

National Manual of Assets and Facilities Management

Volume 5, Chapter 7

Mechanical Systems Operations - Housing Procedure



Document No. EOM-ZO0-PR-000032 Rev 001



Mechanical Systems Operations - Housing Procedure

Document Submittal History:

Revision:	Date:	Reason For Issue
000	28/03/2020	For Use
001	18/08/2021	For Use



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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 housing 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 housing 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 “house facility” is considered including, but not limited to:

- Villa (Multi room single family dwelling)
- Town house (Multi room single family dwelling)
- Low rise housing (Buildings lower than high rise and up to six (6) stories with areas including, but not limited to:
 - Common and/or public access
 - Egress areas
 - Communal areas
 - Common tenant areas (e.g., pool, gym and meeting meeting)
 - Common electrical utilities
- Mixed use buildings
- Compounds containing a variety of some and or all definitions (e.g., villa, town-house and/or low-rise residential/mixed use buildings)
- Mid rise and high rise housing (to be read in conjunction with “National Manual of Assets and Facilities Management – Volume 5, Chapter 7 – Offices”)

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.
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.



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Term	Definition
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
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
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
Housing Facility/Building	All buildings, infrastructure, equipment, plant, embedded systems, and related items that support residential services types, irrespective of their ownership or operation by third parties
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	Residential 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



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Term	Definition
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
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
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
LOTO	Lock Out Tag Out
LP	Low Pressure
LTHW	Low Temperature Hot Water
LVA	Line valve assemblies
MEP	Mechanical Electrical Plumbing
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
PPE	Personal Protective Equipment
PM	Planned Maintenance
PSA	Pressure Swing Adsorption



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Term	Definition
PTW	Permit to Work
PVB	Pressure Vacuum Breaker
QHSE	Quality Health Safety Environment
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)
- American Welding Society (AWS)
- British Standards Institute (BSI)
- Cast Iron Soil Pipe Institute (CISPI)
- Cooling technology institute (CTI)
- 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)
- Manufacturers Standardization Society (MSS)
- 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
- NSF International Standard / American National Standard (NSF/ANSI 55-2019) – Ultraviolet Microbiological Water Treatment Systems
- Occupational Safety and Health Administration (OSHA)
- Plumbing and Drainage Institute (PDI)
- Public Health and Safety Organization (NSF)
- Saudi Arabian Standards Organization (SASO)



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- Saudi 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.
- 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 attention of the housing facility 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 daily operational activities are carried out safely without any hazard to the Operations Team or stakeholders (e.g., visitors, staff). 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 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

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)	<p>An individual who performs the following duties:</p> <ul style="list-style-type: none">• 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



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Role	Description
Facilities Manager (FM)	<p>FM is responsible for:</p> <ul style="list-style-type: none"> 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)	<p>OE is responsible for supervising all installation, maintenance, modification, overhaul, service, and repair of Mechanical, Electrical, and Plumbing (MEP) equipment. The duties included are:</p> <ul style="list-style-type: none"> 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	<p>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</p>
The Chief Executive	<p>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:</p> <ul style="list-style-type: none"> 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)	<p>The Head of HSSE in conjunction with the responsible person shall develop appropriate policies to control risks arising from hazards and control of Legionella and monitor the implementation of these, reporting to the safety committee as necessary</p>
Water Safety Group (WSG)	<p>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, housing facility departments, other staff and operations teams</p>
The Responsible Person	<p>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</p>



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Role	Description
	<p>and knowledge of the systems and their installations to ensure that all operational procedures are carried out in a safe, timely and effective manner.</p> <p>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</p> <p>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.</p> <p>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:</p> <ul style="list-style-type: none"> • pH • Temperature • Total Dissolved Solids (TDS) • Conductivity • Free chlorine residues <p>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.</p>
Designated Person	<p>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</p> <p>The Designated Person shall liaise with the Responsible Person to ensure the effective implementation of the WSP</p> <p>The Responsible person will assign Designated Persons for following tasks:</p> <ul style="list-style-type: none"> • 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	<p>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)</p> <p>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</p>



