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PART 1 - INTRODUCTION

1.1 PURPOSE

A. This section is intended to provide guidelines for Manholes requirements.

PART 2 - GENERAL DESIGN REQUIREMENTS

A. GENERAL

1. General Layout Requirements: There are two types of manhole configurations that are accepted. The preferred configuration is to have forced ventilation with separate utility and support manholes that keep all electrical equipment out of the utility manhole with the hot piping. Requirements for this type of manhole layout are illustrated in Detail 4-1, Typical Steam Manhole Layout with Forced Ventilation. The more traditional configuration is to have natural ventilation with one manhole that includes all electrical equipment. Prior to beginning design for the project, refer to Yale Utilities for direction.

   a. Operators must enter manholes periodically for maintenance and for isolating and starting systems. When entering the manholes, personnel must test for oxygen, possibly provide outside ventilation, and possibly wear harnesses from tripods. The configuration of piping within the manholes shall be made in consideration of an Operator maneuvering around the space with a harness connected to his or her body. Piping shall be routed along the walls as much as possible. Keep the middle area open. Arrange piping so the Operator does not have to crawl over and under things.

   b. When a steam main is heated up after a shutdown or outage, the steam line can be relatively much colder than the steam entering the pipe. When the pipe is re-energized, this causes a significant amount of condensate to form in the distribution piping. Since there is no pressure in the steam main to drive the condensate out through the steam traps and into the condensate return piping,

Operators must manually open drain valves in the manholes and let the condensate spill on the floor. Locate the drain valves so they are accessible and direct the drain away from the Operator. Note that the Operators cannot close these drain valves until the pressure in the system reaches 50 to 100 PSIG to a point where Operators know that the steam traps can push the condensate back through the piped return system. This underlines the need for ventilation in the manholes and sump pumps that are rated for temperature.

c. Consult with Yale Utilities before naming a new manhole or identifying existing manholes. Do not name new manholes MH-1 or 101.

2. Forbidden Utilities
   a. Utilities that are not allowed in manholes under any circumstance include: natural gas, electric greater than 480VAC, telecom, domestic water, and storm sewer.

3. Minimum Size
   a. The minimum size of the utility manhole shall be 8 feet wide by 8 feet long by 6 ½ feet tall (inside dimensions), which must provide adequate space for maintenance accessing piping system, including expansion joints, traps, valves, etc. Only Yale Utilities can permit a smaller manhole size. Provide a separate support manhole for sump pumps, lights, and fan. Minimum size for the support manhole shall be 4 feet wide by 4 feet long by 6 ½ feet tall (inside dimensions).

4. Ventilation System: Forced ventilation shall be used for all locations except as permitted by Yale Utilities. Requirements for natural ventilation are also included below for locations where natural ventilation is accepted by Yale Utilities. The air temperature in an unventilated manhole containing steam can be very difficult for an Operator to do work for any significant amount of time. Also, ventilation helps keep the humidity down. With the reduction of heat and humidity, ventilation helps to protect electrical equipment.

   a. Forced Ventilation: Forced ventilation shall be provided via a fan located in the wall between the support manhole and the utility manhole. Air shall be drawn into the utility manhole through a ventilation pipe from the ceiling. The hot air shall discharge from the top of the utility manhole through a ventilation pipe. The fan shall be rated for 150 deg F, ambient service. The fan shall run continuously - no temperature control shall be provided. The fan shall be direct

drive, 1750 RPM, propeller type, with a guard on the motor side and a backdraft damper on the outlet. The fan shall have aluminum housing and blades. Due to the radiated heat from the steam piping, it is difficult to select fan performance based off of trying to maintain a space temperature. At a minimum, size the fan for the greater of 15 air changes per hour or 500 CFM. The static pressure must be adequate to move the air and it is recommended to be a minimum of 0.5 inches H20. The motor shall be 115VAC, 1-phase, 60 hertz with 15-foot, 3-conductor SOOW type cord with bare lead ends. A single-phase motor starter in a NEMA 250, Type 12 enclosure shall be supplied with the fan assembly and shall be mounted next to the sump pump control panel. Refer to Part 4.A.8 for sump pump control panel location requirements. Label motor starter per Part 4.A.14.

b. Natural Ventilation: Only provide natural ventilation where approved by Yale Utilities. Each manhole shall be designed with a High vent and Low vent. The High vent shall be positioned at the furthest possible location from the Low vent across the manhole and one foot from the ceiling of the manhole. The Low vent shall be positioned one foot from the bottom of the manhole.

