

SECTION 01 11 00

SUMMARY OF WORK

PART 1 GENERAL

1.1 SUMMARY

- A. This section outlines in general the work to be done under a new Contract at the South End Water Pollution Control Centre (SEWPCC).
- B. The Work includes the replacement of an existing Water-Cooled Chiller located in an existing wastewater treatment facility that must be kept in continuous uninterrupted operation. Plan and schedule the Work consistent with specified operational constraints and with the objective of uninterrupted operation of the existing facility.
- C. Supervise, organize, coordinate, and direct construction operations of Sub-trades and Suppliers.
- D. Removal of old Chiller, clean area and prepare foundation and accessories for new chiller installation including piping modification and concrete work.
- E. Supply, install, and put in continuous successful operation equipment and appurtenances specified herein. Include training, commissioning, and operating assistance to City as described herein.
- F. In addition to constructing the works shown on the Drawings, design, construct, and maintain, unless otherwise specified or shown on the Contract drawings, temporary works and facilities required for the construction of the works. Remove temporary works and facilities when construction is completed. Temporary works and facilities include, but are not limited to the following:
 - 1. Formwork for concrete
 - 2. Falsework and bracing for formwork or for other parts of the works while under construction.
 - 3. Bracing and shoring for partially completed masonry, steelwork, precast concrete, or other assembly.
 - 4. Scaffolding
 - 5. Electrical, instrumentation, and water services
 - 6. Blind flanges, valves plugs necessary for conducting leak testing of piping.
 - 7. Temporary Contractor trailers, including servicing (sewer, water, power, communications)
 - 8. Temporary vehicular access and parking development, maintenance, and restoration.
 - 9. Traffic control and signs
 - 10. Ramps and railings for access to facility exit doors impacted by the Work as shown on the drawings and as otherwise required for safe access and egress to and from the facility.
 - 11. Temporary covers for roof and floor openings in the areas of the Work to address safety hazards and water ingress. Supply and install temporary barriers and signage as required.

1.2 WORK COVERED BY CONTRACT DOCUMENTS

- A. The completed Work will provide the City with a new Chiller, CHLR-B679, and includes a supplemental safety features required by Code for refrigerant vapor detection and exhaust ventilation purposes. The Work consists of the demolition of the existing Chiller and replacement with new Chiller, CHLR-B679, located within the basement Boiler Room. The work also includes the installation of new HVAC system and equipment which serves the Chiller CHLR-B679 in the event of a refrigerant leak. The Work is located within the Service Building basement Boiler Room as well as main level Generator Room B109.
- B. Process units being added:
1. Install new exhaust fan EF-B682 and associated ductwork to the new chiller CHLR-B679 sized for 926 L/s (1962 cfm).
 - a. EF-B682 to be interlocked with CHLR-B679.
 - b. EF-B682 final location to be confirmed once GEN-B543 demolition work has been completed.
 2. Install new Refrigerant Vapour Leak Detector AIT-B690 located adjacent to the new chiller CHLR-B679.
 - a. Refrigerant Vapour Leak Detector AIT-B690 to actuate an audible alarm and initiate required exhaust ventilation and interlock the boilers to shut down.
 - b. Refrigerant Vapour Leak Detection AIT-B690 signal to be added to the PCS.
 3. Install 3" discharge line from the new Chiller CHLR-B679 internal PRVs to outdoors.
 4. Fan Switches HS-679-1 and HS-B679-2 to be installed inside and outside the Boiler Room.
- C. Process units being modified:
1. Existing DCS I/O to remain and be integrated into the new Chiller CHLR-B679 control.
 2. CHLR-B679 must be capable of Manual/Auto operation. Manual allows for ON/OFF control at the local panel and auto allows for future ON/OFF control at the DCS.
 3. BLR-B561 interlock with Refrigerant Vapour Leak Detection AIT-B690.
 4. BLR-B562 interlock with Refrigerant Vapour Leak Detection AIT-B690.
 5. EF-B682 Run status to be added to the PCS.
 6. EF-B682 Fail status to be added to the PCS.
 7. There are two controls in the PCS for the Cooling Tower. These existing controls will be removed from the PCS and the Cooling Tower will run from the new Chiller CHLR-B679 instead of the PCS.
 8. The existing control wires will be removed from the PLC and abandoned for the cooling tower control from PCS.
 9. The existing wiring feeds a local disconnect switch located adjacent to the chiller CHLR-B679. The existing wiring is RW90. Existing wiring to be utilized to power the new chiller from MCC.
 10. The new CHLR-B679 is designed to be feed from the same MCC-2B and will utilize an existing 150A breaker.
 11. All of the existing cabling from MCC 2B, 150A breaker to local disconnect, shall be utilized to power the new chiller.
 12. Rebalance existing Chilled Water Pumps P-B662/B663 and Cooling Water Pumps P-B690/B691 as needed.

- D. The Contract includes but is not limited to the following work:
1. Structural
 2. Architectural
 3. Mechanical
 4. Electrical
 5. Instrumentation and control systems
 6. Provide Safe Work Practice (SWP) for transportation and installation of equipment prior to commencement of Work.
 7. Demolition and removal of existing Water-Cooled York Chiller CHLR-B679 (YCWZ77JM0-58PB).
 8. Supply and installation of new Water-Cooled Chiller CHLR-B679.
 9. Supply and installation of all building mechanical upgrades as indicated, including mechanical equipment, piping and valves as shown on the Drawings and Specifications.
 10. Supply and installation of all electrical, instrumentation and control systems as shown on the Drawings and Specifications.
 11. Demolish existing chiller equipment pad.
 12. Supply and install equipment pad for new chiller CHLR-B679.
 13. Supply and installation of Systems Integration Work.
 14. Cleaning upon completion.
 15. Furnishing of materials, equipment, tools, implements, and labor.
 16. Environmental protection
 17. Safe removal and disposal of CHLR-B679 refrigerant R22.
 18. Piping
 19. Valves
 20. Cleaning of all piping, and equipment installed under this Contract in accordance with the technical specifications and in accordance with the Supply Contractor's instructions.
 21. Supply and install all hardware required to mount I&C equipment to piping systems and supply and install all isolation valves required to isolate I&C equipment.
 22. Supply and installation of all pipe coatings, bandings, and touch up of all coatings on piping and equipment installed by the Contractor prior to Total Performance including touch up coatings for City Supplied Equipment using coatings supplied by the Supply Contractor.
 23. Supply and installation of power, instrumentation, and control wiring (regardless of voltage) to all equipment supplied pursuant to any Division of the Specifications unless otherwise specified.
 24. Termination of all wiring, performing all loop checks and the calibration of all process instrumentation and controls, regardless of voltage.
 25. Submittal of all documentation including Shop Drawings, as-constructed Drawings complete with manuals, and other specific documentation as detailed by the Contract documents and required by the Contract Administrator.
 26. Coordinate construction activities and process tie-in work with the Contract Administrator and the City.
 27. Supply and install all chemicals, lubricants, and fuel for the first fill to facilitate the Functional and Demonstration tests.
 28. Provide on-site training sessions to show operations and maintenance staff how to perform maintenance and cleaning. Training should be approximately one (1) hour in length.
 29. Annual start-up, shutdown procedures.

30. Service schedule.
31. Commissioning report including as left setpoint(s), settings/Parameters.
32. Record drawings upon installation and commissioning. Provide nameplate details and bill of material (item, quantity, description, manufacturer and model number).
33. Provide Functional Testing, Performance Testing, Performance Verification and Demonstration Testing for all equipment supplied and installed under this Contract.
34. Warranty period as specified.
35. Provide local representation details and capability.

1.3 WORK NOT COVERED BY CONTRACT DOCUMENTS

- A. Unless otherwise indicated, the following work is provided under separate contract 976-2016, and does not constitute a part of the Work. Refer to Drawings for additional details.
 1. Demolition of 85 kW Standby Generator GEN-B543 and ancillary equipment.

1.4 EQUIPMENT, MATERIAL, AND SERVICES PROVIDED BY THE CITY

- A. The Contract Documents allow for an area on-site for the Contractor's use. The boundary limits must be strictly adhered to in order to minimize the impact to the natural conditions. If space is required, obtain agreement in writing from the City.
- B. The cost of electricity, telephone, gas, or other utilities, whether temporary or permanent, used for heating, lighting, power tools, testing, or other construction related purposes, fencing, security, and conveniences, will be the responsibility of the Contractor. Provide storage facilities, unloading of equipment or materials, maintenance while in storage, installation, labour and maintenance after installation.
- C. When required written notice is given, the city will take equipment out of service and isolate pipelines. A minimum of fourteen (14) Calendar Day notice shall be provided by the Contractor unless otherwise noted in the Specifications. Additional notice time may be required depending on the extent of service disruption.
- D. Draining and flushing of pipelines before removal or making connections is the Contractor's responsibility. The Contractor shall be responsibility for the removal of deposited materials and cleaning as required to perform the Work.

1.5 CONTRACT DRAWINGS

- A. The Drawings are prepared in SI metric units.
- B. For easy reference, Contract Drawings have been divided into Structural, HVAC, Electrical, and Instrumentation and Control. Read the Drawings as a whole, since details applicable to one Section may appear on the Drawings of another Section or Sections.
- C. Contract Drawings give the general location of existing equipment. Contractor shall locate existing piping, ductwork, cable tray and raceway, and equipment to limit interference with existing equipment not to be removed, pedestrian access, crane routes, and required headroom.

- D. Additional drawings showing details in accordance with which the Work is to be constructed may be supplied from time to time by the City or Engineer. Such drawings are for the information of and assistance to the Contractor and will not become a basis for extra payment. The City or Engineer may supply drawings covering additional work. These will be identified as additional work.

1.6 CONTRACT SPECIFICATIONS

- A. For easy reference, the Contract Specifications are divided into divisions. Read the Specifications as a whole, as details applicable to one division may appear in another division or divisions.
- B. Coordinate and be responsible for the work done by Subcontractors.

1.7 WORK COMPLIANCE

- A. Provide Work conforming to the lines, levels and grades specified or shown on the Contract Drawings.
- B. Build Work in a thoroughly substantial and workmanlike manner, in accordance with the Contract Drawings and Specifications, subject to such modifications and additions as may be deemed necessary during its execution. In no case will payment be made for Work in excess of the requirements of the Drawings and Specifications, unless approved in writing by Contract Administrator.

1.8 ENGINEER DESIGN

- A. Where specifications require work to be designed by an engineer, engage an engineer licensed in the Province of Manitoba to design such work.

1.9 EXAMINATION OF EXISTING CONDITIONS

- A. The existing chiller CHLR-B679 is located in the Service Building Boiler Room basement which has an access hatch from above with an opening of 1800 x 1200 mm. Contractor to ensure new chiller dimension will be accessible for final delivery and installation work.
- B. The Contractor's attention is directed to the difficulty of work involved in the running of ductwork, piping and electrical raceway routes through the existing structures and plant. The contract documents indicate the extent of work. However, it is the Contractor's responsibility to examine on site during the time of tendering the proposed pipe and electrical routings to develop a full appreciation of the scope of work.
- C. In most cases the Drawings do not specifically indicate the required cable route to be taken. It is the Contractor's responsibility to determine the best route to feed the equipment, taking into consideration: conflicts with other systems, cable tray requirements, cable ampacity and derating requirements, hazardous locations, voltage drop requirements, and any other relevant conditions that may affect the Work.

1.10 CITY'S STANDARDS DETAILS

- A. The City's Standard Specifications and Details referenced within the Contract Drawings and Specifications and those referenced therein form part of the Contract Documents.
- B. The City's Standard Details are contained in the City's Standards Manual.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 31 13

PROJECT COORDINATION

PART 1 GENERAL

1.1 RELATED WORK AT SITE

A. General:

1. Other work that is either directly or indirectly related to scheduled performance of the Work under these Contract Documents, listed henceforth, is anticipated to be performed at Site by others.
2. Coordinate the Work of these Contract Documents with work of others as specified in General Conditions.
3. Include sequencing constraints specified herein as a part of progress schedule.

1.2 UTILITY NOTIFICATION AND COORDINATION

A. Coordinate the Work with various utilities within Project limits. Notify applicable utilities prior to commencing Work, if damage occurs, or if conflicts or emergencies arise during Work.

1. Manitoba Hydro (electrical and natural gas):
2. MTS (telephone):
3. Contract Administrator
4. South End Water Pollution Control Centre:
 - a. Telephone: 204.986.6159

B. The Contractor shall plan and coordinate the Work knowing that Seniuk Road has spring road restrictions as defined by Manitoba Infrastructure and Transportation.

1.3 PROJECT MILESTONES

A. Progress schedule required under Section 01 32 00, Construction Progress Documentation.

1.4 FACILITY OPERATIONS

A. Continuous performance and operation of the SEWPCC is of critical importance. Schedule and conduct activities to enable the SEWPCC to operate continuously, unless otherwise specified. In the event of conflict between construction activities and SEWPCC operations, SEWPCC operations have priority unless otherwise specified.

B. Perform Work continuously during critical connections and changeovers, and as required to prevent interruption of SEWPCC operations. Continuous Work may require 24 hours per day, 7 days per week to complete the work within the specified time constraints. Coordinate with the Contract Administrator and City.

- C. When necessary, plan, design, and provide various temporary services, utilities, connections, temporary piping and heating, access, and similar items to maintain continuous operations of the SEWPCC at no extra cost to The City.
- D. Do not close lines, open or close valves, or take other action which would affect the operation of existing systems, except as specifically required by the Contract Documents and after authorization from the Contract Administrator. Such authorization will be considered within fourteen (14) days after receipt of Contractor's written request.
- E. Install and maintain temporary connections required to keep the SEWPCC operations online. Sequences other than those specified will be considered upon written request to Contract Administrator, provided they afford equivalent continuity of operations.
- F. Do not proceed with Work affecting the SEWPCC operation without obtaining Contract Administrator's advance approval of the need for and duration of such Work.
- G. The Contractor shall respond to and correct within a 24-hour period any construction related items or issues that lead to unplanned operational constraints on the facility.
- H. Relocation of Existing Facilities:
 - 1. During construction, it is expected that minor relocations of Work will be necessary.
 - 2. Use only new materials for relocated items. Match materials of existing items, unless otherwise shown or specified.
 - 3. Perform relocations to minimize downtime of existing facilities.
 - 4. Install new portions of existing facilities in their relocated position prior to removal of existing facilities, unless otherwise accepted by Contract Administrator.

1.5 ADJACENT FACILITIES AND PROPERTIES

- A. Examination:
 - 1. After effective date of the agreement and before Work at Site is started, Contractor, Contract Administrator, the City, and affected property Citys and utility Citys shall make a thorough examination of pre-existing conditions including existing buildings, structures, and other improvements in vicinity of Work, as applicable, which could be damaged by construction operations.
 - 2. Periodic reexamination shall be jointly performed to include, but not limited to, cracks in structures, settlement, leakage, and similar conditions.
- B. Documentation:
 - 1. Record and submit documentation of observations made on examination inspections in accordance with paragraph 1.7 CONSTRUCTION PHOTOGRAPHS.
 - 2. Upon receipt, Contract Administrator will review, sign, and return one record copy of documentation to Contractor to be kept on file in field office.
 - 3. Such documentation shall be used as indisputable evidence in ascertaining whether and to what extent damage occurred as a result of Contractor's operations, and is for the protection of adjacent property Citys, Contractor, and The City.

1.6 CONSTRUCTION PHOTOGRAPHS

- A. The Contractor must photographically document all phases of the project including preconstruction, construction progress, and post-construction and submit photographs to the Contract Administrator.
- B. Preconstruction and Post-construction:
 - 1. After effective date of the agreement and before Work at Site is started, and again upon issuance of Substantial Performance, take a minimum of 48 pictures of construction Site and property adjacent to perimeter of construction Site.
 - 2. Particular emphasis shall be directed to structures both inside and outside the Site.
 - 3. Format: Digital, minimum resolution of 1152 by 864 pixels and 24 bit.
- C. Digital Images:
 - 1. Archive using a commercially available photograph management system.
 - 2. Label each storage media with Project and The City's name, and week and year images were produced.

1.7 AUDIO-VIDEO RECORDINGS

- A. Prior to beginning Work on existing facilities and structures, and again within 10 days following date of Substantial Performance, record video of the existing facilities and structures.
- B. In the case of preconstruction recording, no Work shall begin in the area prior to Contract Administrator's review and approval of content and quality of video for that area.
- C. Particular emphasis shall be directed to physical condition of existing structures, concrete and pipework within pipeline or structure alignment.
- D. Contract Administrator shall have right to select subject matter and vantage point from which videos are to be taken.
- E. Videotaping shall be by a professional commercial videographer, experienced in shooting exterior and interior construction videos.
- F. Video Format and Quality:
 - 1. Digital (MPEG-4), with sound.
 - 2. Video:
 - a. Produce bright, sharp, and clear images with accurate colors, free of distortion and other forms of picture imperfections.
 - b. Electronically, and accurately display the month, day, year, and time of day of the recording.
 - 3. Audio:
 - a. Audio documentation shall be done clearly, precisely, and at a moderate pace.
 - b. Indicate date, Project name, and a brief description of the location of taping, including:
 - 1) Facility name;
 - 2) Process Area and Structure

3) Direction of coverage, including engineering stationing, if applicable.

G. Documentation:

1. Digital Video Disc (DVD) Label:
 - a. Tape number (numbered sequentially, beginning with 001).
 - b. Project Name.
 - 1) Facility name;
 - 2) Process Area and Structure
 - c. Date and time of coverage.
2. Project Video Log: Maintain an ongoing log that incorporates above noted label information for videotapes on Project.

1.8 REFERENCE POINTS AND SURVEYS

- A. Existing base horizontal and vertical control points are designated on Drawings.
- B. Locate, confirm, and protect control points. Preserve permanent reference points during construction.
- C. Make no changes or relocations without prior written notice to the Contract Administrator.
- D. Report to the Contract Administrator when a reference point is lost or destroyed, or requires relocation because of necessary changes in grades or locations.
- E. Require Manitoba Land Surveyor to replace control points in accordance with the original survey control.
- F. Contractor's Responsibilities:
 1. Provide additional survey and layout required to layout the Work.
 2. Check and establish exact location of existing facilities prior to construction of new facilities and any connections thereto.
 3. The Contractor shall review the current installations provided by others as it relates to the Work. Present any conflicts/interferences between the conditions shown on the Drawings and the existing structures to the Contract Administrator for resolution.
 4. Establish lines and levels; locate and lay out by instrumentation (GPS, Total Station, etc.)
 5. Establish pipe invert and centerline elevations.
 6. In event of discrepancy in data shown on the Drawings, request clarification before proceeding with the Work.
 7. Maintain complete accurate log of survey Work as it progresses as a record document.
 8. On request of Contract Administrator, submit documentation.
 9. Provide competent employee(s), tools, total station equipment, stakes, and other equipment and materials to:
 - a. Establish control points, lines, and easement boundaries.
 - b. Check layout, survey, and measurement of Work.
 - c. Measure quantities for payment purposes.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 SALVAGE OF MATERIALS

- A. Materials to be salvaged include:
 - 1. York Chiller
- B. Salvage materials for the City's use.
 - 1. Remove material with extreme care so as not to damage for future use.
 - 2. Promptly remove from Work area salvaged materials.
 - 3. Store materials where instructed by the Contract Administrator onsite.
- C. Meet with Contract Administrator and the City prior to starting to dismantle equipment or piping designated to be salvaged. Contract Administrator will indicate locations where equipment is to be disconnected.
- D. Provide new or repair equipment or material specified or indicated to be salvaged if damaged by the Contractor. Clean and protect equipment from dust, dirt, natural elements, and store as directed.

3.2 CUTTING, FITTING, AND PATCHING

- A. Cut, fit, adjust, or patch Work and work of others, as required, to make Work complete.
- B. Contractor shall provide a coring plan for all conduit and piping passing through existing walls. Coring shall be considered incidental to the work.
- C. Obtain prior written authorization of Contract Administrator before commencing Work to cut or otherwise alter:
 - 1. Structural or reinforcing steel, structural column or beam, elevated slab, trusses, or other structural member.
 - 2. Weather- or moisture-resistant elements.
 - 3. Efficiency, maintenance, or safety of element.
 - 4. Work of others.
- D. Restore existing work, underground utilities, and surfaces that are to remain in completed Work including concrete-embedded piping, conduit, and other utilities as specified and as shown.
- E. Make restorations with new materials and appropriate methods as specified for new Work of similar nature; if not specified, use recommended practice of manufacturer or appropriate trade association.

- F. Fit Work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces and fill voids.

END OF SECTION

SECTION 01 32 00

CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 GENERAL

1.1 SUBMITTALS

- A. Detailed Work Schedule:
 - 1. Submit detailed work schedule as per D18.

1.2 PRELIMINARY BASELINE SCHEDULE

- A. In addition to the requirements outlined in D18, the Contractor shall prepare a preliminary Baseline Schedule for presentation and discussion at the Preconstruction Meeting. The preliminary Baseline Schedule shall depict the initial development of the Baseline Schedule and include critical work to illustrate the Contractor's understanding of the Work for discussion at the Preconstruction Meeting.

1.3 BASELINE AND CURRENT SCHEDULE

- A. In addition to the requirements outlined in D18, the Contractor shall include the following in the Baseline Schedule and Current Schedule:
 - 1. Letter of Intent.
 - 2. Permits.
 - 3. Mobilization.
 - 4. Submittals, with review time. Contractor may use schedule of Shop Drawings and Samples specified in Section 01 33 00, Submittal Procedures
 - 5. Early procurement activities for long lead equipment and materials.
 - 6. Major equipment design, fabrication, factory testing, and delivery dates.
 - 7. Initial Site work, including equipment mobilization, material delivery, and any work to complete scope of work.
 - 8. Specified Work sequences and construction constraints.
 - 9. Tie-in work with existing structures and facilities.
 - 10. Major structural, mechanical, equipment, electrical, architectural, and instrumentation and control Work.
 - 11. Show complete interdependence and sequence of construction and work-related activities reasonably required to complete the Work.
 - 12. Identify the work of separate stages and other logically grouped activities, and clearly identify critical path of activities.
 - 13. Reflect sequences of the Work, restraints, delivery windows, review times, contract times and Critical Stages, Section 01 31 13, Project Coordination, Section 01 79 00, Demonstration and Training, and Section 01 91 14, Equipment Testing and Startup.
 - 14. Project close-out summary.
 - 15. Demobilization summary.
- B. The Baseline and Current Schedule shall be a comprehensive computer-generated schedule using CPM, generally as outlined in Associated General Contractors of America (AGC)

Publication No. 1107.1, "Construction Planning and Scheduling, latest edition. If a conflict occurs between the AGC publication and this specification, this specification shall govern.

- C. Activity duration for Submittal review shall not be less than review time specified unless clearly identified and prior written acceptance has been obtained from Contract Administrator.
- D. Network Graphical Display:
1. Plot or print on paper not greater than 30 inches by 42 inches or smaller than 22 inches by 34 inches, unless otherwise approved.
 2. Title Block: Show name of Project, The City, date submitted, revision or update number, and the name of the scheduler. Updated schedules shall indicate data date.
 3. Identify horizontally across top of schedule the time frame by year, month, and day.
 4. Identify each activity with a unique number and a brief description of the Work associated with that activity.
 5. Indicate the critical path.
 6. Show, at a minimum, the controlling relationships between activities.
 7. Plot activities on a time-scaled basis, with the length of each activity proportional to the current estimate of the duration.
 8. Plot activities on an early start basis unless otherwise requested by Contract Administrator.
 9. Provide a legend to describe standard and special symbols used.
- E. Schedule Report:
1. On 8-1/2-inch by 11-inch white paper, unless otherwise approved.
 2. List information for each activity in tabular format, including, at a minimum:
 - a. Activity identification number.
 - b. Activity description.
 - c. Original duration.
 - d. Remaining duration.
 - e. Early start date (actual start on updated work schedules).
 - f. Early finish date (actual finish on updated work schedules).
 - g. Late start date.
 - h. Late finish date.
 - i. Total float.
- F. Updated Current Schedule shall reflect:
1. Progress of Work to within 5 Business Days prior to submission.
 2. Approved changes in Work scope and activities modified since submission.
 3. Delays in submittals or resubmittals, deliveries, or Work.
 4. Adjusted or modified sequences of Work.
 5. Other identifiable changes.
 6. Revised projections of progress and completion.
 7. Report of changed logic.
- G. Produce detailed sub-schedules during the Work, upon request of the Contract Administrator, to further define critical portions of the Work such as facility shutdowns.
- H. If Contractor fails to complete activity by its latest scheduled completion date and this failure is anticipated to extend contract times, Contractor shall, within 7 Business Days of such

failure, submit a written statement as to how Contractor intends to correct nonperformance and return to acceptable current work schedule. Actions by Contractor to complete the Work within contract times (or Critical Stages) will not be justification for adjustment to Contract Price or contract times.

- I. The Contract Administrator may order Contractor to increase plant, equipment, labour force, or working hours if Contractor fails to:
 1. Complete a Critical Stage activity by its completion date.
 2. Satisfactorily execute Work as necessary to prevent delay to overall completion of the Work, at no additional cost to the City.

1.4 NARRATIVE PROGRESS REPORT

- A. Format:
 1. Organize same as Current Schedule.
 2. Identify, on a cover letter, reporting period, date submitted, and name of author of report.
 3. Provide narrative progress report monthly to Contract Administrator.
- B. Contents:
 1. Number of days worked over the period, work force on hand, construction equipment on hand (including utility vehicles such as pickup trucks, maintenance vehicles).
 2. General progress of Work, including a listing of activities started and completed over the reporting period, mobilization/demobilization of subcontractors, and major milestones achieved.
 3. Contractor's plan for management of Site (e.g., lay down and staging areas, construction traffic), utilization of construction equipment, buildup of trade labour, and identification of potential Contract changes.
 4. Identification of new activities and sequences as a result of executed Contract changes.
 5. Documentation of weather conditions over the reporting period, and any resulting impacts to the work.
 6. Description of actual or potential delays, including related causes, and the steps taken or anticipated to mitigate their impact.
 7. Changes to activity logic.
 8. Changes to the critical path.
 9. Identification of, and accompanying reason for, any activities added or deleted since the last report.
 10. Steps taken to recover the schedule from Contractor-caused delays.

1.5 SCHEDULE ACCEPTANCE

- A. Contract Administrator's acceptance will demonstrate agreement that:
 1. Proposed schedule is accepted with respect to:
 - a. Contract times, including completion and all Critical Stages are within the specified times.
 - b. Specified Work sequences and constraints are shown as specified.
 - c. Specified City Supplied Equipment or material arrival dates, or range of dates, are included.
 - d. Access restrictions are accurately reflected.
 - e. Functional, Demonstration, and Performance and testing times are as specified.

- f. Submittal review times are as specified.
2. In all other respects, Contract Administrator's acceptance of Contractor's schedule indicates that, in Contract Administrator's judgement, schedule represents reasonable plan for constructing Work in accordance with the Contract Documents. Contract Administrator's review will not make any change in Contract requirements. Lack of comment on any aspect of schedule that is not in accordance with the Contract Documents will not thereby indicate acceptance of that change, unless Contractor has explicitly called the nonconformance to Contract Administrator's attention in submittal. Schedule remains Contractor's responsibility and Contractor retains responsibility for performing all activities, for activity durations, and for activity sequences required to construct Work in accordance with the Contract Documents.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 33 00

SUBMITTAL PROCEDURES

PART 1 GENERAL

1.1 DEFINITIONS

- A. Action Submittal: Written and graphic information submitted by Contractor, that requires Engineer's review.
- B. Informational Submittal: Information submitted by Contractor, that does not require Engineer's review. Submittals not meeting conditions of the Contract will be returned.

1.2 PROCEDURES

- A. Direct submittals to the Contract Administrator.
- B. The Contractor shall follow the City's procedures regarding submittals of electronic files in the City Document Management System (DMS), transmission of electronic submittals and identification of project specific documents and equipment at no cost to the City. Submittals shall follow the Winnipeg Sewage Treatment Program (WSTP) Projection Document Numbering Standard. A copy of the numbering standard will be provided to the Contractor.
- C. Electronic Submittals: Submittals shall be made in electronic format.
 - 1. Each submittal shall be electronic file in Adobe Acrobat Portable Document Format (PDF). Use latest version available at time of execution of Agreement.
 - 2. Electronic files that contain more than 10 pages in PDF format shall contain internal book marking from index page to major sections of document.
 - 3. PDF files shall be set to open "Bookmarks and Page" view.
 - 4. Add general information to each PDF file, including title, subject, author, and keywords. PDF files shall be set up to print legibly at 8.5 inches by 11 inches, or 11 inches by 17 inches, or 22 inches by 34 inches. No other paper sizes will be accepted.
 - 5. Submit new electronic files for each resubmittal.
 - 6. Include copy of Transmittal of Contractor's Submittal form, located at end of section, with each electronic file.
 - 7. Contract Administrator will reject submittals that are not electronically submitted.
 - 8. Submit authorization for Contract Administrator to reproduce and distribute each file as many times as necessary for Project documentation.
 - 9. Detailed procedures for handling electronic submittals will be discussed at Preconstruction Meeting.
- D. Schedule of Submittals:
 - 1. Provide a table listing all the submittals anticipated for each specification section. Include the following information:
 - a. Specification Section
 - b. Total Number of Submittals for each specification section.

- c. Identify each submittal by its submittal number in accordance with the numbering and tracking system as specified by its name or title.
 - d. Identify each submittal by its name or title.
 - e. Identify the estimated date of submission to the Contract Administrator.
 - f. and status for each submittal
2. Provide updates of Schedule of Shop Drawings and Sample Submittals at progress meetings.

E. Transmittal of Submittal:

1. Contractor shall:
 - a. Review each submittal and verify the following prior to submission:
 - 1) Compliance with Contract Documents.
 - 2) Field measurements.
 - 3) Field construction criteria.
 - 4) Catalog number and similar data.
 - b. Affix uniform approval stamp to each submittal before submitting to Engineer.
 - 1) Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval, and statement certifying that field measurements, field construction criteria, materials, dimensions, catalog numbers, and similar data have been determined and verified, and submittal has been reviewed, checked, and approved for compliance with Contract Documents and check and coordinate each item with other applicable, approved, shop drawings and Contract requirements.
 - 2) Contract Administrator will not review submittals that do not bear Contractor's approval stamp and will return them without action.
 - 3) Contract Administrator will not review submittals received directly from a Subcontractor or Supplier and will return them without action.
2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form Supplement-1 attached at end of this section.
3. Identify each submittal with the following:
 - a. Numbering and Tracking System:
 - 1) Sequentially number each submittal.
 - 2) Resubmission of submittal shall have original number with sequential alphabetic suffix.
 - b. Specification section and paragraph to which submittal applies.
 - c. Project title and City Bid Opportunity number.
 - d. Date of transmittal.
 - e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
4. Identify and describe each deviation or variation from Contract Documents.
5. Include Contractor's written response to each of Contract Administrator's review comments with resubmission of submittals stamped "Exceptions Noted, Resubmit".
6. Submit Contractor's written acknowledgement and confirmation of acceptance of each of Contract Administrator's review comments on submittals stamped "Exceptions Noted".

F. Format:

1. Do not base Shop Drawings on reproductions of Contract Documents.

2. Package submittal information by individual Specification section. Do not combine different Specification sections together in submittal package, unless otherwise directed in Specification.
 3. Present in a clear and thorough manner and in sufficient detail to show kind, size, arrangement, and function of components, materials, and devices, and compliance with Contract Documents.
 4. Index with labeled tab dividers in orderly manner.
- G. Timeliness:
1. Schedule and submit in accordance with schedule of submittals, and requirements of individual Specification sections.
 2. Submit Shop Drawings and Samples well in advance of scheduled manufacturing, fabrication, or delivery date for associated equipment or material.
 3. Coordinate submittals prepared by multiple trades such that information is available to allow prior review and sufficient review time where work of one trade interfaces with or affects work of another.
- H. Failure to submit Shop Drawings and Samples in ample time is not to be considered sufficient reason for an extension of the schedule outlined in the Supplemental Conditions and no claim for extension by reason of such default will be allowed. Processing Time:
1. Time for review shall commence on Contract Administrator's receipt of submittal.
 2. Contract Administrator will act upon Contractor's submittal and transmit response to Contractor not later than 10 Working Days after receipt, unless otherwise specified.
 3. Resubmittals will be subject to same review time.
- I. Resubmittals:
1. Clearly identify each correction or change made and include revision date.
 2. Provide clear response to each itemized comment by Contract Administrator on the submittal, whether or not action has been taken, and description of action.
 3. No adjustment of the schedule or Contract Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmittals.
 4. No adjustments of the schedule outlined in the Supplemental Conditions or Contract Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmittals.
 5. The City may deduct cost of additional reviews from Contract Price.
- J. Incomplete Submittals:
1. Contract Administrator will return entire submittal for Contractor's revision if preliminary review deems it incomplete.
 2. When any of the following are missing, submittal will be deemed incomplete:
 - a. Contractor's review stamp completed and signed.
 - b. Transmittal of Contractor's Submittal completed and signed. All requested information is not provided.
 - c. Submittals missing Professional Engineer's seal and signature, where it is required.
 - d. Submittal does not contain metric units for dimensions.
- K. Submittals not required by Contract Documents:
1. Will not be reviewed and will be returned stamped "RECEIVED FOR INFORMATION"

- L. Do not revise submittals after they have been reviewed and stamped “No Exceptions Taken”, “Exceptions Noted”, or “For Information Only”.
- M. Contract Administrator will complete up to two reviews of each submittal at no cost to Contractor. The City will deduct cost of additional reviews from Contract Price.

1.3 ACTION SUBMITTALS

A. General:

1. Prepare and submit Action Submittals required by individual Specification sections.
2. Engineer will review Action Submittals only for general conformance with design concept and general compliance with Contract Documents.
3. Contract Administrator’s review does not relieve Contractor from compliance with requirements of Contract Documents nor from errors in submittals or Contractor’s design.
4. Contractor is responsible for confirmation of dimensions at jobsite; fabrication processes; means, methods techniques, sequences and procedures of construction; coordination of Work of all trades; and performance of Work in safe and satisfactory manner.
5. At Contract Administrator’s option, Contract Administrator’s review comments and review stamp will be placed either directly on submitted copies of Shop Drawings or on separate submittal review comment form.
6. Fabrication performed, materials purchased, or Work commenced or completed on site prior to the review and acceptance of shop drawings or samples for Work requiring such submittals will at Contractor’s own risk. The City will not be liable for expenses or delay due to corrections or remedies to conform to Contract or accepted submittals.
7. Where work is to be designed by Contractor, comply with applicable codes and furnish submittals signed and sealed by professional engineer licensed in Province of Manitoba, as required by Specifications. If requested, calculations shall be submitted for review. Calculations shall also be signed and sealed by a professional engineer registered in the Province of Manitoba.
8. Work to conform to accepted shop drawings and samples.

B. Shop Drawings:

1. Copies: One electronic copy.
2. Identify and Indicate:
 - a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
 - b. Equipment and Component Title: Identical to title shown on Drawings.
 - c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
 - d. Project-specific information drawn accurately to scale.
3. Manufacturer’s standard schematic drawings and diagrams as follows:
 - a. Modify to delete information that is not applicable to the Work.
 - b. Supplement standard information to provide information specifically applicable to the Work.
4. Product Data: Provide as specified in individual Specifications.
5. Foreign Manufacturers: When proposed, include following additional information:
 - a. Names and addresses of at least two companies that maintain technical service representatives close to Project.
 - b. Complete list of spare parts and accessories for each piece of equipment.

6. Units: Submit all Shop Drawings in SI metric units.
7. Required submittals include but are not limited to:
 - a. Catalogue Drawings: Include reprints of catalogue drawings of proprietary articles of standard fabrication and manufacture for the work.
 - b. Shop Drawings: Include dimensioned line drawings and related specifications, information and literature for custom fabricated articles and equipment.
 - c. ISA data sheets for all instruments.
8. Make no change in drawings after they have been reviewed and accepted.

C. Samples:

1. Copies: Two, unless otherwise specified in individual Specifications.
2. Preparation: Mount, display, or package Samples in manner specified to facilitate review of quality. Attach label on unexposed side that includes the following:
 - a. Manufacturer name.
 - b. Model number.
 - c. Material.
 - d. Sample source.
3. Manufacturer's Color Chart: Units or sections of units showing full range of colors, textures, and patterns available.
4. Full-size Samples:
 - a. Size as indicated in individual Specification section.
 - b. Prepared from same materials to be used for the Work.
 - c. Cured and finished in manner specified.
 - d. Physically identical with product proposed for use.
5. Do not use materials in Work which are in any way inferior to Samples submitted and reviewed. Match accepted samples.
6. Review of samples notwithstanding, materials that are unsound or imperfect when delivered to site will be rejected.
7. Retain reviewed samples on site readily available to Contract Administrator.

D. Action Submittal Dispositions: Contract Administrator will review, mark, and stamp as appropriate, and distribute marked-up copies or submittal review comment forms as noted:

1. No Exceptions Taken (NET):
 - a. Contractor may incorporate product(s) or implement Work covered by submittal.
 - b. Distribution:
 - 1) One copy furnished to the City.
 - 2) One copy furnished Resident Project Representative.
 - 3) One copy retained in Contract Administrator's file.
 - 4) Remaining copies returned to Contractor appropriately annotated.
2. Exceptions Noted (EN):
 - a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Contract Administrator's notations.
 - b. Distribution:
 - 1) One copy furnished to the City.
 - 2) One copy furnished Resident Project Representative.
 - 3) One copy retained in Contract Administrator's file.
 - 4) Remaining copies returned to Contractor appropriately annotated.

3. Exceptions Noted, Resubmit (ENR):
 - a. Make corrections or obtain missing portions and resubmit.
 - b. Contractor may not incorporate product(s) or implement Work covered by submittal, except portions where indicated Contractor may begin to incorporate product(s) or implement Work covered by the submittal in accordance with the Engineer's notations.
 - c. Distribution:
 - 1) One copy furnished to the City.
 - 2) One copy furnished Resident Project Representative.
 - 3) One copy retained in Contract Administrator's file.
 - 4) Remaining copies returned to Contractor appropriately annotated.

1.4 INFORMATIONAL SUBMITTALS

- A. General:
 1. Copies: Submit electronic copy, unless otherwise indicated in individual Specification section.
 2. Refer to individual Specification sections for specific submittal requirements.
 3. Where work is to be designed by Contractor, comply with applicable codes and submit Shop Drawings signed and sealed by professional engineer licensed in the Province of Manitoba.
 4. Contract Administrator will review each submittal for general conformance with design intent and general compliance with Contract Documents. Contract Administrator's review does not relieve the Contractor from compliance with requirements of Contract documents nor from errors in the submittal or Contractor's design.
 5. Work to conform to accepted shop drawings and samples.
- B. Certificates:
 1. General:
 - a. Provide notarized statement that includes signature of entity responsible for preparing certification.
 - b. Signed by officer or other individual authorized to sign documents on behalf of that entity.
 2. Welding: In accordance with individual Specification sections.
 3. Installer: Prepare written statements on manufacturer's letterhead certifying that installer complies with requirements as specified in individual Specification sections.
 4. Material Test: Prepared by qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.
 5. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual Specification sections.
 6. Manufacturer's Certificate of Compliance: In accordance with Section 01 43 33, Manufacturers' Field Services.
 7. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 43 33, Manufacturers' Field Services.
- C. Construction Photographs and Video: In accordance with Section 01 31 13, Project Coordination, and as may otherwise be required in Contract Documents.

- D. Contract Closeout Submittals: In accordance with Section 01 77 00, Closeout Procedures.
- E. Contractor-Design Data:
1. Written and graphic information.
 2. List of assumptions.
 3. List of performance and design criteria.
 4. Summary of loads or load diagram, if applicable.
 5. Calculations.
 6. List of applicable codes and regulations.
 7. Name and version of software.
 8. Information requested in individual Specification section.
 9. Seal and signature of professional engineer licensed in the Province of Manitoba.
- F. Manufacturer's Instructions: Written or published information that documents manufacturer's recommendations, guidelines, and procedures in accordance with individual Specification sections.
- G. Operation and Maintenance Data: As required in Section 01 78 23, Operation and Maintenance Data.
- H. Schedules:
1. Schedule of Submittals: Prepare separately or in combination with Progress Schedule as specified in Section 01 32 00, Construction Progress Documentation.
 - a. Show for each, at a minimum, the following:
 - 1) Specification section number.
 - 2) Identification by numbering and tracking system as specified under Paragraph Transmittal of Submittal.
 - 3) Estimated date of submission to Contract Administrator, including reviewing and processing time.
 - b. On a monthly basis, submit updated schedule to Contract Administrator if changes have occurred or resubmittals are required.
 2. Progress Schedules: In accordance with Section 01 32 00, Construction Progress Documentation
- I. Special Guarantee: Supplier's written guarantee as required in individual Specification sections.
- J. Statement of Qualification: Evidence of qualification, certification, or registration as required in Contract Documents to verify qualifications of engineer, materials testing laboratory, specialty Subcontractor, trade, Specialist, consultant, installer, and other professionals.
- K. Submittals Required by Laws, Regulations, and Governing Agencies:
1. Submit promptly notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, provincial, or local governing agency or their representative.
 2. Transmit to Contract Administrator for the City's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

L. Test and Inspection Reports:

1. General:
 - a. Shall contain signature of person responsible for test or report.
 - b. Complete an equipment report prior to the site testing each item of rotating mechanical equipment. During testing complete the remainder of the equipment report. Submit the reports for inclusion in the Installation, Operation and Maintenance manual.
 - c. Before operating equipment, engage the services of a qualified manufacturer's service representative to inspect, operate, test, and adjust the equipment after installation.
2. Factory:
 - a. Identification of product and Specification section, type of inspection or test with referenced standard or code.
 - b. Date of test, Project title and number, and name and signature of authorized person.
 - c. Description of inspection, test results, adjustments made, quantitative results, and suggestions for precautions to be taken for correct maintenance.
 - d. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
 - e. Provide interpretation of test results, when requested by Contract Administrator.
 - f. Verify that the equipment and its installation conforms to the requirements of the Contract for the service intended and is ready for permanent operation. Submit copies of report for binding into the installation, operation and maintenance manuals.
 - g. Other items and requirements as identified in individual Specification sections.
3. Field: As a minimum, include the following:
 - a. Project title and number.
 - b. Date and time.
 - c. Identification of product and Specification section.
 - d. Type and location of test, Sample, or inspection, including referenced standard or code.
 - e. Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
 - f. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
 - g. Provide interpretation of test results, when requested by Contract Administrator.
 - h. Other items as identified in individual Specification sections.
 - i. Inspection Includes:
 - 1) Soundness (without cracked or otherwise damaged parts).
 - 2) Completeness of installation as specified and as recommended by manufacturer.
 - 3) Correctness of setting, alignment, and relative arrangement of various parts of system.
 - j. Operate, test, and adjust equipment to prove it is correctly installed to operate under the intended conditions.
 - k. Equipment will only be accepted after receipt of the manufacturer's representative's report.
 - l. Submit notice in writing at least 48 hours before manufacturer's representative is scheduled to perform these services.

- m. Modify or replace equipment or materials failing required tests.
 - n. Perform additional testing required due to changes of materials requested by Contractor or due to failure of materials or construction to meet specifications.
- M. Maintenance Materials:
- 1. Submit special tools, lubricants, maintenance materials, spare parts, Manuals, As-built Drawings, and reports to the Contract Administrator.
 - 2. Submissions to include a complete list of items delivered. Submissions must be acknowledged in writing as being received by the Contract Administrator.
 - 3. Submit manuals a minimum of one (1) week prior to commissioning of the equipment.
 - 4. Submission of manuals in a state as reviewed and accepted deficiency free is a prerequisite for Substantial Performance.
- N. Testing and Startup Data: In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
- O. Training Data: In accordance with Section 01 43 33, Manufacturers' Field Services.
- P. Interference Drawings:
- 1. Before installation of structural, mechanical, and electrical systems, prepare an integrated set of interference drawings in cooperation with all trades.
 - 2. Show locations and relationship of all trades in mechanical and electrical equipment rooms, pipe spaces, tunnels, galleries, and basements, and all electrical conduits and pipes to be cast into structural slabs, wall, and columns.
 - 3. Submit updated interference drawings as Work progresses.
 - 4. Make necessary relocations due to interference between trades, as a result of incomplete interference drawings, at no cost to the City.
- Q. As-Built Documents: In accordance with Section 01 77 00, Closeout Procedures.
- R. Bills of Materials:
- 1. Provide two (2) copies of complete Bill of Materials for all equipment, valves, valve operators, and instrumentation.
 - 2. Provide copies on letter size paper arranged and bound together alphabetically in separate three-ring binders.
- S. Spare Parts and Loose Items List:
- 1. Submit recommended spare parts list together with the first shop drawings submittal for all designated equipment. The detailed specifications state which equipment requires recommended spare parts lists. Where not stated in specifications, provide manufacturer's recommended list of spare parts. Reference specification section number for each designated equipment on spare parts list.
 - 2. The recommended spare parts list must include, but not limited to:
 - a. Item number.
 - b. Description of spare part or item.
 - c. Equipment vendor or suppliers name.
 - d. Reference specification section (and clause, if applicable).
 - e. Quantity of item or part.
 - f. Lead time.

- g. Date received.
 - h. Date turned over to the City.
 - i. Price of each part at time of submittal and delivery.
 - j. Comments.
 - 3. The recommended spare parts list will be used by the City as a guide for planning suitable spare parts inventory prior to acceptance of the equipment.
 - 4. Submit updated spare parts list indicating spare parts handed over to the City.
- T. Extra Materials List:
 - 1. Submit recommended extra materials list with first submittal of designated items. The detailed specification state which items require extra materials. Reference specification section number for each item listed.
 - 2. The extra materials list must include, but not limited to:
 - a. Item number.
 - b. Description of extra materials.
 - c. Extra material supplier name.
 - d. Reference specification section (and clause, if applicable).
 - e. Quantity of extra material.
 - f. Date received.
 - g. Date turned over to City.
 - h. Comments.
 - 3. Submit updated extra materials list indicating items handed over to the City.
- U. Equipment Control Log:
 - 1. Submit log listing equipment installed under Contract referencing applicable specification section for each piece of equipment.
 - 2. Include in equipment control log:
 - a. Equipment description.
 - b. Reference specification section (and clause, if applicable).
 - c. Equipment tag number.
 - d. Equipment Vendor or supplier.
 - e. Date required on site.
 - f. Date delivered to site.
 - g. Date installed.
 - h. O&M Manual submitted and accepted.
 - i. Training completed.
 - j. Pre-start health and safety review completed.
 - k. Start-up date.
 - l. Comments.
 - 3. Submit updates as equipment is installed, or if schedule dates change.
- V. Information Submittal Dispositions:
 - 1. If submittal meets requirements of Contract, Contract Administrator will forward copies to appropriate parties. Some copies will be marked "For Information Only" (FIO).
 - 2. If Engineer determines that submittal does not meet requirements of Contract, submittal will be considered unacceptable. In such instances, submittal may be returned marked "Exceptions Noted, Resubmit" (ENR). Engineer will retain one copy and return remaining copies with review comments to Contractor for correction and resubmission.

1.5 APPLICATION FOR PAYMENT

- A. In accordance with the City Standard Payment Procedures.
- B. Material and equipment delivered to site of Work will not be paid for until pertinent Shop Drawings have been reviewed and accepted.

1.6 SUPPLEMENTS

- A. The supplements listed below, following “End of Section”, are part of this Specification.
 - 1. Forms: Transmittal of Contractor’s Submittal

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

TRANSMITTAL OF CONTRACTOR'S SUBMITTAL (ATTACH TO EACH SUBMITTAL)	
DATE: _____	
TO: _____ _____ _____ _____ _____ FROM: _____ <div style="text-align: center;">Contractor</div> _____ _____ _____	Submittal No.: _____ <input type="checkbox"/> New Submittal <input type="checkbox"/> Resubmittal Project: _____ Project No.: _____ Specification Section No.: _____ (Cover only one section with each transmittal) Schedule Date of Submittal: _____
SUBMITTAL TYPE: <input type="checkbox"/> Shop Drawing <input type="checkbox"/> Sample <input type="checkbox"/> Informational	

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. and Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that (i) Contractor has complied with the requirements of Contract Documents in preparation, review, and submission of designated Submittal and (ii) the Submittal is complete and in accordance with the Contract Documents and requirements of laws and regulations and governing agencies.

