



Learning Science via Standards



IS 17526



GM/L-XXXXXXXXXX

Vacuum Flask

Lesson 35

July 2023



Nurturing Young Minds as Ambassadors of Quality and Standards



Foreword

Everything around us, whether natural phenomena or manmade products can be explained through science. The product which are used in our daily life are outcome of conscious efforts by the mankind to fulfil and exceed the needs of the present and demands of the future. Students are taught science as part of their school curriculum, to enable them to understand the various scientific laws and principles and also to inculcate the habit of exploring the world through the lens of science. Quality characteristics of any product or service are decided based on the stated and implied needs and are generally described in a document called 'Standard'. Science and standards are inseparable and integral aspect of any product.

Bureau of Indian Standards (BIS), the national standards body of India, is mandated for establishment and promotion of standards and creating a quality ecosystem in the country. This is achieved through developing Indian Standards on products and services through the active involvement of relevant stakeholders and dissemination of information of such standards for their use and implementation across all sectors of economy. Academia, as an important stakeholder of BIS, has been contributing towards development of standards through research activities and providing inputs related to technological advancements in product development, their characteristics and use as well as methods of tests. BIS, on its part has also been promoting standards in academia through a variety of programmes. This has since been institutionalized in the form of "Standards Clubs" which are being established in educational institutions across India to nurture the young minds as ambassadors of quality and standards and prepare them for dealing with these aspects in future.

In this initiative of BIS, called "Learning Science via Standards", a series of Lesson Plans are made elaborating the various scientific concepts, laws and principles to help students understand their practical applications via standards. The series comprises of a variety of subjects for insights into the scientific laws and principles and relating them to the quality characteristics of products used in day-to-day life. First 10 Lesson Plans in the series are released on the occasion of World Consumer Rights Day on 15 Mar 2023. Second Set of 10 Lesson Plans were released on 10 Jun 2023 by Hon'ble Minister of State during the Governing Council Meeting of BIS.

The Lesson Plans are expected to serve as a useful tool for the teaching fraternity for imparting knowledge on scientific laws and principles through their practical applications in activities and products around us and facilitate an interactive learning experience for the students.



Vacuum Flask

Vacuum flasks are amazing inventions that keep hot things hot and cold things cold for a long time. They work by creating a vacuum between two walls of the flask, which prevents heat from transferring by conduction or convection. Vacuum flasks are used mainly for keeping food products and items at a desired temperature so that they maintain their taste and flavor without deterioration for some reasonable time.

The vacuum flask was invented in 1892 by Sir James Dewar, a Scottish chemist and physicist. Dewar was working on a way to store liquefied gases, and he found that the vacuum flask could keep them cold for much longer than any other method. Vacuum flasks are now used all over the world for a variety of purposes.

They are popular for keeping drinks hot or cold on the go, and they are also used in laboratories, hospitals, and other settings where it is important to keep temperature-sensitive materials stable. Over the years, vacuum flasks have evolved to become more efficient and durable. They are now made from a variety of materials, including glass, metal, and plastic. They also come in a wide range of shapes and sizes, so there is a vacuum flask to fit every need.



1. Components of a Vacuum Flask

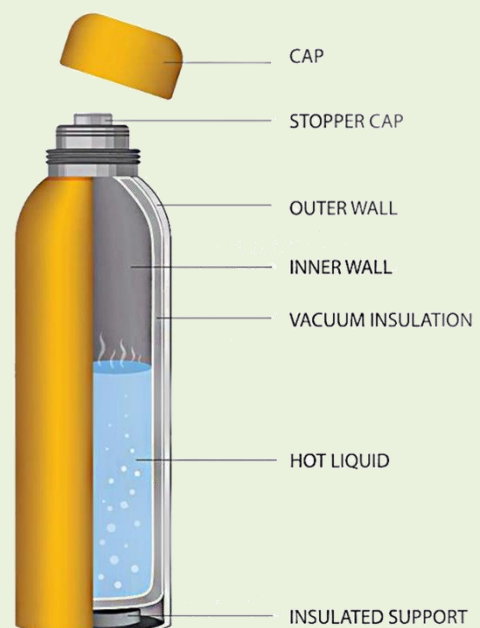
A vacuum flask consists of two containers, an inner and an outer one, which are typically made of materials like glass or metal. These containers are carefully designed to fit together, leaving a space between them. The space between the inner and outer containers is partially evacuated of air, creating a near-vacuum. This vacuum layer plays a vital role in reducing heat transfer. The major components of a vacuum flask are:

a) Inner flask

The inner flask is the most important component of a vacuum flask. It holds the liquid and prevents heat from transferring to or from the outside environment. The inner flask is typically made of glass or metal.

