BUREAU OF INDIAN STANDARDS

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Learning Science via Standards



IS 16192

Part 1

Wheel Rim

Lesson 37

July 2023





STANDARDS CLUB

BUREAU OF INDIAN STANDARDS

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.

Wheel Rims

Wheel rims are an essential part of any automotive vehicle. They are the outer part of the wheel that holds the tire in place. Rims come in a variety of styles, materials, and sizes. They can be made of steel, aluminum, or even carbon fiber.

The first wheel rims were made of wood. They were used on chariots and other early vehicles. Steel rims became popular in the early 1900s. They were strong and durable, but they were also heavy. Aluminum rims became popular in the 1960s. They were lighter than steel rims, but they were also more expensive.



Today, there are a variety of wheel rim materials and styles available. Steel rims are still the most common type of rim, but aluminum rims and carbon fiber rims are becoming increasingly popular. Rims can be plain or they can be decorated with various finishes, such as chrome, polished, or painted.

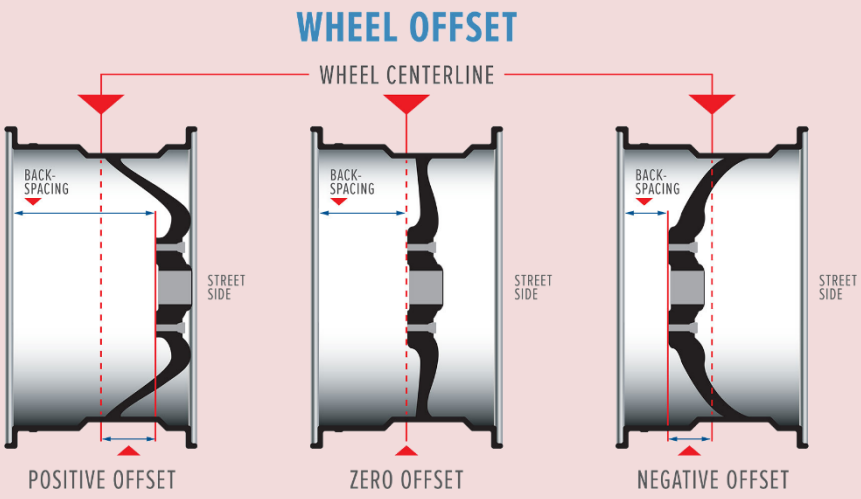


Rims play an important role in the performance of a vehicle. They affect the handling, braking, and fuel efficiency of the vehicle. The right set of rims can make a vehicle look better and perform better.

1. Wheel Rims: Classification

Wheel rims are an essential part of any automotive vehicle. They are the outer part of the wheel that holds the tire in place. There are many different types of wheel rims available, each with its own unique properties.

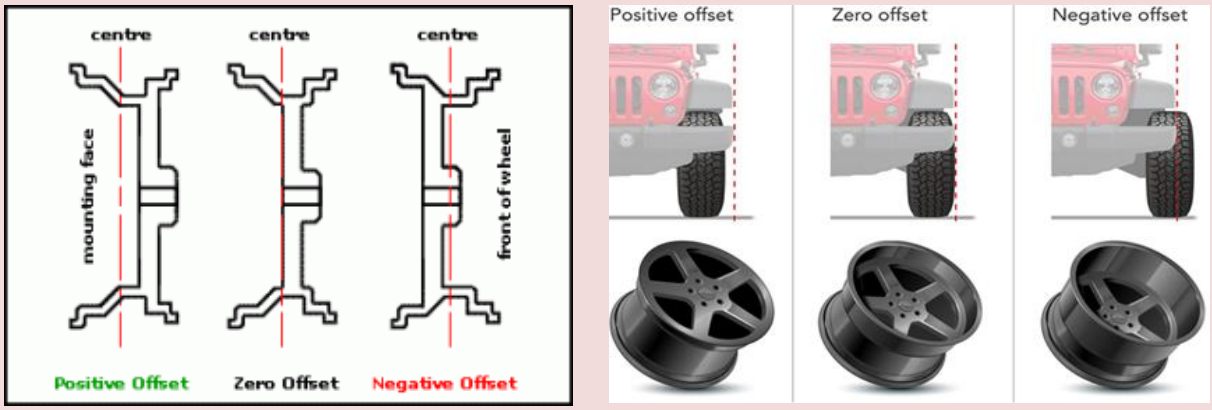
There are a few key terms that are important to define and understand. These terms can affect the performance of your vehicle, so it is important to get them right.



