BUREAU OF INDIAN STANDARDS

www.bis.gov.in

Learning Science via Standards



IS 8034

CM/L-XXXXXXXXXX

Lesson 51

Oct 2023

Submersible Pumpsets





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.

Submersible Pumpsets

Submersible pumpsets are special devices used for pumping fluids, and they have a motor sealed inside that is closely connected to the pump body. This entire assembly is submerged in the fluid that needs to be pumped. The history of submersible pumpsets dates back to ancient times when simple manual pumps were used for drawing water from wells and springs. However, significant advancements occurred during the 20th century, driven by engineers and inventors aiming to create more efficient water extraction solutions.

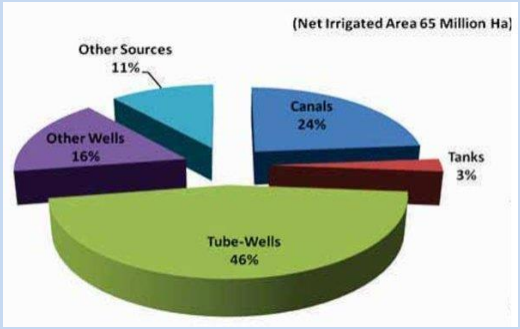
These pumps evolved from being surface-mounted to innovative submersible versions designed to operate underwater directly at the water source. The transformation of submersible pumpsets has been remarkable, expanding their applications beyond agricultural irrigation and domestic water supply. They are now widely used in various sectors, including industries, municipalities, construction, and renewable energy applications. Modern submersible pumpsets are built using advanced materials, precise engineering, and sophisticated control systems, enhancing their performance, energy efficiency, and durability.

In 1928 Armenian oil delivery system engineer and inventor Armais Arutunoff successfully installed the first submersible oil pump in an oil field. In 1929, Pleuger Pumps developed the design of the submersible turbine pump, the forerunner of the modern multi-stage submersible pump.

In the present day, submersible pumpsets have become indispensable for agriculture, powering irrigation systems to improve crop yields and ensure food production. They also play a crucial role in providing clean and safe drinking water for urban and rural communities. With their ability to be submerged in water, they are highly efficient and reliable. These innovative pumpsets continue to shape water management practices, ensuring sustainable utilization and conservation of water resources.

1. Why Water is Important

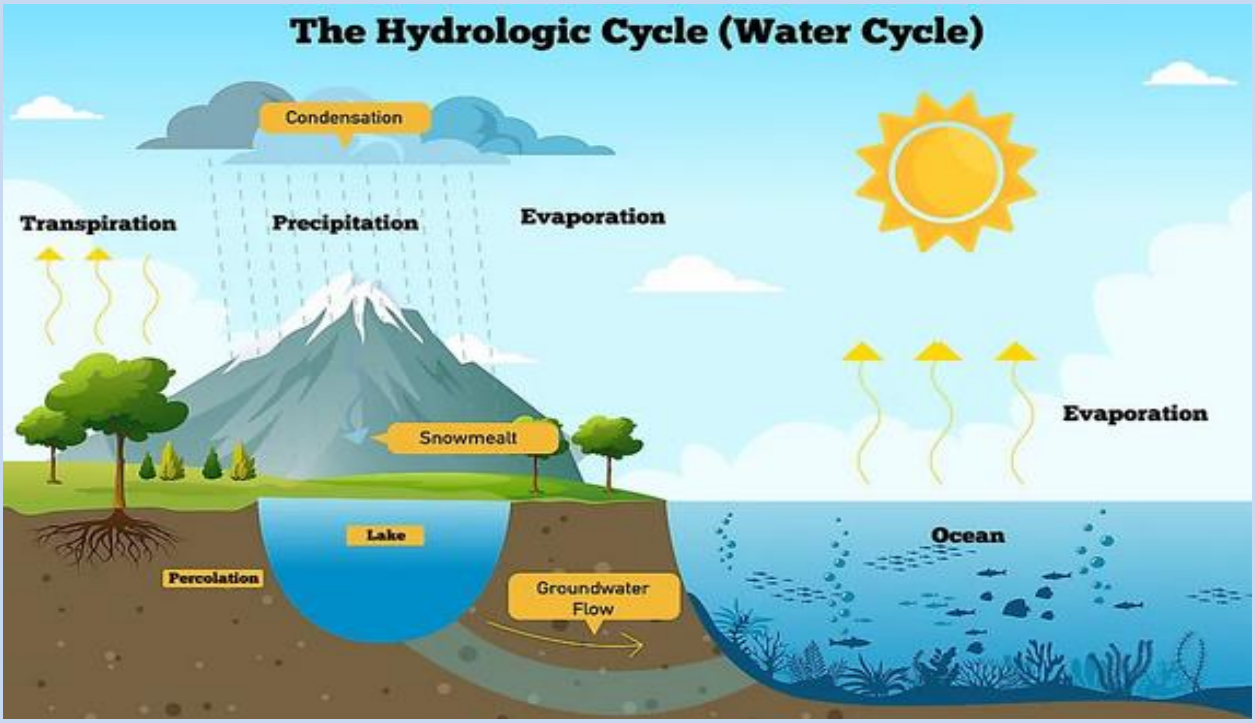
As a precious and essential resource, water is essential for all life forms and various human activities. In agriculture, it sustains crop growth through irrigation. The domestic sector depends on it for drinking, cooking, and sanitation. Industries use water in manufacturing processes. Municipalities require it for public supply and wastewater treatment. Its significance lies in supporting life and economic development.



