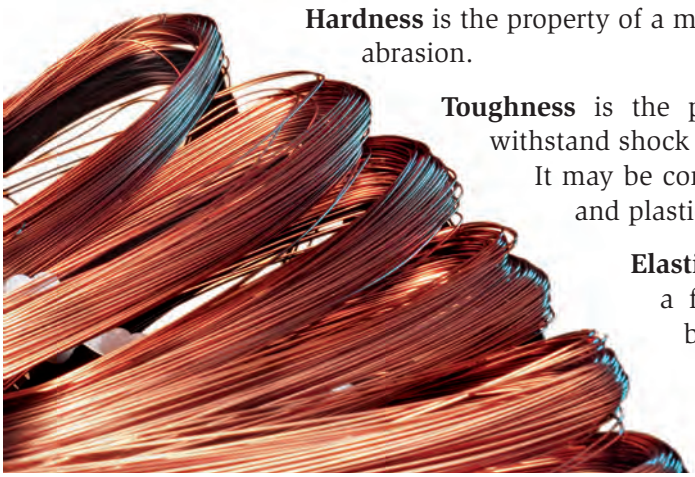
**Strength** is the property that enables a metal to resist deformation under load without breaking, bending, shattering or deforming.

- Tensile strength is a measurement of the resistance to being pulled apart when placed in a tension load.
- Fatigue strength is the ability of material to resist various kinds of rapidly changing stresses.
- Impact strength is the ability of a metal to resist suddenly applied loads.

**Hardness** is the property of a material to resist cutting, penetration or abrasion.

**Toughness** is the property that enables a material to withstand shock and to be deformed without cracking. It may be considered as a combination of strength and plasticity.

**Elasticity** is the ability of a material to absorb a force and flex in different directions before returning to its original shape after the load is removed.



*Copper wire is used for its good electrical conductivity*

*Answer the following questions.*

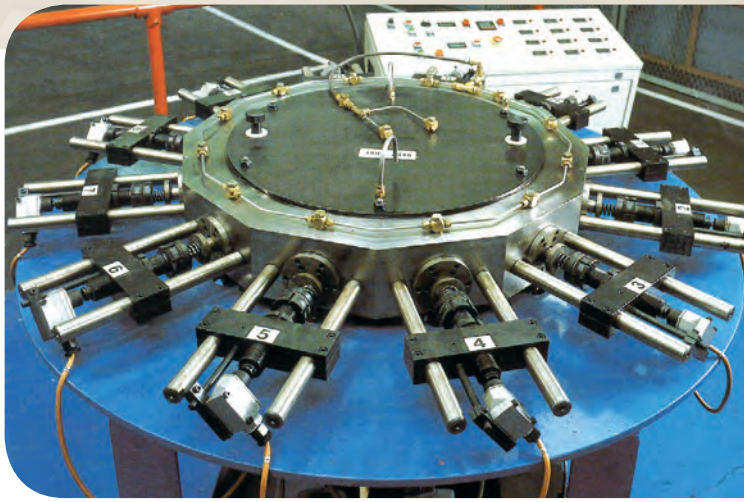
**a.** Can you mention some of the properties which characterise each material?

**b.** Do you know the differences between mechanical and electrical properties of materials?

**c.** Do you know what stress is?

**d.** Describe what strength is.

**e.** Can a malleable object be shaped into different forms easily?



**Plasticity** is the ability of a material to deform permanently without breaking. This property is the opposite of strength.

**Brittleness** is the opposite of plasticity. A brittle metal breaks or shatters before it deforms. White cast iron and glass are good examples of such materials.

**Ductility** is the property that enables a material to stretch, bend, or twist without cracking or breaking. This makes it possible for a material to be drawn into thinner sections.

**Malleability** is the property that enables a material to be deformed by compressive forces without developing defects. A malleable material can be stamped, hammered, forged, pressed, or rolled into thin sheets.

**MECHANICAL PROPERTIES OF METALS/ALLOYS**
(ranked in descending order of the given property)

| TOUGHNESS | BRITTLENESS | DUCTILITY | MALLEABILITY | CORROSION RESISTANCE |
|---|---|---|---|---|
| Copper | White Cast Iron | Gold | Gold | Gold |
| Nickel | Gray Cast Iron | Silver | Silver | Platinum |
| Iron | Hardened Steel | Platinum | Aluminium | Silver |
| Magnesium | Bismuth | Iron | Copper | Mercury |
| Zinc | Manganese | Nickel | Tin | Copper |
| Aluminium | Bronzes | Copper | Lead | Lead |
| Lead | Aluminium | Aluminium | Zinc | Tin |
| Tin | Brass | Tungsten | Iron | Nickel |
| Cobalt | Structural Steels | Zinc | | Iron |
| Bismuth | Zinc | Tin | | Zinc |
| | Monel | Lead | | Magnesium |
| | Tin | | | Aluminium |
| | Copper | | | |
| | Iron | | | |

# B. LOADS AND STRESSES

A **load** is an external force acting on a body. A **stress** is an internal force in a body that resists the tendency of an external force (i.e. a load) to change its shape.
Common types of stress are **compression**, **tension**, **shear**, **torsion**, **bending** and **impact**, or a combination of these stresses, such as **fatigue**.

- *Compression stresses* develop within a material when forces compress or crush the material.
- *Tension* (or *tensile*) stresses develop when a material is subject to a pulling load.
- *Shearing stresses* occur within a material when external forces are applied along parallel lines in opposite directions.
- *Torsion stress* occurs when a material is subject to a twisting force.
- *Bending stress* develops when it is subject to a combination of tension and compression loads.
- *Impact stress* occurs when a material is under a force applied gradually and maintained over a long period.
- *Fatigue* is often measured in mechanical structures and is referred to as the ability to resist repeated cycles of combined stresses such as tension and bending.