a) Types of Wheel Rims Based on Hub Position

i) **Hub Position**

- **Positive offset:** The mounting face of the disc is located in front of the centerline of the hub. This means that the wheel will sit further outboard than a wheel with a zero offset.
- **Zero offset:** The mounting face of the disc is located at the centerline of the hub. This means that the wheel will sit flush with the hub.
- **Negative offset:** The mounting face of the disc is located behind the centerline of the hub. This means that the wheel will sit further inboard than a wheel with a zero offset.



Pictorial view of Positive, Zero and Negative offset wheel

ii) **Impact on Vehicle**

The hub position of a wheel rim can have a significant impact on the vehicle. A positive offset wheel rim will make the vehicle wider, while a negative offset wheel rim will make the vehicle narrower. This can affect the handling and stability of the vehicle.

iii) **Choosing the Right Hub Position**

The right hub position for a vehicle will depend on the desired look and performance. For example, a vehicle that is used for racing may require a negative offset wheel rim to improve handling. A vehicle that is used for cruising may require a positive offset wheel rim to improve stability.

b) Types of Wheel Rims Based on Material

The most common materials used for wheel rims are steel, aluminum, and magnesium. Each material has its own advantages and disadvantages.

i) **Steel Wheels: Affordable and Reliable**

Steel wheels, composed of iron and carbon, are commonly found on budget cars. While they are cost-effective and straightforward, they have certain drawbacks. Steel wheels tend to be heavier, impacting fuel economy, and their slower heat dissipation can lead to increased brake wear. However, they are reliable and provide sufficient strength for everyday use.



ii) **Alloy Wheels: Lightweight and Stylish**



Alloy wheels, crafted from aluminum or magnesium alloys, offer numerous advantages over steel wheels. These wheels exhibit greater strength due to the combination of metals, while being lighter in weight. The reduced weight enhances fuel efficiency and improves overall vehicle handling. Additionally, alloy wheels provide better heat conduction and often boast a visually appealing design.

iii) **Chrome Wheels: Aesthetic Appeal with Added Protection**



Chrome wheels are essentially alloy or steel wheels coated with chrome. While this coating primarily enhances the wheel's appearance, it offers some protection against oxidation. However, it is important to note that the chrome coating does not provide any performance benefits. Chrome wheels are favoured by those seeking a shiny and eye-catching look for their vehicles.

Choose the wheel rims that best suit your needs and preferences, whether it's the cost-effectiveness of steel, the lightweight allure of alloy, or the polished aesthetics of chrome.

c) Types of Wheel Rims Based on Manufacturing Process

- **Cast rims:** These rims are made by pouring molten metal into a mold. This is the most common method of manufacturing wheel rims.



Casting



- **Forged rims:** These rims are made by heating metal and then hammering it into shape. This process produces a stronger and lighter rim.



Forging



- **Spun rims:** These rims are made by spinning a metal disc until it takes the desired shape. This is a less common method of manufacturing wheel rims, but it can produce a unique and stylish rim.

Activity

Q.1 : What is an alloy?
A: An alloy is a mixture of chemical elements, at least one of which is a metal.

Q.2: Is steel an alloy or metal?
A: Steel is an alloy made from a mixture of iron and carbon.

Q.3: Why is aluminum alloy used?
A: Aluminum alloy wheels are preferred due to their lightweight nature, which provides improved fuel efficiency and better handling. They also offer superior heat conduction and are more ductile.

Q.4: Why are chromium wheels used?
A: Chromium wheels are chosen for their enhanced aesthetics and corrosion resistance. The chrome coating not only adds a shiny appearance but also provides protection against oxidation and other forms of corrosion.