a) **Sources of Water and Water Cycle:** Various sources of water include surface water from rivers, lakes, and reservoirs, groundwater from wells and aquifers, rainwater harvesting, and desalinated seawater. Other sources include springs, glaciers, and ice caps. These diverse sources play a crucial role in providing water for various human needs and sustaining ecosystems.

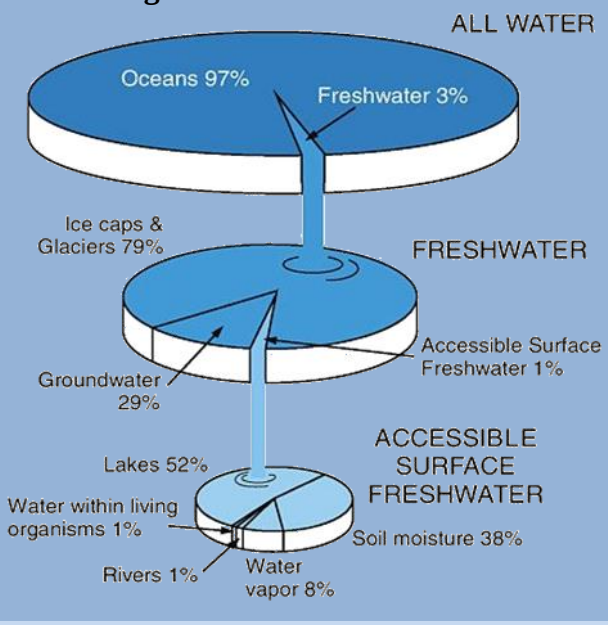
The water cycle, also known as the hydrological cycle, is a continuous process where water evaporates from oceans, lakes, and rivers, condenses into clouds, falls back to the Earth as

precipitation (rain or snow), and flows back into bodies of water or underground reservoirs, completing the cycle. It sustains life and maintains ecological balance.



Que: Why do we need to take water from beneath the ground?

Ans: Ocean water cannot be used for day-to-day life unless it undergoes rigorous treatment. This is due to high hardness and salinity of ocean/sea water. Groundwater is the second largest available reservoir of freshwater. For groundwater sources and low-leveled surface sources, pumps are required to lift the water as it cannot flow under gravity.