By: _____
Contractor (Authorized Signature)

SECTION 01 35 29.01

HEALTH AND SAFETY

PART 1 GENERAL

1.1 REFERENCES

- A. Manitoba Workplace Safety and Health Act and associated regulations.
- B. Applicable National Fire Protection Association Codes and Standards.
- C. City of Winnipeg Contractor Safety Health and Environment Orientation Plan - CD-PMPC-03 (Appended to this section)

1.2 CONSTRUCTION – SAFETY MEASURES

- A. The Contractor shall be designated as the “Prime Contractor” as defined by the Manitoba Workplace Safety and Health Act.
- B. Observe and enforce all construction safety measures required by code, Workers' Compensation Board, Manitoba Workplace Safety and Health, and all applicable statutes. Appoint a suitably qualified employee who has sole responsibility on-site on behalf of the Contractor, for compliance with the requirements and so advise the City in writing with copy to the Contract Administrator.
- C. In case of an emergency, the Contractor shall immediately contact the shift operator at 204-479-5299 (7:00 AM to 4:30 PM) or the North End Water Pollution Control Centre Central Control Contact Number 204-986-4798 (4:30 PM to 7:00 AM). Secondary emergency contact number is 204-794-4468.
- D. Meet or exceed the latest revision of all local, federal, provincial laws, regulations, standards, and industry best practices relating to health and safety.
- E. Be solely responsible for safety of the Work under this Contract and for complying with and ensuring that every person on the Site complies with the requirements contained within the Contract documents and regulatory requirements.
- F. Perform the Work, or ensure that it is performed, in a manner to avoid risk of injury, security or damage to persons or property, adjacent property, or environment.
- G. Perform a health and safety pre-qualification of all lower-tiered subcontractors prior to contract award and only accept lower-tiered subcontractors that have demonstrated an ability to comply with health and safety requirements and are below industry average for incidents.
- H. Provide safe access, egress, and equipment in accordance with Occupational Health and Safety Regulations for entry into all areas by employees, subcontractors, the City, and the

Contract Administrator or representative. Where hazardous areas or confined space entry exists, implement procedures defined by the latest revision of the applicable regulations.

- I. Designate a qualified safety representative at the Project Site with responsibility for preventing accidents and implementing and supervising the Safety Plan and other safety programs. The safety representative shall attend all project safety meetings, participate fully in all activities outlined in the Safety Plan and shall devote whatever time is necessary to perform such duties properly. Contractor's safety representative shall provide Contract Administrator with requested information and shall have the authority to immediately correct safety deficiencies.
- J. Prior to the commencement of the Work, review and become fully familiarized with all local, provincial, and federal regulatory requirements and the following documentation:
 - 1. South End Water Pollution Control Centre site safety rules, emergency evacuation, spill response procedures, permits, and other applicable procedures.
 - 2. Contract Documents.
- K. In event of a conflict between any provisions of the various regulatory requirements, the most stringent provision shall govern.
- L. Ensure that all employees and subcontractors are competent, as prescribed by the applicable legislation, in performing the Work and have been trained accordingly.
- M. Prior to commencement of any Work, throughout the Work as required, and at the Contract Administrator's request, make the following documentation available:
 - 1. A copy of the Contractor's project specific Health and Safety Plan.
 - 2. Emergency response and evacuation procedures, including local contact names and numbers.
 - 3. Procedures in the event of a spill including local contact names and numbers.
 - 4. Training and orientation training records of employees or subcontractors.
 - 5. Applicable Material Safety Data Sheets.
- N. Provide and maintain first aid, hygiene, washrooms, potable water, and fire prevention equipment, at the Site in accordance with the applicable regulatory requirements.
- O. Establish, maintain, and mark clear paths of access and egress for routine and emergency personnel and vehicles.
- P. Erect signage acceptable to the Contract Administrator at all entry points to the Site identifying the name, address, and telephone number of the Contractor and to advise personnel and visitors entering the Site of the requirements respecting entry.
- Q. Ensure adequate coordination and communication between all parties on Site in regards to safety.
- R. In addition to the Manitoba Workplace Health and Safety Act and applicable Regulations reporting requirements, report all incidents, near misses, spills, environmental damage, and property damage to the City and Contract Administrator immediately. An incident

investigation must be conducted and a copy of the complete report provided to the City and Contract Administrator within 24 hours.

- S. Provide a copy of all Ministry of Labour inspection reports, orders, and charges to the City and the Contract Administrator immediately.

1.3 SPECIAL PROTECTION AND PRECAUTIONS

- A. Comply with the South End Water Pollution Control Centre Health and Safety Procedures where necessary. The City will provide facility orientation materials to the Contractor. Provide orientation training to all Contractor's staff, subcontractors, Contract Administrator, and visitors on Site and maintain a record of this training.

1.4 WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM

- A. Comply with applicable health and safety regulatory requirements, including but not limited to Workplace Hazardous Materials Information System (WHMIS) regulations.
- B. Maintain a copy of the current Material Safety Data Sheets (MSDSs) for all hazardous chemicals or substances brought onsite by Contractor or any lower-tiered subcontractors.
- C. If such materials or substances are part of any item requiring a shop drawing or other submittal, provide the MSDS with the submittal.
- D. Provide and maintain a copy of MSDSs to the City and Contract Administrator.

1.5 DESIGNATED SUBSTANCES

- A. Designated substances may be present on Site. Known designated substances will be noted in the Drawings, and Specifications, and in Appendices –Pinchin Asbestos Laboratory Certificate of Analysis (Pinchin, 2023). Refer to Sections 02 82 11, 02 82 12 and 02 82 13 for instructions on asbestos abatement.
- B. If a designated substance which has not been identified in the Drawings and Specifications is located during the performance of the Work, stop Work in that area and immediately notify the Contract Administrator.

1.6 MATERIAL HANDLING

- A. Store, stack, place, remove, and handle materials on Site in a stable and secure manner so as not to endanger the safety of personnel or cause damage to property.
- B. Secure materials which, by virtue of their configuration or weight, cannot be stored or stacked in a secure and stable manner, against tipping, collapse, or falling by use of appropriate bracing systems, structures, or equipment.
- C. Ensure that vehicles, construction machinery, and materials handling equipment are only operated on the Project by persons suitably qualified to do so.

1.7 CITY'S HEALTH AND SAFETY AUDITOR

- A. The Contractor acknowledges that the City may employ the services of an occupational health and safety auditor, an environmental inspector, or other authorized inspector knowledgeable in the local statutes, laws, or by laws for the purpose of conducting inspections of the Site.
- B. Grant the auditor, inspector, or any other inspector full and unimpeded access to the Site, at all times, and immediately comply with any direction issued by the auditor, inspector, the City, or any other inspector.
- C. This provision does not change the Contractor's role and responsibility as the General Contractor. The auditor is the City's method for ensuring due diligence is exercised.
- D. The Contractor's health and safety representative shall accompany the safety auditor on Site visits where requested.
- E. The safety auditor will report any observations made during inspections and audits and assign these to the Contractor. The Contractor will be granted access to these documents. It will be the responsibility of the Contractor to review these documents and take whatever action is necessary to fulfill its responsibility as the General Contractor.

1.8 WORK IN HAZARDOUS AREAS

- A. Work in Confined Spaces:
 - 1. Work activities in confined spaces must be in accordance with the latest revision of the Occupational Health and Safety Act and applicable Regulations
- B. Hazardous Areas Classification in Existing Structures:
 - 1. Areas considered to be hazardous and classified as Class I Division I Group D or as Class I Division 2 Group D per CSA C22.1, Canadian Electrical Code are indicated on the Drawings.
 - 2. After start-up of operations, work performed in these locations must proceed in accordance with applicable regulatory requirements.

1.9 FIRE PROTECTION

- A. Provide adequate supplementary fire protection facilities including but not limited to ample hand-operated 15 to 20 pound multipurpose dry chemical extinguishers in each facility. Provide temporary hose lines in areas where construction is in progress until the permanent fire protection is placed into service. Do not block hydrant hose connections and other fire fighting equipment by construction equipment and make readily accessible at all times.
- B. Dispose of all combustible rubbish promptly and safely. Prompt disposal is particularly needed for material subject to spontaneous ignition such as oily waste and paint rags.
- C. Monitor and control probable ignition sources as necessary to prevent the threat of fire.

- D. Minimize hot work including but not limited to operations involving open flames, heat, or sparks such as brazing, cutting, grinding, soldering, and torching. If there is a practical and safer way to do the work without hot work, the alternative method shall be used.
- E. Hot work shall end no less than one (1) hour prior to end of shift and area inspected prior to daily departure by the Contractor's site supervisor and / or tradesman.

1.10 EXPLOSION-PROOF CONSTRUCTION

- A. Certain areas may be designated on the Drawings as "explosion proof", "hazardous", or may be classified under CSA C22.1, Canadian Electrical Code. Where areas have such designation, provide explosion proof electrical equipment that meets the requirements of CSA C22.1, Canadian Electrical Code.
- B. In hazardous areas as defined above, provide intrinsically safe mechanical devices and equipment such as non-sparking aluminum wheels for fans, pneumatic operators for dampers and aluminum clappers for check valves on pipelines conveying gaseous fuels.
- C. Temporary structures such as fabrication shops, storage areas, and offices will not be permitted within existing facility structures unless approved by the Contract Administrator.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 41 00

REGULATORY REQUIREMENTS

PART 1 GENERAL

1.1 SUBMITTALS

- A. Quality Control Submittals: Submit certificates from inspecting authorities for electrical work, pressure piping among others.

1.2 APPLICABLE CODES

- A. Comply with the latest edition of the codes and standards referenced in Contract Documents and following statutes and codes and all amendments thereto:
 - 1. The Manitoba Nuisance Act
 - 2. The Public Health Act
 - 3. The Manitoba Building Code Act and Regulations.
 - 4. National Building Code of Canada.
 - 5. Occupational Health and Safety Act and Regulations for Construction Projects, covering safety, hazardous materials, and Workplace Hazardous Material Information.
 - 6. Manitoba Plumbing Code.
 - 7. Canadian Environmental Protection Act
 - 8. Canadian Electrical Code.
 - 9. Manitoba Workplace Safety and Health Act
- B. For purposes of the Manitoba Workplace Safety and Health Act, the Contractor will be designated the “Prime Contractor” and assumes the responsibility of the Prime Contractor as set out in the Act and its regulations.

1.3 PERMITS, APPROVALS, AND LICENCES

- A. The Contractor is responsible for obtaining all permits for carrying out the scope of work including any updates to the existing building permit if needed.
- B. A copy of each approval or permit will be available at Contract Administrator’s office for review. Contractor shall examine the approvals and permits and conform to the requirements contained therein and such requirements are hereby made a part of these Contract documents as fully and completely as though the same were set forth herein. Failure to examine the approvals and permits will not relieve Contractor from compliance with the requirements stated therein.
- C. Apply for, obtain, and pay for all other permits, approvals, licences and governmental inspections required for the performance of the Work.
- D. Contract Administrator will provide Contractor with a clean set of Drawings and Specifications, as necessary, for each application.

- E. Where electrical enclosures and panels do not have CSA labels, arrange for each such electrical enclosure or panel to be inspected by the electrical authority having jurisdiction.
- F. Arrange for all other regulatory inspections and final inspections required.
- G. The Contractor shall be solely responsible, without limitations, for any delays arising from the Contractor's failure to plan for the required inspections and to ascertain the availability of the Permit/Approval/Licensing Inspectors to complete the required inspections for the Works under this Contract. The related costs and expenses incurred by the Contractor shall be borne by the Contractor, with no change in the Contract Price and/or Contract Time.

1.4 NOISE CONTROL ON-SITE

- A. Abide by all local ordinances. Adjust hours of operation accordingly.

1.5 DUST CONTROL ON-SITE

- A. Perform dust control measures to minimize dust generation.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 43 33

CONTRACTOR FIELD SERVICES

PART 1 GENERAL

1.1 SUBMITTALS

A. Submittals:

1. Qualifications of Contractor's Representative
2. Contractor's Certificate of Compliance
3. Form 100: Certificate of Equipment Delivery
4. Form 101: Certificate of Readiness to Install
5. Functional and Performance Test Plans, including manufacturers' startup forms and checklists
6. Equipment Training Materials and Agendas as per Section 01 79 00 Demonstration and Training
7. Form T-1: Certificate of Satisfactory Classroom Training, and Form T-2: Certificate of Satisfactory Field Training as per Section 01 79 00 Demonstration and Training
8. Functional Testing results and Form 102: Certificate of Satisfactory Installation as per Section 01 91 14 Equipment Testing and Facility Startup
9. Performance Test reports and Forms 103: Certificate of Equipment Satisfactory Performance, as per Section 01 91 14 Equipment Testing and Facility Startup
10. Form 104: Certificate of Satisfactory Process Demonstration, and Form 105 Certificate of Satisfactory Process Performance as per Section 01 91 14 Equipment Testing and Facility Startup

1.2 REQUIRED FIELD SERVICES

- A. The Contractor shall provide authorized Manufacturer Representative field services to assist in the training, testing, startup and Commissioning. All costs associated with providing Manufacturer Representative field services, including but not limited to travel, accommodations and meals, shall be borne by the Contractor.
- B. The Contractor shall provide field engineering services to measure quantities, layout the Work, confirm subsurface conditions, and record as-built conditions.

1.3 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

- A. Authorized Manufacturer's Representative, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment Manufacturer to issue the certifications required of the Manufacturer. Additional qualifications may be specified elsewhere.
- B. Representative subject to acceptance by Contract Administrator. No substitute representatives will be allowed unless prior written approval by such has been given.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 CONTRACTOR'S CERTIFICATE OF COMPLIANCE

- A. A Contractor's Certificate of Compliance, a copy of which is attached to this Section, shall be completed in full and submitted prior to shipment of product or material or execution of the services.
- B. Contract Administrator may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted Certificate of Compliance.
- C. The form shall certify that the proposed product or material specified conforms to or exceeds specifications. Attach supporting reference data, affidavits, and certifications as appropriate.
- D. May reflect recent or previous test results on material or product, if acceptable to Contract Administrator.

3.2 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

- A. Provide Manufacturers' services when required by an individual Specification section, to meet the requirements of this Section.
- B. Where time is necessary in excess of that stated in the Specifications for Manufacturers' services, or when a minimum time is not specified, the time required to perform the specified services shall be considered incidental.
- C. Schedule Manufacturer' services to avoid conflict with other onsite testing or other Manufacturers' onsite services.
- D. Determine, before scheduling services, that all conditions necessary to allow successful testing have been met.
- E. Only those days of service approved by Contract Administrator will be credited to fulfill the specified minimum services.
- F. When specified in individual specification sections, Contractor shall arrange for the Manufacturer's onsite services to provide:
 - 1. Inspection and checking as required following delivery as warranted by Manufacturer and necessary to sign off on Certificate of Equipment Delivery Form 100.
 - 2. Instruction to the Contractor of the specific requirements related to equipment installation, and the Contractor and Manufacturer's representative sign off on Certificate of Readiness to Install Form 101.
 - 3. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.

4. Revisiting the site as required to correct problems and until installation and operation are acceptable to Contract Administrator.
5. Resolution of assembly or installation problems attributable to, or associated with, respective Manufacturer's products and systems.
6. Assistance during equipment Functional Testing and Performance Testing, as per Section 01 91 14 Equipment Testing and Facility Startup.
7. Assistance during Unit Process and Facility Demonstration Testing and Performance Verification as per Section 01 91 14 Equipment Testing and Facility Startup.
8. Training of the City's personnel in the operation and maintenance of respective product as per Section 01 79 00 Demonstration and Training.
9. Additional requirements may be specified elsewhere.

3.3 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

- A. When specified in individual Specification section, submit prior to shipment of product or material.
- B. Contract Administrator may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.
- C. Signed by product Manufacturer certifying that product or material specified conforms to or exceeds specified. Attach supporting reference data, affidavits, and certifications as appropriate.
- D. May reflect recent or previous test results on material or product, if acceptable to Contract Administrator.

3.4 FORM 100 CERTIFICATE OF EQUIPMENT DELIVERY

- A. When so specified, a FORM 100 CERTIFICATE OF EQUIPMENT DELIVERY, a copy of which is attached to this section, shall be completed and signed by the equipment Manufacturer's representative and the Contractor.
- B. Such form shall certify that the signing party is a duly authorized representative of the Manufacturer, is empowered by the Manufacturer to inspect the equipment to certify that the equipment was delivered to the Contractor in satisfactory condition, with no visible evidence of exterior damage or defects.

3.5 FORM 101 CERTIFICATE OF READINESS TO INSTALL

- A. When so specified, a FORM 101 CERTIFICATE OF READINESS TO INSTALL, a copy of which is attached to this section, shall be completed and signed by the equipment Manufacturer's representative and the Contractor.
- B. Such form shall certify that the signing party is a duly authorized representative of the Manufacturer, is empowered by the Manufacturer to familiarize the Contractor with specific requirements related to equipment installation, and to verify that the Contractor understands the required installation procedures prior to equipment installation.

3.6 TRAINING

- A. Refer to Section 01 79 00, Demonstration and Training.

3.7 EQUIPMENT TESTING AND FACILITY STARTUP

- A. Refer to Section 01 91 14, Equipment Testing and Facility Startup.

3.8 SUPPLEMENTS

- A. The supplements listed below, following “End of Section”, are part of this Specification.
 - 1. Contractor’s Certificate of Compliance
 - 2. Form 100: Certificate of Equipment Delivery
 - 3. Form 101: Certificate of Readiness to Install

END OF SECTION

CONTRACTOR'S CERTIFICATE OF COMPLIANCE

CITY _____ PRODUCT, MATERIAL OR SERVICE
SUBMITTED: _____

PROJECT NAME: _____

PROJECT NO: _____

COMMENTS: _____

Comments: _____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20__

Contractor: _____

By Contractor's Authorized Representative (*print*): _____

(Authorized Signature)



Water and Waste Department • Service des eaux et des déchets

Form 100
CERTIFICATE OF EQUIPMENT DELIVERY

We certify that the equipment listed below has been delivered into the care and custody of the Contractor. The equipment has been found to be in satisfactory condition. There is no visible evidence of exterior damage or defects.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description:
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: XXX-2023
Equipment Tag No.:
Specification Reference:

Print Name	Signature	Date
(Authorized Representative of Manufacturer)		

Print Name	Signature	Date
(Authorized Representative of Contractor)		

Print Name	Signature	Date
(Authorized Representative of Contract Administrator)		



Water and Waste Department • Service des eaux et des déchets

Form 101
CERTIFICATE OF READINESS TO INSTALL

We have familiarized the installing contractor of the specific requirements related to the equipment listed below and am satisfied that the installing contractor understands the required installation procedures.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description:
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: XXX-2023
Equipment Tag No.:
Specification Reference:

Print Name

Signature

Date

(Authorized Representative of Manufacturer)

We certify that we have received satisfactory installation instructions from the equipment Manufacturer/vendor.

Print Name

Signature

Date

(Authorized Representative of Contractor)

SECTION 01 45 16.13

CONTRACTOR QUALITY CONTROL

PART 1 GENERAL

1.1 INSPECTION

- A. Allow Contract Administrator access to Work. If part of Work is no preparation at locations other than place of Work, allow access to such Work whenever it is in progress.
- B. Give timely notice requesting inspection if Work is designated for special test, inspections or approvals by Contract Administrator instructions.
- C. If Contractor covers or permits to be covered Work that has been designated for special tests, inspections, or approvals before such is made, uncover such Work, have inspections or tests satisfactorily completed and make good such Work.
- D. Contract Administrator may order part of Work to be examined if Work is suspected to not be in accordance with Contract Documents, correct such Work and pay cost of examination and correction. If such Work is found in accordance with the Contract Documents, the City will pay cost of examination and replacement if necessary.

1.2 QUALITY CONTROL

- A. The city will provide services of independent inspection company to perform the following routine quality control services, at no cost to the Contractor:
 - 1. Concrete cylinder testing, aggregate testing and cement testing for both cast-in-place- concrete and precast concrete items.
 - 2. Welding of structural steel and pipe joints.
 - 3. Torque of high-strength bolts.
 - 4. Load tests of structural items.
- B. The City's tests do not relieve Contractor of his own quality control.
- C. Contract Administrator may request samples at any reasonable time. Cooperate with Resident Project Representative. Provide concrete and other materials for tests as may be required.
- D. Additional testing required to prove the adequacy of construction shall be at Contractor's expense, where the routine test shows the construction to be inadequate or where Contractor's materials and procedures have not been as specified or when work has proceeded without observation.
- E. Such additional testing or retesting will be performed by a testing agency approved by City.

1.3 PROCEDURES

- A. Notify Contract Administrator in advance of requirement for tests, in order that attendance arrangements can be made.
- B. Submit samples and/or materials required for testing, as specifically requested in specifications. Submit with reasonable promptness and in orderly sequence to not cause delays in Work.
- C. Provide labour and facilities to obtain and handle samples and materials on site. Provide sufficient spaces to store and cure test samples.

1.4 REJECTED WORK

- A. Remove deficient Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by the Contract Administrator as failing to conform to Contract Documents.
- B. Make good other Contractor's work damaged by such removals or replacements promptly.

1.5 REPORTS

- A. Submit one electronic (PDF) copy of inspection and test reports to Contract Administrator.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 61 00

COMMON PRODUCT REQUIREMENTS

PART 1 GENERAL

1.1 REFERENCES

- A. Canadian Standards Association (CSA):
 - 1. C22.2 No. 100-04, Motors and Generators – Sixth Edition.
- B. Manufacturers Standardization Society of the Valves and Fitting Industry:
 - 1. SP-6, Standard Finishes for Contact of Pipe Flanges and Connecting – End Flanges of Valves and Fittings.
- C. National Building Code, with Manitoba Building Code amendments.

1.2 DEFINITIONS

- A. Products:
 - 1. New items for incorporation in the Work, whether purchased by Contractor or the City for the Project, or taken from previously purchased stock and may also include existing materials or components required for reuse.
 - 2. Includes the terms material, equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change meaning of such other terms used in Contract Documents, as those terms are self-explanatory and have well recognized meanings in construction industry.
 - 3. Items identified by Manufacturer's product name, including make or model designation, indicated in Manufacturer's published product literature, that is current as of the date of the Contract Documents.

1.3 ENVIRONMENTAL REQUIREMENTS

- A. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of -45 degrees C to 45 degrees C, unless otherwise specified.

1.4 PREPARATION FOR SHIPMENT

- A. When practical, factory assemble products. Mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable protective coating.
- B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or tag outside of each package or crate to indicate its purchase order number, bill of lading number, contents by name, name of Project and Contractor, equipment number, and approximate weight. Include complete packing list and bill of materials with each shipment.

- C. Extra Materials, Special Tools, Test Equipment, and Expendables:
 - 1. Furnish as required by individual Specifications.
 - 2. Schedule:
 - a. Ensure that shipment and delivery occurs concurrent with shipment of associated equipment.
 - b. Transfer to the City shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
 - 3. Packaging and Shipment:
 - a. Package and ship extra materials and special tools to avoid damage during long term storage in original cartons insofar as possible, or in appropriately sized, hinged-cover, wood, plastic, or metal box.
 - b. Prominently displayed on each package, the following:
 - 1) Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
 - 2) Applicable equipment description.
 - 3) Quantity of parts in package.
 - 4) Equipment manufacturer.
 - 4. Deliver materials to Site.
 - 5. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to the City.
- D. Request a minimum 7-day advance notice of shipment from manufacturer. Upon receipt of manufacturer's advance notice of shipment, promptly notify Contract Administrator of anticipated date and place of equipment arrival.
- E. Factory Test Results: Reviewed and accepted by Contract Administrator before product shipment as required in individual Specification sections.

1.5 DELIVERY AND INSPECTION

- A. Deliver products in accordance with accepted current progress schedule and coordinate to avoid conflict with the Work and conditions at Site. Deliver anchor bolts and templates sufficiently early to permit setting prior to placement of structural concrete.
- B. Deliver products in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Include on label, date of manufacture and shelf life, where applicable. Include ULC and CSA labels on products so specified.
- C. Unload products in accordance with manufacturer's instructions for unloading or as specified. Record receipt of products at Site. Inspect for completeness and evidence of damage during shipment.
- D. Remove damaged products from Site and expedite delivery of identical new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.6 HANDLING, STORAGE, AND PROTECTION

- A. Handle and store products in accordance with Manufacturer's written instructions and in a manner to prevent damage. Provide Manufacturer's recommended maintenance during storage, installation, and until products are accepted for use by the City.
- B. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to assure that products are maintained under specified conditions, and free from damage or deterioration. Keep running account of products in storage to facilitate inspection and to estimate progress payments for products delivered, but not installed in the Work.
- C. Store electrical, instrumentation, and control products, and equipment with bearings in weather-tight structures maintained above 15 degrees C. Protect electrical, instrumentation, and control products, and insulation against moisture, water, and dust damage. Connect and operate continuously all space heaters furnished in electrical equipment.
- D. Store fabricated products above ground on blocking or skids, and prevent soiling or staining. Store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.
- E. Store finished products that are ready for installation in dry and well-ventilated areas. Do not subject to extreme changes in temperature or humidity.
- F. Hazardous Materials: Prevent contamination of personnel, storage building, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

1.7 QUALITY

- A. Products, materials, equipment and articles incorporated in Work shall be new, not damaged or defective, and of best quality for purpose intended. If requested, furnish evidence as to type, source and quality of products provided.
- B. Defective products, whenever identified prior to completion of Work, will be rejected, regardless of previous inspections. Inspection does not relieve responsibility, but is precaution against oversight or error. Remove and replace defective products at own expense and be responsible for delays and expenses caused by rejection. Should disputes arise as to quality or fitness of products, decision rests strictly with the Contract Administrator based upon requirements of Contract Documents.
- C. Unless otherwise indicated in specifications, maintain uniformity of manufacture for any particular or like item throughout building.
- D. Permanent labels, trademarks and nameplates on products are not acceptable in prominent locations, except where required for operating instructions, or when located in mechanical or electrical rooms.

1.8 METRIC PROJECT

- A. Unless otherwise noted, this project has been designed and is to be constructed in the International System (SI) of Units metric system of measurements.
- B. During construction, when specified metric elements are unattainable at the time they are required to meet the construction schedule, the Contractor shall notify the Contract Administrator in writing and suggest alternative substitutions. Costs due to these substitutions shall be borne by the Contractor.

1.9 MANUFACTURER'S INSTRUCTIONS

- A. Unless otherwise indicated in specifications, install or erect products in accordance with Manufacturer's instructions. Do not rely on labels or enclosures provided with products. Obtain written instructions directly from manufacturers.
- B. Notify the Contract Administrator in writing, of conflicts between specifications and Manufacturer's instructions, so that the Contract Administrator will establish the course of action.
- C. Improper installation or erection of products, due to failure in complying with these requirements, authorizes the Contract Administrator require removal and re-installation at no increase in Contract Price or Contract Time.

PART 2 PRODUCTS

2.1 GENERAL

- A. Provide manufacturer's standard materials suitable for service conditions, unless otherwise specified in the individual Specifications.
- B. Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.
- C. Like items of products furnished and installed in the Work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions in same or similar manner.
- D. Do not use materials and equipment removed from existing premises, except as specifically permitted by Contract Documents.
- E. Provide interchangeable components of the same manufacturer, for similar components, unless otherwise specified.

- F. Equipment, Components, Systems, and Subsystems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable Workplace Safety and Health, provincial, and local health and safety regulations.
- G. Regulatory Requirement: Coating materials shall meet federal, provincial, and local requirements limiting the emission of volatile organic compounds and for worker exposure.
- H. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, stainless steel, or hot-dip galvanized or aluminum coated 12 mm mesh expanded steel. Provide hot-dip galvanized or stainless steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water. Eliminate sharp edges with suitable borders neatly welded.
- I. Provide materials and equipment listed by ULC and CSA wherever standards have been established by that agency.
- J. Equipment Finish:
 - 1. Provide manufacturer's standard finish and color, except where specific finish or color is indicated.
- K. Special Tools and Accessories: Furnish to the City, upon acceptance of equipment, all accessories required to place each item of equipment in full operation. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.
- L. Lubricants:
 - 1. Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by the City.
 - 2. Provide Canadian made lubricants readily available in Canada. To the extent possible, provide lubricants compatible with products currently used in the City's maintenance operations.
 - 3. Furnish lubricants in original sealed containers, correctly identified as to brand and grade.
- M. Nameplates:
 - 1. Provide for all equipment and motors, securely mounted in a readily visible location.
 - 2. 16-gauge stainless steel with 6 mm high die-stamped inscriptions.
 - 3. Inscriptions to include the following as a minimum:
 - a. Motors: In accordance with the requirements of C22.2 No. 100.
 - b. Equipment: Model number, serial number, size, performance data at rated capacity, impeller diameter, speed, efficiency, and other pertinent data, as applicable.
 - 4. Data in SI metric units.
- N. Bolted Connections: Project bolt ends minimum 3 mm but not more than one bolt diameter beyond nut faces.

- O. Flanges: Arrange with bolt holes straddling vertical centreline. Provide flanges finished in accordance with MSS SP-6.
- P. Bearings: Unless otherwise specified, provide bearings for rotating equipment suitable for ABMA B-10 life expectancy of minimum 100,000 working hours at rated conditions of service.

2.2 FABRICATION AND MANUFACTURE

A. General:

1. Manufacture parts to North American standard sizes and gauges.
2. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
3. Design structural members for anticipated shock and vibratory loads.
4. Modify standard products as necessary to meet performance Specifications.

B. Lubrication System:

1. Require no more than weekly attention during continuous operation.
2. Convenient and accessible. Oil drains with bronze or stainless steel valves and fill-plugs easily accessible from the normal operating area or platform. Locate drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. Provide constant-level oilers or oil level indicators for oil lubrication systems.
4. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

C. Equipment Base Plates:

1. Common base plate for equipment and driver, fabricated from heavy cast iron or welded structural steel section minimum 13 mm thick.
2. Provided with mounting plates minimum 19 mm thick for equipment and driver with mounting surfaces machined to average arithmetical roughness height of 3.0 microns maximum.
3. Provided with grout holes, vent holes, and anchor bolt holes.
4. For equipment where leakage or condensation may occur, equipped with drip lip or gutter, 25 mm NPT bossed drain connection at low point, and drain piping to building drainage system.

2.3 SOURCE QUALITY CONTROL

- A. Where Specifications call for factory testing to be witnessed by Contract Administrator, notify Contract Administrator not less than 14 days prior to scheduled test date, unless otherwise specified.
- B. Calibration Instruments: Bear the seal of a reputable laboratory certifying instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).
- C. Factory Tests: Perform in accordance with accepted test procedures and document successful completion.

PART 3 EXECUTION

3.1 WORKMANSHIP

- A. Ensure Quality of Work is of highest standard, executed by workers experienced and skilled in respective duties for which they are employed. Immediately notify the Contract Administrator if required Work is such as to make it impractical to produce required results.
- B. Do not employ anyone unskilled in their required duties. The Contract Administrator reserves the right to require dismissal from Site, workers deemed incompetent or careless.
- C. Decisions as to standard or fitness of Quality of Work in cases of dispute rest solely with the Contract Administrator, whose decision is final.

3.2 INSPECTION

- A. Inspect materials and equipment for signs of pitting, rust decay, or other deleterious effects of storage. Do not install material or equipment showing such effects. Remove damaged material or equipment from the Site and expedite delivery of identical new material or equipment. Delays to the Work resulting from material or equipment damage that necessitates procurement of new products will be considered delays within Contractor's control.

3.3 INSTALLATION

- A. The existing chiller CHLR-B679 is located in the Service Building Boiler Room basement which has an access hatch from above with an opening of 1800 x 1200 mm. Contractor to ensure new chiller dimension will be accessible for final delivery and installation work.
- B. Equipment Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.
- C. No shimming between machined surfaces is allowed.
- D. Repaint painted surfaces that are damaged prior to equipment acceptance.
- E. Handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's instructions, and as may be specified. Retain a copy of manufacturers' instruction at Site, available for review at all times.
- F. For material and equipment specifically indicated or specified to be reused in the Work:
 - 1. Use special care in removal, handling, storage, and reinstallation to assure proper function in the completed Work.
 - 2. Arrange for transportation, storage, and handling of products that require offsite storage, restoration, or renovation. Include costs for such Work in the Contract Price.

3.4 FIELD FINISHING

- A. In accordance with Section 09 90 00, Painting and Coating and individual Specification sections.

3.5 ADJUSTMENT AND CLEANING

- A. Perform required adjustments, tests, operation checks, and other startup activities.

3.6 LUBRICANTS

- A. Fill lubricant reservoirs and replace consumption during testing, startup, and operation prior to acceptance of equipment by the City.

END OF SECTION

SECTION 01 73 03

EXECUTION REQUIREMENTS

GENERAL

1.1 SUBMITTALS

- A. Submittals: in accordance with Section 01 33 00 - Submittal Procedures
- B. Submit written request in advance of cutting or alteration which affects:
 - 1. Structural integrity of elements of project.
 - 2. Integrity of weather-exposed or moisture-resistant elements.
 - 3. Efficiency, maintenance, or safety of operational elements.
 - 4. Visual qualities of sight-exposed elements.
 - 5. Work of City or separate contractor.
- C. Include in request:
 - 1. Identification of project.
 - 2. Location and description of affected Work.
 - 3. Statement on necessity for cutting or alteration.
 - 4. Description of proposed Work, and products to be used.
 - 5. Alternatives to cutting and patching.
 - 6. Effect on Work of City or separate contractor.
 - 7. Written permission of affected separate contractor.
 - 8. Date and time work will be executed.

1.2 MATERIALS

- A. Required for original installation.
- B. Change in Materials: Submit request for substitution in accordance with Section 01 33 00 - Submittal Procedures.

1.3 PREPARATION

- A. Inspect existing conditions, including elements subject to damage or movement during cutting and patching.
- B. After uncovering, inspect conditions affecting performance of Work.
- C. Beginning of cutting or patching means acceptance of existing conditions.
- D. Provide supports to assure structural integrity of surroundings; provide devices and methods to protect other portions of project from damage.
- E. Provide protection from elements for areas which are to be exposed by uncovering work; maintain excavations free of water.

1.4 EXECUTION

- A. Execute cutting, fitting, and patching to complete Work.
- B. Fit several parts together, to integrate with other Work.
- C. Uncover Work to install ill-timed Work.
- D. Remove and replace defective and non-conforming Work.
- E. Remove samples of installed Work for testing.
- F. Provide openings in non-structural elements of Work for penetrations of mechanical and electrical Work.
- G. Execute Work by methods to avoid damage to other Work, and which will provide proper surfaces to receive patching and finishing.
- H. Employ original installer to perform cutting and patching for weather-exposed and moisture-resistant elements, and sight-exposed surfaces.
- I. Cut rigid materials using masonry saw or core drill. Pneumatic or impact tools not allowed on masonry work without prior approval.
- J. Restore work with new products in accordance with requirements of Contract Documents.
- K. Fit Work to pipes, sleeves, ducts, conduit, and other penetrations through surfaces.
- L. At penetration of fire rated wall, ceiling, or floor construction, completely seal voids with firestopping material in accordance with Section 07 84 00 - Firestopping, full thickness of the construction element.
- M. Refinish surfaces to match adjacent finishes: Refinish continuous surfaces to nearest intersection. Refinish assemblies by refinishing entire unit.
- N. Conceal pipes, ducts and wiring in floor, wall and ceiling construction of finished areas except where indicated otherwise.

1.5 WASTE MANAGEMENT AND DISPOSAL

- A. Separate waste materials for reuse and recycling.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 74 11

CLEANING

PART 1 GENERAL

1.1 PROJECT CLEANLINESS

- A. Maintain Work in tidy condition, free from accumulation of waste products and debris, including that caused by City or other Contractors.
- B. Remove waste materials from site at daily regularly scheduled times or dispose of as directed by Contract Administrator. Do not burn waste materials on site.
- C. Make arrangements with and obtain permits from authorities having jurisdiction for disposal of waste and debris.
- D. Provide onsite containers for collection of waste materials and debris.
- E. Provide and use marked separate bins for recycling.
- F. Dispose of waste materials and debris off site.
- G. Clean interior areas prior to start of finishing work and maintain areas free of dust and other contaminants during finishing operations.
- H. Store volatile waste in covered metal containers and remove from premises at end of each working day.
- I. Provide adequate ventilation during use of volatile or noxious substances. Use of building ventilation systems is not permitted for this purpose.
- J. Use only cleaning materials recommended by manufacturer of surface to be cleaned, and as recommended by cleaning material manufacturer.
- K. Schedule cleaning operations so that resulting dust, debris and other contaminants will not fall on wet, newly painted surfaces nor contaminate building systems.

1.2 FINAL CLEANING

- A. When Work is Substantially Performed remove surplus products, tools, construction machinery and equipment not required for performance of remaining Work. Leave the Work and adjacent areas affected in a cleaned condition satisfactory to The City and Contract Administrator.
- B. Remove waste products and debris other than that caused by others and leave Work clean and suitable for occupancy.

- C. Prior to final review remove surplus products, tools, construction machinery and equipment.
 - D. Remove waste products and debris.
 - ~~E.~~ Remove waste materials from site at regularly scheduled times or dispose of as directed by Contract Administrator.
 - F. Make arrangements with and obtain permits from authorities having jurisdiction for disposal of waste and debris.
 - G. Clean and polish glass, mirrors, hardware, wall tile, stainless steel, chrome, porcelain enamel, baked enamel, plastic laminate, and mechanical and electrical fixtures. Replace broken, scratched or disfigured glass.
 - H. Remove stains, spots, marks and dirt from decorative work, electrical and mechanical fixtures, furniture fitments, walls, and floors.
 - I. Clean lighting reflectors, lenses, and other lighting surfaces.
 - J. Vacuum clean and dust building interiors, behind grilles, louvres and screens.
 - K. Inspect finishes, fitments and equipment and ensure specified workmanship and operation.
 - L. Broom clean and wash exterior walks, steps and surfaces; rake clean other surfaces of grounds.
 - M. Remove dirt and other disfiguration from exterior surfaces.
 - N. Clean and sweep roofs, gutters, areaways, and sunken wells.
 - O. Sweep and wash clean paved areas.
 - P. Clean equipment and fixtures to sanitary condition; clean or replace filters of mechanical equipment.
 - Q. Clean roofs, downspouts, and drainage systems.
 - R. Remove debris and surplus materials from crawl areas and other accessible concealed spaces.
 - S. Use only cleaning materials recommended by manufacturer of surfaces to be cleaned.
- 1.3 WASTE MANAGEMENT AND DISPOSAL
- A. Separate waste materials for reuse and recycling.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 77 00
CLOSEOUT PROCEDURES

PART 1 GENERAL

1.1 SUBMITTALS

- A. Informational Submittals:
1. Submit prior to application for final payment.
 - a. As-built Documents: As required in General Conditions.
 - b. Reviewed Shop Drawings and Samples: As required in the General Conditions.
 - c. Special Bonds, Special Guarantees, and Service Agreements.
 - d. Releases or Waivers of Liens and Claims: As required in General Conditions.
 - e. Extra Materials / Spare Parts: As required by individual Specification sections.

1.2 AS-BUILT DOCUMENTS

- A. Quality Assurance:
1. Furnish qualified and experienced person, whose duty and responsibility shall be to maintain as-built documents.
 2. Accuracy of Records:
 - a. Coordinate changes within as-built documents, making legible and accurate entries on each sheet of Drawings and other documents where such entry is required to show change.
 - b. Purpose of Project as-built documents is to document factual information regarding aspects of the Work, both concealed and visible, to enable future modification of the Work to proceed without lengthy and expensive site measurement, investigation, and examination.
 3. Make entries within 24 hours after receipt of information that a change in the Work has occurred.
 4. Prior to submitting each request for progress payment, request Contract Administrator's review and approval of current status of as-built documents. Failure to properly maintain, update, and submit as-built documents may result in a deferral by Contract Administrator to recommend whole or any part of Contractor's Application for Payment, either partial or final.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 MAINTENANCE OF AS-BUILT DOCUMENTS

- A. General:
1. Promptly following commencement, secure from Contract Administrator at no cost to Contractor, one complete set of Contract Documents. Drawings will be full size.

2. Delete Contract Administrator title block and seal from all documents.
3. Label or stamp each as-built document with title, "AS-BUILT DOCUMENTS," in neat large printed letters.
4. Record information concurrently with construction progress and within 24 hours after receipt of information that change has occurred. Do not cover or conceal Work until required information is recorded.

B. Preservation:

1. Maintain documents in a clean, dry, legible condition and in good order. Do not use as-built documents for construction purposes.
2. Make documents and Samples available at all times for observation by Contract Administrator.

C. Making Entries on Drawings:

1. Using an erasable colored pencil (not ink or indelible pencil), clearly describe change by graphic line and note as required.
 - a. Color Coding:
 - 1) Green when showing information deleted from Drawings.
 - 2) Red when showing information added to Drawings.
 - 3) Blue and circled in blue to show notes.
2. Date entries.
3. Call attention to entry by "cloud" drawn around area or areas affected.
4. Legibly mark to record actual changes made during construction, including, but not limited to:
 - a. Depths of various elements of foundation in relation to finished first floor data if not shown or where depth differs from that shown.
 - b. Horizontal and vertical locations of existing and new Underground Facilities and appurtenances, and other underground structures, equipment, or Work. Reference to at least two measurements to permanent surface improvements.
 - c. Location of internal utilities and appurtenances concealed in the construction referenced to visible and accessible features of the structure.
 - d. Locate existing facilities, piping, equipment, and items critical to the interface between existing physical conditions or construction and new construction.
 - e. Changes made by Addenda and Field Orders, Work Change Directive, Change Order, Written Amendment, and Contract Administrator's written interpretation and clarification using consistent symbols for each and showing appropriate document tracking number.
5. Dimensions on Schematic Layouts: Show on as-built drawings, by dimension, the centerline of each run of items such as are described in previous subparagraph above.
 - a. Clearly identify the item by accurate note such as "cast iron drain," "galv. water," and the like.
 - b. Show, by symbol or note, vertical location of item ("under slab," "in ceiling plenum," "exposed," and the like).
 - c. Make identification so descriptive that it may be related reliably to Specifications.

3.2 FINAL CLEANING

- A. At completion of the Work or of a part thereof and immediately prior to Contractor's request for Certificate of Substantial Performance; or if no certificate is issued, immediately prior to Contractor's notice of completion, clean entire Site or parts thereof, as applicable under 01 74 11 Cleaning.

END OF SECTION

SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Detailed information for the preparation, submission, and Contract Administrator's review of operations and maintenance (O&M) data, as required by individual Specification sections.

1.2 DEFINITIONS

- A. Preliminary Data: Initial and subsequent submissions for Contract Administrator's review.
- B. Final Data: Contract Administrator-accepted data, submitted as specified herein.
- C. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of equipment. Examples of typical maintenance operations include but are not limited to lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.
- D. Instructional Manual: An organized compilation of operating and maintenance data including detailed technical information, documents and records describing operation and maintenance of individual systems, subsystems and components as specified in individual sections of this specification.

1.3 SEQUENCING AND SCHEDULING

- A. Equipment and System Data:
 - 1. Preliminary Data:
 - a. Do not submit until Shop Drawing for equipment or system has been reviewed and returned stamped "NO EXCEPTIONS TAKEN" or "EXCEPTIONS NOTED" by Contract Administrator.
 - b. Submit prior to shipment date.
 - 2. Final Data:
 - a. Submit Instructional Manual not less than 30 days prior to equipment or system field Functional Testing.
 - b. Submit Compilation Formatted and Electronic Media Formatted data prior to Substantial Performance of Project.

1.4 DATA FORMAT

- A. Preliminary Manual Format:
 - 1. Binder: Commercial quality, permanent, three-ring binders with durable plastic cover.
 - a. Three hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data
 - 2. Size: 8-1/2 inches by 11 inches, minimum.

3. Cover: Identify manual with typed or printed title “OPERATION AND MAINTENANCE DATA, VOLUME NO. ___ OF ___,” and list:
 - a. Project title.
 - b. Contractor’s name, address, and telephone number.
 - c. If entire volume covers equipment or system provided by one supplier include the following:
 - 1) Identity of general subject matter covered in manual.
 - 2) Identity of equipment number and Specification section.
4. Provide each volume with title page and typed table of contents with consecutive page numbers. Place contents of entire set, identified by volume number, in each binder.
5. Table of contents neatly typewritten, arranged in a systematic order:
 - a. Include list of each product, indexed to content of each volume.
 - b. Designate system or equipment for which it is intended.
 - c. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
6. Section Dividers:
 - a. Heavy, 80 pound cover weight, tabbed with numbered plastic index tabs.
 - b. Fly-Leaf:
 - 1) For each separate product, or each piece of operating equipment, with typed description of product and major component parts of equipment.
 - 2) List with each product:
 - a) Name, address, and telephone number of Subcontractor, supplier, installer, and maintenance contractor, as appropriate.
 - b) Identify area of responsibility of each.
 - c) Provide local source of supply for parts and replacement.
 - 3) Identity of separate structure as applicable.
 - 4) Maintenance Summary (Format in accordance with paragraph 1.6.D)
7. Assemble and bind material in same order as specified in the Contract Documents.
8. Material shall be suitable for reproduction, with quality equal to original.

B. Final Instructional Manual Format:

1. Compile all Contract Administrator-accepted preliminary O&M data into a hard-copy, hard-bound set as detailed in Section B above and in electronic media format as described in paragraph C.

C. Electronic Media Format:

1. Portable Document Format (PDF):
 - a. After all preliminary data has been found to be acceptable to Contract Administrator, upload electronic copies of O&M data to the City’s DMS (Aconex) in PDF format and in native file format as applicable
 - b. Files to be exact duplicates of Contract Administrator-accepted preliminary data. Arrange by specification number and name.
 - c. Files to be fully functional and viewable in most recent version of Adobe Acrobat.
 - d. PDF files to be indexed and searchable.
 - e. CD Cover: Identify with typed or printed title “OPERATION AND MAINTENANCE DATA, VOLUME NO. ___ OF ___,” and list:
 - 1) Project title.
 - 2) Contractor’s name, address, and telephone number.

- 3) Identity of equipment number and Specification section.

1.5 SUBMITTALS

A. Informational:

1. Data Outline: Submit an electronic copy of a detailed outline of proposed organization and contents of final data prior to preparation of preliminary data.
2. Preliminary Data:
 - a. Submit three (3) hard copies for Contract Administrator's review.
 - b. If data meets conditions of the Contract:
 - 1) One (1) copy will be returned to Contractor.
 - 2) One (1) copy will be forwarded to The City.
 - 3) One (1) copy will be retained in Contract Administrator's file.
 - c. If data does not meet conditions of the Contract:
 - 1) Two (2) copies will be returned to Contractor with Contract Administrator's comments (on separate document) for revision.
 - 2) One (1) copy with comments will be retained in Contract Administrator's file.
 - 3) Resubmit three (3) copies revised in accordance with Contract Administrator's comments.
3. Final Data: Submit six (6) hard copies in format(s) specified herein.

1.6 DATA FOR SYSTEMS, SUBSYSTEM AND COMPONENTS

A. Content For Each Unit (or Common Units) and System unless otherwise specified:

1. Product Data:
 - a. Include only those sheets that are pertinent to specific product.
 - b. Clearly annotate each sheet to:
 - 1) Identify specific product(s) or part(s) installed.
 - 2) Identify data applicable to installation.
 - 3) Delete references to inapplicable information.
 - c. Function, normal operating characteristics, and limiting conditions.
 - d. Serial Numbers
 - e. Performance curves, engineering data, nameplate data, and tests reports for all pumps.
 - f. Complete nomenclature and commercial number of replaceable parts.
 - g. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
 - h. Spare parts ordering instructions.
 - i. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).
2. As-installed, color-coded piping diagrams.
3. Charts of valve tag numbers, with the location and function of each valve.
4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:
 - a. Format:
 - 1) Provide reinforced, punched, binder tab; bind in with text.
 - 2) Reduced to 8-1/2 inches by 11 inches, or 11 inches by 17 inches folded to 8-1/2 inches by 11 inches.

