Schedule 18

Appendix 18U – Process Mechanical Design Guide

SECTION A. DEFINITIONS

A.1 Definitions

A.1.1 Capitalized terms used in this Appendix 18U have the meanings given in Schedule 18 – Technical Requirements or in the Design Build Agreement.

SECTION B. LAYOUT AND ACCESS

B.1 Platforms and Suspended Walkways

B.1.1 All platforms and suspended walkways shall have the following minimum dimensions:

(a) clear height of 2100 mm; and

(b) clear width of 1000 mm.

B.1.2 Provide larger platforms or walkways as required to meet minimum clear space dimensions around equipment as specified in the Technical Requirements.

B.2 Equipment

B.2.1 Provide the minimum clearances specified in **Table *1*** around all process equipment, unless otherwise specified by the manufacturer or by any requirement within the DBA.

Table 1: Minimum Clearances around Rotating Equipment

Rating	Front	Side	Rear
< 7.5 kW (10 hp)	1000 mm	300 mm	As required by manufacturer
7.5 kW (10 hp) – 37 kW (50 hp)	1200 mm	800 mm	300 mm
37 kW (50 hp) – 75 kW (100 hp)	1200 mm	1000 mm	600 mm
> 75 kW (100 hp)	1200 mm	1200 mm	1000 mm

B.2.2 Provide additional clearance, as required, where portable manual lifting devices such as portable gantry cranes are used to lift the equipment.

B.2.3 Provide sufficient clearances for removal and refitting of the serviceable components of all installed equipment without removal or dismantling of either:

(a) unrelated parts of the equipment being serviced; or

(b) adjacent equipment, including walkways or platforms, in part, or in whole.

B.2.4 Locate local control panels and other ancillary devices not integral to the unit outside the minimum clearances specified in Table 1.

B.2.5 Where multiple parallel units are provided, ensure the drive orientation and direction of rotation are identical for all units to minimize spare parts inventory.

B.2.6 Locate wash downs and drains in logical areas to facilitate equipment cleaning.

B.3 Pumps

B.3.1 Place pumps as close as possible to the suction source. Minimize the number of bends and fittings on the suction pipe.

B.3.2 Top suction and top discharge lines shall include removable spool pieces.

B.4 Compressors and Blowers

B.4.1 Place compressors and blowers as close as possible to the suction source.

B.4.2 Top suction and top discharge lines shall include removable spool pieces.

B.5 Piping

B.5.1 Ensure that all piping provides sufficient head clearance, is not a tripping hazard, or a barrier to equipment access.

B.5.2 Do not install piping directly above any equipment that requires lifting for maintenance, removal, or repair.

B.5.3 Place piping close to walls where it can be readily supported. If piping must be near a wall but not supported from it, maintain a minimum clearance of 600 mm between the outermost pipe flange and the wall.

B.5.4 For flushing sewage and grit pipelines for maintenance, provide flushing connections at each side of mainline and branch shut-off valves, pump suction valves, and discharge isolation valves.

B.5.4.1 Flushing water connections shall be permanently piped.

B.5.4.2 Ensure that valve isolation is provided to allow for flushing flexibility.

B.5.4.3 Orient flushing point connections as appropriate to direct the flushing flow.

B.5.5 Ensure adequate space is available for installation of pipe supports and seismic bracing.

B.5.6 Install reducers on the suction side of pumps flat-on-top to prevent air or gas entrapment.

B.5.7 Wall penetrations shall be perpendicular to the wall. Provide a puddle flange and a flanged end on both sides of concrete wall penetrations. Provide cored penetrations with Link-Seal or double Link-Seal as appropriate for the installation.

B.5.8 Provide valve isolation such that any pipe segment may be taken out of service without affecting other pipe segments.

B.5.8.1 Provide valves on branches as close to main headers as possible.

B.5.9 Sewage service check valves shall be installed on horizontal pipes only. To prevent the accumulation of solids on the downstream side of the flapper, do not install swing check valves in vertical piping runs.

B.5.10 Provide a coupling or pipe joint within 4 pipe diameters of valves, flow meters, and other inline devices for easy disassembly.

B.5.10.1 If placing a coupling or pipe joint within 4 pipe diameters results in flow disturbances that affect flow meters or other inline devices, provide sufficient additional straight length in accordance with the manufacturer's installation requirements or Good Industry Practice.

B.5.11 Provide thrust restraint for sleeves and other couplings that are not self-restraining.

B.5.12 Provide sufficient straight pipe runs on the upstream and downstream side of all instrumentation in accordance with the manufacturer's installation requirements or Good Industry Practice.

B.5.13 Coordinate with other disciplines to ensure no conflict between piping and other components or the Infrastructure such as cable tray, sprinkler systems, lighting, etc.