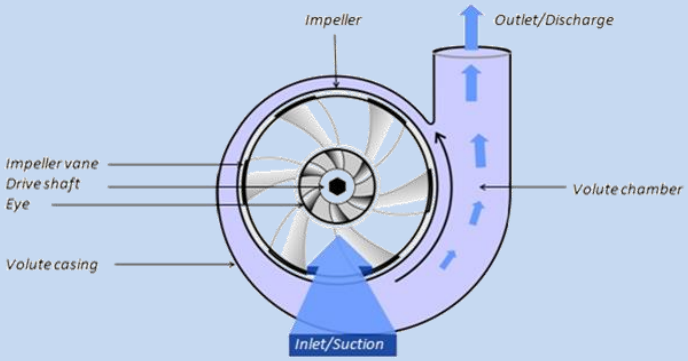


2. Pumps and the Working Principle

What is Pump? A pump is a mechanical device that transfers fluids (liquids or gases) or slurries from one location to another using mechanical or electrical energy. Its primary function is to move substances from a lower level to a higher level, making it useful for lifting water or other fluids to overcome height differences.

A centrifugal pump works by using an impeller, which is a set of curved vanes, to move fluid. The impeller is connected to a motor and rotates rapidly. Fluid enters the impeller at its center and exits along the curved vanes. As the fluid moves through the impeller, its pressure increases. The pump

casing is designed in a way that the cross-sectional area increases towards the outlet, further increasing the fluid pressure as it exits the pump. This process allows the pump to move fluids from a low level to a high level with great efficiency.

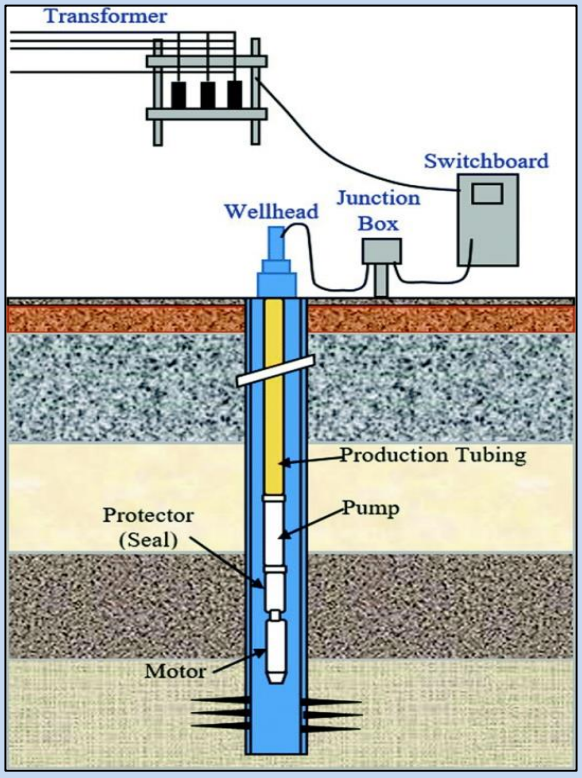


Submersible Pumps: Submersible pumps as the name suggests are made to be fully submerged in water. We use submersible pumps for pumping groundwater.

Working Principle of submersible Pump: It is a centrifugal water pump, meaning it has a motor that powers an impeller designed to rotate and push water outwards. The water forced outwards is pushed to next stage above. This movement creates a suction pressure at the intake for the incoming water. The water movement creates suction from the inlet below. This create a forced water movement from bottom to top.

The motor is responsible for rotation of the impeller which is creating a centrifugal force. The motor is located within a waterproof seal and closely coupled to the body of the pump which it powers.

Submersible pump set is used to push water to the surface by converting rotary energy into kinetic energy into pressure energy.



Questions for Discussion

True or False

- *Do we need to supply electric power to the motor of a submersible pump through a long electric cable beneath the ground?*

3. Main Components Functions and Science

The major components of a submersible pumpset are intrinsically linked to fundamental scientific laws and concepts, showcasing the remarkable relationship between physics and engineering in the realm of fluid dynamics and energy conversion.

a) **Submersible Motor:** The motor converts electrical energy into mechanical energy using the principle of electromagnetic induction. It follows Faraday's law of electromagnetic induction, where a changing magnetic field induces a voltage in a conductor, causing the motor to rotate and drive the pump impeller.

b) **Pump Impeller:** The impeller generates centrifugal force through the rotational motion imparted by the motor. This motion is based on the principle of rotational dynamics, which states that an object will continue to rotate unless acted upon by an external force. The impeller's curved vanes accelerate water radially outward, creating pressure and flow.