b) Outer flask

The outer flask protects the inner flask from damage and insulates it from the environment. The outer flask is typically made of the same material as the inner flask, but thicker to provide more mechanical strength to bear the pressure from outside environment. It should resist collapse into vacuum between the flasks. The inside flask has positive pressure inside so does not collapse.



c) Vacuum

The vacuum space between the inner and outer flasks prevents heat from transferring by conduction or convection. The vacuum is created by removing all of the air from the space between the flasks. This is done by pumping out the air until there is a very low pressure.

d) Reflective coating

The reflective coating on the inner flask reflects heat back into the flask. This prevents heat from escaping by radiation. The reflective coating is typically made of silver or gold, which are both good reflectors of heat.

e) Vacuum seal

The vacuum seal prevents air from entering the vacuum space. This is important because air would allow heat to transfer by conduction or convection. The vacuum seal is typically made of rubber or plastic, which are both good insulators of heat.

The components of a vacuum flask work together to create a very effective heat insulator. This is why vacuum flasks are so useful for keeping drinks hot or cold for long periods of time.

Activity

Q1: What comes to your mind when you hear the word “Vacuum”?

Ans: Space that is completely empty of all substances, including air or other gases.

Q2: What would be the effect of a vacuum on humans & Animals?

Ans: Humans and animals exposed to vacuum will lose consciousness after a few seconds and die of hypoxia within minutes.

Note: *Hypoxia is a condition in which the body or a region of the body is deprived of adequate Oxygen supply at the tissue level.*

2. Manufacturing of Vacuum Flasks

The manufacturing process of vacuum flasks involves a series of steps to craft these remarkable vessels that keep our food and beverages at desired temperatures. Let's dive into the process of bringing these thermal guardians to life.

a) Design and Material Selection: The manufacturing of vacuum flasks begins with the design phase. Engineers and designers determine the shape, size, and features of the flask to meet customer requirements. The selection of materials is crucial, typically including glass, metal, and plastics, chosen for their durability, thermal insulation properties, and visual appeal.

b) Inner and Outer Container Production: The production process starts with the fabrication of the inner and outer containers. These containers are carefully formed using manufacturing techniques specific to each material. For example, glass containers may undergo blowing or moulding processes, while metal containers are shaped through techniques like deep drawing or injection moulding for plastics.

c) Assembly and Vacuum Creation: Once the containers are ready, they are meticulously assembled. The inner and outer containers are sealed together, leaving a space between them.



To create the vacuum, specialized machines or methods are used to evacuate the air from the gap between the containers. This near-vacuum environment minimizes heat transfer by conduction and convection.

- d) Coating and Insulation Enhancement:** To further enhance the insulation properties, additional coatings may be applied to the inner or outer surfaces of the flask. These coatings can consist of reflective materials or insulating layers that help to reduce heat loss/gain and improve overall thermal performance.
- e) Testing and Quality Assurance:** Each vacuum flask undergoes rigorous testing to ensure its functionality, durability, and insulation capabilities. Tests may include checking for leaks, evaluating insulation efficiency, and assessing overall product quality. Only flasks that meet stringent quality standards move forward in the manufacturing process.
- f) Finishing and Packaging:** After passing quality control, the vacuum flasks go through finishing processes. These can include polishing, painting, or applying decorative elements to enhance their visual appeal. The flasks are then carefully packaged, ready to be shipped to retailers or directly to consumers.

