National Manual of Assets and Facilities Management

Volume 5, Chapter 7

Mechanical Systems Operations - Healthcare Procedure

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1.0 PURPOSE

The purpose of this document is to provide guidelines and best practices to the Entity to implement and manage the operations of mechanical systems within the healthcare facilities. It is essential to operate and manage mechanical systems according to the installation and design methodology to achieve efficient and effective operations.

These guidelines are based on the operations management strategy/techniques of the mechanical equipment, which includes the following:

- Energy savings related techniques
- Cost and investments considerations
- Efficiency and performance of plant, machinery and equipment
- Assistance with cost savings and prevention
- Future investment on replacement or additional maintenance of mechanical (PME) system as part of an overall life cycle replace plan

2.0 SCOPE

The scope of this document is to provide implementation guidelines for operation management of healthcare entities as per the site specific requirements and best international standards. Providing Facilities Management (FM) service providers guidance for improving the operation management processes in relation to mechanical systems operational activities which provide the benefits such as, but not limited to:

- Increased equipment life to meet with design life cycle plan
- Reduced downtime of plant and services through effective and targeted maintenance
- Utilization of best in class maintenance services of systems
- Visibility of plant condition through effective reporting
- Increased efficiencies and reduced utility costs

These guidelines contain operation management expectations consistent with the Expro approach, using best practice developed through industry experience. Furthermore, they provide adequate references and best practice to follow as a minimum requirement in order to ensure optimal performance of the mechanical systems

For the purpose of this document, “a healthcare facility” has been defined as any location where healthcare services are provided including, but not limited to:

- Hospitals
- Clinics
- Nursing homes
- Dental care facilities
- Psychiatric healthcare facilities/institutes

Notwithstanding the recommendations presented in this document, the final responsibilities for the efficient operations management of mechanical systems shall remain with the Entity and/or Operations Engineer (OE).

3.0 DEFINITIONS

Term	Definition
Acid	A chemical that reduces the pH of water and reacts with alkali or base, commonly used for removing scale and other deposits from systems and sometimes used as a scale inhibitor
Aerosol	Gas delay in medium of solid, liquid. & Solid and liquid Particles velocity drops.

Term	Definition
Air conditioning	A form of air treatment whereby temperature, humidity, ventilation and air cleanliness are controlled within the acceptable parameters limits determined by the requirements of the air-conditioned enclosure
Algae	Simple organisms like plants that require light for growth, typically found in aquatic environments
Alkali	A chemical that increases the pH of water and reacts with an acid
Alkalinity	The concentration of alkali in water (measured by titration with standard acid solution)
Amines	An organic compound derived from ammonia by the replacement of one or more hydrogen atoms by organic groups
Antibodies	Substances in the blood that destroy or neutralize toxins or components of bacteria known generally as antigens; and are formed as a result of the introduction into the body of the antigen to which they are antagonistic
Bacterium	A microscopic, unicellular prokaryotic organism, without a nuclear membrane
Balance pipes	Pipe(s) between adjoining duty towers and between duty and standby towers
Biocide	A substance that kills microorganisms
Biofilm	A community of microorganisms of different types growing together on a surface so that they form a slime layer
Bleed	A deliberate intermittent or continuous discharge of system water to drain to allow the admission of makeup water to the system, thereby controlling the concentration of dissolved or suspended solids in the water
Blow-down	Another term for bleed
Bromine	A chemical very similar to chlorine; used as a biocide and sometimes as a disinfectant. The practical difference between bromine and chlorine when used as a biocide is that bromine remains effective at higher pH levels
Chlorinate	To add chlorine to water, usually in the form of a Sodium Hypochlorite
Chlorine	A chemical used as a biocide and for disinfection to kill microorganisms in the treatment of water (see bromine, combined chlorine, and free chlorine)
Cold Water	Running water without heat or utility services
Combined chlorine	The amount of chlorine that has reacted with nitrogenous/organic materials to form chlorine compounds
Competence	The quality or state of having enough knowledge, judgment, skill, or strength (as for a particular duty or in a particular respect).
Concentration Factor	It is used to compare the level of dissolved solids in the cooling water with that dissolved in the makeup water {also known as Cycles of Concentration (COC) or concentration ratio}
Conductivity	The capacity of the ions in the water to carry electrical current
Conductivity Controller	A device that measures the electrical conductivity of water and helps control it to a preset value (standard limits)
Cooling water system	A heat exchange system comprising a heat-rejection plant and interconnecting recirculating water pipework (with associated pumps, valves and controls).
Corrosion coupons	Small strips of various types of metal, placed in racks in water circuits that can easily be removed, weighed and/or inspected to enable the corrosion characteristics of the water to be assessed.
Corrosion inhibitors	Chemicals designed to prevent or slow down the waterside corrosion of metals.
Dead leg	A length of water system pipework leading to a fitting through which water only passes when there is draw-off from the fitting, thereby providing the potential for stagnation
De-aeration	Introducing Air to metals
Dip slide	Coated plastic/glass slide on which microorganisms can be grown, examined and quantified. They provide a broad indication of microbial growth only

Term	Definition
Disinfection	Reduction in the number of microorganisms to safe levels (acceptable limits) by either chemical or non-chemical means (e.g., biocides, heat, or radiation)
Dispersant	A chemical that loosens organic material, such as biofilm, adhering to surfaces
Drift	Water droplets and aerosols entrained in the air that discharges from a cooling tower or evaporative condenser
Drift Eliminator	Equipment containing a complex system of baffles designed to minimize drift (see drift) discharging from a cooling tower or evaporative condenser
Evaporative Cooling	The process of evaporating part of a liquid which removes the necessary latent heat of evaporation from the main bulk of the liquid, thereby cooling it
Facilities Management	The International Organization for Standardization defines FM as the organizational function which integrates people, place and process within the built environment
Free Chlorine	The amount of chlorine available to act as a disinfectant in water
Half Life	The time taken for the level of a treatment chemical to decrease to half its original value
Halogen	A grouping of chemical elements that include bromine and chlorine
Healthcare Facility/Building	All buildings, infrastructure, equipment, plant, embedded systems, and related items that support the delivery of healthcare and services of all types, irrespective of their ownership or operation by third parties
Heat Exchanger	A device for transferring heat between fluids which are not indirect contact with each other
Hot Water	Hot water is heat transfer process that uses an energy source to heat water
Incubation temperature	The temperature dip slides or inoculated culture media should be held at, long enough for bacterial growth to become evident
Legionella	A bacterium (or bacteria) of the genus Legionella
Legionella Pnuemophila	A species of bacterium that is the most common cause of Legionnaires' disease and Pontiac fever
Legionnaires' disease	A form of pneumonia caused by bacteria of the genus legionella.
Makeup water	Fresh water added to a recirculating water system to compensate for losses by evaporation, bleed, drift, wind effect, and leakage
Mechanical System	Healthcare building service using machines. which includes plumbing, elevators, escalators, and HVAC Systems
Ohmmeter or Megger	Special type of ohmmeter used to measure the electrical resistance of insulators
Reverse Osmosis system (RO)	A water purification process that uses a semi-permeable membrane to remove ions, unwanted molecules, and larger particles from drinking water
Scaling Indices	These are predictors for the scale-forming or corrosive properties of water
Shot dose	A single dose of a chemical, sometimes called a 'shock' or 'shot' dose
Total Dissolved Solids	The quantity of solids dissolved in the water, measured in mg/L
Total Viable Counts	The total number of culturable bacteria (per volume or area) in each sample
Wind Effect	Water lost when wind forces an unusual flow pattern through the base of a cooling tower and blows droplets out of the tower
Abbreviations	
AHU	Air Handling Unit
ANSI	American National Standards Institute
AVSU	Area Valve Service Units
BMS	Building Management System
BSL	Bio Safety Level
CAFM	Computer Added Facility Management
CBV	Circuit Balancing Valve
CCTV	Closed Circuit Television
CDC	Communicable Disease Center

Term	Definition
CHWR	Chilled Water Return
CHWS	Chilled Water System
CMMS	Computerized Maintenance Management System
COSHH	Control of Substances Hazardous to Health Regulations
CSSD	Central Sterile Services Department
CT	Cooling Tower
DCA	Double Check Assembly
DCP	District Cooling Plant
DVAS	Dental Air & Vacuum Systems
FCU	Fan Coil Unit
FM	Facilities Management/Facilities Manager
FOG	Fat Oil Grease
FOM	Facilities Operation Management
FRP	Fiber Glass Reinforced Plastic
GAC	Granular Activated Carbon
GRE	Glass Reinforced Epoxy
GRP	Glass Reinforced Plastic
GRV	Glass Reinforced Vinyl Ester
HDPE	High-density polyethylene
HP	High Pressure
HSC	Health Safety Group
HSSE	Health Security Safety and Environment
HTHW	High Temperature Hot Water
HTM	Health Technical Memorandum
HVAC	Heating, Ventilation, and Air Conditioning
ICU	Intensive Care Unit
LOTO	Lock Out Tag Out
LP	Low Pressure
LTHW	Low Temperature Hot Water
LVA	Line valve assemblies
MEP	Mechanical Electrical Plumbing
MGPS	Medical Gases Pipeline System
MS	Mild Steel/Mechanical Systems
MSDS	Materials Safety Data Sheet
MTHW	Medium Temperature Hot Water
NFPA	National Fire Protection Association
NICU	Neonatal Intensive Care Unit
O&M	Operations and Maintenance
OE	Operations Engineer
OEM	Original Equipment Manufacturer
PDS	Product Data Sheet
pH	The logarithm of the reciprocal of the hydrogen ion concentration in water, expressed as a number between 0 and 14 to indicate how acidic or alkaline the water is. Neutral = pH 7
PICU	Pediatric Intensive Care Unit
PPE	Personal Protective Equipment
PM	Planned Maintenance
PSA	Pressure Swing Adsorption
PTW	Permit to Work
PVB	Pressure Vacuum Breaker
QHSE	Quality Health Safety Environment

Term	Definition
RCC	Reinforced Cement Concrete
RPZ	Reduced Pressure Zone
SOP	Standard Operating Procedure
SSF	Side Stream Filtration System
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TH	Total Hardness
TSD	Technical Services Department
TSS	Total Suspended Solids
UPVC	Unplasticized Polyvinyl Chloride
UV	Ultraviolet
VIE	Vacuum Insulated Evaporator
WMP	Water Management Plan/Program
WSG	Water Safety Group
WTS	Water Treatment Systems

Table 1: Definitions

4.0 REFERENCES

- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM) International
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- American Society of Mechanical Engineers (ASME VIII Part 1) – Boiler and Pressure Vessel Code
- American Society of Plumbing Engineers (ASPE)
- American Society of Sanitary Engineering (ASSE)
- American Water Works Association (AWWA)
- British Standards Institute (BSI)
- Cooling technology institute (CTI)
- Health Technical Memorandum (HTM 02-01) – Medical Gas Pipeline Systems
- Health Technical Memorandum (HTM 04-01) – Safe Water in Healthcare Premises
- HVAC systems and OEM instructions and guidelines – ASHRAE/ANSI/ANRI
- International Association of Plumbing and Mechanical Officials (IAPMO)
- International Organization for Standardization (ISO 9001/14001)
- Municipal and Rural Affairs(MOMRA) Regulations on Technical Requirements for Wastewater Treatment Plants in Large Complexes (Government and Private Sectors) Arabic Translated document on Last Updated on 2/7/1423 AH.
- National Fire Protection Association (NFPA 45) – Fire Protection for Laboratories Using Chemicals
- National Fire Protection Association (NFPA 50) – Standard for Bulk Oxygen Systems at Consumer Sites
- National Fire Protection Association (NFPA 50A) – Standard for Gaseous Hydrogen Systems at Consumers Sites
- National Fire Protection Association (NFPA 55) – Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks
- National Fire Protection Association (NFPA 99) – Healthcare Facilities Code
- NSF International Standard / American National Standard (NSF/ANSI 55-2019) – Ultraviolet Microbiological Water Treatment Systems
- Plumbing and Drainage Institute (PDI)
- Public Health and Safety Organization (NSF)
- Saudi Arabian Standards Organization (SASO)
- SBC 701 (Plumbing Code) – When there is any conflict with the Saudi building code, only the Saudi Building Code will be applied

- SBC 702 (Private Sewage Disposal Code) – When there is any conflict with the Saudi building code, only the Saudi Building Code will be applied
- Underwriters Laboratories (UL)
- White Book EPM-KEM-GL-000001 Rev 002 – Mechanical Design Guidelines

International best practices and standards shall be selectively applied based on the evaluation of individual requirements. Where the standards stipulated conditions conflict, the most stringent shall govern, unless otherwise noted herein. When there is any conflict with the Saudi Building Code (SBC), only the Saudi Building Code will be applied.

5.0 RESPONSIBILITIES

The Ministry is the final Authority Having Jurisdiction (AHJ) unless specifically stated otherwise in other sections of the National Manual of Assets and Facilities Management. If a conflict is discovered between these guidelines and other operations management documents, it shall be brought to the attention of the healthcare engineering team, FM service provider or specialist contractors; who will provide a resolution or direction to ensure that all mechanical systems goals and requirements have been met.

5.1 Management Responsibilities

It is the responsibility of Entity management to ensure that inspections, services, and operational activities are carried out safely without any hazard to the Operations Team or stakeholders (e.g., patients and medical staff of healthcare facility). Clear lines of managerial responsibility should be in place to prevent any ambiguity for the safe operations of mechanical systems. Management should conduct a periodic review and inspection of the systems in order to ensure that the operational standards are being met. Mechanical systems require periodic inspections and verification. Hence, management should ensure that a competent team is appointed to perform all these assessments. The Operations Management Team shall ensure that staff are adequately trained and competent to carry out operational tasks which should include, but not limited to:

- Staff briefing
- Safe systems of works
- Personal Protective Equipment (PPE)
- Quality control and assurance
- Health, Safety, Security and Environment (HSSE)
- Risk Assessment and Method Statement (RAMS)
- Permit to Work (PTW) process
- Stakeholder communication
- Training
- Staff vaccination and periodic health checkups of Facilities Operation Management (FOM) staff

5.2 Designated Staff Functions

Only trained and competent persons should be appointed by management to operate and maintain the mechanical systems.