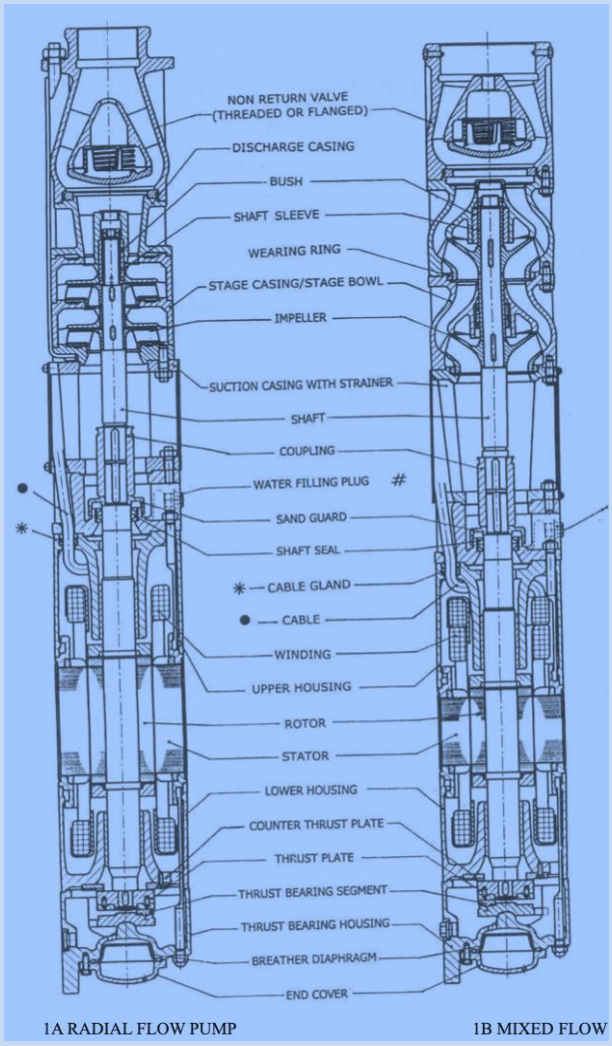


Question: Which material is commonly used for constructing submersible pump impellers? a) Cast iron b) Stainless steel

c) Copper d) Aluminum

Answer: b) Stainless steel

c) **Pump Casing:** The pump casing directs the flow of water efficiently through the pump. It is designed using fluid dynamics principles, considering the conservation of momentum and Bernoulli's principle, which relates pressure and velocity of the fluid.



d) **Shaft:** The shaft connects the motor to the impeller, transferring the rotational motion from the motor to the pump. This function is based on Newton's first law of motion, which states that an object in motion remains in motion unless acted upon by an external force.

e) **Bearings:** Bearings reduce friction and enable smooth rotation of the shaft. They rely on the principles of lubrication and rolling friction, ensuring the efficient operation of the pump.

f) **Seals:** Seals prevent water from entering the motor, ensuring electrical insulation and protecting internal components. The sealing mechanism is based on the principles of fluid dynamics and preventing leakage due to pressure differences.

g) **Power Cable:** The power cable connects the pump to the surface power source, allowing electricity to flow through the motor. The function of the power cable is governed by Ohm's law, which relates current, voltage, and resistance in an electrical circuit.

h) **Non-Return Valve:** The valve allows water to flow in one direction only, preventing backflow. This function is based on the principle of fluid dynamics and the behavior of pressure differentials.

i) **Control Box:** The control box regulates the power supply to the motor, providing thermal and overload protection. Its functionality relies on electrical engineering principles, including circuit design and protection mechanisms.

j) **Discharge Pipe:** The discharge pipe carries pumped water from the pump to the desired application. Its design considers fluid dynamics principles to minimize frictional losses and optimize flow.

k) **Strainer:** The strainer filters out debris and large particles from entering the pump, preventing clogging and damage. It operates based on the concept of sieving and filtration.