- 3) Where reduction is impractical, fold and place in 8-1/2-inch by 11-inch envelopes bound in text.
 - 4) Identify Specification section and product on Drawings and envelopes.
 - b. Relations of component parts of equipment and systems.
 - c. Control and flow diagrams.
 - d. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
 5. Instructions and Procedures: Within text, as required to supplement product data.
 - a. Format:
 - 1) Organize in consistent format under separate heading for each different procedure.
 - 2) Provide logical sequence of instructions for each procedure.
 - 3) Provide information sheet for The City's personnel, including:
 - a) Proper procedures in event of failure.
 - b) Instances that might affect validity of guarantee or Bond.
 - b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
 - c. Operating Procedures:
 - 1) Startup, break-in, routine, and normal operating instructions.
 - 2) Test procedures and results of factory tests where specified.
 - 3) Regulation, control, stopping, and emergency instructions.
 - 4) Description of operation sequence by control manufacturer.
 - 5) Shutdown instructions for both short and extended duration.
 - 6) Summer and winter operating instructions, as applicable.
 - 7) Safety precautions.
 - 8) Special operating instructions.
 - d. Maintenance and Overhaul Procedures:
 - 1) Routine maintenance.
 - 2) Guide to troubleshooting.
 - 3) Disassembly, removal, repair, reinstallation, and re-assembly.
 6. Guarantee, Bond, and Service Agreement: In accordance with Section 01 77 00, Closeout Procedures.

B. Content for Each Electric or Electronic Item or System:

 1. Description of Unit and Component Parts:
 - a. Function, normal operating characteristics, and limiting conditions.
 - b. Performance curves, engineering data, nameplate data, and tests.
 - c. Complete nomenclature and commercial number of replaceable parts.
 - d. Interconnection wiring diagrams, including control and lighting systems.
 2. Circuit Directories of Panelboards:
 - a. Electrical service.
 - b. Controls.
 - c. Communications.
 3. List of electrical relay settings, and control and alarm contact settings.
 4. Electrical interconnection wiring diagram, including control and lighting systems.
 5. As-installed control diagrams by control manufacturer.
 6. ISA S20 data sheets for all instruments.
 7. Operating Procedures:
 - a. Routine and normal operating instructions.

- b. Sequences required.
 - c. Safety precautions.
 - d. Special operating instructions.
 8. Maintenance Procedures:
 - a. Routine maintenance.
 - b. Guide to troubleshooting.
 - c. Adjustment and checking.
 - d. List of relay settings, control and alarm contact settings.
 9. Manufacturer's printed operating and maintenance instructions.
 10. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
- C. Content for Programmable Devices/Components/Sub-systems:
1. The following requirements are minimum requirements applicable to programmable equipment such as VFDs, ASDs, microprocessor based devices, PLCs, Human-Machine-Interfaces, computers, and other programmable devices. Additional requirements may be specified elsewhere.
 2. As-Constructed version of shop drawings.
 3. Functional description.
 4. Wiring details.
 5. Configuration Records; record of switch settings, program listings and parameter settings, after commissioning.
 6. Maintenance manuals.
 7. User guides, technical reference and programming manuals.
 8. CD-ROMs copies of:
 - a. Manuals.
 - b. Settings, databases and templates. Include both native format of files and ASCII-exported version.
 - c. Application programs.
 9. Cable and software for use on The City's notebook computer for revising/downloading the settings and software.
- D. Maintenance Summary:
1. Compile individual Maintenance Summary for each applicable equipment item, respective unit or system, and for components or sub-units.
 2. Format:
 - a. Use Maintenance Summary Form bound with this section or electronic facsimile of such.
 - b. Each Maintenance Summary may take as many pages as required.
 - c. Use only 8-1/2-inch by 11-inch size paper.
 - d. Complete using typewriter or electronic printing. Hand-written and hand-printed entries are will not be accepted.
 3. Include detailed lubrication instructions and diagrams showing points to be greased or oiled; recommend type, grade, and temperature range of lubricants and frequency of lubrication.
 4. Recommended Spare Parts:
 - a. Data to be consistent with manufacturer's bill of materials/parts list furnished in O&M manuals.

- b. "Unit" is the unit of measure for ordering the part.
- c. "Quantity" is the number of units recommended.
- d. "Unit Cost" is the current purchase price.

1.7 DATA FOR MATERIALS AND FINISHES

- A. Content for Architectural Products, Applied Materials, and Finishes:
 - 1. Manufacturer's data, giving full information on products:
 - a. Catalog number, size, and composition.
 - b. Color and texture designations.
 - c. Information required for reordering special-manufactured products.
 - 2. Instructions for Care and Maintenance:
 - a. Manufacturer's recommendation for types of cleaning agents and methods.
 - b. Cautions against cleaning agents and methods that are detrimental to product.
 - c. Recommended schedule for cleaning and maintenance.

- B. Content for Moisture Protection and Weather Exposed Products:
 - 1. Manufacturer's data, giving full information on products:
 - a. Applicable standards.
 - b. Chemical composition.
 - c. Details of installation.
 - 2. Instructions for inspection, maintenance, and repair.

1.8 SUPPLEMENTS

- A. The supplements listed below, following "End of Section", are part of this Specification.
 - 1. Forms: Maintenance Summary Form.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION

SECTION 01 79 00

DEMONSTRATION AND TRAINING

PART 1 GENERAL

1.1 DESCRIPTION

- A. This section contains requirements for training the City staff, by persons retained by the Contractor specifically for the purpose of proper operation and maintenance of all equipment supplied and installed under this Contract, including City-Supplied Equipment.
- B. The Contract Administrator will develop the overall training plans with input from the Contractor, Manufacturers or vendors, and the City. The Contractor shall be responsible for providing qualified training instructors, classroom and field lesson plans as detailed in the Specifications and as described herein.
- C. Arrange for Manufacturers' Representatives to supply detailed classroom and hands-on training to the City's operations personnel, maintenance personnel, and select on-call personnel on operation and maintenance of specified product (system, subsystem, and component) and as may be required in applicable Specifications.
- D. The City will require training for at least two (2) shifts for each specified training session. Allow at least the minimum specified number of hours or days of training for each City staff shift for each specified product (system, subsystem, and component).
- E. To facilitate scheduling of the City personnel, the City may elect to divide sessions into operation-specific topics and maintenance-specific topics as applicable, to allow operations/on-call staff and maintenance staff to attend separately. The Contractor shall coordinate with the Contract Administrator and the City.
- F. Training will be scheduled at least four weeks in advance of the respective training sessions.
- G. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with the City and familiar with operation and maintenance manual information specified in Section 01 78 23, Operation and Maintenance Data.
- H. Training sessions to be conducted by qualified Manufacturers' Representatives of the various equipment suppliers, with a minimum of two years' experience. Manufacturers' Representatives shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
- I. The Contract Administrator has the authority to determine if the training is sufficient based on the lesson plan submitted by the Contractor.
- J. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

1.2 SUBMITTALS

- A. Submit the following information to the Contract Administrator 30 days prior to the first training session. The material will be returned as either “NO EXCEPTIONS TAKEN”, “EXCEPTIONS NOTED” or “EXCEPTIONS NOTED - RESUBMIT”.
1. Lesson plan and supplemental training manuals, handouts, visual aids and other reference material required for each training session.
 2. Submit proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.
 3. Lesson Plan: When training of the City personnel is specified, prepare for each required course, a lesson plan containing but not limited to the following information:
 - a. Title and objectives.
 - b. Recommended types of attendees (e.g., managers, engineers, operators, maintenance).
 - c. Course description and outline of course content.
 - d. Format (e.g., lecture, self-study, demonstration, hands-on).
 - e. Instruction materials and equipment requirements, including supplemental training manuals, handouts, visual aids and other reference material required for each training session.
 - f. Resumes of instructors providing the training.
 4. Training Schedule:
 - a. Submit not less than 21 calendar days prior to start of equipment installation and revise as necessary for acceptance.
 - b. List specified equipment and systems that require training services and show:
 - 1) Respective manufacturer.
 - 2) Estimated dates for installation completion.
 - 3) Estimated training dates.
 - c. Adjust schedule to ensure training of appropriate personnel as deemed necessary by the City, and to allow full participation by Manufacturers’ Representatives. Adjust schedule for interruptions in operability of equipment.
 - d. Coordinate with Section 01 32 00, Construction Progress Documentation, and Section 01 91 14, Equipment Testing and Facility Start-up.
 - e. Individual sessions shall not exceed 4 hours. A break should be incorporated into sessions that exceed 2 hours. Training session anticipated to exceed 4 hours can be assigned to multiple-sessions; however, no more than one 3-hour and one 4-hour sessions (7 hours total) may be delivered to the same participants in a single day. Two successive 4-hour sessions may be delivered to alternating shifts of attendees in a single day (i.e., one group of attendees in the morning, and a second group of attendees in the afternoon). Training sessions requiring more than 7 hours may be delivered on separate days.
 - f. Classes shall not be scheduled concurrently.

1.3 LOCATION AND TRAINING FACILITIES

- A. The City will provide the classroom training facilities.
- B. Field training sessions shall take place at the equipment location.

1.4 FORMAT AND CONTENT

- A. The training sessions shall be comprised of both classroom training and field training. As a minimum, they shall cover the following topics for each item of equipment or system:
1. Training will cover:
 - a. Familiarization
 - 1) Safety
 - 2) Operation
 - 3) Troubleshooting
 - 4) Preventative and predictive maintenance
 - 5) Corrective maintenance
 - 6) Parts
 - 7) Local representation
 - b. Classroom Training
 - 1) As a minimum, classroom equipment/system training must be completed prior to Functional Testing and will include:
 - a) The specific equipment location in the plant and operational overview. Use slides and drawings to aid discussion.
 - b) Purpose and function of the equipment/system.
 - c) The operating theory of the equipment/system.
 - d) Start-up, shutdown, normal operation and emergency operating procedures, including system integration and electrical interlocks, if any.
 - e) Safety items, standard operation procedures (SOPs), and safe work procedures (SWPs) related to operation of the equipment.
 - f) Routine and preventative and predictive maintenance
 - g) Disassembly and assembly of equipment if applicable
 - h) Normal and major repair procedures
 - i) Inspection and troubleshooting procedures including the use applicable test instruments and the “pass” and “no pass” test instrument readings
 - j) Calibration procedures
 - 2) The Contractor shall integrate a PCS Demonstration System into any classroom training course where:
 - a) The content includes equipment monitoring and control via the HMI.
 - b) The content includes alarming and alarm response.
 - c) The content includes coordination of maintenance events and states to PCS/HMI status indications; or
 - d) The use of the PCS Demonstration System would clarify and/or aid in the training of the Training Participants.
 - e) Where use of the PCS Demonstration System is included in a training course, the Contractor shall:
 - (1) Provide the PCS Demonstration System in accordance with the Specifications;
 - (2) Make certain that the PCS Demonstration System in no way impacts the actual operating PCS or in any other way expose the PCS to any risk of inadvertent operation; and
 - (3) Provide a second projector and screen to display the HMI Operator Workstation to all participants.

- c. Field Training
 - 1) As a minimum, field equipment training for operations personnel shall include
 - a) Identification of equipment: location of primary element; location of instrument readout; discussion on purpose, basic operation, and information interpretation.
 - b) Discussion and demonstration of standard operating procedures, safe work procedure, and daily visual inspection of system operations.
 - c) Discussion and demonstration of the preventative maintenance activities, and predictive maintenance activities where applicable.
 - d) Discussion and demonstration of start-up and shutdown procedures.
 - e) Demonstration of routine disassembly and assembly of equipment if applicable.
 - f) Identification and review of safety items and demonstration of safety procedures, if feasible.
 - g) Review of Contractor prepared Operation and Maintenance Manuals.
 - h) Demonstration of operating parameter adjustment for optimized equipment/system operation.

1.5 VIDEO RECORDING

- A. The Contractor shall notify all training providers that the training sessions will be videotaped.
- B. Supply video recording of instruction sessions, including manufacturers' representatives' hands-on equipment instruction and classroom sessions.
- C. Arrange for and carry the cost of videotaping one complete training session for each item of equipment and each system.
- D. The video record of training shall be provided in MPEG-4(.mp4) format. The digital file must be named with course title and reference to the training plan. The files shall be fully indexed and cataloged with file labeled stating equipment or system, classrooms or field session, and date recorded.
- E. Videotaping shall be by professional commercial videographer, experienced in shooting training videos.
- F. Video Format and Quality:
 - 1. Digital (MPEG-4), with sound.
 - 2. Video:
 - a. Produce bright, sharp, and clear images with accurate colors, free of distortion and other forms of picture imperfections.
 - b. Electronically, and accurately display the month, day, year, and time of day of the recording.
 - 3. Audio:
 - a. Audio recorded during documentation shall be done clearly, precisely, and at a moderate pace.

- G. Documentation:
 - 1. Digital Video Disc (DVD) Label:
 - a. Tape number (numbered sequentially, beginning with 001).
 - b. Project Name.
 - 1) Facility name.
 - 2) Process area and equipment
- H. The digital files shall be fully indexed and cataloged with files labels stating equipment or system, classroom or field session, and date recorded.

1.6 EQUIPMENT AND SYSTEMS FOR TRAINING

- A. The chiller shall be supplied by a Canadian vendor with local Manitoba representation for startup, operation, maintenance, and training in Winnipeg. Service capability within 24 hours upon callup is required.

1.7 TRAINING COMPLETION FORMS

- A. Form T-1 to be signed by the trainer, the Contract Administrator, and by a City Staff representative for each City shift when classroom training has been completed. One (1) form is to be used for each item of equipment and each system for which training has been provided. Once all classroom training sessions have been completed, Form T1 is to be submitted to the Contract Administrator.
- B. Form T-2 to be signed by the trainer, the Contract Administrator, and by a City Staff representative for each City shift when field training has been completed. One (1) form is to be used for each item of equipment and each system for which training has been provided. Once all field training sessions have been completed, Form T2 is to be submitted to the Contract Administrator.
- C. The supply of adequate training, including completion of Forms T-1 and T-2 is a required prerequisite for handover of equipment, Unit Processes and Facility Areas as appropriate to the City.

1.8 SUPPLEMENT

- A. Supplements listed below, following “End of Section,” is a part of this Specification:
 - 1. Form T-1 Certificate of Satisfactory Classroom Training
 - 2. Form T-2 Certificate of Satisfactory Field Training

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION (Not Used)

END OF SECTION



Water and Waste Department • Service des eaux et des déchets

Form T-1

CERTIFICATE OF SATISFACTORY CLASSROOM TRAINING

We have completed classroom training in the operation and maintenance of the equipment as listed below.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description: [Redacted]
Equipment Supply Bid Opp. No.: [Redacted]
Equipment Install Bid Opp. No.: XXX-2023 [Redacted]
Equipment Tag No.: [Redacted]
Specification Reference: [Redacted]

List of Attendees:

[Redacted] [Redacted] [Redacted]

[Redacted] _____ [Redacted] _____
Print Name Signature Date
(Trainer)

[Redacted] _____ [Redacted] _____
Print Name Signature Date
(Authorized Representative of Contract Administrator)

[Redacted] _____ [Redacted] _____
Print Name Signature Date
(Authorized Representative of City)



Water and Waste Department • Service des eaux et des déchets

Form T-2

CERTIFICATE OF SATISFACTORY FIELD TRAINING

We have completed field training in the operation and maintenance of our equipment as listed below.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description: [Redacted]
Equipment Supply Bid Opp. No.: [Redacted]
Equipment Install Bid Opp. No.: XXX-2023 [Redacted]
Equipment Tag No.: [Redacted]
Specification Reference: [Redacted]

List of Attendees:

[Redacted] [Redacted] [Redacted]

[Redacted]	[Redacted]	[Redacted]
_____	_____	_____
Print Name (Trainer)	Signature	Date
[Redacted]	[Redacted]	[Redacted]
_____	_____	_____
Print Name (Authorized Representative of Contract Administrator)	Signature	Date
[Redacted]	[Redacted]	[Redacted]
_____	_____	_____
Print Name (Authorized Representative of City)	Signature	Date

SECTION 01 91 14

EQUIPMENT TESTING AND FACILITY STARTUP

PART 1 GENERAL

1.1 SUBMITTALS

- A. Informational Submittals:
1. Completed Manufacturer's Certificate of Proper Installation, and completed Form 102 – Certificate of Satisfactory Installation as required by individual Specification sections. Submit prior to beginning Facility Startup procedures.
 2. Testing:
 - a. Functional Test, Performance Test, Demonstration Test, and Performance Verification plans, procedures, and log formats: Submit as part of Shop Drawing submittal for the respective piece of equipment.
 - b. Functional Test, Performance Test, Demonstration Tests, and Performance Verification schedules: Submit at least 14 days prior to start of related testing.
 - c. Unit Process, Facility Area and Facility startup and performance evaluation plans: Incorporated into the Project Commissioning Plan at least 21 days prior to commencement of respective startup and Demonstration Testing.
 3. Certification of calibration for testing equipment, when so specified.
 4. Documentation of HVAC systems balancing results, when so specified.

1.2 COORDINATION WITH EXISTING SYSTEM SUBSYSTEM AND/OR COMPONENTS

- A. Commissioning of Unit Processes and Facility Areas and components must be coordinated with existing facilities as agreed upon by the Contract Administrator and the City.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor-supplied equipment: The Contractor shall be responsible for Functional Testing, Performance Testing, Demonstration Testing, and Performance Verification of equipment and or Unit Processes supplied under this Contract as described herein, and as required by the various equipment Specifications.
- B. The general sequence of Commissioning, testing and startup events is summarized by the following table, and in the Commissioning Structure flow chart included as a Supplement to this Section.

Sequence Item	Description
A. Testing prior to Equipment Shipment	<ul style="list-style-type: none"> 1) Factory Acceptance Testing (FAT) completed 2) Submit Manufacturer’s Certificate of Compliance when specified in individual Specification section
B. Testing Prerequisites	<ul style="list-style-type: none"> 1) Functional Test and Performance Test Plans submitted and reviewed as part of Shop Drawing submittals 2) Supply Contractor or Manufacturer’s Representative, Contract Administrator, and Contractor inspect equipment delivery 3) Contractor accepts equipment delivery 4) Supply Contractor or Manufacturer’s Representative, Contractor, and Contract Administrator complete Form 100 – Certificate of Equipment Delivery 5) Contractor stores equipment on Site or in Contractor warehouse 6) Supply Contractor or Manufacturers’ Representatives to provide installation instructions/training to Contractor 7) Supply Contractor or Manufacturers Representative, and Contractor to complete Form 101 – Certificate of Readiness to Install 8) Contractor to complete equipment installation and Unit Process and/or Facility Area construction 9) Supply Contractor or Manufacturers Representative, and Contractor to submit O&M Instructional Manuals not less than 30 days prior to Functional Testing 10) Relevant Classroom Training has been completed, and Form T-1 signed and submitted prior to equipment Functional Testing
C. Functional Testing	<ul style="list-style-type: none"> 1) Supply Contractor or Manufacturers’ Representatives inspect installation 2) Supply Contractor or Manufacturers’ Representatives, and Contractor to complete Functional Testing of equipment 3) Submit Manufacturer’s Certificate of Proper Installation Form

Sequence Item	Description
	4) Supply Contractor or Manufacturers’ Representatives, and Contractor complete and sign Form 102- Certificate of Satisfactory Installation
D. Performance Testing	<p>1) Supply Contractor or Manufacturers’ Representatives to conduct all necessary checks prior to confirming equipment is ready to run</p> <p>2) Supply Contractor or Manufacturers’ Representatives, and Contractor begin equipment startup and Performance Testing process</p> <p>3) Supply Contractor and/or Manufacturers’ Representatives, and/or Contractor complete equipment field training of City staff prior to, or in conjunction with equipment Performance Testing, unless otherwise specified and complete and submit Form T-2 Certificate of Satisfactory Field Training for each piece of equipment specified.</p> <p>4) Supply Contractor or Manufacturers’ Representatives, and Contractor complete Performance Test on each piece of equipment as specified.</p> <p>5) Contractor shall complete equipment related deficiency items identified, and retest equipment as required.</p> <p>6) All required parties sign Form 103 – Certificate of Equipment Satisfactory Performance for each piece of equipment.</p> <p>7) Contractor submit completed Form(s) 103 – Certificate of Equipment Satisfactory Performance</p>
E. Demonstration Testing	<p>1) With assistance from the Commissioning Team, the Contractor shall complete Unit Process and Facility Area Classroom Training of City staff prior to Demonstration Testing and complete and submit Form T-1 Certificate of Satisfactory Classroom Training for each Unit Process, Facility Area required</p> <p>2) With assistance from the Commissioning Team, the Contractor shall complete Unit Process and Facility Area field training of City staff prior to, or in conjunction with Demonstration Testing and complete and submit Form T-2 Certificate of Satisfactory Field Training for each Unit Process, Facility Area required</p> <p>3) Unit Process, Facility Area and Facility Startup and Performance Evaluation Forms incorporated into the Project Commissioning Plan prior to respective startup and Demonstration Testing</p>

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

Sequence Item	Description
	<p>4) The Contractor shall review the Demonstration Testing operational requirements (output and performance) with Contract Administrator and the City</p> <p>5) Contractor shall confirm required City staff is available</p> <p>6) Contractor shall review safety procedures as required with Contract Administrator and the City</p> <p>7) With assistance from the Commissioning Team, the Contractor shall commence Demonstration Testing of Unit Process or Facility Area (Contractor, Supply Contractor and/or Manufacturers' Representatives operate equipment during Demonstration Testing, unless otherwise agreed to by the Commissioning Team, under the supervision and direction of the City)</p> <p>8) Contractor shall complete Performance Testing and sign-off Form 104 – Certificate of Satisfactory Process Demonstration</p> <p>9) Contractor shall complete process related deficiency list items</p> <p>10) After Forms T-1, T-2, 100, 101, 102, 103 and 104 are completed, City to operate and maintain Unit Process and/or Facility Area</p>
F. Performance Verification	<p>1) Contractor shall review Performance Verification operational requirements (output & performance) with the Commissioning Team</p> <p>2) Contractor shall assist the Commissioning Team to commence Performance Verification of Unit Process or Facility Area (Contractor, Supply Contractor and/or Manufacturers' Representatives operate equipment during Performance Verification, unless otherwise agreed to by the Commissioning Team, under the supervision and direction of the City)</p> <p>3) Contractor shall complete Performance Verification (may be conducted in conjunction with Demonstration Testing if flows and loading allow)</p> <p>4) Contractor shall complete and Submit process Startup and Performance Evaluation Forms</p>

Sequence Item	Description
	5) Commissioning Team to sign and submit Form 105 – Certificate of Satisfactory Process Performance
	6) Contractor shall complete process related deficiency list items

3.2 ROLES AND RESPONSIBILITIES

A. Contractor’s Responsibilities:

1. Designate and furnish one or more Contractor’s personnel to act as the Contractor’s testing and startup representative to coordinate and expedite Commissioning.
 - a. Such person or persons shall be available at all times during the equipment, process testing and verification period(s).
2. As part of the Commissioning Team, assist the City and Contract Administrator in developing the Project Commissioning Plan as required.
3. Coordinate with and report directly to the Contract Administrator.
4. Attend Commissioning meetings in Winnipeg, Manitoba.
5. Meet with the Supply Contractors and Manufacturers’ Representatives and be trained on the installation of all equipment. Sign-off Form 101: Certificate of Readiness to Install.
6. Maintenance of equipment and subsystems until hand-over to the City.
7. List of all personnel who the Contractor plans to provide for Demonstration Testing and hand-over with information indicating their qualifications for this work.
8. Operate and/or provide operating assistance of all equipment installed under this Contract, and with the assistance of the Supply Contractors and Manufacturers’ Representatives as required, to complete all testing (Functional, Performance, Demonstration) and Performance Verification.
9. Liaise with the Supply Contractors and Manufacturers’ Representatives as required during installation and Functional Testing to ensure proper equipment installation, and sign-off Form 102: Certificate of Satisfactory Installation.
10. Correct all installation deficiencies as required by the Supply Contractors and Manufacturers’ Representatives.
11. Red tag, lockout and maintain control of all power supplies, valves, etc., associated with the equipment being tested.
12. Provide personnel representing the appropriate sub-contractors and equipment Manufacturers during training and Commissioning period as per the Current Schedule and Specifications, and as directed by the Contract Administrator.
13. Operate all equipment under the direction of the Supply Contractors and Manufacturers’ Representatives as required during equipment Performance Testing. Issue and sign Form 103: Certificate of Equipment Satisfactory Performance.
14. Operate all equipment under the direction of the Supply Contractors and Manufacturers’ Representatives as required during process Demonstration Testing. Issue and sign Form 104: Certificate of Satisfactory Process Demonstration.
15. After completion of Form 104 and all related site Training, green tag, and turn over control of all power supplies, valves, etc., to the City and Contract Administrator.
16. If Performance Verification is performed in conjunction with the process Demonstration Testing, operate all equipment under the direction of the Supply Contractors and

Manufacturers' Representatives as required during process Performance Verification. If Performance Verification is performed at a later date due to inadequate flows or loading at the time of Demonstration Testing, furnish Manufacturer's Representative and provide operational support to the City as required.

17. Issue and sign Form 105: Certificate of Satisfactory Process Performance.
18. Furnish Manufacturer's Representative and provide operational support to the City as required during Overall Facility Performance Verification.
19. Issue and sign Form 106: Certificate of Overall Facility Performance Verification.
20. Provide the Contract Administrator with red-lined as-built Drawings.
21. Additional responsibilities as specified in other sections.

B. The City Responsibilities:

1. As part of the Commissioning Team, assist the Contractor and Contract Administrator in developing the Project Commissioning Plan as required.
2. Provide water, power, and other items as required for testing and facility startup, unless otherwise indicated. The Contractor shall supply and install all chemicals, lubricants, and fuel required for the first fill.
3. Operate Unit Processes and devices, with support of the Contractor and Manufacturer's Representative as required during Performance Verification of Unit Processes and Facility Areas, if Performance Verification is performed separately from the Demonstration Testing.
4. Operate Process Units and devices, with support of the Contractor, Supply Contractor and Manufacturer's Representative as required during the Overall Facility Performance Verification.
5. Provide labor and materials as required for sampling and laboratory analyses. Initial sampling and testing will be paid for by the City. Any required re-testing due to non-compliance will be borne by the Contractor.
6. Furnish Supply Contractor Representative(s) on City-Supplied equipment for assistance.
7. Make available spare parts, special tools, and operation and maintenance information for City equipment, and City-Supplied equipment as applicable.

3.3 EQUIPMENT TESTING

A. Preparation:

1. General:
 - a. Complete installation of each unit and related processes before testing, including all related Manufacturer's Representative services.
 - b. Furnish qualified Manufacturer's Representatives, when required by individual Specification sections, to assist in testing.
 - c. Obtain from Manufacturer's Representative the Manufacturer's Certificate of Proper Installation Form, and signed Form 102 – Certificate of Satisfactory Installation in accordance with Section 01 43 33, Contractor's Field Services, as specified by individual Specification sections.
 - d. Notify the City, Contract Administrator, and Manufacturer's Representative in writing at least 14 days prior to scheduled date of testing.
 - e. Schedule equipment testing and startup meetings to discuss test schedule, plan of test, materials, chemicals and liquids required, facilities operations interface, and City involvement.

- f. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required to conduct testing.
- g. Provide written documentation of Functional Test and Performance Test results on Contractor's form for each piece of equipment tested. Provide space on form for Contract Administrator's signature verifying that testing has been completed as per specification.

B. Functional Test:

- 1. Conduct as specified in individual Specification sections.
- 2. Provide written test report form for each item of equipment to be tested, to include the minimum information:
 - a. City/Project Name.
 - b. Equipment or item tested.
 - c. Date and time of test.
 - d. Type of test performed (Functional or Performance).
 - e. Test conditions.
 - f. Test results.
 - g. Signature space for Contractor, Manufacturer's Representative and Contract Administrator representatives.
- 3. An example of the Functional Test plan form is appended at the end of this section.
- 4. For specific requirements for the testing and commissioning of electrical and automation systems, refer to the following Sections, and incorporate requirements defined therein into the procedures described in this Section as and where appropriate.
 - a. 26 08 05 Acceptance Testing – Electrical
 - b. 40 99 92 Automation Testing and Commissioning.
- 5. Prior to Functional Testing, the following conditions shall be met for that particular piece of equipment or sub-system:
 - a. O&M Instructional Manuals have been completed and submitted not less than 30 days prior to Functional Testing, in accordance with Section 01 78 23 Operation and Maintenance Data.
 - b. Construction completed as necessary to provide working equipment, systems and subsystems, with safety features in working order.
 - c. Equipment, piping, electrical wiring, and instrumentations are installed.
 - d. All gearboxes, bearings, etc. have been checked for first fill of oil to manufacturer's recommended level.
 - e. Water containing structures shall have passed a water tightness test. Leakage tests and piping hydraulic tests completed and any leaks repaired.
 - f. Tagging, signage, pipe labels, panel identification, and wiring identification have been completed to the extent necessary to identify items being testing.
 - g. Safety devices and equipment are installed, fully functional, adjusted, and tested including the operation and setting of safety valves.
 - h. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by Manufacturer in accordance with the Specification and Drawings.
 - i. Electrical system installation checks have been completed including all specified electrical equipment and cable tests and grounding system tests

- j. Automation system installation checks have been completed, including I/O checks and individual loop tests. Instrument calibration and scaling will be performed where applicable.
 - k. Mechanical/civil checks : equipment location & fixing alignment, tagging, gland packing & lubrication, pipe support inspections, tank hydrostatic tests, pattern tests, rotation tests.
 - l. Pipework installation & pressure tests.
 - m. Painting & insulation inspection records.
 - n. Cleaning, rinsing, and flushing of pipework
 - o. Calibrate testing equipment in accordance with Manufacturer's instructions.
 - p. Turn rotating equipment by hand when possible, and safe to do so, to confirm that equipment is not bound.
 - q. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
 - r. Adjust clearances and torque.
 - s. Balance HVAC systems, measuring airflow (L/s) static pressure, and component pressure losses in coordination with the requirements specified in individual sections.
6. Ready-to-test determination will be by Contract Administrator based at least on the following:
- a. Notification by Contractor of equipment readiness for testing.
 - b. Acceptable testing plan.
 - c. Acceptable Operation and Maintenance Manuals.
 - d. Receipt of Manufacturer's Certificate of Proper Installation.
 - e. Adequate completion of Work adjacent to, or interfacing with, equipment to be tested, including items to be supplied by the City.
 - f. Availability and acceptability of Manufacturer's Representative, when specified, to assist in testing of respective equipment.
 - g. Satisfactory fulfillment of other specified Manufacturers' responsibilities.
 - h. Equipment and electrical tagging complete.
 - i. Delivery of all spare parts and special tools.
7. Form 102 Certificate of Satisfactory Installation:
- a. Form 102 Certificate of Satisfactory Installation shall be completed and signed by the equipment Manufacturer's Representative and the Contractor. Such form shall certify that the signing party is a duly authorized representative of the Manufacturer, is empowered by the Manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to assure that the equipment installation has been completed satisfactorily and that any defects have been remedied prior to equipment Performance Testing.
 - b. When, in Contract Administrator's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to Performance Testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Contract Administrator's signature on the Equipment Test Report and on Form 102 – Certificate of Satisfactory Installation, a copy of which is attached to this section.

C. Performance Testing:

1. Conduct as specified in individual Specification sections.

2. Notify Contract Administrator at least 14 days prior to scheduled date of test.
3. Performance Testing shall not commence until equipment has been approved by Contract Administrator as having satisfied Functional Test requirements specified, and Form 102 – Certificate of Satisfactory Installation had been signed by all required parties.
4. Follow approved testing plan and detailed procedures specified.
5. Source and type of fluid, gas, or solid for testing shall be as specified.
6. Unless otherwise indicated, supply all labor, materials, and supplies for conducting the test and taking all Samples and performance measurements.
7. Prepare performance test report summarizing test method and results.
8. Unless otherwise specified, equipment performance tests shall consist of a minimum of one (1) hour of continuous operation of the equipment while meeting its specified operating criteria.
9. When, in Contract Administrator’s opinion, equipment meets performance requirements specified, such equipment will be accepted as conforming to Contract requirements. Such acceptance will be evidenced by Contract Administrator’s signature on the Equipment Test Report and completion of Form 103 – Certificate of Satisfactory Performance.
10. Complete and sign Form 103 – Certificate of Equipment Satisfactory Performance upon satisfactory completion of each equipment Performance Test.

3.4 PROCESS DEMONSTRATION AND PERFORMANCE VERIFICATION

A. General:

1. In order to facilitate continuous operation of the Work, Demonstration Testing and Performance Verification of the Unit Processes and Facility Areas will occur.
2. Contractor, Supply Contractor and/or Manufacturers’ Representatives shall operate equipment during Demonstration Testing and Performance Verification, unless otherwise agreed to by the Commissioning Team, under the supervision and direction of the City.
3. Sequence startup of each piece of equipment and each sub-process to the point that the complete process area is operational for evaluation of Unit Process and Facility Area performance.
4. Provide Subcontractor and equipment Manufacturers’ staff as specified, and adequate to prevent delays.
5. Schedule ongoing Work so as not to interfere with or delay the completion of Process Demonstration and Performance Verification Testing.
6. Copies of Form 104 and Form 105 are included as Supplements to this Section. These Supplements contain Form 104s and Form 105s specific to a number of critical Unit Processes and Facility Areas. Additional Form 104s and 105s may be required.

B. Demonstration Testing:

1. The Demonstration Testing is intended to demonstrate the reliable operation of the individual Unit Processes.
2. The Demonstration Test shall comprise of running the identified Unit Process continuously for a minimum of 3-days at pre-determined operating conditions without interruption, or as otherwise specified.
3. Contractor, Supply Contractor and/or Manufacturers’ Representatives shall operate equipment during Demonstration Testing, unless otherwise agreed to by the Commissioning Team, under the supervision and direction of the City.

4. Equipment must be accepted by Contract Administrator as having met requirements of specified Functional and Performance Testing prior to the Demonstration Testing.
5. Demonstrate proper operation of required interfaces within and between individual Unit Processes.
6. Demonstration Testing of any Unit Process shall be considered complete when, in opinion of Contract Administrator, Unit Process or Facility Area has operated in the manner intended for 3 (three) continuous days without significant interruption, unless otherwise specified. This period is in addition to training, Functional, or Performance Testing periods specified elsewhere.
 - a. Significant Interruption: May include any of the following events:
 - 1) Failure of Contractor to provide and maintain qualified onsite personnel as scheduled.
 - 2) Failure to meet specified performance for more than 2 (two) consecutive hours.
 - 3) Failure of any critical equipment or unit process that is not satisfactorily corrected within five (5) hours after failure.
 - 4) Failure of any noncritical equipment or unit process that is not satisfactorily corrected within eight (8) hours after failure.
 - 5) As determined by Contract Administrator.
 - b. A significant interruption will require Demonstration Test then in progress to be stopped and restarted after corrections are made.
7. Verify that each unit process is capable of performing its intended function(s), including fully automatic and computerized operation.
8. When, in the Contract Administrator's opinion, the Demonstration Test has been completed successfully, such Unit Process will be accepted as conforming to Contract requirements. Upon such acceptance, Form 104 – Certificate of Satisfactory Process Demonstration shall be signed by all required parties, and the City will take over operation and maintenance of the identified Unit Process or Facility Area.
9. After the Unit Process or Facility Area is operating, complete, Performance Testing of those items of equipment not previously tested, where agreed upon by Contract Administrator.

C. Performance Verification

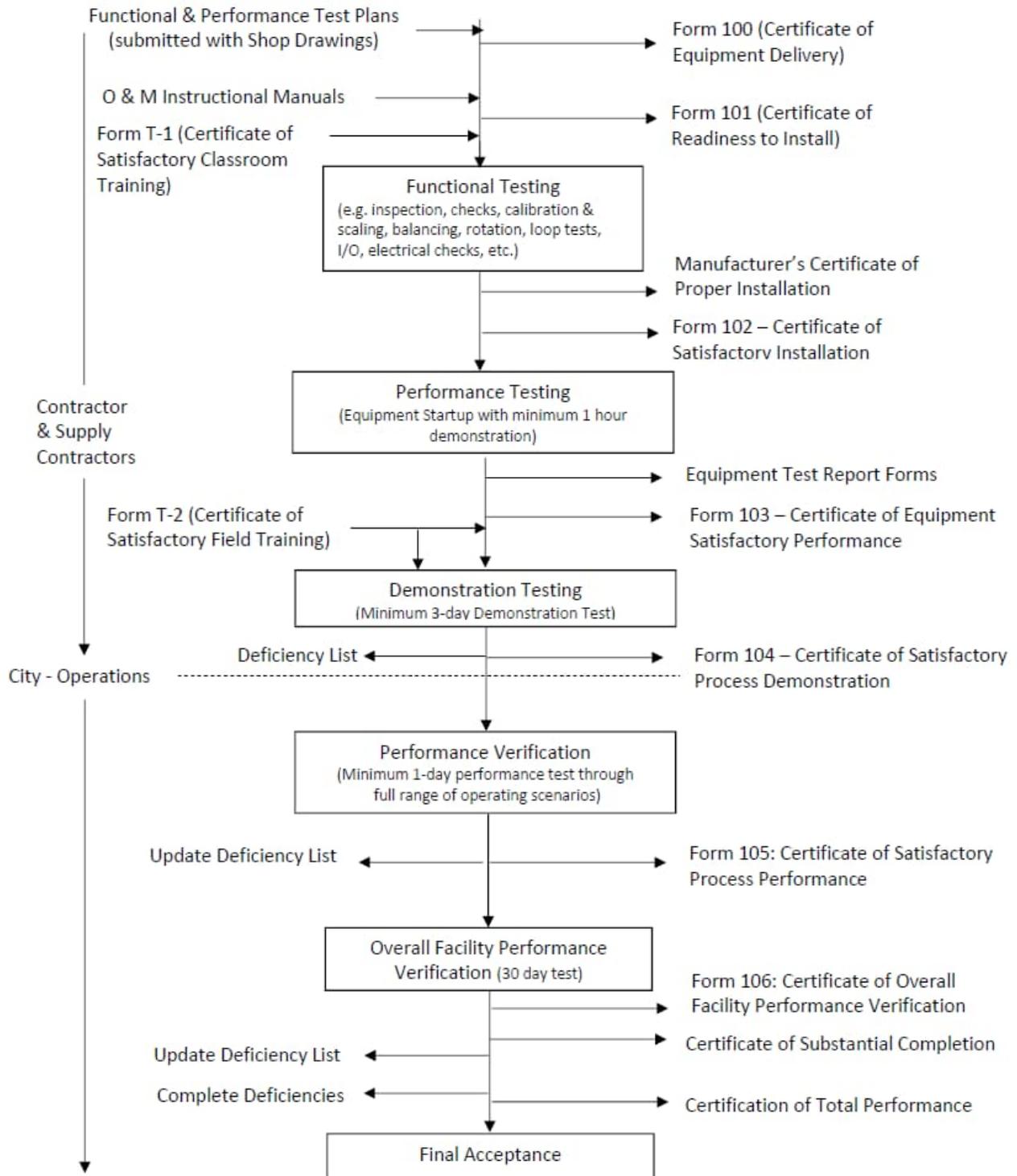
1. Performance Verification is intended to demonstrate that the individual Unit Processes meet the intended design requirements.
2. The Performance Verification shall comprise of running the identified Unit Process between their specified minimum and maximum operating conditions over a 1-day period, or as otherwise specified, when flows and load conditions allow.
3. Evaluate the full capabilities of the Unit Process, including, but not limited to the performance of the computer system.
4. Contractor, Supply Contractor and/or Manufacturers' Representatives shall operate equipment during Performance Verification, unless otherwise agreed to by the Commissioning Team, under the supervision and direction of the City.
5. The Performance Verification may take place in conjunction with the Demonstration Test, if conditions and flows allow.
6. Upon successful completion of each Performance Verification, a copy of Form 105 – Certificate of Satisfactory Process Performance shall be signed by all required parties.

3.5 SUPPLEMENT

- A. Supplements listed below, following “End of Section,” are a part of this Specification:
1. Commissioning Structure
 2. Example of Functional (or Performance) Test Plan Form
 3. Form 102 Certificate of Satisfactory Installation
 4. Form 103 Certificate of Equipment Satisfactory Performance
 5. Form 104(s) Certificate(s) of Satisfactory Process Demonstration
 6. Form 105(s) Certificate(s) of Satisfactory Process Performance
 7. Form 106 Certificate of Overall Facility Performance Verification

END OF SECTION

Commissioning Structure



**EXAMPLE of FUNCTIONAL (or PERFORMANCE)
TEST PLAN FORM**

CITY: _____

PROJECT: _____

Unit Process Description: (Include description and equipment number of all equipment and devices):

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves to be opened/closed, order of equipment startup, etc.):

Startup Requirements (Water, power, chemicals, etc.):

Evaluation Comments: _____

Contractor Certification that Unit Process is capable of performing its intended function(s), including fully automatic operation:

Firm Name: _____

Startup Representative: _____
(Authorized Signature)

Date: _____, 20



Water and Waste Department • Service des eaux et des déchets

Form 102

CERTIFICATE OF SATISFACTORY INSTALLATION

We have completed our checks and inspection of the installation of our equipment as listed below and confirm that it is satisfactory and that any defects have been remedied except any as noted below.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description:
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:
Outstanding Defects:

Print Name _____ Signature _____
(Authorized Representative of Manufacturer)

Date _____

Print Name _____ Signature _____
(Authorized Representative of Contractor)

Date _____

Print Name _____ Signature _____
(Authorized Representative of Contract Administrator)

Date _____



Water and Waste Department • Service des eaux et des déchets

Form 103

CERTIFICATE OF EQUIPMENT SATISFACTORY PERFORMANCE

We certify that the equipment listed below has been continuously operated for a minimum of one (1) consecutive hour and that the equipment operates satisfactorily and meets its specified operating criteria. No defects in the equipment were found and as such are classified as “conforming”.

Project: SEWPCC B679 Chiller Replacement Project
Equipment Description:
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:

Print Name	Signature	Date
(Authorized representative of Manufacturer)		

Print Name	Signature	Date
(Authorized representative of Contractor)		

Print Name	Signature	Date
(Authorized representative of Contract Administrator)		



Water and Waste Department • Service des eaux et des déchets

Form 104

CERTIFICATE OF SATISFACTORY PROCESS DEMONSTRATION

We certify that the process system listed below has been continuously operated for a minimum of three (3) consecutive days and tested as per the Specifications using process fluid and that the process meets its Demonstration Testing criteria. No defects in the process system were found and as such are classified as “conforming”.

Project: SEWPCC B679 Chiller Replacement Project
Process/Facility Description: CHLR-B679 Chiller System
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:

Print Name _____ Signature _____
(Authorized Representative of Contractor)

Date _____

Print Name _____ Signature _____
(Authorized Representative of Contract Administrator)

Date _____

Print Name _____ Signature _____
(Authorized Representative of City)

Date _____



Water and Waste Department • Service des eaux et des déchets

Form 104

CERTIFICATE OF SATISFACTORY PROCESS DEMONSTRATION

We certify that the process system listed below has been continuously operated for a minimum of three (3) consecutive days and tested as per the Specifications using process fluid and that the process meets its Demonstration Testing criteria. No defects in the process system were found and as such are classified as “conforming”.

Project: SEWPCC Upgrading/Expansion Project
Process/Facility Description: Chiller Refrigerant Leakage Exhaust System
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:

Print Name _____ Signature _____
(Authorized Representative of Contractor)

Date _____

Print Name _____ Signature _____
(Authorized Representative of Contract Administrator)

Date _____

Print Name _____ Signature _____
(Authorized Representative of City)

Date _____



Water and Waste Department • Service des eaux et des déchets

Form 105

CERTIFICATE OF SATISFACTORY PROCESS PERFORMANCE

We certify that the process system listed below has been continuously operated and tested as per the Specifications using process fluid and that the equipment meets its Performance Verification criteria. No defects in the process system were found and as such are classified as “conforming”.

Project: SEWPCC B679 Chiller Replacement Project
Process/Facility Description: CHLR-B679 Chiller System
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:

Print Name _____ Signature _____
(Authorized Representative of Contractor)

Date _____

Print Name _____ Signature _____
(Authorized Representative of Contract Administrator)

Date _____

Print Name _____ Signature _____
(Authorized Representative of City)

Date _____



Water and Waste Department • Service des eaux et des déchets

Form 105

CERTIFICATE OF SATISFACTORY PROCESS PERFORMANCE

We certify that the process system listed below has been continuously operated and tested as per the Specifications using process fluid and that the equipment meets its Performance Verification criteria. No defects in the process system were found and as such are classified as “conforming”.

Project: SEWPCC Upgrading/Expansion Project
Process/Facility Description: Chiller Refrigerant Leakage Exhaust System
Equipment Supply Bid Opp. No.:
Equipment Install Bid Opp. No.: 929-2023
Equipment Tag No.:
Specification Reference:

Print Name Signature
(Authorized Representative of Contractor)

Date

Print Name Signature
(Authorized Representative of Contract Administrator)

Date

Print Name Signature
(Authorized Representative of City)

Date

SECTION 02 41 13
SELECTIVE SITE DEMOLITION

PART 1 GENERAL

1.1 SUMMARY

- A. Comply with Division 1, General Requirements.

1.2 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
 - 1. CSA S350-M 1980 Code of Practice for Safety in Demolition of Structures.
- B. NFPA 241 Safeguarding Building Construction and Demolition Operations.

1.3 SUBMITTALS

- A. Submit cleaning operation schedule.
- B. Submit Shop Drawings for bracing and shoring signed and sealed by a licensed engineer.
- C. Submit for review proposed method of substrate preparation.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 PREPARATION

- A. Disconnect electrical and mechanical systems in areas of selective demolition to rules and regulations of authorities having jurisdiction.
- B. Post warning signs on equipment, which will remain in operation in areas of selective demolition.
- C. Disconnect and cap mechanical services in accordance with requirements of local authority having jurisdiction or pay for having this work done by local authority.
- D. Do not disrupt active or energized utilities in area of selective demolition.

3.2 DEMOLITION

- A. Do work in accordance with CSA-S350.

- B. Work of this Section is of selective nature. The work includes but not necessarily limited to removal and dismantling of:
 - 1. Remove concrete or portions of concrete where shown on Drawings.
 - 2. Relocate.
 - 3. Clean.
- C. Demolish in manner to minimize dusting. Keep dusty materials wetted.

3.3 EXISTING CONDITIONS

- A. Take over existing structure, with selective demolition work based on existing condition at time of examination prior to bidding. Carefully examine existing structure, equipment and conditions.
- B. Protect existing to minimize damage to existing.
- C. Make good existing finishes disturbed or otherwise damaged during selective demolition, by qualified tradesmen. Match existing materials and finishes.
- D. Make good existing materials and finishes disturbed or otherwise damaged by alterations to mechanical and electrical equipment and piping. Match existing materials and finishes.

3.4 PROTECTION

- A. Prevent movement, settlement, or damage of existing structure and adjacent structures, walks, paving and parts of existing building to remain in service.
- B. Prevent debris from collecting and blocking mechanical and electrical systems, which will remain in operation.
- C. Prevent dust from leaving the source and from entering mechanical and electrical system. Maintain water and electrical systems.
- D. Where openings are scheduled in existing masonry, remove sufficient existing masonry units for tothing-in of new masonry units.
- E. Protect interior of parts and items, which are not to be demolished, from exterior elements at all times.
 - 1. Maintain water and airtight enclosures.
 - 2. Provide thermal barrier to match existing exterior thermal barrier.
 - 3. Protect building service lines from damage.
- F. Turn over to the City, dismantled items, which are in good condition, and store at location and as directed by the Contract Administrator.

3.5 CLEANING

- A. After selective demolition clean existing substrates to sound, clean surface free from extraneous matter. Use only non-ionic surfactants.