Role	Description
Maintenance/Operations Manager (MM/OM)	An individual who performs the following duties: • Ensuring implementation and adhesion to operational procedures • Providing the appropriate personal protective equipment (PPE) to all employees and subcontractor personnel operating at the facility • Verifying the health, safety, environment and security matters • Ensuring implementation of effective PTW systems
Facilities Manager (FM)	FM is responsible for:

	• Creating documents in accordance with the procedures as instructed by OEM • Monitoring compliance with the Standard Operating Procedures (SOP) • Providing advice and guidance on the implementation of the procedure
Operations Engineer (OE)	OE is responsible for supervising all installation, maintenance, modification, overhaul, service, and repair of Mechanical, Electrical, and Plumbing (MEP) equipment. The duties included are: • Ensuring that the work performed follows blueprints, SOP manufacturer specifications, recommendations, O&M manuals, written and/or verbal instructions, checklists and guides • Planning, scheduling, work permits, and assigning work to staff in order to ensure adequate resources for efficient performance of duties • Monitoring jobs to ensure quality and compliance with standards, update records, report on performance, and resolve issues • Instructing personnel on activities related to mechanical maintenance to ensure an acceptable work performance level • Supervising or assisting in personnel actions including, but not limited to, hiring, performance appraisals, promotions, and scheduling time off • Performing other duties as assigned
Duty Holder	Entity/Organization should have responsibilities of their employees regarding health and safety. Organizations should delegate the duty of daily operations, which includes the management of health and safety, to the Managing Director. The Entity/organization should appoint a water treatment specialist or third party specialist/auditor/contractor to identify and control legionella bacteria. It is important for the appointed person, known as the Responsible Person(s), to have enough authority, competence, and knowledge of understanding systems installation to ensure all operational procedures are carried out in a timely and effective manner
The Chief Executive	The Chief Executive shall appoint a "Responsible Person" to co-ordinate and supervise the implementation of Legionella precautions in accordance with relevant statutory Approved Codes of Practice and associated guidance. The Chief Executive shall also: • Appoint, in writing, 'Responsible Persons' to be responsible for daily operations management of water hygiene, Legionella risks and compliance with current regulations and standards in the region • Ensure that the Responsible Persons are aware of their roles and responsibilities and are competent enough to carry them out
Health Safety Security and Environment (HSSE)	The Head of HSSE in conjunction with the responsible person shall develop appropriate polices to control risks arising from hazards and control of Legionella and monitor the implementation of these, reporting to the safety committee as necessary
Water Safety Group (WSG)	In order to implement the mandatory duties within an organization, the Duty Holder should appoint a WSG to undertake the commissioning, development, implementation and review of a Water Safety Plan (WSP). The aim of the WSG is to ensure the safety of all water used by public, residents, and staff, in order to minimize the risk of infection associated with waterborne pathogens and 'the control of legionella bacteria in domestic hot and cold water'. These water management and monitoring arrangements should ensure responsible planning, consultation and dissemination of the arrangements made within a water risk assessment plan and shall maintain details of appointees with responsibilities for the control of legionella and the reporting of relevant information to stakeholders, healthcare facility departments, and non-medical staff and operations teams
The Responsible Person	The 'Responsible Person' should have enough status and authority to carry out the duties assigned to them. This person should also attain the necessary competence and knowledge of the systems and their installations to ensure that all operational procedures are carried out in a safe, timely and effective manner. The Responsible Person should have a clear understanding of their duties and the

	overall health & safety management structure and policy within the organisation. It should be the duty of the HSSE team to make sure all responsible teams should have undergone the health & safety management refresher course, at least once a year The Responsible Person shall advise on and monitor the arrangements for the risk assessment of water and advise on the control and monitoring of water distribution systems and wet cooling towers. This shall include liaison with contractors who are appointed to conduct risk assessments of relevant water systems and wet cooling towers or for carrying out appropriate maintenance of these systems where identified. The responsible person should manage the on-site water testing on daily basis to make sure that water quality is up to the acceptable limits. Below listed are some water parameters for on-site testing: • pH • Temperature • Total Dissolved Solids (TDS) • Conductivity • Free chlorine residues Other parameters of periodic testing should be undertaken as required by the Entity (or advised by specialist contractor. The test equipment should be calibrated on a regular basis. Water samples should be submitted to an authorized laboratory for microbiological testing periodically as outlined in the WSP.
Designated Person	All departments responsible for water systems in which there is a reasonably foreseeable risk of Legionella colonization shall appoint a “Designated Person” to be capable of management and supervision of Legionella precautions relevant to these systems The Designated Person shall liaise with the Responsible Person to ensure the effective implementation of the WSP The Responsible person will assign Designated Persons for following tasks: • Water quality testing and monitoring to be carried for wet cooling towers on weekly basis. • Any modification/refurbishment (building) to water systems (Wet Cooling Tower) that could affect the safe operation of the water distribution networks. • Any processes that have been identified as being subject to legionella control arrangements • Any proposal to install new/old, modify or remove a wet cooling tower • Any activities/occupation that could affect the safe operation of water systems
Facilities Operation Manager	Facilities Operation Manager will appoint contractors who are responsible for ensuring that systems are designed and installed in compliance with approved consultant specifications. Contractors are to be registered with the Legionella Control Association and a copy of their registration certificate is to be held on file (Refer to Expro White Book – Mechanical Design Guidelines Volume 6 Chapter 7) The Responsible Person is to approve each stage of the design and acceptance in conjunction with Expro White Book – Mechanical Design Guidelines Volume 6 Chapter 7. The facilities Project Manager liaising with the Responsible Person is responsible for ensuring that the water system conditions are maintained throughout the healthcare to include controls such as weekly flushing of unused water networks and a chlorination of altered areas during the works, no sooner than one week prior to occupancy or re-occupancy

	The Facilities Operation Manager in conjunction with the Responsible Person will be responsible for ensuring that all PME and services can meet any increased demand where a system has been extended, and for the provision of all as-fitted drawings at the time of handover, together with all commissioning data. No system will be accepted unless the Responsible Person has given the final written approval

Table 2: Designated Staff Functions

6.0 PROCESS

This section provides operations and management guidelines and best practices to be followed by the FOM team as mandatory, minimally acceptable requirements for the following systems:

- Water Treatment Systems
- Fire Protection Systems (Refer to Volume 5 Chapter 10)
- HVAC Systems (Refer to Volume 5 Chapter 4)
- Plumbing Systems
- Generator/Fuel Systems
- Medical Gas Pipeline Systems
- Chiller Systems

6.1 Water Treatment Systems

Water treatment is a method of purifying the water by improving its water quality within the acceptable water quality parameter range. The treated water may be used for different applications e.g., dialysis treatment, laboratories, drinking, irrigation, landscaping. This treatment is crucial for human health and allows people to benefit from both drinking and irrigation water from underground sources combined with municipality/community water supplies. Few additional water treatment sub systems are provided below:

- Chilled Water System (Closed Loop Secondary System)
- Cooling Towers or Condenser Water (Open Loop System)
- DCP Cooling Towers
- CSSD RO Treatment Plant
- Dialysis RO System (Potable RO)
- Hydrotherapy Pool System
- Steam Boilers Water Treatment (Laundry)
- Potable/Domestic Water Treatment Systems
- Filtration Systems (UV Systems)
- Neutralization Plant
- Gray Water Treatment Plant
- Sewage Treatment Plant (STP)

This section also provides guidelines and best practices for the following:

- Microbiological Growth Monitoring and Control measures
- Arrangements for Managing Legionella Risk Assessment Plan
- Mandatory Controls, Parameters and Limits

6.1.1 Chilled Water System (Closed Loop Secondary System)

Chilled water systems are utilized within a healthcare facility to provide air conditioning particularly to patients and clinical areas where cooling is combined with the Heating and Ventilation system for a comfortable and controlled indoor environment within the facility.

Additionally, the chilled water may be used for direct cooling of principal equipment within the healthcare facility for surgical and monitoring equipment requiring high capacity cooling to function correctly. This may also be utilized in the healthcare facilities computer and data network, data centers where high degrees of heat may be generated from IT equipment.

The temperature rise usually averages between 6 to 9 degrees, but for some systems, it can exceed substantially. Generally closed systems require little or no makeup water. The water vents out except for pump seal leaks, expansion tank overflows and surface evaporation from the systems. Dedicated equipment is generally employed to automatically undertake small amounts of makeup water. Excess water usage should be investigated at the earliest possible to maintain system integrity and prevent overuse of expensive chemical. This periodic makeup requires regular analysis for control of correct treatment chemical residuals and should be considered in the maintenance schedule for the facility.

Automatic dosing and online monitoring systems may be used in the chilled water system to accurately control the levels of chemicals within the closed loop system. The chilled water system should be manually checked by a competent and certified person, who may be a specialist contractor (water treatment). Samples should be provided to an authorized laboratory on a periodic basis, at no greater than 6 monthly intervals (check local requirements) for the levels of inhibitors and biocides (oxidizing biocides) contained within the system. The purpose of these chemicals is to protect the system from the following:

- Internal (closed loop) corrosion from the entry of contaminants from make-up water
- Build up of bacteria in the closed loop system during operation
- Air entry and loss of water during the maintenance
- Closed loop system pipe leakage

6.1.2 Cooling Towers or Condenser Water (Open Loop System)

The cooling towers sub system is a process of heat rejection within the building or facility and linked to the production of chilled water. The cooling tower extracts heat from the condensing water, which is utilized to service the chillers within a facility and lower the temperature by using external cooling, generally to atmosphere. This will allow the water to circulate to the plant, machinery and equipment at a lower temperature.

6.1.3 District Cooling System/Plant (DCP)

In certain applications, the provision of cooling for a facility may be obtained from DSP. The DCP may be wholly dedicated to a facility or could be from a shared community supplied resource. It is the responsibility of the FOM to maintain these systems and prevent any dangers to adjacent facilities. Therefore, the same level of cleanliness should be employed as if the plant was under the direct control of the entity. Records should be available to demonstrate that the required checks are being undertaken on water systems to ensure that they comply with published standards and should be available upon request.

A DCP may supply services as a part of community supply for the individual healthcare and associated buildings or may be an individual customer. It is therefore the responsibility of service provider to demonstrate the maintenance program of DCP – as the primary supply of water to distribution until heat exchangers (primary circuit) within the facility. Records should be available as part of the agreed Service Level Agreement (SLA) between Entity and supplier. Distribution of the water using this technique would then be under the responsibility of healthcare Facilities Operating Client (FOC). The secondary circuit should be maintained by the building's landlord FOC or healthcare FOM team.

6.1.4 CSSD RO (Reverse Osmosis) System

Reverse osmosis (RO) is a water purification process which uses a semi-permeable membrane to remove ions, unwanted molecules, dissolved solids, and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome the osmotic pressure. RO systems can remove dissolved and suspended minerals and chemicals along with biological species from water to be used in both industrial processes and the production of potable water. The output should be monitored to ensure that it meets with the required water quality parameters and specifications. Testing should be carried out at regular intervals to ensure compliance with the latest HTM standard (HTM 04-01). Additionally, periodic maintenance should be undertaken by facility teams, or specialist supplier to maintain these systems to a high standard.

Chemical dosing systems are also employed within this type of equipment to protect and prolong life of the semi-permeable membranes.

The RO plant provides a refined solution due to the following reasons:

- The water is produced on demand having passed to service via the sub-micron filter and associated equipment
- The stored water should be recirculated to prevent stagnation occurring and ensure that membranes and components do not become dry, allowing bacteria to propagate
- The issue of buying bottled water is reduced, thereby reducing cross contamination and reduction of waste

6.1.5 Dialysis RO System

Water treatment represents a fundamental aspect of modern hemodialysis technology. Water supplied to healthcare facilities is of the same quality as that supplied to homes but its use in hemodialysis requires further treatment as impurities can be responsible for many unwelcome acute side effects. Therefore, many healthcare facilities will install additional RO plant for a higher quality water that is mandatory to maintain patient health and reduce likelihood of infection.

6.1.6 Hydrotherapy Pool Water Treatment

This treatment is used in a warm water pool designed for aquatic physiotherapy and rehabilitation treatment. It is used to treat people post injury, surgery, or for medical condition management. The water temperature is usually 33-36ºC, which is generally greater than that found in recreational swimming pool applications.

The Hydrotherapy Pool should be tested for Legionella and other water borne bacteria that may affect patients and staff. The particular bacteria and contaminants may require to be reviewed on a periodic basis or upon notices received from CDC organizations. As per hydrotherapy treatment requirements and best industrial practice, Original Equipment Manufacturer (OEM) recommendations and best standards are recommended to test water more regularly compared to swimming pools since these are used more often than the swimming pools. Excess of use creates more favorable conditions for the growth and proliferation of several waterborne pathogens, combined with transmission of bacteria and virus from patients' conditions.

Several important issues need to be considered that will help pool owners, managers, and operators to manage the risks associated with hydrotherapy facilities to keep staff and patients safe and ensure compliance with the local authority body regulations.

