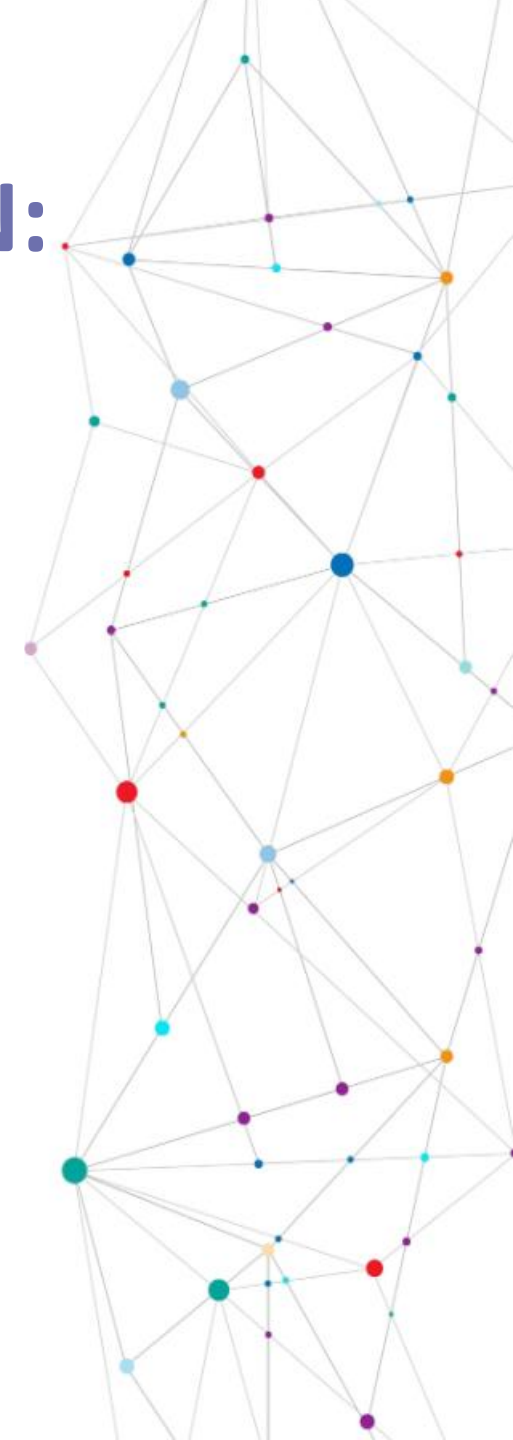


MEDICAL PERSPECTIVE ON HOSPITAL DESIGN: HOW HOSPITAL DESIGN IMPACTS PATIENT CARE AND OUTCOMES

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INTRODUCTION

WHAT IS HOSPITAL ENGINEERING?

? **Design, management, optimization and maintenance** of the infrastructures, equipment and technological systems that support the activities of hospitals and healthcare centers.

Hospital design and construction

- Hospital architecture
- Regulations and standards
- Accessibility and functionality



INTRODUCTION

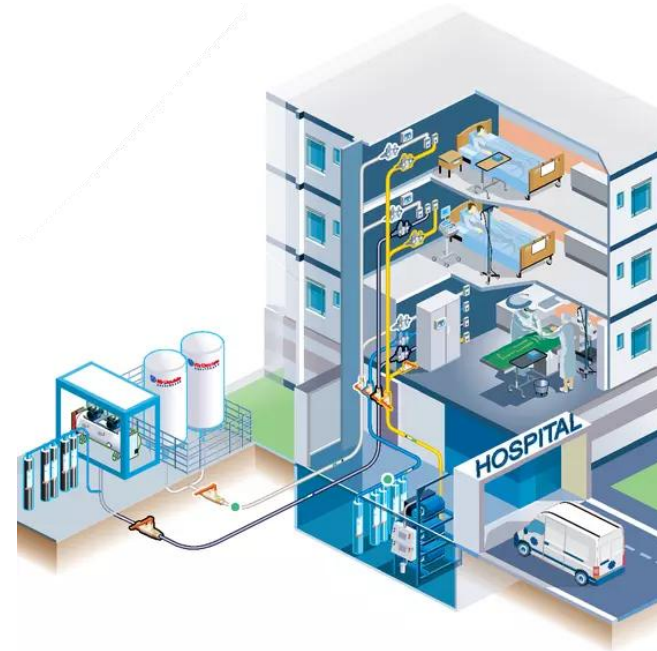
Maintenance of medical equipment

- Equipment lifecycle management
- Equipment technology
- Equipment management systems



Climate control, electrical and plumbing systems

- Climate control systems (HVAC)
- Electricity
- Plumbing



INTRODUCTION

Waste management

- Hazardous and non-hazardous waste
- Separation and recycling strategies



Information technology (IT)

- Electronic medical records
- Hospital management systems
- Telemedicine and remote monitoring



INTRODUCTION

Security and control

- Fire protection
- Access control
- Emergency prevention and management

Energy efficiency and sustainability

- Energy efficiency strategies
- Sustainability in construction

Integration and coordination of systems

- Interaction of complex systems
- Process automation



INTRODUCTION

DIFFERENCE BETWEEN HOSPITAL ARCHITECTURE AND HOSPITAL ENGINEERING

Hospital engineering and hospital architecture are two closely related disciplines, but have different approaches and responsibilities in the design, construction and operation of hospitals. Their main differences are:

Main focus

- Hospital Engineering: Focuses on the management, maintenance and optimization of the technical and functional systems that enable a hospital to function.
- Hospital architecture: Focuses on the design and spatial planning of hospital facilities.