- B. Where openings are scheduled in existing masonry, remove sufficient existing masonry units for footing in of new masonry units.
- C. Test clean area designated by the Contract Administrator. Use accepted, cleaned area as the standard for the remainder of the cleaning work.

3.6 DISPOSAL OF WASTE

- A. Dispose waste off site at location acceptable to authorities having jurisdiction.
- B. Remove waste from Site daily. Do not store on Site.
- C. Do not use waste as fill.

3.7 CLEANING - MASONRY

- A. Preparation
 1. Clean existing masonry to extent shown.
 - a. Seal, pack with removable masking, or repair defective jointing and other openings in the work area to minimize water, dust or solvent infiltration of the masonry wall.
 2. Dry brush and if necessary scrape large accumulations of foreign matter from walls, ledges, cornices and the like. Use moderate pressure 345 kPa dry air blasts to remove as much loosely attached soil and dust as possible before commencing main cleaning operations. Exercise care when blasting around decorative material or extremely friable masonry.
 3. Wet the masonry surface soiling by soaking with a low-pressure misting system to swell and loosen soiling.
 4. Use as little water as possible; keep soiling moist. Avoid excessive wetting and soaking of the masonry. Ensure water used does not penetrate the building.
 5. Use nozzles that give a nebulized droplet spray. Maintain a constant nozzle distance from wall face. Vary nozzle pressure to suit cleaning requirements without damaging the masonry surfaces.
 6. Do not use strongly acidic water on carbonate material such as limestone or calcareous sandstones, or masonry bounded with lime mortar.
 7. Establish details of the setup of equipment, incorporate of other related and accepted cleaning methods, and degree of cleaning achieved at the beginning of the job during the test patch operations.
 8. Brush heavily soiled areas with natural bristle or nylon brushes and scrape with wood or plastic tools to loosen deposits and improve the action of the water misting.
 9. Employ a final rinse-down with a pressurized water spray when the soiling reaches a state that allows easy removal without over-working of the masonry surface with the gun and without damaging the masonry.
 10. Make the cleaned masonry surfaces free of foreign matter and uniform in appearance without streaks or variations caused in the cleaning process.
 11. The finish of the masonry after cleaning generally to match the test-cleaned area. If excessive scaling or roughness occurs during cleaning operations, cease operations and notify the Contract Administrator promptly.
 12. Ensure that manufacturer's proprietary materials for cleaning are free from materials detrimental to appearance or performance of the masonry facing.

13. At completion of the work, remove masking and protective covers and thoroughly clean the glass surfaces on the exterior of the building.

END OF SECTION

SECTION 02 81 11

ASBESTOS ABATEMENT – TYPE 1

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Requirements and procedures for asbestos abatement of Type 1 (Low Risk) work related to chrysotile asbestos-containing materials of the type describe within.

1.2 REFERENCES

- A. Canadian General Standards Board (CGSB).
 - 1. CAN/CGSB-1.205-2003, Sealer for Application of Asbestos-Fibre Releasing Materials.
- B. Department of Justice Canada (Jus).
 - 1. Canadian Environmental Protection Act, 1999 (CEPA).
- C. Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - 1. Material Safety Data Sheets (MSDS).
- D. The Government of Manitoba, Workplace Safety and Health Division (WSH)
 - 1. Chapter W210 10/02, The Workplace Safety and Health Act, Manitoba Workplace Safety and Health Act and Regulation, 2015
 - 2. Guidelines for Working With Asbestos, 2008 (WSH)
- E. Transport Canada (TC).
 - 1. Transportation of Dangerous Goods Act, 1992 (TDGA).
- F. Underwriters' Laboratories of Canada (ULC).

1.3 SCOPE OF WORK

- A. Refer to Item 1.3 of Section 02 82 13, Asbestos Abatement – Type 3.
- B. Section 02 82 11, Asbestos Abatement – Type 1 defines procedures and requirements only for handling non-friable asbestos. Performance of such work is responsibility of each Section required to handle, cut, drill, or remove non-friable asbestos as necessary to perform work of their respective Sections. Such work shall be done in strict accordance with handling requirements specified in Section 02 82 11, Asbestos Removal – Type 1.
- C. Demolish and dispose underground sanitary sewer and storm water pipes, which are asbestos containing materials as required to complete the Work. Laws of province of Manitoba shall govern this work.

- D. Contractor shall observe all such laws and shall obtain and pay all permits, notices, fees, taxes, duties as may be required. Likewise, it is responsibility of contractor to comply with the *Manitoba Workplace Safety and Health Act and Regulation*.
- E. Comply with requirements of this Section when performing following Work:
 - 1. Removal of Type 1 asbestos-containing materials as required to complete the Work.
- F. Approximate locations and quantities are provided in Appendices - Pinchin Asbestos Laboratory Certificate of Analysis (Pinchin, 2023). These values are for information purposes only. Prior to tender, the Contractor shall be solely responsible to obtain and verify quantities and locations on-site and confirm that all known asbestos-containing materials have been included in the lump sum bid.
- G. Abate, load, transport and dispose of all known hazardous building materials including asbestos, requiring removal to complete the Work, prior to demolition. The City reserves the right to request modifications to the Contractors Abatement Plan as appropriate to meet minimum expectations of safety.
- H. The Contractor shall be responsible for obtaining information regarding the types of materials identified by reviewing and understanding the information provided in the reports and reference drawings, and by reviewing the City Site to confirm and satisfy any assumptions made on the material types and quantities.
- I. The Contractor shall include Type 1 asbestos abatement work in the Detailed Abatement Plan as described in Section 02 82 13, Asbestos Abatement – Type 3.
- J. Removal of articles remaining in the Facility at commencement of the work is the responsibility of the Contractor.
- K. Containment, removal, and disposal of materials on the property at commencement of the work is the responsibility of the Contractor. Measures and procedures for dust suppression, worker protection, and waste collection shall be provided to satisfy requirements of Section 01 35 13 Special Project Procedures and within the Detailed Abatement Plan outlined in item 1.3 F of this Section.
- L. Maintain only emergency electrical and mechanical services passing through asbestos work area. All other services must be deactivated during abatement work.
- M. Provide heat, water, and power where necessary to perform the work.
- N. Provide necessary cranes, lifting devices, scaffolding, elevated work platforms, and safety equipment to adequately complete the work and maintain worker safety. The Contractor shall provide Engineer stamped drawings and approvals for scaffolding and work platforms where required by law and as otherwise specified.
- O. All work will be subject to inspection and air monitoring inside and outside asbestos work area by the City's Contract Administrator. Any contamination of surrounding areas, indicated by visual inspection or air monitoring, shall necessitate complete cleanup of affected areas at no additional cost to the City.

- P. Contractor to erect a project health and safety board. Health and safety board to contain contact information, MSDS's, Safety Policy, AHAs, project specifications, project reports, site specific environmental remediation strategy and action plan, etc.
- Q. Notify Manitoba Workplace Safety and Health **at least 5 days** prior to beginning abatement work.
- R. Ensure all necessary permits for asbestos abatement work, variance, demolition, etc. are posted at the Site prior to start of work.

1.4 DEFINITIONS

- A. Refer to Item 1.4 of Section 02 82 13, Asbestos Abatement – Type 3.

1.5 SUBMITTALS

- A. Refer to Item 1.5 of Section 02 82 13, Asbestos Abatement – Type 3.

1.6 REGULATIONS

- A. Refer to Item 1.6 of Section 02 82 13, Asbestos Abatement – Type 3.

1.7 SUPERVISION

- A. Refer to Item 1.7 of Section 02 82 13, Asbestos Abatement – Type 3.

1.8 QUALITY ASSURANCE

- A. Refer to Item 1.8 of Section 02 82 13, Asbestos Abatement – Type 3.

1.9 DEFINITIONS

- A. HEPA Filter: High Efficiency Particulate Aerosol filter at least 99.97 per cent efficient in collecting 0.3 micrometer aerosol.
- B. Non Friable Material: Material that when dry cannot be crumbled, pulverized or powdered by hand pressure. Includes, but not limited to, following asbestos containing products: vinyl asbestos floor tiles, resilient sheet flooring, acoustic ceiling and wall tiles, gaskets, seals, packings, friction products, drywall joint compounds and asbestos cement panels, shingles and piping.
- C. Gryphon Sheeting: Gryphon sheeting of 0.15 mm (6 mil) minimum thickness with tape seals along edges, around penetrating objects, over cuts and tears, and elsewhere as required to provide continuous membrane protection.
- D. Authorized Visitor(s): The City's Third Party Inspector or person(s) representing regulatory agencies, and person(s) authorized by them.

- E. Asbestos Work Area(s): Area(s) where work takes place which will, or may, disturb asbestos containing material.

1.10 SUBMITTALS

- A. Refer to Item 1.2 of Section 02 82 13, Asbestos Abatement – Type 3.

1.11 REGULATIONS

- A. Refer to Item 1.6 of Section 02 82 13, Asbestos Abatement – Type 3.

1.12 SUPERVISION

- A. Refer to Item 1.7 of Section 02 82 13, Asbestos Abatement – Type 3.

1.13 QUALITY ASSURANCE

- A. Refer to Item 1.8 of Section 02 82 13, Asbestos Abatement – Type 3.

1.14 WORKER AND VISITOR PROTECTION

- A. Respirators are not mandatory for work with non-friable asbestos containing materials, however, for this project, provide non-powered air half face respirator with minimum P100 filter cartridges in accordance with NIOSH Part 84 requirements. Provide proper instruction to workers in use of respirators including qualitative and quantitative fit testing. Replace filters as necessary, according to manufacturer's instructions. Workers shall not wear facial hair that affects seal between respirator and face. Contractor to post on job bulletin City instructions, procedures and information pertaining to abatement work.
- B. Provide, and insist on using, facilities for washing of hands and face by every worker when leaving asbestos work area. Prohibit smoking, eating and drinking in asbestos work area.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Asbestos Waste Receptors: Two separate containers of which 1 shall consist of 0.15 mm (true 6 mil) minimum thickness sealable polyethylene bag. Other container may be 0.15 mm (true 6 mil) minimum thickness polyethylene bag. Outer container shall be adequate to prevent perforating rips, or tears during filling, transport or disposal. Containers must be acceptable to disposal facility selected, and WSH, and shall be clearly marked to indicate that contents contain asbestos.
- B. HEPA Vacuum: Vacuum with all necessary fittings, tools and attachments. Air must pass HEPA filter before discharge.
- C. Sprayer: Garden type portable manual sprayer, low velocity, capable of producing mist or fine spray.

- D. Gryphon Sheeting: 0.15 mm (6mil) minimum thickness unless otherwise specified; in sheet size to minimize joints.
- E. Tape: Tape suitable for sealing gryphon to surface encountered under wet conditions using amended water and under dry conditions.
- F. Amended Water: Water with non-ionic water wetting agent added.

PART 3 EXECUTION

3.1 PREPARATION

- A. Before disturbing non friable asbestos materials except those used as flooring, cover floor and furnishings below work with gryphon sheeting.
- B. Wherever dust on surface within asbestos work area is likely to be disturbed, remove beforehand with HEPA vacuum or damp cloth.

3.2 REMOVAL OF VINYL ASBESTOS TILE

- A. Start removal by wedging heavy-duty scraper in seam of two adjoining tiles and gradually forcing edge of 1 tile up and away from floor. Do not break off pieces of tile, but continue to force balance of tile up.
- B. When first tile is removed, place it, without breaking into smaller pieces, into asbestos waste receptor.
- C. Continue removal of tiles using hand tools and removing tiles intact wherever possible. When adhesive is spread heavily or is quite hard, it may prove easier to force scraper through tightly adhered areas by striking scraper handle with hammer using blows of moderate force while maintaining scraper at 25 to 30 degree angle to floor. When even this technique cannot loosen tile, removal can be simplified by heating tile with hot air gun or infrared heaters until heat penetrates through tile and softens adhesive. Do not use powered electric scrapers.
- D. After removal of small area scrape up adhesive remaining on floor with hand scraper until only thin smooth film remains. Where deposits are heavy or difficult to scrape, hot air gun or infrared heaters may be used. Deposit scrapings into asbestos waste receptors. Do not dry scrape surface of adhering pieces of tile.
- E. On completion of area, clean floor with HEPA vacuum.

3.3 REMOVAL OF OTHER NON FRIABLE ASBESTOS MATERIALS

- A. Where possible wet material to be disturbed.
- B. Place drop sheets on ground surfaces within work area and isolate exterior work area using yellow caution tape. Use hand scraping to remove material adhering to substrate.

- C. Immediately place removed material in asbestos waste receptor. Clean surrounding surfaces and asbestos work area frequently with HEPA vacuum or with wet methods.
- D. Dispose of drop sheets as asbestos waste. Do not reuse.

3.4 INSPECTION

- A. Refer to Item 3.13 of Section 02 82 13, Asbestos Abatement – Type 3.

3.5 WASTE TRANSPORT AND DISPOSAL

- A. Conform to requirements of national and provincial regulations and guidelines related to the transportation and disposal of hazardous waste.
- B. Check with waste disposal facility to determine type of waste containers acceptable.
- C. Waste disposal shall be sent to a disposal facility approved by the City.
- D. Check with waste disposal facility to determine type of waste containers acceptable.
- E. Ensure shipment of containers to waste disposal facility is taken by waste hauler licensed to transport asbestos waste.
- F. Each load requires completion of bill of lading showing type and weight of hazardous waste being transported. Provide copies of bill of lading indicating acceptance of waste at waste disposal facility.
- G. Co-operate with third party inspectors and immediately carry out instructions for remedial work at dump to maintain environment, at no additional cost to the City.
- H. Ensure waste disposal facility is fully aware of hazardous material being dumped.
- I. Ensure that containers used for disposal are locked and covered at all times.

END OF SECTION

SECTION 02 82 12

ASBESTOS ABATEMENT – TYPE 2

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Requirements and procedures for asbestos abatement of Type 2 (Medium Risk) work related to chrysotile asbestos-containing materials of the type describe within.

1.2 REFERENCES

- A. Canadian General Standards Board (CGSB).
 - 1. CAN/CGSB-1.205-2003, Sealer for Application of Asbestos-Fibre Releasing Materials.
- B. Department of Justice Canada (Jus).
 - 1. Canadian Environmental Protection Act, 1999 (CEPA).
- C. Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - 1. Material Safety Data Sheets (MSDS).
- D. The Government of Manitoba, Workplace Safety and Health Division (WSH)
 - 1. Chapter W210 10/02, The Workplace Safety and Health Act, Manitoba Workplace Safety and Health Act and Regulation, 2015
 - 2. Guidelines for Working With Asbestos, 2008 (WSH)
- E. Transport Canada (TC).
 - 1. Transportation of Dangerous Goods Act, 1992 (TDGA).
- F. Underwriters' Laboratories of Canada (ULC).

1.3 SCOPE OF WORK

- A. Refer to Item 1.3 of Section 02 82 13, Asbestos Abatement – Type 3.
- B. Laws of province of Manitoba shall govern this work. Contractor shall observe all such laws and shall obtain and pay all permits, notices, fees, taxes, duties as may be required. Likewise, it is responsibility of contractor to comply with the *Manitoba Workplace Safety and Health Act and Regulation*.
- C. Comply with requirements of this Section when performing following Work:
 - 1. Removal of Type 2 asbestos-containing materials as required to complete the Work.
- D. Approximate locations and quantities are provided in Appendices - Pinchin Asbestos Laboratory Certificate of Analysis (Pinchin, 2023). These values are for information purposes only. Prior to tender, the Contractor shall be solely responsible to obtain and verify quantities

and locations on-site and confirm that all known asbestos-containing materials have been included in the lump sum bid.

- E. Abate, load, transport and dispose of all known hazardous building materials including asbestos, requiring removal to complete the Work, prior to demolition. The City reserves the right to request modifications to the Contractors Abatement Plan as appropriate to meet minimum expectations of safety.
- F. The Contractor shall be responsible for obtaining information regarding the types of materials identified by reviewing and understanding the information provided in the reports and reference drawings, and by reviewing the City Site to confirm and satisfy any assumptions made on the material types and quantities.
- G. The Contractor shall include Type 2 asbestos abatement work in the Detailed Abatement Plan as described in Section 02 82 13, Asbestos Abatement – Type 3.
- H. Removal of articles remaining in the Facility at commencement of the work is the responsibility of the Contractor.
- I. Containment, removal, and disposal of materials on the property at commencement of the work is the responsibility of the Contractor. Measures and procedures for dust suppression, worker protection, and waste collection shall be provided to satisfy requirements of Section 01 35 13, Special Project Procedures and within the Detailed Abatement Plan outlined in item 1.3 F of this Section.
- J. Maintain only emergency electrical and mechanical services passing through asbestos work area. All other services must be deactivated during abatement work.
- K. Provide heat, water, and power where necessary to perform the work.
- L. Provide necessary cranes, lifting devices, scaffolding, elevated work platforms, and safety equipment to adequately complete the work and maintain worker safety. The Contractor shall provide Engineer stamped drawings and approvals for scaffolding and work platforms where required by law and as otherwise specified.
- M. All work will be subject to inspection and air monitoring inside and outside asbestos work area by the City or the Contract Administrator. Any contamination of surrounding areas, indicated by visual inspection or air monitoring, shall necessitate complete cleanup of affected areas at no additional cost to the City.
- N. Contractor to erect a project health and safety board. Health and safety board to contain contact information, MSDS's, Safety Policy, AHAs, project specifications, project reports, site specific environmental remediation strategy and action plan, etc.
- O. Notify Manitoba Workplace Safety and Health **at least 5 days** prior to beginning abatement work.
- P. Ensure all necessary permits for asbestos abatement work, variance, demolition, etc. are posted at the Site prior to start of work.

1.4 DEFINITIONS

- A. Refer to Item 1.4 of Section 02 82 13, Asbestos Abatement – Type 3.

1.5 SUBMITTALS

- A. Refer to Item 1.5 of Section 02 82 13, Asbestos Abatement – Type 3.

1.6 REGULATIONS

- A. Refer to Item 1.6 of Section 02 82 13, Asbestos Abatement – Type 3.

1.7 SUPERVISION

- A. Refer to Item 1.7 of Section 02 82 13, Asbestos Abatement – Type 3.

1.8 QUALITY ASSURANCE

- A. Refer to Item 1.8 of Section 02 82 13, Asbestos Abatement – Type 3.

1.9 WORKER AND VISITOR PROTECTION

- A. Instructions: Before entering asbestos work area(s), instruct workers and visitors in use of respirators, entry and exit from enclosures and all aspects of work procedures and protective measures. Instruction shall be provided by a person who is trained to competently perform this task.
- B. Full Face Respirator: During wet removal and cleanup in enclosed asbestos work area workers, supervisors, and authorized visitors shall be supplied with and use powered air-purifying full-face respirator (PAPR) with N-100, R-100 or P-100 filters. Replace filters daily or test according to manufacturer's specifications and replace as indicated. Provide proper instruction to workers and visitors in use of respirators, cleaning, inspection, and storage and ensure all personnel and visitors are fit-tested using qualitative and/or quantitative techniques. Maintain respiratory protection equipment in proper functioning and clean condition. No supervisor, worker or authorized visitor shall wear facial hair which affects seal between respirator and face. Maintain respiratory protection equipment in proper functioning and clean condition, or remove from Site.
- C. Protective Clothing: Provide workers and visitors in full-enclosure sites with full body coveralls with integral hoods. Once coveralls are worn in asbestos work area, dispose of as contaminated waste. Workers and visitors shall wear other protective apparel required by regulations, including but not limited to: hard hats, safety shoes, and hearing protection.
- D. Before entering enclosure(s) put on respirator with new or tested filters, clean coveralls and head covers. Wear coveralls with hoods up at all times.
- E. Workers may leave enclosure, only after all disturbance of asbestos-containing materials is complete and enclosure has been cleaned-up. When leaving enclosure workers and visitors use HEPA vacuum to clean exterior of respirator to remove visible contamination, and remove

gross contamination from coveralls and other protective equipment. Immediately upon leaving enclosure workers and visitors shall remove coveralls and wash face and hands thoroughly with soap and water; wet clean inside of respirator. Remove filters and dispose of or test filters according to manufacturer's specifications. Place coveralls and used filters in receptacles for disposal with other asbestos contaminated materials. Coveralls can be reused, to maximum of 8 hours wear, if coveralls remain inside work area.

- F. Do not eat, drink, smoke or chew gum or tobacco except in established locations outside the Asbestos Work Area.
- G. Workers and visitors shall be fully protected as specified herein whenever possibility of disturbance of asbestos exists.
- H. Compressed air shall not be used to clean up or remove dust from any surface.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Polyethylene Sheeting: 0.15 mm (6 mil) minimum thickness unless otherwise specified; in sheet size to minimize joints.
- B. Rip-Proof Polyethylene: 0.20 mm (8 mil) fabric made up from 0.13 mm (5 mil) weave and 2 layers 0.04 mm (1.5 mil) poly laminate, in sheet size to minimize joints.
- C. Tape: Tape suitable for sealing polyethylene to surface encountered under both wet conditions using amended water, and dry conditions.
- D. Wetting Agent: Non-foaming surface active agent; mixed with water in concentration to provide thorough wetting of asbestos fibre: Standard of Acceptance, Asbesto-Wet, distributed by Asbetec Distributors, or approved equal in accordance with B8, with approval from Contract Administrator.
- E. Amended Water: Water with wetting agent added.
- F. Asbestos Waste Receptors: Two separate containers of which 1 shall consist of 0.15 mm (true 6 mil) minimum thickness sealable polyethylene bag. Other container may be 0.15 mm (true 6 mil) minimum thickness polyethylene bag. Outer container shall be adequate to prevent perforating rips, or tears during filling, transport or disposal. Containers must be acceptable to disposal facility selected, and WSH, and shall be clearly marked to indicate that contents contain asbestos.
- G. Slow - drying sealer: non-staining, clear, water - dispersible type that remains tacky on surface for at least 8 hours and designed for purpose of trapping residual asbestos fibres.
 - 1. Sealer: flame spread and smoke developed rating less than 5.
- H. Sprayer: Garden-type portable manual sprayer, low velocity, capable of producing mist or fine spray.

- I. HEPA Vacuum: Vacuum with all necessary fittings, tools and attachments. Air must pass HEPA filter before discharge.

PART 3 EXECUTION

3.1 FULL-ENCLOSURE ASBESTOS WORK AREAS

- A. Move equipment, tools, and stored materials which can be moved without disturbing asbestos-containing materials.
- B. Remove elements which can be removed without disturbing friable asbestos material.
- C. If working from within building, arrange to disable the air handling and ventilation systems supplying or exhausting from asbestos work area enclosure(s) as required. Ensure air-handling systems remain disabled for duration of work.
- D. Erect wood or metal framing between asbestos work area and remaining building area, as necessary to support polyethylene sheeting enclosures. Free standing enclosure shall have completely sealed polyethylene top.
- E. Use sufficient layers to provide adequate protection. Protect floors with at least 1 layer of polyethylene sheeting. Where walls are protected with sheeting, cover floors first so that wall polyethylene overlaps floor layer by at least 300 mm (12 inches).
- F. Where applicable clean previously contaminated surfaces with HEPA vacuum before covering with sheeting.
- G. If enclosure is used for more than 1 shift, construct airlock for entry to and exit from enclosure. Clean enclosure prior to exiting at completion of each shift.
- H. Establish negative pressure in asbestos work area as described in Section 02 82 13, Asbestos Abatement – Type 3. Operate negative pressure units or HEPA vacuums continuously from this time until completion of contaminated work.
- I. Provide soap, water and towels for washing of worker's face and hands when exiting enclosure.
- J. Maintain emergency and fire exits from asbestos work area, or establish alternative exits satisfactory to authorities having jurisdiction.
- K. Ensure existing power supply to asbestos work area is isolated and disconnected where necessary. Do not disrupt power supply to remainder of building.

3.2 MAINTENANCE OF ENCLOSURES

- A. Maintain enclosures in tidy condition.

- B. Ensure barriers and polyethylene linings are effectively sealed and taped. Repair damaged barriers and remedy defects immediately upon discovery.
- C. Visually inspect enclosures at beginning of each working period.

3.3 COMMENCE ASBESTOS REMOVAL OR CLEANUP WORK WHEN

- A. Arrangements have been made for disposal of waste.
- B. Asbestos work areas enclosures and parts of building required to remain in use are effectively segregated. Negative pressure equipment is operating continuously.
- C. Tools, equipment and materials waste receptors are inside enclosure.
- D. Arrangements have been made for work area security.
- E. Signs are displayed in all areas where access to sealed asbestos work areas possible. Signs shall read:

CAUTION

Asbestos Hazard Area
No Unauthorized Entry
Wear assigned protective equipment
Breathing asbestos dust may cause serious bodily harm.

- F. Proof of notification to MHS has been submitted.
- G. The City's Third Party Inspector has been notified of intention to proceed and has reviewed enclosures and equipment.

3.4 ASBESTOS DISTURBANCE IN ENCLOSURE

- A. Before commencing work, prepare Site as described in Items 3.1, 3.2 and 3.3.
- B. Seal opening to enclosure with tape after entry of worker. Worker shall remain inside enclosure until disturbed asbestos-containing materials are removed and enclosure has been effectively cleaned.
- C. Perform work required inside enclosure. Trades personnel may enter enclosure to perform Type 2 operations under the guidance of competent worker.
- D. When cleaning or removing asbestos-containing drywall walls within enclosure, spray asbestos-containing material with amended water. Saturate asbestos to prevent release of airborne fibres during removal. Place fully saturated asbestos directly into waste containers.
- E. Treat materials removed including used polyethylene sheeting as asbestos contaminated waste and dispose of as such.

- F. Following completion of work, clean surfaces from which asbestos has been disturbed with HEPA vacuum, or wet-sponge if appropriate to remove all visible material.
- G. Carefully place asbestos waste in inner bag of asbestos waste receptor. Clean inner bag surface of gross contamination and place in clean 6 mil outer bag. If waste is likely to tear inner bag, then instead of outer bag use fibre or metal drum, cardboard or wood box, or other suitably sturdy container.
- H. After wet-sponging or vacuuming to remove visible asbestos, wet clean entire enclosure. Apply coat of sealer to all surfaces from which asbestos has been disturbed. Apply thinned coat (sufficient to coat all surfaces) to interior of polyethylene enclosure prior to tear down.

3.5 TEAR DOWN OF PROTECTION

- A. When dismantling enclosure, carefully roll polyethylene toward centre of enclosure. As polyethylene is rolled away, immediately remove any visible debris with HEPA vacuum.
- B. Place polyethylene sheeting seals, tape, cleaning material, coveralls, and other contaminated waste in asbestos waste receptors for transport. Remove any debris fallen behind plastic with HEPA vacuum.
- C. Clean-up asbestos waste receptors and equipment used in work, and remove from asbestos work area(s) via drum and equipment decontamination enclosure systems, at appropriate time in sequence. Double bag waste immediately prior to transport from Site to disposal bin.
- D. Final review may be carried out by Contract Administrator to ensure no dust or debris remains.

3.6 RE-ESTABLISHMENT OF OBJECTS AND SYSTEMS

- A. When clean-up is complete, reinstall items removed to facilitate asbestos related operation, in their proper positions. Reconstruction and reinstallation shall be by tradesmen qualified in work being reinstalled or reconstructed.
- B. For buildings not scheduled for demolition, make good all damage at completion of work.

3.7 AIR MONITORING

- A. Refer to Item 3.12 of Section 02 82 13, Asbestos Abatement – Type 3.

3.8 INSPECTION

- A. Refer to Item 3.13 of Section 02 82 13, Asbestos Abatement – Type 3.

3.9 WASTE TRANSPORT AND DISPOSAL

- A. Conform to requirements of national and provincial regulations and guidelines related to the transportation and disposal of hazardous waste.

- B. Check with waste disposal facility to determine type of waste containers acceptable.
- C. Waste disposal shall be sent to a disposal facility approved by the City.
- D. Check with waste disposal facility to determine type of waste containers acceptable.
- E. Ensure shipment of containers to waste disposal facility is taken by waste hauler licensed to transport asbestos waste.
- F. Each load requires completion of bill of lading showing type and weight of hazardous waste being transported. Provide copies of bill of lading indicating acceptance of waste at waste disposal facility.
- G. Co-operate with third party inspectors and immediately carry out instructions for remedial work at dump to maintain environment, at no additional cost to the City.
- H. Ensure waste disposal facility is fully aware of hazardous material being dumped.
- I. Ensure that containers used for disposal are locked and covered at all times.

END OF SECTION

SECTION 02 82 13

ASBESTOS ABATEMENT – TYPE 3

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Requirements and procedures for asbestos abatement of Type 3 (High Risk) work related to chrysotile asbestos-containing materials of the type describe within.

1.2 REFERENCES

- A. Canadian General Standards Board (CGSB).
 - 1. CAN/CGSB-1.205-2003, Sealer for Application of Asbestos-Fibre Releasing Materials.
- B. Department of Justice Canada (Jus).
 - 1. Canadian Environmental Protection Act, 1999 (CEPA).
- C. Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - 1. Material Safety Data Sheets (MSDS).
- D. The Government of Manitoba, Workplace Safety and Health Division (WSH)
 - 1. Chapter W210 10/02, The Workplace Safety and Health Act, Manitoba Workplace Safety and Health Act and Regulation, 2015
 - 2. Guidelines for Working With Asbestos, 2008 (WSH)
- E. Transport Canada (TC).
 - 1. Transportation of Dangerous Goods Act, 1992 (TDGA).
- F. Underwriters' Laboratories of Canada (ULC).

1.3 SCOPE OF WORK

- A. Laws of province of Manitoba shall govern this work. Contractor shall observe all such laws and shall obtain and pay all permits, notices, fees, taxes, duties as may be required. Likewise, it is responsibility of contractor to comply with the *Manitoba Workplace Safety and Health Act and Regulation*.
- B. Comply with requirements of this Section when performing following Work:
 - 1. Removal of Type 3 asbestos-containing materials as required to complete the Work.
- C. Approximate locations and quantities are provided in Appendices - Pinchin Asbestos Laboratory Certificate of Analysis (Pinchin, 2023). These values are for information purposes only. Prior to tender, the Contractor shall be solely responsible to obtain and verify quantities and locations on-site and confirm that all known asbestos-containing materials have been included in the lump sum bid.

- D. Abate, load, transport and dispose of all known hazardous building materials including asbestos, requiring removal to complete the Work, prior to demolition. The City reserves the right to request modifications to the Contractors Abatement Plan as appropriate to meet minimum expectations of safety.
- E. The Contractor shall be responsible for obtaining information regarding the types of materials identified by reviewing and understanding the information provided in the reports and reference drawings, and by reviewing the City Site to confirm and satisfy any assumptions made on the material types and quantities.
- F. Asbestos-containing materials and other designated substances that may be present in areas deemed inaccessible shall be included as a unit price in the Base Bid – Provisional Items to include abatement, loading, transporting and disposing of which will be quantified and paid for by the City for additional asbestos-containing materials or other Designated Substances identified after Third Party Inspector quantification and certification.
- G. The Contractor shall provide a Detailed Abatement Plan that outlines a site and building specific environmental remediation strategy, ensuring all potential hazards and building related environmental impacts are considered during the abatement process. The Detailed Abatement Plan shall include the following:

Abatement Plan Type	Deliverable Requirement	Abatement Plan Requirements
Detailed Abatement Plan	Issue two weeks after award of work. No document size limit. Provide a table of contents and clearly identify sections by using section dividers	1) In addition to the requirements listed in the accepted Preliminary Abatement Plan listed above, provide additional details related to the proposed abatement methods and procedures. Include drawings and other supporting documents to further define isolation boundaries, equipment work paths, decontamination areas, and overall site operation over the course of the project.
		2) Provide Activity Hazard Analysis (AHA) forms for all abatement work types, including but not limited to: heat stress, cold weather work, confined space entry, aerial lift operation, hot work, cutting, torching, grinding, large equipment use, waste handling, and other varied measures and procedures.

Abatement Plan Type	Deliverable Requirement	Abatement Plan Requirements
		3) Outline an Emergency Response Plan which shall include all steps to follow in case of an emergency on the removal sites. The plan shall include the way to access, emergency decontaminate, and evacuate the site.
		4) Inspection, monitoring and sampling protocols will be designed by the Contract Administrator based on the Preliminary Abatement Plan and will be implemented into the final Abatement Plan upon approval by the Contract Administrator.
		5) The Detailed Abatement Plan will be reviewed by the City, Contract Administrator and the City’s Third Party Inspector. and is subject to review by other Stakeholders. No application for extra funds will be entertained by the City for additional costs incurred as associated with plan reviews, plan changes, meetings, revisions, and addition inspection provisions and requirements.

- H. Removal of articles remaining in the Facility at commencement of the work is the responsibility of the Contractor.
- I. Containment, removal, and disposal of materials on the property at commencement of the work is the responsibility of the Contractor. Measures and procedures for dust suppression, worker protection, and waste collection shall be provided to satisfy requirements of Section 01 35 13 Special Project Procedures and within the Detailed Abatement Plan outlined in item 1.3 F of this Section.
- J. Maintain only emergency electrical and mechanical services passing through asbestos work area. All other services must be deactivated during abatement work.
- K. Provide heat, water, and power where necessary to perform the work.
- L. Provide necessary cranes, lifting devices, scaffolding, elevated work platforms, and safety equipment to adequately complete the work and maintain worker safety. The Contractor shall provide Engineer stamped drawings and approvals for scaffolding and work platforms where required by law and as otherwise specified.
- M. All work will be subject to inspection and air monitoring inside and outside asbestos work area by the City’s Contract Administrator. Any contamination of surrounding areas, indicated

by visual inspection or air monitoring, shall necessitate complete cleanup of affected areas at no additional cost to the City.

- N. Contractor to erect a project health and safety board. Health and safety board to contain contact information, MSDS's, Safety Policy, AHAs, project specifications, project reports, site specific environmental remediation strategy and action plan, etc.
- O. Notify Manitoba Workplace Safety and Health at least 5 days prior to beginning abatement work.
- P. Ensure all necessary permits for asbestos abatement work, variance, demolition, etc. are posted at the Site prior to start of work.

1.4 DEFINITIONS

- A. Air Lock: Temporary chamber sealed with polyethylene sheeting; curtained doorways constructed at either end with a minimum of 6 feet (2.0 metres) separation; minimum width is 36 inches (900 mm).
- B. Amended Water: water with non-ionic surfactant wetting agent added to reduce water tension to allow wetting of fibres.
- C. Asbestos-Containing Materials (ACMs):
 - 1. a friable material containing 0.1% or greater asbestos, including fallen materials and settled dust.
 - 2. a non-friable material containing 1.0% or greater asbestos, including fallen materials and settled dust.
- D. Asbestos Waste Container: An impermeable container acceptable to the waste disposal facility and regulations. New Materials Only. Labelled as required. Comprised of one of the following:
 - 1. A 6 mil (0.15 mm) sealed polyethylene bag, inside a second 6 mil (0.15 mm) sealed polyethylene bag.
 - 2. A 6 mil (0.15 mm) sealed polyethylene bag, positioned inside or outside a rigid sealed container of sufficient strength to prevent perforation of the container during filling, transportation and disposal.
 - 3. A sealed Glove Bag, inside a 6 mil (0.15 mm) sealed polyethylene bag.
 - 4. A sealed Glove Bag, inside a rigid sealed container of sufficient strength to prevent perforation of the container during filling, transportation, and disposal.
- E. Asbestos Work Area: Area where work takes place, which will, or may, disturb ACM.
- F. Authorized Visitors: The City, Contract Administrator or the City's Third Party Inspector and persons representing regulatory agencies.

- G. Curtained Doorway: arrangement of closures to allow ingress and egress from one room to another while permitting minimal air movement between rooms, typically constructed as follows:
 - 1. Place two overlapping sheets of polyethylene over existing or temporarily framed doorway, secure each along top of doorway, secure vertical edge of one sheet long one vertical side of doorway, and secure vertical edge of other sheet along opposite vertical side of doorway.
 - 2. Reinforce free edges of polyethylene with duct tape and weight bottom edge to ensure proper closing.
- H. DOP Test: A testing method used to determine the integrity of the Negative Pressure unit using dioctyl phthalate (DOP) HEPA filter leak test.
- I. Fitting: Any elbow, valve, tee, reduction, etc. that is present on a pipe system.
- J. Flexible Ducting: Tubing with metal reinforcement or approved equal in accordance with B8; diameter to equal negative air discharge.
- K. Friable Material: Material that when dry can be crumbled, pulverized, or powdered by hand pressure and includes material that is crumbled, pulverized or powdered.
- L. HEPA vacuum: High Efficiency Particulate Air filtered vacuum equipment with filter system capable of collecting and retaining fibres greater than 0.3 microns in any dimension at 99.97% efficiency.
- M. Mechanical Systems: Components that make up a building's plumbing, heating, ventilation, or process systems including but not limited to piping, fittings, vessels, pumps, tanks, ducts, air-handling units, processing equipment, etc.
- N. Milestone Inspection: Inspection of the Asbestos Work Area at defined point in the removal operation.
- O. Negative pressure: system that extracts air directly from work area, filters such extracted air through High Efficiency Particulate Air filtering system, and discharges this air directly outside work area to exterior of building.
 - 1. .1 System to maintain minimum pressure differential of 5 Pa relative to adjacent areas outside of work areas, be equipped with alarm to warn of system breakdown, and be equipped with negative air pressure device to continuously monitor and automatically record pressure differences.
- P. Negative Pressure Device: Contractor to supply and install electronic Negative Pressure Recorder complete with digital print out for precise real time monitoring of negative pressure levels. Standard of acceptance – Omniguard III by Engineering Solutions Inc., approved equal in accordance with B8.
- Q. Occupied Area: Any area of the building outside the Asbestos Work Area.
- R. Personnel: All Contractors' employees, subcontractors employees, supervisors, and authorized visitors.

- S. Polyethylene: Either polyethylene sheeting or rip-proof polyethylene sheeting of 0.15 mm (6 mil) minimum thickness with tape along edges around penetrating objects, over cuts and tears, and elsewhere as required to provide a continuous polyethylene membrane to protect underlying surfaces from water damage or damage by lock-down agents, and to prevent escape of asbestos fibres through sheeting into Occupied Areas.
- T. Type 1 Work: as described in WSH Guideline for Working with Asbestos.
- U. Type 2 Work: as described in WSH Guideline for Working with Asbestos.
- V. Type 3 Work: as described in WSH Guideline for Working with Asbestos.

1.5 SUBMITTALS

- A. Prior to Commencing Work:
 - 1. Site-Specific Health and Safety Plan for the removal of all Hazardous Materials from the Facility.
 - 2. Preliminary and Detailed Abatement Plan
 - 3. Submit proof of Contractor's Asbestos Liability Insurance.
 - 4. Names and credentials of the:
 - a. Overall Asbestos Abatement Superintendent.
 - b. Shift Superintendents.
 - c. Workers.
 - 5. Submit proof satisfactory to Asbestos Abatement Monitoring & Inspection Agent that employees have had instruction on hazards of asbestos exposure, respirator use, dress, entry and exit from Asbestos Work Area, and aspects of work procedures and protective measures.
 - 6. Submit proof that supervisory personnel have attended asbestos abatement course, of not less than two days duration, approved by Asbestos Abatement & Inspection Agent. Minimum of one supervisor for every ten workers. Worker's Compensation Board status and transcription of insurance.
 - 7. Documentation including test results, fire and flammability data, and Material Safety Data Sheets for chemicals or material used in the course of the project including but not limited to:
 - a. Sealing Agent (Encapsulant).
 - b. Wetting Agent.
 - c. Lock-down agent.
 - d. Rip-proof polyethylene.
 - e. Other chemicals or materials proposed for use in the course of the asbestos abatement project.
 - 8. Submit Provincial and/or local requirements for Notice of Project Form.
 - 9. Proposed schedule for each phase of the work providing the following for each separate Asbestos Work Area:
 - a. Duration of abatement work in each Asbestos Work Area.
 - b. Proposed average daily work force.
 - c. Milestone inspection dates.
 - 10. Submit proof satisfactory to Asbestos Abatement Monitoring & Inspection Agent that suitable arrangements have been made to dispose of asbestos-containing waste in accordance with requirements of authority having jurisdiction.

1.6 REGULATIONS

- A. Comply with Federal, Provincial and local requirements including “Manitoba Guidelines for Working With Asbestos.”
- B. The Worker's Compensation Act, Safety Regulations Governing Building, Construction and Demolition.
- C. Workplace Health and Safety Act, (most recent edition).
- D. Contractor shall ensure that:
 - 1. Measures and procedures prescribed under the Workplace Health and Safety Act are carried out.
 - 2. Every employee and every worker on project complies with applicable act and regulations.
 - 3. Health & safety of workers and public is protected.
 - 4. All material handling and associated equipment conform to and are operated in accordance with "Workplace Hazardous Materials Information System" (WHMIS).
 - 5. Advise the City whenever work is expected to be hazardous to employees and/or public.
 - 6. Contractor may be requested to provide information on their health & safety record.

1.7 SUPERVISION

- A. Provide onsite, an Overall Asbestos Superintendent, with authority to oversee all aspects of the work, including but not limited to, estimating and negotiation of changes to the contract, update of submission requirements, scheduling, manpower and equipment requirements, and direct communication and coordination with the City, the Contract Administrator, or the City's Third Party Inspector.
- B. Provide onsite, in addition to the Overall Asbestos Superintendent, and for each work shift, a Shift Superintendent who has authority regarding all aspects related to manpower, equipment, and production.
- C. Supervisory personnel must hold a recognized certificate proving attendance at an asbestos removal training course (two-day minimum duration) acceptable to the City and have supervised a minimum of five other asbestos abatement/demolition projects in similar size and/or complexity.
- D. The Overall Asbestos Superintendent or the Shift Superintendent must be on site at all times during work that is at risk of disturbing ACM. Failure to comply with this requirement will result in a stoppage of all work, at no cost to the City.
- E. Replace supervisory personnel with approved replacements within three working days of a written request from the City. The City reserves the right to request replacement of supervisory personnel without explanation.
- F. Asbestos Abatement Contractor cannot replace supervisory personnel without written approval from the City.

1.8 QUALITY ASSURANCE

- A. Ensure work proceeds to schedule, and meets all requirements of this Section. Perform work so that airborne asbestos, asbestos waste, or water runoff do not contaminate areas outside the asbestos work area. The Contract Administrator or Third Party Inspector is empowered to order a shutdown of work when a leak or breach of isolation has occurred or is likely to occur.
- B. Pay cost to the City of inspection and air monitoring performed as result of failure to perform work satisfactorily regarding quality, safety, or schedule.
- C. Use only skilled and qualified workers for all trades required for this work.
- D. All work of this section involving electrical, mechanical, carpentry, glazing, etc. shall be performed by licensed persons experienced and qualified for the work required.
- E. The City, Contract Administrator, or Third Party Inspector will not be responsible for and will not have control or charge of construction means, methods, techniques, sequences or procedures, or for safety precautions and programs required for the work in accordance with the applicable construction safety legislation, other regulations or general construction practice. The City, Contract Administrator or Third Party Inspector will not be responsible for or have control or charge over the acts or omissions of the Asbestos Abatement Contractor, their Subcontractors or their agents, employees, or other persons performing any of the work.

1.9 WORKER AND VISITOR PROTECTION

- A. Instructions: Before entering asbestos work area, instruct workers and visitors in use of respirators, dress, showers, entry and exit from asbestos work areas, and all aspects of work procedures and protective measures. Instruction shall also include training in hazards of asbestos exposure and be provided by a person who is trained to competently perform this task.
- B. Full Face Respirator: During wet removal and cleanup in enclosed asbestos work area workers, supervisors, and authorized visitors shall be supplied with and use powered air-purifying full-face respirator (PAPR) with N-100, R-100 or P-100 filters. Replace filters daily or test according to manufacturer's specifications and replace as indicated. Provide proper instruction to workers and visitors in use of respirators, cleaning, inspection, and storage and ensure all personnel and visitors are fit-tested using qualitative and/or quantitative techniques. Maintain respiratory protection equipment in proper functioning and clean condition.
- C. Protective Clothing: Provide workers and visitors in full-enclosure sites with full body coveralls with integral hoods. Once coveralls are worn in asbestos work area, dispose of as contaminated waste. Workers and visitors shall wear other protective apparel required by regulations, including but not limited to: hard hats, safety shoes, and hearing protection.
- D. Before entering asbestos work area(s) remove street clothes in clean change room and put on respirator with new or tested filters, clean coveralls and head covers before entering equipment and access areas or asbestos work area. Store street clothes, uncontaminated footwear, towels etc. in clean change room.

- E. Persons leaving asbestos work area(s) shall remove gross contamination from clothing before leaving asbestos work area. Proceed to equipment and access area and remove all clothing except respirator. Place contaminated work suit in receptacles for disposal with other asbestos contaminated materials. Footwear, clothing, hardhats, protective eyewear, etc., shall be left in equipment and access area to dry for later use. Still wearing respirator proceed naked to showers. Clean respirator to ensure that visible contamination is removed. After having thoroughly washed hair and body with shampoo and soap, remove respirator. Remove filters and dispose of in container provided for this purpose or test filters according to manufacturer's recommendation. Dispose of filters as necessary. Wet clean inside of respirator. Upon completion of asbestos abatement, dispose of footwear as contaminated waste or clean before removing from equipment and access area, or carry in sealed plastic bag to next site.
- F. Following showering, proceed to clean change room, dry off and dress in street clothes. Store respirators in fashion to allow them to be put on prior to entering asbestos work area at start of next shift without contaminating clean area. If re-entry to asbestos work area is to take place after having left for eating or drinking, follow procedures in item 1.9 D.
- G. Removal of waste and equipment from holding room of waste decontamination enclosure system shall be performed by workers entering from outside. These workers shall wear clean coveralls and half-face, asbestos approved, respirator as specified in item 1.9 B and 1.9 C. No worker shall use this system as means to leave or enter asbestos work area.
- H. Do not eat, drink, smoke or chew gum or tobacco except in established locations outside the Asbestos Work Area.
- I. Workers and visitors shall be fully protected as specified herein when possibility of disturbance of asbestos exists.
- J. Compressed air shall not be used to clean up or remove dust from any surface.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Polyethylene: 0.15 mm (6 mil) minimum thickness unless otherwise specified.
- B. Rip-Proof Polyethylene: 0.20 mm (8 mil) fabric made up from 0.13 mm (5 mil weave and two layers 0.04 mm (1.5 mil).
- C. Tape: Tape suitable for sealing polyethylene to surface encountered, under both wet conditions using amended water, and dry conditions.
- D. Wetting Agent: Non-foaming surface active agent; mixed with water in concentration to provide thorough wetting of asbestos fibre: Standard of Acceptance, Asbesto-Wet, distributed by Asbetec Distributors, approved equal in accordance with B8.
- E. Amended Water: Water with wetting agent added.

- F. Asbestos Waste Receptors: Two separate containers of which 1 shall consist of 0.15 mm (true 6 mil) minimum thickness sealable polyethylene bag. Other container may be 0.15 mm (true 6 mil) minimum thickness polyethylene bag. Outer container shall be adequate to prevent perforating rips, or tears during filling, transport or disposal. Containers must be acceptable to disposal facility selected, and MHS, and shall be clearly marked to indicate that contents contain asbestos.
- G. Slow - drying sealer: non-staining, clear, water - dispersible type that remains tacky on surface for at least 8 hours and designed for purpose of trapping residual asbestos fibres.
 - 1. Sealer: flame spread and smoke developed rating less than 5.
- H. HEPA Vacuum: Vacuum with all necessary fittings, tools and attachments. Air must pass HEPA filter before discharge.
- I. Protective Coveralls: Disposable full body coveralls complete with elasticized hoods made of spun polyolefin material Tyvek by Dupont or nonwoven material Kleenguard by
- J. Encapsulant: Serpiflex Shield or approved equal in accordance with B8 upon approval from Contract Administrator.