SECTION C. LIFTING AND EQUIPMENT REMOVAL

C.1 Portable Lifting Devices

C.1.1 Portable lifting devices may be used for equipment components weighing less than 500 kg.

C.1.1.1 Portable lifting devices are not acceptable for the regular movement of chemicals or other consumables.

C.1.2 Where portable lifting devices are proposed, ensure that clearances and access is provided around the equipment to enable a controlled movement of the equipment from its installed position to its off-loading position.

C.1.2.1 Travelling or slewing motion of the load shall be at a speed such that it does not produce a pendulum motion during the lift and cause shifting of the load. It shall also be free of pinching points.

C.1.3 Portable lifting devices may include:

(a) moveable gantry cranes;

(b) portable davits with fixed bases; and

(c) hand-operated hoists (i.e chain hoist) with permanent attachment points.

C.1.4 Where moveable gantry cranes are proposed, provide a storage location for the gantry crane near the equipment to be serviced. Ensure the gantry crane can be moved from the storage location into position above the equipment without disassembly and reassembly. Show the moveable gantry crane in the proposed storage location on the drawings.

C.1.4.1 Moveable gantry cranes are not acceptable for lifting equipment located outdoors.

C.1.5 Where portable davits are proposed, ensure that an engineered davit base is included in the design.

C.1.5.1 Floor-mounted davit bases shall be flush with the floor unless it can be proven that there the davit base will not be a tripping hazard.

C.1.5.2 Davit bases shall have a removable cover to prevent accumulation of grit and debris in the recess when it is not in use.

C.1.5.3 All davit bases and their operating radii shall be shown on the drawings.

C.1.5.4 Davit basis shall be constructed of material suitable for the environment.

C.1.5.5 Ensure compatibility of davits and davit bases for the Infrastructure.

C.1.5.6 Where multiple staged lifts will be required, provide a second lifting attachment point on the davit arm.

C.1.5.7 Floor davit bases shall be engineered and sealed by a Professional Engineer.

C.1.6 Where hand-operated hoists are proposed, ensure that an engineered attachment point is included in the design.

C.1.6.1 Ensure all lifting points are reasonably accessible, considering the frequency of maintenance.

C.1.6.2 Where multiple lifts will be required, provide a second lifting attachment point.

C.1.6.3 All lifting points shall be shown on the drawings.

C.1.6.4 Lifting eyes and other attachment points shall be constructed of material suitable for the environment.

C.1.6.5 Lifting eyes and other attachment points shall be engineered and sealed by a Professional Engineer.

C.2 Permanent Lifting Equipment

C.2.1 Provide permanent motorized hoist, monorails, or cranes where:

(a) the weight of any piece of equipment in its entirety, or any of its removable components exceeds 1,000 kg;

(b) lift frequency for normal operation or maintenance may exceed bi-weekly; or

(c) lifting is a normal operating procedure, regardless of weight, (example: regular movement of polymer bags).

C.2.2 All motorized hoists, monorails, or cranes are required to maintain and hold the load during a power lift.

SECTION D. PUMPING SYSTEMS

D.1 Non-Clog Dry Pit Centrifugal Pumps

D.1.1 Use non-clog dry pit centrifugal pumps for pumping typical sludges and slurries.

D.2 Submersible Non-Clog Pump

D.2.1 Wetwell mounted pump motor cooling shall be by virtue of the motor being submerged in the fluid. Cooling using water jackets or sewage recirculation systems shall not be used.

SECTION E. HYDRAULIC DESIGN

E.1 Hydraulic Calculations

E.1.1 Provide performance overlap for systems with parallel duty pumps. Ensure proper pump sequencing to allow smooth transition and avoid flow surges when starting and stopping lag and stand-by pumps.

E.2 Sump and Wet Well Design

E.2.1 For sumps and wet wells (other than the raw sewage wet well), install level measurement devices in the most quiescent region of the well (low turbulence, waves, or vortices) to avoid widely fluctuating or unstable level signals. A stilling well may be required.

E.2.1.1 Provide means of access to the stilling well, if used, to allow manual cleaning.

SECTION F. STORAGE TANKS

F.1 Material Selection

F.1.1 Tank materials must be compatible with the commodity that is to be stored. The material must not corrode or deteriorate over time.

F.2 Tank Features

F.2.1 Atmospheric tanks shall be equipped with a vent line, routed to the outdoors where necessary, and fitted with an insect screen. Size vent lines properly to prevent tank collapse during pump out or drainage, or over-pressurizing the tank during filling or purging.

F.2.2 When two tanks (containing the same commodity) are in parallel, combine the overflow lines such that one tank will first overflow into the second tank before it overflows to drain or to the containment system.

F.2.3 Provide tanks with labels indicating the tank capacity, the chemical to be stored and its specific gravity.