**1** *Referring to the texts above find the English terms for the following Italian words.*

**a.** *durezza* .....
**b.** *resistenza* .....
**c.** *fragilità* .....
**d.** *tenacità* .....
**e.** *comportarsi* .....
**f.** *sopportare* .....
**g.** *taglio* .....
**h.** *fatica* .....

**2** *Find the Italian terms for the following English words.*

**a.** load .....
**b.** crush .....
**c.** bend .....
**d.** shatter .....
**e.** flex .....
**f.** shape .....
**g.** twist .....
**h.** sheet .....

GLOSSARY

**to bend**: piegarsi
**brittleness**: fragilità - friabilità
**to hammer**: lavorare con il martello
**hardness**: durezza
**melting point**: punto di fusione
**pulling load**: forza di trazione
**to shatter**: frantumarsi
**shear**: taglio
**sheet**: foglio, lastra
**strength**: resistenza
**toughness**: tenacità
**to twist**: torcersi
**white cast iron**: ghisa bianca
**to withstand**: sopportare

**3** *Choose the correct options.*

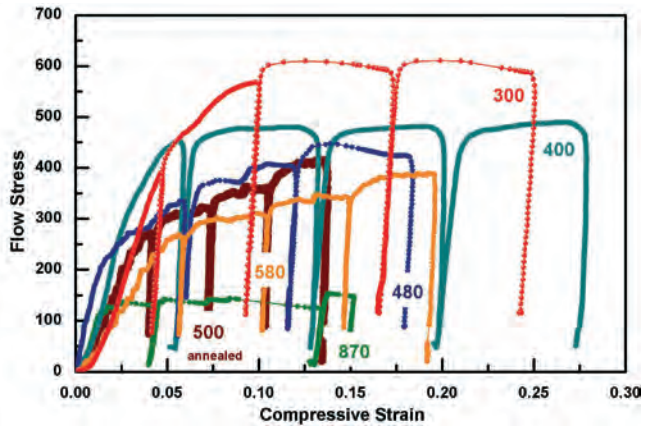
**a.** Compression stresses develop when a material is subject to
1. a pulling load.
2. a crushing force.
3. sliding forces.

**b.** A hard material
1. doesn't resist scratching.
2. is affected by penetration.
3. resists surface abrasion.

**c.** A tough material
1. withstands shocks.
2. easily breaks.
3. can easily bend.

**d.** A brittle metal
1. deforms without breaking.
2. breaks before it deforms.
3. bends without cracking.

**e.** Strength is
1. the property of a metal to resist deformation.
2. the ability of a material to resist abrasion.
3. the property of a material to deform without breaking.




**4** *Now listen and check your answers.*

**5** *Ask and answer the following questions in turns.*

**a.** What are the most common types of stress?
**b.** What kind of properties do solid materials have?
**c.** What is fatigue strength?
**d.** What does plasticity refer to?
**e.** What is the difference between hardness and toughness?
**f.** What kind of property is ductility?
**g.** When can you say that a material is brittle?
**h.** What are the properties of a malleable material?

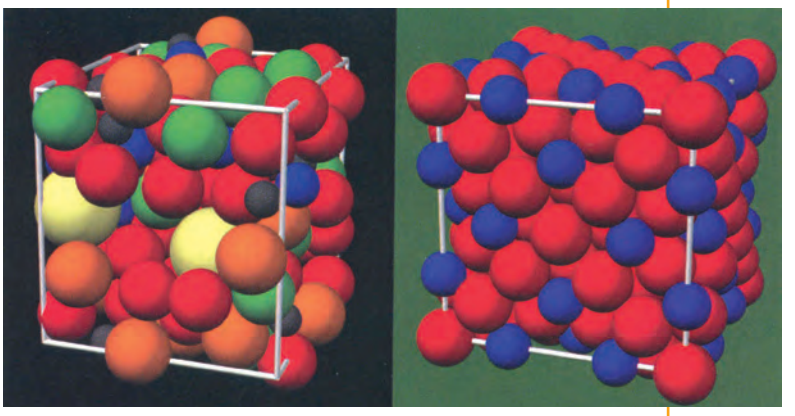
**6** *Write down the answers and join them into a brief passage on the properties of metals.*

**7** PET *PAIR WORK. Referring to the texts above and the table on p. 47, Student A asks Student B about the properties of a chosen metal. Then exchange roles.*

MOVING DEEPER

### Classification of structural materials

Structural materials can be classified into two broad categories: **metals** and **composites**. The former can be further catalogued into **ferrous metals** and **non-ferrous metals**. The latter are generally divided into three groups: **polymer-matrix composites**, **metal-matrix composites** and **ceramic-matrix composites**.



*Computer-generated models of glassy steel*

UNIT 2

# METALS

**This Unit is about the most widely used engineering materials. It deals with metals, their general characteristics and classification as ferrous and non-ferrous. It looks at their different properties and various applications.**

## A. METALS: GENERAL CHARACTERISTICS

**1** *Listen to the recording and complete the text with the words in the box.*

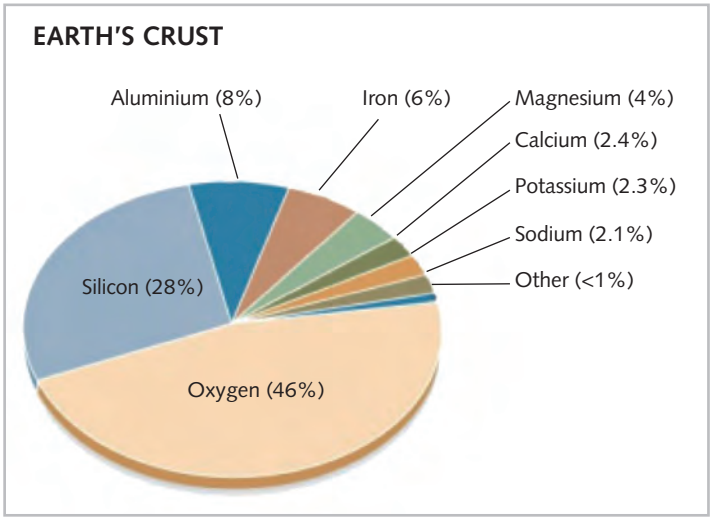
non-ferrous – semi-metals – high – substances – consisting – properties – defined
carry out – malleable – mixed – classified – employed – ores – conductors – components