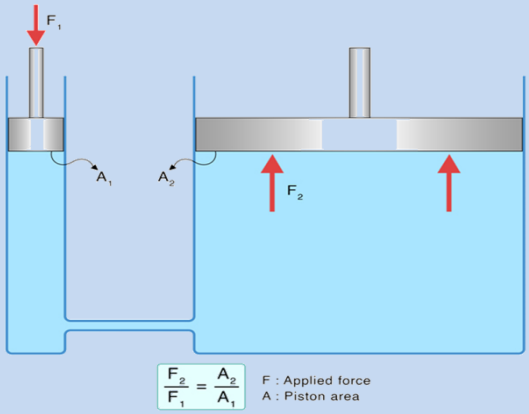
l) **Guide Rails and Coupling:** Guide rails and coupling provide support and alignment for lowering and raising the pumpset in the well. Their function is based on mechanical engineering principles, ensuring proper installation and operation.

Question: Which component of a submersible pumpset is responsible for increasing the fluid's pressure? a) Motor b) Impeller c) Diffuser d) Casing

Answer: b) Impeller

4. Scientific Laws for Submersible Pumpset Design and Performance

i) **Pascal's Law:** Pascal's law, also known as the principle of transmission of fluid-pressure, states that pressure applied to a confined fluid at any point is transmitted undiminished throughout the fluid in all directions. This law is essential in understanding the hydraulic principles governing the operation of submersible pumpsets.



The formula for Pascal law is:

$$F = PA$$

where, Where F is the force applied, P is the pressure transmitted, and A is the cross-sectional area.

Question: Can you give some examples where Pascal's Law is applicable?

Ans.- Hydraulic Press, Hydraulic Lift, Hydraulic jack, and many other industrial equipment and machinery.

ii) **Hydraulics:** Hydraulics is a fundamental concept in the design and working of submersible pumpsets. It involves the study of fluids and their behavior under pressure, enabling the pumpset to move and transfer water efficiently.

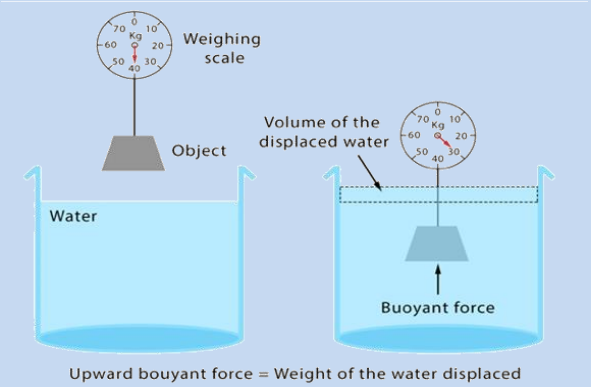
The hydraulic power supplied by a pump is calculated as

Power = (P x Q)/600

where power is in kilowatts [kW], P is the pressure in bars, and Q is the flow in litres per minute.

iii) **Fluid Mechanics:** Fluid mechanics deals with the properties of fluids and the forces they experience during motion. In submersible pumpsets, fluid mechanics principles are used to optimize pump efficiency and performance.

iv) **Archimedes' Principle:** Archimedes' principle states that an object immersed in a fluid experience an upward buoyant force equal to the weight of the fluid it displaces. This principle is relevant in understanding the buoyancy and stability of submersible pumpsets in water.



The formula of Archimedes' Principle is:

Fb = ρ x g x V.

where, Fb = buoyant force, ρ = density of the fluid

V = submerged volume. g = acceleration due to gravity

Question: What is the difference between Centre of Gravity and the Centre of buoyancy?