1) The High and Low vent pipes shall be routed to a common point. The maximum length of either vent pipe shall be 30 feet. The common point shall be positioned to be out of traffic (pedestrian and vehicular) travel ways and in the most conspicuous area located near the manhole.

2) Each vent pipes shall terminate with a "goose neck", 36 inches above grade. The High and Low "goose necks" shall be 180 degrees from each other. The exposed portion of the vent pipes shall be painted with a rust inhibitive paint whose color shall be black or a more appropriate color to architecturally blend with the surroundings. In sensitive architectural areas, the vent pipes can be terminated below grade, within a vent coffer, similar to Detail 4-3, Vent Coffer Details.

c. Ventilation Piping
1) Whether for forced or natural ventilation, the vent piping shall be as follows:
2) Vent pipes for forced ventilation shall be sized by the Engineer to keep air velocity to acceptable levels and in consideration of static pressure.

Vent pipes for forced and natural ventilation shall be a minimum of 8" nominal pipe size. Larger pipe sizes may be required for forced ventilation and natural ventilation of larger manholes.

3) Vent Pipe Material: Shall be:
   a) Cast iron pipes. Refer to Part 3.B.2, Penetrations for sealing the vent piping penetrations; or,
   b) Schedule 40 steel pipes. The steel pipes shall be cast within the manhole walls with a water stop. All steel shall be painted, refer to Part 12, Painting.
4) The High and Low vent pipes shall be routed to a common point. The maximum length of either vent pipe shall be 30 feet. The common point shall be positioned to be out of traffic (pedestrian and vehicular) travel ways and in the most conspicuous area located near the manhole.
5) Each vent pipes shall terminate with a "goose neck", 42 inches above grade. The High and Low "goose necks" shall be 180 degrees from each other. The exposed portion of the vent pipes shall be painted black, or a more appropriate color to architecturally blend with surroundings as approved by Yale Utilities. In sensitive architectural areas, the vent pipes can be terminated below grade, within a vent coffer, similar to Detail 4-3, Vent Coffer Details. No mushroom style caps shall be used - experience has shown that snow drift blocks air flow.

5. Minimum Cover
   a. The minimum cover on top of manholes shall be in accordance to the following areas:
      1) Paved areas (parking lots, driveways, roadways, sidewalks, etc.): 18 inches.
      2) Landscape areas (lawn/grassed areas, planting beds, etc.): 3 feet

6. Manhole Lids/ Access Doors: Provide for utility and support manholes.
   a. Vehicle Traffic Areas:
      1) Opening: Each shall meet HS-20 traffic loading requirements.
         a) Grade Rings: Provide 2 or 3 reinforced concrete rings, of 6-8 inch total thickness and match 42 inch diameter frame and cover.
         b) Gaskets: ASTM C 443, rubber.
         c) Joints inside and outside shall be patched with non-shrink grout.
      2) Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, heavy-duty, traffic bearing, ductile iron, 42 inch opening by 7 to 9 inch riser

with 4 inch minimum width flange, and 44 inch minimum diameter cover, indented top design, with lettering "STEAM" or "CHW" cast into cover.

3) Manhole Security/Lock:
   a) Provide "LockDown" manhole security system by LockDown-LockDry, a Division of BartonSouthern (800-572-3110) for each manhole opening.
   b) Provide one "Abloy" PL330/25 padlock or "Best" 41B722 padlock and keys for each "LockDown" system.

b. Non Vehicle Traffic Areas:
   1) General: Furnish each access door assembly manufactured as an integral unit, complete with all parts, and ready for installation, meeting HS-20 traffic loading requirements.
   2) Aluminum Access Doors and Frames: Fabricate units of aluminum.
      a) 6 mm aluminum diamond plate with stiffeners for doors.
      b) 6 mm aluminum channel with perimeter anchor flange for frame.
      c) Doors shall be insulated with polystyrene insulation and provided with stainless steel hinges and chrome plated hardware.
      d) Provide Bilco Type "J", Babcock-Davis "B-FHA" Series, or acceptable.
   3) The frame drain shall be routed to the sump at the bottom of the manhole.
   4) Doors shall be spring loaded to open.
   5) Provide two keys for each door.