Natural elements are usually (a) ..... into four main groups: metals, non-metals, noble gases and (b) ..... . Metals and non-metals (plastics, ceramics) are the engineering materials mostly (c) ..... in the manufacturing of finished products and mechanical engineers are expected to have a complete knowledge of their (d) ..... and processing methods in order to choose the best solutions for the task they have to (e) ..... .
As regards the metallic elements, they form less than 25% of the Earth's crust: aluminium, iron, calcium, sodium, potassium and magnesium are the most common ones. The majority are extracted from their (f) ..... and are in combination with other (g) ..... , such as carbonates, sulphides, oxides, while only a few metals (silver, platinum, gold and copper) can be found free in nature.

*Iron meteorite*

*Answer the following questions.*

**a.** What do you know about materials and different types of materials?
**b.** What are the most common metals?
**c.** What metals are largely employed in engineering?
**d.** What is an alloy?
**e.** What different types of steel do you know?




The properties of metals vary greatly but, in general, they can be (h) ..... as hard, strong, (i) ..... , ductile, or fusible materials. They are good (j) ..... of heat and electricity; they have high density as well as (k) ..... melting points.
From the chemical point of view, metals are classified as "pure metals" and "alloys". The former are metals (l) ..... of one type of atom (e.g. aluminium, copper), while the latter are metallic substances consisting of two or more different types of atoms. In other words, alloys are compounds made up of two or even more (m) ..... , at least one of which is a metal: bronze and brass are alloys consisting of two metals (copper + tin; copper + zinc), while steel is an alloy consisting of a metal and a non-metal (iron + carbon).
In industry, metals are often (n) ..... together to form alloys and improve their original properties, and are usually classified as either "ferrous" or "(o) ..... ", according to whether they contain iron or not.

**2** *Read the text again and then ask and answer the following questions in turns.*

**a.** How are natural elements usually grouped?
**b.** Which are the most widely used engineering materials?
**c.** What are the main properties of metals?
**d.** What do "pure metals" consist of?
**e.** What are alloys? What do they consist of?
**f.** How are metals classified in industry?

**3** *Write down the answers and join them into a brief passage on metals.*

GLOSSARY

**alloy**: lega
**brass**: ottone
**compound**: composto
**copper**: rame
**Earth**: terra
**either... or**: o... oppure...
**the former… the latter**: il primo... il secondo…
**to improve**: migliorare
**melting point**: punto di fusione
**task**: compito
**tin**: stagno

# B. FERROUS METALS

*Steel manufacturing*

## Iron

Silvery and magnetic, iron has limited applications in its pure form. It is therefore mixed with carbon and other elements to improve its original characteristics and form widely-used alloys.

## Cast iron

Hard but brittle, neither malleable nor ductile, cast iron contains from 2% to 4% carbon. It is widely used for low-stress components and greatly appreciated for its low cost. It varies a lot according to the form of carbon it contains and it is usually classified as "white iron" or "grey iron". "Ductile iron" is a new variety of grey iron, very tough and strong.

## Plain carbon steels

These are metal alloys usually classified as "mild steel", "medium carbon steel" or "high carbon steel", according to the quantity of carbon they contain. As the percentage of carbon increases, steel becomes harder, stronger, less ductile and more difficult to weld, while the melting-point and the resistance to temperature decrease.

## Alloy steels

Alloy steels contain carbon and alloying elements improving their properties. Stainless steels and tool steels are the most widely known types: chromium and nickel are added to the former in order to increase durability and resistance to rust or corrosion. The latter contain tungsten, molybdenum and other alloying elements which give them very high strength, hardness and wear resistance.

*Stainless steel wheel nuts*

## High-strength low-alloy steels

HSLA steels are cheaper than regular alloy steels because they contain smaller amounts of the alloying elements; furthermore, they are also stronger and lighter.

**4** *PAIR WORK. In turns say if these statements are true (T) or false (F) and correct the false ones.*

| | | T | F |
|---|---|---|---|
| **a.** | Pure iron finds few applications. | ☐ | ☐ |
| **b.** | Iron's characteristics cannot be improved. | ☐ | ☐ |
| **c.** | Cast iron is relatively cheap. | ☐ | ☐ |
| **d.** | The form of carbon is important in cast iron. | ☐ | ☐ |
| **e.** | Plain carbon steels consist mainly of carbon and iron. | ☐ | ☐ |
| **f.** | The carbon content affects the properties of the alloys. | ☐ | ☐ |
| **g.** | The higher the carbon content, the stronger the steel. | ☐ | ☐ |
| **h.** | High carbon steels are very ductile and easy to weld. | ☐ | ☐ |

## 5 *Refer back to the texts on steel and alloy steels and match the beginning of each sentence with the correct ending.*

**a.** Tungsten is added
**b.** When resistance to corrosion is needed
**c.** Steel has different classifications
**d.** Chromium is added
**e.** Because of the alloying elements
**f.** Exceptionally light, strong and rather convenient,