PART 3 EXECUTION

3.1 PREPARATION

- A. Full-enclosure Asbestos Work Area(s):
 - 1. The Contractor is responsible to move all equipment, tools, furnishings, and stored materials without disturbing asbestos-containing materials.
 - 2. Deactivate air handling and ventilation systems supplying or exhausting from asbestos work area(s). Schedule this shut-down with Contract Administrator and the City.
 - 3. All wall and horizontal surfaces not scheduled for demolition and removal shall be pre-cleaned using damp cloth or sponge techniques prior to placement of polyethylene sheeting to any wall or floor surfaces. HEPA equipped vacuum cleaners may also be used to perform this task.
 - 4. If necessary, caulk and seal ducts and duct shafts to remain in service as required, to make airtight. Cut and cap supply ducts with rigid sheet metal caps and seal. Perform work at appropriate time under contaminated conditions if necessary.
 - 5. Seal off openings such as doorways, windows, vents, service holes in walls and grilles to non-operating ducts with polyethylene sheeting with tape or with polyurethane foam as appropriate.
 - 6. Cover wall and floor surfaces not scheduled for demolition and removal with polyethylene sheeting sealed with tape. Provide two separately sealed layers of reinforced polyethylene sheeting. Separately seal floor drains or openings. Use sufficient layers (two) and necessary sheathing for walking surface to protect floors which may be damaged. Cover floors first so that polyethylene extends at least 300 mm (12 inches) up walls then cover walls to overlap floor sheeting. Provide additional protection for floors likely to be damaged by amended water, by covering floor with rip-proof polyethylene sheeting sealed with tape.

7. Cover with polyethylene sheeting, motors, heating units, fire apparatus, door closers, benches, shelving, storage racks, valves, taps, controllers, lights, and other fixtures and furnishings which are not being removed from asbestos work area and which could be damaged and/or which cannot be readily cleaned at completion of this work. Pre-clean surfaces potentially contaminated with asbestos, with HEPA vacuum or damp cloth prior to installing protection.
8. Install plywood enclosures, covered with rip-proof polyethylene sheeting to protect equipment or fixtures scheduled to be salvaged in asbestos work area(s) that may be damaged.
9. Establish negative pressure in asbestos work areas in buildings not scheduled for demolition and removal. Volume of air shall be sufficient to ensure airflow is maintained from clean areas into asbestos work area. Vent units to outside of building by removing, and later replacing, windows, and/or providing flexible ducting. Locate vents to discharge air away from building access points or sidewalks. Do not discharge air into building interior. Leak test negative air units prior to commencement of abatement at operating position, using DOP method. Provide reports for unit efficiency test results within 48 hours of testing, including calibration certificates for testing equipment. Venting of exhaust air through occupied area shall be in rigid airtight ductwork. Operate negative pressure units continuously from this time until completion of final air monitoring. Replace pre-filters as necessary to maintain airflow. Maintain negative air pressure of 5 Pascal (-0.02 inches water column) pressure reduction within asbestos enclosure with respect to surrounding areas.
10. Negative pressure to be measured with a device at regular intervals. Measurements to be posted on health and safety board on a daily basis.
11. Where required, remove and replace windows for the exhausting of negative air units for each Type 3 work area.
12. Maintain emergency and fire exits from asbestos work area, or establish alternative exits satisfactory to authorities having jurisdiction.
13. Ensure existing power supply to asbestos work area is isolated and disconnected where necessary. Provide ground fault electrical system where application of amended water is required for wetting asbestos-containing materials. Supply all electrical apparatus from this ground fault system. Ensure safe installation of electrical lines and equipment.
14. Provide temporary lighting in asbestos work area to levels that will permit work to be done safely and well.
15. Provide fire extinguisher at each emergency exit, and in decontamination facilities. Protect extinguishers with polyethylene sheeting in manner that will not hamper emergency use.

3.2 WORKERS' DECONTAMINATION ENCLOSURE SYSTEM

- A. Construct workers' decontamination enclosure at entrance to each asbestos work area. Worker decontamination enclosure system shall comprise three interconnecting rooms as listed in items 3.2 B, 3.2 C, and 3.2 D. Provide a set of curtain doorways between each room, and at both dirty and clean entrances to enclosure systems.
- B. Equipment and Access Room: Build room between shower room and asbestos work area. Install waste receptor, and storage facilities for worker's shoes and any protective clothing to be reworn in asbestos work areas. Equipment and access room shall be large enough to

accommodate specified facilities, and other equipment needed, and at least one worker allowing sufficient space to undress comfortably. Minimum size 3 square metres (30 sq. ft.).

- C. Shower Room: Build room between clean room and equipment and access room. Provide constant separate supplies of hot and cold water. Provide valves controllable at shower(s) to regulate water temperature. Provide rigid piping with watertight connections and connect to water sources and drains. Provide soap, clean towels and appropriate containers for disposal of used respirator filters. Direct wastewater to sanitary sewer drains or temporary holding tanks via water filtering system consisting of a minimum two-stage filtering system (25-micron and 5-micron filters).
- D. Clean Room: Build room between shower room and clean areas outside of enclosures. At doorway to clean room, provide vented wood door, with locking passage set. Provide hangers for workers' street clothes and personal belongings. Provide storage for clean protective clothing and respiratory equipment. Install water heater, if required.

3.3 WASTE AND EQUIPMENT DECONTAMINATION ENCLOSURE SYSTEM

- A. Construct system comprised of three linked rooms: Purpose of this system is to provide means to decontaminate drums, scaffolding, material containers, vacuum and spray equipment; and other tools and equipment for which worker decontamination system is not suitable. Provide curtain doorways between rooms, and at both dirty and clean entrances to Enclosure System.
- B. Staging Area: Build staging area in asbestos work area for gross removal of dust and debris from waste containers and equipment, labeling and sealing of waste containers, and temporary storage pending removal to container cleaning room.
- C. Container Cleaning Room: Build container cleaning room between staging area and holding room. Room shall be of sufficient size to allow proper washing of equipment and drums or double bagging of asbestos waste. Treat wash water as asbestos contaminated waste.
- D. Holding Room: Build holding room between container cleaning room and uncontaminated area. Holding room shall be of sufficient size to accommodate largest item of equipment used and ten waste containers.

3.4 CONSTRUCTION OF DECONTAMINATION ENCLOSURES

- A. Floor: Prior to erecting wall framing, lay 1 sheet of rip-proof polyethylene sheeting over floor area to be covered by enclosures. Turn 600 mm (24 inches) of rip-proof polyethylene sheeting up outside of enclosure, overlapping with polyethylene sheeting covering perimeter walls. Provide second layer of rip-proof polyethylene sheeting to all floors, extending 600 mm up inside of enclosure walls.
- B. Walls: Build load-bearing walls of 39 mm x 89 mm (2 inches by 4 inches) wood framing, 400 mm (16 inches) o.c. with continuous top and sill plates. Cover both sides walls with polyethylene sheeting. Walls exposed to asbestos work area shall be covered with min. 9 mm (3/8 inches) plywood sheeting or hardboard. Caulk seal and tape plywood joints. Walls exposed to occupied area shall be covered with good one side 9 mm plywood.

- C. Roof: Size of joists shall be determined by span, loads, use and Code. Use as a minimum 39 mm by 138 mm (2 inches by 6 inches) joists. Cover joists with 19 mm (3/4 inches) plywood sheeting. Seal and tape joints, and cover with two layers of rip-proof polyethylene sheeting. At underside of joists install one layer of polyethylene sheeting.
- D. Doorways: Build curtain doorways designed so that when workers or drums and equipment move through doorway, one of two barriers comprising doorway always remains closed.

3.5 MAINTENANCE OF ENCLOSURES

- A. Maintain enclosures in tidy condition.
- B. Ensure barriers and polyethylene sheeting linings are effectively sealed and taped. Repair damaged barriers and remedy defects immediately upon discovery.
- C. Visually inspect enclosures at beginning and end of each working period.

3.6 DO NOT COMMENCE ASBESTOS REMOVAL WORK UNTIL

- A. Arrangements have been made for disposal of waste.
- B. Asbestos work areas and decontamination enclosures are effectively segregated. Negative pressure equipment is operating continuously.
- C. Tools, equipment and waste materials receptors are on hand.
- D. Arrangements have been made with the City's Third Party Inspector for work area security.
- E. Signs are displayed in areas where access to sealed asbestos work area is possible. Signs shall read:

CAUTION

Asbestos Hazard Area

No Unauthorized Entry

Wear assigned protective equipment

Breathing asbestos dust may cause serious bodily harm.

- F. Proof of notification to MHS has been submitted.
- G. The City's Third Party Inspector has been notified of intention to proceed and has reviewed enclosures, equipment and procedures.

3.7 CONTAMINATED PREPARATION FOR FULL-ENCLOSURE ASBESTOS WORK AREA

- A. Before performing any contaminated work, prepare Site as described in item 3.1, 3.2, 3.3, 3.4, 3.5, and 3.6.
- B. Where required, using full protective procedures including amended water and HEPA vacuum, install upper seals as necessary to allow polyethylene sheeting to be fastened to structure. Each of two sheets forming wall of enclosure shall be fastened separately to deck using tape, spray adhesive, rapid setting foam or other suitable method. Provide suitable framing to support polyethylene sheeting. Seal holes in existing perimeter walls, columns, deck etc., to ensure an airtight asbestos work area.
- C. Promptly seal holes or penetrations in structure above ceiling, ducts, etc. to provide airtight enclosure around asbestos work area(s).
- D. Protect electrical, communication, life safety and control systems to remain in place in asbestos work area with polyethylene sheeting. Seal joints and holes in un-insulated HVAC ductwork to remain operational through an asbestos work area, using tape and rip-proof polyethylene sheeting.

3.8 REMOVAL

- A. In areas of wet removal of spray or trowel applied material, spray asbestos with amended water using airless spray equipment. Saturate asbestos to substrate to prevent release of airborne fibres during removal. Fully saturated asbestos may be scraped directly into waste containers or may be allowed to fall to floor.
- B. Remove, under contaminated conditions, bulkheads and non-load bearing walls necessary to allow complete removal of friable asbestos. Remove all or parts of walls sufficiently to remove asbestos within wall or enclosure.
- C. Any replacement of blocks, bricks or other masonry removed to allow access to asbestos shall be replaced by the Contractor. Clean and seal seams and openings in surface of ducts prior to disposal.
- D. Remove asbestos-containing pipe and fitting insulation in layers, while maintaining all exposed surfaces of insulation or lagging in wet condition. Full saturation of insulation will not be required if material is immediately bagged and not allowed to fall to floor.
- E. Seal ends of pipe and duct insulation at perimeters of asbestos work area with heavy coat of high temperature sealer.
- F. Place asbestos waste in asbestos waste receptors. If drums are used for waste disposal, drums shall be sealed and cleaned in waste decontamination enclosures. If double plastic bags are used, inner bag shall be cleaned of gross contamination and placed in a clean 6 mil outer plastic bag in container cleaning room immediately prior to transfer from Site.
- G. Treat all materials removed to expose asbestos, as asbestos-contaminated waste unless such materials are specified to be reused.

3.9 CLEAN-UP

- A. Clean surfaces with brushes and vacuum or wet-sponge to remove visible dust and debris.
- B. Remove sealed and labelled asbestos waste receptors and dispose of in authorized disposal area in accordance with requirements of disposal authority.
- C. After brushing and wet-sponging to remove visible asbestos, wet clean entire asbestos work area including equipment and access area, polyethylene sheeting and equipment used in process. Floor and wall surfaces, ducts, and similar items not covered with polyethylene sheeting must be wet cleaned.
- D. Request visual inspection and acceptance. Following inspection and acceptance, apply heavy coat of slow drying sealer to all surfaces from which asbestos has been removed. Apply thinned coat (sufficient to coat all surfaces) to other surfaces in asbestos work area including all polyethylene sheeting and surfaces scheduled for demolition. Allow minimum of 12 hours flushing time with no disturbance of asbestos work area. Operate negative air units during this period for buildings scheduled to remain in place.

3.10 DISMANTLING OF PROTECTION

- A. Following cleaning specified in above, and when air sampling shows that asbestos levels on both sides of seals do not exceed 0.01 fibres/cc as determined by membrane filter method at 400-500X magnification phase contrast illumination, as described in NIOSH 94-113 approved equal in accordance with B8, proceed with final cleanup.
- B. Remove polyethylene sheeting exposed during contaminated work including upper surfaces plus any underlying sheeting contaminated by water leaks, rips, tears, or exposed by failure of upper layer. Wear half face piece respirator and disposable coveralls during removal of sheeting. Carefully roll sheeting away from walls to centre of asbestos work area. As sheeting is rolled away from walls and corners, HEPA vacuum visible debris.
- C. While removing top layer of sheeting from surfaces protected by two layers of sheeting, cut lower sheeting so as to expose horizontal surfaces that may be contaminated with asbestos debris. HEPA vacuum any visible debris.
- D. Place polyethylene sheeting, seals, tape, cleaning material, clothing, and other contaminated waste in asbestos waste receptors for transport. Remove with HEPA vacuum any debris which may have fallen behind sheeting.
- E. Clean asbestos work area(s), equipment and access area, washing/showering room, and other enclosures that may have been contaminated during work.
- F. Clean asbestos waste receptors and equipment used in work and remove from asbestos work area(s) via drum and equipment decontamination enclosure system, at an appropriate time in sequence.
- G. Remove hoardings, temporary lighting, equipment and facilities provided for work. A final review may be carried out by the City's Third Party Inspector to ensure that no dust or debris

remains. Asbestos abatement contractor responsible for inspecting and cleaning all adjacent spaces to the asbestos abatement work area. Adjacent work areas to be left free of construction related dust and debris.

3.11 RE-ESTABLISHMENT OF OBJECTS AND SYSTEMS

- A. When cleanup is complete re-establish mechanical and electrical systems to remain operative in proper working order, where required. Arrange for, and pay costs of electrical or mechanical repairs needed due to work of this Section.
- B. For buildings not scheduled for demolition, make good all damage at completion of work.

3.12 AIR MONITORING

- A. The City's Third Party Inspector will arrange for air samples to be taken from commencement of work until completion of cleaning operations, both inside and outside of asbestos work area(s) enclosures in accordance with NIOSH methods.
- B. Air monitoring will be performed using Phase Contrast Microscopy (PCM) following the NIOSH method 7400.
- C. Co-operate with the Asbestos Abatement Contractor in collection of air samples, including providing workers to wear sampling pumps for up to full-shift periods. Asbestos Abatement Contractors forces must exercise care with Asbestos Abatement Contractor's equipment. The City reserves the right to back charge the Contractor for re-sampling of samples damaged by tampering or abuse. In addition, the Contractor will be responsible for the cost of testing equipment repairs resulting from the actions of the Contractor's forces.
- D. If air monitoring or visual inspection shows that areas outside current asbestos work area(s) enclosure or decontamination facilities are contaminated above 0.01 fibre/cc., clean these areas in same manner as that applicable to asbestos work areas, at no cost to the City. The area will be considered contaminated until visually inspected and air monitoring results are less than 0.01 fibres/cc.
- E. If air monitoring in work areas shows airborne fibre levels exceed normal levels for wet removal, workers shall use positive pressure supplied air respirators with full-face piece.
- F. If final air sampling by the City's Contract Administrator shows that levels in completed asbestos work area do not exceed 0.01 fibres/cc. as determined by NIOSH 7400 Method - "A" counting rules, proceed with dismantling of enclosures.
- G. Clearance level is < 0.01 f/cc. Clearance sampling will only be conducted in structures scheduled to remain in place or as directed by the City.

3.13 INSPECTION

- A. From commencement of work until completion of clean-up operations, the City's Third Party Inspector will be present on a part-time basis.

- B. Be fully responsible for coordination of all Work.
- C. Provide access to the Inspector to carry out necessary reviews/inspections
 - 1. After the abatement work has been completed, the work shall be inspected by a City's Inspector. Any discrepancies found shall be reported in writing. Contractor shall rectify discrepancies identified before proceeding.
- D. The following Milestone Inspections will take place at Contractor's cost:
 - 1. Milestone Inspection A – Clean Site Preparation: Inspection of preparations and set-up prior to contaminated work in the Asbestos Work Area.
 - 2. Milestone Inspection B – Contaminated Perimeter Preparation: Inspection of preparations at perimeter of Asbestos Work Area.
 - 3. Milestone Inspection C – Before Bulk Removal: Inspection of Asbestos Work Area prior to start of major ACM removal.
 - 4. Milestone Inspection D – Visual Clearance: Inspection of Asbestos Work Area after removal of all asbestos but prior to application of lock-down agent.
 - 5. Milestone Inspection E – Air Monitoring Clearance: Inspection and air monitoring after the application of lock-down agent but prior to removal of polyethylene from within the Asbestos Work Area.
 - 6. Milestone Inspection F – Dismantling Inspection: Inspection after removal of polyethylene prior to dismantling perimeter seal and decontamination facility.
- E. In addition to the Milestone Inspections, inspection of the Asbestos Work Area will be performed to confirm the Asbestos Abatement Contractor's compliance with the requirements of the specification and governing authorities. Any deviations from these requirements, which have not been approved in writing, may result in a stoppage of work, at no additional cost to the City.
- F. The Asbestos Abatement Contractor is empowered by the City to inspect adherence to specified procedures and materials, and to inspect for final cleanliness and completion. Additional labour or materials expended by the Asbestos Abatement Contractor to provide satisfactory performance to the level specified should be at no additional cost.
- G. If the Asbestos Work Area is found unacceptable by the standards specified or required by governing authorities, the work required to meet the standards and obtain consent to proceed from the Asbestos Abatement Contractor, shall be performed at no additional cost to the City.
- H. The Asbestos Abatement Contractor is empowered by the City to order a shutdown of work when a leakage of asbestos from the controlled Asbestos Work Area has occurred or is likely to occur. These conditions include, but are not limited to, failure of negative pressure systems, inadequate wetting, failure of the perimeter enclosure, water leaks, etc. Additional labour or materials to rectify these or other unsatisfactory conditions shall be at no cost to the City.
- I. Pay cost to provide re-inspection of work found not to be in accordance with these specifications and requirements of authorities having jurisdiction.
- J. Inspection and air monitoring performed as a result of Asbestos Abatement Contractor's failure to perform satisfactorily regarding quality, safety, or schedule shall be back-charged to the Contractor.

3.14 WASTE TRANSPORT AND DISPOSAL

- A. Conform to requirements of national and provincial regulations and guidelines related to the transportation and disposal of hazardous waste.
- B. Check with waste disposal facility to determine type of waste containers acceptable.
- C. Waste disposal shall be sent to a City approved disposal facility.
- D. Ensure shipment of containers to dump is taken by waste hauler licensed to transport asbestos waste.
- E. Each load requires completion of bill of lading showing type and weight of hazardous waste being transported. Provide copies of bill of lading indicating acceptance of waste at waste disposal facility.
- F. Co-operate with provincial inspectors and immediately carry out instructions for remedial work at dump to maintain environment, at no additional cost to the City.
- G. Ensure waste disposal facility is fully aware of hazardous material being disposed.
- H. Ensure that containers used for disposal are locked and covered at all times.

END OF SECTION

SECTION 03 10 00

CONCRETE FORMWORK AND ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

- A. Comply with Division 1, General Requirements.
- B. This Section forms part of Section 03 30 00, Cast-in-Place Concrete.

1.2 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
 - 1. Canadian Standards Association (CSA):
 - a. A23.1, Concrete Materials and Methods of Concrete Construction.
 - b. S269.1, Falsework for Construction Purposes.
 - c. S269.2-M, Access Scaffolding for Construction Purposes.
 - d. S269.3-M, Concrete Formwork
 - 2. American Concrete Institute (ACI):
 - a. 347, Guide to Formwork for Concrete.
 - 3. National Lumber Grades Authority (NLGA):
 - a. Standard Grading Rules for Canadian Lumber.

1.3 DESIGN REQUIREMENTS

- A. Design formwork in accordance with CSA S269.1, S269.2-M, and S269.3-M and CSA A 23.1-09 Clause 6.5 Formwork to provide specified finishes.
- B. Design formwork and falsework to carry dead loads and construction live loads.
- C. When high range water reducer (superplasticizer) is used in concrete mix, design forms for full hydrostatic pressure.
- D. Make joints in forms watertight.
- E. Design formwork to meet variations from a reference system specified in CSA A23.1-09 Clause 6.4 Construction Tolerances for Cast-in-Place Concrete.

1.4 SUBMITTALS

- A. Shop Drawings:
 - 1. Submit formwork and falsework drawings bearing seal and signature of a Professional Engineer licensed in the Province of Manitoba for record purpose.
 - 2. Formwork and falsework Shop Drawings will not be reviewed for structural adequacy.

3. Be fully responsible for the design, construction, and maintenance of formwork and falsework.
 - a. Show design criteria as specified in CSA A23.1-09 Clause 6.5.2.1.
4. Indicate:
 - a. For suspended slabs
 - 1) Shoring left in place until concrete has reached specified strength.
 - 2) Re-shoring below slabs or beams supporting shoring above.
 - a) Lateral bracing system.
 - b. For walls and columns on top of slabs and beams
 - 1) Shoring left in place until concrete in walls and columns above has reached specified strength.
 - 2) Lateral bracing system.
5. Layout of panel joints, form liners, and tie hole pattern. Method of sealing form tie hole. Coordinate with details where shown.
6. Double Wall Construction: Show details of double wall forming and premolded joint filler attachment.
7. Two unstamped copies of the Shop Drawings will be returned with Contract Administrator's comments.

B. Product Data Sheets:

1. Submit Manufacturer's product data sheets including materials, allowable loading, installation, application, and maintenance instructions for:
 - a. Lumber for formwork and falsework.
 - b. Plywood for formwork and falsework.
 - c. Formwork for curved surfaces.
 - d. Tubular column forms.
 - e. Form release agent.
 - f. Form ties.
 - g. Controlled permeability form liner.

C. Samples: One each as follows:

1. Form ties.
2. Form liners.

D. Informational Submittals:

1. Statement of qualification for formwork designer.
2. Contractor's Certificate of Proper Installation.

1.5 QUALIFICATIONS

- A. Formwork, Falsework, and Shoring Designer: An engineer licensed in the province of Manitoba.

1.6 QUALITY ASSURANCE

A. Mockup Panels:

1. Comply with the requirements of Section 03 39 00, Concrete Curing and Finishes
2. Construct one panel for each form liner type specified.

3. Construct mockup panels to demonstrate wall finish.
 - a. Minimum dimensions 2400 mm by 2400 mm.
 - b. Demonstrate sandblasting to show how uniform appearance will be achieved regardless of age of concrete.
 4. Construct panels with specified materials, forming systems, reinforcing details, and leakage prevention techniques.
 5. Show architectural details, joints, form ties, form liners, and reinforcing bar spacers to produce finished surface required.
 6. Test form release agent on one mockup panel to ensure no adverse effects are caused on form or form liner materials.
 7. Cast panels from minimum of 3-cubic metre truck mixer load.
 8. Approved panels establish standard of quality by which concrete work will be judged.
 9. Replace panels if not representative of Work as specified.
 10. Panels may be incorporated into Work if approved by Contract Administrator
 11. Construct additional 2400 mm by 2400 mm panel or use Contract Administrator-selected portion of as-cast wall surface hidden from view to develop and test patching techniques and mixes.
- B. Construct additional panels and use to demonstrate repair material and application procedures and obtain approval prior to using material to repair project structures.

PART 2 PRODUCTS

2.1 FORM MATERIALS

- A. General:
1. Materials:
 - a. Lumber for Formwork and Falsework: Grade-marked sawn lumber graded in accordance with NLGA.
 - b. Plywood for Formwork: High density overlay (plastic overlay) grade plywood. Plywood may be of lower finish grade when use in conjunction with form liner.
 - c. Fibreglass or steel forms in undamaged condition, of sufficient strength and surface smoothness to produce specified finish.
 2. Circular Structures:
 - a. Conform forms to circular shape of structure.
 - b. Straight panels may be substituted for circular forms provided panels do not exceed 600 mm in horizontal width and angular deflection is no greater than 3-1/2 degrees per joint.
 3. Void Forms:
 - a. Bio-degradable: Suitable to support construction load with a controlled built-in strength loss.
 - b. Manufacturer: Void Form International Ltd.
- B. Form Liners:
1. Controlled Permeability Form Liner:
 - a. Controlled pore size, maximum 0.08 mm to permit drainage of excess water; water permeability at 200 mm water head of 20 L per square metre per second.
 - b. Liner must be noncompressible under wet concrete pressure.

- c. Manufacturer and Product:
 - 1) Dupont; Zemdrain MD (re-use up to 2 times).
 - 2) Fibertex; Formtex (do not re-use).
- C. Painted Surface Forms: High density overlay plywood surfaces.
- D. Form Release Agent:
 - 1. Use form release agent on all cast in place concrete except where form liners is used.
 - 2. Material: Release agent that does not bond with, leave residue on, stain, or adversely affect concrete surfaces, and does not impair subsequent treatments of concrete surfaces when applied to forms
 - 3. Freezing point: Minus 15 degrees C or lower.
 - 4. Manufacturers and Products:
 - a. BASF; MasterFinish RL 211.
 - b. Cresset Chemical Company; Crete-Lease 20-VOC.
 - c. W.R. Meadows of Canada Ltd.; Sealtight Duogard.
 - d. Euclid Admixture Canada, Inc.; Eucoslip VOX.
- E. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides preventing loss of paste or water between the two surfaces.
- F. Form Ties:
 - 1. Material: Steel.
 - 2. Spreader Inserts:
 - a. Conical or spherical type.
 - b. Design to maintain positive contact with forming material.
 - c. Furnish units that will leave no metal closer than 25 mm to concrete surface when forms, inserts, and tie ends are removed.
 - 3. Wire ties not permitted.
 - 4. Flat bar ties for panel forms; furnish plastic or rubber inserts with minimum 25 mm depth and sufficient dimensions to permit patching of tie hole.
 - 5. Water Stop Ties: For water-holding structures, below grade structures, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
 - a. Integral steel water stop 2.6 mm thick and 16 mm in diameter tightly and continuously welded to tie.
 - b. Neoprene water stop 5 mm thick and 24 mm diameter whose center hole is 1/2-diameter of tie, or molded plastic water stop of comparable size.
 - c. Orient water stop perpendicular to tie and symmetrical about center of tie.
 - d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.
 - e. Through bolt ties are not permitted for water-holding structures.
 - 6. Through-Bolts: Tapered minimum 25 mm diameter at smallest end.
 - a. Not permitted for water-holding structures, below grade structures, pipe galleries, and accessible spaces below finish grade.
 - 7. Elastic Vinyl Plug:
 - a. Use in conjunction with through-bolt type form ties.
 - b. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length, and diameter upon removal forming watertight seal.

- c. Manufacturer and Product: Dayton/Richmond Co., A58 Sure Plug.
- G. Stay-Form: Form at joints with waterstop as manufactured by AMICO Type No. 66-26 GA minimum.

PART 3 EXECUTION

3.1 FORM SURFACE PREPARATION

- A. Remove water, snow, ice, laitance, curing compound, loose soil, and other debris and thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants prior to coating surface.
- B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by the Manufacturer.
- C. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.
- D. Form Liners: Provide liners with full sheets and place seams at horizontal and vertical grooves. Prepare as recommended by Manufacturer.
 - 1. Use anchorage systems recommended by Manufacturer to anchor liner to formwork.
 - 2. Do not use form release agent on formwork.

3.2 ERECTION

- A. General:
 - 1. Unless specified otherwise, follow applicable recommendations of CSA S269.1, S269.2-M and S269.3-M.
 - 2. Align form joints and make watertight. Keep number of joints to a minimum.
 - 3. Laterally brace formwork and falsework and prevent displacement during concrete placement.
 - 4. Form chases, openings, projections, recesses, expansion joints and construction joints.
 - 5. Form around pipes, mechanical, and electrical equipment which penetrate the concrete structure.
 - 6. Incorporate frames, castings, pipes, sleeves, and similar items into formwork.
 - 7. Do not re-use damaged formwork which may not provide a uniform consistent finish.
 - 8. Do not re-use controlled permeability form liner when water drainage from the liner has reduced to 75 percent of its first use drainage performance.
- B. Beveled Edges (Chamfer):
 - 1. Form 20 mm bevels at concrete edges, unless otherwise shown.
 - 2. Where beveled edges on existing adjacent structures are other than 20 mm, obtain Contract Administrator's approval of size prior to placement of beveled edge.
- C. Wall Forms:
 - 1. Locate form ties and joints in an uninterrupted uniform pattern.

2. Inspect form surfaces prior to installation to assure conformance with specified tolerances.
 3. Do not use through-the-wall removable form ties for walls of liquid holding structures and exterior walls below grade.
 4. Where excavation shoring system is used as formwork, fasten form tie to shoring in a suitable manner to withstand applied loads.
 5. Double Wall Construction:
 - a. Joint Filler Attachment:
 - 1) Use attachments to secure premolded joint filler to one wall only.
 - 2) Secure premolded joint filler without gaps and separations keeping concrete from second wall pour from penetrating thickness and space occupied by premolded joint filler. Seal all premolded joint filler joints by tapping.
 - b. Do not use form ties or other devices permanently penetrating premolded joint filler between walls or produce a rigid connection between walls.
 - c. Ensure first cast wall has attained the greater of the wall design concrete strength or the construction strength required, as determine by form design engineer, prior to casting second wall. Determine strength based on field cast and cured test cylinders.
- D. Formwork with Form Liners:
1. Construct forms to structurally withstand deflection, movement, leakage, high hydraulic pressures resulting from rapid filling and heavy-high frequency vibration.
 2. Lay out form joints and ties in uniform pattern, unless otherwise shown.
 3. Use plywood forms when using form liners. Plywood may be of lower finish grade when used in conjunction with form liners.
 4. Controlled permeability form liner applications:
 - a. Coordinate with Section 03 39 00, Concrete Curing and Finishes.
 - b. For liquid holding structures provide liner on both faces except at tunnels and galleries apply liner on wet side only. Provide liners in full sheets. Place seams at regular horizontal and vertical pattern. Prepare as recommended by the Manufacturer.
 - c. Use anchorage systems recommended by the Manufacturer to anchor liner to formwork. Close anchorage of liner is recommended to prevent wrinkling of the liner.
 - d. Do not use form release agent on formwork.
- E. Form Tolerances: Comply to tolerances of CSA A23.1.
- F. Fasteners: Use only galvanized nails and fasteners when such fasteners will be left in place in the permanent structure.
- G. Void Forms: Brace void forms to prevent distortion and floatation.
- H. Shoring under walls or columns:
1. When constructing concrete walls or columns on top of slabs or beams, provide shoring under these slabs or beams to carry the total construction load.
 2. Leave shoring in place until the compressive strength of the concrete in the wall above has reached 75 percent of its specified 28-day compressive strength.
- I. Lateral Supports: Where required, brace walls until permanent lateral supports are in place.

- J. Formwork at Construction and Expansion Joints: Provide formwork incorporating water stop in joint. Use “Stay-Form” for joints with waterstop. Install Stay-Form as per Manufacturer’s installation instructions and as shown on Drawing details.

3.3 FORM REMOVAL

- A. Remove wall and column formwork as soon as possible after concrete has attained adequate strength to support its own weight and superimposed loads, without cracking or deflecting excessively in order to facilitate effective finishing, but not earlier than 30 hours after concrete placement if:
 - 1. Concrete is sufficiently hard so as not to sustain damage by form removal operations, and
 - 2. Curing and protection operations are maintained.
- B. Elevated Structural Slabs, and Beams: Remove formwork after concrete has reached 75 percent of its specified 28-day compressive strength as determined by field cure test cylinders.
- C. Remove nails, fasteners, tie wire and similar items at the surface.

3.4 MANUFACTURER’S SERVICES

- A. Form liner Manufacturer’s Representative to provide installation assistance at Site, and inspection. Contractor to provide inspection report certifying acceptable liner installation in accordance with the Manufacturers’ Specifications.

END OF SECTION

SECTION 03 21 00

REINFORCING BARS

PART 1 GENERAL

1.1 SUMMARY

- A. Requirements for the 66 kV Substation, refer to Section 03 20 00, Concrete Reinforcing.
- B. Products supplied but not installed under this section:
 - 1. Reinforcing bars for grouted in dowels.
 - 2. Reinforcing bars for reinforced masonry.

1.2 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
 - 1. Canadian Standards Association (CSA):
 - a. A23.1, Concrete Materials and Methods of Concrete Construction.
 - b. A23.3, Design of Concrete Structures.
 - c. G30.18-M, Carbon Steel Bars for Concrete Reinforcement.
 - d. W47.1, Certification of Companies for Fusion Welding of Steel.
 - e. W186-M, Welding of Reinforcing Bars in Reinforced Concrete Construction.
 - 2. American Society for Testing and Materials International (ASTM):
 - a. A1064/A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
 - 3. Reinforcing Steel Institute of Canada (RSIC):
 - a. Reinforcement Steel Manual of Standard Practice.
 - 4. International Conference of Building Officials (ICBO):
 - a. ICBO Research Report.

1.3 SUBMITTALS

- A. Samples and Product Data Sheets:
 - 1. Submit three samples and three copies of Manufacturer's product data sheets including installation and maintenance instructions for:
 - a. Chairs, bolsters, bar supports, and side form spacers.
 - b. Dowel bar splicer.
 - c. Mechanical splices.
- B. Shop Drawings:
 - 1. Reinforcing Bars:
 - a. Submit reinforcing bar placement drawings prepared in accordance with Reinforcement Steel Manual of Standard Practice by the Reinforcing Steel Institute of Canada and as specified below.
 - b. Indicate reinforcing bars that form part of an individual concrete placement and reinforcing bars that extend into adjacent placements.

- c. For each reinforcing bar placement Shop Drawing, submit a separate bar list and bending schedule showing size, shape, dimensions, and numbers of bars required for each bar type.
 - d. Identify reinforcing bars in the bar list and bending schedule with a separate bar mark that corresponds to bar marks shown on reinforcing bar placement drawings.
 - e. If bar list and bending schedule contain details of bars of more than one reinforcing bar placement drawing, then arrange bar marks in separate groups for each placement drawing. Clearly indicate for each bar mark the corresponding reinforcing bar placement drawing number.
 - f. For slabs, show a separate plan indicating concrete thicknesses, reinforcing bars, and dowels for walls and columns cast in slab.
 - g. For walls, show separate elevations indicating concrete thicknesses, reinforcing bars, and dowels for slabs and adjacent walls cast in wall.
 - h. Do not add new information on previously reviewed Shop Drawings.
 - i. Reinforcing bar placement Shop Drawings will be reviewed for bar sizes, locations, and spacing, and will receive submittal stamp and signed. Reviewed bar list and bending schedule will be dated only.
2. Submit Shop Drawings of dowel bar splicers detailing locations, size, and type.
- C. Quality Control Submittals:
1. Submit certified mill test reports of steel reinforcing bars: Determine physical and chemical properties of steel reinforcing in accordance with requirements of CAN/CSA-G30.18-M.
 2. Dowel Bar Splicers:
 - a. Current International Conference of Building Officials (ICBO) Research Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
 - b. Verification that device threads have been tested and meet requirements for thread quality, in accordance with Manufacturer's published methods.
 3. Submit welding certificate in accordance with CSA W47.1 and CSA W186-M.

1.4 QUALITY ASSURANCE

- A. Welder Qualifications: CSA W47.1 and CSA W186-M certified.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Ship bundles of reinforcing bars identified by tags containing bar marks along with bar list.
- B. Store materials to prevent deterioration or contamination. Deteriorated or contaminated materials will be rejected and must be removed from Site.

PART 2 PRODUCTS

2.1 MATERIALS

A. Reinforcing Bars:

1. Deformed steel bars: CAN/CSA-G30.18-M; Grade 400R except Grade 400 W where welding is indicated or specified. Do not substitute with epoxy-coated bars.

B. Mechanical Splices:

1. Mechanical Threaded Connections: Furnish metal coupling sleeve with internal threads engaging threaded ends of bars, capable of developing in tension or compression 125 percent of yield strength of bar.
 - a. Manufacturers and Products:
 - 1) DB-SAE by Dayton/Richmond by Dayton Superior.
 - 2) Lenton Form Saver by Erico Canada Inc.
 - 3) D150 DBR Coupler and DBR Setting-Splice Bar, with size equivalent to DB-SAE, by Dayton Superior Canada Limited.

C. Dowel-in bar: Suitable for existing dowel bar splicer with rolled UNC or tapered threads as required:

1. DI by Dayton/Richmond by Dayton Superior.
2. Splice bar by Erico Canada Inc.
3. D-51, D-52, or D-53, with size equivalent to DI, by Dayton Superior Canada Limited.

D. Welded Wire Reinforcement:

1. ASTM A1064 wire of 517 MPa (75 ksi) minimum tensile strength.
2. Furnish flat sheets only, rolled sheets not permitted.

2.2 ACCESSORIES

A. Tie Wire:

1. Black, soft-annealed 1.6 mm diameter wire.
2. Nylon-, epoxy-, or plastic-coated wire.

B. Bar Supports and Spacers:

1. Adequate for accurate placing and as required for construction loads.
2. Provide non-conductive bar supports in contact with exposed surfaces that has geometry and bond characteristics that prevents moisture movement from the surface to the reinforcement.
3. In beams, columns, walls, and slabs exposed to view after form removal: Small concrete blocks made up of same color and strength as concrete being placed around them.
4. Precast concrete supports of same strength as concrete for reinforcing in concrete placed on grade.
5. Do not use plastic or stainless steel bar supports or side form spacers.
6. Design and fabricate special bar supports for top reinforcing bars in slabs where standard bar supports are not high or strong enough.

2.3 FABRICATION

A. Reinforcing Bars

1. Comply with CSA A23.1 Clause 6.0 and CSA A23.3.
2. Tolerances:
 - a. Length: Plus or minus 25 mm.
 - b. Height of truss bar: Plus 0 to minus 10 mm.
 - c. Outside dimensions of stirrups, ties, and spirals: Plus or minus 10 mm.
 - d. Other bends: Plus or minus 25 mm.
3. Use longest bar possible.
4. Keep number of splices to a minimum.
5. Do not weld chairs, bolsters, bar supports, or spacers to reinforcing bars.

B. Reinforcing Splices:

1. Lap Splices:
 - a. Splice by lapping reinforcing bars, unless specified otherwise.
2. Welded Splices:
 - a. Full-penetration direct butt-splice welds in accordance with CSA W186-M and as specified.
3. Splices in Welded Wire Reinforcement:
 - a. Provide lap of 1-1/2 times the spacing of the bar or minimum 200mm.

PART 3 EXECUTION

3.1 PREPARATION

- A. Notify Contract Administrator when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.
- B. Clean reinforcing bars of loose rust, mill scale, dried cement paste, mud, oil, or other coatings that will affect adhesion in accordance with CSA A23.1-04, Clause 6.1.5 Surface Conditions of Reinforcement, prior to placing concrete.
- C. Coat wire projecting from bar supports with dielectric material, epoxy, or plastic.

3.2 REINFORCING BAR INSTALLATION

- A. Place reinforcement within tolerances specified in CSA A23.1-09 Clause 6.6.8 Tolerances for location of reinforcement.
- B. Splicing:
 1. Use lap splices, unless otherwise shown or permitted in writing by Contract Administrator.
 2. Welded Splices: Accomplish by full penetration groove welds and develop a minimum of 125 percent of yield strength of bar in tension and compression.
 3. Stagger splices in adjacent bars where indicated a minimum of 1500 mm.

- C. Dowel Bar Splicers:
 - 1. Use only in areas specifically approved in writing by Contract Administrator.
 - 2. Install threaded rods as recommended by Manufacturer with threads totally engaged into coupling sleeve and in accordance with ICBO Research Report.
 - 3. Install dowel bar splicers with plastic setting plugs.
 - 4. Lightly grease internal threads in accordance with Manufacturer's printed instructions.
 - 5. Maintain minimum edge distance and concrete cover.
- D. Mechanical Splices:
 - 1. Install mechanical splices in accordance with Manufacturer's printed instructions. Request presence of Manufacturer's Representative to verify proper installation.
- E. Tying Reinforcing Bars:
 - 1. Bend tie wire away from concrete surface. Ensure a cover for tie wires, form tie bolts etc are same as the reinforcing bars. Do not let reinforcing tie wire touch formwork or be exposed in the finished concrete structure.
- F. Reinforcement around Openings: On each side and above and below pipe or opening, place an equivalent area of steel bars to replace steel bars cut or disrupted for opening. Extend steel reinforcing a standard lap length beyond opening at each end.
- G. Welding Reinforcement:
 - 1. Only Type W bars may be welded.
 - 2. Do not perform welding until welder qualifications are approved.
- H. Dowels Threaded Into Dowel Bar Splicers in Existing Structures
 - 1. Expose existing dowel bar splicers.
 - 2. Remove plastic setting plugs and clean threads.
 - 3. Thread dowel-in bars into the dowel bar splicers and tighten securely to develop required strength in tension and compression.
 - 4. If the existing dowel bars are damaged or not usable inform Contract Administrator immediately.
- I. Straightening and Rebending: Field bending of reinforcing steel bars is not permitted.
- J. Unless permitted by Contract Administrator, do not cut reinforcing bars in field.

3.3 WELDED WIRE REINFORCEMENT INSTALLATION

- A. Use only where specifically shown.
- B. Extend reinforcement to within 50 mm of edges of slab, and lap splices at least 1-1/2 courses of wire spacing or minimum 200 mm.
- C. Tie laps and splices securely at ends and at least every 600 mm with tie wire.
- D. Install 15M reinforcing bars at 2000 mm maximum spacing in each direction, supported on chairs, to securely support welded steel wire reinforcement during concrete placement. Ensure the reinforcement remains at intended clearances as specified or indicated.

E. Do not use reinforcement that has been rolled. Install flat sheets only.

3.4 TESTS AND INSPECTION

- A. An independent testing agency will be retained by the City to visually inspect and test reinforcing steel welds as specified in Section 05 05 23, Welding-Quality Assurance.
- B. An independent testing agency will be retained by the City to inspect each mechanical splice and dowel bar splicer and verify each component is installed in accordance with Manufacturer's instructions and ICBO Research Report.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

- A. Requirements for the 66 kV Substation, refer to Section 03 05 10, Cast-in-Place Concrete – Short Form.
- B. Comply with Division 1, General Requirements.
- C. Comply with requirements of CSA A23.1 and A23.2, except where noted otherwise in this Specification.
- D. The following sections form part of this Section:
 - 1. Section 03 10 00, Concrete Forming and Accessories
 - 2. Section 03 21 00, Reinforcing Bars
 - 3. Section 03 15 00, Concrete Joints and Accessories
 - 4. Section 03 39 00, Concrete Curing
 - 5. Section 03 60 00, Grouting.
- E. Do not use materials that are toxic in installed condition. Do not use volatile organic compounds where not permitted by law. Where use of volatile organic compounds is permitted, provide adequate ventilation and take necessary safety precautions.
- F. Section Includes:
 - 1. Normal-density concrete.
 - 2. Fill concrete.
 - 3. Bonded concrete toppings.
 - 4. Repair of cracks that develop in concrete.

1.2 DEFINITIONS

- A. Exposed Concrete: Visible concrete surfaces inside or outside of structures, including surfaces above liquid level.
- B. Hydraulic Structures: Liquid holding or containment structures whether above and/or below grade and includes roofs of the containment structure.
- C. Habitable structures: Structures that are accessible and may be used for storage or conveyance or utilities.
- D. Below Grade structures: Structures that are below or partially below grade. Below grade habitable structures, for water tightness requirements, are considered hydraulic structures.

- E. Defective Areas: Surface defects that include honeycomb, rock pockets, indentations greater than 5 mm, cracks 0.1 mm or wider as well as any crack that leaks in hydraulic structures and below grade habitable spaces; cracks 0.25 mm and wider in non-hydraulic structures, spalls, chips, air bubbles greater than 12 mm in diameter, pinholes, bug holes greater than 4 mm in diameter, embedded debris, lift lines, sand lines, bleed lines, leakage from form joints or penetrations or openings, fins and other projections, form pop outs, texture irregularities, and stains and other color variations that cannot be removed by cleaning.
- F. New Concrete: Less than 60 days old.
- G. Type of concrete: Project specific concrete type and shall not be confused with type of cements or finishes.
- H. Exposure classes of concrete: As defined in Table 1 CSA A23.1-09
- I. Water/Cementing Material Ratio (W/C): A weight ratio of total water content including admixtures over the weight of all cementing materials.

1.3 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
 - 1. Canadian Standards Association (CSA):
 - a. A23.1, Concrete Materials and Methods of Concrete Construction.
 - b. A23.2, Test Methods and Standard Practices for Concrete.
 - c. A3001, Cementitious Materials for Use in Concrete.
 - d. A3002, Masonry and Mortar Cement.
 - e. A3003, Chemical Test Methods for Cementitious Materials for Use in Concrete and Masonry.
 - f. A3004, Test Methods and Standard Practices for Cementitious Materials for Use in Concrete and Masonry.
 - g. A3005, Test Equipment and Materials for Cementitious Materials for Use in Concrete and Masonry.
 - 2. American Concrete Institute (ACI):
 - a. 304.2R, Placing Concrete by Pumping Methods.
 - 3. American Society for Testing and Materials International (ASTM):
 - a. C157 Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
 - b. C260, Standard Specifications for Air-Entraining Admixtures for Concrete.
 - c. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
 - d. C900, Standard Test Method for Pullout Strength of Hardened Concrete.
 - e. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
 - f. C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method.

1.4 PERFORMANCE REQUIREMENTS

- A. Concrete for the project is used in waste water facilities. Ph for the liquids is normally neutral at about 7. Various chemicals are added to help the process. Degradation of organic material

emits gases like hydrogen sulphide which when combined with moisture forms mild sulphuric acid. Life expectancy of waste water plant is 60 to 80 years.

B. Water Tightness:

1. Concrete as placed for *hydraulic structure* and *below grade habitable structure* shall be watertight.
2. No visible leaks will be permitted in hydraulic structures and below grade structures.
3. Roofs of hydraulic structures and below grade structures and other roofs, shall be water tight.
4. Coordinate leakage test in accordance with requirements of Section 01 35 13, Special Project Procedures.
5. Repair cracks in *hydraulic structures* and *below grade structures* that are leaking or are damp.
6. Repair cracks that are wider than 0.4 mm in dry areas. Repair to match surrounding concrete surfaces.
7. Repair joints that are leaking or are damp.

C. Type of Concrete Class of Exposure and Compressive Strengths.

1. Normal-density concrete:
 - a. Type A: Class of Exposure S-3- 30 MPa at 56 days, W/C 0.45.
 - b. Type B: Fill Concrete - Class of Exposure: N;15 MPa at 28 days W/C as required.
 - c. Type C: Class of Exposure: C-2 -32 MPa at 28 days w/c 0.45.
 - d. Type D: Bonded concrete topping: Class of Exposure: N, 30 MPa at 56 days w/c/ 0.45.
 - e. Type E: Bonded concrete topping: Class of Exposure: S-3; 30 MPa at 56 days w/c 0.45.

D. Performance requirement for temperatures during curing.

1. Design concrete mix taking in the account the expected ambient temperature during the curing. Peak curing temperature of concrete shall not exceed 40 degrees C and shall not be less then 10 degrees C.

E. Density.

1. Air entrained normal density concrete: As defined in CSA 23.1-09 Clause 3 except the density shall be not less than 2250 kg/m³.

F. Concrete Shrinkage at 28 Day Drying Age:

1. 0.040 percent maximum for laboratory trial mixes of proposed concrete made with 40 mm aggregate with and without superplasticizer.
2. 0.045 percent maximum for laboratory trial mixes of proposed concrete made with 20 mm aggregate with and without superplasticizer.
3. If shrinkage specimen tests for concrete exceed shrinkage limits, modify concrete mix to reduce shrinkage. Repeat tests with new mix.
4. Test shall be conducted as per modified ASTM C157 as specified herein.

- G. Bond Strength for Concrete Topping:
 - 1. Tensile bond strength between bonded concrete topping and substrate concrete: 1.0 MPa, minimum.
- H. Construction Tolerances:
 - 1. Comply with CSA A23.1-09 Clause 6.4 unless noted otherwise.
- I. Concrete Finishes:
 - 1. As specified in Section 03 39 00, Concrete Curing.