7. Ladders
   a. Comply with ANSI A14.3.
   b. Siderails: Continuous, 1/2 by 2-1/2 inch steel flat bars, with eased edges, spaced 18 inches apart.
   c. Bar Rungs: 3/4 inch diameter steel bars, spaced 12 inches o.c.
   d. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.
   e. Support each ladder at top and bottom and not more than 60 inches o.c. with welded or bolted steel brackets. Size brackets and fasteners to support design loads specified in ANSI A14.3. Refer to Detail 4-4.
   f. Provide non-slip surfaces on top of each rung, either by coating rung with aluminum- oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.

g. Galvanize ladders, including brackets and fasteners, to G-90 at all locations.
h. Provide extension egress sections (ladder extension safety post) to all ladders similar to "Bilco Ladder-Up" or approved equal.

8. Sump Pumps
   a. The prevention of the flooding of a manhole is critical to life safety and energy savings. A flooded manhole can cause condensate induced water hammer in the steam piping system and cause catastrophic failure. Flooded manholes destroy insulation and severely decrease the life of the system. In addition, flooded manholes are very difficult to service because they have to be pumped out from above and they are usually very hot because the insulation is usually gone. For these reasons, sump pumps cannot be "value engineered" out of the design of a utility manhole that contains steam or condensate piping.
   b. Sump pumps shall be located in the support manhole so that the electronics are located in the cooler space, outside of the utility manhole. A trench shall be provided to the sump from the utility manhole to the support manhole.
   c. Provide duplex electric powered sump pumps which shall be alternate lead/lag. When one pump is not doing the duty, the other pump shall energize to help handle the load. Single pump systems are not allowed. No steam powered sump pumps are allowed.
   d. Sump pump capacity shall be a minimum of 25 GPM for manholes with no chilled water piping or with chilled water piping under 8" NPS. Sump pumps in manholes that have chilled water piping of 10" NPS or greater shall be sized for 50 GPM.
   e. Due to ease of construction, the preference for the basin is to have a 3' diameter by 3' deep stainless steel cylinder. Basins of concrete or cast iron can also have minimum dimensions of 3' x 3' x 3'. The sump shall have a 1/2" grid stainless steel mesh over the top to prevent large debris from entering the sump and to allow maintenance crew to clear the debris from the up top, not down in the sump. Do not provide an integral strainer with the pump so that it does not clog. Do not provide enclosed basins - there are no floor drains in the manholes. Water shall make its way on the floor to the sump.
   f. General Pump Specifications
      1) Pumps shall be vertical, centrifugal, end suction, single stage, complete with float switch controls. The pump shall be rated to handle liquids up to 200 degrees F for manholes that have steam or condensate. For manholes that have chilled water only, the sump pumps can be rated for liquids up to 100 degrees F. The pump shall have 1/2 inch solids

handling capability.

2) Casing: Cast iron with integral cast-iron inlet strainer and Ryton legs to elevate the pump to permit flow into the impeller. Discharge female threaded connection shall be arranged for vertical discharge and suitable for plain-end pipe connection. Casing shall have epoxy coating for corrosion resistance. Provide stainless steel lifting ring, screws, and bolts.
3) Impeller: Statically and dynamically balanced, open or semi open, overhung, single suction, vortex style, fabricated from Nylon, keyed to shaft and secured by a locking cap screw. Volute to be epoxy-coated cast iron.
4) Seals: Mechanical seals.
5) Submersible Motor: 460VAC, 3 phase, 60 hertz oil filled for rapid heat dissipation with 15-foot, 3-conductor SOOW type cord with bare lead ends.
6) Acceptable Manufacturers: Crane Barnes, Goulds, Little Giant, or Zoeller