3. Critical Performance Characteristics of a Wheel Rim

Wheel rims are essential components of automotive vehicles, the following critical performance characteristics such as strength, durability, weight, and heat dissipation, play a vital role in ensuring safe and efficient vehicle operation:

a) **Strength and Durability:** The strength and durability of a wheel rim are vital for withstanding various road conditions, including bumps, potholes, and impacts. A robust wheel rim ensures the structural integrity of the wheel assembly, minimizing the risk of failure and potential accidents.

b) **Load-Carrying Capacity:** The load-carrying capacity refers to the maximum weight that a wheel rim can support without compromising its performance or safety. Adequate load-carrying capacity ensures that the wheel can handle the weight of the vehicle, passengers, and cargo, maintaining stability and preventing deformation.

c) **Weight:** The weight of a wheel rim plays a crucial role in overall vehicle performance, including acceleration, handling, and fuel efficiency. A lighter wheel rim reduces the unsprung mass, enhancing suspension response and minimizing energy consumption.

d) **Heat Dissipation:** Efficient heat dissipation is essential for preventing excessive heat buildup during braking or high-speed driving. A wheel rim that dissipates heat effectively helps maintain optimal brake performance, preventing brake fade and ensuring safe braking distances.

e) **Corrosion Resistance:** Corrosion resistance is crucial to protect the wheel rim from rust and deterioration caused by exposure to moisture, road salt, and environmental elements. A

corrosion-resistant wheel rim maintains its appearance, longevity, and performance over an extended period.

f) Aesthetic Appeal: The aesthetic appeal of a wheel rim enhances the overall appearance and visual appeal of the vehicle. A stylish and visually pleasing wheel rim adds a touch of personalization and can contribute to the overall impression and value of the vehicle.

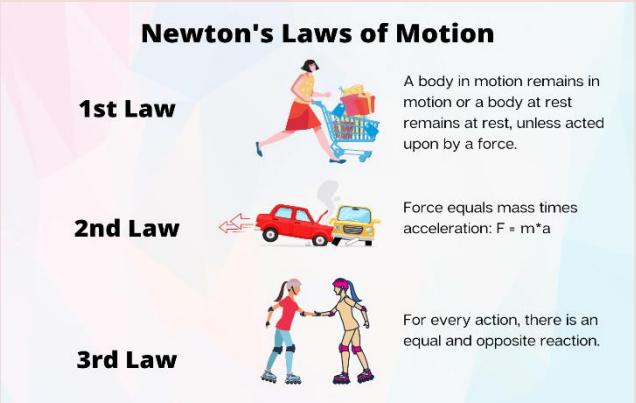
g) Ease of Maintenance: Wheel rims that are easy to clean and maintain simplify the upkeep of the vehicle's appearance. Quick and effortless maintenance ensures that the wheel rims remain in good condition and extend their lifespan.

By prioritizing these critical performance characteristics, wheel rims can deliver optimal safety, performance, and aesthetics, enhancing the overall driving experience.

4. Scientific Laws for Optimal Wheel Rim Design and Performance

Some of the laws, concepts, and principles of science that are applicable to the design, working, manufacturing, and performance evaluation of wheel rims, especially cornering fatigue and radial fatigue testing:

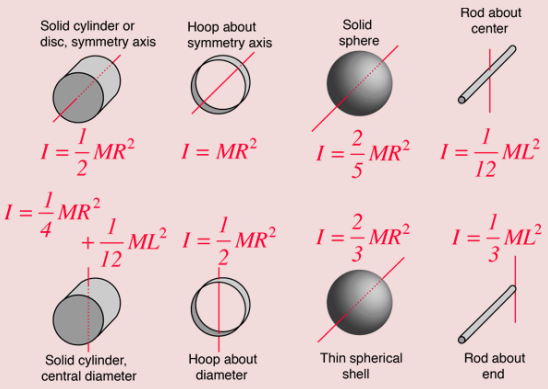
a) **Newton's Laws of Motion:** Newton's laws of motion describe the relationship between force, mass, and acceleration. They are essential for understanding how wheel rims interact with the road and how they are affected by forces such as braking, acceleration, and cornering.



For example, Newton's first law of motion states that an object in motion will stay in motion unless acted upon by an unbalanced force. This means that a wheel rim will continue to rotate unless it is slowed down or stopped by a force such as braking or friction.

b) **Moment of Inertia:** The moment of inertia is a measure of an object's resistance to rotational motion. It is important for understanding how wheel rims are affected by forces that cause them to rotate, such as cornering forces.