Responsibilities and tasks

- Hospital Engineering:
 - Design and implementation of technological systems
 - Maintenance and calibration of medical equipment.
 - Management of resources such as water, energy and waste.
 - Ensuring the technical safety of the hospital.
 - Optimization of resources to improve efficiency and reduce operating costs.
- Hospital architecture:
 - Design and planning of the physical structure of the hospital.
 - Creating designs that respect accessibility, safety and comfort regulations.
 - Incorporation of sustainability and energy efficiency criteria in the architectural design.
 - Ensuring that spaces are functional and adequate for the needs of medical staff and patients.

INTRODUCTION

DIFFERENCE BETWEEN HOSPITAL ARCHITECTURE AND HOSPITAL ENGINEERING

Interaction between the two disciplines:

Although the approaches of hospital engineering and hospital architecture are different, the two disciplines **must work** collaboratively during the hospital design and construction process to ensure that the infrastructure is both functional and efficient. The architect must create a design that allows for the implementation of technical systems in an appropriate manner, while the hospital engineer ensures that these systems are feasible and aligned with the operational needs of the hospital.

Temporal approach

- Hospital engineering: Hospital engineering has a long-term focus, as it is responsible for the maintenance and optimization of systems throughout the life of the hospital. This includes preventive maintenance of equipment, upgrading of medical technology, management of energy and air conditioning systems, etc.
- Hospital Architecture: The architectural focus is primarily on the design and construction phase. Although architects may be involved in renovations and refurbishments, their main task is to create a functional and aesthetic infrastructure that serves as the basis for the long-term operation of the hospital.

INTRODUCTION

IMPORTANCE OF HOSPITAL DESIGN

Hospital design is crucial because it directly impacts the operational efficiency, safety and well-being of patients and medical staff.

Proper design optimizes

- The flow of people and resources
- Reduces infection risks
- Improves the quality of care
- Creates a comfortable and accessible environment.

It also contributes to the sustainability and energy efficiency of the hospital, ensuring that the facilities are functional in the long term. A well-designed hospital facilitates more effective medical care and reduces stress for both patients and workers.



INTRODUCTION

RELATIONSHIP WITH MEDICINE AND PATIENT CARE

Hospital engineering plays a key role in medicine and patient care by providing the infrastructure, technology and systems necessary to ensure efficient, safe and high quality medical care.

- The guarantee of a Safe and Functional Environment
- Technological Support for Diagnosis and Treatment
- Optimizing Hospital Management
- Infection Prevention and Waste Management



OBJETIVES

- Ensure patient and staff safety
- Optimizing the use of resources
- Improving the quality of healthcare services
- Ensuring the continuous operation of hospital systems
- Complying with public health regulations and standards
- Managing medical technology properly
- Promoting environmental sustainability
- Optimizing hospital waste management
- Improving patient comfort and well-being
- Encouraging innovation in processes and technologies
- Facilitating communication and coordination between different departments
- Promoting staff training and continuing education



IMPORTANCE OF HOSPITAL DESIGN IN HEALTHCARE

Hospital design is a determining factor in the quality and efficiency of healthcare, as it directly influences patient safety, the operability of medical staff and the optimization of resources.

IMPACT ON HOSPITAL SAFETY AND EFFICIENCY

Safety and efficiency are fundamental pillars in the design and operation of a hospital.

Hospital Safety

- Power backup systems
- Infection control
- Structural and fire safety
- Hospital waste management

Operational Efficiency

- Workflow optimization
- System automation:
- Resource management



IMPORTANCE OF HOSPITAL DESIGN IN HEALTHCARE

HOW PLANNING, CONSTRUCTION AND MAINTENANCE INFLUENCE HOSPITAL EFFICIENCY

Construction: Implementation of Systems and Technologies

During construction, hospital engineering is responsible for integrating the key systems that will enable the hospital to operate efficiently.

- Electromechanical installations: Medical gas networks, air conditioning, electrical system with backup, and potable and wastewater networks.
- Digital infrastructure: Implementation of secure communication networks for monitoring systems, telemedicine and electronic medical records.
- Security systems: Surveillance cameras, access control and fire detection systems.

Maintenance: Key to the Hospital's Continuous Operation

Maintenance is essential to prolong the useful life of the infrastructure and ensure that all systems function optimally.

- Preventive maintenance: Inspection and calibration of medical equipment, review of electrical systems, and air quality verification.
- Corrective maintenance: Urgent repairs to avoid service interruptions.
- Energy management: Monitoring of energy and water consumption to reduce operating costs.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

The design of a hospital is a complex process that must ensure the safety, comfort and well-being of both patients and healthcare professionals. Hospital engineering must consider multiple factors that have a direct impact on the quality of medical care and patient recovery.

One of the fundamental aspects is patient safety, which implies the implementation of spaces that minimize risks of infections, falls and medical errors. Lighting plays an essential role, since an adequate distribution of natural and artificial light contributes to visual comfort, stress reduction and efficiency in clinical procedures. Likewise, the choice of colors influences the perception of the hospital environment, and can generate feelings of tranquility or alertness depending on their application in different areas.

The use of appropriate materials is key to preventing nosocomial infections, so antibacterial surfaces that are easy to clean and resistant to disinfectants should be selected. Environmental noise is also a critical factor, since high levels can affect patient recovery and staff performance, so efficient acoustic planning is required.

Air conditioning is another essential element, ensuring optimal temperature and air quality for comfort and prevention of respiratory diseases. In addition, hospital waste management must be carefully designed to avoid biological and environmental hazards, ensuring safe and efficient handling.