g. Sump pump discharge piping shall be configured to allow for easy dismantling of pump for removal and replacement.
h. Install a non-slam check valve and gate valve on the discharge side of pump.
i. Duplex Sump Pump Control Panel: The pump manufacturer shall provide a factory- assembled, and UL listed and labeled duplex sump pump control panel for each pair of sump pumps. For the preferred configuration where there is a utility manhole and a support manhole, the duplex sump pump control panel shall be located in the building supplying power for the sump pump circuit. For the traditional manhole configuration where there is only a utility manhole, the control panel shall be included in the manhole. Refer to Yale Utilities for sump pump control panel power supply location. The control panel shall be supplied with the following components:
    1) NEMA 4X stainless steel enclosure with ANSI 61 light grey exterior and white interior. The enclosure shall have external mounting tabs for wall mounting.
    2) Three-pole molded case thermal magnetic circuit breaker sized for motor load, with external flange mounted disconnect switch handle. External disconnect switch handle shall be capable of being padlocked in the open position.
    3) NEMA rated motor starters with three-pole motor circuit protectors to provide individual motor starter short circuit protection, three-pole magnetic contactors, and Class 10 ambient compensated bimetal overload relays.

4) Control power transformer with primary and secondary fuses, line voltage primary and 120V grounded secondary, with a minimum of 50VA additional capacity.
5) Door-mounted HAND-OFF-AUTO selector switch, START pushbutton, STOP pushbutton, RESET pushbuttons for overload relays, red LED MOTOR STOPPED, and green LED MOTOR RUNNING pilot lights for each pump motor.
6) Solid state lead-lag pump alternator with float status lights.
7) Lag pump delay start relay.
8) Alternator shall be suitable for four sump float operation (low level - pumps off, lead pump on, lag pump on, high level alarm). Dry contact shall be provided for remote high level alarm notification.
9) Alternator selector switch to override the lead-lag alternator and allow operation of pump 1 or pump 2 only.
10) 115V anti-condensation heater connected to 120V control transformer. Heater shall be provided with adjustable thermostat and over-temperature control.
11) Local external high level alarm light and horn.
12) 115VAC service light to provide internal panel illumination during service work.
13) Internal 115VAC duplex convenience receptacle.
14) Terminal blocks shall be provided for connection of level controls and other control wiring as required for proper pump installation.
15) Motor starters, relays, and other internally mounted components shall be DIN rail mounted.
16) Internal wiring shall be THHN/THWN/MTW 600V insulated copper wire.
17) Wire between devices shall be neatly routed inside plastic wireways with slots for wiring and snap-on plastic covers.
18) Field wiring shall be terminated at insulated terminal strips with compression plates. No more than two wires shall be installed at each terminal.
19) Sump float switches shall be mounted from top to bottom in the following order:
    a) High Level Alarm
    b) Lag Pump On
    c) Lead Pump On
    d) Low Level

20) Pump sequence of operation shall be as follows:
   a) Sump empty: Pumps off.
   b) Sump level rises to lead pump float switch: Start lead pump.
   c) Sump level rises to lag pump float switch: Start lag pump.
   d) Sump level rises to high level alarm float switch: Transmit high level alarm to Yale Customer Service Control Center. Refer to Yale Utilities for location of alarm termination location.
   e) Shut off pumps when level falls below low level float switch.
   f) Pumps alternate lead and lag for next pump out cycle.

9. Lighting
   a. Provide 2-lamp, 32-watt, 4-foot fluorescent fixture with electronic T8 ballast, universal voltage (120-277VAC), polycarbonate lens, stainless steel latches, and non-metallic housing. Manufactures shall be Simkar (Catalog No. OV451232-B11SSUNV) or approved equal.
   b. Light fixtures shall be mounted as close to the manhole ceiling as possible.
   c. For manhole throats that are deeper than 10 feet, mount light fixture vertically in throat to provide lighting for ladder access. Light fixture shall not impede personnel access into the manhole.
   d. Manhole maintained light level shall be 10 footcandles minimum.
   e. Provide 20A, 120/277VAC, Marine Grade, single-pole toggle switch with lighted handle. Handle shall illuminate when the switch is on. Manufacturer shall be Hubbell (Catalog No. HBL1221PL). Alternate manufacturers are not allowed.
   f. Provide silicone rubber weatherproof switch plate for use with above light switch. Manufacturer shall be Hubbell (Catalog No. HBL1795). Alternate manufacturers are not allowed.
   g. Light switch shall be mounted as close to the manhole throat opening as possible.
10. Receptacles
   a. Provide 20A, 125VAC, Marine Grade, duplex ground fault circuit interrupter (GFCI) receptacle. Manufacturer shall be Hubbell. Alternate manufacturers are not allowed.
   b. Provide Marine Grade weatherproof cover plate for use with above receptacle. Manufacturer shall be Hubbell. Alternate manufacturers are not allowed.
   c. Receptacle shall be mounted as closed to the manhole throat opening as possible.
   d. Receptacles in manhole shall be mounted 4 feet above finished floor. One receptacle per chamber of manhole is required.