The moment of inertia of a wheel rim is affected by its mass, shape, and material. A wheel rim with a high moment of inertia will be more resistant to rotational motion than a wheel rim with a low moment of inertia.



c) **Stress and Strain:** Stress is a force that is applied to an object, while strain is the deformation that is caused by the force. The relationship between stress and strain is known as Hooke's law.

Hooke's law is important for understanding how wheel rims are affected by forces such as braking, acceleration, and cornering. When a wheel rim is subjected to a force, it will deform. The amount of deformation is proportional to the amount of force.

d) **Fatigue Failure:** Fatigue failure is a type of failure that occurs when an object is subjected to repeated stresses that are below the object's ultimate strength. Fatigue failure is a major concern for wheel rims, as they are subjected to repeated stresses from braking, acceleration, and cornering. Fatigue failure can be prevented by designing wheel rims with a high fatigue life. The fatigue life of a wheel rim is the number of cycles that it can withstand before it fails. Following two tests are carried out to determine the fatigue strength of a wheel rim:

i) **Cornering Fatigue Testing (Durability against bending moment):**

Before we understand this test, we need to know what is bending moment?

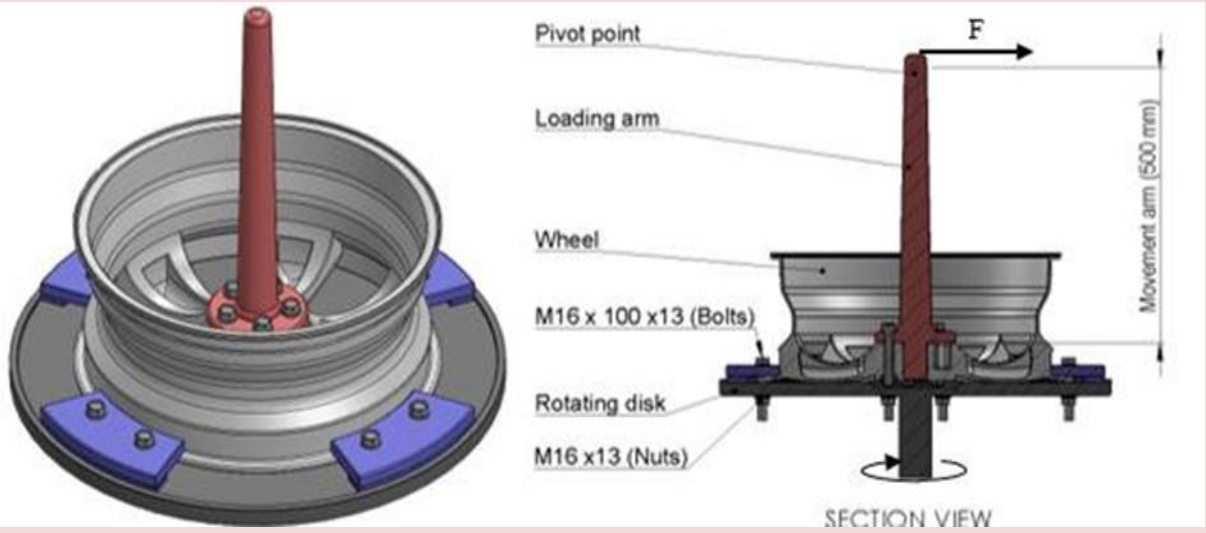
Bending Moment: Bending moment is a force that causes a beam or other structural element to bend. It is calculated by multiplying the force by the distance from the force to the neutral axis of the beam. The bending moment in a wheel rim can be calculated using the following formula:

$$\boldsymbol{M = F \times d}$$

Where, M is the bending moment
F is the force
d is the distance from the force to the neutral axis

The bending moment is greatest at the point where the force is applied.

Cornering fatigue testing is a type of testing that is used to determine the durability of wheel rims against bending moment. In cornering fatigue testing, a wheel rim is subjected to repeated cornering loads. The number of cycles that the wheel rim can withstand before it fails is then determined. The most affected area for the bending moment fatigue test is around the hub bolt hole area. This is because the hub bolt hole area is subjected to the highest stresses during cornering. As can be seen from the stress-strain analysis, the stresses in the hub bolt hole area are significantly higher than the stresses in other areas of the wheel rim. The results of cornering



fatigue testing can be used to design wheel rims that are more durable against bending moment. By understanding the areas of the wheel rim that are most susceptible to failure, engineers can design wheel rims with features that help to distribute the stresses more evenly.