All these aspects, from lighting to waste management, must be integrated into a hospital design based on safety, efficiency and the well-being of patients and staff, thus ensuring an optimal environment for medical care.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

DESIGN OF A HOSPITAL

The design of a hospital is a multidisciplinary process that must prioritize patient safety, efficiency and well-being. Hospital engineering seeks to optimize every aspect of the environment, ensuring efficient workflows, state-of-the-art technology and biosecurity measures that contribute to quality medical care. This process is composed of several essential phases that guarantee the functionality and sustainability of the health center.

Planning and feasibility study

- Needs analysis: An exhaustive study of the healthcare demand in the hospital's area of influence must be carried out.
- Location and setting: Site selection is a determining factor in hospital planning.
- Standards and regulations: Hospital construction must comply with health and safety regulations established by national and international bodies.
- Budget and financing: It is crucial to accurately estimate the costs associated with building, equipping, and operating the hospital.
- Sustainability and energy efficiency: Sustainability strategies should be incorporated from the planning stage to reduce the hospital's environmental impact.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Architectural and engineering design

The architectural and engineering design of a hospital is a key stage that determines the functionality, safety and efficiency of the health facility.

FUNCTIONAL DISTRIBUTION

- **Critical Areas:** include operating rooms, intensive care units (ICU), emergency rooms and specialized laboratories. These areas require a design that minimizes the risk of infection and facilitates rapid care.
- **Semi-Critical Areas:** These include consulting rooms, hospital rooms, diagnostic imaging areas and general laboratories. These should be efficiently connected to critical areas.
- **Non-Critical Areas:** These include administration, cafeterias, waiting rooms and staff rest areas. Their design should ensure comfort and accessibility for patients and visitors.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Architectural and engineering design

ONE-WAY FLOW DESIGN

One of the keys to infection prevention is unidirectional flow design, which establishes a clear and efficient circulation system within the hospital. This system ensures that critical areas (such as operating rooms, ICUs and isolation rooms) connect to lower-risk areas so that medical personnel and equipment do not accidentally carry contaminants between these areas.

- Separate flows for personnel, equipment and materials: The hospital should have separate circulation routes for medical personnel, patients and materials, preventing the same corridors or doors from being used for multiple purposes.
- Emergency Escape Routes: In addition to regular operational flows, hospitals should consider evacuation routes in case of emergencies
- Disinfection and intermediate transit zones: A well-designed hospital should also incorporate disinfection zones or transition areas where personnel or materials moving between clean and contaminated areas can be disinfected or decontaminated.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Architectural and engineering design

USE OF DIFFERENTIAL PRESSURE SYSTEMS

Another important strategy for separating clean areas from contaminated areas is the use of differential pressure systems. These systems control the air flow in specific areas to prevent air from a contaminated area from mixing with air from clean areas.

- Positive and negative pressure: In critical areas, such as operating rooms, positive pressure is maintained, which means that air flows into the room, preventing outside air or air from contaminated corridors from entering the space. On the other hand, in isolation or infection treatment areas, a negative pressure can be maintained, ensuring that any pathogens released into the air are contained within the zone, without escaping into surrounding areas.
- Efficient ventilation: The correct implementation of these ventilation systems is essential to ensure that air does not mix between risk areas and sterile areas, contributing significantly to the prevention of nosocomial infections. The combination of controlled pressure and high-efficiency HEPA filters provides an almost impenetrable barrier against contaminants, ensuring that patients in critical areas receive the cleanest possible air.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Architectural and engineering design

RESTRICTED ACCESS DESIGN

To ensure the integrity of the separation of clean and contaminated areas, restricted access is another essential component of hospital design. Critical areas, such as operating rooms or ICUs, should have controlled access restricted to authorized personnel only, with strict procedures for entry.

- Access control: The use of access cards or biometric systems to restrict unauthorized entry helps ensure that only trained and authorized personnel can access these areas. This prevents germs from being carried from external to internal areas.
- Mandatory protective clothing: In the most critical areas, the design should include protective clothing areas (such as changing rooms) where personnel are outfitted before entering high-risk areas. Equipment cleaning protocols: In addition to access, hospitals should incorporate a design that allows for frequent cleaning of medical equipment and tools before they are used in high-risk areas. Sterilization equipment should be strategically located to ensure that all instruments are disinfected prior to contact with vulnerable patients.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Architectural and engineering design

STRUCTURAL SAFETY

Hospitals must be designed to withstand natural disasters, such as earthquakes, floods and fires. The following must be considered:

- Seismic energy isolation and dissipation systems.
- Clear and accessible evacuation routes.
- Fire systems with automatic sprinklers, alarms and adequate signage.

TECHNOLOGICAL INFRASTRUCTURE

- Secure Communication Networks
- Hospital Information Systems (HIS)
- Data Processing Centers (DPC)
- State-of-the-art medical equipment.
- Process automation, including robots for medication dispensing and surgical assistance.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Construction and Supervision

The construction and supervision phase is crucial for the efficient and safe implementation of the hospital design. During this stage, appropriate materials are selected, compliance with regulations is supervised and the necessary technological infrastructures are integrated to guarantee the correct operation of the hospital. Strict quality control in construction is essential to ensure the safety and durability of the building.

SELECTION OF APPROPRIATE MATERIALS

One of the most relevant elements in this regard is the use of antimicrobial materials in floors and walls. These materials play a crucial role in preventing infections and creating a safe and hygienic hospital environment, which has a direct impact on patient well-being.

Antimicrobial materials are those that have been treated or manufactured with agents that inhibit the growth of bacteria, viruses and fungi.