11. Wire and Cable - Steam and Condensate Manholes
    a. All power and control conductors shall be UL listed, Type SF-2, stranded copper, 600 Volt Appliance and Fixture Wire. Manufacturers shall be Allied Wire & Cable, Cable USA, First Capitol Wire & Cable, York Wire & Cable, Inc. or approved equal. Aluminum conductors are not allowed.
12. Wire and Cable - Chilled Water Manholes
    a. All power and control conductors shall be UL listed, Type XHHW, 600V, stranded copper cable. Manufacturers shall be Southwire Company, American Insulate Wire Corp., General Cable, or approved equal. Aluminum conductors are not allowed.
13. Conduit and Accessories
    a. Exposed conduit shall be rigid galvanized steel. The conduit exterior and interior shall be hot-dipped galvanized in accordance with ANSI C80.1. The conduit threads shall be hot-dipped galvanized after fabrication. The conduit shall be provided with a corrosion protective coating. Conduit shall be NRTL-listed and labeled under UL 6. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube Company, or Western Tube & Conduit Corporation.
    b. Conduit elbows, couplings, and fittings shall be rigid galvanized steel. Elbows, couplings, and fittings shall be hot-dipped galvanized and also have a corrosion protective coating. All conduit accessories shall be NRTL and UL listed.
    c. Sheet metal pull boxes and junction boxes shall be NEMA 250, Type 4X fiberglass or stainless steel. All boxes shall be UL listed.
    d. Cast metal outlet and device boxes shall be galvanized and epoxy- or polyester-coated malleable iron, Type FD or FS, with gasketed cover. All boxes shall be UL listed.
    e. Conduit bodies shall be galvanized cast steel or malleable iron Form 8 with oil-resistant gasket and galvanized cast steel or malleable iron cover. Provide mogul bodies for fittings in trade sizes 2 inch and larger. Conduit bodies shall be UL listed.
    f. Exposed conduit at connections to transformers, motor-driven equipment, vibrating equipment, and equipment requiring position adjustment shall be liquidtight flexible metal conduit (LFMC). The conduit shall be of the flexible steel type GP with PVC jacket and used in accordance with NEC Article "Liquidtight Flexible Metal Conduit: Type LFMC." The conduit shall be NRTL-listed and labeled under UL 360. UL listed steel insulated-throat screw-in connectors, suitable for use as a grounding fitting, shall be used where LFMC conduit is used.

14. Identification
    a. Equipment Identification
        1) Label shall be engraved, laminated acrylic punched or drilled for screw mounting with white letters on a black background. Minimum letter height shall be 3/8 inch.
        2) Fasteners shall be self-tapping, stainless-steel screws.
        3) Mount to front panel of equipment.
        4) Legend shall be as follows:
        5) Equipment designation (i.e. Sump Pump No. 1 Control Panel)
        6) Power source equipment designation and circuit breaker number (if fed from a panelboard) (i.e. Panelboard DP-1 Ckt. 21, 23, 25)
        7) Power source location - Building, Room and/or Floor (i.e. Central Power Plant, 2nd Floor Electrical Room)

    b. Receptacle and Light Switch Identification
        1) Label shall be engraved, laminated acrylic punched or drilled for screw mounting with white letters on a black background. Minimum letter height shall be 3/8 inch.
        2) Fasteners shall be self-tapping stainless-steel screws.
        3) Mount label on wall next to receptacle or switch.
        4) Legend shall be as follows:
            a) Power source equipment designation and circuit breaker number (i.e. Panelboard DP-4 Ckt. 15)
            b) Power source location - Building, Room and/or Floor (i.e. Central Power Plant, 3rd Floor Mechanical Room)

    c. Raceway Identification
        1) Label shall be colored, heavy duty, waterproof, fade resistant self-adhesive vinyl.
        2) System color identification for low voltage systems equipment shall be as follows:
            a) Power Circuits: Black letters, indicating system or service and voltage, on an orange field.
            b) Control Wiring: Green and red.
        3) Apply colored tape around conduit as follows:
            a) At least once in each 20 feet of conduit.
            b) Where conduit enters inaccessible spaces.
            c) At least once in each room or area through which the conduit

passes.