6.1.6.1 Microbiological Testing of Hydrotherapy Pool Water

Bacteria can enter the hydrotherapy pool in different ways including, but not limited to:

- Source of water
- Bathers
- Organic materials
- Pool filters
- Faults in the mechanical components of the pool
- Environmental
- Oil/medicines (e.g., ointments, oil, gels) applied externally on patients' bodies

A risk assessment gives a more detailed recommendation about the types and frequency of water testing. Ideally the following actions should be taken:

- Daily basic water parameters check e.g., pH, temperature, TDS, Free Chlorine Residuals (FRS)
- Taking weekly microbiological samples for bacterial testing
- Following maintenance or major works, modification or refurbishment of the systems
- Following extensive cleaning, super chlorination, disinfection of pool or associated equipment

6.1.7 Steam Boilers Water Treatment (Laundry Systems)

Steam is a vital part of healthcare facilities operations as the medium is self-propelled. Many applications of steam include, e.g., sterilization, humidification and heating, domestic hot water provision. Central steam generation is normally undertaken within a dedicated area or building. Distribution is through pipe systems rated (temperature & pressure) and insulated to protect the users and facility. Operators and users should be made aware of the dangers and must be made to follow the guidelines contained within the HSSE of the National Manual of Assets and Facilities Maintenance Volume 10. Following the removal of lagging materials, the entity should undertake risk assessment to ensure that asbestos lagging is not disturbed, and its location must be clearly identified.

6.1.7.1 Steam Utilization in Healthcare Facility

- **Hot Tap Water:** Healthcare facilities have a critical need for significant amounts of hot water (e.g., sinks, showers, kitchens, sterilization, CSSD). Steam is a cost-effective solution for the healthcare facility's entire hot water demand
- **Heating:** Steam can be used for space heating. This is often achieved by pumping water around the heating circuits (e.g., radiators) and is referred to as Low Temperature Hot Water (LTHW)
- **Laundry:** Steam's versatility enables it to be used easily in many parts of the laundry. Steam is a useful medium for on-site laundry facilities to assist with the high turnover of services

6.1.7.2 Water Quality

Water quality is the main element in maintaining well-organized boiler operations as dissolved suspended solids present in water can increase fuel costs or cause equipment damage. The loss of efficiency or equipment damage is due to scale, sludge or corrosion that are all caused by water impurities. In addition to damage to the boiler, impurities in the water can carry-over in the steam, causing equipment damage throughout the steam system. These guidelines are available in the owner's Operations and Maintenance (O&M) manual, from the Original Boiler Manufacturer or OEM which the contractors submitted during Handing Over and Taking Over. Water quality regulations should be in place to maintain and monitor water quality. Repairing leaks in the steam, condensate systems and returning the condensate back to the boiler system will minimize the water treatment costs and improve system issues resulting from treated makeup water.

6.1.7.3 Treatment Systems – External to the Boiler

- **Water Softener:** Most of the water used in healthcare, commercial, residential and small scale industrial boilers comes from a municipal supply or from wells or other sources of water supply. Raw supplied water Total Hardness (TH) should be monitored as this can be a major factor in reducing efficiency of the healthcare facility. This can be overcome with the addition of a water softener but with a subsequent increase in cost of operation/maintenance. A softener system must be regenerated on a regular basis to maintain softness of water. System regeneration should be noted on the boiler log. A regular supply of salt should be arranged by the entity as this is a major consumable in the production of softened water to be used in the facility for softener regeneration
- **De-Aerators:** Oxygen within the system may cause airlocks to occur thereby reducing the flow. It also allows the proliferation of bacteria combined with food sources within the water chemistry. Hence, in order to remove oxygen and other dissolved gases from both the boiler makeup water and the condensate return water, a deaerator is combined with the system to remove small quantities of air following system top up

6.1.7.4 Treatment Systems – Internal to the Boiler

Chemical additives and boiler blow down are used to control water chemistry inside the boiler. Trained water treatment personnel must choose chemical additives with care, based on e.g., steam system design, level, type of impurities in the water, end use of the steam. For instance, steam used for food processing and steam used in healthcare facilities for humidification have different regulations for allowable additives.

- **Chemical Additives:** Chemical additives address a variety of issues including, e.g., residual impurities in the water, residual oxygen levels and the pH levels. The OEM or Water Treatment Specialist should be consulted to ensure the chemicals used are efficient and cause no serious implication when added within the system. Operators should be aware of the dangers of the chemicals in use and copies of COSHH, MSDS, or Product Data Sheet (PDS) should always be available at the point of use or storage
- **Blow Down:** Blow down is used to eliminate sludge that has formed and to reduce the concentration of impurities in the boiler. The water quantity and type of blow down (continuous vs. intermittent) is dependent on the individual situation including, e.g., water quality, water treatment program, boiler pressure, and makeup water quantities. Blow down should be a part of water treatment equipment control so that chemical injection is inhibited during periods of blow down

6.1.8 Potable/Domestic Water Treatment Systems

The process used in the Domestic Water Treatment System includes the following:

- Physical processes (e.g., settling, sedimentation, filtration)
- Chemical processes (e.g., cleaning, disinfection)
- Biological processes (e.g., sand filtration, carbon filtration)

Such plants are used to remove particles and organisms that lead to diseases, thereby protecting the public welfare and supply pure drinkable water to the people. Drinking water quality should be maintained to the measures including taste, sight, and smell.

6.1.8.1 Disinfection Method

A small amount of chlorine is added, or some other disinfection method is used to kill any bacteria or microorganisms that may be present in the water. Periodic testing should take place to ensure levels of chlorine are maintained within the system. This may be undertaken by a simple comparator device by building technicians. In case of any systems modification or refreshment, a flushing and disinfection process should be carried out based on the recommendations from water treatment specialist contractors.

6.1.8.2 Water Storage

Domestic water is stored in a closed tank or reservoir and water treatment (disinfection) takes place across the circulation of water through automatic dosing systems. The water then flows through pipes to healthcare and business units in the community.

In healthcare facilities, many types of tanks are used, based on building the requirements and application of water being used. The main examples are Reinforced Cement Concrete (RCC)/Concrete tanks, polygon tanks, Glass Reinforced Epoxy (GRE), Fiber Glass Reinforced Plastic (FRP), GRP, GRV and other types of tanks. Most likely all the tanks are available in basement or roof top of the building.

Water is stored in healthcare facilities for the following reasons:

- To provide backflow protection to the utility supply
- To provide a reserve supply during disruption of the incoming cold-water supply (this encompasses water quality as well as water quantity issues)
- To reduce the maximum demand for cold water supply
- To reduce the pressure from the distribution system
- Medical treatment purpose (dialysis, CSSD and others)

It is very important to keep tanks clean, super chlorinated periodically and disinfected since domestic water may be used for various applications within the healthcare facility. As part of the regular operations and maintenance, domestic water tanks should be cleaned at six (6) months intervals (check local requirements). Supply water networks should be disinfected, chlorinated or super chlorinated following any tank maintenance or internal cleaning.

Domestic water systems that are fed from a storage tank can, if not correctly maintained and cleaned, cause a risk of Legionnaires' disease. The possible reasons include, but not limited to:

- Temperature is within the growth window for bacteria (20-60^{o}C)
- Systems are open to the atmosphere at outlets
- Aerosols may be produced
- Water can stagnate through irregular use or inadequate turnover
- Presence of materials used for construction, modifications, and system design, e.g., dead legs

It is, therefore, of paramount importance to take following corrective measures:

- Operate at correct temperature, e.g., cold water below 20^{0}C and hot water above 60^{0}C (since legionella will grow at temperatures up to 60^{0}C)
- Pay careful attention to design and materials of construction
- Maintain clean conditions
- Monitor BMS system for site conditions
- Monitor water level indicators to ensure tanks are maintained within optimal range

6.1.8.3 Operation Management

The maintenance regime should be thorough for both tanks fed hot and cold water to the systems. All the relevant procedures should be followed from the manual. Further information related to maintenance activities associated with these systems may be found in the National Manual of Assets and Facilities Maintenance Volume 6.

Daily

- Sentinel Point checks (temperature monitoring)
- Flush all outlets in areas of low usage for at least two minutes

Weekly

- Visual inspection of water tank for, e.g., overflow, unusual noises, rectify if possible, and log as required
- Check identify and record sentinel points in the facilities and measure the tap water temperatures. These should be below 20^{0} C after running the water outlet for 2 minutes
- Check the monthly automatic chlorine dosing system e.g., calibration, circulation of chemical, pump stroke rate, chemical additives levels, chemical quantities availability, and other parameters that may be prescribed

6.1.9 Filtration System (UV System)

In healthcare sectors, filtration and UV systems play an important role and their maintenance is very important to preserve and maintain the water quality. On a monthly basis, it is imperative to maintain the filtration and UV system by having a Water Treatment Specialist Company do the servicing. UV systems are able to remove 99% of bacteria from the water. Even with this performance, ultraviolet disinfection has following limitations:

- **"Point" Disinfection:** UV units/lamps can kill bacteria at single point in watering system and will not provide any continuous disinfection effect to downstream in case of a single bacteria passing through unharmed (100% of killing bacteria can't be guaranteed)
- **Cells Not Removed:** In UV systems, bacteria are not removed but are converted into pyrogens. The killed microorganisms and any other contaminants in the water are a food source for any bacteria that survive downstream of the UV system. Which is why the UV piping in water systems are periodically disinfected with chemical disinfectants

6.1.10 Neutralization Plant/pH Neutralization Water Treatment Systems

Chemical pH neutralization is process of balancing the excess acid or alkaline in the water. Furthermore, flow balance is the process of controlling velocity and flow compositions. Practically, chemical neutralization is achieved by balancing of the pH level to achieve the acceptable treatment level.

Neutralization is achieved through the addition of an acid and a base chemical. Dependent upon acceptable pH limit & requirements, most of the effluents can be neutralized at a pH range of 6 to 9 prior to discharge from the main discharge to municipal system, from the healthcare facility.

6.1.10.1 Fundamentals of Neutralization Plant

In a healthcare facility, since the neutralization plant plays a vital role in the operations, it is of extreme importance to have a maintenance schedule for the plant. Water Treatment Specialists should be appointed to maintain the plant on a monthly basis and provide any emergency response. On-site operations must be done by the healthcare FM service provider, FOM or the engineering team FMC following training.

6.1.10.2 Post Water Treatment

After the water softening process, it is commonly required to check the pH value of alkaline streams as the chemicals in use for pre-treatment can modify pH levels. Therefore, a requirement for the post treatment is necessary for efficiency of the neutralization plant.

6.1.11 Gray Water Treatment System

Gray water recycling system is a technology used to collect the water already used for other activities, clean and plumb it back for reuse. Gray water includes water used for bathing, wash basin and washing clothes but excludes sewage. The uses include water for laundry and toilet flushing, and irrigation of plants. Treated gray water can be used to irrigate both food and non-food producing plants. The nutrients in the gray water (e.g., phosphorus and nitrogen) provide an excellent food source for the plants.

The major benefits of gray water use are:

- The need for fresh water is reduced, saving on freshwater supply and use can significantly reduce healthcare water bills, and has a broader benefit in reducing demands on public water supply
- The amount of wastewater entering sewers or on-site treatment systems is reduced. It is recommended that each municipal department uses its own (municipal waste of neutralization treatment plant) rather than sharing gray water with other healthcare waste. This avoids potential conflicts and increases confidence in the quality of the gray water system

6.1.12 Sewage Treatment Plant (STP)

Sewage treatment is a method for segregating sludge and wastewater with help of a chemical, physical and biological process, thereby removing the contamination with the help of a biological process to produce treated water. The sewage treated water can be used for irrigation, toilet flushing and industrial equipment washing.

In healthcare, a STP is used based on the area of occupancy and will be sized to undertake the expected throughput, volume generated. Since most large healthcare facilities have STP systems, maintaining the STP becomes very important. Operations management of the STP should be carried out as per OEM recommendations and water quality should be maintained as per specified design parameters. Monthly services are recommended to maintain a healthy system in accordance with latest HTM standards. There may also be statutory requirements to be adhered which are confirmed by the facility owner. All operatives who come into contact should undergo periodic medical checks, vaccination and it is advisable that they are inoculated against common diseases generated from human waste and effluent.

6.1.13 Microbiological Growth Monitoring and Control Measures

Provided good chemical control parameters are maintained in the systems, the normal sampling frequency is monthly. If there has been deterioration in water quality, more frequent sampling may be required. Heavily used systems, or systems used by people at greater risk of infection, may also be sampled more frequently than monthly. If ill health has been associated with the system, samples for suspected pathogens should be collected. Procedures for outbreaks/contamination should be in place to respond to undesirable bacterial results.

6.1.14 Arrangements for Managing Legionella Risk Assessment Plan

The water systems may propose a serious human health risk because of bacterial effects if left unmonitored and poorly maintained. Therefore, it is the prime responsibility of FOM to perform regular maintenance of these systems in order to reduce the bacteria prevalence and ensure that effective measures are applied. These measures must be recorded in a file held on-site.

Legionella Pnuemophila is a type of bacterium found naturally in freshwater environments, such as lakes, rivers and streams. It may become a serious health concern if this bacterium type spreads in man-made Water Systems including, but not limited to:

- Large plumbing systems and pipeline networks
- Cooling towers and associated basins
- Cold and hot water tanks and heaters
- Showerheads, hand sprays and sink faucets
- Decorative fountains and water features and fountains
- Life safety systems, such as sprinklers where water may have become stagnant
- Cooling tower water vapors or mist

Therefore, the healthcare facility should provide a management function for monitoring and control of water systems and associated plant. An example structure is shown below:

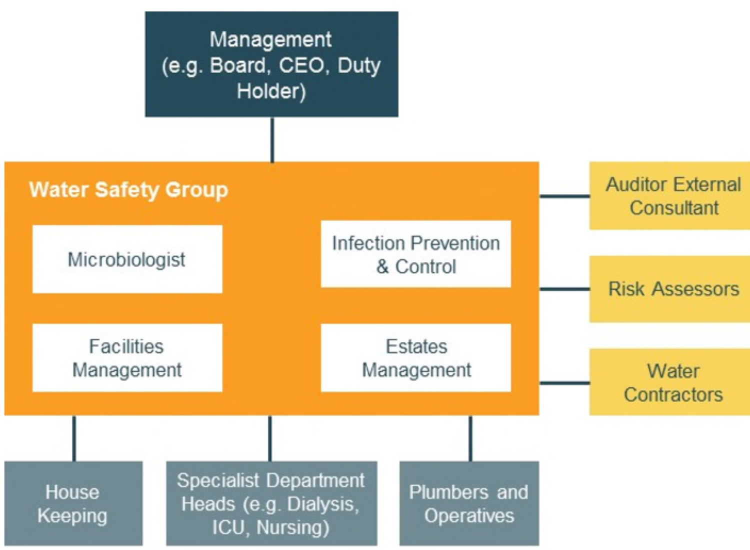

Figure 1: Organization Structure for the Duty Holder

6.1.14.1 Legionella Growth Factors

Healthcare facilities, such as treatment rooms, clinics, laboratories, patient wards and nursing homes, usually serve large number of people who are at the highest risk for Legionnaires' disease. These include older people, and those who have certain risk factors, predominantly a weakened immune system emanating from pre-existing conditions and associated respiratory problems.