- **Antimicrobial Floors:** Antimicrobial flooring is especially useful where patients are in direct contact with the floor and where the circulation of personnel, medical equipment and visitors is constant.
- **Antimicrobial Walls and Surfaces:** Hospital walls must also meet stringent hygiene standards. Wall panels and coatings with antimicrobial properties help keep surfaces cleaner for longer, minimizing the need for aggressive cleaning that could damage surfaces and create areas of risk.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Construction and Supervision

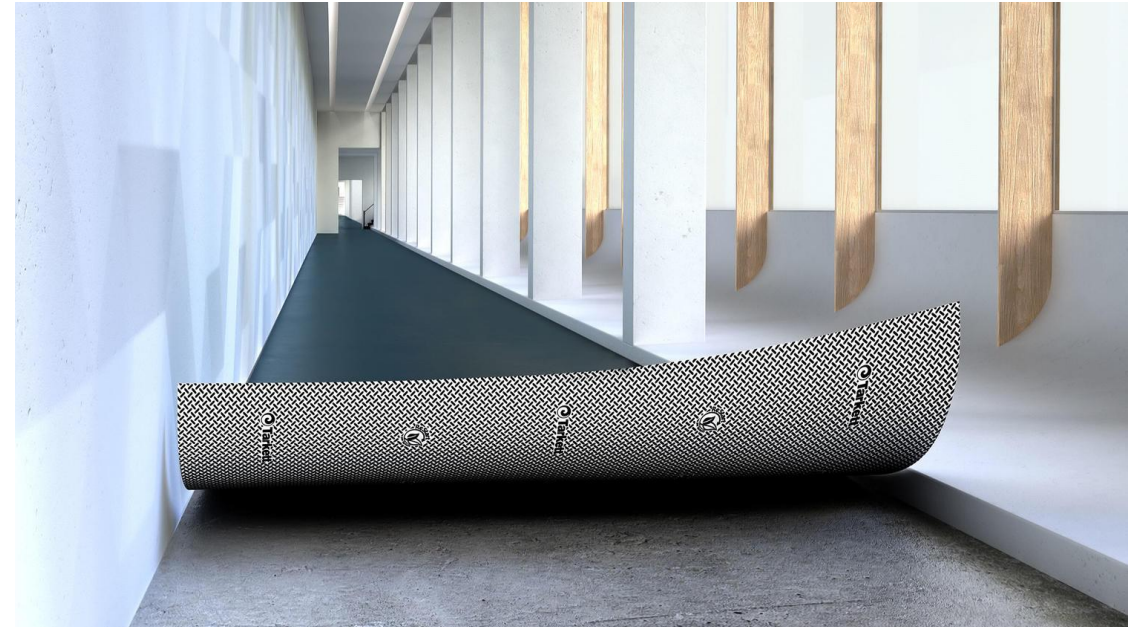
The use of antimicrobial materials not only benefits infection prevention, but also has a direct impact on the patient's overall health and well-being by creating a safer environment.

Antimicrobial materials contribute to patient protection by reducing the chances of exposure to pathogens, which can result in faster recovery and fewer complications.

In addition to physical safety, antimicrobial materials also influence the perception of cleanliness within the hospital.

The feeling of cleanliness can influence the perception of safety, which can result in a more positive and less stressful experience for patients, which is crucial for emotional and psychological recovery.

Because of these materials and by keeping surfaces cleaner for longer, hospitals can optimize their cleaning resources, which also contributes to operational efficiency.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

HOSPITAL FACILITIES

From the hospital engineering point of view, hospital facilities play a fundamental role in patient care and safety. A modern hospital must not only have adequate space for the provision of medical services, but also infrastructure and systems that ensure optimal conditions for patient recovery.

Electricity

The electrical system of a hospital is a critical infrastructure that must guarantee the continuity and quality of the electrical supply, ensuring the uninterrupted operation of vital medical equipment and essential services. This system is composed of several key elements that enable the distribution and management of energy.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Electricity

POWER ARRIVAL CENTER

The power arrival center is the point where the hospital receives the power supply from the public distribution network. Generally, it is connected to medium voltage and is equipped with:

- Protection and maneuvering cells: Devices such as circuit breakers, disconnecting devices and fuses to protect the system against overloads and short circuits.
- Energy meters: To control and record electricity consumption.
- Instrument transformers: To supervise electrical parameters and ensure adequate monitoring.

As this is a critical facility, the hospital has two power lines coming from different supply points. This guarantees the power supply at all times, since, in the event of a failure in one of the lines, the other will remain operational to maintain the supply. Depending on the typology of the hospital, these lines are distributed to the different hospital buildings and then to the transformation center of each building or directly transformed into low voltage



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Electricity

TRANSFORMATION CENTERS

Since the energy arrives at medium voltage, it is necessary to reduce it to levels suitable for use in the hospital facilities. To this end, transformation centers containing the following are installed:

- Power transformers: Since the energy arrives at medium voltage, it is necessary to reduce it to levels suitable for use in the hospital facilities.
- Protection cubicles: Since the energy arrives at medium voltage, it is necessary to reduce it to levels suitable for use in the hospital facilities.
- Distribution bars: These are the conductor elements that distribute the transformed energy to the various electrical panels in the hospital.
- Ventilation and cooling systems: Since transformers and other electrical equipment generate heat during operation, the transformer stations are equipped with ventilation and cooling systems.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Electricity

LOW VOLTAGE PANELS

Low voltage switchboards are fundamental elements in the hospital's electrical infrastructure, since they are responsible for the distribution of electrical energy to the different areas and equipment. These switchboards ensure that power is supplied efficiently and safely, and are equipped with protection and control elements to manage the electrical flow and guarantee the safety of the installations. The most relevant components found in these switchboards are detailed below:

- General and sectional switches:
- Circuit breakers
- Voltage regulators
- Uninterruptible Power Supplies (UPS)