SECTION G. PIPING SYSTEMS

G.1 General Requirements

G.1.1 Process mechanical piping includes all piping directly associated with any and all treatment processes. The majority of process mechanical piping shall be located within buildings, tunnels, and galleries.

G.1.2 Coordinate concrete encased piping with the structural engineering discipline and buried process mechanical piping with the civil engineering discipline to ensure proper design for earth loads and traffic loads.

G.2 Pipe Specifications

G.2.1 Refer to Schedule 18 – Technical Requirements – Appendix 18B – Specifications for additional requirements.

G.3 Pipe Flow Velocities

G.3.1 Pipelines shall be sized to limit velocities as shown in Table 2.

Table 2: General Flow Velocities

Type	Velocity
Gravity	1) an average velocity of 1.2 to 1.5 m/s, 2) a minimum velocity of 0.6 m/s (to prevent settling of solids); 3) a maximum velocity of 2.4 to 2.7 m/s (to minimize erosion and head loss).
Pressure	1) an average velocity of 1.5 to 2.4 m/s, 2) a minimum velocity of 0.6 to 0.9 m/s; and 3) a maximum velocity of 3.0 to 3.6 m/s.
Air	1) 6 to 9 m/s for sizes 75 mm diameter and smaller, 2) 9 to 15 m/s for sizes 100 to 250 mm, 3) 15 to 19 m/s for sizes 300 to 600 mm; and 4) 19 to 33 m/s for sizes 750 mm and larger.

G.4 Piping Identification

G.4.1 All piping shall be identified in accordance with the *WWD Identification Standard* and the *WWD NEWPCC Paint Colour Standard*, which are found in Schedule 18 – Technical Requirements – Appendix 18D – City Standards.

SECTION H. VALVES

H.1 Valve Specifications

H.1.1 Refer to Schedule 18 – Technical Requirements – Appendix 18B – Specifications for additional requirements.

H.2 Manually Operated Valves

H.2.1 Provide hand wheel operators for manual valves 200 mm in diameter and larger

H.2.2 Provide wrench levers operators for quarter-turn valves (plug, butterfly, and ball) smaller than 200 mm.

H.2.3 Operator force shall not exceed 177 N under any operating condition, including initial breakaway. Provide gear reduction operator when force exceeds 177 N.

H.2.4 Provide buried valves with square head operating nuts, extension stems, and valve boxes at grade. Gate valves shall generally be the rising stem type; use non-rising stems only where space is limited.

H.3 Power Actuated Valves

H.3.1 Power-actuated valves shall be installed where required for automatic process control. Additionally, power actuators shall be provided for the following applications:

(a) valve operation is required at least once per shift;

(b) quick valve operation may be required because of an emergency;

(c) slow valve operation may be required to prevent water hammer;

(d) large valves where manual operation would be cumbersome; and

(e) valves which are difficult to access.

H.4 Electric Actuated Valves

H.4.1 Provide electric motor operators with manual override for power-actuated valves, for both open-close service and modulating service.

H.4.2 Small open-close valves (20 mm and smaller) shall be solenoid operated.

H.4.3 In general, 120V single-phase actuators shall be used for valves 50 mm and smaller; 600V three-phase actuators shall be used for valves 100 mm and larger.

H.4.4 Use City's standard actuators as specified in Schedule 18 – Technical Requirements – Appendix 18E – Standardized Goods.

H.4.5 Ensure the running and breakaway torque safety factors ratings are appropriate for the specific valve type and service. Actuators shall be rated at least twice the valve operating torque, or twice the breakaway torque, whichever is greater, unless it can be proven, in writing, that a lower safety factor is sufficient. Minimum safety factors for clean fluid applications are as follows:

(a)	butterfly valves:	1.3 (with proof)
(b)	eccentric plug valves:	1.5 (with proof)
(c)	gate valve:	1.5 (with proof)
(d)	sluice and slide gates:	2.0 (no exceptions)

H.4.6 Ensure actuator duty rating is greater than the worst operating case.

H.4.7 Ensure solid-state modulating actuators are specified for control applications.

H.5 Pneumatic Operated Valves

H.5.1 Pneumatic operated valves shall be limited to the following applications:

(a) fast opening or closing of the valve is required for process control; or

(b) failsafe valve operation is required.

H.5.2 Pneumatic actuators shall comply with AWWA C541 and shall include air sets, exhaust mufflers, speed controls, pilot solenoids and safety-vented isolation valves.

H.6 Control Valves

H.6.1 The appropriate valve flow characteristic (quick opening, linear, equal percentage, modified parabolic) shall be selected based on the application (pressure relief, pressure control, flow control, level control) and the proportion of total system head loss available as pressure drop across the valve.

H.6.2 The turndown ratio (the ratio of maximum to minimum flow) shall not exceed 5:1.