15. Structural Requirements
    a. Reinforcing Bars: ASTM A 615 Grade 60 (ASTM A 615M Grade 400), deformed.
    b. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire bar-type supports complying with CRSI specifications
    c. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to The Designer for preparing and reporting proposed mix designs.
    d. Design mixes to provide normal weight concrete with the following properties as indicated on drawings and schedules:
        1) 4000 psi (27.6 MPa), 28-day compressive strength; water-cement ratio, 0.45 maximum (non-air-entrained).

B. WATERPROOFING MATERIALS

Provide one of the following options or a combination of two of the options:

1. Option 1
   Provide a dual-waterproofing, resealable, composite sheet membrane system composed of high-density polyethylene with a sodium-bentonite face designed for buried concrete or masonry construction, as manufactured by Tremco, equal system.
    a. Obtain primary waterproofing materials of each type required from a single manufacturer to greatest extent possible. Provide accessory materials that are approved by membrane manufacturer.

    b. Membrane Properties: Equal to Tremco "Paraseal Membrane LG", or equal for use on buried vertical and horizontal conditions such as backfilled foundation walls, below slab with bentonite-side up, retaining walls and ponds:
        1) Puncture resistance: 95 psi.
        2) Tensile strength: 4,000 psi.
        3) Water permeability through membrane: 2.7 x 10-13 cm3/cm2/sec.
        4) Water permeability through seam: 4.6 x 10-13 cm3/cm2/sec.
        5) Resistance to hydrostatic head: 150 feet-zero leakage
        6) Percent elongation: 700 percent
        7) Water migration under membrane: 0 at 150 ft. water head

8) Warranted crack-bridging capability: developing cracks to 1/8 inch
9) Sheet size: 24'-0" x 4'-0"

c. Auxiliary Materials
1) Adhesives and Joint Tape: Provide types of adhesive compound and tapes recommended by waterproofing sheet manufacturer for bonding to substrate (if required), for waterproof sealing of seams in membrane, and for waterproof sealing of joints between membrane and flashings, adjoining surfaces, and projections through membrane.
2) Primers: Provide type of concrete primer recommended by manufacturer of sheet waterproofing material for applications required.
3) Flashing Materials: Except as otherwise indicated, provide types of flexible sheet material for flashing as recommended by waterproofing sheet manufacturer.
4) Protection Board: Provide type of protection board recommended by waterproofing sheet manufacturer. Include adhesives recommended by manufacturer.

2. Option 2
Provide a Pre-applied Integrally Bonded Sheet Waterproofing Membrane: A 1.2 mm nominal thickness composite sheet membrane comprising 0.8 mm (0.030 in.) of high density polyethylene film, and layers of specially formulated synthetic adhesive layers. The membrane shall form an integral and permanent bond to poured concrete to prevent water migration at the interface of the membrane and structural concrete. Provide membrane with the following physical properties:

Property	**Test Method**	**Typical Value**
Color		White
Thickness	ASTM D 3767 Method A	1.2 mm (0.046 in.) nominal
Low Temperature Flexibility	ASTM D 1970	Unaffected at -23°C (-10°F)
Elongation	ASTM D 412 Modified1	> 300%
Crack Cycling at -23°C (- 10°F), 100 Cycles	ASTM C 836	Unaffected
Tensile Strength, Film	ASTM D 412	27.6 MPa (4,000 lbs/in.2) minimum
Peel Adhesion to Concrete	ASTM D 903 Modified2	880 N/m (5.0 lbs/in.)