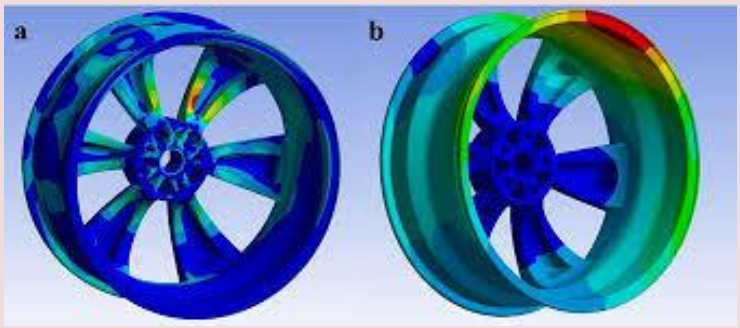
ii) **Radial Fatigue Testing (Durability against Radial Load):**



Radial fatigue testing is a type of testing that is used to determine the fatigue life of wheel rims. In radial fatigue testing, a wheel rim is subjected to repeated radial loads. The number of cycles that the wheel rim can withstand before it fails is then determined.

Radial fatigue testing is an important part of the design process for wheel rims. By conducting radial fatigue testing, engineers can ensure that wheel rims have a long fatigue life and are not susceptible to fatigue failure.

As can be seen from the stress-strain analysis, the maximum displacement occurs on the inner surface of the wheel rim and the maximum stress happens on the edges of designed spoke slots on the backside.



a) Stress b) Deformation

Activity

Q1 : What do you understand by Moment ?

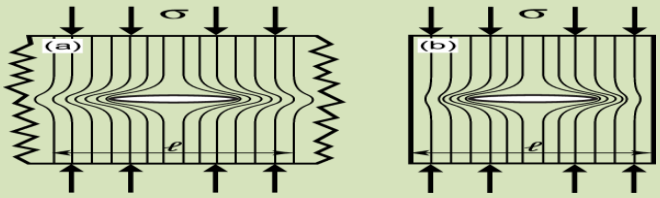
Ans: The Moment of a force is a measure of its tendency to cause a body to rotate about a specific point or axis. Moment = Force x Distance or M = F*d

Q2: What is advantage of Radial fatigue test?

Ans: Similar to the cornering fatigue test, the radial fatigue test is intended to simulate the dynamic loading of the wheel during cornering of the road.

Q3: What is stress concentration?

Ans: In solid mechanics, a stress concentration is a location in an object where the stress is significantly greater than the surrounding region. Stress concentrations occur when there are irregularities in the geometry.



5. Interesting facts about Wheel Rims

a) The first wheels were made of solid wood. These wheels were heavy and difficult to maneuver, but they were a major improvement over the previous method of transportation, which was dragging logs behind.

b) The first spoked wheels were invented in China around 2000 BC. These wheels were made of wood with spokes made of bamboo. They were much lighter and more maneuverable than solid wheels, and they allowed for faster travel.

c) The first metal wheels were made of bronze. These wheels were stronger than wooden wheels, but they were also more expensive. They were only used by wealthy individuals or for military purposes.

d) The first steel wheels were made in the 19th century. These wheels were much stronger than bronze wheels, and they were also more affordable. They quickly became the standard for most vehicles.

e) The first aluminum wheels were made in the early 20th century. These wheels were even lighter than steel wheels, and they were also more corrosion-resistant. They are now the standard for many high-performance vehicles.

f) The most expensive wheel rim ever sold was a set of 24-carat gold wheels that were made for a Bugatti Veyron. The wheels cost $2 million.