Opportunistic microorganisms present in the plumbing premise grow well in drinking Water Distribution Systems and can diseases in humans. Examples of these include Pseudomonas, Acinetobacter, Burkholderia, Stenotrophomonas, Non-Tuberculous Mycobacteria, Naegleria Fowleri and various species of fungi and other microorganisms. Many of the environmental factors that are conductive for Legionella growth allow growth of other opportunistic pathogens as well.

Factors promoting Legionella growth within the healthcare facility water systems include, but not limited to:

- **Changes in Water Pressure:** Changes in water pressure due to vibrations and other factors may remove biofilms and release legionella bacteria along with other associated microorganisms. Biofilm is a slimy layer in pipes on which microorganisms thrive as a ready food source, which allows these pathogens a safe harbor from disinfectants. Therefore, significant changes are made to existing systems where the installation of new services is done through a regime of cleaning, flushing and disinfection. For further guidance, refer to BSRIA Guide to Commissioning Water Systems – BG2 (2010)
- **Water Main Breaks:** Water Main Breaks can introduce dirt and other materials into the water that consume all the available disinfectant
- **Variations in Water Quality:** Variations in the Water Quality may increase sediments, lower disinfectant levels, lower chemical additives, increase turbidity and/or push pH levels outside the recommended range. In addition to this, the supplier may change the disinfectant chemicals or additives concentration, which can impact the water management programs and building operations of water networks
  It is the responsibility of Operations Team (FOM) to monitor the changes and act accordingly. During the period of outage where the water is obtained from external temporary sources, the same quality levels and testing must be applied to prevent contamination of the existing distribution system

6.1.14.2 Water Management Plan (WMP)

WMP helps in avoiding dangerous/hazardous conditions and reduction of Legionella growth and other related microorganisms in the building water networks. Developing and maintaining a WMP is a multi-step process that requires continuous review and regular update, in particular, following modification/refurbishment.

There are eight key activities that are routinely performed in Legionella WMP:

- Establish a WMP for the team
- WMP provides building water networks schematic flow diagram and explains flow of water in the building's system
- WMP helps to identify the sentinel points for possible legionella growth in stagnant water
- WMP controls and monitors the legionella growth in water networks
- WMP ensures that prescribed control limits are met and achieved as recommended by the OEM
- Ensure that the designed and programmed WMP is effective to the healthcare facility
- Document and communicate all the activities through a dedicated water systems logbook and retain records
- Appoint a Responsible Person to oversee

Generally, the fundamentals of productive WMP are following:

- Maintain water temperatures outside the Legionella ideal growth range (Min 20°C – Max 60°C)
- Prevent water stagnation and ensuring adequate disinfection
- Maintain building area plumbing, plants, machinery, equipment, and other related fixtures. Thereby protecting them from scale, corrosion, algae and biofilm growth that may provide favorable conditions for legionella growth
- Operations Team (FOM) and Water Management Team to work together for identifying and reducing the legionella and other microorganism's growth

- Conduct routine checks of control measures to keep an eye on areas at risk. Take immediate action, if a problem is found or suspected within the water
- After implementation of WMP, monitor key areas on regular basis for potentially dangerous conditions
- Programs should include predetermined responses to correct hazardous conditions

The FOM team will require a brief that is in line with all the requirements of the WSP and approved by the WSG, which will include amongst others:

- The scope of work
- Reporting procedure
- Accountability and responsibility
- Level of responsibility
- Competency and certification
- Response time required to correct faults
- Emergency response actions and plans
- Criteria for quality of service, works and equipment
- Energy-saving policy
- SOP and registered logbooks
- Mitigation plans
- Licenses for specialist access equipment and vehicles
- Incident/Root cause analysis reports

FOM teams are to enter all the information needed to input and track equipment in the healthcare facilities management department's Computerized Maintenance Management System (CMMS).

The following process, business rules, and information requirements apply for the purpose of identification and tracking of the pipework and equipment:

- Barcode tag number
- Equipment nomenclature
- Equipment serial number
- Manufacturer
- Model
- Serial number (if available)
- Building name
- Room number
- Recommended planned maintenance procedures and frequencies (e.g., monthly, quarterly, semi-annually or annually)
- Dedicated checklist
- Parts requirements for SOPs

Special conditions for access or unusual tools needed, should be noted in the comments.

6.1.14.3 Legionella Analysis Parameters

Within the healthcare sector, microbiological testing should be done once a month by sampling on Cooling Towers, Make Up Water, Blow Down Water, Basin Water as well as on the Closed Loop Systems. Below are few of the water testing parameters for Legionella are:

- Legionella Species
- Legionella Pnuemophila Sero Group 1
- Legionella Pnuemophila Sero Group 2-14

Legionella analysis will be conducted in a local laboratory that is approved and accredited for the purpose of water analysis. The department responsible for any relevant system should ensure that the arrangements to which this policy refers are implemented. Facility engineering staff (FOM) must ensure that samples are taken at prescribed intervals and dispatched to the laboratory immediately after being taken as delays can produce incorrect results.

- Engineering teams (FOM) shall be responsible for hot and cold water storage and distribution systems, forming part of the service infrastructure of a building up to the fixed outlet of the supply. For example, a fixed tap or showerhead
- All healthcare facility departments shall be responsible for water systems forming part of their operational equipment whether it is connected to the building supply. Systems to be considered as follows:
    - Use water stored within the system, either in a tank or in a pipework which is not drained down at the end of each use – systems such as CSSD RO, dialysis RO and surgical equipment cleaning or washing equipment
    - Have a temperature of water exceeding 20°C but less than 60°C; Therefore, there is a likelihood of microbial growth
    - Are not completely enclosed due to which there may be a potential for the release of aerosol

Note: Systems utilizing building supplied water and releasing it directly to the drain do not require treatment unless this water is later used for the irrigation or other purpose where it may come into direct contact with patients, staff or visitors. In the case of water from a neutralization plant, or any other medically sourced water that cannot be discharged directly to the municipal drain, discharging of such water should be treated prior to disposal, or separate arrangements made for collection and disposal.

6.1.14.4 Control and Monitoring of Legionella

Risk assessment is required for different types of water systems which are exposed to the Legionella bacteria. The risk assessment shall be in written form that has to be periodically reviewed by the Responsible Person and update following any changes or modifications in the facilities. In particular, the assessment should be reviewed every 2 years or more often at the discretion of the Responsible Person and whenever major changes are proposed to the system.

Legionella Risk Assessment Plan (LRAP) controls and measures if any modifications/refurbishment are required for the systems to ensure the safe operations. Its helps to identify/monitor the quality parameters within the water networks.

Identified areas of concern from a risk assessment generally fall under the following categories:

- Category 1 – Action to be taken within 1 x month, or immediately, depending on severity
- Category 2 – Action to be taken within 3 x months of the date of audit
- Category 3 – Action to be completed prior to annual audit review

Following types of water systems must have a RAP developed for them since these are considered to present a risk of legionella bacteria:

- Water systems incorporating a cooling tower
- Water systems incorporating an evaporative condenser or cooling towers system
- Hot and cold water systems
- Other plant and systems containing water that is likely to exceed 20°C but less than 60°C, and which may release a spray or aerosol during operation or when being maintained

The assessment should also account for the following:

- Potential for droplet formation (shower heads, basin taps and hand spray with spray outlets, fountains and water features)
- Water temperature
- Risk involved to those who will inhale water droplets
- Means preventing or controlling the risk

The Entity/Organization associated with the systems shall assign a Responsible Person and appoint Specialist Contractor to ensure that the assigned tasks are carried out regularly and as recommended by the OEM. The risk assessment plan includes the schematic drawings of each system to which it relates.

6.1.15 Mandatory Controls, Parameters and Limits

6.1.15.1 Wet Cooling Towers

The assigned Responsible Person shall carry out regular inspection and maintain the records as follows:

- Check halogen levels (3 times per week)
- Take a weekly dip-slide of the condensing water
- Record the results of the above checks in the tower logbook
- Forward these results in a specified format to the Responsible Person on a weekly basis to enable monitoring checks and carry out any follow up actions
- Record the maintenance repair works carried out on the cooling towers and update activities to the responsible person, or specialist water treatment supplier
- Check and monitor scale and corrosion through the use corrosion coupons
- Check and monitor water quality parameters daily. Additional checks may be required if parameters are found out of specification

The Responsible Person shall monitor the above and organize a water treatment contract for the following;

- Supply of chemicals
- On-site available chemicals minimum quantities
- Water analysis
- Microbial growth checks
- Regular cooling tower basin cleaning and others
- Compliance with local body regulations and updating the training records
- Daily, weekly and monthly CT water treatment systems services reports

6.1.15.2 Reduction in Energy Consumption

Side stream filtration reduces the likelihood of scale and fouling on the heat exchangers. Even the smallest layer of scale or fouling on heat exchange surfaces can reduce the rate of heat exchange, forcing the system to work harder to achieve the required cooling. Therefore, the addition of side stream filtration can assist with maintaining water quality and reduce utility consumption.

6.1.15.3 Reduction in Chemical Use

Side stream filtration systems is process of removing suspended particles, it needs additional treatment such as coagulation, dispersants, flocculation and biocide treatments. OEM should be contracted to maintain the SSF (side stream filtration) system for regular and emergency servicing. SSF should always be in a running condition, and as and when required, maintenance should be carried out as per recommendations from OEM.

6.1.15.4 Corrosion Monitoring

A dedicated system of monitoring the internal condition of water systems may be used. Typically, this could be through the corrosion coupons installed within the system to monitor the rate of corrosion evidenced. These will generally be measured and reported by the Water Treatment specialist, following maintenance visits.

6.1.15.5 Health, Safety, Security & Environment (HSSE)

The equipment used by staff engaged in water systems and water treatment should be competent for the operations of these systems. Various chemicals and compounds are used within these systems that have an inherent risk to personnel welfare. Therefore, the associated Material Safety Data Sheet (MSDS) or COSHH data sheet or PDS should always be consulted prior to use. These compounds predominantly are corrosive by nature and any small spills should be cleared at the earliest opportunity. Personal Protective Equipment (PPE) are also highlighted for the chemicals usage and handling and compounds in use, these will be detailed within the MSDS and are mandatory for all personnel.

6.2 Fire Protection Systems

Fire and Life Safety systems are the principal use of water systems within a facility. Monitoring and controls associated with the supply to these systems remains under the control and monitoring of the Entity technical team. Further information on the operations of these systems can be found in the associated section of the National Manual of Assets and Facilities Management – Volume 5 Chapter 10 Life Safety Systems.

6.3 Heating, Ventilation and Air Conditioning (HVAC) Systems

HVAC systems are the principal use of water systems for heating and cooling of the indoor environment. As per site specific requirements to be adopted. Monitoring and controls associated with the water supply to these systems remain under the control and monitoring of the Entity Technical Team. As an energy saving initiative, HVAC systems thermostats and controls should be switched off when areas are not in use. Further information on the operations of these systems can be found in the associated section of the National Manual of Assets and Facilities Management – Volume 5 Chapter 4 HVAC Systems.

6.4 Plumbing Systems

Plumbing constitutes a system of pipes and fixtures installed in a healthcare facility for the distribution and use of potable water (cold and hot) and the removal of waterborne wastes.

Plumbing systems in healthcare facilities may consist of underground tanks which are supplied with water via healthcare or water department distribution supply lines. A piped distribution system is utilized to transport the water throughout the facility. Water may be distributed to overhead, basement, or outside healthcare storage area tanks. Therefore, for overhead tanks the use of gravity ensures that the water reaches the healthcare water outlets. Boosted systems may also be employed as an alternative and building owners FOC/operators FOM should confirm with the designers the method in use.

The overhead and basement tanks can be eliminated if water is distributed directly from the underground tank to kitchen and toilet outlets. There comes the need for pumps which can give uninterrupted supply of water with the required pressure to the outlets so that when one opens the tap, the user gets a continuous supply of water. Such pumps are called Hydro-Pneumatic/Circulation/Booster pumps.

The advantage of such a plumbing system eliminates the need of overhead tanks in the buildings. Furthermore, these pumps are designed to get the required equal pressure to all floors, unlike traditional methods of installation where water flows from underground tanks to overhead tanks. Because of which the upper floors receive water at reduced pressure, whereupon the lower & ground floors receive water at high pressure due to gravity and greater height requiring pipe systems with greater pressure rating. Additionally, this system also results in energy savings as the pumps are controlled to operate during periods of demand.

The use of Boosted Water Pumps may provide the advantage of achieving energy savings. By eliminating the requirement for the supply of water to floors above theoretical lift height to the upper floors for overhead tanks used with gravity fed systems, using large pumps. Continuous power supply backed up by generators may also be required to operate this system efficiently as lack of power to the pumps would leave only reserve holding within tanks for distribution for a limited duration. These systems and back up facilities should be checked periodically by the Engineering Team FOM so that clinical services are maintained to a high degree of availability.

6.4.1 Types of Plumbing Systems

- Domestic hot water and cold water piping
- Sanitary waste and vent piping
- Water treatment piping
- Storm and secondary (emergency) storm drainage piping
- Irrigation Piping systems
- Fire line piping systems

6.4.1.1 Domestic Hot Water and Cold Water Piping

Domestic hot & cold water piping in healthcare buildings will have hot water heaters, boiler systems, or other types of heating systems to provide hot and cold water services to the healthcare facility.