1.5 SUBMITTALS

- A. Product Data Sheets:
 - 1. Submit three copies of Manufacturer's product data sheets including installation, application, and maintenance instructions for:
 - a. Chemical admixtures.
 - b. Bonding agent.
 - c. Crack injection material.
 - d. Repair materials.
- B. Concrete Mix Design:
 - 1. Design in accordance with CSA 23.1-09 Table 5 based on performance requirements.
 - 2. Submit proposed mix, and supplier's applicable standard deviations.
 - 3. Tabulate concrete mixes. Indicate type of cements, size of coarse aggregate; water/cementing material ratio, admixtures used, air content, slump, and locations of use for each mix. Identify mix with pump or bucket type of discharge. Also identify mix for cold weather and hot weather concreting..
 - 4. Submit a mix that will not result in segregation when high-slump flowing concrete is used.
 - 5. Submit detailed plan for cold weather placement, curing and protection of concrete in weather for ambient temperatures below 5 degrees C.
 - 6. Submit detailed plan for hot weather placements, curing and protection of concrete for ambient temperatures over 27 degrees C.
 - 7. Concrete mix designs will be reviewed for conformance with requirements of the Specifications and will be returned with Contract Administrator's comments.
- C. Source Quality Control Submittals:
 - 1. Provide certification that source for fine and coarse aggregates are not subject to deleterious expansion.
 - 2. Drying shrinkage Test:
 - a. Perform laboratory trial mixes of concrete used on project. Make two sets of three specimens for each shrinkage test.
 - b. Provide test for Concrete containing:
 - 1) 40 mm aggregate with or without the use of superplasticer.
 - 2) 20mm aggregate with or without the use of superplasticer.
 - c. Prism Specimen Size: 100 mm by 100 mm by approximately 280 mm with effective gauge length of 250 mm.

- d. Specimens: Fabricate, cure, dry and measure as specified in ASTM C157 and modified as follows:
 - 1) Remove specimens from molds aged 23 hours plus or minus 1 hour after trial batching.
 - 2) Place immediately in water at 22.8 degrees C plus or minus 2 degrees C for at least 30 minutes.
 - 3) Measure the specimen within 30 minutes thereafter to determine original length and then submerge in saturated limewater at 22.8 degrees C plus or minus 2 degrees C.
 - 4) Measure specimens at age 7 days to determine expansion expressed as percentage of original length. Length at age 7 days shall be base length for drying shrinkage calculations (0 days drying age).
 - 5) Store specimens immediately in humidity control room maintained at 22.8 degrees C plus or minus 2 degrees C and 50 percent plus or minus 4 percent relative humidity for remainder of test.
 - 6) Measure to determine shrinkage expressed as percentage of base length and report separately for 7, 14, 21, and 28 days of drying after the 7 days of moist curing.
 - 7) Computing Drying Shrinkage Deformation of Each Specimen:
 - a) Difference between base length (at 0 days-drying age) and length after drying at each test age.
 - b) Compute average drying shrinkage deformation to nearest 0.001 percent at each test age.
 - c) If drying shrinkage of any specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.

D. Quality Control Submittals:

1. Submit Concrete quality control plan for the project. Include the following:
 - a. Certification from a professional engineer who has designed the mix based on the requirements of the Contract Documents and that concrete mix will meet the performance requirements. Where the mix designer is not a professional engineer, then the signing officer of the ready mix plant shall sign the certification.
 - b. Identify the Company and contact names of subcontractors, material suppliers, and testing companies involved with concrete manufacture and placement.
 - c. Identify concrete requirements for each element of the project.
 - d. Identify all tests that will be used for material acceptance and indicate minimum specification requirements for each test.
 - e. Identify the frequency of testing for each test.
 - f. Identify the course of action to be taken if the testing program indicates that specification requirements have not been met.
 - g. Concrete quality control plan shall not take precedence over any other Contract documents.
2. Submit concrete delivery records.

E. Concrete Placing Schedule:

1. Submit concrete placing schedule.
2. Certificates:
3. Submit certificate of Ready Mixed Concrete Production Facilities.

4. Submit certification that aggregates will not, nor have the potential to, react with cement to result in deleterious expansion in the concrete.
5. Submit certification that deleterious substances in aggregate are within limits specified in CSA A23.1-09, Table 12 - Limits for Deleterious Substances and Physical Properties of Aggregates.
6. Submit certification that proposed performance mix will produce concrete meeting the requirements of Specifications.
7. Submit certification that proposed mix design strengths have been selected allowing for the supplier's standard deviations as indicated in CSA A23.1-09, Clause 4.4.6.6- Compressive Strength Requirements..
8. Submit certification that proportion of supplementary cementing material in combination of General Use (GU) hydraulic cement will provide the performance of the specified cement type.
9. Submit certification that bonding agent, if used, will meet the requirements of Specifications.
10. Submit certification that crack injection materials are suitable for continuous submersion and that they will not release toxic materials into the water.

1.6 QUALITY ASSURANCE

- A. Ready Mixed Concrete Producer: Certified member in good standing of the local Ready Mixed Concrete Association.
- B. Concrete Testing:
 1. Testing of concrete for materials, compression and water content of freshly mixed concrete will be done by agencies paid for by the City.
 2. Pay for additional testing required because of changes in material or the mix proportions, as well as any extra testing of concrete or materials occasioned by their failure to meet the specification requirements.
 3. The use of testing services does not relieve the Contractor of his responsibility to provide materials and construction in compliance with the Drawings and Specifications.
- C. Pre-placement Meeting:
 1. Hold a meeting at least four weeks prior to the initial placement of concrete to review the detailed requirements for preparing the concrete design mixes, finishes, and procedures for concrete placement for the structures.
 2. Arrange for the attendance at the meeting of the Contract Administrator, The City, and of concrete Subcontractors, Manufacturers, and suppliers including, but not limited, to the following:
 - a. Contractor's superintendent.
 - b. Laboratory responsible for field quality control.
 - c. Ready-mix concrete producer.
 - d. Admixture Manufacturer(s).
 - e. Concrete pumping and conveying equipment supplier.
 - f. Concrete formwork and finishing subcontractors.
 3. Notify the Contract Administrator at least 10 Business Days prior to the scheduled date of the meeting.
 4. The Contract Administrator will set an agenda for the meeting at least five Business Days prior to the scheduled date of the meeting.

5. Contractor to provide work plan detailing:
 - a. Production plant capacity
 - b. Control of traffic on Site
 - c. Equipment to be used and availability of stand by
 - d. Personnel resources
 - e. Quality assurance procedures
 - f. Safety on Site
 - g. Lighting

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Comply with Manufacturers' recommendations for delivery, storage, and handling.
- B. Store materials in a manner that will prevent deterioration or contamination. Deteriorated or contaminated materials will be rejected and must be removed from Site.

1.8 SITE CONDITIONS

- A. Cold Weather Requirements:
 1. The following requirements are in addition to CSA A23.1 -09, Clause 7.4.1.5 - Cold Weather Concreting.
 2. Provide temperature-controlled enclosures for areas where concrete is placed whenever ambient air temperature is 5 degrees C or lower.
 3. Protect concrete from the adverse effects of space-heated enclosures including local overheating and combustion products.
 4. Heat mix-water and, if necessary, aggregates when air temperature is at or below, or predicted to go below, 5 degrees C at any time during the next 24 hours.
 5. Maintain temperature of reinforcing bars and forms above 5 degrees C prior to placing concrete.
 6. Maintain temperature of concrete when deposited in forms not less than 15 degrees C and not higher than 25 degrees C.
 7. Maintain temperature of concrete at surfaces at least 10 degrees C for a minimum period of seven days after placing and achieving minimum 75 percent of specified strength. Concrete temperature may then be lowered to ambient air temperature at a rate of 1.2 degree C per hour or 10 degrees C per day.
 8. Keep concrete continuously moist during the curing period.
- B. High-temperature Control Requirements:
 1. The following requirements are in addition to CSA A23.1-09, Clause 7.4.1.4 - Hot Weather Concreting.
 2. Limit peak temperature during the curing period to 40 degrees C maximum. Placing temperature that will satisfy this requirement depends on ambient temperature, humidity at the time of placing, thickness of the concrete, and curing methods employed.
 3. Consider use of retarders, low- heat cement, slag replacement, ice in mixing water, pre-cooling of aggregates, cooling of concrete through continuous wet curing, and similar methods in order to prevent concrete temperatures from exceeding the above specified peak temperature at any time.

4. Monitor concrete temperatures for walls and slabs. After concrete temperature has peaked, control rate of cooling to ambient air temperature at a rate of 1/2 degree C per hour to prevent cracking.
 5. Notwithstanding requirements of subparagraphs .1 and .2 above, do not place concrete with temperature higher than 25 degrees C. Concrete with temperature in excess of 25 degrees C on arrival at the Site will be rejected. Remove rejected concrete from the Site.
- C. Protection:
1. Protect freshly placed concrete from damage due to construction operations and from cold, heat, rain, snow, running water, drying winds, and any other circumstances which would likely cause deterioration of concrete quality.
 2. Use waterproof insulated covers or other suitable materials to enclose freshly placed concrete under these conditions.
- D. Frost Protection for Slabs on Grade:
1. Provide continuous protection for slabs on grade to prevent subgrade below from freezing during cold weather. Provide heated enclosures and insulation as required.
 2. Sub-grade below completed tanks may be protected against frost by filling with water to a minimum depth of 2000 mm. Place log booms, 200 mm diameter, at maximum spacing of 5000 mm in each direction to abate ice pressures on tank walls. Break ice on formation.
- E. Influence of Ambient Concrete Temperature on Concrete Crack Control:
1. To minimize the formation of thermal cracks during placement and curing, maintain previously cured concrete and concrete that will be placed against it at the same temperature.
 2. Failure to minimize temperature differential between adjacent pours will result in temperature induced cracking. Repair such cracks as specified in this Section.
- F. Ground Vibration Limitations:
1. Do not place concrete if the vibration level exceeds the limits specified in Section 01 35 13, Special Project Procedures.
- G. Backfilling and Service Loads Restrictions:
1. Verify that backfill is not higher than the finished grades indicated.
 2. Verify that equipment for backfilling and compaction on top of slab will not impose loads greater than those indicated.
 3. Verify that concrete in walls, and slabs, struts, and cross walls, which frame into the walls providing lateral stability, has been placed and has attained specified compressive strength before backfilling against walls or subjecting walls to service loads.
 4. Verify that concrete in slabs, and support components have reached specified compressive strengths before backfilling or subjecting slabs to service loads.
 5. Verify that the leakage test is successfully completed before backfilling.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Portland Cements/ Blended Hydraulic Cements:
 - 1. CSA A23.1 Table 7 Types of blended hydraulic cement:
 - a. Type: MSb, HSb. as appropriate
 - 2. Supplementary Cementing materials shall be limited to ground granulated blast-furnace slag (S), fly ash (F) and silica fume (SF).
- B. Aggregates:
 - 1. Normal-density Concrete:
 - a. Coarse aggregate: CSA A23.1, with gradation in accordance with Table 11; rough and angular gravel or crushed stone.
 - b. Fine aggregate: CSA A23.1, with gradation in accordance with Table 10; natural sand.
- C. Admixtures:
 - 1. Compatible with each other and with other concrete materials.
 - 2. Calcium chloride, thio-cyanates, or admixtures containing more than 0.05% chloride ions are not permitted.
 - 3. Air-entraining admixture: ASTM C260; non-detergent type.
 - 4. Water-reducing admixtures: ASTM C494; Type A.
 - 5. Set-retarding admixture: ASTM C494; Type B.
 - 6. Superplasticizing admixture: ASTM C494; Type F 1 or G 2.
- D. Water: CSA A23.1; clear and free from oil, acid, alkali, organic matter, or other deleterious substances with a maximum soluble chloride ion content of 0.10 percent by weight.
- E. Bonding Agent: Suitable for conditions of service and performance requirements of this Section.

2.2 CONCRETE MIXES

- A. General:
 - 1. Establish proportions of cementing materials, aggregates, water, and admixtures required to produce consistent workable concrete that when placed properly is watertight and durable with strength and other properties specified. Comply with CSA A23.1-09 Clause 4.3.6 Volume Stability Considerations.
 - 2. Use same type and brand of cement/cementing material throughout.
 - 3. Comply with and allow for the supplier's Standard Deviation as specified in CSA A23.1-04 Clause 4.4.6.6- Compressive Strength Requirements. If the concrete supplier has no established Standard Deviations for concrete of the specified strengths, use a value of 4 MPa minimum.
 - 4. Use high-slump concrete by addition of superplasticizing admixture for walls and columns.

- B. Types of Normal-density Concrete:
1. Type A-Exposure Class S3: Concrete for structures, equipment bases, pipe supports, concrete encased duct banks, benching, and concrete wearing slab, containing reinforcing bars, unless specified otherwise.
 2. Type B-Exposure Class N: Fill concrete and mud mat unless specified otherwise.
 3. Type C-Exposure Class C-2: Concrete for sidewalks, curbs and gutters
 4. Type D: Concrete for bonded topping for precast members
 5. Type E: Concrete for bonded topping for clarifier
- C. Mixes for Normal-density Concrete:
1. Cementing Materials Content:
 - a. Provide cementing materials contents as required to meet performance.
 2. Coarse Aggregates:
 - a. Gradation in accordance with CSA A23.1, Table 11: Nominal size 40 mm to 5 mm, unless noted otherwise.
 - b. Gradation in accordance with CSA A23.1, Table 11 : Nominal size 20 mm to 5 mm, for walls and slabs less than or equal to 300 mm thick, beams, slabs with monolithic beams, columns, and Type B concrete.
 - c. Nominal size 10 mm to 2.5 mm, for bonded concrete topping and concrete in steel pans.
 3. Air Content:
 - a. Comply with CSA A23.1-09, Table 4 - Requirements for the Air Content Categories.
 - b. Provide air content category 2, unless noted otherwise.
 - c. Provide air content category 1 for loading bays, parking areas, and below grade and hydraulic structures, sidewalks curbs and gutters. If high volume supplementary cementing material (HVSCM) is used consult with the Contract Administrator on air content requirements for steel trowelled slabs.
 - d. Provide 3 percent maximum air content for concrete forming floors where floor hardener is used.
 4. Admixtures:
 - a. Use water-reducing admixture as necessary.
 - b. Use superplasticizing admixture with a retarder when required as per Clause 1.8.B.
- D. Mix for Bonded Concrete Topping:
1. Type E concrete Exposure Class S3
 2. Coarse aggregate: CSA A23.1; gravel or crushed stone with gradation in accordance with CSA A23.1, Table 11: nominal size 10 mm to 2.5 mm for topping thickness of 100 mm maximum.
 3. Fine aggregate: CSA A23.1; natural sand.
 4. Admixtures: Use superplasticizing admixture.
 5. Slump: After adding superplasticizing admixture 125 plus or minus 30 mm.
 6. Air Content:
 - a. Provide air content category 2, unless noted otherwise.
- E. Mix for Filling Openings and Box Outs:
1. Refer to Specification Section 03 60 00, Grouting.

- F. Mix for Wall and Column Grout:
 - 1. Mix same as for wall and column placements except no coarse aggregate
- G. Mix for Pumped Concrete:
 - 1. Comply with ACI 304.2R and this Specification.
 - 2. Uniform grading curves for fine and coarse aggregate.
 - 3. Superplasticizing admixture may be used for pumped concrete.
 - 4. Do not use admixtures which promote bleeding.
 - 5. Successfully used previously or for new mix carry out pumping test for successful placement.

2.3 SOURCE QUALITY CONTROL

- A. Testing by an independent laboratory in accordance with CSA A23.1 and A23.2, where test results less than one year are not available, to determine:
 - 1. Chemical composition and physical properties of aggregates.
 - 2. Presence and quantity of deleterious substances in aggregates.

PART 3 EXECUTION

3.1 PREPARATION

- A. General:
 - 1. Determine requirements of other trades, inform concerned trades, and assume responsibility for location, installation, and quality of items which affect the work of this Section.
- B. Preparation of Surfaces:
 - 1. Remove water, snow, ice, loose soil, laitance, curing compound, wood, and other debris from surfaces on or against which new concrete will be placed.
 - 2. Roughen and clean surfaces of previously placed concrete against which subsequent concrete will be placed.
- C. Bonded Concrete Topping:
 - 1. Prepare surface of substrate concrete for application of bonded concrete toppings in accordance with the requirements of CSA A23.1-09 Clause 7.6.4. 1 Preparation of Base Course Surface.

3.2 PLACING CONCRETE

- A. General:
 - 1. Do not commence concrete placing until sufficient manpower and equipment is available to complete the placement expeditiously preventing the formation of cold joints, and to produce specified surface finish.
 - 2. Provide standby equipment for critical items in case of equipment failure.
 - 3. Verify that cast-in-place accessories, inserts, and reinforcement are set correctly and are not disturbed during concrete placement.
 - 4. Place concrete on dry and clean substrate.

5. Place concrete between expansion or construction joints in one continuous operation.
 6. Submit field review quality control sheet as provided in Section 01 35 13, Special Project Procedures.
- B. Depositing:
1. Deposit concrete in a manner that prevents segregation in accordance with CSA A23.1-09 Clause 7.2.4 - Depositing.
- C. Time Limitations on Concrete Placement:
1. Do not use concrete after a period of two hours has passed since first mixing of ingredients.
 2. Do not use high-slump concrete after slump falls below 100 mm for non-flowing concrete and 125 mm for flowing concrete. Where permitted, re-temper in accordance with Manufacturer's printed instructions. Monitor, and correct if required, air content of concrete that has been re-tempered.
- D. Adverse Weather Conditions:
1. Make suitable arrangements to prevent damage to fresh concrete, under adverse weather conditions.
 2. Do not allow rain, sleet, or snow to increase mixing water or damage surface finish.
 3. Plan placement frequency such that lift lines will not be visible in exposed concrete finishes.
 4. Provide windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
 5. Do not place concrete when ambient temperature is below 5 degrees C or approaching 5 degrees C and falling, without special protection.
 6. Do not place concrete against frozen earth or ice, or against forms and reinforcement with frost or ice present.
 7. Provide heated enclosures when air temperatures are below 5 degrees C.
 8. Maintain surface temperature of concrete above 5 degrees C.
 9. External Heating Units:
 - a. Vent heating units to atmosphere and do not locally heat or dry concrete. Where water cure is specified, maintain wet condition.
 - b. Do not exhaust heater flue gases, directly into enclosed area
 10. Temperature Monitoring:
 - a. Provide thermocouple wires in concrete for temperature monitoring.
- E. Wall and Column Grout:
1. Deposit 75 mm of wall and column grout evenly along horizontal construction joints in bottom of form through an elephant trunk immediately before placing wall or column concrete.
- F. Time Interval Between Concrete Placements:
1. Construction Joints: 7 days wet cure continuously.
 2. Expansion Joints/Contraction Joints: 1 day.
 3. Wait at least 2 hours after depositing concrete in long columns and walls thicker than 200 mm before depositing concrete in beams, girders, or slabs supported thereon.
 4. For columns and walls 3 m in height or less, wait at least 45 minutes prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon

G. Consolidation:

1. Consolidate the concrete during and immediately after depositing, thoroughly and uniformly by means of tamping, hand tools, finishing machines, and vibrators in order to obtain dense, watertight, homogeneous concrete well bonded to reinforcing bars.
2. Carefully vibrate concrete around waterstops, to make sure thorough contact.
3. Bend edge of horizontal waterstops slightly upward allowing concrete to flow under and completely fill space below the waterstop. Verify no air is trapped below waterstop and concrete is in contact with waterstop over its entire surface area.
4. Provide sufficient windows in forms or to allow for concrete placement through windows and for visual observation of concrete.
5. Vibration consolidation not to exceed distance of 1 m from point of placement.
6. Do not allow concrete to form cold joints.

H. Bonded Concrete Toppings:

1. Place bonded concrete topping complete with embedded items as indicated on the Drawings within specified tolerances.
2. Comply with the requirements of CSA A23.1-09 Clause 7.6.4.2 Bonding Systems, except that the responsibility of inspecting the substrate concrete surface and selecting a bonding procedure rests with the Contractor.
3. Do not place concrete topping in inclement weather.
4. Verify tensile bond strength of topping with the substrate concrete by testing.
5. Where bonded concrete topping is required after equipment installation, such as for clarifiers, coordinate finishing method and use of equipment for finishing with equipment Manufacturer.

I. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change due to shrinkage
2. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
3. Should placement sequence result in cold joint located below finished water surface, install water stop in joint.

3.3 REPAIR OF TEMPERATURE AND SHRINKAGE INDUCED CRACKS

- A. Repair cracks in the completed structures employing a polyurethane injection technique to make such cracks completely watertight after repair.
- B. Remove surface injection materials following completion of work and finish affected areas to match surrounding concrete.
- C. For dry areas, propose repairs to meet the specifications.
- D. Pay for such remedial work at no expense to the City.

3.4 REPAIR OF JOINTS

- A. Repair joints in the completed structures employing a polyurethane injection technique to make such joints completely watertight after repair.

- B. Remove surface injection materials following completion of work and finish affected areas to match surrounding concrete.
- C. Pay for such remedial work at no expense to the City.

3.5 REPAIR OF BONDED CONCRETE TOPPING

- A. If topping is poorly bonded or delaminated, remove and replace the topping over the affected area.
- B. Pay for such remedial work at no expense to the City.

3.6 CONCRETE BONDING

- A. Horizontal Construction Joints in Reinforced Concrete Walls:
 - 1. Thoroughly clean and saturate surface of joint with water.
 - 2. Limit wall and column grout placement to maximum 75 mm and minimum 30 mm thickness.
 - 3. Do not deposit grout from pump hoses or large concrete buckets, unless specified placement thickness can be maintained and verified through inspection windows close to joint.
 - 4. Limit concrete placed immediately on top of grout to 300 mm thick. Thoroughly vibrate to mix concrete and grout together.
- B. To Existing Concrete:
 - 1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 6 mm.
 - 2. Saturate surface with water for 24 hours prior to placing new concrete.

3.7 FIELD QUALITY CONTROL

- A. General:
 - 1. Tests will be made throughout progress of the Work and will be paid for by the City to determine concrete quality. Tests will be in accordance with CSA A23.1 and A23.2. Provide labour, concrete, and other facilities for making the test specimens.
 - 2. Provide and maintain facilities for storing and initial curing of test cylinders, and provide suitable crates for shipping test cylinders in accordance with CSA A23.2-09 Test Method A23.2-3C - Making and Curing Concrete Compression and Flexural Test Specimens. Provide microwave oven and facility of carrying out test in field.
 - 3. The testing laboratory shall provide the test results to the City, Contract Administrator, Contractor and material supplier within 5 days of availability. For test that fails to meet the Specification inform Contract Administrator, Contractor and material supplier within 48 hours of the test.
 - 4. Testing company in coordination with the Contractor shall consider using on line secured website such as CMATS to record, view and distribute concrete test data. Data shall be entered in standard format as designed by the software. Protocol for distribution and filing of test results shall be agreed upon at the pre-placement meeting.

B. Standard Strength Tests:

1. Provide concrete for one standard strength test consisting of 4 cylinders for each 100 m³ of concrete of each type placed in any day. If the amount placed, for each type of concrete is less than 100 m³ in a day, provide concrete for one standard strength test of 4 cylinders . One cylinder will be tested at 7 days and one at 28 days and two cylinders at 56 days.

C. Concrete Temperature Monitoring:

1. Monitor temperature of concrete starting immediately after placement until the end of 7 days curing period.
2. Record ambient temperature during concrete monitoring period also.
3. Install thermocouple wire sensors in sufficient numbers, into each concrete pour in excess of 20 cubic metres poured in one day, to truly represent the concrete temperatures of the pour.
4. Connect thermocouple wires to central temperature logger that records the temperatures at regular interval of one half hour.
5. Provide records of temperatures daily of previous 24 hours.
6. For each pour, at the end of the curing period, provide temperature graphs of the concrete and the ambient temperature.
7. Consider the use of temperature monitoring system such as Hobo U12 Outdoor Thermocouple Temperature Logger with software and thermocouple wire sensors supplied by Onset Computer Company.

D. Air Content Tests:

1. Testing agency will carry out air content tests in accordance with CSA A23.1 and A23.2.

E. Slump Tests:

1. Testing agency will carry out slump tests in accordance with CSA A23.1 and A23.2.

F. Failure to Meet Strength, Air Content, or Slump Requirements:

1. When measured slump or air content falls outside of required limits, carry out a check test immediately on another portion of the same sample. In the event of a second failure, the concrete will be considered to have failed to meet the requirements. Remove the whole batch, from which the samples were taken, off the Site.
2. When the strength requirement provisions are not met, carry out one or more of the alternatives:
 - a. Change the mix proportions
 - b. Carry out nondestructive testing
 - c. Provide additional curing on portions of the structure represented by the test specimen.
 - d. Core drill portion of the structure in question and test cored cylinder in accordance with CSA 23.2-09 Test method A23.2-14C Obtaining and testing drilled cores for compressive strength.
 - e. Load test structure to design loading
 - f. Other test the City may require for acceptance.
3. When, after carrying out these requirements, there is still doubt about of the adequacy of the concrete, strengthen or replace, as directed, portions of the Work which failed to develop the required strength.

G. Uniformity of Mixed Concrete

1. If the results of slump, slump flow, air content or density for any mix design do not comply with CSA A23.1-09, Table 13 - Determination of Within-Batch Uniformity, alter mixing operations and equipment until tests indicate that the requirements are satisfied.

H. Bonded Concrete Topping:

1. Bonded concrete topping finishes will be inspected 60 days after completion to verify that a continuous bond between the substrate concrete and the topping has been achieved. The topping will be chain dragged or tapped with a blunt metal object. Detection of a hollow sound will be considered as inadequate bonding.
2. Core each hollow sounding area as requested by the Contract Administrator, to determine bonding adequacy. Pay for coring which may be necessary.
3. Resolve disputes regarding tensile bond strength between substrate concrete and topping, including extent of affected areas by conducting tests.
4. Determine bond strength in accordance with procedure outlined in CSA A23.2-09, CSA A23.2-09 -6B-Determination of bond strength of bonded toppings and overlays and direct tensile strength of concrete mortar and grout.
5. Only tests meeting the strength requirements will be paid by the City. Pay for cost of unsuccessful tests.

I. Concrete Delivery Records:

1. Submit with each batch of concrete before unloading, a typed delivery ticket prepared at the ready mix plant containing following information:
 - a. Name of ready-mix batch plant.
 - b. Date and serial number of ticket, truck plate number
 - c. Name of Contractor.
 - d. Project Name.
 - e. Specific class of concrete with identifying mix number.
 - f. Amount of concrete in cubic metres
 - g. Time loaded or of first mixing of cement and aggregates.
 - h. Amount of admixtures, or water added on Site.
2. Keep records of the time when each load arrives at the Site and when discharge is completed. Record the temperature of fresh concrete.

END OF SECTION

SECTION 03 39 00

CONCRETE CURING AND FINISHES

PART 1 GENERAL

1.1 SUMMARY

- A. Requirements for the 66 kV Substation, refer to Section 03 35 00, Concrete Finishing.
- B. Comply with Division 1, General Requirements.
- C. This Section forms part of Section 03 30 00, Cast-in-Place Concrete.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. Canadian Standards Association: CSA A23.1-09 Concrete Materials and Methods of Concrete Construction.
 - 2. American Concrete Institute: ACI 309.2R Identification and Control of Visible Effects of Consolidation on Formed Concrete Surfaces
 - 3. American Society for Testing and Materials International (ASTM):
 - a. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
 - b. C1315, Standard Specification for Liquid Membrane-Forming Compounds having Special Properties for Curing and Sealing Concrete.
 - 4. American Society of Concrete Contractors: Guide for Surface Finish of Formed Concrete.

1.3 DEFINITIONS

- A. Aggregate transparency: Mottled surface appearance resulting from deficiencies in the mortar.
- B. Air surface voids: Also termed as air pockets or bug holes. Small regular or irregular cavities resulting from entrapped air bubbles in the surface of formed concrete. Air surface voids less than 12 mm in diameter or depth may be acceptable unless specified otherwise.
- C. Fin /form streaking: A narrow linear projection on foamed concrete surface resulting from mortar flow into spaces in the formwork.
- D. Finish: The texture of a surface after consolidating and finishing operation has been performed.
- E. Form offsets: An abrupt change in alignment, either horizontally or vertically.
- F. Honeycomb: Condition of irregular voids due to failure of the mortar to effectively fill the space between coarse aggregate particles generally in formed concrete.

- G. Laitance: A thin weak brittle layer of cement and aggregate fines on concrete surface.
- H. Layer lines: Dark lines on formed surfaces indicating boundary between concrete placements. Cold joints are one form of layer lines.
- I. Soundness: A quantitative measure of suitability of concrete to perform as a solid substrate or base for a coating or patching material. Sound concrete substrates usually exhibit strength and cohesiveness without excessive voids or cracks.
- J. Subsidence cracking: Tension cracking when concrete settles after initial set.
- K. Surface defects: Includes air surface voids, form streaking, sand streaking, aggregate transparency, colour variation, layer lines, cold joints, soft areas, offsets and bulges. Air surface voids or bug holes smaller than 12 mm are not considered as defects as long as they are generally spaced out.
- L. Porosity: Small voids that allow fluids to penetrate an otherwise impervious material.

1.4 SUBMITTALS

- A. Quality Control Submittals:
 - 1. Manufacturer's Representative and application personnel. Names and phone number.
 - 2. Manufacturer's certificate of compliance for products furnished.
 - 3. Statement of Qualifications.
 - 4. Manufacturer's product service record.
 - 5. Manufacturer's printed procedures for preparation, product application, protection of finished surface, and post-application cleanup.
 - 6. Manufacturer's Site specific installation instructions.
 - 7. Manufacturer's certificate of proper installation.
- B. Product Data Sheets
 - 1. Submit three copies of Manufacturer's product data sheets including installation, application, and maintenance instructions for:
 - a. Curing compound
 - b. Floor Surface sealer
 - c. Non metallic shake on floor hardener
 - 2. Evaporation retardant.
- C. Shop Drawings
 - 1. Submit Shop Drawings indicating finishes for floors and walls.
 - 2. Curing methods proposed.

1.5 QUALITY ASSURANCE

- A. Concrete finishers: Skilled personnel with a minimum of five years proven satisfactory experience finishing concrete of comparable size and scope.

- B. Engage Manufacturers' Representative for on Site supervision prior to, during, and after applications. Verify that specified products are correctly applied; amount and finishing procedures comply with Manufacturer's printed instructions for project.
- C. Pre-installation Training: Manufacturer-approved training of application personnel and quality control inspectors for finishes.
- D. Conference Prior to Slab Placement:
 - 1. Conducted by Contractor.
 - 2. Agenda:
 - a. Concrete mix design.
 - b. Placing techniques.
 - c. Finishing techniques.
 - d. Product application procedures.
 - e. Equipment required for the procedures.
 - 3. Attendees:
 - a. Contractor's superintendent.
 - b. Subcontractor's representative involved in concrete placement and finishing.
 - c. Resident Inspector from Contract Administrator's Office.
 - 4. Note pre-concrete conference is also conducted under Section 03 30 00, Cast-in-Place Concrete.
- E. Mockups: Install one 1800 mm by 1800 mm area for each type of floor and wall finish to demonstrate that the material and methods produce a finished product acceptable to the Contract Administrator. Do not commence concrete work until mockups have been accepted by the Contract Administrator.
 - 1. Mockup will establish the standard of quality for finishes.
 - 2. Use specified materials at a location designated by Contract Administrator.
 - 3. Notify Contract Administrator 5 days in advance of commencement of mockup.
 - 4. Make mockups for following finishes:
 - a. Slab
 - 1) Steel Trowel Finish Type S1
 - 2) Wood Float Finish Type S2
 - 3) Nonslip Finish Type S3
 - 4) Dry shake Floor Hardener Finish Type S3B
 - 5) Bonded Concrete topping Type S6
 - b. Wall
 - 1) Smooth Wall finishing for Painting Type W2A
 - 2) Smooth Wall finishing for Waterproofing Type W2B
 - 3) Controlled Permeability Form Liner Type W3A
 - 4) Smooth Rubbed Finish Wall W4
 - 5) Sack Rubbed Finish Type W5

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prevent deterioration or contamination of stored materials. Deteriorated or contaminated materials will be rejected and must be removed from Site.

1.7 SITE CONDITIONS

- A. Comply with special requirements of Section 03 30 00, Cast-in-Place Concrete. for work under cold weather and high temperature conditions.
- B. During curing, ensure the temperature is kept uniform over the whole surface and across the cross section of the concrete. A temperature gradient across the member may cause cracking. Protect the concrete surface from rapid drying due to high concrete and or ambient temperatures, low humidity, high winds, or heated interiors.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Curing Compound:
 - 1. ASTM C309 1.
- B. Combination Curing and Sealing Compound:
 - 1. Conforming to ASTM C1315, Clear, non yellowing compound.
 - 2. Manufacturer and product:
 - a. Sika Canada Inc., Florseal WB 25.
 - b. BASF: MasterkureCC 1315WB.
 - c. Euclid Admixture Canada, Inc., Super Diamond Clear.
 - d. Dayton Superior Canada Limited; Day Chem Cure & Seal: 1315 (J 22).
- C. Floor Surface Sealer:
 - 1. Clear, liquid surface sealer and dust-proofer.
 - 2. Manufacturer and product
 - a. Sika Canada Inc., Sikafloor 3S.
 - b. Dayton Superior Canada Limited, Sure Hard Densifier J 17.
- D. Evaporation Retardant:
 - 1. Fluorescent color tint that disappears completely upon drying.
 - 2. Manufacturers and Products:
 - a. BASF; MasterKure ER 50.
 - b. Euclid Chemical Co.; Eucobar.
- E. Shake on Floor Hardener:
 - 1. Premixed blend of mineral aggregates, emery particles, wetting and densifying agents, and Portland cement, shake on type;
 - 2. Manufacturer and Product
 - a. Sika Canada Inc.; Sika Emericrete SH,
 - b. Euclid Admixture Canada, Inc.; Surfex
 - c. BASF; MasterTop 110ABR
 - d. Dayton Superior Canada Limited; Quartz Tuff
- F. Polyethylene sheet: CGSB 51 GP 51M; 0.15 mm thick.

- G. Wet curing materials: Non-staining waterproof curing paper, burlap, or canvas coverings.
- H. Bonding agent: Suitable for conditions of service and performance requirements of this Section.

PART 3 EXECUTION

3.1 PREPARATION

- A. Review the requirements for applied finishes.

3.2 TOLERANCES

- A. General
 - 1. Comply with CSA A23.1- 09, Clause 7.5.1 – Surface Tolerances for slabs and floor.
- B. Straightedge Method:
 - 1. Very Flat: Finish tolerance 3 mm in 3000 mm. Surface of base slab applied bonded concrete toppings in clarifiers.
 - 2. Flat: Finish tolerance 5 mm in 3000 mm. Surfaces to receive a vinyl tile, epoxy floor finish or other thin applied floor finish; surfaces to receive ceramic tile or quarry tile on thin set bond coat; surfaces of concrete toppings; and exposed surfaces of concrete floors.
 - 3. Moderately Flat: Finish tolerance 8 mm in 3000 mm. Surfaces to be covered with cladding or to receive insulation, built up roofing, or membrane waterproofing; top of roof slabs of structures, tanks, tunnels, conduits, and similar areas to be covered with backfill.
 - 4. Conventional: Finish tolerance 12 mm in 3000 mm. Surfaces where a bonded concrete topping will be applied.

3.3 CONCRETE FINISHING

- A. General:
 - 1. Concrete finishing effort is directly dependent on forming, concrete placing, and curing techniques. Perform finishing procedures until specified finishes are achieved.
 - 2. Complete concrete finishing in areas where mechanical and electrical equipment will be installed prior to commencement of such installation.
 - 3. Where floor slopes and drains are indicated on the Drawings, the floor must be constructed so that water flows to the drain(s) without ponding.
- B. Slab or Floor Surfaces:
 - 1. General:
 - a. Carry out finishing operations in accordance with CSA A23.1 09, Clause 7.5.3 – Initial Finishing of Horizontal Surfaces.
 - b. Initial finishing operations consist of placing, spreading, consolidation vibrating, and screeding, immediately followed by bull floating, or darbying.
 - c. Complete leveling and consolidation before free moisture or bleeding of free water rises to top surface.

- d. Provide at least one standby power trowel. Provide sufficient finishers and equipment for the work.
 - e. Take precautions necessary to protect the finish against inclement weather.
 - f. Commence final finishing operations by finishing the edges and grooving as required followed by floating and trowelling, when concrete has stiffened sufficiently to prevent the working of excess mortar to the surface and is able to sustain foot pressure, and after removing free bleed water.
 - g. Straighten with straightedge as often as necessary to achieve specified floor tolerances.
2. Steel Trowel Finish (Type S-1):
 - a. Trowel surface with steel hand or power trowel in accordance with CSA A23.1-09, Clause 7.5.4.3. Trowelling, keeping blade flat at first and raising blade angle a little more on subsequent passes. Leave surface smooth, dense, of fine uniform texture without a swirl and free of blemishes.
 - b. Do not use dry cement or additional water during trowelling. Do not over finish.
 - c. Do not use power machine when concrete has not attained necessary set to allow finishing. Do not introduce high and low spots in slab during trowelling.
 3. Wood Float Finish (Type S-2):
 - a. Bring surface to required finish plane.
 - b. Wood float concrete surface in accordance with CSA A23.1-09, Clause 7.5.4.2 Floating.
 - c. Remove laitance and leave surface clean.
 4. Nonslip Finish (Type S-3):
 - a. Provide nonslip surface finish by swirl-trowelling the surface in accordance with CSA A23.1-09, Clause 7.5.6.1 – Nonslip Surfaces.
 5. Broom Finish (Type S-4):
 - a. Provide nonslip surface finish by brooming the surface in accordance with CSA A23.1-09, Clause 7.5.6.1 - Nonslip Surfaces with application of steel or fibre brooms at least 450 mm wide.
 - b. Pull broom gently over the surface from side to side at right angles to direction of traffic, with adjacent strokes slightly overlapping.
 - c. Produce a broom finish surface free from porous spots, irregularities, depressions, or rough spots with uniform corrugations less than 3 mm.
 6. Scratch Finish Type (S-5):
 - a. Provide scratch finish. Produce closely spaced grooves approximately 5 mm in accordance with CSA A23.1-09, Clause 7.5.6.2 - Scratch Finish.
 7. Bonded Concrete Topping (Type S-6):
 - a. Wood float and screed with straightedge float, and finish producing a smooth even surface.
 - b. In the clarifiers install bonded concrete topping in accordance with the scraper mechanism supplier's requirements.
 - c. Wood float and screed with straightedge connected to the clarifier rake arm.
 - d. Produce a smooth even surface throughout
 8. Dry shake on powder application (Type S-7):
 - a. After initial finishing of horizontal surface as stated above wait for concrete to set to a point that leaves an indentation of 6 to 10 mm when walked upon.
 - b. Concrete should be bleed free and can support the weight of the power trowel
 - c. Float open the surface.

- d. Apply portion of dry shake powder evenly over the area as specified for the application by hand or mechanical spreader.
 - e. Power float the surface as soon as the dry shake material absorbs the moisture from the base slab.
 - f. As soon as concrete is hardened sufficiently power trowel to specified Type S-1 finish/Type S-3 finish./
 - g. Application Rate:
 - 1) For capillary waterproofing Type S-7A:
 - a) Shake apply capillary waterproofing powder at the rate of 1.3 kg/m² on concrete slabs.
 - b) Float into surface until uniformity in coverage is obtained.
 - c) Comply with Manufacturer's printed instructions for installation and curing.
 - 2) Floor hardener Type S-7B:
 - a) Shake apply floor hardener at a minimum rate of 7.5 kg/m². Apply the shake mix in two separate applications using approximately two thirds of the total amount specified for the first application and the balance for the second.
 - b) Apply hardener evenly over the floor surface in one direction.
 - c) Machine float just enough to bring moisture completely through the shake and to embed and compact the shake into the base concrete.
 - d) Immediately following the floating of the first shake apply the balance of the hardener. Spread shake evenly and in direction perpendicular to the first shake. Float as specified for the first shake.
 - e) Comply with Manufacturer's printed instructions for installation and curing.
 - 9. Type S-8 Formed underside of slab
 - a. See under formed surfaces.
 - 10. Floor Surface Sealer:
 - a. Treat surfaces subject to traffic in the finished structure, such as slabs, stairs, landings, walkways, and similar locations, with a surface sealer except if the surfaces have been cured with dual purpose curing and sealing compound.
 - b. Apply sealer in accordance with the Manufacturer's printed instructions.
 - c. Do not use surface sealer where bonded finishes or waterproofing is scheduled.
- C. Formed Surfaces:
- 1. General Finishing:
 - a. Finish in accordance with CSA A23.1-09, Clause 7.7 Finishing of formed surfaces unless noted otherwise.
 - 1) Remove face formwork as soon as practical to facilitate repair of surface defects. Remove nails and remnant of form and form oils. Repair surface defects.
 - 2) Avoid damaging corners and keep edges sharp.
 - b. Formwork Tie Holes:
 - 1) Cut formwork ties 25 mm from surface of concrete.
 - 2) Make edges of depressions sharp.
 - 3) Fill depressions with pre-blended non shrink non ferrous grout of same colour as the concrete.

- c. Irregularities:
 - 1) Grind smooth fins, projections, irregularities, and offsets, including those at construction joints.
 - 2) Where irregularities and offsets cannot be remedied by grinding, chip concrete surface sufficiently deep and apply thoroughly bonded pre-blended non shrink non ferrous grout in similar procedure for repair of honeycomb and defective concrete.
- d. Surface Depressions:
 - 1) Fill surface voids size greater than 12 mm and other surface depressions with a sand cement mortar to match the surface of surrounding concrete.
- e. Spalled Corners:
 - 1) Use repair materials of similar appearance and strength as the surrounding concrete to reconstruct corner to match adjacent corners.
- f. Honeycomb, Soft Areas, and Defective Concrete:
 - 1) Do not repair honeycomb, soft areas, and defective concrete until reviewed by Contract Administrator and permission granted to proceed with the repair work.
 - 2) Remove honeycomb, soft areas,, and defective concrete down to sound concrete with edges slightly undercut or perpendicular to the surface. Remove a minimum depth of 25 mm. No feather edges are permitted.
 - 3) Pre-dampen patch area.
 - 4) Use pre blended non shrink non ferrous grout of same colour as the concrete for exposed concrete surfaces.
 - 5) Use bonding agents in patching work.
 - 6) Patch surface slightly higher than the surrounding concrete.
 - 7) Wet cure patches to equivalent of 10 days minimum.
 - 8) When patched surface has hardened, rub surface with carborundum brick to a true surface, free from streaks, discolourations, and other imperfections, to match flush with surrounding concrete.
- g. Subsidence cracking:
 - 1) Depending on the depth, locations and function of the structure the repair system may require injection grouting and repairs similar to the defective concrete.
- 2. Type W -1 (Ordinary Wall Finish)
 - a. Carry out general finishing as specified above.
- 3. Type W -2 (Smooth Wall Finish)
 - a. Carry out general finishing as specified above.
 - b. Fill air surface voids greater than 3 mm.
 - c. Fill nail head depression more than 2mm deep.
 - d. Provide wall finish similar to Photo 1 P1 Finish as presented in Guide for Surface Finish of Formed Concrete.
- 4. Type W -2 A (Smooth Wall Finish for Painting).
 - a. Prepare surfaces to Type W-2 finishing standard.
 - b. Coordinate finish with the requirement for painting specification
- 5. Type W -2 B (Smooth Wall Finish for Application of Waterproofing)
 - a. Prepare surfaces to Type W-2 finishing standard.
 - b. Coordinate finish with the requirement for water proofing specification

6. Type W -3 (Form Liner Finishes)
 - a. Type W-3A (Controlled Permeability Form Liner):
 - 1) Coordinate installation and stripping of Form Liner, in accordance with manufactures recommendation and as specified in Section 03 10 00, Concrete Forming and Accessories.
 - 2) Strip forms as soon as possible to ensure the textured surface finish is not damaged
 - 3) Carry out general finishing as specified above.
7. Type W-4 (Smooth Rubbed Finish):
 - a. Provide smooth rubbed finish of uniform appearance as specified in CSA A23.1-09, Clause 7.7.4.3 Smooth Rubbed Finish.
 - b. Do not commence rubbing or grinding until surface defects are repaired and patching materials are hardened.
 - c. Dress surfaces by rubbing or grinding with bricks of carborundum, emery, or other abrasive material to a smooth and even surface to the best grade of architectural concrete work. Wet and rub surfaces until surfaces are even and of uniform smooth appearance. Prevent rounding edges, obliterating the bevel lines on edges and corners, and chipping or cracking the finished edges.
 - d. Water cure walls to receive smooth rubbed finish.
 - e. If the rubbed finish work cannot start in timely manner then the specified surfaces shall receive Sack- rubbed Finish.
8. Type W-5 (Sack rubbed Finish):
 - a. Repair form offsets, sand streaking and layered lines.
 - b. Complete Type W2 finishing as specified.
 - c. Fill all air surface voids.
 - d. Sack rub cement finish to form a smooth finish of uniform appearance as specified in CSA A23.1-09, Clause 7.7.4.4 - Sack Rubbed Finish.
 - e. Clean sand for finishing mortar shall pass 630 micron sieve size.
 - f. Completed finished surface shall be uniform in appearance free of blemishes, discolorations or surface voids or dimples. Surfaces not meeting the requirements shall be corrected to the satisfaction of the Contract Administrator.
 - g. Apply a second coat of sack rubbed cement finish to produce a smooth uniform appearance if required to obtain acceptance.
 - h. On completion thoroughly wash the surfaces with clean water
9. Type W-6 (Abrasive blast Finish):
 - a. Intent of this procedure is to remove surface skin to depth no more than 1.5 mm, and expose only fine aggregate and air holes near surface, thus producing uniform texture.
 - b. Perform abrasive blasting on building or on concrete surfaces in same area of view at same time and obtain uniformity of appearance.
 - c. Same person must accomplish abrasive blasting on one structure and on concrete in same area.
 - d. Perform abrasive blasting to match approved mockup panel.
 - e. Abrasive: Use clean silica sand, free of foreign materials, and supplied in sealed sacks.
 - f. Provide samples with different degree of effort for approval of the Contract Administrator.

10. Columns, Beams and Curbs, sides of equipment and pipe saddle supports:
 - a. Provide Type W-2 or W-4/5 finish.
11. Type S- 8 (Formed Underside of Slab Finish):
 - a. When forming is removed, grind off projections on underside of slab and patch defective areas, including small shallow air pockets.
12. Related Unformed Surfaces:
 - a. Screed and float tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring in units cast in forms to a texture consistent with that specified for the formed surface unless some different finish is specified elsewhere.

3.4 CURING CONCRETE

- A. Begin curing immediately following placing and finishing in accordance with CSA A23.1-09 clause 7.4.2 except as noted below.
- B. Rate of evaporation is depend on relative humidity, concrete temperature and winds velocity; for rate of evaporation of moisture from concrete surface covered with water see CSA A23.1 appendix D Guidelines for curing and protection.
- C. Wet cure for 10 consecutive days at a minimum temperature of 10 degrees C. This requirement supersede CSA23.1 -09 Table 20 Allowable curing regimes.
- D. Control initial drying shrinkage and plastic shrinkage for slabs. Provide wind breaks and or shades as required. Provide continuous fog mist when drying shrinkage is likely due to heat or wind. Cover the concrete surface with wet burlap when finishing is complete to start continuous wet curing.
- E. Establish the requirements of specified finishes for concrete surfaces before applying curing compound. Verify that curing compound is compatible with applied finishes.
- F. Do not use curing compounds on surfaces:
 1. Where concrete or bonded concrete topping will be applied.
 2. Where high temperature control requirements are in force.
- G. Formed Surfaces (Walls and Columns)
 1. Wet cure as specified by pouring water between the formwork and concrete surface where possible.
 2. As an alternative, cure as specified above until formwork is removed. Immediately after removal of formwork, provide 24 hours saturation followed by application of curing compound in accordance with Manufacturer's printed instructions.
- H. Unformed Surfaces (Slabs)
 1. Cover with absorbent material kept continuously saturated as soon as cement will not wash out or finish be damaged.
 2. As an alternative, wet cure for 24 hours then seal with two complete coats of curing compound applied in accordance with the Manufacturer's instructions. Maintain coating during the curing period.