Ans.- The centre of gravity of a body is the point where the total gravitational force of a body can be considered to act whereas, the centre of buoyancy is the centre of gravity of the volume of water displaced by the body when immersed in the water.

v) **Bernoulli's Principle:** Bernoulli's principle states that if the fluid flows horizontally so that no change in gravitational potential energy occurs, then a decrease in fluid pressure is associated with an increase in fluid velocity. In submersible pumpsets, Bernoulli's principle is crucial in determining the pressure changes that occur during the pumping process.

The common form of Bernoulli's equation is :

The Bernoulli's Equation

$$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$$

shutterstock.com · 1870640671

P is the static pressure (the pressure of the fluid)

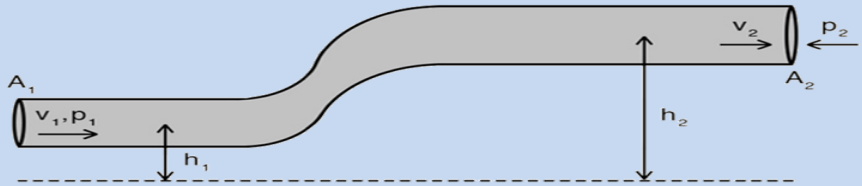
ρ is the density

V is the velocity

G is the gravitational acceleration

H is the elevation of the fluid

Bernoulli's theorem describes the relation between velocity, pressure, and elevation of a flowing fluid in a streamline.



$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

A_1, A_2 : Cross-sectional areas at points 1 and 2
p_1, p_2 : Pressures
v_1, v_2 : Velocities
h_1, h_2 : Elevations

Question: Name some hydraulic devices where Bernoulli's principle is applicable?

Ans.- Orificemeter, pitot tube and venturimeter

vi) **Conservation of Energy:** The principle of conservation of energy is essential in the efficient design and operation of submersible pumpsets. It ensures that the input energy is effectively converted into hydraulic energy to lift and transfer water.

vii) **Material Science:** Material science is employed to select suitable materials for various components of the submersible pumpset. The choice of materials affects the durability, corrosion resistance, and overall performance of the pumpset.

viii) **Manufacturing Processes:** Various manufacturing processes, such as casting, machining, and assembly, are used to produce submersible pumpsets with precise dimensions and tolerances for optimal functionality.

ix) **Flow Rate and Discharge:** The flow rate and discharge capacity of the submersible pumpset determine its ability to transfer water at a specified rate. These characteristics are essential for various applications, such as irrigation and water supply.

x) **Head and Total Dynamic Head (TDH):** The head represents the height to which the pump can lift water, while TDH includes the additional pressure losses in the pumping system. Understanding these characteristics is vital in selecting the right pumpset for specific applications.

By applying these science laws, concepts, and principles in the design, manufacturing, and performance evaluation of submersible pumpsets, engineers and manufacturers can develop efficient, durable, and high-performing pumpsets suited for various water transfer applications.

Question: Do you know the purpose of a wear ring in a submersible pump?

a) It reduces vibration b) It increases flow rate

c) It improves efficiency d) It prevents metal to metal contact

Answer: d) It prevents metal to metal contact

5. Major Performance Characteristics of a Submersible Pumpset



a) **Flow Rate:** Flow rate measures the volume of water delivered by the pump per unit of time, usually expressed in liters per minute (LPM) or gallons per minute (GPM). It is a crucial performance characteristic as it determines how quickly the pump can deliver water to the intended application. A higher flow rate is essential for efficient irrigation, water supply, or drainage systems.

b) **Head or Total Dynamic Head (TDH):** The head represents the vertical distance from the pump's intake to the point of discharge. It measures the pump's ability to lift water against gravity and overcome resistance in the piping system. The head is vital for determining the pump's suitability for various applications, especially when pumping water from deep wells or elevating water to higher locations.

c) **Efficiency:** Pump efficiency is the ratio of the hydraulic power output to the electrical power input, expressed as a percentage. Higher efficiency means the pump can convert more electrical energy into useful hydraulic energy, reducing energy consumption and operating costs. Efficient pumps contribute to sustainable energy usage and minimize environmental impact.