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Role	Description
	responsible for ensuring that the water system conditions are maintained throughout the housing facility 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
- 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 range. The treated water may be used for different applications e.g., 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)
- Potable/Domestic Water Treatment Systems
- Filtration Systems (UV Systems)
- Neutralization Plant
- Gray Water Treatment Plant
- Sewage Treatment Plant (STP)
- Swimming Pools

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 housing facility to provide air conditioning where cooling is combined with the Heating and Ventilation system for a comfortable and controlled indoor environment within the facility.

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



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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 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.

6.1.3.1 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.

6.1.3.2 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 business units in the community.

In housing 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 housing facilities for the following reasons:

- To provide backflow protection to the utility supply



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- 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

It is very important to keep tanks clean, super chlorinated periodically and disinfected since domestic water may be used for various applications within the housing 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°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°C and hot water above 60°C (since legionella will grow at temperatures up to 60°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

6.1.3.3 Operation Management

The maintenance regime should be thorough for both tanks fed hot and cold water 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°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

6.1.4 Filtration System (UV System)

In housing facilities, 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



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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

6.1.5 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 housing facility.

6.1.5.1 Fundamentals of Neutralization Plant

In a housing 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 housing FM service provider, FOM or the engineering team FMC following training.

6.1.5.2 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.

6.1.6 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 housing facilities 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 housing department uses its own (municipal waste of neutralization treatment plant) rather than sharing gray water with other waste. This avoids potential conflicts and increases confidence in the quality of the gray water system

6.1.7 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 a housing facility, a STP is used based on the area of occupancy and will be sized to undertake the expected throughput, volume generated. Since most large residential buildings 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.

6.1.8 Swimming Pool Treatment

In housing facilities, there may be a swimming pool to be used by public. It is essential that these areas are maintained in a professional manner as they can be a source of contamination and spread of infection.

In swimming pools, chlorine is a very important additive to prevent the spread of infection. Chlorine is formed of calcium hypochloride (solid form) and sodium hypochloride (liquid form). When chlorine is added to the swimming pool it generates various chemicals like hypochlorous acid. To maintain swimming pool conditions, a skilled operator with high level of knowledge and understanding of the local and international standards should be employed. To meet the acceptable water quality limits, water must be continually circulated through filtration systems to remove particulate matter that provide a food source to bacteria. Water analysis must be conducted on regular basis to identify sources of bacteria and to eliminate these sources to ensure it does not return to the pool. Chlorine levels must be tested daily by using a simple low cost comparator.

The main function of the circulation and filtration system is the removal of suspended, colloidal and organic matter to ensure the pool water is clear, colorless and odorless. Filtration and swimming pool water should be blown down as per the water authority local regulations. As this water often has a greater level of dissolved solids and chemicals, due to which it may be restricted by the authority for entering municipal drainage systems.

6.1.9 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.

6.1.10 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



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- 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 housing facility should provide a management function for monitoring and control of water systems and associated plant. An example structure is shown below:

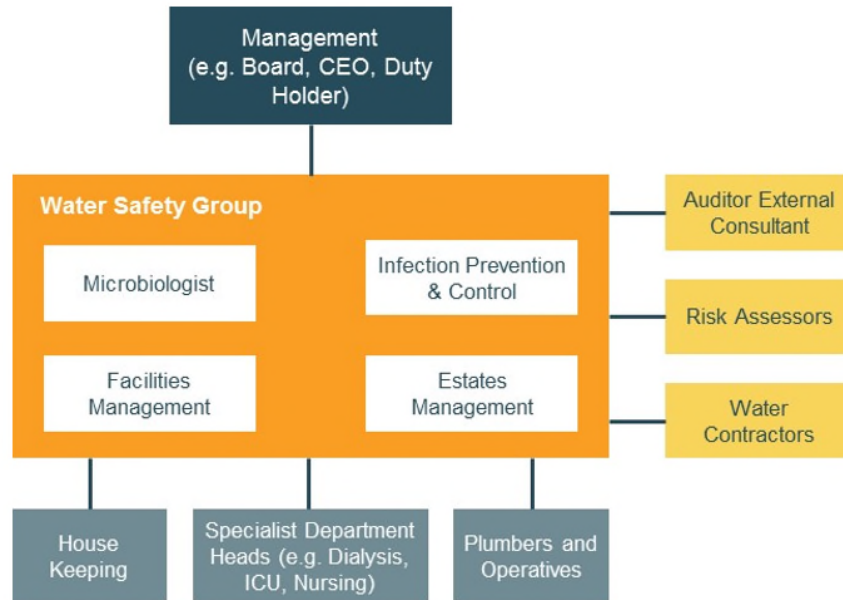


Figure 1: Organization Structure for the Duty Holder

6.1.10.1 Legionella Growth Factors

Opportunistic microorganisms present in the plumbing premise grow well in drinking Water Distribution Systems and can cause 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 conducive for Legionella growth allow growth of other opportunistic pathogens as well.

Factors promoting Legionella growth within the housing 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



6.1.10.2 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 housing 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 housing facility 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:



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- 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.

6.1.10.3 Legionella Analysis Parameters

Within the residential 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 housing 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
 - 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 residents, staff or visitors. In the case of water from a neutralization plant 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.

6.1.10.4 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.



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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.

6.1.11 Mandatory Controls, Parameters and Limits

6.1.11.1 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



6.1.11.2 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.

6.1.11.3 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.

6.1.11.4 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.

6.1.11.5 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 housing facility for the distribution and use of potable water (cold and hot) and the removal of waterborne wastes.

Plumbing systems in housing facilities may consist of underground tanks which are supplied with water via housing facility or water department distribution supply lines. A piped distribution system is utilized to



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transport the water throughout the facility. Water may be distributed to overhead, basement, or outside housing facilities storage area tanks. Therefore, for overhead tanks the use of gravity ensures that the water reaches the facility 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 Facility 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 residential buildings will have hot water heaters, boiler systems, or other types of heating systems to provide hot and cold water services to the housing facility.

In housing 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 a housing facility, 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 housing facilities, 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 housing facility; 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 housing 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 housing 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. Residential sectors 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. 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.

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

6.4.2 Plumbing Equipment

6.4.2.1 Water Softener

In residential sector, 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 housing facilities. 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 facility 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 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 calorifier 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 housing facility, several types of pumps are used for different applications such as 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 housing 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 (m³). The water meter box will have a metal or plastic lid and may be marked as "Water Meter." In housing 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 housing 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



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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 housing 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 housing 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 housing facilities are most likely to use different types of generators. Listed below are the most commonly used generators in these facilities.

6.5.1 Diesel Generators

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



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- Exhaust systems
- Lubrication system
- Battery charger
- Control panel
- Main assembly frame

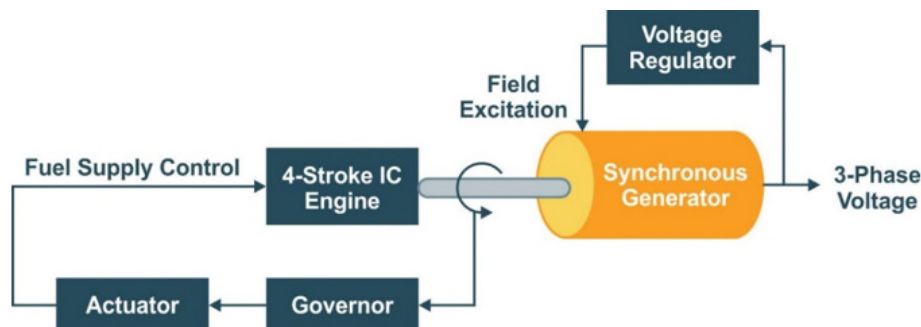


Figure 2: Diesel Generator Parts

In housing facilities, 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 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.