H.6.3 The required valve operating range shall be maintained within 15 to 80 percent of the maximum flow coefficient (Cv) for optimum control. Valves shall be sized to pass the maximum flow at minimum pressure drop with the valve operating at not more than 80 percent of maximum capacity.

H.6.4 In a throttled constant-speed pump system, the pressure drop across the valve at maximum flow shall be at least 40 percent of the system total frictional loss (including the control valve) when the system static head exceeds 70 of the total dynamic head (TDH), at least 30 percent when the static head is 50 to 70 percent of the TDH, and at least 20 percent when the static head is less than 50 percent of the TDH.

H.6.5 In a system where static pressure or head moves liquid from one vessel to another, the pressure drop across the valve at maximum flow shall be at least 10 percent of the system static pressure, or 40 percent of the system total frictional loss (including the control valve), whichever is greater.

H.6.6 In all cases, the valve shall be at least 10 percent open at the maximum throttling (minimum flow at maximum pressure drop) position. The minimum opening is 15 percent.

H.7 Check Valves

H.7.1 Check valves shall be installed on all pipes where passive backflow prevention is not present and where backflow is not desired.

H.7.2 Swing check valves on pump discharges to have a weighted lever arm with visual indication of position.

H.7.3 Install check valves on pump discharges upstream of isolation valve.

H.7.4 Check valve alone is not sufficient for isolation.

SECTION I. DRAWINGS

I.1 Process Plan Drawings

I.1.1 Process plan drawings are required for every floor elevation, including the roof if equipment is located on the roof.

I.1.2 Show the arrangement of all process equipment, including all piping.

I.1.3 As a minimum, show all pipe supports for piping 600 mm and larger.

I.1.4 All equipment and valves shall be identified.

I.1.5 Show pipe elevations.

I.1.6 Produce drawings at the following scales:

(a) 1:50 recommended; or

(b) maximum of 1:100 where there is limited equipment and piping detail to show.

I.1.6.2 Include a scale bar.

I.2 Process Plan Overview Drawings

I.2.1 Where process plan drawings may only show a portion of the process, process plan overview drawings are required to show the complete floor elevation for all floors with major equipment, including the roof if equipment is located there.

I.2.2 Show the arrangement of all major equipment and piping.

I.2.3 Produce drawings at the following scales:

(a) 1:100 – 1:150 recommended; or

(b) maximum of 1:200 where there is limited equipment and piping detail to show.

I.2.3.2 Include a scale bar.

I.3 Process Section and Detail Drawings

I.3.1 Provide process section and detail drawings to completely make clear the required installation of the process systems.

I.3.2 Clearly identify all materials of construction

I.3.3 Clearly show all dimensions.

I.3.4 As a minimum, show all pipe supports for piping 600 mm and larger.

I.3.5 Show all equipment and valves.

I.3.6 Produce drawings at the following scales:

(a) 1:50 recommended; or

(b) maximum of 1:100 where there is limited equipment and piping detail to show.

I.3.6.2 Include a scale bar.

SECTION J. OTHER DOCUMENTS

J.1 Equipment List

J.1.1 Provide a comprehensive Master Equipment Schedule, to align with the requirements of this section, and Schedule 18, Section C.

J.1.1.1 Organize the list into a separate document for each process area (area code).

J.1.2 Include the following in the list:

(a) equipment identifier;

(b) equipment description;

(c) P&ID drawing number;

(d) equipment datasheet document number;

(e) location;

(f) equipment type;

(g) service; and

(h) other information as applicable.

J.1.3 Produce equipment lists in Microsoft Excel.

J.2 Equipment Datasheets

J.2.1 Provide equipment datasheets for each piece of equipment, including at a minimum, all equipment with electric motors or internal combustion engines.

J.2.2 Provide complete and comprehensive details to specify the application and supply requirements for the equipment.

J.2.3 Include pump curves for pumps.

J.2.4 Produce equipment datasheets in Microsoft Word with charts, diagrams, etc. included as applicable.

J.2.5 A unique datasheet with a unique document number shall be provided for each piece of equipment. The only exception is as follows:

(a) a single datasheet may describe multiple units where the equipment is 100% identical, including motor size, rotation, etc. Indicate the number of units and their unique tag numbers.

J.3 Valve List

J.3.1 Provide a comprehensive valve list.

J.3.2 The list shall be organized in a master list that can be sorted by process area, valve type, size, etc.

J.3.3 Include gates and stop logs in the valve list.

J.3.4 Include the following in the valve list:

(a) valve identifier;

(b) valve description;

(c) valve type;

(d) actuator;

(e) P&ID drawing number;

(f) specification / datasheet document number;

(g) location;

(h) service; and

(i) other information as applicable.

J.3.5 Produce the valve list in Microsoft Excel.