d) **Power Consumption:** Power consumption indicates the electrical energy required to operate the pump. Lower power consumption is desirable as it results in reduced energy bills and less strain on power sources. Energy-efficient pumps help promote sustainable practices and reduce greenhouse gas emissions.

e) **Material of Construction:** The materials used in the pump's construction play a vital role in its durability and resistance to corrosion or wear. High-quality materials ensure the pump's longevity and reduce maintenance costs, contributing to a sustainable and reliable water supply system.

f) **Maximum Operating Temperature:** The maximum operating temperature specifies the highest temperature at which the pump can safely function without damage. It is crucial to know this characteristic, especially when dealing with applications involving hot water or extreme weather conditions.

g) **Noise Level:** The noise level of the pump is an important consideration for residential or urban settings. Lower noise levels contribute to a quieter environment and improved living conditions.

h) **Reliability and Maintenance Requirements**: A reliable pump with low maintenance needs ensures a continuous water supply without frequent breakdowns. Reduced maintenance also results in less material waste and lower environmental impact.

i) **Overload Protection:** Pumps with built-in overload protection mechanisms safeguard the motor from excessive stress during voltage fluctuations or pump blockages. This feature enhances the pump's longevity and prevents premature failure.

By considering these performance characteristics, users can choose a submersible pumpset that matches their specific needs, leading to efficient water usage, reduced energy consumption, and sustainable water management practices. Additionally, well-maintained and reliable pumps contribute to water conservation and environmental protection.

Question: Which test is conducted to determine the performance characteristics of a submersible pump? a) Pressure test b) Leakage test c) Efficiency test d) Resistance test

Answer: c) Efficiency test

6. How Efficiency of a Pump is Calculated

In simple terms, pump efficiency refers to the ratio of power out to power in. It's the mechanical power input at the pump shaft, measured in horsepower (HP), compared to the hydraulic power of the liquid output, also measured in HP. For instance, if a pump requires 1000 HP to operate and produces 800 HP of hydraulic power, it would have an efficiency of 80%.

$$\textbf{\textit{Overall Efficiency of a pump}} = \frac{Output}{Input}$$

Unit of efficiency = %

Output of a pump is measured in terms of Head (H) and discharge (Q).

$$\textbf{\textit{Efficiency}}\ (\eta) = \frac{\rho g Q H}{P}$$

Where, ρ is density and P is Input Power

Input is determined by multiplication of Input voltage and Current drawn by motor measurement tools Ammeter, Voltmeter, Wattmeter.

a) Why is pump efficiency important?

A more efficient pump saves you money. A highly inefficient pump will waste energy when moving fluid in a system, resulting in higher electricity costs to power the pump. There is also the element of maintenance costs; an inefficient pump will wear quicker than an efficient pump, meaning a loss in revenue income (because the pump is not functioning, stopping production), more labour and time to getting the pump up and running, and more spares being required per year to repair the pump.



b) Friction reducing gadgets

Ball bearings: Bearings are small parts of pump systems that play a critical role. They bear the load of the pump, allowing rotation. They must be properly lubricated and temperatures monitored to prevent failure. They reduce friction, noise, and vibration to help prevent excess wear and tear.

7. Some Interesting Facts:

a) Submersible pumps have revolutionized the field of groundwater extraction. They have made it possible to access water from deep wells and provide a reliable water supply for various purposes, including agriculture, municipal water systems, and residential use.

b) These pumps are often used in offshore applications, such as oil and gas production, where they are deployed at great depths to extract fluids from beneath the seabed.

c) Some submersible pumps are equipped with built-in sensors and controls to monitor and protect the pump from various conditions such as overheating, low water levels, or excessive vibration.

d) Submersible pumps can handle a wide range of fluid types, including clean water, wastewater, slurry, corrosive liquids, and abrasive materials. The selection of pump materials and impeller designs can be tailored to suit the specific fluid being pumped.



e) Submersible pumps are typically electrically powered. The electric motor is sealed and insulated to ensure safe operation underwater. The motor and pump are often housed in a single unit.

f) Submersible pumpsets use oil-filled motors for cooling: To ensure the efficient cooling of the electric motor, submersible pumpsets often have oil-filled motors. The oil helps dissipate heat generated during the motor's operation, preventing overheating and enhancing the pumpset's longevity.