Lap Adhesion	ASTM D 1876 Modified3	440 N/m (2.5 lbs/in.)
Resistance to Hydrostatic Head	ASTM D 5385 Modified4	>70 m (231 ft)
Puncture Resistance	ASTM E 154	990 N (180 lbs) minimum
Permeance	ASTM E 96 Method B	<0.6 ng/m2sPa (0.01 perms)
Water Absorption	ASTM D 570	<0.5%

a. Footnotes:
   1) Elongation of membrane is run at a rate of 50 mm (2 in.) per minute.
   2) Concrete is cast against the protective coating surface of the membrane and allowed to cure (7 days minimum). Peel adhesion of membrane to concrete is measured at a rate of 50 mm (2 in.) per minute at room temperature.
   3) The test is conducted 15 minutes after the lap is formed as per manufacturer's instructions and run at a rate of 50 mm (2 in.) per minute at -4°C (25°F).
   4) Hydrostatic head tests are performed by casting concrete against the membrane with a lap. Before the concrete sets a 3 mm (0.125 in.) spacer is inserted perpendicular to the membrane to create a gap. The cured block is placed in a chamber where water is introduced to the membrane surface up to a head of 70 m (231 ft) of water, which is the limit of the apparatus.

Properties	**Test**	**Requirement**
Tensile Strength	ASTM D412	1200 psi
Ultimate Elongation	ASTM D412	410%

   5) Elastomeric nosing: Cold-applied 2-part polyurethane resin mixed with sand particle aggregate. Material shall flow so as to fill voids in concrete blockout and underneath perforated flanges of sealing insert creating watertight bond with sealing insert.

Properties	**Test**	**Requirement**
Tensile Strength	ASTM D 2240	600 psi
Ultimate Elongation	ASTM D 2240	25%

b. Provide a Fluid Applied Waterproofing Membranes: A two part, self-curing,

synthetic rubber based material. Fluid applied membranes shall meet or exceed the performance requirements of ASTM C 836 and other ASTM standards as shown in the following table.

1) Waterproofing Membrane Physical Properties

Property	**Test Method**	**Typical Value**
Color		terra cotta
Cured Film Thickness	ASTM D 3767 Method A 1.5 mm (0.060 in.) nominal	1.5 mm (0.060 in.) nominal
Solids Content	ASTM D 1644 100%	100%
Flexibility, 180° bend over 25 mm (1 in.) mandrel at 32°C (-25°F)	ASTM D 1970	Unaffected
Elongation	ASTM D 412	500% minimum
Peel Adhesion to Concrete	ASTM D 903 Modified	880 N/m (5 lbs/in.)

2) Protection Board
   a) Asphalt Hardboard: A premolded semi-rigid protection board consisting of bitumen, mineral core and reinforcement. Provide 3 mm (0.125 in.) thick hardboard over waterproofing on horizontal surfaces.
   b) Expanded Polystyrene Protection Board: 25 mm (1 in.) thick for vertical applications with the following characteristics.
   c) Normal Density: 16 kg/m3 (1.0 lb/ft3)
   d) Thermal Conductivity, K factor: 0.24 at 5°C (40°F), 0.26 at 24°C (75°F)
   e) Thermal Resistance, R-Value: 4 per 25 mm (1 in.) of thickness.

C. WATERPROOFING METHODS
   1. General
      Install waterproofing per manufacturer recommendation. Both membrane options can be used during blind side concrete pours. Option 1 and the Fluid Applied Waterproofing portion of Option 2 can be used with access to concrete pour and stripping of forms or for precast units.
   2. Membrane Insallation
      a. Membrane Installation, Vertical Applications

1) Substrates shall be smooth and sound.
2) Strictly comply with installation instructions in manufacturer's published literature, including but not limited to, the following:
   a) Apply membrane with the HDPE film facing the prepared soil retention system (wood lagging, sheet piling, gunite, shotcrete, etc.). Remove the release liner and fasten membrane along uncoated edge to plywood with large head nails or staples.
   b) Apply succeeding sheets by overlapping the previous sheet 75 mm (3 in.) along the uncoated edge of the membrane. Side laps must be firmly rolled to ensure a tight seal.
   c) Overlap the ends of the membrane 75 mm (3 in.). Apply manufactured provided tape centered over the end lap and roll firmly to ensure a tight seal. Remove release liner for Option 2.
3) The Sub-Contractor has the option of using fluid-applied waterproofing, in lieu of pre-applied membrane waterproofing on vertical surfaces. For vertical blindside surfaces, ie., against lagging, the contractor must use pre-applied integrally bonded waterproofing.