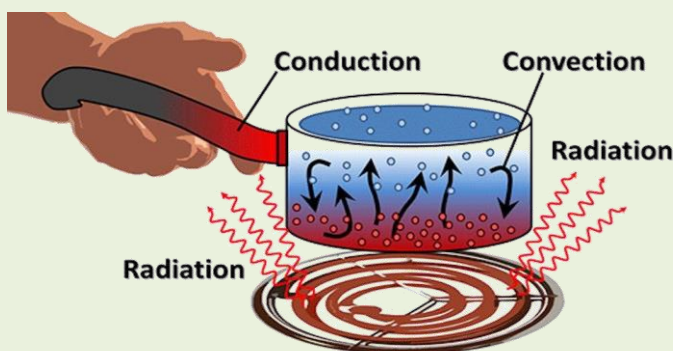
Activity (Manufacturing)

Ask the following questions to students and ask them to research and find out appropriate answers of respective questions.

- Can anyone explain the construction of Vacuum flask?
- How the flask can be manufactured?
- How does a vacuum flask prevent heat transfer?
- What are the ways to create and maintain vacuum?

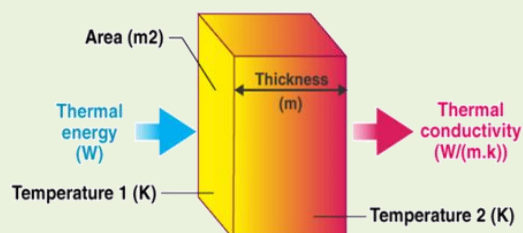
3. Scientific Laws for Optimal Design and Performance

- a) Heat Transfer:** Understanding the science of heat transfer is essential in comprehending the working principles and performance of vacuum flasks. Let's delve into the concepts of conduction, convection, radiation, and thermal conductivity, and explore their relevance to the design and functionality of vacuum flasks.
 - i) Conduction:** Conduction is a process where heat is transferred through direct contact between molecules. In the context of vacuum flasks, conduction plays a crucial role in preventing heat transfer between the inner and outer containers. The vacuum layer in a vacuum flask acts as an effective insulator, inhibiting heat conduction and maintaining the desired temperature of the contents.
 - ii) Convection:** Convection involves heat transfer through the movement of fluids, driven by temperature differences. Although convection primarily occurs in gases and liquids, it has minimal impact on heat transfer in vacuum flasks. The near-vacuum environment within



the flask eliminates the presence of fluids, thus significantly reducing convective heat transfer.

- iii) **Radiation:** Radiation is the transfer of heat through the emission of electromagnetic waves. While radiation can occur in vacuum flasks, it is greatly minimized by several design elements. The outer surface of a vacuum flask is often coated with a reflective material, reducing the emission and absorption of thermal radiation. This coating helps maintain the temperature inside the flask by minimizing heat loss through radiation.
- iv) **Thermal Conductivity:** Thermal conductivity is a property that describes a material's ability to conduct heat. It is the measure of the rate of heat transfer through a material per unit area per unit temperature gradient. The unit of thermal conductivity is typically Watts per meter-Kelvin ($\text{W/m}\cdot\text{K}$). The value of thermal conductivity depends on the composition and structure of a material, and can range from low values for insulating materials to high values for conductive materials.



In the context of vacuum flasks, materials with low thermal conductivity are typically chosen for the inner and/or outer containers. This selection helps reduce heat conduction through the flask's walls, enhancing its insulation capabilities and improving overall thermal performance.

Activity (Basic Principles)

Ask the following questions to students and ask them to research and find appropriate answers of respective questions.

- What is conduction, convection and radiation?
- What is the difference between conduction, convection and radiation?
- What is thermal conductivity?
- Give examples of good conductors and bad conductors of heat.
- What is the thermal conductivity of air and vacuum?
- What are the possible ways of heat transfer/loss from the vacuum flask?

b) Thermodynamics: The principles of thermodynamics play a significant role in understanding the design and performance of vacuum flasks. Let's explore how the concepts of open, closed, and isolated systems, along with the laws of thermodynamics, relate to the functioning of vacuum flasks.

i) Thermodynamic Systems:

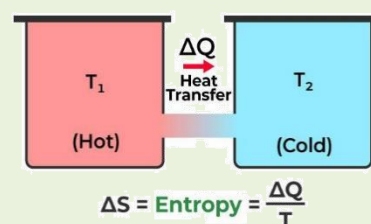
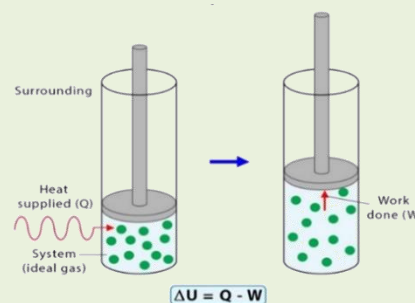
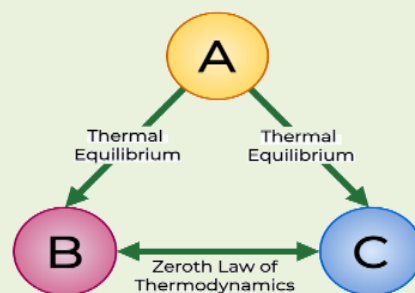
- **Open System Relevance:** Although vacuum flasks are not considered open systems, it is important to understand the concept. In an open system, both energy and mass can be exchanged with the surroundings. However, in the case of a vacuum flask, the exchange of energy occurs through heat transfer, while mass remains confined within the flask.



- **Closed System Significance:** Vacuum flasks can be seen as closed systems, where only energy can be exchanged with the surroundings. The flask's insulation properties limit heat transfer greatly, enabling the maintenance of the desired temperature inside.
- **Isolated System:** The system in which neither energy nor mass can be exchanged with the surroundings.

ii) Thermodynamic Laws:

- **Zeroth Law of Thermodynamics:** The zeroth law states that when two systems are in thermal equilibrium with a third system, they are also in thermal equilibrium with each other. In the context of a vacuum flask, the zeroth law ensures that the temperature of the contents inside the flask remains constant and in equilibrium with the surrounding environment.
- **First Law of Thermodynamics:** The first law, also known as the law of conservation of energy, states that energy can neither be created nor destroyed but can only change forms. In a vacuum flask, this law is relevant as the flask preserves the energy in the form of heat, preventing its loss to the surroundings. The insulation and vacuum layer reduce heat transfer, maintaining the thermal energy of the contents.
- **Second Law of Thermodynamics:** The second law describes the natural direction of heat flow, stating that heat moves from hotter objects to colder objects, unless energy is supplied to reverse the direction. In the case of a vacuum flask, the vacuum layer and insulation hinder heat flow from the contents to the surroundings, ensuring the contents' temperature remains stable.



The design and functionality of vacuum flasks align with the principles of thermodynamics. By creating an environment with limited heat transfer through insulation and a vacuum layer, the flask minimizes energy exchange with the surroundings. This design ensures the preservation of the contents' temperature, keeping them hot or cold for an extended period.

Activity (Basic Principles)

- Do you know vacuum flask is also a type of thermodynamic system?
- Can you specify the type of thermodynamic system for vacuum flask?

4. Key Performance Characteristics of Vacuum Flasks

Understanding the performance characteristics of vacuum flasks is essential to assess their effectiveness in maintaining temperature, durability, and user convenience. Let's explore the major characteristics and parameters that determine the performance of vacuum flasks.

a) Material Properties:

- i) **Stainless Steel:** The inner container of a vacuum flask is commonly made of stainless steel (grade 304 or higher), known for its corrosion resistance, longevity, and ability to withstand high temperatures. Stainless steel also ensures easy cleaning and eliminates odor retention, making it suitable for food and beverage storage.
- ii) **Mechanical Properties:** Factors like tensile strength, yield strength, ductility, and modulus of elasticity influence the flask's structural integrity and durability.
- iii) **Physical Properties:** Properties such as density, thermal conductivity, electrical conductivity, and thermal expansion impact the heat transfer characteristics of the flask.
- iv) **Chemical Properties:** Reactivity, corrosion resistance, and biocompatibility of materials used in the flask affect its resistance to degradation and potential interactions with contents.