6. Questions

1. What is a wheel rim?
   a) The outer edge of the tire
   b) The central part of the wheel that connects to the axle
   c) The hubcap covering the wheel
   d) The portion of the wheel that touches the ground
   Answer: b) The central part of the wheel that connects to the axle

2. Which material is commonly used to manufacture modern wheel rims?
   a) Steel
   b) Wood
   c) Aluminium alloy
   d) Plastic
   Answer: c) Aluminum alloy

3. The purpose of the wheel rim is to:
   a) Increase vehicle weight
   b) Provide a mounting surface for the tire
   c) Enhance vehicle aerodynamics
   d) Reduce fuel efficiency
   Answer: b) Provide a mounting surface for the tire

4. Which size is typically NOT a standard wheel rim diameter for passenger vehicles?
   a) 15 inches
   b) 16 inches
   c) 17 inches
   d) 20 inches
   Answer: d) 20 inches

5. What is the primary advantage of using steel wheel rims?
   a) Lighter weight for better fuel efficiency
   b) Enhanced vehicle appearance
   c) Greater resistance to corrosion
   d) Improved heat dissipation
   Answer: c) Greater resistance to corrosion

6. Which type of wheel rim design allows for better brake cooling and airflow?
   a) Solid disc design
   b) Spoke design
   c) Split-spoke design
   d) Alloy mesh design
   Answer: b) Spoke design

7. Which factor is crucial to consider when replacing wheel rims to ensure proper fitment?
   a) The colour of the rim
   b) The number of lug nuts

c) The tire's tread pattern
d) The diameter and width of the rim
Answer: d) The diameter and width of the rim

8. Run-flat tires are compatible with certain wheel rims designed to support the tire even after a loss of air pressure. What is the main drawback of these rims?
   a) Reduced fuel efficiency
   b) Increased road noise
   c) Limited ride comfort
   d) Higher manufacturing costs
   Answer: c) Limited ride comfort

9. For off-road or heavy-duty applications, wheel rims made of steel are preferred due to their:
   a) Lighter weight
   b) Ability to improve fuel efficiency
   c) Superior aesthetics
   d) Robust durability and strength
   Answer: d) Robust durability and strength

Lesson Plan Subjects

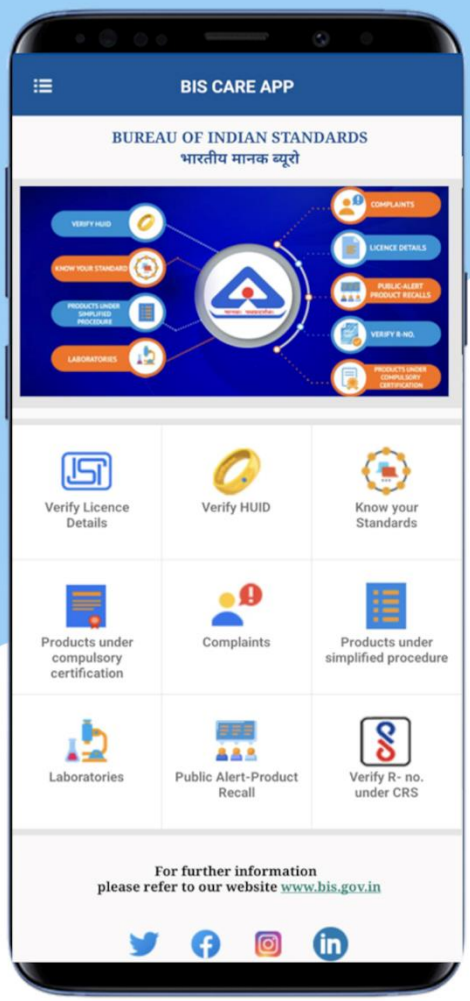
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1.	Caustic Soda	**21.**	Ballpoint Pen
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9.	Cement Ash Brick	**29.**	Precast Concrete
10.	Paints	**30.**	Stainless Steel
11.	Boric Acid	**31.**	Weighing balance
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17.	Milk Powder	**37.**	Wheel Rim
18.	Pressure Cooker	**38.**	Water Storage Tank
19.	Plywood	**39.**	PVC Pipes
20.	Multipurpose dry batteries	**40.**	Refrigerator

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42.	Electric Mixer	**48.**	Hearing Aids
43.	Family Sized Biogas Plant	**49.**	Microwave Oven
44.	Fire Extinguisher	**50.**	Solid and Hollow Block
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Manak Bhavan,
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