b. Membrane Installation, Horizontal Applications
1) Earth and stone substrates shall be well compacted to produce an even, solid substrate. Remove loose aggregate or sharp protrusions. Concrete substrates shall be smooth or broom finished and monolithic. Fill gaps or voids greater than 13 mm (0.5 in.). Remove standing water prior to membrane applications. Membrane waterproofing shall be used for all horizontal blindside conditions, ie. underneath all slabs, mats and wall footings poured on-grade or on working slabs.
2) Strictly comply with installation instructions in manufacturer's published literature, including but not limited to, the following:
   a) Apply membrane with the HDPE film facing the prepared substrate. Remove the release liner during application when using Option 2. Sheet Membrane shall be used for all horizontal blindside conditions, i.e, underneath all slabs, mats and wall footings poured on-grade or on working slabs.
   b) Apply succeeding sheets by overlapping the previous sheet 75 mm (3 in.) along the uncoated edge of the membrane. Lap area must be firmly rolled to ensure a tight seal.
   c) Overlap the ends of the membrane a minimum of 75 mm (3 in.) and apply manufacturer provided tape centered over the lap and roll firmly to ensure a tight seal.

c. Protection
   1) Protect membrane in accordance with manufacturer's recommendations until placement of concrete. Inspect for damage just prior to placement of concrete and make repairs in accordance with manufacturer's recommendations

d. Inspection and Repair
   1) All waterproofing must be inspected and approved by waterproofing manufacturer's representative prior to pouring concrete. The representative shall submit a written report to the Designer and the Construction Manager describing the condition of all waterproofing. If the waterproofing is unacceptable, define what types of repairs need to be implemented for approval. A final approval report must be submitted by the representative to the Designer prior to pouring concrete

3. Fluid Applied Installation
   a. The Sub-Contractor shall examine conditions of substrates and other conditions under which this work is to be performed and notify the Construction Manager, in writing, of circumstances detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected.
   b. Preparation of Substrates
      1) Refer to manufacturer's literature for requirements for preparation of substrates. Surfaces shall be structurally sound and free of voids, spalled areas, loose aggregate and sharp protrusions. Remove contaminants such as grease, oil and wax from exposed surfaces. Remove dust, dirt, loose stone and debris. Use repair materials and methods, which are acceptable to manufacturer of the fluid-applied waterproofing.
      2) Cast-In-Place Concrete Substrates:
      3) Waterproofing application may commence as soon as the substrate can accept foot traffic. Surface shall be free of any visible water.
      4) Fill form tie rod holes with concrete and finish flush with surrounding surface.
      5) Repair bugholes over 13 mm (0.5 in.) in length and 6 mm (0.25 in.) deep and finish flush with surrounding surface.
      6) Remove scaling to sound, unaffected concrete and repair exposed area.
      7) Grind irregular construction joints to suitable flush surface.
      8) Masonry Substrates: Apply waterproofing over concrete block and brick with smooth trowel-cut mortar joints or parge coat.
      9) Plywood Substrates: Pretreat all plywood joints with 75mm (3 in.) wide, reinforced self-adhesive tape. Secure all fasteners.

10) Related Materials: Treat joints and install flashing as recommended by waterproofing manufacturer.

c. Installation
   1) Refer to manufacturer's literature for recommendations on installation, including but not limited to, the following:
      a) Apply minimum 3.0 mm (0.120 in.) in all areas to be waterproofed.
      b) If area to be waterproofed is in direct sunlight and temperature is rising, apply "scratch coat" (a thin application of fluid applied waterproofing) prior to the full application of the waterproofing membrane.
      c) In applications where a minimum slope of 11 mm/m (0.13 in./ft) can not be achieved, a two coat application of membrane is recommended to achieve the total thickness.
      d) Apply protection board and related materials in accordance with manufacturer's recommendations.

d. Cleaning and Protection
   1) Remove any masking materials after installation. Clean any stains on materials, which would be exposed in the completed work.
   2) Protect completed membrane waterproofing from subsequent construction activities as recommended by manufacturer.

e. Inspection and Repair
   1) All waterproofing must be inspected and approved by waterproofing manufacturer's representative prior to pouring concrete. The representative shall submit a written report describing the condition of all waterproofing. If the waterproofing is unacceptable define what types of repairs need to be implemented for approval. A final approval report must be submitted by the representative to the Designer prior to pouring concrete.

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