- I. Bonded Concrete Toppings
 - 1. Wet cure for 10 consecutive days if no bonding agent has been used.
 - 2. If a bonding agent has been used, employ curing methods for the concrete topping which will produce a cure equivalent to 10 days wet curing and which is in accordance with the bonding agent Manufacturer's printed instructions.
 - 3. Protect and prevent damage to concrete topping floor finishes. Repair damaged sections.
 - 4. Protect topping from freezing for a minimum of 14 days after placing.

3.5 PROTECTION

- A. Keep traffic, which would affect or disturb the curing procedures, off the finished surfaces for a period of seven days.
- B. Protect exposed concrete finishes against damage until acceptance of the work by the City. Do not allow rain, sleet, or snow to increase mixing water or damage surface finish.
- C. Protect floors which are to receive architectural finishes against contamination by oil, paint, or other deleterious materials which may affect finish.
- D. Protect items set into floors from damage. Verify that alignment is not disturbed.

3.6 TESTS AND INSPECTION

- A. Vapor Transmission Test: Conduct test on new and existing concrete to show that no surface moisture exists prior to application of specified special floor treatment, as follows:
 - 1. Place polyethylene plastic sheet, minimum 1.2 m by 1.2 m and sealed along four sides with duct tape to prevent moisture transmission by evaporation, over concrete floor area for 24 hours.
 - 2. Indication of moisture transmission will be apparent by accumulation of moisture on enclosed surface of polyethylene sheet.
 - 3. Do not apply concrete bonding agent until test results indicate moisture is not being transmitted from concrete surface.

3.7 MANUFACTURER'S SERVICES

- A. Provide services of Manufacturer's Representative at Site in accordance with in Section 01 43 33, Contractor Field Services, for installation assistance, inspection and certification of proper installation, and training of application personnel.
 - 1. Technical assistance with design and adjustment of concrete mixes to receive floor finishes and toppings.
 - 2. Technical assistance to assure and certify application and installation of system being used.
 - 3. Consultation, direction, and certification of mockup, for full-scale application of floor finishes, and at other times as needed.
 - 4. Attendance at the conference prior to slab placement to finalize proper methods and procedures.

3.8 FIELD QUALITY CONTROL

- A. Measure floor flatness and levelness. Report deficiency. Propose method to remediate. Repair as required.
- B. Flood the sloped floor surface with water to a depth necessary and allow the water to flow into drain(s). Observe all areas of ponding. Repair all depressed area exceeding the following:
 - 1. For dry areas ponding depth greater than 3 mm.
 - 2. For tank floors ponding depth greater than 20 mm.

3.9 SCHEDULE OF CONCRETE FINISHES

- A. Provide concrete finishes as scheduled:

Area	Type of Finish	Notes
EXTERIOR SLABS		
Roof slab/exposed	S-3	
Roof slab/covered with roofing and waterproofing material	S-1	
Water-holding tanks and basins/top of wall	S-1	
Other water-holding tanks and basins	S-1	
Stairs and landings	S-3	
Sidewalks	S-4	
Other exterior slabs	S-2	
Approach slab	S-2	
INTERIOR SLABS		
Buildings, pipe galleries, and other dry areas	S-1	
Hydraulic channels	S-1	
Underside of elevated slabs	S-8	
Equipment bases	S-1	
Surface to receive bonded topping	S-5	
Bonded topping	S-1	
Loading docks	S-7B	
Where shake on hardener is applied	S-7B	
EXTERIOR WALL SURFACES		
Above grade/exposed (above a point 150 mm below finish grade)	W-2	

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

Area	Type of Finish	Notes
Above grade/covered with brick veneer or other finish material	W-1	
Backfilled (below a point 150 mm below finish grade)	W-3A	
INTERIOR WALL SURFACES		
Pipe supports, and equipment bases in dry areas	W-2	
Water-holding tanks, channels, troughs and basins	W-3A	
Buildings, pipe galleries, and other dry areas	W-5	

END OF SECTION

SECTION 07 84 00

FIRESTOPPING

PART 1 GENERAL

1.1 SUMMARY

- A. Comply with Division 1, General Requirements.

1.2 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
1. ASTM E814 Standard Test Method for Fire Tests of Penetration Firestop Systems.
 2. CAN/ULC S101 Standard Methods of Fire Endurance Tests of Building Construction and Materials.
 3. CAN/CGSB 19.13 Sealing Compound, One-Component, Elastomeric, Chemical Curing.
 4. CAN/ULC S102 Method of Test for Surface Burning Characteristics of Flooring, Floor Coverings, and Miscellaneous Materials and Assemblies.
 5. CAN/ULC S115 Standard Method of Fire Tests of Firestop Systems.
 6. Underwriters Laboratories of Canada (ULC) Firestop Systems and Components
 7. ULC Guide No. 40U19 Firestop Systems.
 8. ULC Guide No. 40U18 Fire Resistance Ratings.

1.3 SYSTEM DESCRIPTION

- A. Performance Requirements: Provide firestop systems with materials that have been manufactured and installed to maintain performance criteria stated by manufacturer without defects, damage, or failure.
- B. Provide fire stopping and smoke seal materials and systems to provide closures to fire and smoke at openings around penetrations, at unpenetrated openings, at projecting or recessed items, and at openings and joints within fire separations and assemblies having a fire resistance- rating, including openings and spaces at perimeter edge conditions.
1. Provide seals to form draft tight barriers to retard the passage of gas, flame and smoke, and, except where specified otherwise, firefighter's hose stream and the passage of liquids.
 2. Seal openings to provide and maintain the fire resistance rating of the adjacent floor, wall or other fire separation assembly to the requirements of and acceptable to the authorities having jurisdiction and the Contract Administrator.
- C. Fire stopping and smoke seals within mechanical (inside ducts, dampers) and electrical assemblies (inside bus ducts) will be provided as part of the work of Divisions 23 and 26 respectively. Fire stopping and smoke seals around the outside of such mechanical and electrical assemblies where they penetrate rated fire separations are part of the work of this Section.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Experienced in performing the Work of this section and specializing in the installation of work similar to that required for this project.
- B. Preinstallation Meetings: Conduct preinstallation meeting to identify where seals are required and verify project requirements, substrate conditions, manufacturer's installation instructions, and manufacturer's warranty requirements.
- C. Conform to both the temperature and flame ratings of CAN/ULC S115 and, where applicable, to ASTM E814, and other requirements of authorities having jurisdiction for fire stopping and smoke seal materials.

1.5 SUBMITTALS

- A. Submit Shop Drawings indicating the ULC assembly number and diagram of ULC approved assembly of each condition. Submit drawings indicating layout, profiles, product components, required temperature rise and flame rating, thickness, installation methods and materials of fire stopping and smoke seals, damming materials, anchorages and fastenings, size of opening, adjacent materials and number of penetrations.
- B. Submit manufacturer's product data for materials and prefabricated devices, providing descriptions sufficient for identification at the Project Site. Include manufacturer's printed instructions for installation.
- C. Submit samples of each type of fire stopping and seal material.
- D. Submit manufacturer's certification that installed fire stopping and smoke seal materials comply with specified requirements.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Deliver and store materials in original wrappings and containers with manufacturer's seals and labels intact. Protect materials from damage and environmental conditions in accordance with manufacturer's instructions.

1.7 SITE CONDITIONS

- A. Comply with manufacturer's instructions for temperature, relative humidity, and substrate moisture content during application and curing of materials.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. A/D Fire Protection Systems Inc.
- B. 3M Canada Canada Inc.
- C. Hilti Canada Inc.

D. Tremco Ltd.

2.2 MATERIALS

A. General:

1. Fire stopping and smoke seals: Certified and listed by ULC in accordance with CAN/ULC S115 and bearing ULC label, asbestos free materials and systems complying with standards specified herein, by one or more of the specified acceptable manufacturers, installed in accordance with tested assemblies acceptable to authorities having jurisdiction to provide an effective barrier against the passage of flame, smoke and gases, and to provide a flame and temperature rating in accordance with the requirements of the applicable building code for openings in the respective fire resistance rated floor, wall or other assembly.
2. Service penetration assemblies: Certified by ULC and listed in ULC Guide No. 40 U19.
3. Service penetration firestop components: Certified by ULC and listed in ULC Guide No. 40 U19.13 under the Label Service of ULC.
4. Flame, temperature, hose stream (FTH) ratings: To requirements of authorities having jurisdiction.
5. Cable density within cable trays: Listed for a minimum of 38 percent actual and 100 percent visual.
6. Cementitious matrices: Minimum 2758 kPa compressive strength when cured, to retard cable tray warping within the fire stop seal.
7. Fire stopping and smoke seals at openings intended for ease of re-entry: An elastomeric or re-enterable cementitious matrix or putty seal. Do not use a non re-enterable cementitious seal at such locations.
8. Fire stopping and smoke seals at openings around penetrations for electrical bus ducts, pipes, ductwork and other electrical and mechanical items requiring sound and vibration control or allowance for expansion, contraction and other movement: An elastomeric seal. Do not use a cementitious or rigid seal at such locations.
9. Primers: To manufacturer's recommendation for specific material, substrate, and end use.
10. Damming and backup materials, supports and anchoring devices: To manufacturer's recommendations, and in accordance with the tested assembly.
11. Packing Material: Batts or blankets, of material, thickness, density and compression required for the listed assembly.
12. Pipe and duct insulation and wrappings: Compatible with fire stopping systems.
13. Intumescent pads: Permanently pliable type.
14. Sealants and putty for vertical and overhead joints: Non-sagging.
15. Sealants and fluid seals at floors: Self-levelling.

B. Fire Stopping and Smoke Seal System 4:

1. Fire stopping: Fire dampers specified under Division 40, Process Integration.
2. Smoke Seal: One component silicone base chemical curing sealant complying with CAN/CGSB 19.13-M, gun grade, non sag consistency or fire stopping silicone sealant.

C. Firestopping and Smoke Seal System 5: Firestop Block CFS-BL by Hilti Canada, ASTM E84, ASTM E814, UL 1479, CAN/ULC-S115, ASTM G21, Intumescent flexible block complete with firestop putty and/or intumescent fire stop sealant.

- D. Firestop Collars system 6: Firestop Collar CP-643 N/CP-644 by Hilti Canada, UL 1479, ASTM E814, CAN/ULC-S115, ASTM E84, ASTM G21, with firestop wrap strips.
- E. Firestopping and Smoke Seal System 7: Intumescent Firestop Composite Sheet/Panels, CS-195+ by 3M, Spec Seal Composite Sheet by Anixter. ASTM E814, UL 1479, ASTM E84, ASTM E814, UL 1479, CAN/ULC-S115. Rigid firestop panel consisting of intumescent layer bonded to galvanized steel and reinforced with steel mesh, complete with required studs and framing system.

PART 3 EXECUTION

3.1 PREPARATION

- A. Examine sizes and conditions of voids to be filled to establish correct thicknesses and installation of materials. Ensure that substrates and surfaces are dry and frost free.
- B. Clean bonding surfaces to remove deleterious substances including dust, paint, rust, oil, grease and other foreign matter which may otherwise impair effective bonding.
- C. Do not apply fire stopping and smoke seals to substrates and surfaces previously painted or treated with sealer, curing compound, water repellent, or other coatings unless tests have been performed to ensure compatibility of materials. Remove coatings as required.
- D. Ensure that pipe and duct insulation and wrappings occurring within openings to receive fire stopping and smoke seal under this Section are installed prior to work of this Section and that the insulation and wrapping within fire seals is a ULC listed component of the system to be installed under this Section, unless ULC certified assembly permits such other insulation and wrapping to remain within the assembly. Co-ordinate the work of this Section with the work of Division 40, Process Integration. Ensure the continuity and integrity of thermal and vapour barriers where such are removed, altered, or replaced, to the acceptance of Division 40, Process Integration and the Contract Administrator.
- E. Prepare surfaces and prime in accordance with manufacturer's directions.
- F. Mask where necessary to avoid spillage and over coating onto adjoining surfaces; remove stains on adjacent surfaces.

3.2 PENETRATION SIZING

- A. Sizing of service penetrations to be fire stopped, other than for fire damped openings:
 - 1. Single, circular penetration are sleeved under work of Division 40, Process Integration and Division 26, Electrical.
 - 2. Multiple penetrations of circular elements are defined as more than one circular penetration having a maximum space of 100 mm between closest faces of such penetrating elements. Forming of such multiple penetrations is responsibility of respective trades whose service penetrates the rated assembly, and such formed opening to be a square or rectangular frame around a group of penetrations in which maximum clearance between outer penetration element and face of opening to be 25 mm.

3. Singular and multiple rectangular penetrations to be created in same manner as the above-mentioned multiple circular penetrations, but the edge clearance may be increased to maximum 50 mm.
4. At fire dampers, make clearances as required by testing authorities.

3.3 MIXING

- A. Mix components in a mixer, clean and free of used and set materials and surface contaminants.
- B. Thoroughly mix components in accurate proportions.
- C. Apply mixed materials within time limit recommended by the manufacturer.

3.4 APPLICATION

- A. General:
 1. Apply fire stopping and smoke seals in accordance with manufacturer's instructions and tested designs to provide the required temperature and flame rated seal, and to prevent the passage of smoke and liquids.
 2. Provide temporary forming as required and remove forming only after materials have gained sufficient strength and after initial curing.
 3. Completely fill and seal voids with fire stopping and smoke seal materials.
 4. Tool or trowel exposed surfaces except where self-levelling products make this unnecessary.
 5. Remove excess products promptly as work progresses and upon completion.
 6. Allow materials to cure. Do not cover up materials until full curing has taken place.
 7. Notify Contract Administrator when completed installations are ready for inspection and prior to concealing or enclosing fire stopping and smoke seals.
- B. System 4:
 1. At fire damper perimeters, apply a 6 mm to 10 mm bead of service penetration fire stop sealant as a smoke seal at interface of retaining angles around fire dampers where retaining angles meet fire rated walls/floors/ceilings or membranes thereof as well as at the interface of retaining angles and duct or fire damper. Provide two sealant beads per side, four beads per damper at wall dampers. Seal top side only at floor dampers.
- C. Firestopping and Smoke Seal System 5:
 1. Install for multiple or grouped pipes/conduits square/rectangular opening through fire rated assemblies.
- D. Firestop Collars System 6:
 1. Install for penetration through existing fire rated assemblies.
- E. Firestopping and Smoke Seal System 7:
 1. Install for multiple or group of HVAC ducts through square/rectangular opening through fire rated assemblies.

3.5 CLEAN UP

- A. Remove excess materials and debris and clean adjacent surfaces immediately after application.
- B. Remove temporary dams after initial set of fire stopping and smoke seal materials.

END OF SECTION

SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.1 SUMMARY

- A. Comply with Division 1, General Requirements.
- B. Refer to Colour Schedule in this Section for items to be painted.

1.2 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
 - 1. ASTM D523 Standard Test Method for Specular Gloss.
 - 2. Steel Structures Painting Manual Vol. 2 - Systems and Specifications.
 - 3. Occupational Health and Safety Act, O.Reg. 213/91 and 692.
 - 4. National Fire Code of Canada.
 - 5. NSF International (NSF): 61 Drinking Water System Components – Health Effects.
 - 6. SMAQMD (South Coast Air Quality Management District) Rule 1113 Architectural Coatings.

1.3 SUBMITTALS

- A. List of materials: Prior to commencement of work, submit three copies of list with name of manufacturer, number, grade and quality of materials proposed for use on this project.
- B. Product and safety data sheets: Submit WHIMIS MSDS – Material Safety Data Sheets for each paint system. Submit 3 copies of paint system data sheet and three copies of each data sheets.

1.4 QUALITY ASSURANCE

- A. Prior to commencement of painting operations meet at Site with material supplier's representative and with the Contract Administrator to review these Specifications, painting work to be done and following related items:
 - 1. Equipment use and servicing
 - 2. Material storage and application techniques
 - 3. Surface preparation and ambient temperature
 - 4. Inspection requirements
 - 5. Inspection reports
 - 6. Hold points or check points
 - 7. Safety requirements during application
 - 8. Mock ups or samples of coatings in highly corrosive environment
- B. Submit report of alternative recommendations for adverse conditions encountered.

- C. Arrange with the paint manufacturer to visit the Site at intervals during the surface preparation and painting operations to insure that the proper surface preparation has been completed, the specified paint products are being used, the proper number of coats and thickness are being applied and the agreed finishing procedures are being used, and that the paint manufacturer regularly submits written reports.
- D. Field Sample:
 - 1. A sample area located in the building will be designated by the Contract Administrator.
 - 2. Apply samples of finishes in the sample area in the presence of the Contract Administrator, Contractor and paint manufacturer. Apply the samples with the correct material, number of coats, colour, texture and degree of gloss required. Refinish if required, until acceptance is obtained.
 - 3. Leave test areas undisturbed until completion of the work. Accepted work in the test area will serve as a standard for similar work throughout the Project.
- E. Regulatory Requirements:
 - 1. Meet SCAQMD Rule 1113 Architectural Coatings and regulatory requirements limiting the emission of volatile organic compounds.
 - 2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC PA 3, Guide to Safety in Paint Applications.
 - c. Federal, provincial, and local agencies having jurisdiction.

1.5 SITE CONDITIONS

- A. Do not paint interior surfaces at temperatures below 3 degrees C above dewpoint or on surfaces where condensation has or will form due to presence of high humidity and lack of proper ventilation.
- B. Follow manufacturer's product data for application conditions.
- C. Only materials conforming to SCAQMD Rule 1113 Architectural Coatings are allowed to be applied on Site.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Paint and related materials: Akzo Nobel Coatings Ltd. (Canada).
- B. Protective coating system is based on materials manufactured by Akzo Nobel Coatings Ltd. (Canada) and represents standard of quality. Comparable systems by PPG Canada Inc., Sherwin-Williams Company are acceptable.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine surfaces which are to be finished including existing surfaces that require refinishing.
- B. Report surfaces which are defective, or which cannot be prepared by usual sanding and cleaning. Report unsatisfactory Site and environmental conditions.
- C. Commence work after corrective work has been completed.

3.2 PREPARATION

- A. Commencement of work means acceptance of Job Site and substrate conditions.
- B. Protect work performed under separate Sections from paint splatter, overspray and accidental spill.
- C. Remove soiled and used rags, waste and empty containers from the building daily.
- D. Take precautions to prevent fire.
- E. Exercise special precautions for safety of workmen applying coating in enclosed areas by meeting requirements outlined in Occupational Health and Safety Act and Regulations for Construction Projects.
- F. Comply with instructions on paint manufacturer's Safety Data Sheets.
- G. Related Work: Surface preparation and prime coat of metal surfaces are specified to form part of the permanent protective coating in Division 5 - Metals, Division 8 – Openings, Division 10 - Specialties, Division 11 - Equipment, Division 40 – Process Integration, Division 41 – Material process and Handling Equipment, Division 22 – Plumbing, Division 23 – Heating, Ventilating, and Air-Conditioning (HVAC), Division 26 – Electrical, including responsibility for surface preparation, shop painting, and field touch-ups after erection. Be responsible for field painting of steel items which will remain exposed, after completion of erection and touch-up of shop primer, including items shop finished with a protective coating, unless specified otherwise.
- H. Provide surface preparation in accordance with SSPC Manual Volume 2 "Systems and Specifications", Chapter 2.
- I. Apply primer within time recommended after surface preparation. Comply with SSPC-PA-1 for application techniques, requirements and precautions.
- J. Comply with CGSB 85-GP Series.
- K. Remove cover plates of service devices, surface hardware, frames of lighting fixtures and other obstructions and reinstall them after painting work is completed. Replace units damaged while performing work under this contract.

- L. Clean surfaces to be finished from machine, tool or sanding marks, dust, grease, soiling, or any extraneous matter.
- M. Test surfaces for moisture content. Do not apply materials to substrate when moisture content, exceeds 12 percent as determined by accepted moisture testing device.
- N. Ferrous metal surfaces Prepare in accordance with surface preparation specifications outlined by the "Steel Structures Painting Council". Use method indicated in appropriate Protective Coating System.
- O. Manufacturer's bituminous protective coating: Abrasive Blast Clean to SSPC SP 6 and shop prime with same primer specified for coating system.
- P. Shop welds: Grind smooth and rounded and abrasive blast in accordance with SSPC commercial type blasting SP 6. Remove weld flux and other surface contaminants.
- Q. Field welds: Use hand wire brush followed by cleaning with solvent swab in accordance with SSPC SP 1.
- R. Unpassivated galvanized metal and plain aluminum surfaces: Wash thoroughly with Trisodium Phosphate or Oakite 31 by Oakite Corp., Oakville, Ont., solution mixed in accordance with manufacturers printed instructions. Rinse thoroughly. Follow instructions on Product Data sheets.
- S. Galvanized surfaces that have been passivated: On small areas use abrasive buffing with bronze wool pad SP 2 or power wire brush SP 3 and clean with solvent. On large areas use brush off blast SP 7 and clean with solvent.
- T. Concrete surfaces: Remove mold release oil with Xylol. If smooth etch for better adhesion. Follow instructions on manufacturer's Product Data sheets.
- U. Concrete surfaces treated with capillary waterproofing: Do not commence application until capillary waterproofing is minimum two weeks old. Rinse thoroughly with water and spray with solution one part muriatic acid to eight parts of potable water. Allow ten minutes of contact and rinse thoroughly with water.
- V. Concrete block surfaces: Remove dirt, grease, dust and other contaminants. Fill holes and cracks with patching plaster.
- W. Wood surfaces: Carefully sand before finishing.
- X. Surfaces primed by item manufacturer: Prepare according to recommendations on Product Data sheets.
- Y. Factory finished surfaces: Sand down for adhesion in accordance with SSPC SP 2.
- Z. Copper surfaces: Solvent clean and buff in accordance with SSPC SP-2.
- AA. Fabric jacketed surfaces: Clean of dust. Follow instructions on Product Data sheets.

3.3 APPLICATION

- A. Apply paint materials free from defects.
- B. Mask surfaces where necessary, to prevent contamination or marring of adjacent material, or different protective coating system.
- C. Prevent overspray onto adjacent surfaces or properties.
- D. Do not apply paint over sealant.
- E. Verify that fabric jacketed pipes and ducts have been sized prior to painting.
- F. Confirm piping and ducting systems have successfully passed tests specified, prior to painting.

3.4 APPLICATION - MISCELLANEOUS EXISTING SURFACES

- A. Repaint surfaces or rooms adjacent to rooms where alterations or renovations have been carried out and which have been damaged or otherwise disturbed by the alterations or renovations. Where such damage occurs, repaint completely.
- B. Remove oil, grease, mildew, chemicals and other foreign matter from existing surfaces to be coated.
- C. If coatings on existing surfaces have failed so as to affect the performance or appearance of coatings to be applied, or if such coatings can be scraped off, remove them and prepare their substrates correctly. Dull hard or glossy surfaces by sanding, or other abrasive methods prior to painting.
- D. Repaint surfaces entirely between changes of plane which have been incorporated into the existing work and existing work which has been damaged, altered or otherwise disturbed during renovation operations. Apply two coats of paint or enamel over the existing finish to match the previous finish.

3.5 APPLICATION – GENERAL

- A. Apply finish coats of paint in thickness per coat specified.
- B. If minimum dry film thickness (DFT) in micrometres (microns) is not achieved, apply additional coat(s) until required thickness is obtained.
- C. Apply paint in accordance with SSPC Manual Volume 2 – “Systems and Specifications”, Chapter 5.1.
- D. Sand semi gloss, medium and high gloss finishes lightly between coats, unless otherwise approved by the coating manufacturer.

- E. Gloss terms of following values when tested in accordance with ASTM D523 Test for Specular Gloss:

Gloss Term	Gloss Value
Flat	5 to 20
Eggshell	20 to 40
Semi-gloss	40 to 60
Gloss, medium	60 to 80
Gloss, high	80 to 90

- F. Finish work uniformly as to sheen, gloss, colour and texture free from sags, runs and other defects and under adequate illumination.
- G. Apply materials in accordance with directions and instructions of manufacturers of materials. Do not use adulterants.
- H. Do not paint sprinkler heads, over ULC or other fire rating labels on doors and frames, nor over identification labels on mechanical and electrical equipment.

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

SERVICE USE	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
-------------	---------------------------------	-----------------------------	--------------------	---------------------------------------

3.6 SCHEDULE - PROTECTIVE COATING SYSTEMS

By Akzo Nobel Coatings Ltd. (Canada)

A. CONCRETE BLOCK & CONCRETE: INTERIOR

1. Low chemical, moisture and sulfide fume exposure	<u>PRIME:</u> (Concrete Block) U-36250 Block Filler Primer	See Art. 3.2	1	150 min.
	<u>PRIME:</u> (Concrete) U-36600 Latex Sealer Primer	See Art. 3.2	1	38
	<u>FINISH:</u> Devflex 4216L Waterborne Acrylic Semi-Gloss Enamel		2	38-50
2. High humidity, moisture, condensation, spray exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	See Art. 3.2	1	50-75
	<u>FINISH:</u> Truglaze WB 4428 Waterborne Epoxy Gloss Coating		2	50-75
3. Containment area (ALUM)	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	See Art. 3.2	1	50-75
	<u>FINISH:</u> Truglaze WB 4428 Waterborne Epoxy Gloss Coating		2	50-75

B. STRUCTURAL STEEL

1. Not receiving full protective coating system, concealed exposure	<u>PRIME:</u> Devguard 4360 Low VOC Universal Primer	SP-6	1	50
	<u>FINISH:</u> Devgard 4360 Low VOC Universal Primer		1	50

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

SERVICE USE	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
-------------	---------------------------------	-----------------------------	--------------------	---------------------------------------

C. STEEL & CAST IRON

1. Low chemical, moisture and sulfide fume exposure	<u>PRIME:</u> Devguard 203 Waterborne Epoxy Primer <u>FINISH:</u> Truglaze 4428 High Build Epoxy Coating	SP-6	1 2	50-60 50
2. High humidity, moisture, condensation, spray exposure	<u>PRIME:</u> Devguard 203 Waterborne Epoxy Primer <u>FINISH:</u> Truglaze 4428 High Build Epoxy Coating	SP-6	1 2	50-60 50
3. Chemically corrosive exposure	<u>PRIME:</u> Devguard 203 Waterborne Epoxy Primer <u>FINISH:</u> Truglaze 4428 High Build Epoxy Coating	SP-10	1 1	125-175 75-100
4. Ground conditions - buried	<u>COAT:</u> Devran 224 HS High Build Epoxy Coating	SP-6	2	150-200

D. STEEL & CAST IRON - HIGH TEMPERATURE

1. Service temperature up to 233°C	<u>PRIME:</u> Devoe HT-10 Heat Resistant Modified Silicone Zinc <u>FINISH:</u> Devoe HT-10 Heat Resistant Modified Silicone Zinc	SP-5	1 1	38-50 38-50
2. Service temperature 150°C to 495°C	<u>COAT:</u> Devoe HT-10 Heat Resistant Modified Silicone Zinc	SP-10	2	25

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

<u>SERVICE USE</u>	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
3. Steel, cast iron pipe under insulation - up to 83°C	<u>COAT:</u> Catha-Coat 302H Reinforced Inorganic Zinc	SP-6	1	75-100
4. Steel, cast iron up to 150°C	<u>COAT:</u> Catha-Coat 302H Reinforced Inorganic Zinc	SP-6	1	75
	<u>FINISH:</u> Devoe HT-4H Heat Resistant Modified Silicone Zinc		1	38-50

E. STEEL & CAST IRON & DUCTILE IRON - SUBMERGED

1. Totally or partially submerged in wastewater	<u>SHOP PRIME:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating	SP-10	1	150-200
	<u>FINISH:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating	SP-10	1	150-200
2. Totally or partially submerged in potable water	<u>PRIME:</u> Bar-Rust 233H Multi-Purpose	SP-10	1	150-200
	<u>FINISH:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating		1	150-200

F. DUCTILE IRON

1. Low chemical, moisture and sulfide fume exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-6	1	50-60
	<u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating		2	50

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

<u>SERVICE USE</u>	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
2. High humidity, moisture, condensation, spray exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-2/SP-3	1	50-60
	<u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating		2	50
3. Ground conditions - buried	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer <u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating	SP-10	1	150-200
4. Chemically corrosive atmosphere, fumes, and spills exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-10	1	125-175
	<u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating		1	75-100

G. GALVANIZED STEEL - INTERIOR

1. Low chemical, moisture and sulfide fume exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-7	1	75-100
	<u>FINISH:</u> Devthane 379 H Aliphatic Urethane Gloss-Enamel or Devthane 349 QC Aliphatic urethane Gloss		2	50-75
			2	50-75

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

SERVICE USE	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
2. High humidity, moisture, condensation, spray exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-7	1	75-100
	<u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating		2	50-75
3. Chemically corrosive exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-7	1	125-150
	<u>FINISH:</u> Truglaze 4428 Waterborne Epoxy Gloss Coating		1	75-100

H. GALVANIZED STEEL - SUBMERGED

1. Totally or partially submerged in wastewater	<u>PRIME:</u> Bar-Rust 235 H Multi-Purpose Epoxy Coating	SP-7	1	150-200
	<u>FINISH:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating		1	150-200
2. Totally or partially submerged in potable water	<u>PRIME:</u> Bar-Rust 235 H Multi-Purpose Epoxy Coating	SP-7	1	150-200
	<u>FINISH:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating		1	150-200

I. BITUMINOUS COATED SURFACES

1. Non-submerged and non-severe service exposure	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-2/SP-3	2	25
	<u>FINISH:</u> Devflex 4216L Waterborne Acrylic Semi-Gloss Enamel		2	50

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

<u>SERVICE USE</u>	PROTECTIVE COATING SYSTEM	SURFACE PREPA— RATION	NO. OF COATS	MIN. D.F.T. PER COAT IN MICRONS
2. Non-submerged, high humidity, moisture, condensation, spray	<u>PRIME:</u> Devran 203 Waterborne Epoxy Primer	SP-2/SP-3	2	25
	<u>FINISH:</u> Devflex 4216L Waterborne Acrylic Semi-Gloss Enamel		2	50
3. Submerged service in wastewater	<u>PRIME:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating	SP-10	1	150-200
	<u>FINISH:</u> Bar-Rust 233 H Multi-Purpose Epoxy Coating		1	150-200

3.7 COLOUR SCHEDULE - BUILDING ITEMS

- A. Exposed Structural Steel: To later selection.
- B. CMU and Concrete Walls (including columns) and Ceilings: To match existing.

3.8 COLOUR SCHEDULE - ELECTRICAL

- A. Aluminum Cable Trays: Unfinished.
- B. Electrical Panels: Prefinished ANSI/ASA #61 Grey. For painting refer to Colour Schedule - General.

3.9 COLOUR SCHEDULE - PIPING (PROCESS AND SERVICE)

- A. Comply with Pipe Identification System identified in Section 40 05 53, Identification Labels for Equipment, Fabricated Tanks, Valves and Piping Systems. Existing piping colour code.
- B. Stainless Steel, PVC and Aluminum Surfaces: Do not paint full surface. Paint only ferrous accessories such as flanges, valves, couplings and similar items to match classification colour of labels. Exceptions are:
- C. Gas piping - paint full surface of pipe classification colour "Yellow"
- D. Fire protection piping - paint full surface of pipe classification colour "Red"

3.10 COLOUR SCHEDULE - DUCTING (HVAC)

- A. Galvanized Steel and Fabric-jacketted Surfaces Exposed to View: Paint full surface of duct.
- B. Galvanized Steel and Fabric-jacketted Surfaces not Exposed to View: Do not paint.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
 2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
 3. Canadian Associated Air Balance Council (CAABC): National Standards for Field Management and Instrumentation Total System Balance.
 4. National Environmental Balancing Bureau of Canada (NEBBC):
 - a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
 - b. Procedural Standards for Measuring Sound and Vibration.
 5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.2 SUBMITTALS

- A. Informational Submittals:
1. Documentation of experience record of testing authority.
 2. Documentation of current CAABC or NEBBC certifications for those technicians in responsible charge of the work under this Contract.
 3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
 4. Written verification of calibration of testing and balancing equipment.
 5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.3 QUALITY ASSURANCE

- A. Air Balancing and Test Agency Qualifications:
1. Certification by CAABC or NEBBC for testing, adjusting and balancing of HVAC systems.
 2. Corporately and financially independent organization functioning as an unbiased testing authority.
 3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
 4. Have a proven record of at least five similar projects.
 5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.
- B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.
- C. Drives for Belt-Driven Fans:
 - 1. Furnish cast iron or flanged steel sheaves.
 - 2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.1 GENERAL

- A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the CAABC, NEBBC or SMACNA.
- B. Adjust and balance the following systems:
 - 1. EF-B682 exhaust air system.
 - 2. Chilled water system (existing).
 - 3. Cooling water system (existing).

3.2 ADJUSTING AND BALANCING AIR SIDE

- A. Preparation:
 - 1. Prior to beginning the Work, perform the following activities:
 - a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
 - b. Recommend to Contract Administrator dampers that need to be added or replaced in order to obtain proper air control.
 - c. Verify proper startup procedures have been completed on the system
 - d. Verify controls installation is complete and system is in stable operation under automatic control.
 - e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer's recommended calibration interval before beginning the Work.
- B. General:
 - 1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
 - 2. Lock and mark final positions of balancing dampers with permanent felt pen.
 - 3. Correct fan and airflow measurements for Site elevation.
 - 4. For neutral rooms, the allowable variations are plus 5 percent /minus 5 percent for supply and plus 5 percent/minus 5 percent for exhaust.

5. For positive rooms, the allowable variations are plus 5 percent/minus 0 percent for supply and plus 0 percent/minus 5 percent for exhaust.
6. For negative rooms, the allowable variations are plus 5 percent/minus 0 percent for exhaust and plus 0 percent/minus 5 percent for supply.

C. Equipment Data:

1. Collect the following data and included in final report:
 - a. Type of unit.
 - b. Equipment identification number.
 - c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
 - d. Motor data (frame, kW, volts, FLA rpm, and service factor).
 - e. Sheave manufacturer, size, and bore.
 - f. Belt size and number.
 - g. Sheave centerline distance and adjustment limits.
 - h. Starter and motor overload protection data.
 - i. Include changes made during the course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
 - a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation aforementioned.
 - b. After final adjustments, do not operate motor above nameplate amperage on any phase.
 - c. After final adjustments, do not operate fan above maximum rated speed.
 - d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
 - e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to unit manufacturer and Contract Administrator if drive or belt changes were made.
4. Adjust exhaust air dampers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, dampers, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. Adjust air volumes on exhaust grilles, to the quantity shown, with allowable variation aforementioned.
2. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
3. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

3.3 ADJUSTING AND BALANCING WATER SIDE

- A. Preparation: Prior to beginning the Work, perform the following activities:
1. Review shop drawings and installed system for adequate and accessible balancing devices and test ports.
 2. Recommend to Contract Administrator devices needed to be added or replaced in order to obtain proper water control.
 3. Verify proper startup procedures have been completed on system.
 4. Verify controls installation is complete and system is in stable operation under automatic control.
 5. Verify hydronic systems have been filled and are clean. Examine a sample of strainers to ensure cleanliness.
 6. Verify manual air vents have been bled and expansion tanks and automatic air vents are functioning.
 7. Verify control valves and coil connections are complete and properly installed.
- B. General:
1. In addition to the new equipment and sub-systems provided under this contract, the balancing work shall include the cooling and chilled water side of the existing Chilled Water Cooling system.
 2. When adjustments are made to a portion of a water system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
 3. Correctly adjust water flow readings for mixtures other than pure water.
 4. Throttling of butterfly and other nonbalancing device valves shall not be allowed.
 5. Lock and mark final positions of balancing devices with a centerpunch or permanent felt pen.
- C. Equipment Data:
1. Collect the following data and include in final report:
 - a. Type of pump.
 - b. Equipment identification number.
 - c. Equipment nameplate data (including manufacturer, model, size, type, impeller size and serial number).
 - d. Pump capacity (flow rate and differential pressure).
 - e. Drive data.
 - f. Motor data (frame, kW, volts, FLA rpm, and service factor).
 - g. Starter and motor overload protection data.
 - h. Include changes made during course of system balancing.
- D. Pumps:
1. Verify impeller size through a “dead-head” test. Do not perform on positive displacement pumps.
 2. Adjust water to achieve design flows at all modes of operation during single and multiple pump operation.
 3. Test redundant and stand-by pumps.
 4. After final adjustments, do not operate motor above nameplate amperage on any phase.
 5. Read and record pressures at pump inlet and discharge for each test condition.
 6. Read and record motor amperage on all phases for each test condition.

7. Record and mark final position of balancing cocks, valves, and operators with a permanent felt pen or centerpunch.

E. Terminal Flow Devices:

1. Adjust water systems for required flow rates at each coil, connection, and terminal device.
2. Provide proper flow through individual fin tube sections, evaporator and condenser circuits, and each pump.
3. Measure and adjust flow through valves and valve bypass lines.
4. Record and mark final position of balancing cocks, valves, and operators with a permanent felt pen or centerpunch.
5. Read and record differential pressures across coils, control valves, and chiller bundles.

F. Tolerances:

1. Cooling Water Flow Rate: Plus 10 percent to minus 10 percent.

3.4 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 14, Equipment Testing and Facility Startup.

B. Performance Testing:

1. Vibration Testing:

- a. Upon completion of air and water system balance, perform vibration testing as specified below for the following rotating or reciprocating equipment:
 - 1) Cooling water pumps.
 - 2) Chilled water pumps.
- b. Vibration Test Procedures:
 - 1) Take measurements at each bearing housing, using a calibrated electronic analyzer.
 - 2) Record log shall include equipment symbol, location, identification, and peak-to-peak displacement in a direction parallel to shaft in a horizontal plane, and in a direction perpendicular to shaft in both horizontal and vertical planes.
 - 3) Maximum Peak-to-Peak Amplitude Levels:

Rotational Speed (rpm)	Vibration Amplitude (mils)
250	3.5
500	2.0
750	1.5
1,000	1.0
1,500	0.75

- 4) Notify Contract Administrator if amplitude exceeds upper limit specified.
- 5) After readjustment for vibration, measure and record only the readjusted equipment to determine its conformance with design.

- C. Balancing Log Report Requirements:
1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
 2. Log and record operational information from every test for each system, as necessary to accomplish services described.
 3. Include equipment data for units tested.
 4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
 5. Indicate recorded Site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
 6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.
- D. Quality Control Verification:
1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
 - a. Air and water balancing procedures, vibration tests, and verification of test results.
 - b. Perform spot tests with measuring equipment used in original tests, at random points selected by Contract Administrator.
 - c. Results of these spot tests shall agree with balance logs within percentage tolerances specified. Where this accuracy cannot be verified, rebalance portions of system as requested by Contract Administrator.
 - d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

SECTION 23 21 13

HYDRONIC PIPING—GENERAL

PART 1 GENERAL

1.1 DEFINITIONS

- A. The following is a list of abbreviations which may be used in this section:
1. ID: Inside Diameter.
 2. WOG: Water, Oil, Gas.

1.2 SUBMITTALS

- A. Action Submittals: Shop Drawings to include the following:
1. Coordination Drawings: Provide 1:50 scale drawings of mechanical rooms, showing relationship between piping and other trades.
 2. Name of system.
 3. Pipe: ASTM number, grade if known, type, wall thickness, and material.
 4. Fittings: ASTM number, grade if known, class, type, wall thickness, and material.
 5. Joint type.
 6. Flanges: ASTM number, grade, class, type, and material.
 7. Bolt and nut material.
 8. Thread joint sealant material.
 9. Flange gasket material and rating.
 10. Unions: ASTM number, type, material, and rating.
 11. Type of welding.
 12. Paint data sheets.
- B. Informational Submittals:
1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements:
1. Piping materials, products and installation shall comply with ASME B31.9, ASME B31.1, and local codes.
- B. Qualifications:
1. Mechanical Grooved Pipe Connections: Field grooving shall be performed by qualified operator, having demonstrated manufacturer's recommended grooving procedures.
- C. Manufacturer, pressure class, size, and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. In accordance with Section 01 61 00, Common Product Requirements.
- B. Piping:
 - 1. Free of rust and scale.
 - 2. Install plastic end caps/plugs on each end of pipe.
 - 3. Maintain end caps/plugs through shipping, storage, and handling to prevent pipe end damage, and to eliminate dirt and construction debris from accumulating inside of pipe.
 - a. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
 - b. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
 - c. Linings and Coatings: Prevent excessive drying.
 - d. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
 - e. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.
- C. Storage:
 - 1. Where possible, store materials inside and protect from weather.
 - 2. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Piping and Fittings:
 - 1. Refer to Pipe Data Sheet(s), Article Supplements.
 - 2. In accordance with ASME B31.9 and ASME B31.1, as applicable.
 - 3. Unless otherwise indicated, fittings and accessories connected to pipe shall be of same material as pipe.
 - 4. Bullhead tees are not permitted.
- B. Piping System Cleaner:
 - 1. Detergent cleaning compound similar to Nalco 2567.
 - 2. Suitable for removal of organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor.
 - 3. Suitable for system metals without deleterious effects.
 - 4. Cleaner shall not contain phosphate.

2.2 COMPONENTS

- A. Supports: In accordance with Section 40 05 15, Piping Support Systems.
- B. Insulation: In accordance with Section 40 42 13, Piping Insulation.

- C. Grooved Mechanical Pipe Connections:
1. General:
 - a. Grooved mechanical pipe joint system consisting of pipe couplings, fittings, valves, and other grooved components.
 - b. Grooved components shall be product of one manufacturer.
 2. Application:
 - a. Pipe Joints: Grooved mechanical joint system may be used as option to pipe welding, threading, or flanged methods where indicated on Piping Data Sheets.
 - b. Pump Flexible Connectors:
 - 1) Grooved mechanical pipe flexible couplings may be used in lieu of piping flexible connectors.
 - 2) Locate couplings at first three points at pump connection.
 - 3) Not acceptable for in-line pump applications.
 3. Components:
 - a. Refer to Piping Data Sheet(s) for coupling, fitting and other grooved component requirements.
 - b. Couplings and fittings shall have enamel coating.
 - c. Use full-flow fittings; fabricated or mitered fittings not acceptable.
 4. Manufacturers:
 - a. Victaulic Co.
 - b. Grinnell.
 - c. Star Pipe Products.

2.3 ACCESSORIES

- A. Vent and Drain Valves:
1. Pipeline, 50 mm Diameter and Smaller: 12 mm vent, 25 mm drain, unless shown otherwise.
 2. Pipeline, 65 mm Diameter and Larger: 20 mm vent, 25 mm drain, unless shown otherwise.
- B. Wells and Tappings:
1. Pipeline, 50 mm Diameter and Smaller: Use piping tee fitting.
 2. Pipeline, 65 mm Diameter and Larger: Use threadolets or sockolets.
- C. Leak Plates:
1. Provide leak plate welded to pipe at building walls for moisture barrier; consisting of steel plate flange 100 mm larger in outside diameter than pipe.
 2. Locate leak plate at mid-point of pipe passing through wall.
 3. See Section 40 27 01, Process Piping Specialties, for link seal.
- D. Threaded Joint Sealants:
1. Nontoxic, chemically inert, nonhardening rated for minus 45 degrees C to plus 260 degrees C, bearing UL, ULC, CGA, and NSF approvals.
 2. Teflon tapes are not allowed.
- E. Flange Gaskets:
1. Asbestos free and suitable for pressure temperatures and fluid of piping system.
 2. Nonmetallic gaskets in accordance with ASME B16.21.

- F. Corrosion Protection Coatings: Refer to Section 09 90 00, Painting and Coating, for details of coating requirements.

2.4 FINISHES

- A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify size, material, joint types, elevation, horizontal location, and pipe service of pipelines to be connected to new equipment or existing pipe.
- B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.
- C. Welding Electrodes: Verify proper grade and type, free of moisture and dampness, and that coating is undamaged.

3.2 PREPARATION

- A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.
- B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.
- C. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.
- D. Refer to Piping Schedule and Section 09 90 00, Painting and Coating for additional requirements.

3.3 INSTALLATION

- A. In accordance with ASME B31.9 and ASME B31.1, and these Specifications.
- B. General:
 - 1. Install piping to allow adequate service space for equipment.
 - 2. Install vertical piping plumb.
 - 3. Where interferences develop in field, offset or reroute piping as required to clear such interferences.
 - 4. Install valves, control valves and piping specialties, including items furnished by others, as specified and detailed.
 - 5. Make connections to equipment installed by others where that equipment requires piping services indicated in this Section.
 - 6. Protect piping from weather and paint promptly to prevent corrosion.

7. Pitch horizontal mains up at 25 mm per 12 m in direction of flow.
 8. Provide straight lengths of pipe upstream and downstream of flow measuring devices as required for accurate flow measurement.
- C. Piping Expansion: Provide anchors, expansion joints, swing joints and expansion loops so piping may expand and contract without damage to itself, equipment, or building.
- D. Aboveground Piping:
1. Group piping wherever practical at common elevations.
 2. Install piping to conserve building space and to not interfere with use of space and other work.
 3. Run piping parallel to building or column lines and perpendicular to floor, unless shown otherwise.
 4. Install piping at such heights not to obstruct any portion of window, doorway, stairway, or passageway.
 5. Install piping so no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection.
 6. Nonmetallic piping shall not be installed in occupied spaces and ventilation plenum spaces.
 7. Piping Clearance (unless otherwise shown):
 - a. Over Walkway and Stairs: Minimum of 2.3 m, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - b. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 1 m, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - c. From Adjacent Work: Minimum 25 mm from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
 - d. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
 8. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
 9. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.
- E. Grooved Mechanical Pipe Connections:
1. Use factory grooved pipe in accordance with coupling manufacturer's specifications or field grooved pipe in accordance with same specifications using specially designed tools available for application.
 2. Lubricate pipe and coupling gasket, align pipe, and secure joint in accordance with coupling manufacturer's specifications.
 3. Support pipe as indicated in Article Hangers and Supports, except as modified below.
 4. Support each horizontal pipe section at least once between couplings and whenever change in flow direction takes place.
 5. Support vertical pipe at every other floor or every other pipe length, whichever is most frequent.
 6. Set base of riser or base fitting on pedestal or foundation.

7. Follow coupling manufacturer's installation recommendations if they are more stringent than above requirements.

F. Fittings:

1. Mitered ells, welded branch connections, notched tees and "orange peel" reducers are not allowed.
2. Unless specifically indicated, reducing flanges and reducing bushings are not allowed, except reducing bushings may be used for air vents and instrumentation connections.
3. Unless otherwise indicated, for upfeed risers use top or top 45-degree connection to main, and for downfeed risers use side or bottom 45-degree connection to main.
4. Do not use mechanically formed tee fittings.

G. Joints:

1. General:
 - a. Refer to Piping Data Sheet(s) for acceptable joint methods for each piping system.
 - b. Make piping joints in accordance with [ASME B31.9 and ASME B31.1,] and these Specifications.
2. Preparation:
 - a. Ream ends of pipes and tubes and remove burrs.
 - b. Bevel plain ends of steel pipe.
 - c. Remove scale, slag, dirt and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints:
 - a. Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.
 - b. Cut threads full and clean using sharp dies.
 - c. Cut threads so no more than three threads remain exposed after joint is made.
 - d. Ream threaded pipe ends to remove burrs and restore full ID.
 - e. Apply thread sealants to cleaned male threads.
 - f. Assemble joint to appropriate depth and remove excess pipe joint compound from tightened joint.
4. Flanged Joints:
 - a. Clean flange surfaces and align flange surfaces parallel.
 - b. Select appropriate gasket material, size, type and thickness for service application.
 - c. Bolt holes of gaskets shall be cut slightly larger than bolt diameter and gasket ID shall be slightly larger than flange ID.
 - d. Position gasket concentrically so compression is equally distributed over entire gasket surface.
 - e. Lubricate bolts and run nuts down by hand.
 - f. Tighten nuts in proper sequence so gasket is compressed evenly, and to torque specified by bolt manufacturer.
 - g. Retorque bolts 12 hours to 24 hours after startup.
5. Soldered Joints:
 - a. Construct joints in accordance with AWS, Soldering Handbook or CDA, Copper Tube Handbook.
 - b. Clean fitting and tube with emery or sand cloth.
 - c. Remove residue from cleaning operation, apply flux and assemble joint.
 - d. Use solder to secure joint as specified for specific piping service.