In healthcare facilities, pipes for both hot and cold water should be well-maintained in accordance with monthly, quarterly, half-yearly and yearly inspection if required. Based on the types and life cycle of pipes, leakage detection test shall be carried out at least once a year. During the leakage identification, any leakages found need to be rectified immediately without interrupting the facility operations. After the completion of leak rectifications, the entire water network should be disinfected and chlorinated with the help of the Water Treatment Company recommendations that are based on the size and system volume of both hot water and cold water distribution lines.

In healthcare, the supply line cold water should be closely monitored for water temperatures. There is generally a dual supply of cold and hot water as per the requirements from each department in the facility.

6.4.1.2 Sanitary Waste & Vent Piping

Sanitary waste piping carries wastewater and matter from a structure. Vent pipes are parts of sanitary waste systems and vent gas should be released outdoors. In healthcare, breakage or leakage of the sanitary waste pipe needs to be identified and rectified by the FOM. An annual inspection for Planned Maintenance (PM) and checking should be undertaken.

Wastewater and sewage water discharging into the sanitary drainage system shall have a temperature of 60°C or less. When higher temperatures exist, an approved cooling method or a separate drainage line shall be provided using heat resistant or thermal piping. Building sanitary waste that cannot discharge by gravity shall be made to discharge into a tightly covered and vented sewage ejector from which the effluent shall be lifted and discharged into the gravity sanitary system by automatic pumping equipment and components. Connections and changes in direction shall be designed with drainage fittings. The fittings shall not have interior ledges, shoulders, or reductions capable of retarding or obstructing flow.

6.4.1.3 Water Treatment Piping

There are many types of pipes available for water treatment. In healthcare; MS, HDPE, UPVC, HD and galvanized pipes are used based on the application of the system and the purpose of usage. As a part of maintenance regime, the sewage, neutralization plant pipes, and kitchen pipes must be inspected through a CCTV camera to identify any blockages as per the annual PM regime. It is the responsibility of the facility plumber to inspect as part of the operations management.

6.4.1.4 Storm and Secondary (Emergency) Storm Drainage Piping

Storm water in healthcare facilities, internal roads, parking lots, garden areas development space, commercial or industrial developments have various components that make up a storm sewer system. These components consist of:

- Conveyance pipes
- Catch basins
- Manholes
- Roadside ditches

- Storm water facilities (e.g., dry wells, bioswales, detention ponds, wet ponds, oil/water separators),
- Landscaping (both hardscape and soft cape)
- Any other structure that collects, conveys, controls, and/or treats storm water

Regardless of the components, all storm sewer systems eventually discharge into 'waters of the state' which are streams, rivers, lakes, wetlands, and groundwater. Therefore, they should not be connected to any system that may cause contamination or environmental impact.
Fuel interceptors must be serviced and maintained to prevent any cross contamination.

The disposal of facility storm water is an approved third party process for area disposal. Roofs, paved areas, and courtyards shall be drained into the public storm system or an approved place of disposal. It should be inspected yearly and there should be a maintenance plan for the storm water pipes.

Work inside underground structures requires special Occupational Safety and Health Administration (OSHA) – Required Confined Space Equipment and Procedures (Refer to National Manual of Assets and Facilities Management Volume 10 – HSSE).

6.4.1.5 Irrigation Piping System

Irrigation pipes/tubes in between the zone control valves and sprinkler head or expansion are called "laterals". Lateral pipes/tubes are not pressurized unless valve is open, and the irrigation sprinklers are in operation. In healthcare facilities, there are many areas that use irrigation pipes e.g., in gardens and sprinkler systems.

Irrigation system pipes should be maintained as per the requirements of plumbing services and design specifications of the systems. Healthcare areas should have weekly, monthly, half yearly, and yearly maintenance plan for the pipes inspection, checking and system blockage.

As specified in water treatment section, the pipes should be maintained as per water quality and site-specific requirements for plant. PM should be implemented to maintain the pipes of the irrigation system.

Sprinkler irrigation is a method of supply irrigation water like natural rainfall. Water is distributed through a system of pipes, usually by use of a medium pressure pump. It is sprayed into the air through sprinklers into small water drops which descend to the ground. The water pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. Considerations must be taken for the effect of the sprinklers in the public domain and should be documented in the WMP as this is a recognized source of water droplet which may carry legionella bacteria due to water stagnation.

Added Benefits of Irrigation Piping System

- Irrigation pipes has a lower water consumption rate than flood irrigation system
- Is highly adaptable to rough terrain, with large differences in elevation at the surface
- Allows dosing of the water with good accuracy as and when required
- Distribution depends on the wind, material, seasons although at low wind speeds, it is very homogeneous
- Can also be used for application of frost irrigation and application of phytohormones. Chance of water droplets may be a danger to public in gardens, children's play areas and other areas within the facility
- Corroded, damaged pipes may cause leakages within irrigation systems, which may lead to water contamination of the water source and areas from backflow from the system. Therefore, preventers should be fitted in supply lines to prevent this

6.4.1.6 Fire Line Piping System:

Fire and Life Safety systems are the principal use of water systems within a facility. Monitoring and controls associated with the supply to these systems is the responsibility of the Entity Technical Team (FOM). Risers and mechanical cabinets should be inspected regularly as water in fire safety systems tends to remain static for long periods which may lead to corrosion and scale within the system.

Please refer to National Manual of Assets and Facilities Management Chapter 5.10 for further information and guidance on Fire Suppression Systems: Sprinkler systems, Pre action systems, Dry Riser & Wet Riser.

6.4.1.7 Drainage Systems

The drainage system shall be closed with sealed floor drains and valve connections to equipment when not in use.

- Floor drains shall have a minimum seal of 65 mm deeper than the negative difference in air pressure
- Floor drains shall be filled with a disinfectant solution when not used to eliminate the possibility of spreading organisms between different areas served by the same connected sections of the piping system
- Drainage pipe material shall be based on the expected chemical composition of the effluent and the sterilization method
- Treated discharge from a containment system shall be piped separate from the sanitary piping until it reaches the exterior of the facility. Prior to connecting it to the sanitary drainage system, the treated discharge shall be provided with a monitoring system and sampling port

6.4.1.8 Waste Systems

Infectious and biological wastes have the same basic characteristics as other types of laboratory and production facility wastes but with the addition of bio-hazardous materials. Bio-hazardous material is suspended in the waste stream with live organisms that, if not contained, have the potential to cause infection and other diseases.

Bio-hazardous waste may be discharged from many sources including, but not limited to:

- Fermentation tanks and associated equipment
- Process centrifuges
- Sinks, both hands washing and other processes
- Containment area floor drains
- Janitor closet drains
- Necropsy table drains
- Autoclave drains
- Contaminated condensate drains
- Containment design shall conform to acceptable and appropriate containment practices based
- On the hazard potential

Biosafety Waste Level Classification

The biological containment classification consists of four different bio-safety levels, listed below:

- **Biosafety Level 1 (BSL1) Containment:** This is a typical biological research facility classification for work with low hazard agents:
  - Viable microorganisms not known to cause disease in healthy adults. Their standard features consist of easily cleaned, impervious bench surfaces and hand wash sinks
  - Contaminated liquid and solid waste shall be treated to remove biological hazards before disposal
- **Biosafety Level 2 (BSL2) Containment:** This level is like biosafety level 1 except the microorganisms may pose some risk:
  - Equipment and work surfaces shall be wiped down with a suitable disinfectant
  - All liquid wastes shall be immediately decontaminated by mixing with a suitable disinfectant
- **Biosafety Level 3 (BSL3) Containment:** Involves organisms posing a significant risk or represents a potentially serious threat to health and safety:
  - Liquid waste is kept within the space or facility and steam sterilization is done prior to discharge or disposal
  - A hand washing sink routed to sterilization shall be located adjacent to the facility. Vents from plumbing fixtures shall be filtered

- **Biosafety Level 4 (BSL4) Containment:** Activities in healthcare facility require a very high level of containment:
  - The organisms present have life threatening potential and may initiate a serious epidemic disease.
  - All BSL3 requirements apply plus showers shall be provided for personnel at the air lock where clothes are changed upon entry and exit
  - A bio-waste treatment system shall be provided within a facility to sterilize liquid waste. Liquid waste decontamination system shall be provided to collect and sterilize decontaminants in liquid waste

6.4.1.9 Laboratory Systems

Laboratory Neutralization Tank

Neutralization tanks are used to collect the laboratory corrosive waste from healthcare treatment rooms and operation theaters. These assist in maintaining the pH levels of the waste following dilution by a complimentary chemical to neutralize. Treated effluent can then be discharged from the facility drain to the municipal sewage. Compliant with local body regulations and guidelines imposed. The size of tanks is designed based on laboratory requirements.

Acid neutralization tanks are usually located in the basement of the healthcare facilities buildings. Waste from the labs and preparation rooms is directed into these tanks. They are filled with marble chips and the waste flows through the chips. Along with neutralization, tanks for water treatment are also connected to the same tank. For more details, please refer water treatment plants for neutralization described earlier.

Laboratory Compressed Air System

Compressed air is an important medium for transferring energy in certain laboratory processes. Compressed air is used for power tools such as air hammers, drills, wrenches and other equipment that may be used in surgical processes.

Laboratory Nitrogen System

The nitrogen is normally supplied via a form or cryogenic storage called a Vacuum Insulated Evaporator (VIE). This is normally serviced by the Nitrogen Gas Supply Company. As part of the system, there are also various safety valves in case of insulation loss (loss of vacuum), and safety pressure relief valves. There is also a large evaporator (along with a liquid detection shut off valve) which is designed to prevent liquid nitrogen entering the nitrogen gas system and ensure that the nitrogen is supplied at a temperature above dew point; to prevent pipework “sweating”. In some laboratories, the liquid nitrogen is piped into the laboratory area as a liquid via a vacuum insulated line, which needs regular maintenance of the auto degassing heads along its length. Depleted oxygen detectors are installed and should be checked as part of regular maintenance.

Laboratory Piping and Appurtenances

All installations should be installed to the current standards of the OEM. All changes are to be recorded in installed systems documentation and should be regularly updated. Maintenance and installation should only be undertaken by qualified/certified or installers/maintainers. It is imperative that any new services are not attached to obstruct these services. As in the event of an issue, it will be more difficult to carry out a repair on a piece of service pipework.

The laboratory gas services are piped as a group together i.e. medical air, surgical air, nitrous oxide, oxygen, carbon dioxide, and vacuum. The installed water services are generally grouped together and individually insulated. All these services should be able to be reached independently, to avoid shutting down of whole pipework groups.

6.4.2 Plumbing Equipment

6.4.2.1 Water Softener

In healthcare, water treatment plays an important role for domestic water supply from municipality or ground water, or other sources of water. After softening of water this water is used in all areas of the healthcare facilities e.g. CSSD, STP dialysis, transplantation, laundry areas. The softening system needs regeneration after regular intervals which will be automatically taken care of through a set of control valves. The regeneration (back washing) steps are programmed in the controller. Softening is attained by the replacement of hard ions with sodium ions (which have no scaling capacity) by means of ion exchanger (resin). After ion exchanger has finished its exchange capacity, it regenerates automatically. This is achieved by having a solution of sodium chloride percolate through the mass of resin. Daily and weekly checks should be undertaken by the healthcare technical team (FOM). Maintenance activities would normally be undertaken by a specialist contractor for water softeners and basic training should be provided to the facility certified plumber.

6.4.2.2 Water Heaters

Appliances that provide a continual supply of hot water are called water heaters, hot water heaters, hot water tanks, boilers, heat exchangers, geysers, or calorifiers. The name of water heaters varies region by region. Whether these water heaters are for potable or non-potable water usage, their CSSD, dialysis, domestic or industrial applications are based on energy sources.

Types of Water Heaters

- Instantaneous water heater
- Plate heat exchangers
- Storage calorifiers
- Limited storage calorifiers

There should be adequate access to heaters and calorifiers for PM inspection and cleaning, removal and replacement of the tube bundles and the entire calorifier. All calorifiers and water heaters must be fitted with a drain valve located in an accessible position at the lowest point on the vessel so that the accumulated sludge may be removed effectively from the lowest point. The drain point should be of enough diameter to empty the vessel within a reasonable time. Drain valves should be ball type to avoid clogging, and a drainage gully and discharge pipe of sufficient capacity to be provided to accommodate the volume of flow from the calorifiers drain.

Instantaneous Water Heaters

This type of heater can be further subdivided into:

- Instantaneous water heaters for single or multi-point outlets: these devices are usually either electrically or gas heated. The general principles and limitations of instantaneous water heaters are given in BS6700: 2006, BS EN 806-1-5: 2000-2012 and BS8558: 2011
- The hot water flow rate is limited and is dependent upon the heater's power rating. The water in instantaneous water heaters is usually heated to around 55°C at its lowest rate, and its temperature will rise and fall inversely to its flow rate. Close control of temperature is of particular importance for showers where user's protection is paramount importance. To attain constant temperatures on delivery, water flow and pressure must also be controlled
- This form of hot water heating should be considered only for smaller premises or where it is not economically viable to run a hot water circulation to a remote outlet

Instantaneous-Type Water Heaters for Distribution Systems

These devices which normally use steam or high/medium pressure hot water as the primary heating medium, are designed to heat their rated throughput of water rapidly from cold to the design outlet temperature. They can be used either to feed directly into a hot water distribution system or in conjunction with a storage vessel which reduces the load on the heater during periods of peak demand. This type of heater includes:

- **Hot Water Generators:** These are vertical instantaneous water heaters that contain modular helical primary coils normally served by steam, Medium Temperature Hot Water (MTHW) or High Temperature Hot Water (HTHW)

Plate Heat Exchangers

Plate heat exchangers consist of several rectangular plates sandwiched between two flat end plates and held together by tie bolts. Primary liquid is directed through alternate pairs of plates while the domestic hot water is normally fed in a counter flow direction through the remaining pairs of plates. This type of heat exchanger can be extended easily, or shortened, to suit changes in hot water demand.