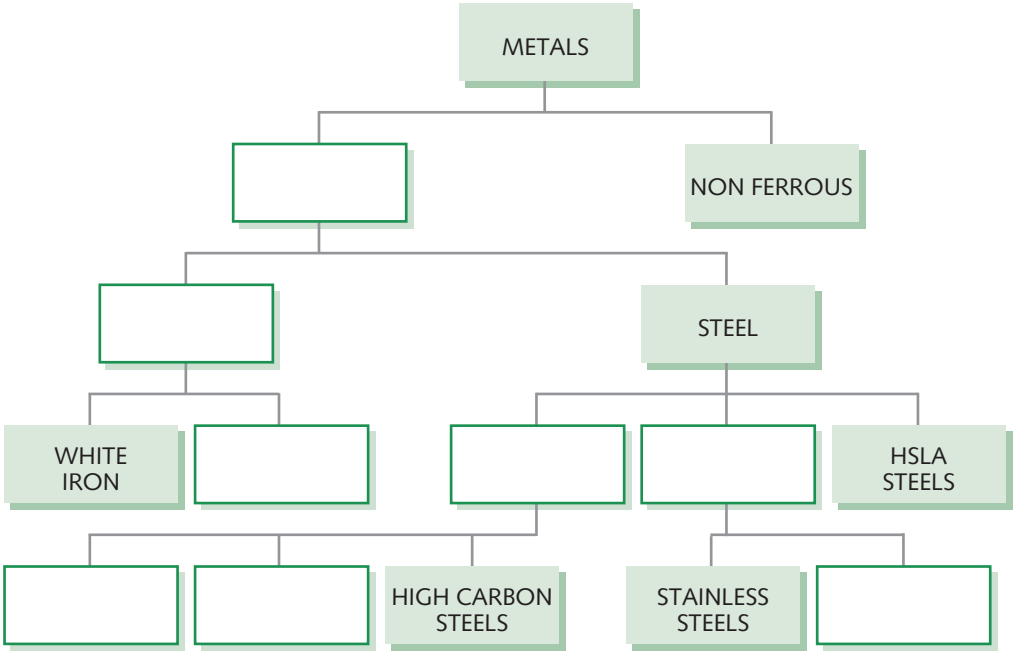
☐ **1.** to resist corrosion.
☐ **2.** alloy steels are not cheap.
☐ **3.** according to the carbon content.
☐ **4.** HSLA steels often replace alloy steels.
☐ **5.** to improve hardness.
☐ **6.** stainless steels are employed.

## 6 *PAIR WORK. Ask and answer the following questions in turns.*

**a.** What do alloy steels consist of?
**b.** What are stainless steels used for?
**c.** Which properties do tungsten, molybdenum, chromium and nickel improve?
**d.** Why are tool steels employed for wear-intensive machinery?
**e.** Which advantages do HSLA steels offer?

*Stainless steel wires*

## 7 *Complete the following diagram referring back to what you have just read about metals.*




GLOSSARY

**to add**: aggiungere
**furthermore**: inoltre
**to improve**: migliorare
**therefore**: perciò
**wear**: consumo, logoramento
**to weld**: saldare

# C. WHAT IS STEEL?

**8** *Choose the appropriate title for each paragraph:*

Grades – Production – History – Applications – Properties

**Par. 1** .....

Steel, the world's foremost construction material, is an alloy of iron containing between 0.2% and 2% carbon. The advent of commercial steel production in the late 19th century was a result of Sir Henry Bessemer's creation of an efficient way to lower the carbon content in cast iron. By lowering the amount of carbon in iron to about 2%, harder and more malleable steel is produced.

**Par. 2** .....

Today, most steel is produced by a basic oxygen steelmaking (BOS) method, so named because it requires oxygen to be blown into large vessels containing molten iron and scrap steel while the use of electric arc furnaces (EAF) now accounts for about one third of all steel production.

**Par. 3** .....

Over 3,500 different grades of steel exist. Commercial steels are generally classified into four groups depending on their metal alloy content and end-use applications:

1. Carbon Steels
2. Alloy Steels
3. Stainless Steels
4. Tool Steels

**Par. 4** .....

Different types of steels are produced according to the properties required for their applications, and various grading systems are used to distinguish steels based on these properties. The table below lists the properties of steels at room temperature (25 °C).

**Par. 5** .....

From stainless and high temperature steel to flat carbon products, its various forms and alloys offer different properties to meet a wide range of applications. For these reasons, as well as the metal's combination of high strength and a relatively low production cost, steel is now used in countless products.

GLOSSARY

**to account for**: equivalere, rappresentare
**cast iron**: ghisa
**countless**: innumerevole
**flat**: (qui) semplice
**foremost**: principale
**molten**: fuso
**scrap**: scarti di lavorazione
**vessel**: recipiente

## General properties of steels

| PROPERTIES | CARBON STEELS | ALLOY STEELS | STAINLESS STEELS | TOOL STEELS |
|---|---|---|---|---|
| Density (1000 kg/m$^3$) | 7.85 | 7.85 | 7.75-8.1 | 7.72-8.0w |
| Elastic Modulus (GPa) | 190-210 | 190-210 | 190-210 | 190-210 |
| Poisson's Ratio | 0.27-0.3 | 0.27-0.3 | 0.27-0.3 | 0.27-0.3 |
| Thermal Expansion ($10^{-6}$/K) | 11-16.6 | 9.0-15 | 9.0-20.7 | 9.4-15.1 |
| Melting Point (°C) | | | 1371-1454 | |
| Thermal Conductivity (W/m-K) | 24.3-65.2 | 26-48.6 | 11.2-36.7 | 19.9-48.3 |
| Specific Heat (J/kg-K) | 450-2081 | 452-1499 | 420-500 | |
| Electrical Resistivity ($10^{-9}$ W-m) | 130-1250 | 210-1251 | 75.7-1020 | |
| Tensile Strength (MPa) | 276-1882 | 758-1882 | 515-827 | 640-2000 |
| Yield Strength (MPa) | 186-758 | 366-1793 | 207-552 | 380-440 |
| Percent Elongation (%) | 10-32 | 4-31 | 12-40 | |
| Hardness (Brinell 3000 kg) | 86-388 | 149-627 | 137-595 | 210-620 |

**9** *Complete the following parts of sentences.*

**a.** Steel is an alloy of ..... .
**b.** Sir Henry Bessemer created an ..... .
**c.** If you lower the amount of carbon in iron to about 2%, ..... .
**d.** Most steel is produced by ..... .
**e.** One third of all steel is produced by ..... .
**f.** There are about 3,500 different grades of steel ..... .
**g.** Steel is now used in countless products ..... .
**h.** Steel's various forms and alloys offer different properties:
  **1.** ..... iron and carbon in variable percentage.
  **2.** ..... efficient way to lower the carbon content in cast iron.
  **3.** ..... steel becomes harder and more malleable.
  **4.** ..... a basic oxygen steelmaking (BOS) method.
  **5.** ..... electric arc furnaces (EAF).
  **6.** ..... with unique physical, chemical and environmental properties.
  **7.** ..... because it combines high strength and a relatively low production cost.
  **8.** ..... to meet a wide range of applications.