6.6.1 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).

6.6.2 Essential Functions and Responsibilities for Operations of Chillers

6.6.2.1 Maintenance Manager

Maintenance Manager must adhere to:

- Site and system inductions



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- 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

6.6.2.2 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

6.6.2.3 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 other 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 housing 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 facility engineering team (FOC). Daily routine checking, inspection, and greasing should be carried by FM services providers.

7.0 ATTACHMENTS

Attachment 1: EOM-ZO0-TP-000019: Start Up Checklist – Mechanical Systems – Housing

Attachment 2: EOM-ZO0-TP-000020: Shutdown Checklist – Mechanical Systems – Housing

Attachment 3: EOM-ZO0-TP-000021: Systems Monitoring/Daily Rounds Checklist – Mechanical Systems – Housing

Attachment 4: EOM-ZO0-TP-000022: Emergency Response Action Checklist – Mechanical Systems – Housing



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Attachment 1: EOM-ZO0-TP-000019 - Start Up Checklist - Mechanical Systems - Housing

Water Treatment Systems

Housing 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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2	Method Statement & Risk Assessments available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3	Chemical Material Safety Data Sheets & Product Data Sheet (MSDS & PDS) checks available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4	Location of first-aid instructions and supplies available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	Emergency eyewash and showers available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6	Emergency evacuation plan reviewed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7	Emergency contact details of the responsible person and the contractors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9	Ventilation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Pre Approvals					
10	System Owner/Manager/Engineering team approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
11	End-user Department Head approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
13	Specialist Contractor's schedule of work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
14	Approved permit to work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
System Readiness					
15	System pressure checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
16	System temperature checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
17	Chemical levels checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
18	System's hazard free and no chemical spillage checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
19	Water test kit checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
20	Chemicals stocks & expiry checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
21	Required tools checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
22	Opening and closing valve checks (LOTO)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
23	Confirm with schematic and Building Management System (BMS)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
24	Areas are cleaned and egressed checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Pre Start Checks					
25	System faults free/alarms free checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
26	Equipment manufacturer's startup procedure available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
27	Automatic controller checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
28	Parameters set point checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
29	Water meters/gauges reading checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
30	Dosing tanks filled with chemicals checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
31	Water treatment system's basic inspection checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
32	Previous service reports checks (3 rd party specialist)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	



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Attachment 2: EOM-ZO0-TP-000020 - Shutdown Checklist - Mechanical Systems - Housing

Water Treatment Systems

Housing Facility Name:		Reference No.		REV-000		
No.	Shutdown Checklist	CHECKED SATISFACTION				
		N/A	YES	NO		
Water Treatment Systems						
Health and Safety						
1	Required Personal Protective Equipment (PPE) available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
2	Method Statement & Risk Assessments available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
3	Chemical Material Safety Data Sheets & Product Data Sheets (MSDS & PDS) checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
4	Location of first-aid instructions and supplies available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
5	Emergency eyewash and showers available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
6	Emergency evacuation plan reviewed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
7	Emergency contact details of the responsible person and the contractors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
8	Life Safety Systems (fire extinguishers, sprinklers, gas suppression & fire alarm)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
9	Ventilation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Pre Approvals						
10	System Owner/Manager/Engineering team's approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
11	End-user Department Head approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
12	Quality, Health, Safety and Environment Management (QHSE) approvals available	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
13	Specialist Contractor's schedule of work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
14	Approved permit to work	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Standby System Condition						
15	System's operating condition checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
16	System's leakage free checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
17	System's fault/alarm free checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
18	Water flow checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
19	System's parameters' checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Pre Shutdown Checks						
20	System's alarm free checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
21	Automatic control panel parameter checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
22	Set Points and dosing pump stroke rates' checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
23	Pressure gauges	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
24	Water meters/gauges	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
25	Dosing tank's checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
26	All related valves' open - closeout checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
Routine Stop						
27	LOTO remove checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
28	Stop chemical dosing feeder	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		
29	Stop water supply	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		