Low voltage panels play an essential role in the safe and efficient distribution of power within the hospital, ensuring that all areas and equipment have a reliable and protected power supply. Thanks to the combination of protections, energy control and backup systems, both safety and continuity of electrical service are guaranteed, essential elements in a hospital environment.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Electricity

BACKUP AND SECURITY SYSTEMS

Electric power is a critical resource in any hospital, since the operation of essential medical equipment, such as respirators, monitors, life support systems, and other key devices for patient care, depends on a constant and reliable supply. Therefore, it is essential to implement backup and safety systems to ensure that, in the event of any interruption in the power supply, vital equipment continues to operate without inconvenience. The main systems implemented are as follows:

- Power generators
- Battery banks
- Monitoring systems



The comprehensive design of these backup and security systems is carefully planned to ensure that, even in critical situations, the hospital continues to operate safely and reliably. This comprehensive approach not only ensures the hospital's operational continuity, but also minimizes risks related to power failures and reinforces the safety of patients and workers, ensuring that the medical infrastructure functions efficiently and smoothly at all times.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Gas supply

The design of the gas supply system in a hospital must be carefully planned to ensure its continuous operation, safety and efficiency. This system must be capable of supplying all areas of the hospital that require it, such as operating rooms, intensive care units (ICU), emergency areas, recovery rooms, hospitalization units, among others. In addition, it must have the capacity to distribute the gases through a network of pressurized pipes, which goes from the main tanks or sources to the points of final use in each room or ward.

The piping system is generally made of stainless steel or other resistant materials that prevent leaks and allow for proper maintenance. The gas is distributed through a series of regulators, safety valves, and gauges that control the pressure and flow of gases in the different areas of the hospital. As far as the hospital environment is concerned, the most commonly used gases are:

- Medical Oxygen.
- Medical Air.
- Nitrous Oxide.
- Carbon dioxide.
- Sterilization gases.
- Vacuum.
- Nitrogen



The system is composed of several backup components that ensure uninterrupted operation, even in situations of failure or interruption. This supply is classified into three levels, each with a specific function to ensure that the gas always reaches the point of use without interruption:

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Gas supply

GAS SUPPLY SOURCES

These are the equipment or elements that generate clinical gases, which are concentrated in rooms specially designed for this purpose (Gas Central). These may consist of a cryogenic station, or a central gas generating equipment (air compressor/s and vacuum pump/s) or high pressure gases stored in cylinders.

Supply system equipped with associated control equipment, which supplies the gas to the distribution network. It can be of three types:

- Primary. The primary supply is the main source of the system and is responsible for providing gas on a continuous basis to the piped distribution network.
- Secondary. The secondary supply acts as an automatic backup source that comes on line when the primary supply fails or runs out.
- Standby. The standby supply is the last layer of protection, used only when both the primary and secondary supplies fail or cannot supply the piped distribution network.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Gas supply

PRESSURE REGULATORS

Regulators are flow control equipment designed to maintain a constant pressure downstream of them, regardless of variations in inlet pressure or changes in flow requirements.

DISTRIBUTION

Medical gases, such as oxygen, compressed air, nitrous oxide, and carbon dioxide, are distributed through a network of pressurized pipelines. This system connects the sources of supply - whether cylinders, cryogenic tanks or generating plants - to the points of consumption, which include key areas of the hospital such as the Surgical Block, Intensive Care Units (ICU), Emergency Room (ER), and patient rooms. The piping network must be designed to ensure a continuous flow, without interruptions and with a balanced distribution among the different areas of the hospital.

- Independent Distribution System for Critical Areas
- General Networks and Balancing Rings
- Cut-off Valves and Maintenance

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Gas supply

MAINTENANCE

From the hospital engineer's point of view, the design and maintenance of the piping network for the supply of medical gases must ensure that gas reaches all critical areas of the hospital continuously and safely, without interruption or risk. Protective measures, segmented networks and pressure balancing in the pipelines are essential to ensure that patients receive the right treatment at all times.

The job of the hospital engineer involves not only the installation and design of these networks, but also the constant monitoring of their operation and the implementation of safety protocols to mitigate any potential risks. The ability to adapt to emergency situations, manage system expansions and perform maintenance effectively are crucial competencies to ensure that the medical gas distribution system continues to operate efficiently and safely, providing the resources necessary for the well-being of patients.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

In a hospital environment, the availability of a safe, efficient and continuous hot and cold water system is essential to ensure the quality of medical care and patient safety. These facilities not only supply basic hygiene and comfort needs, but also play a critical role in the prevention of infections, the proper functioning of medical equipment, and the performance of specialized clinical procedures.

- **HOT WATER:** Cleaning and disinfecting surgical instruments, maintaining optimal conditions in areas
- **COLD WATER:** Human consumption, cooling of medical equipment, air conditioning and preparation of medical solutions

Since hospitals serve populations with compromised immune systems, it is crucial that water facilities meet strict quality and microbiological control standards. The presence of microorganisms such as *Legionella pneumophila* in hot water systems or contamination of drinking water can pose a significant health risk to patients.

In this context, hospital engineering plays a key role in the planning, design and implementation of water systems that not only ensure the operability of the hospital infrastructure, but also contribute to patient safety, minimizing the risk of nosocomial infections and guaranteeing a reliable and efficient supply at all times.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

RELEVANCE OF WATER TO PATIENT SAFETY

The quality and availability of water in hospitals has a direct impact on patient safety, as it influences several critical areas, such as:

1. Hospital Hygiene and Infection Control

- Adequate water supply allows for frequent hand washing by healthcare personnel, reducing disease transmission.
- Cleaning and disinfection of surfaces, rooms, operating rooms and medical equipment depend on a reliable water system.
- Sterilization of surgical instruments requires high quality water to eliminate pathogenic microorganisms.
- Microbiological surveillance programs should be implemented for water used for cleaning and disinfection.