# D. WHAT IS STEEL USED FOR?

Steel is both the most widely used and most recycled metal material on earth. Steel applications can be divided into five sectors:

## 1. Construction

The majority of steel goes into the construction industry. Sustainable steel structures can be built quickly at a low price. Steel, in its various forms and alloys, can be designed to meet the requirements of unique projects, which allow it to be incorporated into the infrastructure of any environment. Depending on the conditions that the structure is exposed to, steel can be alloyed or surface treated differently for protection. Steel can be found in: low and high-rise buildings, education and hospital buildings, sports stadiums, stations, bridge deck plates, piers and suspension cables, harbours and tunnels.

## 2. Transport

Engineering steels are wrought steels that are designed to have certain specific levels of elasticity, strength, ductility and corrosion resistance. They are used in the general engineering and manufacturing sectors, but the bulk goes to transport vehicles. Steel accounts for over 50% of the weight of an average car. Advanced high-strength steels (AHSS) are used in vehicles and different types of steel are used for the car body, doors, engine, gearbox, steering, suspension, wheel axles and interiors. Besides the automotive market, steel is found in transport materials such as trucks, trains, rails, ships, aircraft and jet engine components.

## 3. Energy

All segments of the energy sector, including nuclear, wind power, electric and natural gas, demand steel for infrastructure. Steel is also used for resource extraction, such as in offshore platforms, earth-moving and quarrying equipment, cranes and fork-lifts. Due to the demanding environments, carbon, micro-alloyed, high strength and stainless steels are all used in the production of offshore platforms and pipelines. In addition to these, many other energy projects rely on large amounts of steel: oil and gas wells and platforms, pipelines, electricity power components, wind turbines and transmission towers.

## 4. Packaging

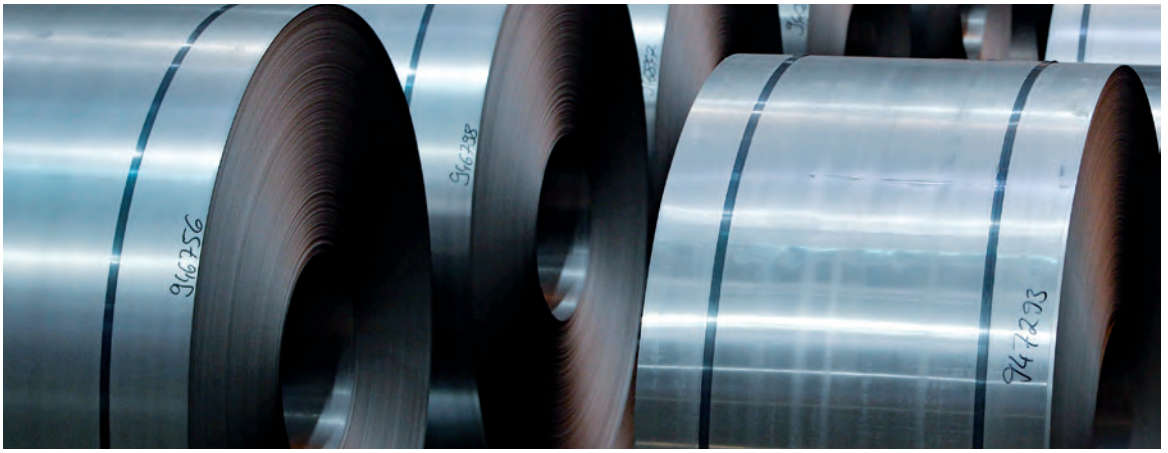
Steel packaging protects goods from water, air and light exposure and is fully recyclable. This method of storage has been around for over 200 years. Steel allows for high-speed filling and lightweight, easy to open packaging. The majority of steel packaging goes into food and beverage containers, aerosols and closures (e.g. bottle caps).

## 5. Appliances and industry

About 75% of the weight of typical household appliances comes from steel. Steel is found in appliances like fridges, washing machines, ovens, microwaves, sinks, cutlery, etc. Steel is also used in many industrial goods like farm vehicles and machinery, storage tanks, tools, structures, walkways and protective equipment.

**10** *Read the text again and complete the following table putting the different applications of steel into the appropriate sector.*

| CONSTRUCTION | TRANSPORT | ENERGY | PACKAGING | APPLIANCES INDUSTRY |
|---|---|---|---|---|
| | | | | |



GLOSSARY

**to allow for**: consentire
**bulk**: il grosso, il primato
**crane**: gru
**cutlery**: posateria
**due to**: a causa di
**earth-moving**: movimento a terra
**fork-lift**: montacarichi
**gearbox**: cambio
**harbour**: porto
**household appliances**: elettrodomestici
**meet the requirements**: soddisfare i requisiti
**offshore platform**: piattaforma in alto mare
**pier**: molo
**plate**: lastra
**quarry**: estrazione
**rely on**: avvalersi
**surface treated**: trattato in superficie
**steering**: sterzo
**sustainable**: sostenibile
**truck**: camion
**well**: pozzo
**wheel axle**: asse della ruota
**wrought**: lavorato

# E. THERMAL TREATMENTS ON STEEL

A **heat treatment** is the **controlled** heating and cooling of metals to alter their physical and mechanical properties and improve their performance. Thermal treatments have three main steps: **heating** materials to a given temperature, **maintaining** this temperature for a certain time and finally **cooling** them to room temperature. By **softening** or **hardening** metals, heat treatments aim at:

1. improving workability
2. increasing strength or hardness
3. enhancing resistance to fracture
4. ensuring stabilization against varying environmental conditions
5. reducing any residual stress due to part fabrication.