Storage Calorifiers

Storage calorifiers are usually cylindrical vessels mounted either vertically or horizontally; the base of a vertical calorifiers should be convex, with the vessel being supported on its feet. Heater batteries are usually located near the bottom of the cylinder, which can give rise to an area containing water beneath the battery, which is significantly below the storage temperature. Pumps may be fitted within the installation to negate this effect. Galvanized cylinders are particularly susceptible to scale formation, which can also provide a source of nutrition and shelter for bacteria.

Limited Storage Calorifiers

These calorifiers can either have an independent heating facility such as oil or gas burners or electric elements or use primary water/steam from a boiler to heat the water via a heat exchanger. The equipment is available in a range of storage capacities and recovery flow rates. This type of equipment is particularly suitable where the systems are decentralized, and water heaters are required close to the point of use.

Solar Hot Water Heaters

Solar Water Heating is the conversion of sunlight into heat for water heating using a solar thermal collector. They use water only, or both water and a working fluid. They are heated directly or via light-concentrating mirrors and operate independently or as hybrids with electric or gas heaters.

There are generally five types of solar hot water systems:

- Thermosiphon Systems
- Direct-Circulation Systems
- Drain-Down Systems
- Indirect Water-Heating Systems
- Air Systems

Details of the above will be with the specialized applications and are not covered here.

6.4.2.3 Pumps

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps operate by some mechanism (typically reciprocating or rotary) and consume energy to perform mechanical work moving the fluid. In healthcare facility, several types of pumps are used for different applications such as CSSD, dialysis, domestic, sewage, storm water, irrigation, and hot and cold waters in high-rise buildings. The OE should refer to OEM for Operations and Maintenance manuals and requirements as per the systems application.

Types of Pumps

- Circulation Pumps

- Booster Pumps
- Sump pumps
- Chiller pumps
- Condenser pumps
- Fire pumps

For further information, refer to National Manual of Assets and Facilities Management Volume 5 Chapter 10 – Life Safety Systems.

6.4.2.4 Grease Trap Interceptors

These items should be fitted in areas where grease or contaminants are generated. On no account should these be discharged to the drainage network. When kitchen wastewater flows through a grease interceptor, the grease and oil rise to the surface level inside the trap using a system of baffles, plastic wall structures inside a grease interceptor that slows down and often control the flow of water. The captured Fats, Oils and Grease (FOG), fills the trap from the top down. A grease interceptor shall receive the drainage from fixtures and equipment, with grease-laden waste from food preparation areas. Grease trap interceptors receive waste from its associated components and its equipment which allows FOG to be discharged.

Entities should have a maintenance regime in place to keep the equipment in operation and must not be bypassed. Additionally, a collection service agreement for removal and disposal should be arranged. Grease trap interceptors are cleaned once in month. Based on the site specific requirements. The cleaning should be conducted by third party municipal approved and accredited company or supplier proficient in providing specialty services to healthcare facilities.

6.4.2.5 Sump Pit

Sump pit shall consist of a gasket waterproof cover with controls like those provided for a plumbing sump pump with the provisions for chemical treatment and sterilization. These are used to collect waste water from low lying areas.

6.4.2.6 Kill Tank Assembly

It consists of a duplex tank arrangement, allowing one batch to be decontaminated while the other is filling.

- Tank size shall be based on the facility type but common practice is for each tank to have the capacity to contain one day's effluent plus the chemicals used for decontamination
- A fully automatic control system shall be provided to ensure that chemicals are injected in correct amounts and for the required duration for deactivation of the bio-matter

6.4.2.7 Water Meter

Water meter is a measuring tool that measures the volume of water delivered to a property. Some water meters measure water in gallons while others measure in cubic feet or cubic meters (m^3). The water meter box will have a metal or plastic lid and may be marked as "Water Meter." In healthcare facilities, most of the domestic water networks line have water meters.

6.4.2.8 Pressure Gauges

Pressure gauge is an instrument for measuring and indicating the condition of a fluid (liquid or gas) that is specified by the force that the fluid would exert, when at rest on a unit area, such as pounds per square inch or newton's per square centimeter. Where possible the normal system pressure should be shown on or adjacent to the gauge. Common uses include zoning, where the normal operating range is shown in green, and the out-of-limits shown in red. Gauges may also be calibrated in dual measuring systems and the most commonly found is 'bar' as a unit of measure.

Materials

For water, oil and other non-corrosive fluid, brass spray type spare parts should be used, whereas for corrosive fluids, stainless should be used.

Pulsation

If pressures are expected of violent pulsation, high frequency oscillations or sudden shock occurrence, a snubber should be considered. Winters snubber incorporates a sintered porous 316 stainless steel snubbing element with a large surface area to ensure long-term effectiveness on most pressured media. Snubber is available in three viscosity classifications e.g., heavy oil, water and air. Brass, stainless steel can be specified depending on the media used.

Temperatures

The normal ambient temperature ranges are -40°C to 120°C (-40°F to 250°F) for dry gauges and -20°C to 65°C (-4°F to 150°F) for glycerin filled gauges. Process temperatures up to 400°C (752°F) can be monitored when a gauge is dry and appropriate external cooling is applied. In situations where the process temperature is extreme, utilizing a syphon and remote mounting the pressure gauge with a capillary and diaphragm seal are reasonable alternatives.

Vibration

Vibration can influence reading of pressure gauges. These areas should be avoided as much as possible. Vibration effects can be minimized using a dampening liquid such as glycerin or silicone. In case of high vibrations, flexible tube connections to diaphragm are preferable.

6.4.2.9 Thermostat

Thermostat is a device/equipment that measures the temperature up to certain limits. It works on the mechanism of solid thermal expansion of materials. A traditional thermostat has two pieces of different metals bolted together to form what is called a bimetallic strip (or bimetal strip). Strip is a barrier between electrical circuit which is connected to heating systems.

6.4.2.10 Back flow Preventers

Back flow preventers are the devices used in the potable water systems to prevent the return of water to the utility and avoid contamination. The systems may have received a secondary dose of chemicals which if allowed to enter the public network may cause health related issues. In water supply systems, water is normally maintained at a significant pressure to enable it to flow from the tap, shower, or any other fixture.

There are several types of backflow preventers, most commonly used include Pressure Vacuum Breaker (PVB), Reduced Pressure Zone (RPZ), and the Double Check Assembly (DCA). These are installed in the water systems next to the isolation valve.

6.4.2.11 Plumbing Fixtures

A plumbing fixture is an exchangeable device which can be connected to a plumbing system to deliver and drain and sewage water. Standard plumbing fixtures are individually tested so that the amount of liquid waste that can be discharged through their outlet orifices in each interval is measured.

In a healthcare facility, several types of plumbing fixtures are used. Commonly used items are listed below:

- Water Closets
- Bidet Floor Mounted
- Sink
- Bathtub
- Showers & Combinations
- Electric Water Coolers
- Urinals
- Lavatories

- Faucets

They are used in pipelines to protect equipment such as pumps, meters, control valves, steam traps, and regulators. Conical line strainers are used to protect fluid and gas handling equipment by removing the debris.

6.4.2.12 Valves

A valve is an item of equipment that controls the flow of liquid (gases, fluids, solids, foam or slurries) by opening and closing or partially open and close. In Entity facilities, there are several types of valves available. But the most common types in use are:

Types of valves

- Butterfly Valve
- Gate Valve
- Ball Valve
- Check Valve
- Plug Valve
- Balancing Valve
- Trap Seal Primer Valve

Trap Seal Primer Valve

Trap Seal Primer Valve is a device used to add water to traps. This is to maintain the vapor seal and stop vermin and insects from entering a facility from the sewer system. Trap primer mitigates this problem by injecting water, either directly or indirectly, into the trap to maintain the water seal indefinitely. Trap seals are a necessity in drains that are infrequently used.

6.4.2.13 Safety Equipment

Safety equipment are the apparatus which can provide initial treatment after an incident that may involve a hazardous chemical exposure or spillage in healthcare facilities. There are two types of safety equipment that can be used for such an incident and these are listed below:

- **Emergency Eyewash:** Emergency eyewash equipment is used to drench or flush the eyes with water when dust, irritants, or chemicals enter the eye. These devices are sometimes referred to as "eye wash fountains" in healthcare facilities found in most of the water treatment plant rooms, irrigation plant rooms, plumbing plant rooms and fire pump rooms. Maintenance of these are on monthly basis and an annual maintenance regime should also be implemented
- **Emergency Showers:** A safety shower is a unit designed to wash an individual's head and body which has encountered hazardous chemicals. Large volumes of water have to be utilized and the end user should remove the dangerous & contaminated chemical cloths upon completion. Eyewash stations are installed to flush the eye and face only whereas the emergency showers are used to wash the end-users head and body. These should not be used for eyewash, due to high pressure, it may cause an eye injury

6.5 Generators/Fuel Systems

A generator is a mechanical machine that converts one form of energy into another, especially mechanical energy into electrical energy, as a dynamo, or electrical energy into sound, as an acoustic generator. The healthcare sector is most likely to use different types of generators. Listed below are the most commonly used generators in these facilities.

6.5.1 <u>Diesel Generators</u>

A generator using an internal combustion engine as the power source is called a diesel generator. Diesel generators are generally designed to run at 1800 rpm (some will run at 1200 or 900 rpm, depending on application and site specific requirements). Diesel generators produce electricity by using diesel and converting the mechanical energy to electrical energy. The main parts of a diesel generator are listed below:

- Engine/Prime Mover
- Alternator
- Fuel system
- Voltage Regulator
- Cooling System
- Exhaust systems
- Lubrication system
- Battery charger
- Control panel
- Main assembly frame

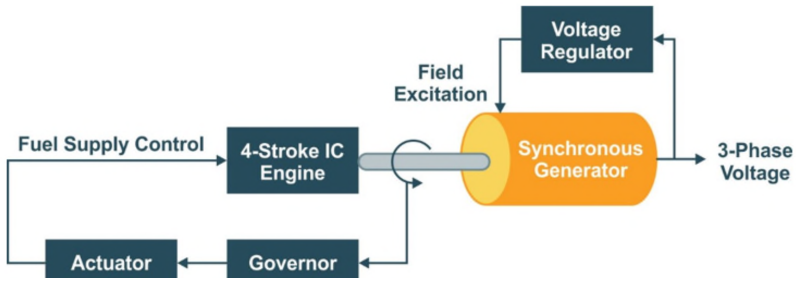

Figure 2: Diesel Generator Parts

In healthcare, generators are important, and these should be maintained on a monthly basis. There is a need to monitor the diesel level at regular intervals so that the system is readily available in the event of a utility outage. Below listed are some of the points for the maintenance team (FOM) to undertake during routine PM and periodic checks:

- Regular general inspection of generators. Generator inspection involves checking leakages, oiling and greasing, coolant levels checks, belt and hose inspection and battery terminals and electrical cables visual inspections
- It is important to inspect the oil as well, as it must be changed regularly. Oil change frequency depends on the OEM recommendations, how often the generator is used and the work environment

Generators should only be operated by trained, experienced and competent personnel who are familiar with the systems employed for cooling, air supply and exhaust and provision of fuel supply. The area must be checked prior to starting for safe operations. Where necessary, ventilation shutters must be opened, and exhaust flues checked prior to use.

The generator should only be connected to the electrical distribution system by personnel who are competent and authorized to carry out switching operations. As incorrect operation has the potential for inflicting serious injury or damage if done incorrectly.

Generator Maintenance Requirements

- Annual fuel tank cleaning and filtering, as diesel may degrade if left to stagnate without rotation. Where possible, fuel stocks should be rotated to prevent stagnation and build-up of microbiological growth and corrosion inside the tank
- Fuel storage should be in areas that are at a constant temperature to avoid moisture build-up.
- Tanks should be vented to the atmosphere
- The cooling system is to be maintained, which requires checking the coolant level at existing intervals. Coolant should be changed during the shutdown/maintenance periods

- Inspection of battery power for standby generators, this is main issue cause of failure. Make sure the batteries are robust and remain charged
- Where generator start systems utilize compressed air, the reservoir pressure must be checked to ensure that it remains standby. Check also for system leaks, which may be evidenced by 'icing' of the system pressure reducer

Further information of generators systems and electrical backup systems, Uninterrupted Power Supply (UPS) and other systems are contained in National Manual of Assets and Facilities Management Volume 5 Chapter 8.

6.5.2 Gas Turbine Generators

A gas turbine generator is an engine that produces electrical current similar to the process outlined above. The gas turbine is an alternative to the Diesel Generator and are generally designed for continuous running applications. The maintenance and operation of these systems should be undertaken by trained and competent personnel due to the increased speed of these engines and higher temperatures that they operate.

Gas turbine consists of a Low Pressure (LP) followed by a High Pressure (HP) rotary compressor; generally, there is also an intercooler between the LP and HP sections, to improve efficiency and energy density. The cooled compressed air is then fed into the axial or centrifugal combustion chamber with fuel (kerosene - AVCAT or JET-A1) and an ignition source. The turbine engine thrust, then provides the energy to rotate the exhaust turbines which are connected to the LP and HP inlet turbines (either directly, or through a planetary gearbox). The waste heat can be used to generate steam for site use, site steam supply or a steam turbine to generate additional electricity.