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Attachment 3: EOM-ZO0-TP-000021 - Systems Monitoring/Daily Rounds Checklist - Mechanical Systems – Housing

Water Treatment Systems

Housing 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 check	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2	System assessment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3	System's water quality parameters on site checks (as recommended by OEM)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4	System incoming/supply water quality parameters' checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	Inspect chlorine dosage of chemicals (daily)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6	Daily water sampling and testing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7	Inspect automatic control for monitoring water quality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8	Building Management System (BMS) alarm/faults associated plants condition checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9	Calibration check of chlorine sensor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
10	Daily temperature checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
11	Record-keeping and reporting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12	Standard operating procedures review	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
13	Daily water flushing on systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
14	Daily backwash checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
15	Entry point and distribution residual of water	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
16	Water sampling points and samplings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
17	Available water test kits' checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
18	Chemicals levels checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
19	Chemicals stocks checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
20	Sampling schedule and daily checks on the system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
21	Distribution of water tank levels checks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
22	Inspect cooling tower pond/basin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
23	Filtration systems cartridge replacement and inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
24	Standard Temperature and Pressure (STP) daily air blower's inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
25	Sampling and testing of water chemicals analysis, microbiological and legionella analysis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
26	Check all systems automatic chlorine controllers and dosing pumps settings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
27	Check all water treatment plants blowdown and drain points	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
No.	Reviewer's Comments	Resolution			
Originator's Name/Signature and Date:		Checker's Name/Signature and Date:			



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Attachment 4: EOM-ZO0-TP-000022 - Emergency Response Action Checklist – Mechanical Systems – Housing

Housing Facility Name:		Reference No.		REV-000	
No.	Emergency Response Action Checklist	Checked Satisfactory			
		N/A	YES	NO	
	Introduction				
	This emergency procedure is intended to highlight the key issues that may arise at the departmental level in the event of a mechanical systems failure. It is appreciated that this may be the result of a full site systems 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 residents and staff and to minimize the risk associated with a mechanical systems failure				
Priority 1	Life safety (evacuation plan)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 2	Stabilization of incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 3	Minimization of potential damage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 4	Containment of incident (e.g. chemical spillage)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 5	Assessment of damage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 6	Clean up after incident (post incident plans)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 7	Monitoring weather sources for updated emergency instructions and broadcast warning if issued by weather services	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Priority 8	Building lockdown plan/plant lockdown plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
1	Responsible person shall conduct an initial and ongoing situational assessment of incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
2	The responsible person shall establish an effective communications plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
3	Responsible person shall deploy available resources and request additional resources based upon the needs of the incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
4	Responsible person shall develop an incident organization for the management of the incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
5	Responsible person shall renew, evaluate, and revise the strategy and tactics based upon the needs of the incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
6	Responsible person shall provide for the continuity, transfer, or termination of command	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
7	System shall provide for a routine process of escalation as additional resources are utilized	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
8	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 (SDPs)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
9	The incident management system shall define standardized supervisory assignments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
10	The incident responsible person shall be responsible for controlling communications on the tactical, command, and designated emergency traffic channels for that incident.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
11	Incident responsible person shall responsible for overall responsible for incident	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
12	Incident responsible person shall responsible for developing and/or approving an (IAP)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
13	The incident responsible person shall keep the safety officer informed of strategic and tactical plans and any changing conditions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
15	The communications system shall provide a standard method to give priority to the transmission of emergency messages and notification of imminent hazards over that of routine communications to all levels of the incident command structure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	