Each metal has its own specific chemical composition and so alterations in physical and structural properties take place at a different, definite critical temperature and require a distinct method and rate of cooling, depending on the material involved. Therefore, the choice of the most adequate thermic treatment is strictly dependant on the characteristics of the material selected and the desired results. Not all heat treatments are suitable for all metals.
As regards **steel**, a successful heating process entails the precise recognition of its "**critical point**", which is the point at which a transformation phase occurs during heating and cooling. Through the correct identification of this transformation point, you can predict the behaviour of the type of steel in use and set the most suitable temperature, time and cooling rate in order to obtain specifically required properties such as hardness, toughness and workability. Due to its good response to thermal processes and widespread commercial use, **steel** is by far the most frequently used material in thermal treatments.

GLOSSARY

**to alter**: modificare
**definite**: preciso
**rate**: velocità
**recognition**: riconoscimento
**to set**: fissare, impostare
**widespread**: diffuso

**11** *In the text above, find the English equivalents of the Italian words listed below.*

**a.** *raffreddamento* .....
**b.** *prestazione* .....
**c.** *ambientale* .....
**d.** *modifiche* .....
**e.** *velocità* .....
**f.** *comportamento* .....
**g.** *tenacità* .....

**12** *Find the correct matching for each of the following terms.*

| | | | |
|---|---|---|---|
| **a.** | workability | ☐ **1.** | A quality, attribute or distinctive characteristic of something. |
| **b.** | enhancing | ☐ **2.** | A reaction that arises from a specific stimulus. |
| **c.** | thermic process | ☐ **3.** | The relative ease with which a material may be formed by some shaping methods. |
| **d.** | response | ☐ **4.** | A treatment related to heat. |
| **e.** | property | ☐ **5.** | The degree of hotness or coldness of a body or environment. |
| **f.** | temperature | ☐ **6.** | Improving the qualities of something. |

**13** *Complete the following sentences with the missing information to be found in the text.*

**a.** Carrying out a thermic treatment means ..... in order to .....
**b.** The steps to follow in a thermic treatment are .....
**c.** ..... thermic treatments are applied to materials in order to improve their properties.
**d.** Metals must be stabilized in order to cope with .....
**e.** Metals react ..... because .....
**f.** The selection of the most successful heat treatment depends on .....
**g.** The knowledge of the transformation point of steels allows ..... to be established.

# F. SOFTENING THERMIC TREATMENTS

**14** *Complete the text with the words given below.*

annealing – brittleness – crackings – dimensional – furnace – industry – machinable
purpose – removing – tempered – thermic – treatments

Annealing, normalizing, tempering, marquenching and austempering are common 1) ..... processes aimed at reducing strength or hardness, improving toughness, 2) ..... residual stresses and restoring ductility.

**Annealing** entails heating steel and cast iron to a certain temperature and then allowing them to cool slowly and uniformly. The 3) ..... of annealing is to soften the steel and make it less brittle and more 4) ..... . It is also used to eliminate the effects of welding or other previous heat treatments. Cooling occurs in the same furnace used for heating and this can result in a time consuming, expensive process.

**Normalizing** is similar to annealing but requires a higher temperature and a much faster cooling process. It is cheaper than 5) ..... because cooling occurs outside the 6) ..... . It increases strength, ductility and impact resistance reducing internal and surface stress caused by previous heat treating or shaping processes such as casting, forging or rolling. Normalizing enhances machinability and provides 7) ..... stability for further heat treatments.

**Tempering** is aimed at reducing 8) ..... and restoring ductility after rapid cooling. All hardened steels must be 9) ..... before use because their high level of hardness and low toughness makes them prone to 10) ..... . Tempering involves gently heating and slow cooling; temperature must be set very carefully in order to find a delicate balance between hardness and toughness.

Other treatments largely employed in 11) ..... are **marquenching** and **austempering**. Both processes reduce internal stress and cracks, substantially increasing impact resistance. They are isothermal heat 12) ..... applied to previously hardened steels and consist in holding steel in a molten salt bath at a certain temperature and then cooling it at a moderate speed. Austempering offers even higher ductility, impact resistance and lower distortion than marquenching but it cannot be applied to all types of steel.

GLOSSARY

- **casting**: fusione
- **to enhance**: aumentare
- **forging**: forgiatura
- **isothermal**: a temperatura costante
- **molten**: fuso
- **to occur**: verificarsi
- **prone to**: incline a
- **to restore**: ripristinare
- **to result in**: causare, determinare
- **rolling**: laminazione
- **to temper**: temperare
- **toughness**: tenacità
- **welding**: saldatura