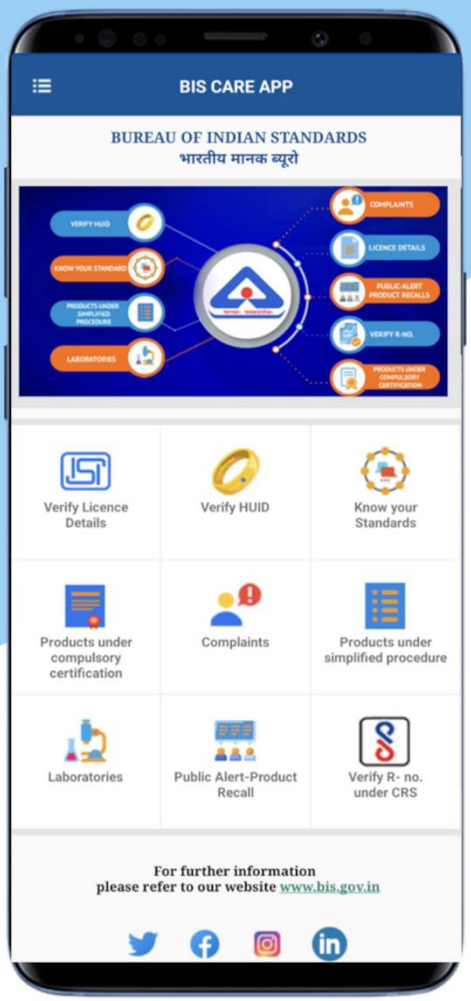
g) Submersible pumpsets have anti-clogging features: Many modern submersible pumpsets are equipped with anti-clogging mechanisms, such as vortex impellers or grinder pumps. These features prevent debris or solids from causing blockages in the pump and ensure smooth operation, even in wastewater or sewage applications.

Lesson Plan Subjects

Published

1.	Caustic Soda	**27.**	Plugs and Socket
2.	Football	**28.**	Solar Flat Plate Collectors
3.	Cement	**29.**	Precast Concrete
4.	Gas Stove	**30.**	Stainless Steel
5.	Geyser	**31.**	Weighing balance
6.	Helmet	**32.**	Steel Bar
7.	LED Bulb	**33.**	Thermometer
8.	LPG Cylinders	**34.**	Tyres for buses and trucks
9.	Cement Ash Brick	**35.**	Vacuum Flask
10.	Paints	**36.**	Water Meter
11.	Boric Acid	**37.**	Wheel Rim
12.	Ceiling Fan	**38.**	Water Storage Tank
13.	Cables	**39.**	PVC Pipes
14.	Ceramics Tiles	**40.**	Refrigerator
15.	Rear View Mirrors	**41.**	CNG Cylinders
16.	Headphones	**42.**	Hearing Aids
17.	Milk Powder	**43.**	Microwave Oven
18.	Pressure Cooker	**44.**	Solid and Hollow Block
19.	Plywood	**45.**	Submersible Pump set
20.	Multipurpose dry batteries	**46.**	Conduits
21.	Ballpoint Pen	**47.**	Drinking Water
22.	Bicycle	**48.**	Electric Mixer
23.	Electric Iron	**49.**	Family Sized Biogas Plant
24.	Loudspeakers	**50.**	Fire Extinguisher
25.	Pasteurized Milk	**51.**	Power Threshers
26.	Paver Blocks	**52.**	Geosynthetics

BIS CARE APP



A tool for Consumer Empowerment

Scan to Download

GET IT ON Google Play

Download on App Store

Features

- Check the authenticity of the Product with ISI 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 ISI mark by using 'Complaints'
- You can also access products under compulsory certifiction of BIS & Products under simplified procedure of licensing.

How to use BIS Care App

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



मानकः पथप्रदर्शकः

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