6.6 Medical Gas Pipeline Systems (MGPS)

6.6.1 MGPS Personnel Responsibilities

Role	Description
Executive Manager	Executive Manager is defined as the person with ultimate management responsibility including allocation of resources and the appointment of personnel for the organization in which the MGPS are installed
Estates/Operations Manager	The Estates/Operations Manager should have responsibility for the integrity of the MGPS. In a typical healthcare facility employing direct labor, this person are accountable for safe operation
Authorizing Engineer (MGPS)	This engineer should be suitably qualified in accordance with the requirements in Chapter 7 of the HTM 02-01. This person will have specialist knowledge of MGPS for which an Authorized Person (MGPS) will assume responsibility on appointment. He/she acts, and is employed, independently of organization submitting potential Authorized Persons (MGPS) for assessment
Authorized Person (MGPS)	The Authorized Person (MGPS) is defined as that person designated by the Executive Manager to be responsible for the day-to-day management of the MGPS at a particular site or sites. This includes the issue of permits in accordance with the PTW procedure. All Authorized Persons (MGPS) should be appointed in writing by Executive Manager on the recommendation of an Authorizing Engineer
Competent Person (MGPS)	The Competent Person (MGPS) is the person who carries out the installation and/or maintenance work on the MGPS. A list of his/her responsibilities and duties is set out in HTM 02-01 paragraph 6.92. The Competent Person (MGPS) should have received appropriate training and should be on a list of Competent Persons (MGPS). In the case of directly employed labor, this list should be held by the Authorized Person (MGPS); in the case of contracted labor, it should be held by the contractor's Authorized Person (MGPS)
Quality Controller (MGPS)	The Quality Controller (MGPS) is the person designated as the quality controller for MGPS. He/she is responsible for the quality control of the medical gases at the terminal units and plant such as medical air compressors, oxygen concentrators and synthetic air systems

Role	Description
Designated Medical Officer or Designated Nursing Officer (MGPS)	The Designated Medical or Nursing Officer (MGPS) (hereafter Designated Officer (MGPS)) is the person in each department with whom the Authorized Person (MGPS) liaises on any matters affecting the MGPS and who would give permission for a planned interruption to the supply

Table 3: Medical Gas Personnel Responsibilities

6.6.2 Operational Management

Safe operations of medical gas pipeline systems depend on skilled and certified staff who understand the systems and can communicate with clinical staff to ensure patients safety. The pipeline systems contain gas under pressure, which can present a hazard to staff through dangerous atmosphere or oxygen depletion. The Operations Management Team (FOM) should have complete data on systems installation and maintenance manual. To ensure continued patient safety, PTW procedures are very important to manage any possible interruption of the supply.

Medical gas pipeline end user should have awareness of the systems, alarms and pop up warnings, and must participate in the safe operation of the systems. Users should be familiar with the systems and be able to isolate in the event of an emergency such as damage to terminal units within the clinical space, or in the event of a fire and inform clinical staff.

Pottering staff responsible for the safe handling and use of medical gas systems cylinders should receive specific training before being permitted to change cylinders or cylinder regulators. Medical gas systems documents should have list of key persons involved in operation and maintenance handling. This will include nominating medical and nursing staff, risk manager/fire safety officers, pharmacy staff and the quality controller for the site, including competent personnel (who may be in-house staff or contractors). The pottering staff should list e.g., updated drawings and include schedules of plant, terminal units, area valve service units (AVSUs), and alarms. The Authorized Person (Medical Gas Pipeline System) has a key role in the preparation of the necessary documentation, for example operational policy and its review and management. Thereafter, operating the PTW procedure, advising users about the systems and training the pottering staff.

Many of the difficulties arising from failure of medical gas supplies can be avoided if operational protocols are in place before emergencies arise. It is recommended that an Operational Policy should be prepared. This should be based on a fully documented compliance survey in which the MGPS is examined in the light of current requirements, particularly those of the HTM 02-01.

6.6.2.1 PTW System Process

Safety rules and procedures for MGPS are necessary to ensure that the integrity and performance of the system are maintained. The purpose of the permit issued under this PTW system is to safeguard the integrity of the MGPS and hence, patient safety; it is not intended as a permit to protect the safety of individuals operating or working on the system. PTW process is applicable to internal (FOM) and specialist contractors along with any 3rd party contractors are arranged by the FOC, before commencing of any works in healthcare facilities on MGPS.

6.6.2.2 Isolation of Plant and Pipeline System

The Authorized Person (MGPS) is responsible for witnessing the isolation of valves/AVSUs/LVAs and for making safe, the plant, or system to be worked upon. No section of a MGPS should be worked on, filled with inert shield gas or pressure-tested, unless it is adequately isolated from any section in use or available for use.

6.6.2.3 Replacement of Cylinders/Recharging of Cryogenic Liquid Storage Vessels

Permits are not necessary for the routine replacement of cylinders on manifolds nor for the recharging of cryogenic liquid supply systems, provided there is no danger of the supply being disrupted when these tasks are undertaken. It is essential that pottering staff responsible for cylinder replacement receive appropriate training in these techniques.

6.6.2.3 Familiarity with Systems and Equipment

Personnel should be familiar with the specific systems and/or equipment for which they will be responsible. This familiarization process will be additional to the more generic training provided at dedicated centers, or when attending training courses at other healthcare facilities, both of which may use different types of equipment and/or system configurations.

6.6.2.4 Cylinder Management

Responsibility for gas cylinders should be clearly defined in the operational policy. This would include the training of personnel in the correct procedures for cylinder handling during storage and transportation. Medical gas plant rooms should be kept locked, except when work is in progress in them, with a prominently displayed notice indicating location of the spare key.

It is essential that risk assessments are carried out as part of the cylinder management process, good cylinder management is important for the following reasons:

- Good documentation establishes conformity of identity and quality
- Stock control issues are important in maintaining adequacy and continuity of supply
- Improper methods of cylinder storage may give rise to serious health and safety issues

6.6.3 Basic MGPS Requirements

Medical gas written scheme of examination is required by the regulations. Written scheme defines the type, frequency and specific parts inspection extent of the medical gas system, particularly those classified as pressure vessels, for which a two-yearly internal visual inspection is usually required.

A competent person is required to prepare this written scheme. Generally, this person is employed by the entities insurers to fulfill their statutory obligation for the authority and continuance of premium. This should also include periodic testing and/or replacement of pressure safety valve replacement schedule once in 5 years.

6.6.4 Components of MGPS

MPGS compose a source of supply, pipeline distribution system, terminal units (to which the user connects and disconnects medical equipment) and a warning/alarm system.

Medical gases system and vacuum systems are distributed throughout healthcare facilities via the pipeline distribution system to provide gas (and vacuum) at the terminal units of medical gas. Terminal units may be wall mounted or installed within medical supply units, such as:

- Operating room pendant fittings
- Bedhead trucking
- Wall fittings that include other facilities such as nurse-call systems
- Connections for patient monitoring systems, alarms, electrical services and audio systems

Medical supply units should comply with the relevant sections of ISO (SO 11197:2004, ISO 7396-1:2016)

The pipeline distribution system also includes area valve service units (AVSUs). These permit isolation of certain parts of the system for servicing or repair. They are also used by clinical or nursing staff during emergency. Line valve assemblies (LVAs) are also included to permit isolation of larger parts of the system for modification and/or repair.

Medical gas pipeline systems (MGPS) in hospitals and other healthcare facilities are utilized to supply specialized gases and their mixtures to various parts of the facility. Products handled by such systems typically include piped oxygen, nitrous oxide, nitrogen, carbon dioxide and medical air to medical areas such as patient rooms, recovery areas and operating rooms. Warning and alarm systems monitor gas flow and alerts facility staff in case of anomalies. There are many types of medical gases used in healthcare environments. All alarm systems should be clearly labelled, and all staff should be trained to take appropriate action in the event of an alarm.

6.6.5 Warning and Alarm Systems

Warning and alarm systems are provided to give information to staff responsible for operating the MGPS, changing cylinders, responding to plant faults, and to the medical staff responsible for the administration of medical gases. These systems should be maintained as part of the Maintenance Management System and where necessary calibrated by an Approved Contractor.

Medical gases are classified as medicinal products and are therefore subject to the same procurement and quality procedures as all other medicinal products. A Pharmaceutical Quality Controller is responsible for quality control of medical gases. Medical gases and vacuum systems must not be used for non-medical purposes, other than as a power source for medical equipment or for testing medical equipment's.

6.6.6 Standards Relevant to Medical Gases

There are currently no regional codes and mandated requirements developed specifically for medical gas pipeline systems however the HTM 02-01 Medical Gas Pipeline Systems-Part B Operational Management shall be used for the basis of the Operation & Maintenance manual. Other standards to consider for a new building would be the National Fire Protection Association (NFPA- 99).

6.6.7 Classification of Gases

- **Permanent Gases:** These are gases that remain in the gaseous state in the cylinders at normal temperatures. The volume of the cylinder content is directly related to the pressure of the gas; for example, at a quarter of the filled pressure, the cylinder is a quarter full. These gases include oxygen and medical air in it
- **Liquefiable Gases:** These are gases that are supplied as a liquid at normal temperatures (for example nitrous oxide and carbon dioxide) or gases supplied as a liquid at a cryogenic temperature, that is, below –40°C (for example liquid nitrogen and liquid oxygen)

6.6.8 Types of Medical Gases

6.6.8.1 Oxygen

Medical gas oxygen used for patients requiring supplemental oxygen via facemask. This is usually accomplished by a large storage system of liquid oxygen at the facility, which is vaporized into a concentrated oxygen supply, pressures are usually around 380 kappa (55 psi). This arrangement is described as a Vacuum Insulated Evaporator (VIE) or bulk tank. In small medical centers with a low patient capacity, oxygen is usually supplied by multiple high-pressure cylinders, as opposed to evaporated liquid oxygen. An oxygen concentrator system may be used to supply an oxygen pipeline system, even though the percentage concentration of oxygen is lower than that derived from liquid or gaseous sources, typically 94% or higher.

6.6.8.2 Nitrous Oxide

Nitrous oxide is supplied to various surgical suites for its anesthetic functions during preoperative procedures. It is delivered to the facility in high-pressure cylinders and supplied through the medical gas pipeline system. Some bulk systems exist but are no longer installed due to environmental concerns and reduced consumption of nitrous oxide. System pressures around 345 kappa (50 psi).

6.6.8.3 Nitrogen

Nitrogen is typically used to power pneumatic surgical equipment during various procedures and is supplied by high-pressure cylinders. Pressures range is around 1.2 MPa (170 psi) to various locations. Nitrogen is also used as a cryogen to freeze and preserve blood, tissue, and other biological specimens.

6.6.8.4 Nitrous Oxide/Oxygen Mixture (50/50)

Nitrous Oxide/Oxygen Mixture (50/50) is a ready-to-use medical gas mixture of 50% nitrous oxide and 50% oxygen that provides rapid, safe, and effective short-term pain relief. It also may be known by its commercial name Entonox or 50/50. Nitrous oxide/oxygen mixture supply systems are usually supplied from a medical gas manifold system in two banks. When full, the cylinders contain liquid and gaseous products with a liquid/gaseous boundary; they must be set upright.

6.6.8.5 Carbon Dioxide

Carbon dioxide is typically used to suspend or inflate various tissues and is used in laser surgeries. Most commonly, carbon dioxide is used in abdominal and thoracic surgeries, where the surgeon may need to move various organs to get to one area of the body. Carbon dioxide can also be combined with oxygen or air for respiratory simulation and treatment of various respiratory disorders. System pressures are maintained at about 345 kappa, or 50 psi.

6.6.8.6 Helium/Heliox

Helium/Heliox is a medical gas mixture of 79% helium and 21% oxygen that allows patients in respiratory distress to breathe more easily. Helium/Heliox is often used to treat fixed partial upper airway obstructions or increased air resistance. It is also used in liquefied form to help MRI machines to reach a superconducting state. This allows the MRI to produce high-resolution body images without exposing the patient to radiation.

6.6.8.7 Medical Air

Medical air is compressed air supplied by a special air compressor, through a dryer (in order to maintain correct dew point levels). Clean outside air is pressurized to around 380 kappa, or 55 psi, and brought inside the patient care areas. Medical air is used extensively in the ICU, PICU, and NICU areas, it cannot be used to provide power to surgery tools during mechanical ventilation or surgical procedures. In smaller facilities, medical air may also be supplied via high-pressure cylinders, pressures are maintained around 345–380 kappa (50.0–55.1 psi).

6.6.8.8 Surgical Air

Surgical air (also known as is instrument air) is compressed purified air used to power surgical equipment. It is generated on site by an air compressor (similar to a medical air compressor) rather than high-pressure cylinders. Instrument air can support multiple medical applications including driving surgical tools, operating pneumatic brakes and tables, central sterile supply, and laboratory air. Early air compressors could not offer the purity required to drive surgical equipment. However, this has changed, and instrument air is becoming a popular alternative to nitrogen. As with nitrogen, pressures range around 700–800 kappa; 100–120 psi regulated down at point of use.

6.6.8.9 Medical Vacuum

Medical vacuum in a healthcare facility supports suction equipment and evacuation procedures, supplied by means of a central vacuum plant system exhausting to the atmosphere. Vacuum will fluctuate across the pipeline but is generally maintained around −75 kappa (−560 mmHg; −22 in Hg) below atmospheric pressure.

6.6.9 <u>Associated Systems</u>

The following systems are associated with the operation and maintenance within a healthcare facility and classified as ‘Pressurized Systems’ under the control of the Clinical Team and Authorized Person.

6.6.9.1 Anesthetic Gas Scavenging Systems (AGSS)

AGSS is a complete system which conveys expired and/or excess anesthetic gases from the breathing system to the exterior of the building(s) or to a place where they can be discharged safely, for example to a non-recirculating exhaust ventilation system. AGSS are classified as active, passive, or semi-active/semi-passive. AGSS were initially introduced to enhance the safety of the environment in which members of staff in proximity with waste anesthetic gases and vapors (agents) work.

6.6.9.2 Dental Air & Vacuum Systems (DAVS)

Dental centers, clinics and surgeries require compressed air to power dental instruments and a vacuum system to remove detritus from the operation site. The performance requirements of dental compressed air and vacuum systems differ from those for medical air and vacuum, and they should be provided in addition to MGPS. To avoid confusion, they will be referred to as dental compressed air and vacuum systems (DCAVS). Medical gas systems should not be used for dental purposes. However, it may be possible to extend a surgical air system into a dental department for dental surgeries, provided that the existing system can meet the resulting increase in demand without being detrimental to the performance of either system.