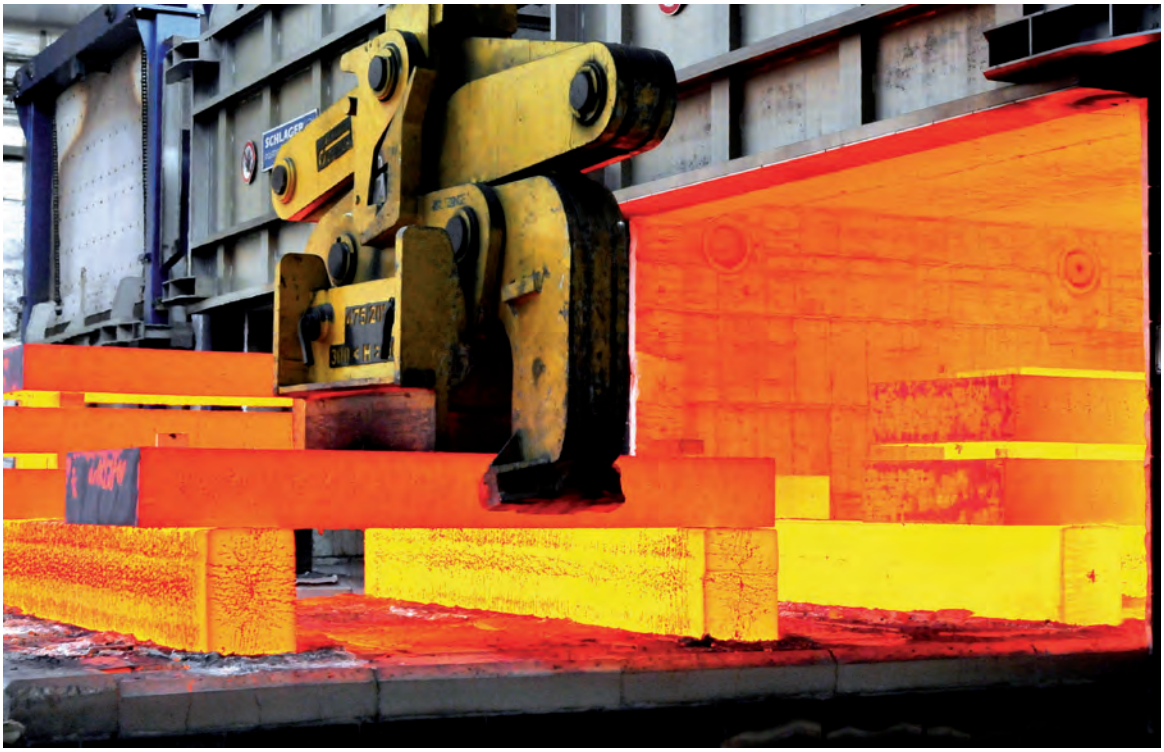
**15** *Find the Italian equivalents for the following terms you have met in the text.*

**a.** annealing .....
**b.** tempering .....
**c.** austempering .....
**d.** residual .....
**e.** cast iron .....
**f.** ductility .....
**g.** further .....
**h.** prone to .....
**i.** balance .....
**j.** employed .....

**16** *Look at the passage again and match each sentence with its ending.*

| | |
|---|---|
| **a.** Annealing is also used to | ☐ **1.** be tempered before use. |
| **b.** Normalizing is | ☐ **2.** can be subjected to austempering. |
| **c.** Steels enhance | ☐ **3.** in a molten salt bath in both marquenching and austempering. |
| **d.** All hardened steels must | ☐ **4.** be kept between hardness and toughness in tempering. |
| **e.** The right balance must | ☐ **5.** eliminate the effects of welding or other previous heat treatments. |
| **f.** Steel is held | ☐ **6.** cheaper than annealing. |
| **g.** Not all types of steel | ☐ **7.** dimensional stability through normalizing. |

# G. HARDENING THERMIC TREATMENTS



Quenching, carburizing and nitriding are thermal processes used for increasing strength and wear resistance.

**Quenching** involves the rapid cooling of hot steel in order to enhance hardness and tensile strength, decrease resilience and deformability; unfortunately, it can cause brittleness. Quenching is usually done to room temperature by using a medium such as forced air, immersion in plain or salt water, or oil. The type of steel and the dimensions of the parts to be hardened influence the choice of the medium. Water is a good rapid quenching medium but it can be corrosive. **Cryogenic quenching** enhances the effects of a previous quenching treatment by cooling materials to deep freeze temperatures using liquid nitrogen, thus obtaining excellent wear resistance which is needed in high carbon steels, stainless steels and tool steels.

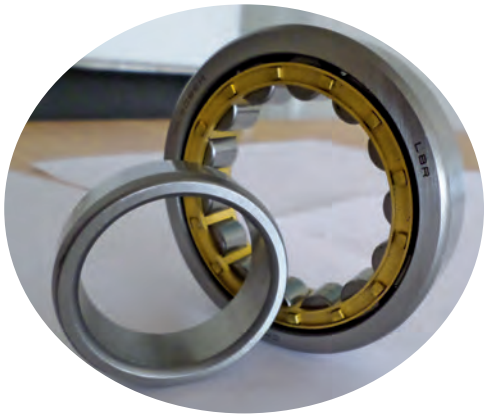
**Carburizing** is one of the oldest methods for the surface-hardening of steel. It is a thermo-chemical treatment which adds carbon to the material's surface to reinforce its outer hardness, leaving the inner part relatively soft but **resilient**. This process is often employed for pistons, pins, gears, ball and roller bearings.

**Nitriding** is also a thermo-chemical treatment, based on the diffusion of nitrogen onto the surface of the material. It is widely used in manufacturing drive gears, crankshafts and cylinder cases.

GLOSSARY

**ball bearings**: cuscinetti a sfera
**carburizing**: carburazione
**crankshaft**: albero a gomito
**drive gear**: ingranaggio di trasmissione
**gear**: ingranaggio
**nitriding**: nitrurazione
**pin**: perno
**to quench**: spegnere, temperare
**resilience**: elasticità
**roller bearing**: cuscinetto a rulli
**thus**: così

**17** *Match each term with its synonym.*



| | | | |
|---|---|---|---|
| **a.** | wear | ☐ | **1.** flexibility |
| **b.** | involve | ☐ | **2.** sum |
| **c.** | enhance | ☐ | **3.** spread |
| **d.** | resilience | ☐ | **4.** deterioration |
| **e.** | dimension | ☐ | **5.** improve |
| **f.** | deep freeze | ☐ | **6.** size |
| **g.** | add | ☐ | **7.** include |
| **h.** | diffusion | ☐ | **8.** extremely cold |