b) Heat Retention Capability: The ability of a vacuum flask to maintain the temperature of its contents is crucial for safety, quality, and consumer satisfaction. Vacuum flasks with excellent heat retention capacity ensure that the contents remain at the desired temperature for a significant duration, preventing rapid cooling or heating. The temperature limits specified by Standard IS 17526:2021 ensure compliance with quality and safety standards.

c) Cold Retention Capability: The cold retention capacity of a vacuum flask is equally important as it ensures the preservation of the liquid's quality, safety, and taste. Adequate cold retention capacity prevents rapid warming of the contents, making the flask suitable for keeping beverages chilled for extended periods. Compliance with the temperature limits specified by Standard IS 17526:2021 guarantees optimal cold retention performance.

d) Impact Resistance: The impact resistance of a vacuum flask determines its ability to withstand accidental drops or impacts without cracking, breaking, or leaking. High impact resistance ensures the flask remains intact, preventing spills and maintaining its functionality and durability even in rugged environments.

e) Holding and Suspension Arrangement:

Convenient holding and suspension arrangements, such as handles, straps, or attachments, allow secure and easy transportation of the vacuum flask. These features prevent accidental dropping and enable hands-free carrying, making the flask suitable for various outdoor activities.



f) Leakage in the Flask/Bottle: One crucial performance characteristic of vacuum flasks is the prevention of leakage. A well-manufactured flask should not have any leaks that could

compromise its functionality. Leakage can be visually inspected by filling the flask with water and observing for any signs of water seepage or dripping.

g) Joint-Leak in the Flask/Bottle: Similarly, the joints of the flask should be free from any leaks. To assess joint-leak, the empty flask can be dipped in water, and the initial and final weight of the flask can be compared. Any significant increase in weight indicates water penetration through the joints, indicating a leak.

h) Resistance to Corrosion/Staining: Vacuum flasks should exhibit resistance to corrosion and staining, particularly when exposed to harsh environments over a long period without routine cleaning and maintenance. Corrosion, oxidation, rusting, or staining can degrade the flask's appearance, structural integrity, and potentially contaminate the contents. A well-designed vacuum flask employs materials and finishes that resist corrosion and staining, ensuring the flask's durability and maintaining its aesthetic appeal.

In conclusion, the design, material properties, heat retention, impact resistance, absence of leakage and joint-leak, and resistance to corrosion/staining are crucial performance characteristics of vacuum flasks, ensuring their functionality and reliability. Compliance with relevant standards, such as Standard IS 17526:2021, guarantees adherence to quality and safety requirements.



Activity (Materials)

Ask the following questions to students and ask them to research and find appropriate answers of respective questions.

- What should be the properties of material used in manufacturing the inner layer of a flask?
- What should be the properties of material used in manufacturing of the outer layer of flask?
- What should be the properties of material used in manufacturing of lid/closure of the flask?
- How corrosion may affect the vacuum flask?
- What is the role of vacuum in the insulation of a vacuum flask?
- Does the thickness of insulation (i.e. vacuumed area) affect the heat transfer in the flask?
- Other than vacuum, what are the different gases that can be used instead of vacuum to improve the performance of the vacuum flasks?



Activity (Quality analysis)

Ask the following questions to students and ask them to research and find out appropriate answers to respective questions.

- What tests may be carried out on the product- vacuum flask to make sure that the product is of good quality?
- What should be the requirements of holding attachments of the flask?
- How can the ability of the flask to retain the temperature of the liquid be tested?
- How can the ability of the flask to sustain accidental drops or impacts be tested?
- Does the aesthetic looks/shape of the vacuum flask affect the performance of the flask?

5. Advantages of Using Vacuum Flasks Complying with Standards

- Increased Efficiency:** Adhering to the standard optimizes processes, leading to improved efficiency and production.
- Enhanced Quality:** Compliance ensures that vacuum flasks meet specified quality requirements, resulting in superior product performance and customer satisfaction.
- Improved Safety:** Following the standard reduces the risk of accidents and incidents, promoting worker and public safety.
- Enhanced Credibility:** Conforming to the standard helps businesses establish credibility and reputation, attracting new customers and business opportunities.

Compliance with the specific standard, IS 17526:2021, ensures adherence to quality benchmarks and industry best practices in vacuum flask manufacturing.