6.6.9.3 Dental Air

Dental air is usually supplied via a compressor, which should be fitted with an air-intake filter and a post compression filtration and dryer system. This ensures that the air is clean and dry, minimizing the risk of contamination of the system by micro-organisms and improving the efficiency of dental instruments.

6.7 Chiller Systems

Chillers are items of plant that are used to generate cold or chilled water which is distributed among buildings to provide air conditioning, or beneficial cooling to auxiliary plant. The chiller removes heat from a liquid either via vapor compression or absorption refrigeration cycle. This liquid can then be circulated through a heat exchanger to cool the equipment, or another process stream (such as air or processed water). As an essential by-product, refrigeration creates waste heat that must be exhausted to the ambient surroundings, for example by cooling towers to the atmosphere. For greater efficiency this waste heat can be recovered for thermal heating purposes in certain applications. These recovery systems are not covered here as would be restricted to special applications.

6.7.1 Refrigerants

Refrigerants are used internally in chillers as their working fluid. Many options for refrigerants are available; when selecting a chiller, the application cooling temperature requirements and refrigerant’s cooling characteristics need to be matched. Other important parameters to consider are the operating temperature and pressures. Where refrigerant loss is suspected, a competent contractor should be employed to identify and rectify the leak before attempting to refill with fresh refrigerant gas. It may be necessary to drain the refrigerant from the system, known as recovery, and prior to any fault rectification. This should be recovered to a dedicated recovery unit or gas bottles for the type of refrigerant in the system. It is particularly important that the correct ‘grade’ of refrigerant is used in any refilling of the system as using the incorrect gas may have a detrimental effect upon the materials used for internal seals leading to greater problems. Mixing of gas will have a detrimental effect upon the system operation as required temperatures will not be achieved.

Refrigerant systems should only be operated by trained and competent personnel who are familiar with pressurized systems and the storage of gasses.

On no account should refrigerant systems be vented to the atmosphere as certain gasses contribute to ozone depletion and is prohibited in accordance with the Montreal Protocol agreement (The Montreal Protocol on Substances that Deplete the Ozone Layer, 1987).

6.7.2 Essential Functions and Responsibilities for Operations of Chillers

6.7.2.1 Maintenance Manager

Maintenance Manager must adhere to:

- Site and system inductions
- Operations systems training
- Personal Protective Equipment (PPE) for all employees and specialists operating at plant rooms
- Address the health, safety, security and environmental matters
- Ensure effective permit-to-work systems process are implemented
- Ensure SOP's, checklists task perspective Risk Assessment Method Statements (RAMS) must be followed
- Storage of refrigerant bottles for evacuation and top-up of systems

6.7.2.2 Operations Engineer

The operations engineer is responsible for:

- Supervising all installation, maintenance, modification, overhaul, service, and repair of chillers and associated systems
- Operations engineer personnel and contractors must participate in the installation, maintenance, and repair to ensure that the work performed is in compliance with blueprints, manufacturer specifications, O&M manuals and guidelines
- Plan, schedule, and assign work and crews to ensure adequate resources for efficient performance of duties
- Monitor jobs to ensure quality and compliance with standards, update records, report on performance, and resolve issues
- Supervise or assist operators to managed tasks safely and effectively

6.7.2.3 Operators

- Must be trained to operate and undertake maintenance, relevant to the competency of chillers and the associated systems
- Must be able to maintain chillers of all types for commercial and healthcare applications
- Must have experience to diagnose and repair electronic, mechanical and electrical components of the chiller as well as associated systems
- Must adhere to site safety policies and industrial practices

In healthcare facilities, the chillers should be maintained as per OEM recommendations and based on site-specific and designed parameters of systems requirements of chillers used for the application of usage. It is recommended to have the OEM of chiller or authorized dealer carry out service on monthly basis. Third party services providers should be hired by either FM services providers (FOM) or Healthcare engineering team (FOC). Daily routine checking, inspection, and greasing should be carried by FM services providers.

7.0 ATTACHMENTS

Attachment 1: EOM-ZO0-TP-000003: Start Up Checklist – Mechanical Systems – Healthcare Sector
Attachment 2: EOM-ZO0-TP-000004: Shutdown Checklist – Mechanical Systems – Healthcare Sector
Attachment 3: EOM-ZO0-TP-000005: Systems Monitoring/Daily Rounds Checklist – Mechanical Systems – Healthcare Sector
Attachment 4: EOM-ZO0-TP-000006: Emergency Response Action Checklist – Mechanical Systems Healthcare Sector

Attachment 1: EOM-ZO0-TP-000003: Start Up Checklist - Mechanical Systems - Healthcare Sector

Water Treatment Systems

Healthcare Facility Name:		Reference No.	REV-000	
No.	Start Up Checklist	CHECKED SATISFACTORY		
		N/A	YES	NO
	Water Treatment Systems			
	Health and Safety			
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐
2	Method statement & risk assessment available	☐	☐	☐
3	Chemical Material Safety Data Sheets & Product Data Sheets (MSDS & PDS) checks available	☐	☐	☐
4	Location of first-aid instructions and supplies available	☐	☐	☐
5	Emergency eyewash and showers available	☐	☐	☐
6	Emergency evacuation plan review	☐	☐	☐
7	Emergency contact details of the responsible person and the contractors available	☐	☐	☐
8	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarms) checks	☐	☐	☐
9	Ventilation	☐	☐	☐
	Preapprovals			
10	System owner/Manager/Engineering teams' approvals available	☐	☐	☐
11	End-user department head approvals available	☐	☐	☐
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐
13	Specialist contractor schedule of work available	☐	☐	☐
14	Approved permit to work	☐	☐	☐
	System Readiness			
15	System pressure checks	☐	☐	☐
16	System temperature checks	☐	☐	☐
17	Chemicals level checks	☐	☐	☐
18	System hazard free and no chemical spillage checks	☐	☐	☐
19	Water test kit checks	☐	☐	☐
20	Chemicals stocks & expiry checks	☐	☐	☐
21	Required tools checks	☐	☐	☐
22	Opening and closing valve checks - Lock Out, Tag Out (LOTO)	☐	☐	☐
23	Confirm with schematic and Building Management System (BMS)	☐	☐	☐
24	Areas are cleaned and egressed checks	☐	☐	☐
	Pre-Start Checks			
25	System fault free/alarm free checks	☐	☐	☐
26	Equipment manufacturer's startup procedure available	☐	☐	☐
27	Automatic controller checks	☐	☐	☐
28	Parameters set point checks	☐	☐	☐
29	Water meters/gauges checks	☐	☐	☐
30	Dosing tanks filled with chemicals checks	☐	☐	☐
31	Water treatment systems basics inspection checks	☐	☐	☐
32	Previous service reports checks (3rd party specialist)	☐	☐	☐

Attachment 2: EOM-ZO0-TP-000004: Shutdown Checklist - Mechanical Systems Healthcare Sector

Water Treatment Systems

Healthcare Facility Name:		Reference No.		REV-000	
No.	Shutdown Checklist	CHECKED SATISFACTORY			
		N/A	YES	NO	
	Water Treatment Systems				
	Health and Safety				
1	Required Personal Protective Equipment (PPE) available	☐	☐	☐	
2	Method statement & risk assessment available	☐	☐	☐	
3	Chemical Material Safety Data Sheets & Product Data Sheets (MSDS & PDS) checks available	☐	☐	☐	
4	Location of first-aid instructions and supplies available	☐	☐	☐	
5	Emergency eyewash and showers available	☐	☐	☐	
6	Emergency evacuation plan review	☐	☐	☐	
7	Emergency contact details of the responsible person and the contractors available	☐	☐	☐	
8	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarms) checks	☐	☐	☐	
9	Ventilation	☐	☐	☐	
	Preapprovals				
10	System owner/Manager/Engineering teams' approvals available	☐	☐	☐	
11	End-user department head approvals available	☐	☐	☐	
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	☐	☐	☐	
13	Specialist contractor schedule of work available	☐	☐	☐	
14	Approved permit to work	☐	☐	☐	
	Standby System Condition				
15	System operating condition checks	☐	☐	☐	
16	System leakage free checks	☐	☐	☐	
17	System faults/alarm free checks	☐	☐	☐	
18	Water flow checks	☐	☐	☐	
19	System parameters checks	☐	☐	☐	
	Pre-Shutdown Checks				
20	System is alarm free checks	☐	☐	☐	
21	Automatic Control Panel parameters checks	☐	☐	☐	
22	Set Points and dosing pump stroke rates checks	☐	☐	☐	
23	Pressure gauges checks	☐	☐	☐	
24	Water meters/gauges checks	☐	☐	☐	
25	Dosing tanks checks	☐	☐	☐	
26	All related valves open-closeout checks	☐	☐	☐	
	Routine Stop				

Attachment 3: EOM-ZO0-TP-000005: Systems Monitoring/Daily Rounds Checklist - Mechanical Systems -Healthcare Sector

Water Treatment Systems

Healthcare Facility Name:		Reference No.		REV-000
No.	**Systems Monitoring/Daily Rounds Checklist**	**CHECKED SATISFACTORY**		
		N/A	**YES**	**NO**
	Water Treatment Systems			
1	System inspection and checking	☐	☐	☐
2	System assessment checks	☐	☐	☐
3	System water quality parameters on site checks (as recommended by OEM)	☐	☐	☐
4	System incoming/supply water quality parameters checks	☐	☐	☐
5	Daily inspection of chlorine dosage of chemicals checks	☐	☐	☐
6	Daily water sampling and testing checks	☐	☐	☐
7	Automatic control for water quality monitoring inspection checks	☐	☐	☐
8	Building Management Systems (BMS) alarm/fault associated plants condition checks	☐	☐	☐
9	Calibration checks of chlorine sensor	☐	☐	☐
10	Daily temperature checks	☐	☐	☐
11	Record keeping and reporting checks	☐	☐	☐
12	Standard Operating Procedures review	☐	☐	☐
13	Daily water flushing on systems checks	☐	☐	☐
14	Daily backwash checks	☐	☐	☐
15	Entry point and distribution of residual water checks	☐	☐	☐
16	Water sampling points and samplings checks	☐	☐	☐
17	Available water test kits checks	☐	☐	☐
18	Chemicals level checks	☐	☐	☐
19	Chemicals stock checks	☐	☐	☐
20	Sampling schedule and daily checks on the system	☐	☐	☐
21	Distribution of water tank levels checks	☐	☐	☐
22	Cooling tower pond/basin inspection checks	☐	☐	☐
23	Filtration systems cartridge replacement and inspection checks	☐	☐	☐
24	Standard Temperature and Pressure (STP) daily air blowers inspection checks	☐	☐	☐
25	Sampling and testing of water chemicals analysis, microbiological and legionella analysis checks	☐	☐	☐
26	All systems automatic chlorine controllers and doing pumps settings checks	☐	☐	☐
27	All water treatment plants blow down and drain points checks	☐	☐	☐
No.	**Reviewer's Comments**	**Resolution**		

Attachment 4: EOM-ZO0-TP-000006: Emergency Response Action Checklist - Mechanical Systems - Healthcare Sector

Mechanical Systems

Healthcare Facility Name:		Reference No.	REV- 000	
No.	Emergency Response Action Rounds Checklist	CHECKED SATISFACTORY		
		N/A	YES	NO
	Introduction			
	This emergency procedure is intended to highlight the key issues that may arise at departmental level in the event of a mechanical system failure. It is appreciated that this may be the result of a full site system failure, but it may also be the result of a local failure for which notification from the entity maybe necessary. The main aim is to provide a structured approach to the safety of patients and staff and to minimize the risk associated with a mechanical system failure			
Priority 1	Life safety (Evacuation Plan)	☐	☐	☐
Priority 2	Stabilization of incident	☐	☐	☐
Priority 3	Minimization of potential damage	☐	☐	☐
Priority 4	Containment of incident (e.g. chemical spillage)	☐	☐	☐
Priority 5	Assessment of damage	☐	☐	☐
Priority 6	Clean up after incident (Post Incidents Plans)	☐	☐	☐
Priority 7	Monitoring weather sources for updated emergency instructions and broadcast warning if issued by weather services	☐	☐	☐
Priority 8	Building lockdown plan/Plant lockdown plan	☐	☐	☐
1	The responsible person shall conduct an initial and ongoing situational assessment of the incident	☐	☐	☐
2	The responsible person shall establish an effective communications plan	☐	☐	☐
3	The responsible person shall deploy available resources and request additional resources based upon the needs of the incident	☐	☐	☐
4	The responsible person shall develop an incident organization for the management of the incident	☐	☐	☐
5	The responsible person shall review, evaluate, and revise the strategy and tactics based upon the needs of the incident	☐	☐	☐
6	The responsible person shall provide for the continuity, transfer, or termination of command	☐	☐	☐
7	The system shall provide for a routine process of escalation as additional resources are utilized	☐	☐	☐
8	The responsible person shall determine which levels and elements of the incident management system are to be implemented in each case and shall develop the command structure for each incident by assigning supervisory responsibilities according to Standard Operating Procedures (SOPs)	☐	☐	☐
9	The incident management system shall define standardized supervisory assignments	☐	☐	☐
10	The incident responsible person shall be responsible for controlling communications on the tactical, command, and designated emergency traffic channels for that incident	☐	☐	☐
11	The incident responsible person shall be responsible for overall responder accountability for the incident	☐	☐	☐
12	The incident responsible person shall be responsible for developing and/or approving an Incident Action Plan (IAP)	☐	☐	☐
13	The incident responsible person shall keep the safety officer informed of strategic and tactical plans and any changing conditions	☐	☐	☐
14	The incident responsible person shall evaluate the risk to responders with respect to the purpose and potential results of their actions in each situation	☐	☐	☐