**18A** PET *Read the text again and decide if the following statements are true (T) or false (F).*

| | | T | F |
|---|---|---|---|
| **a.** | Quenching is expected to reduce brittleness. | ☐ | ☐ |
| **b.** | Dimensions and type of steel affect the choice of the medium in quenching. | ☐ | ☐ |
| **c.** | Liquid nitrogen is employed in the hardening of stainless steel. | ☐ | ☐ |
| **d.** | Carburizing is a recent heat treatment. | ☐ | ☐ |
| **e.** | Softening thermic treatments reduce strength, improve toughness and remove stress. | ☐ | ☐ |
| **f.** | Carburizing involves softening. | ☐ | ☐ |
| **g.** | Annealing can be rather expensive. | ☐ | ☐ |
| **h.** | Cooling takes place outside the furnace in normalization. | ☐ | ☐ |
| **i.** | Quenched steels rarely require tempering. | ☐ | ☐ |
| **j.** | A molten salt bath is employed in both marquenching and austempering. | ☐ | ☐ |

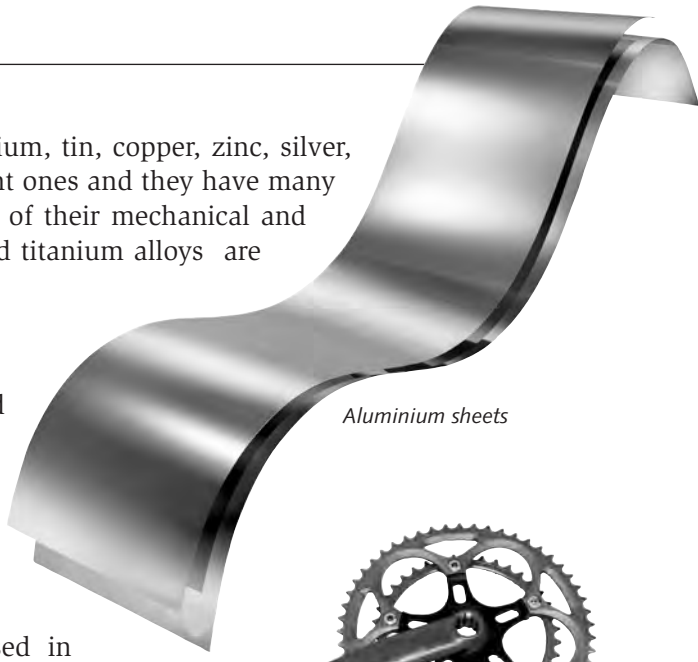
**18B** *Now correct the false statements.*

**19** *Look at the previous texts (E–G) again and answer the following questions.*

**a.** What are thermic treatments used for?
**b.** What does the choice of the right heat treatment depend on?
**c.** What is the purpose of annealing?
**d.** How does normalising differ from annealing?
**e.** What are the main features of tempering?
**f.** What happens during quenching?
**g.** Why is carbon added to the surface of steel in carburizing?

# H. NON-FERROUS METALS

Non-ferrous metals do not contain iron: aluminium, tin, copper, zinc, silver, lead and titanium are some of the most important ones and they have many applications in mechanical engineering because of their mechanical and technological properties. Aluminium, copper and titanium alloys are also widely appreciated.



*Aluminium sheets*

## Aluminium and its alloys

Obtained from bauxite, aluminium is the third most abundant element on Earth and combines easily with oxygen and other common elements in nature. It has many industrial applications because it is hard, strong and light, easily machinable and resistant to corrosion. An excellent conductor of heat and electricity, it is easily recyclable and non-toxic: it is used in the aerospace, shipbuilding, food processing industries, in medical and chemical equipment and many other fields. Aluminium alloys are even stronger and lighter and can undergo almost all the metalworking processes.



*Titanium crank*

## Copper and its alloys

Reddish, ductile, a good conductor of electricity and heat, copper strongly resists corrosion and is useful for both ornamental and practical applications. It is commercially produced mainly to supply the electrical industries, to make water pipes and to form technologically important alloys such as brasses (copper + zinc), bronzes (copper + tin) and cupro-nickels (copper + nickel). These alloys are much stronger, harder and tougher than copper itself.

## Titanium and its alloys

Titanium and its alloys are light, very strong with extremely high corrosion resistance, a high melting point and good creep resistance. They are suitable for aerospace applications, food processing, chemical and bio-engineering applications, surgical and dental implants.

GLOSSARY

**creep**: scorrimento
**even**: persino
**pipe**: tubatura
**surgical**: chirurgico
**to undergo**: subire, sopportare

**20** *Match the beginning of each sentence with the correct ending.*

| | | | |
|---|---|---|---|
| **a.** | Aluminium usually | ☐ **1.** | a wide range of applications. |
| **b.** | Bauxite is | ☐ **2.** | occurs in compounds. |
| **c.** | Aluminium alloys are | ☐ **3.** | the most common aluminium ore. |
| **d.** | Aluminium alloys find | ☐ **4.** | very strong and light. |

**21** *Refer back to the text on aluminium and find a synonym for.*

**a.** more than enough .....
**b.** mixes together .....
**c.** recovered .....
**d.** can be used again .....

**22** *Fill in the chart with the missing information.*

| NON-FERROUS METALS | PROPERTIES | USES |
|---|---|---|
| ALUMINIUM | | – mixed with other metals to form alloys<br>– aircraft, shipbuilding industry<br>– food processing industry<br>– chemical-medical equipment |
| | – reddish, ductile, malleable<br>– good conductor of heat and electricity<br>– highly resistant to corrosion | |
| | | – food-processing industries<br>– chemical and bio-engineering applications<br>– surgical implants |

**23** *PAIR WORK. Refer to the texts above and in turns ask and answer the following questions.*

**a.** Can you list the main properties of copper?
**b.** What is copper usually employed for?
**c.** Which are the most important copper alloys? Why are they important?
**d.** What are the main features and applications of titanium and its alloys?