6. Importance of Circular Economy and Reduction of Carbon Footprint

Circular economy refers to an economic system that aims to minimize waste and maximize resource efficiency by promoting the reuse, recycling, and regeneration of materials. Carbon footprint refers to the total greenhouse gas emissions, particularly carbon dioxide (CO₂), associated with the activities of individuals, organizations, or products. It measures the impact of these emissions on climate change. Reducing carbon footprints involves minimizing the use of fossil fuels, adopting renewable energy sources, and implementing energy-efficient practices to mitigate climate change and promote environmental sustainability.

The concept of circular economy and the reduction of carbon footprint play crucial roles in assessing the environmental impact of vacuum flasks. Let's explore the positive and negative impacts of vacuum flasks in terms of energy savings, waste reduction, raw materials, production processes, and end-of-life management.



Positive impacts:

1. Energy savings: Vacuum flasks contribute to energy savings by minimizing the need for reheating or cooling beverages, reducing energy consumption associated with heating appliances or refrigeration.
2. Waste reduction: Using a vacuum flask instead of disposable cups or single-use beverage containers helps to reduce waste generation, promoting a more sustainable approach to beverage consumption.

Negative impacts:

1. Raw materials: The production of vacuum flasks requires the use of raw materials such as metals and glass, which can have significant environmental impacts if not sourced responsibly or recycled properly.
2. Production process: The manufacturing process of vacuum flasks may involve the emission of pollutants and waste into the air and water, potentially contributing to environmental damage if not managed effectively.
3. End-of-life management: Disposal of vacuum flasks at the end of their life cycle can pose environmental challenges if not handled appropriately. Proper recycling or responsible disposal methods are essential to mitigate negative impacts.

In summary, while vacuum flasks offer benefits in terms of energy savings and waste reduction, it is important to consider the environmental impacts associated with their production, use, and disposal. Embracing circular economy principles and reducing carbon footprints throughout the lifecycle of vacuum flasks can help mitigate these impacts and promote a more sustainable approach.



7. Interesting facts about Vacuum Flasks

- a) **Space Travel Application:** Vacuum flasks have played a crucial role in space exploration. They are used to store and transport liquids and food for astronauts, keeping them at the desired temperature in the extreme conditions of space.
- b) **Guinness World Record for Longest Hot Drink Retention:** The record for the longest time a vacuum flask kept a drink hot was set in 1997. A Thermos flask maintained hot coffee at a temperature of 91.2°C (196.16°F) for 24 hours and 30 minutes!
- c) **Double Vacuum Flask:** Some advanced vacuum flasks, such as those used in scientific applications, feature double vacuum sections. These flasks have an inner flask containing liquid helium and an outer flask containing liquid nitrogen, minimizing the loss of valuable helium.
- d) **Vacuum Flask as a Firestarter:** In emergency situations, the reflective silvered lining of a vacuum flask can be used as a makeshift firestarter. Focusing sunlight onto tinder through the flask's opening can generate enough heat to ignite a fire.
- e) **Inspired by Thermos Bottles:** The term "Thermos" has become synonymous with vacuum flasks in many countries. It originated from the German company Thermos GmbH, which popularized the use of vacuum flasks in the early 20th century.
- f) **Vacuum Flask in Mountaineering:** Vacuum flasks are popular among mountaineers and outdoor enthusiasts as they can keep beverages hot or cold for extended periods. They are often used to enjoy hot drinks at high altitudes, providing a comforting and refreshing experience.
- g) **Impact on Carbonated Beverages:** Carbonated drinks, such as soda or sparkling water, should not be stored in vacuum flasks. The low pressure inside the flask can cause the carbonation to escape rapidly, leading to a potential explosion when the flask is opened.
- h) **Vacuum Flask Art:** Vacuum flasks have been used as creative mediums for art and design. Artists have transformed them into unique sculptures and installations, showcasing the versatility and aesthetic potential of everyday objects.
- i) **DIY Vacuum Flask Experiments:** Vacuum flasks can be the basis for exciting science experiments. From creating a homemade lava lamp to conducting thermal insulation experiments, they provide a practical and engaging way to explore the principles of heat transfer and insulation.