2. Use in Medical Procedures

- Water is used in the preparation of intravenous solutions, dilution of drugs and in dialysis procedures.
- Hot water supply is essential in patient showers and baths, especially in intensive care and geriatric units.
- Water systems should be designed to avoid cross-contamination in medical processes.

3. Prevention of Water Associated Diseases

- *Legionella pneumophila* can proliferate in poorly maintained hot water systems, causing severe respiratory infections.
- Cross-contamination between drinking water and sewage systems can lead to outbreaks of gastrointestinal diseases.
- The accumulation of sediments in pipes favors the formation of biofilms, ideal environments for the growth of resistant microorganisms.
- The implementation of constant monitoring protocols for the detection of pathogenic bacteria is recommended.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

RISKS ASSOCIATED WITH POOR WATER MANAGEMENT IN HOSPITALS

These include, in particular, the following;

1. Microbiological contamination

Microbiological contamination in hospital water systems represents a significant risk to patient health. Various microorganisms can proliferate in water distribution networks if adequate conditions of temperature, circulation and disinfection are not maintained.

- Legionella pneumophila.
- Pseudomonas aeruginosa
- Enterobacteriaceae
- Control measures: Periodic hyperchlorination of the system, maintenance of adequate temperatures and frequent microbiological monitoring are recommended.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

RISKS ASSOCIATED WITH POOR WATER MANAGEMENT IN HOSPITALS

2. Physical and chemical risks

- Patient burns: The distribution of hot water without temperature control can generate severe burns, especially in patients with reduced mobility or altered sensitivity. The use of thermostatic mixing valves is essential to avoid this risk.
- Corrosion of pipes: Inadequate materials can cause the release of heavy metals such as lead and copper in drinking water, affecting the health of patients. The use of 316 stainless steel and multilayer pipes is recommended.
- Water pressure failures: Inadequate water pressure can compromise the functioning of operating rooms, dialysis rooms and ICUs. It is necessary to implement pressurization pumps and constant pressure monitoring systems.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

DESIGN AND MAINTENANCE OF WATER FACILITIES TO ENSURE PATIENT SAFETY2. PHYSICAL AND CHEMICAL RISKS

1. Hot and Cold Water System Design

- Location of Tanks: Storage tanks should be located in safe areas, away from sources of contamination such as sewage systems and hospital waste.
- Correct Sizing: An inadequate design can generate water stagnation, favoring bacterial proliferation.
- Use of Appropriate Materials: The use of galvanized steel should be avoided and materials resistant to corrosion and disinfection treatments should be chosen instead.
- Filtration Systems: The installation of particulate filters and UV filters can help reduce contaminants prior to distribution.

2. Temperature Control and Recirculation

- -Sanitary hot water (DHW) must be kept above 50°C to prevent the proliferation of Legionella.
- Thermostatic mixing valves: regulate the temperature to avoid the risk of burns in patients.
- Return circuits: They guarantee the circulation of hot water, avoiding stagnation.

3. Filtration and Disinfection Systems

- Installation of particle filters at the drinking water inlet.
- Regular disinfection with sodium hypochlorite or chloramines, ensuring residual chlorine levels of at least 0.2 mg/L.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Water system

MAINTENANCE AND RISK PREVENTION STRATEGIES

1. Preventive Maintenance plan
2. Corrective Actions
3. Training of sanitary and technical personal

Hospital water facilities play a crucial role in patient safety. Adequate design, the use of appropriate materials and rigorous maintenance guarantee a safe and risk-free supply. The implementation of preventive and corrective measures minimizes pathogen proliferation and ensures a hospital environment suitable for patient care.

Hospitals must adopt proactive water management strategies to comply with quality standards and regulations, thus protecting the health of patients and ensuring the proper functioning of healthcare services.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

Hospital climate systems play a critical role in ensuring thermal comfort, air quality and environmental safety for patients, medical staff and visitors. In addition, these installations play a fundamental role in preventing nosocomial infections by controlling ventilation, humidity and the concentration of airborne contaminants. The importance of proper design and rigorous maintenance lies in minimizing health risks and optimizing the hospital's energy efficiency.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

ROLE AND OBJECTIVES OF HVAC IN A HOSPITAL

Air conditioning in a hospital is a key element to ensure a safe, comfortable and healthy environment for both patients and medical staff. Its design and implementation must comply with strict quality, efficiency and biosafety standards.

- Temperature control: Maintain a comfortable and stable environment in all areas of the hospital.
- Humidity control: To avoid the proliferation of harmful microorganisms.
- Air filtration: Eliminate contaminants, allergens and pathogenic microorganisms.
- Pressurization of environments: Ensure protection in critical areas such as operating rooms and intensive care units.
- Energy efficiency: Optimize energy consumption without compromising air quality. Translated with DeepL.com (free version)

Good air quality helps to ensure good patient care



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

HVAC SYSTEM COMPONENTS

- Ventilation systems: Allow air renewal and distribution.
- HEPA and ULPA filters: Remove microscopic particles, ensuring clean air.
- Humidification and dehumidification systems: Maintain adequate humidity levels.
- Differential pressurization: Protects sensitive areas by regulating air flow.
- Automation and monitoring systems: Ensure constant control of air quality.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

DIFFERENT AREAS OF THE HOSPITAL



a) Operating rooms



b) Intensive Care Units (ICU)



c) Patient rooms



d) Laboratories and isolation areas

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

TYPES OF ROOMS AND CLASSIFICATION ACCORDING TO RISK

Hospital areas are classified according to the level of risk associated with air contamination, establishing specific ventilation and filtration criteria:

- Low risk areas: include administrative offices, waiting rooms and common patient rooms. Standard ventilation is required with no special pressure requirements.
- Medium risk areas: Include laboratories, examination rooms and outpatient clinics. They require intermediate filtration and moderate ventilation control.
- High-risk areas: Include operating rooms, intensive care units (ICU) and transplant rooms. These areas require rigorous air pressure control, HEPA filtration and high air renewal rates.