Lesson Plan Subjects

Published

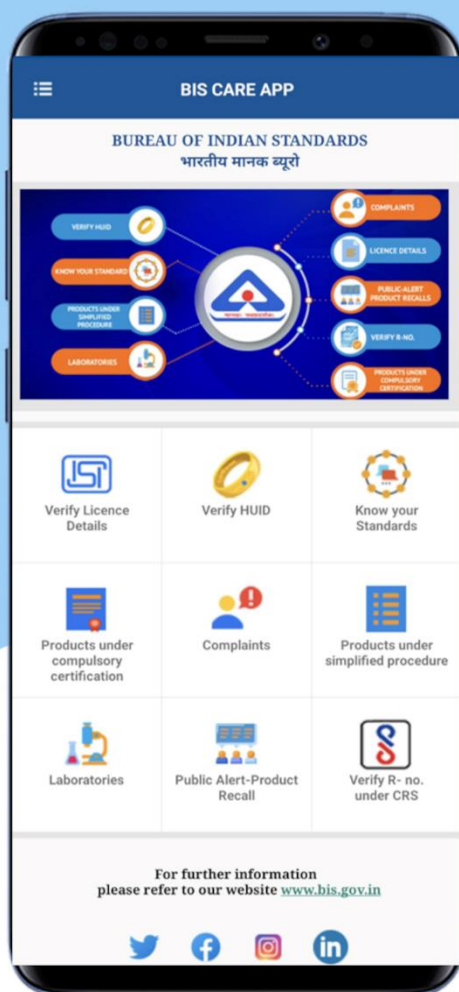
1.	Caustic Soda	21.	Ballpoint Pen
2.	Football	22.	Bicycle
3.	Cement	23.	Electric Iron
4.	Gas Stove	24.	Loudspeakers
5.	Geyser	25.	Pasteurized Milk
6.	Helmet	26.	Paver Blocks
7.	LED Bulb	27.	Plugs and Socket
8.	LPG Cylinders	28.	Solar Flat Plate Collectors
9.	Cement Ash Brick	29.	Precast Concrete
10.	Paints	30.	Stainless Steel
11.	Boric Acid	31.	Weighing balance
12.	Ceiling Fan	32.	Steel Bar
13.	Cables	33.	Thermometer
14.	Ceramics Tiles	34.	Tyres for buses and trucks
15.	Rear View Mirrors	35.	Vacuum Flask
16.	Headphones	36.	Water Meter
17.	Milk Powder	37.	Wheel Rim
18.	Pressure Cooker	38.	Water Storage Tank
19.	Plywood	39.	PVC Pipes
20.	Multipurpose dry batteries	40.	Refrigerator

Forthcoming...

41.	Drinking Water	47.	CNG Cylinders
42.	Electric Mixer	48.	Hearing Aids
43.	Family Sized Biogas Plant	49.	Microwave Oven
44.	Fire Extinguisher	50.	Solid and Hollow Block
45.	Power Threshers	51.	Submersible Pump set
46.	Conduits	52.	Geosynthetics



BIS CARE APP



*A tool
for
Consumer Empowerment*

Scan to Download



Features

- Check the authenticity of the Product with  mark by using 'Verify Licence Details'
- Check the authenticity of Hallmarked Jewellery item with HUID number  by using 'Verify HUID'
- Select 'Know your Standards' for information on any indian standard, Licenses against it and laboratories for this product.
- Get locations of BIS labs and Offices.
- Check the authenticity of electronic products with R-Number  by using 'Verify R-Number under CRS'
- Register complaints regarding quality of Product of misuse of  mark by using 'Complaints'
- You can also access products under compulsory certification of BIS & Products under simplified procedure of licensing.

How to use BIS Care App

- Go to Google play store/App store
- Install BIS Care App
- Register your mobile number



BUREAU OF INDIAN STANDARDS
(THINK, NUDGE, & MOVE DEPARTMENT)
Manak Bhavan,
9, Bahadur Shah Zafar Marg,
New Delhi – 110002.

Follow us on Social Media
Website <https://www.bis.gov.in>



twitter.com/IndianStandards



facebook.com/IndianStandards



instagram.com/indianstandards