AIR FILTRATION STAGES

The filtration process in hospitals is crucial to ensure air quality. It consists of several stages that ensure the progressive removal of particles and contaminants:

- Prefiltration: large particles and dust are removed using G4 or F5 filters, protecting the following filtration levels.
- Intermediate filtration: Use of medium efficiency filters (F7-F9) to capture particles smaller than 1 μm , such as bacteria and spores.
- Absolute filtration: Implementation of HEPA filters (H13-H14) that retain up to 99.995% of 0.3 μm particles, preventing the propagation of microorganisms.
- Additional filtration: ULPA (Ultra-Low Penetration Air) filters or ultraviolet light (UV-C) systems can be used in critical areas for extra removal of viruses and bacteria.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Hospital climate systems

AIR RENEWAL AND RECIRCULATION

The number of air changes per hour (ACH) varies according to the classification of the area:

- Common rooms: 4-6 renewals/hour to maintain a clean environment without excessive energy expenditure.
- Laboratories and examination rooms: 10-15 changes per hour to minimize exposure to chemical and biological contaminants.
- Operating rooms and ICU: 20-25 renewals/hour with positive pressure to avoid external contamination and ensure strict aseptic conditions.

PRESSURE CONTROL SYSTEMS

To prevent infections and the spread of contaminants, different pressures are established in the environments:

- Positive pressure: In operating rooms and ICU to prevent the entry of pathogens from other areas of the hospital.
- Negative pressure: In isolation areas of infectious patients, preventing the exit of contaminants to the rest of the hospital.

Air conditioning in hospitals is a fundamental pillar to ensure the safety and well-being of the occupants. Efficient design, based on advanced standards and technologies, optimizes air quality, reduces infections and improves the energy efficiency of the hospital building. The integration of automation and intelligent control systems represents the future of hospital air conditioning, allowing a more efficient and sustainable management of available resources.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Humanization of facilities

A well-designed environment should not only be functional for medical staff, but also welcoming and humanizing for patients.

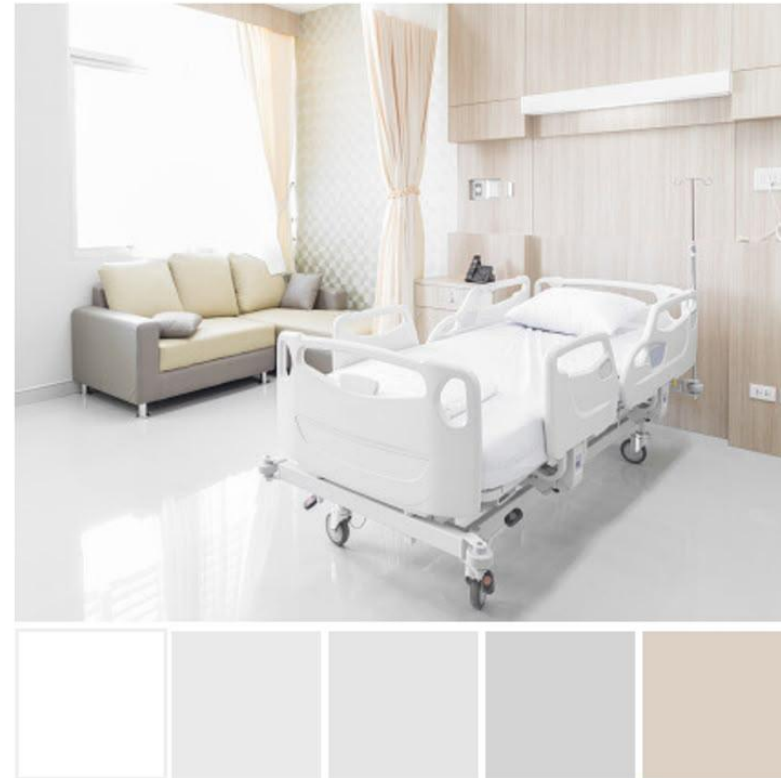
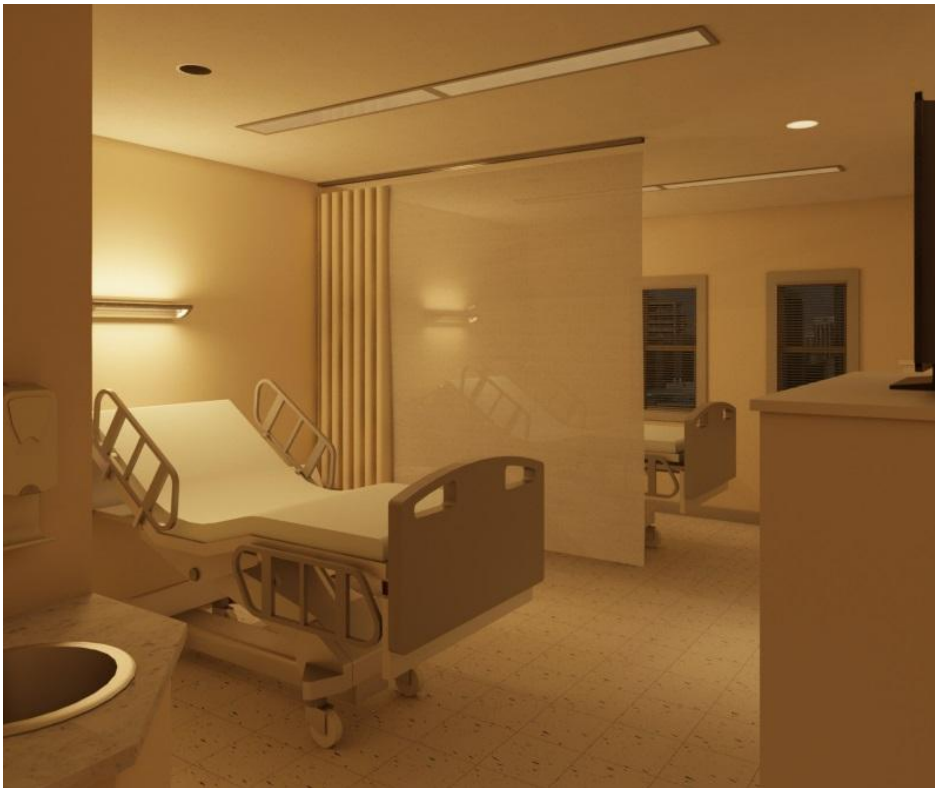
- The incorporation of natural lighting, soft colors and noise-reducing materials helps to reduce stress and anxiety, improving the hospital experience.
- The distribution of spaces should facilitate patient mobility, promoting their autonomy and safety, especially for people with reduced mobility.
- The presence of green areas, rooms with outdoor views and adequate rest areas for family members can also have a positive impact on the patient's recovery, creating a warmer and less impersonal environment.



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Humanization of facilities

LIGHTING AND COLORS



HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Humanization of facilities

Traditional hospitals have been designed primarily with a technical and clinical focus, neglecting the importance of patient comfort. However, studies have shown that a humanized hospital environment contributes to recovery and well-being. Hospital engineering must integrate architectural and technological solutions that ensure a balance between functionality and comfort.

Some key strategies include:

- Large, bright spaces
- Biophilic design.
- Ergonomic and comfortable furnishings.
- Room customization.

Reducing Stress and Anxiety

Hospitals can be intimidating environments, so it is crucial to design spaces that reduce patient stress and anxiety. Some solutions from hospital engineering include:

- Warm colors and materials
- Rest areas for family members.
- Noise reduction.
- Integrating Technology without Losing the Human Factor

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Humanization of facilities

NOISE AND PRIVACY

The constant sound of medical equipment, conversations, alarms and staff movement can cause stress, insomnia and anxiety, interfering with the patient's quality of rest.

SOUND ABSORPTION MATERIALS IN CORRIDORS AND ROOMS

To reduce the impact of noise in hospitals, sound absorption materials can be used in floors, ceilings and walls.

- Acoustical panels in ceilings to decrease sound propagation.
- Vinyl or rubber flooring that reduces noise from footsteps and equipment movement.
- Walls with sound-absorbing acoustical wall coverings in high-traffic areas, such as hallways and waiting rooms.
- Quiet equipment.
- Sound-insulated doors in rooms to minimize external noise interference.

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Operational efficiency and its impact on patient safety and well-being

Operational efficiency in hospitals is a fundamental pillar to ensure patient safety and improve the patient experience during the hospital stay. From a hospital engineering perspective, optimizing workflows and space distribution can reduce waiting times, minimize medical errors and facilitate the work of healthcare staff.

One of the main objectives of hospital design is to avoid bottlenecks in medical care. This is achieved through a detailed study of the flow of people, equipment and materials within the hospital. Some key strategies include:

- Strategic location of critical services
- Separation of patient and medical staff flows
- Efficient internal transport systems
- Digitalization and automation of processes

HOSPITAL ENGINEERING, KEY ELEMENTS IN DESIGN

Operational efficiency and its impact on patient safety and well-being

An efficiently designed hospital not only improves the speed of care, but also reduces medical risks associated with lack of coordination and communication errors.

Some examples of how operational efficiency impacts patient safety include:

- Reduced ED wait times
- Improved coordination between medical areas
- Reduced risk of nosocomial infections

The patient experience within the hospital also depends on the organization of space and ease of access to services. A hospital designed with logical and efficient circulations contributes to:

- Reduced stress and anxiety.
- Greater comfort during the stay.
- Ease of patient mobility.

Hospital planning should focus on the integration of technology, accessibility and functionality to ensure that every process within the hospital is aligned with patient safety and well-being

CONCLUSIONS

Hospital facilities play a fundamental role in the quality of patient care, as they directly impact patient safety, well-being and recovery.

A well-designed hospital not only optimizes the flow of patients and staff, but also reduces the risks of nosocomial infections, improves treatment efficiency and contributes to a more humanized patient experience. Hospital infrastructure must consider essential aspects such as ventilation, lighting, space distribution, accessibility and the incorporation of advanced technologies.

The integration of intelligent and automated systems has proven to be an effective strategy to improve hospital management, allowing continuous monitoring of patients and facilitating real-time medical decision making.

In conclusion, well-planned and modernized hospital facilities not only ensure a safe and functional environment, but also positively influence clinical outcomes and patient satisfaction.

CONCLUSIONS

Hospital engineering is evolving towards a more sustainable, efficient and technological model. Key future trends include:

- Smart hospitals and digitalization
- Sustainability and energy efficiency
- Telemedicine and hospital at home
- Flexible and modular architecture
- Advanced safety and biosecurity

The future of hospital engineering is geared towards technological innovation and sustainability, ensuring that hospitals are more accessible, safe and efficient for the well-being of patients and the optimization of healthcare resources.

THANK YOU

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