6. Brazed Joints:
 - a. Construct joints according to AWS, Brazing Handbook.
 - b. Clean fitting and tube with emery or sand cloth.
 - c. Remove residue from cleaning operation, apply flux and assemble joint.
 - d. Use brazing material to secure joint as specified for specific piping service.
7. Solvent Welded Joints:
 - a. Comply with ASTM F402 for safe handling practices of cleaners, primers, and solvent cements.
 - b. Clean and dry joining surfaces by wiping with clean cloth and applying primer.
 - c. PVC Pressure Piping: Join piping and fittings in accordance with ASTM D2672.

H. Unions and Flanges:

1. Provide at each equipment connection or instrumentation connection to facilitate installation and removal without cutting of piping.
2. Install at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair, or replacement.
3. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal.
4. Required for line sizes 25 mm and larger.
5. Not required on copper piping with soldered joints for 12 mm and 20 mm line sizes.
6. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
7. Concealed unions or flanges are not allowed.

I. Vents and Drains:

1. Vents and drains that are required for completed piping system may or may not be shown on Drawings.
2. Install vents and drains throughout piping systems to permit complete venting and drainage of entire system.
3. Install drains on low points of pipelines as show and at low point locations.
4. Install vents on high points of pipelines as shown and at high point locations.
5. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.

J. Pipe Size Changes:

1. For proper air venting, use eccentric fittings (top of pipe straight) for changes in horizontal pipe sizes with fittings.
2. Concentric fittings may be used for changes in vertical pipe sizes.
3. Where size of pipe segment is not indicated, pipe segment size shall be equal to largest pipe segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

K. Piping Branch Connections:

1. Refer to Piping Data Sheet(s) for branch connection applications.
2. Do not install branch connections smaller than 13 mm nominal pipe size, including instrument connections, unless shown otherwise.
3. Threaded taps in pipe barrel are unacceptable.
4. Materials of branch connections shall match material of piping.

- L. Terminal Equipment Connections:
 - 1. Use minimum of three elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems.
 - 2. Main branches and runouts to terminal equipment may be made at top, side, or bottom of main provided there are drain valves located for complete system drainage, and manual air vents are located as described in these Specifications.
 - 3. Size for supply and return piping connections shall be same as for equipment connections.
 - 4. Install control valves in accessible locations close to connected equipment.
 - 5. Install bypass piping with globe valves around control valve. If multiple, parallel control valves are installed, only one bypass is required.
 - 6. Install ports for pressure and temperature gauges at coil inlet connections.
- M. Slab, Floor, Wall, and Roof Penetrations: In accordance with Section 40 27 01, Process Piping Specialties.
- N. Hangers and Supports: In accordance with Section 40 05 15, Piping Support Systems.
- O. Insulation: In accordance with Section 40 42 13, Piping Insulation.

3.4 APPLICATION

- A. Piping and Fittings:
 - 1. Refer to Piping Schedule, Article Supplements.
 - 2. When piping of lower pressure connects to piping of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first isolation valve in line carrying the lower pressure, unless otherwise shown.

3.5 FIELD FINISHING

- A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.
- B. Heat Shrink Wrap: Apply in accordance with manufacturer's instructions to surfaces that are cleaned, prepared, and primed.
- C. Carbon Steel Pipe:
 - 1. Above Ground: As specified in Section 09 90 00, Painting and Coatings.
- D. Copper Pipe:
 - 1. Above Ground: As specified in Section 09 90 00, Painting and Coatings.
- E. PVC Pipe, Aboveground: As specified in Section 09 90 00, Painting and Coatings.
- F. Accessories:
 - 1. Above Ground:
 - a. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.

- b. Field paint galvanized and black steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coatings, as applicable for base metal material.

3.6 IDENTIFICATION

- A. Aboveground Piping: As specified in Section 09 90 00, Painting and Coatings.

3.7 FIELD QUALITY CONTROL

- A. Pressure Leakage Testing: In accordance with Section 40 80 01, Process Piping Leakage Testing.

3.8 CLEANING

- A. Piping System:

- 1. General:
 - a. Before installation of piping insulation, wash piping exterior surfaces to remove construction dirt, loose scale, and flux.
 - b. Piping systems shall be internally cleaned before they are used for any purpose, except conduct pressure test before cleaning.
- 2. System Flush:
 - a. Flush piping systems with water thoroughly, for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system.
 - b. Bypass pumps and equipment, and remove strainers from strainer bodies.
 - c. Provide temporary piping or hose to bypass coils, control valves, other factory cleaned equipment, and any component which may be damaged, unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.
 - d. Sectionalize system to obtain minimum velocity of 1.8 m/s.
 - e. Provide temporary piping to connect dead-end supply and return headers as necessary.
 - f. Flush bottoms of risers.
- 3. System Cleaning:
 - a. After initial flushing of system, use portable pumping apparatus for continuous 24-hour, minimum, circulation of cold water detergent.
 - b. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer.
 - c. Flush detergent clear with continuous draining and raw water fill for additional 12 hours or until cleaner is removed from system.
 - d. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
 - e. Replace strainers and reconnect permanent pumping apparatus and bypassed apparatus.
 - f. Drain cleaning water to sanitary sewer.

3.9 SUPPLEMENTS

- A. The supplements listed below, following “End of Section,” are part of this Specification.
1. Pipe Data Sheets.

Section Number	Title
23 21 13.01	Hydronic Piping Schedule.
23 21 13.02	Carbon Steel Pipe and Fittings–Hydronic Water Service
23 21 13.03	Copper Tube and Fittings–Hydronic Water Service

END OF SECTION

SECTION 23 21 13.01

HYDRONIC PIPING SCHEDULE

Legend	Service	Size(s) (mm)	Exposure	Piping Material	Specification Section	Operating Pressure (kPag)	Test Type	Test Pressure (kPag)	Pipe Colors and Labels	Notes
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	50 OR LESS	EXP	STL or COP	23 21 13.02 or 23 21 13.04	414	H	1034		
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	65 OR GREATER	EXP	STL	23 21 13.02	414	H	1034		
CWR/CWS	CONDENSER WATER, RETURN/SUPPLY	50 OR LESS	EXP	STL or COP	23 21 13.02 or 23 21 13.04	414	H	1034		
CWR/CWS	CONDENSER WATER, RETURN/SUPPLY	65 OR GREATER	EXP	STL	23 21 13.02	414	H	1034		
RL/RS	REFRIGERANT, LIQUID/SUCTION	ALL	EXP/BUR	CU-ACR	23 23 00	Note 1	Note 1	Note 1		Note 1

NOTES:
1. Refer to Section 23 23 00, Refrigerant Piping, for testing requirements.

LEGEND:

Exposure	Pressure Test	Material
BUR Buried	H Hydrostatic	COP Copper
EXP Exposed	I In Service	CU-ACR Copper, Air Conditioning and Refrigeration
SUB Submerged	P Pneumatic	CPVC Chlorinated PVC
ENC Concrete Encased	NA Not Applicable	DI Ductile Iron
		FRP Fiberglass Reinforced Plastic
		GSP Galvanized Steel Pipe
		HDPE High Density Polyethylene
		PVC Polyvinyl Chloride
		SST Stainless Steel
		STL Carbon Steel
		NC STL Nickel-Copper Alloy Steel

END OF SECTION

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

SECTION 23 21 13.02		
CARBON STEEL PIPE AND FITTINGS-HYDRONIC WATER SERVICE		
Item	Size	Description
General	All	<p>Maximum Pressure:</p> <p>860 kPa; systems with threaded joints.</p> <p>1206 kPa; systems with Class 125 flanged fittings.</p> <p>1720 kPa; systems with Class 150 flanged fittings.</p> <p>2757 kPa; systems with Class 250 flanged fittings or welded joints.</p>
		<p>Maximum Temperature:</p> <p>121 degrees C.</p> <p>[110 degrees C; systems with grooved mechanical couplings pipe connections.]</p>
		Not for steam or steam condensate service.
Pipe	All	Do not use Type F ASTM A53 carbon steel.
	All	Pipe with threaded joints, pressure greater than 690 kPa and temperature greater than 104 degrees C: Carbon steel, ASTM A106 (seamless), Grade B; XS weight (Schedule 80).
	50 mm & smaller	Carbon steel, ASTM A106 (seamless), Grade B or ASTM A53/A53M, Grade B, Type E or Type S; STD weight (Schedule 40).
	65 mm through 250 mm	Carbon steel, ASTM A53/A53M, Grade B, Type E or Type S; STD weight (Schedule 40).
	300 mm through 600 mm	Carbon steel, ASTM A53/A53M, Grade B, Type E or Type S; STD weight (10 mm wall thickness).
Pipe Nipples	50 mm & smaller	<p>Carbon steel, ASTM A106 (seamless), Grade B.</p> <p>Dimensions to ASTM A733.</p> <p>Wall thickness to match adjoining pipe.</p>
Swage Nipples	12 mm – 100 mm	<p>Carbon steel, ASTM A234/A234M Grade WPB.</p> <p>Dimensions to MSS SP-95.</p> <p>Wall thickness to match adjoining pipe.</p> <p>Threaded ends not to exceed 50 mm NPS.</p>
Joints	50 mm & smaller	<p>Threaded: General Purpose (American), ASME B1.20.1.</p> <p>Socket Welded; AWS D1.1/D1.1M and ASME BPVC, Section IX.</p> <p>Flanged/Union: At valves and equipment, as required.</p>

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

SECTION 23 21 13.02		
CARBON STEEL PIPE AND FITTINGS-HYDRONIC WATER SERVICE		
Item	Size	Description
	65 mm & larger	Butt welded; AWS D1.1/D1.1M and ASME BPVC, Section IX. Grooved Mechanical Couplings: May use for hydronic water service but not for hydronic heating water service. Flanged: At valves and equipment.
Fittings	50 mm & smaller	Threaded: Malleable Iron Class 150 or Class 300, ASME B16.3, or Cast Iron Class 125 or Class 250, ASME B16.4.
	65 mm & larger	Butt Welded: Wrought carbon steel, ASTM A234/A234M, Grade WPB; meeting requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise. [Grooved End: Malleable iron ASTM A47/A47M or ductile iron ASTM A536 and ASTM A395, grooved ends to accept couplings without field preparation.]
Unions	50 mm & smaller	Threaded: Malleable iron, ASTM A197/A197M or ASTM A47/A47M, Class 150, Class 250, or Class 300, meeting requirements of ASME B16.3.
Flanges	50 mm & smaller	Socket-Weld or Threaded: Forged carbon steel, ASTM A105/A105M, Grade II, ASME B16.5, Class 150 or Class 300, 1.5 mm raised face.
	65 mm & larger	Butt-Welded: Forged carbon steel, ASTM A105/A105M, ASME B16.5, Class 150 or Class 300 slip-on or welding neck, 1.5 mm raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. [Grooved End: Adapter flange, malleable iron ASTM A47/A47M or ductile iron ASTM A536 and ASTM A395.]
Branch Connections	All	Full sized Fittings or Branch Connection Forgings, as indicated in Branch Connection Table. Fittings: See Fittings, this table. Branch Connection Forgings: Forged carbon steel, same material and weight/schedule as adjoining pipe, ASME B16.9 and MSS SP-97.

SECTION 23 21 13.02		
CARBON STEEL PIPE AND FITTINGS-HYDRONIC WATER SERVICE		
Item	Size	Description
Couplings	50 mm & smaller	Threaded: Malleable iron, ASTM A197/A197M or ASTM A47/A47M.
	[65 mm & larger]	[Grooved End: Rigid joint malleable iron, ASTM A47/A47M or ductile iron, ASTM A536 Grade 65-45-12 and ASTM A395 Grade 65-45-15.]
Bolting	All	Flanges: Carbon steel ASTM A307, Grade A hex head bolts, and ASTM A563 Grade A hex head nuts.
		[Grooved End Couplings: Carbon steel, zinc electroplated, ASTM A183 bolts and nuts, 758 mPa minimum tensile strength.]
Gaskets	All	Flanges: 1.5 mm thick, compressed inorganic fiber with nitrile binder, rated to 371 degrees C and 6900 kPa.
		[Grooved End Couplings: EPDM Grade E compound, ASTM D2000 to 110 degrees C.]
Thread Sealant	50 mm & smaller	Teflon based paste type; tapes are not allowed.

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

BRANCH CONNECTION TABLE																		
HEADER NOMINAL SIZE																		
SIZE	12	80	25	40	50	65	75	100	150	200	250	300	350	400	450	500	600	SIZE
	T	TR	TR	TR	TR	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	13
		T	TR	TR	TR	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	20
			T	TR	TR	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	25
				T	TR	TR	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	40
					T	TR	TR	TH	50									
						T	TR	TR	W	W	W	W	W	W	W	W	W	65
							T	TR	TR	W	W	W	W	W	W	W	W	75
								T	TR	TR	W	W	W	W	W	W	W	100
	LEGEND								T	TR	TR	W	W	W	W	W	W	150
	S = STUB-ON, PLAIN								T	TR	TR	W	W	W	W	W	W	200
	SO = SOCKOLET (NOTE 2)								T	TR	TR	W	W	W	W	W	W	250
	TH = THREDOLET								T	TR	TR	W	W	W	W	W	W	300
	T = FULL SIZED TEE								T	TR	TR	W	W	W	W	W	W	350
	TR = REDUCING TEE, W/ SWAGE OR REDUCER IF REQUIRED								T	TR	TR	W	W	W	W	W	W	400
	W = WELDOLET								T	TR	TR	W	W	W	W	W	W	450
									T	TR	TR	W	W	W	W	W	500	
	NOTES								T	TR	TR	W	W	W	W	W	W	600
	1. REINFORCE AS REQUIRED BY ASME B31.1																	
	2. THREDOLETS ARE REQUIRED FOR TEMPERATURE, INSTRUMENT, AND																	
	SAMPLE CONNECTIONS																	

BRANCH NOMINAL SIZE

END OF SECTION

SEWPCC B679 CHILLER REPLACEMENT PROJECT
TENDER NO. 929-2023

SECTION 23 21 13.03		
COPPER TUBE AND FITTINGS–HYDRONIC WATER SERVICE		
Item	Size	Description
General	All	Maximum Pressure: 1378 kPa. Not for steam or steam condensate service.
	50 mm and less	Maximum Temperature: 121 Degrees C.
	65 mm through 100 mm	Maximum Temperature: 93 Degrees C.
Tube	50 mm and less	Type L copper, seamless, conforming to ASTM B88, hard drawn.
	65 mm through 100 mm	Type L copper, seamless, conforming to ASTM B88, hard drawn.
Fittings	All	Wrought copper, solder joint, conforming to ASME B16.22.
Joints	All	Soldered: In accordance with AWS, Soldering Handbook or CDA, Copper Tube Handbook. Braze: In accordance with AWS, Brazing Handbook.
	65 mm and larger	Flanged: At valves and equipment, as required.
	[50 mm and smaller]	[Unions: At valves and equipment, as required.]
[Unions]	[50 mm and smaller]	[Unions: Wrought copper, solder joint, conforming to ASME B16.22.]
Flanges	All	Wrought copper, socket joint, faced and drilled to Class 150 ASME B16.24.
Branch Connections	All	Fittings (in accordance with this table). Mechanically Formed Tee Connections: Not allowed.
Bolting	All	ASTM A307, carbon steel, Grade A hex head bolts, and ASTM A563 Grade A hex head nuts.
Gaskets	All	1.5 mm thick nonasbestos compression type, full face; manufactured by Cranite or John Manville.
Filler Metals	All	Solder: Lead free with 95-5 tin antimony, 96-4 tin silver, or 94-6 tin silver in accordance with ASTM B32. Flux conforming to ASTM B813. Do not use cored solder. Braze: Classification BAg-1 (silver), conforming to AWS A5.8

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
 2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
 3. American Society of Mechanical Engineers (ASME):
 - a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
 - b. B31.5, Refrigeration Piping and Heat Transfer Components.
 4. American Welding Society (AWS):
 - a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
 - b. BRH, Brazing Handbook.
 5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
 6. National Electrical Manufacturers Association (NEMA).
 7. Underwriters Laboratories of Canada. (ULC).

1.2 DEFINITIONS

- A. ACR: Air conditioning and refrigeration.
- B. NRTL: National Recognized Testing Laboratory.

1.3 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings in 1/100 scale for refrigerant piping showing pipe and tube sizes, flow capacities location, elevations, fittings, accessories, and piping connections.
 2. Manufacturer's data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.
- B. Informational Submittals:
1. Welding certificates.
 2. Field quality control; test report.
 3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.4 QUALITY ASSURANCE

- A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

- B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.
- C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.
- B. Store piping in clean and protected area with end caps in place.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.
- B. Piping, 3 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.
- C. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

2.2 MISCELLANEOUS PIPING PRODUCTS

- A. Brazing Materials:
 - 1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
 - 2. Comply with AWS A5.8M/A5.8 for brazing filler materials.
- B. Refrigerant Specialties:
 - 1. Refrigerant Suction Line Filter-Dryer:
 - a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
 - b. Operating Temperature Rating: 115 degrees C.
 - c. Working Pressure: 3448 kPa.
 - d. Provide size recommended by refrigeration equipment manufacturer.
 - 2. Refrigerant Liquid Line Dryer:
 - a. Provide refrigerant liquid line filter-dryer for all units.
 - b. Operating Temperature Rating: 115 degrees C.
 - c. Working Pressure: 3448 kPa.
 - d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
 - e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
 - a. Shutoff Valves:
 - 1) Forged brass, packed, back seating winged seal cap, 140 degrees C temperature rating 3448 kPa working pressure.
 - 2) Maximum Opening Pressure: 3.45 kPag.
 - 3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
 - b. Manufacturers:
 - 1) Henry Technologies.
 - 2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
 - a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 13 mm conduit adapter, 121 degrees C temperature rating 3448 kPa working pressure.
 - b. Provide valve only if recommended by air-conditioning equipment manufacturer.
 - c. Manual Operator: Provide optional manual operator to open valve.
 - d. Manufacturers:
 - 1) Alco Controls Div.; Emerson Electric Co.
 - 2) Automatic Switch Co.
 - 3) Parker Hannifin Corp.
3. Thermostatic Expansion Valve:
 - a. Body Bonnet and Seal Cap: Forged brass or steel.
 - b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
 - c. Capillary and Bulb: Copper tubing filled with refrigerant.
 - d. Suction Temperature: 4.4 degrees C.
 - e. End Connections: Socket or flare.
 - f. Working Pressure: 4826 kPag.
 - g. Manufacturers:
 - 1) Henry Technologies.
 - 2) Parker Hannifin Corp.
 - 3) Danfoss Group Global.
4. Safety Relief Valve:
 - a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 - b. Seat Disk: Polytetrafluoroethylene.
 - c. Working Pressure: 3448 kPag.
 - d. Operating Temperature: 115 degrees C, maximum.
 - e. Manufacturers:
 - 1) Henry Technologies.
 - 2) Parker Hannifin Corp.
 - 3) Danfoss Group Global.

- D. Refer to Section 40 05 15, Piping and Cable Tray Support Systems, for piping shields and piping support requirements.

PART 3 EXECUTION

3.1 INSTALLATION OF PIPING SYSTEM

- A. Install piping products in accordance with manufacturer's written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.
- B. Install dryers on liquid and suction lines.
- C. Refrigerant Piping:
 - 1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
 - 2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
 - 3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
 - 4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
 - 5. Run piping as shown on Drawings, taking care to avoid interference with other piping, conduit or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
 - 6. Trapping of lines shall not be permitted, except where indicated.
 - 7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
 - 8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
 - 9. Install piping free of sags and bends.
 - 10. Install fittings for changes in direction and branch connections.
 - 11. Install refrigerant piping in protective conduit where installed belowground.
 - 12. Install accumulator in suction line near condensing unit.
 - 13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
 - 14. Slope refrigerant piping as follows:
 - a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - b. Install horizontal suction lines with a uniform slope downward to compressor.
 - c. Install traps and double risers to entrain oil in vertical runs.
 - d. Liquid lines may be installed level.
- D. Pipe Sleeves:
 - 1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
 - 2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 6 mm between outside of pipe or insulation, and inside wall of sleeves.
 - 3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
 - 4. Extend sleeves for insulated pipes 13 mm from wall faces and caulk to sleeve on both sides.
 - 5. Seal terminal ends of pipe insulation with mastic.

6. Extend sleeves for lines passing through floors 75 mm above finished floor slab and caulk to slab.
7. Seal penetrations through fire and smoke barriers according to Section 07 84 00, Firestopping.

E. Braze cap (seal) ends of piping when not connected to mechanical equipment.

3.2 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.3 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS *Brazing Handbook* Chapter "Pipe and Tube".
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BA_g, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.

F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

3.4 PIPE HANGERS

A. Refer to Section 40 05 15, Piping and Cable Tray Support Systems, for piping shields and piping support requirements.

3.5 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer's instructions where not otherwise indicated.

3.6 FIELD QUALITY CONTROL

A. General:

1. Notify Contract Administrator at least 48 hours before testing is performed.
2. Furnish equipment required for tests.

3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 2068 kPag minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 4137 kPag minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
 - a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-mm Hg absolute.
2. Evacuate system with vacuum pump until temperature of 2 degrees C is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 15 kPa.
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

3.7 ADJUSTING

A. General:

1. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
2. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
3. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
4. Perform following adjustments according to manufacturer's written instructions before operating refrigeration system:
 - a. Open shutoff valves in condenser water circuit.
 - b. Verify compressor oil level is correct.
 - c. Open compressor suction and discharge valves.
 - d. Open refrigerant valves, except bypass valves that are used for other purposes.
 - e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

- B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 31 13

METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
 2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
 3. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure Test).
 4. ASTM International (ASTM):
 - a. A36/A36M, Standard Specification for Carbon Structural Steel.
 - b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
 - c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
 - d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
 - e. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
 - f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
 - g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
 - h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
 - i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment.
 - j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
 - k. A1008/A1008M, Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - l. A1011/A1011M, Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
 - m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
 - o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
 - p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

- q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
- r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
- s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
- 5. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
- 6. National Fire Protection Association (NFPA):
 - a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
 - b. 90B Standard for the Installation of Warm Air Heating and Air Conditioning Systems.
 - c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
 - d. 259, Standard Test Method for Potential Heat of Building Materials.
 - e. 701, Standard Method of Fire Test for Flame Propagation of Textiles and Films.
- 7. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
 - a. Duct Construction Standards.
 - b. Guidelines for Seismic Restraints of Mechanical Systems.
 - c. Fibrous Glass Duct Construction Standards.
 - d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
 - e. HVAC Air Duct Leakage Test Manual.
- 8. Underwriters Laboratories Inc. (UL):
 - a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
 - b. 214, Tests for Flame-Propagation of Fabrics and Films.
 - c. 555, Standard for Safety Fire Dampers.
 - d. 555S, Standard for Safety Smoke Dampers.
 - e. Underwriters Laboratories of Canada (ULC).
 - f. National Fire Code of Canada.
 - g. National Building Code of Canada.

1.2 DEFINITIONS

- A. The following is a list of abbreviations which may be used in this section:
 - 1. L/s: litre per second.
 - 2. m/s: m per second.
 - 3. kg/m³: kg per cubic metre.
- B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this Section, the following definitions apply:
 - 1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
 - 2. Joints, duct surface connections including:
 - a. Girth joints.
 - b. Branch and subbranch intersections.
 - c. Duct collar tap-ins.
 - d. Fitting subsections.
 - e. Louver and air terminal connections to ducts.

- f. Access door, and access panel frames and jambs.
- g. Duct, plenum, and casing abutments to building structures.

1.3 SUBMITTALS

A. Action Submittals:

1. Product Data:

- a. Rectangular and Rigid Round Ductwork:
 - 1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
 - 2) SMACNA Figure Numbers for each shop fabricated item.
 - 3) Reinforcing details and spacing.
 - 4) Seam and joint construction details.
 - 5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
- b. Ductwork Accessories:
 - 1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
 - a) Fittings and volume control damper installation (both manual and automatic) details.
 - b) Sealing materials.
 - c) Dampers; include leakage, pressure drop, and maximum back pressure data.
 - d) Duct-mounted access panels and doors.
 - e) Flexible ducts.
 - f) Sheet metal fasteners.

2. Duct Fabrication Drawings:

- a. Drawn after actual job measurements are obtained.
- b. Drawn to a scale not smaller than 6 mm equals 300 mm, on drawing sheets same size as Contract Drawings.
- c. Include the following features:
 - 1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
 - 2) Duct layout, indicating pressure classifications, and sizes in plan view.
 - 3) Duct material and thickness.
 - 4) Fittings and volume control damper installation (both manual and automatic) details.
 - 5) Reinforcing details and spacing.
 - 6) Seam and joint construction details.
 - 7) Penetrations through fire-rated and other partitions.
 - 8) Duct accessories and control devices such as automatic dampers, airflow monitors, terminal units, smoke detectors, regulators, air distribution devices, etc.
 - 9) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
 - 10) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installation.

- 11) Coordination with ceiling suspension members.
- 12) Spatial coordination with other systems installed in same space with duct systems.
- 13) Coordination of ceiling- and wall-mounted access doors and panels required for access to dampers and other operating devices.
- 14) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
- 15) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment installed under Division 23, Heating, Ventilating, and Air-Conditioning (HVAC), Division 40, Process Integration, and Division 26, Electrical.

B. Informational Submittals:

1. Sound Attenuators Certified Test Data:
 - a. Dynamic insertion loss.
 - b. Self-noise power levels.
 - c. Static pressure loss.
 - d. Dimensions and weights.
2. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.4 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA duct construction standard relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Contract Administrator.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.5 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts:]

Item	Quantity
Fusible Links	10% of amount installed

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect ductwork from dirt, water, and debris. During storage on Jobsite, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.
- B. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- C. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.
- D. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.1 SCHEDULES

- A. Ductwork Schedule: Refer to Articles Supplements.

2.2 GENERAL

- A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.
- B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.
- C. Ductwork thinner than 26 gauge will not be allowed.
- D. Ductwork Interior Surfaces:
1. Smooth.
 2. No sheet metal parts, tabs, angles, screws, or other items may project into air ducts, unless otherwise specified.
 3. Seams and joints shall be external.

4. For ductwork that is required to be reinforced. Contractor may use either external or internal reinforcing.

2.3 SHEET METAL MATERIALS

- A. Construct metal duct systems from materials as indicated in Article, Ductwork Schedule.
- B. Where no specific ductwork materials are indicated in Specifications or on Drawings, galvanized steel sheet metal shall be basis of Contract.
- C. Galvanized Steel Ductwork (GS61):
 1. Comply with ASTM A653/A653M and ASTM A924/924M.
 2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
 3. Sheet Designation: CS Type B.
 4. Applicable Specification: ASTM A653/A653M.
 5. (Zinc) Coating Designation: G90.
 6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
 7. Provide mill-phosphatized finish for ducts which are scheduled to be painted.
 8. Provide sheet metal packaged and marked as specified in ASTM A700.
- D. Aluminum Ductwork (AL61):
 1. Comply with ASTM B209.
 2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
 3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or approved equal in accordance with B8.
- E. Stainless Steel Ductwork (SS64):
 1. Comply with ASTM A167, A176, A240/A240M, and ASTM A480.
 2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
 3. Gauge shall comply with SMACNA manual, unless specified otherwise.
 4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.
 5. With No.4 finish on exposed surface for ducts exposed to view.
- F. Stainless Steel Ductwork (Odorous Air) (SS66):
 1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
 2. Stainless Steel Sheet: Type 316/316L, unless indicated otherwise.
 3. Duct construction, including sheet metal gauge and reinforcements, shall comply with SMACNA Round Industrial Duct Construction Standards and SMACNA Rectangular Industrial Duct Construction Standards as applicable, unless specified otherwise.
 4. Finish: No. 2 B (cold-rolled, bright) finish. Welds shall be grinded smooth and passivated.
 5. Longitudinal fusion welded butt seam, flanged fittings, and joints with all seams welded.
 6. Elbows: Provide centerline equal to radius 1.5 times elbow diameter.
 7. Fittings: Continuously welded along seams.
 8. Duct Classification: Class 5 (Corrosive Fumes).
 9. Maintenance load provision: 113 kg.
 10. Duct support spacing shall not exceed a maximum of 4.5 m.

- G. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.
- H. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.4 DUCT SEALING MATERIALS

- A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.
- B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.
- C. Water-Based Sealants:
 - 1. Listed by manufacturer as nonflammable in wet and dry state.
 - 2. Manufacturers and Products:
 - a. Foster; Series 32.
 - b. Childers; CP-145A, 146.
 - c. Rectorseal; Airlok 181.

2.5 FIRESTOPPING

- A. Refer to Section 07 84 00, Firestopping.

2.6 DUCTWORK FASTENERS

- A. General:
 - 1. Rivets, bolts, or sheet metal screws.
 - 2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.
- B. Self-Drilling Screws:
 - 1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
 - 2. Aluminum Ductwork System:
 - a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel, complete with bonded metal and fiber washer for dielectric separation.
 - b. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Clark Craft Fasteners, Tonawanda, NY.
 - 3. Stainless Steel Ductwork System:
 - a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel.

- b. Manufacturers:
 - 1) DB Building Fasteners Inc., Santa Fe Springs, CA.
 - 2) Clark Craft Fasteners, Tonawanda, NY.
 - 3) UCAN Fastening Products.

2.7 DUCTWORK PRESSURE CLASS

- A. Construct duct systems to pressure classifications indicated in Ductwork Schedule
- B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 500 Pa pressure class shall be basis of Contract.

2.8 RECTANGULAR DUCTWORK

- A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.
- B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 480 mm and larger and are 20-gauge or less, with more than 1.0 square meter of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

2.9 RECTANGULAR DUCTWORK FITTINGS

- A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
- B. Elbows:
 - 1. Fit square-turn elbows with vane side rails.
 - 2. Shop fabricate double-blade turning vanes of same material as ductwork.
 - 3. Fabricate with equal inlet and outlet.
 - 4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
 - 5. Manufacturers and Products:
 - a. Elgen; All-Tight.
 - b. Duro-Dyne; Type TR.

2.10 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

- A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections. Field installed taps are not acceptable.

2.11 DUCTWORK HANGERS AND SUPPORTS

- A. General:
 - 1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
 - 2. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
 - 3. Wire hangers are not acceptable.

4. Hanger Spacing:
 - a. Ducts Up to 1500 mm in Largest Dimension: 3.0 m, maximum.
 - b. Ducts Over 1525 mm in Largest Dimension: 2.4 m, maximum.
- B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
 1. Galvanized Steel Ductwork:
 - a. Indoors: Carbon steel, zinc electroplated.
 - b. Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
 2. Aluminum Ductwork Indoors and Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
 3. Stainless Steel Ductwork Indoor and Outdoors: Stainless steel, same ASTM Grade as ductwork.
- C. Building Attachments:
 1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
 2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 100 mm thick.
 3. Upper Attachment (Concrete):
 - a. Drive pin fastener and expansion nail anchor may be used for ducts up to 450 mm maximum dimension.
 - b. Threaded stud fastener may be used for ducts up to 900 mm maximum dimension.
 - c. Concrete attachments shall be made of steel.
- D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fastener.
- E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.12 DUCTWORK FLEXIBLE CONNECTIONS

- A. General:
 1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
 2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
 3. Comply with NFPA 90A and 90B requirements.
 4. Airtight and waterproof.
- B. Materials:
 1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
 2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
 3. Fabric:
 - a. Comply with UL 214 (except teflon coated).
 - b. Woven polyester or nylon for most applications.
 - c. Woven fiberglass for high temperature applications.
 - d. Coating: Vinyl.

- C. Construction:
1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
 2. Standard Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 70 mm wide sheet metal.
 3. Extra Wide Metal Edged Connectors: Strip of fabric 145 mm wide attached to two strips of 70 mm wide sheet metal.
 4. Transverse Metal Edged Connectors: Strip of fabric 90 mm wide attached to two strips of 110 mm wide sheet metal.
- D. Manufacturers:
1. Ductmate; PROflex, Commercial.
 2. Ventfabrics.
 3. Duro-Dyne.

2.13 CEILING ACCESS DOORS

- A. Size: 750 mm by 750 mm.
- B. Finish in baked white enamel.
- C. Manufacturers:
1. Inryco Milcor.
 2. Krueger.

2.14 DUCT INSPECTION DOORS

- A. General:
1. Insulated, gasketed, and at least 375 mm by 375 mm when duct dimensions are large enough.
 2. On ductwork where largest side dimension is less than 400 mm, furnish inspection doors at least 200 mm by 200 mm.
 3. Complete with necessary hardware.
 4. Fabricated of same material as ductwork.
- B. Round Spin-in Type Access Doors:
1. Size: 450 mm and 600 mm diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
 2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
 3. Manufacturers:
 - a. Flexmaster, Inspector Series.
- C. Casing and Plenum Access Doors:
1. Size: 1425 mm high by 600 mm wide minimum where possible.
 2. Complete with hardware, hinges, seals, and latch handles.
 3. Latch Handles: Ventlock, Series No. 260.
 4. Hinges: Venlock, Series No. 200 and No. 300.

- D. Manufacturers:
 - 1. Ventlock.
 - 2. Flexmaster.
 - 3. Duro-Dyne.

2.15 MANUAL DAMPERS

- A. Butterfly Manual Dampers:
 - 1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
 - 2. Align operating handle with damper blade.
 - 3. Provide 50 mm standoff bracket for insulated duct systems.
 - 4. Damper Manufacturers:
 - a. Ruskin.
 - b. American Warming and Ventilating.
 - 5. Operator Manufacturers:
 - a. Accessible Ductwork: Ventlok; Type 620 or 635.
 - b. Accessible Insulated Ductwork: Ventlok; Type 639.
 - c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.
- B. Manual Opposed-Blade Balancing Dampers:
 - 1. Externally operated gang airfoil, damper blades.
 - 2. Fabricate from same material as ductwork.
 - 3. Stainless steel or nylon sleeve bearings.
 - 4. Construction shall have interlocking edges and maximum 250 mm blade width.
 - 5. Manufacturers and Products:
 - a. Ruskin; CD102.
 - b. American Warming & Ventilating; Model VC-31.

2.16 BACK DRAFT DAMPERS

- A. General:
 - 1. Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.
- B. Steel Frame, Nonmetallic Blades:
 - 1. Fabrication:
 - a. Frame: 2 inches by minimum 51 mm by minimum 1.6 mm galvanized steel with windstops to reduce backflow.
 - b. Blades:
 - 1) Style: Single piece, independent.
 - 2) Action: Parallel.
 - 3) Material: Noncombustible, neoprene coated fiberglass.
 - 4) Orientation: Horizontal.
 - 5) Width: Maximum 152 mm.
 - c. Rear Bird Screen: Galvanized expanded metal.

- d. Mounting:
 - 1) Suitable for mounting in vertical or horizontal airflow up positions.
 - 2) Configured for positions as shown on Drawings.
 - e. Finish: Factory applied air-dried epoxy paint on steel damper parts.
 - 2. Performance Data:
 - a. Temperature Rating: Withstand minus minus 34 degrees to 93 degrees C.
 - b. Maximum Back Pressure: 1.0 kPa.
 - c. Maximum System Air Velocity: 5.1 m/s.
 - d. Maximum Spot Air Velocity: 6.1 m/s.
 - 3. Manufacturers and Products:
 - a. Ruskin; Model NMS2.
 - b. Vent Products, Co.
- C. Aluminum, Counterbalanced, Heavy Duty:
- 1. Fabrication:
 - a. Frame: 57 mm by minimum 3.2 mm 6063-T5 extruded aluminum channel with front flange and rear flange and galvanized steel braces at mitered corners.
 - b. Blades:
 - 1) Style: Single piece, overlap frame.
 - 2) Action: Parallel.
 - 3) Orientation: Horizontal.
 - 4) Material: Minimum 1.8 mm 6063-T5 extruded aluminum.
 - 5) Width: Maximum 152 mm.
 - c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
 - d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
 - e. Linkage: Minimum 13 mm aluminum tie bar with stainless steel pivot pins mounted on blades.
 - f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
 - g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
 - h. Mounting:
 - 1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
 - 2) Configured for positions as shown on Drawings.
 - i. Finish: Factory applied air-dried epoxy paint on all damper parts.
 - 2. Performance Data:
 - a. Temperature Rating: Withstand minus 40 to 93 degrees C.
 - b. Maximum Back Pressure: 4 kPa.
 - c. Maximum Air Velocity: 12.7 m/s.
 - d. Operation of Blades:
 - 1) Start to Open: 2.5 Pa.
 - 2) Fully Open: 12.5 Pa.
 - e. Pressure Drop: Maximum 38 Pa at 7.6 m/s through 600 mm by 600 mm damper.
 - 3. Manufacturer and Product: Ruskin; Model CBD6.

2.17 FIRE DAMPERS

- A. Duct Mounted Fire Dampers in Fire Walls with Rating of 2 Hours or Less:
1. NFPA 90A rated for 1-1/2-hour service.
 2. Blades, frame, and mounting angles same material as ductwork.
 3. Accordion style folded blades.
 4. 74 degrees C fusible link.
 5. Approved for installation with 2-hour fire rating.
 6. Rated, manufactured, tested, and approved in accordance with UL 555.
 7. Blades out of airstream when open (Type B or CR) except as noted on the drawings.
 8. Furnish with sleeved frame for duct connections.
 9. Labeled for use in static mode.
 10. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
 11. Corrosive Service Dampers: Type 316 stainless steel.
 12. Manufacturers and Products:
 - a. Ruskin; DIBD20, Type B.
 - b. Nailor-Hart; Model 0130, Type B.
- B. Duct Mounted Fire Dampers in Walls with 3-Hour or Greater Fire Rating:
1. NFPA 90A rated for 3-hour service.
 2. Blades, frame, and mounting angles.
 3. Accordion style folding blades. Air foil type blades for multiblade dampers.
 4. 74 degrees C fusible link.
 5. Approved for installation in 4-hour wall.
 6. Rated, manufactured, tested, and approved in accordance with UL 555.
 7. Blades out of airstream when open (Type B).
 8. Furnish with sleeved frame for duct connection.
 9. Labeled for use in static mode.
 10. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
 11. Corrosive Service Dampers: Type 316 stainless steel.
 12. Manufacturers and Products:
 - a. Ruskin; DIBD23, Type B.
 - b. Nailor-Hart; Model 0530, Type B.

2.18 EXTERNAL DUCT INSULATION

- A. Refer to Section 23 07 00, HVAC Insulation.

2.19 MISCELLANEOUS ACCESSORIES

- A. Sheet Metal Plenums:
1. Fabricate from minimum 18-gauge metal of same material as ductwork.
 2. Brace with frame of same material for rigidity.
 3. Line with sound attenuation material where indicated.
- B. Louver and Grille Blank-Off Sections:
1. Fabricate from 20-gauge sheets of same material as louver/grille.
 2. Line with sound attenuation/insulating material.

3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

C. Auxiliary Drain Pans:

1. Dimensions: Minimum 150 mm larger in both dimensions than equipment it is serving and 51 mm high, minimum.
2. Construction: 16-gauge galvanized steel with brazed joints. Pans shall be watertight and have hemmed edges.
3. Drain Connection:
 - a. Minimum 25 mm or as shown on Drawings.
 - b. Locate at lowest point of drain pan.
 - c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

D. Accessories Hardware:

1. Instrument Test Holes:
 - a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
 - b. Size to allow insertion of pitot tube and other testing instruments.
 - c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
 - a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
 - b. Provide in sizes from 75 mm to 450 mm to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

2.20 REMOVABLE INSECT SCREENS

A. General

Frame	- extruded aluminum channel, 65 mm x 18 mm
	- extruded aluminum angle, 40 x 25 x 3 mm screen frame retainers
Screen Retention Frame	- extruded aluminum with rubber retainer gasket
Insect Screen	- 18 x 14 mesh, .011 gauge, grade 304 stainless steel
Max. Section Size	- 1.5 m x 1.5 m

B. Mounting

Ducting Mounting	- "slide out" screen
	- rubber gasket around screen slot in frame
	- cast aluminum handle rigidly attached to screen retention frame. 2 handles per screen section

Face Mounting	- "lift and remove" screen
	- nylon finger pulls, 25 x 30 x 1.5 mm mounted in screen retention frame

- C. In locations where removable insect screen is associated with air control dampers, supply the two units as an integrated, factory assembled unit.
- D. Manufacturer
 - 1. T.A. Morrison & Company Inc. Series 6000.

2.21 DUCTWORK IDENTIFICATION

- A. Painted Identification Materials:
 - 1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 32 mm high letters for ductwork and not less than 20 mm high letters for access door signs and similar operational instructions.
 - 2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
 - 3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.
- B. Plastic Duct Markers
 - 1. General: Provide manufacturer's standard laminated plastic, color coded duct markers. Conform to the following color code:
 - a. Black text on yellow background: Odorous Air.
 - b. White text on blue background: Services other than hazardous exhaust and odorous air.
 - c. For other hazardous exhausts, use colors and designs recommended by ASME A13.1.
- C. Nomenclature: Include the following:
 - 1. Direction of air flow.
 - 2. Duct service (supply, return, exhaust).
 - 3. Duct origin (from).
 - 4. Duct destination (to).
 - 5. Design L/s.
- D. Manufacturers:
 - 1. W.H. Brady, Co.
 - 2. Seton Identification Products.
 - 3. Craftmark.
 - 4. Brimar Industries, Inc.

PART 3 EXECUTION

3.1 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 3.2 mm misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork run above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
 - a. For uninsulated ducts, allow 25 mm clearance between duct and sleeve, except at grilles, registers, and diffusers.
 - b. For insulated ducts, allow 25 mm clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
 - a. Minimum 102 mm wide on each side of walls or floors where sleeves or prepared openings are installed.
 - b. Fit collars snugly around ducts and insulation.
 - c. Same gauge and material as duct.
 - d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
 - e. Use fasteners with maximum 152 mm centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

- D. Concealment:
1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
 2. Do not encase horizontal runs in solid partitions, except as specifically shown.
 3. Limit clearance to 25 mm where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.
- E. Coordination with Other Trades:
1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
 2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
 3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
 4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.
- F. Shower Room and Toilet Room Exhaust Ductwork:
1. Joints and Seams: Seal watertight.
 2. Slope branch ducts downward to grille.
- G. Fume Hood, Laboratory, and Chlorine Room Exhaust Ductwork:
1. Seal joints and seams with chemical-resistant mastic.
 2. Rivet butt joints with minimum of eight pop rivets.

3.2 RECTANGULAR DUCTWORK

- A. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
- B. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

3.3 RECTANGULAR DUCTWORK FITTINGS

- A. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
- B. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
- C. Make offsets with maximum angle of 45 degrees.
- D. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

3.4 RECTANGULAR DUCTWORK TRANSVERSE JOINTS

- A. Install each run with a minimum of joints.
- B. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.

- C. Mechanical Joint Option:
 - 1. Construct transverse joints with Ductmate 25/35 duct connector systems, W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system.
 - 2. When using W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
 - 3. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
 - 4. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
 - 5. Conform to SMACNA Class A sealing requirements.

3.5 INSULATED FLEXIBLE DUCT

- A. Installation:
 - 1. Where shown, between branch duct and ceiling diffusers and grilles.
 - 2. Without sags, kinks, sharp offsets, or elbows.
 - 3. As straight and taut as possible.
- B. Connection: Connect flexible ductwork to round collars, air distribution devices, and terminal units in accordance with flexible duct manufacturer's recommendations.
- C. Length:
 - 1. Maximum length of low-pressure flexible duct (construction pressure class up to 500 Pa) to be 2400 mm.
 - 2. Maximum length of medium pressure flexible duct (construction pressure class up to 1000 Pa) to be 2400 mm.
- D. Flexible ductwork shall not pass through wall, floor, or fire resistant rated assembly.

3.6 DUCTWORK HANGERS AND SUPPORTS

- A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.
- B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.
- C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.
- D. Support horizontal ducts within 610 mm of each elbow and within 1220 mm of each branch intersection.
- E. Support vertical ducts at maximum interval of 4880 mm and at each floor.
- F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.
- G. In new construction, install concrete insert prior to placing concrete.

3.7 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.8 DAMPERS

A. General:

1. Inspection:
 - a. Inspect areas to receive dampers.
 - b. Notify Contract Administrator of conditions that would adversely affect installation or subsequent utilization of dampers.
 - c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

D. Fire Dampers:

1. At ceiling grille and diffuser fire dampers, provide thermal blankets where required by local authorities.
2. Install 1-1/2-hour rated, unless otherwise indicated, at locations shown and in accordance with SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

3.9 ACCESS DOORS

- A. Ceilings:
 - 1. Install in nonaccessible ceilings below each electric duct heater, booster coil, motorized damper, terminal unit, smoke detector, and fire damper.
- B. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
 - 1. Duct mounted fire damper.
 - 2. Duct mounted smoke or ionization detector.
 - 3. Electric duct heater.
 - 4. Booster coil.
 - 5. Humidifier.
 - 6. Motorized damper.
 - 7. Sail switch.
 - 8. Turning vane.
 - 9. Volume damper.
 - 10. Automatic damper.
 - 11. Temperature controller.
 - 12. Coil, on both upstream and downstream side.

3.10 EXTERNAL DUCT INSULATION

- A. Refer to Section 23 07 00, HVAC Insulation.

3.11 MISCELLANEOUS ACCESSORIES

- A. Auxiliary Drain Pans:
 - 1. Under equipment for which pan is shown on Drawings and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
 - 2. Route drain lines to nearest floor or hub drain independent of any other drain.
 - 3. Slope drain pans toward drain connection to promote drainage.
 - 4. Louver and Grille Blank-off Sections: Attach airtight to louver or grille and install to allow for easy removal.
- B. Inspection Plates and Test Holes:
 - 1. Where required in ductwork for balance measurements.
 - 2. Test holes shall be, airtight and noncorrosive with screw cap and gasket.
 - 3. Extend cap through insulation.

3.12 DUCT SEALING

- A. Seal duct seams and joints as follows:
 - 1. As indicated on Ductwork Schedule
- B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

- C. Seal externally insulated ducts prior to insulation installation.
- D. Provide additional duct sealing as required to comply with Article - Ductwork Leakage Testing.
- E. Seal all audible leak.

3.13 FIRESTOPPING

- A. Refer to Section 07 84 00, Firestopping.

3.14 PAINTING OF DUCTWORK

- A. Refer to Section 09 90 00, Painting and Coating

3.15 DUCTWORK LEAKAGE TESTING

A. General:

1. Tests shall be conducted on completed ductwork systems.
2. Testing of partial installations or limited sections of ductwork will not be acceptable.
3. All ductwork leakage test procedures and results shall be submitted to Contract Administrator for review.
4. Contract Administrator shall retain the right to witness some or all ductwork leakage testing procedures.
5. Contractor shall notify Contract Administrator in writing at least 5 working days prior to ductwork testing.

B. Leakage Criteria:

1. Assemble and install ductwork with maximum leakage limited as follows:
2. Constant Volume Systems:
 - a. Supply Ductwork:
 - 1) Operating Pressure: 0- to 500 Pa
 - a) Allowable Leakage: 2 percent of design airflow.
 - 2) Operating Pressure: 750 Pa and over.
 - a) Allowable Leakage: 1 percent of design airflow.
 - b. Return Ductwork:
 - 1) Operating Pressure: All.
 - 2) Allowable Leakage: 2 percent of design airflow.

C. Leakage Testing Method:

1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain system design static pressure during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.16 BALANCING AND TESTING OF AIR SYSTEMS

- A. Perform testing in accordance with the requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.17 PROTECTION OF INSTALLED WORK

- A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.
- B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.18 CLEANING

- A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.
- B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.
- C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

3.19 SUPPLEMENTS

- A. The supplements listed below, following End of Section, are a part of this Specification:
 - 1. Section 23 31 13.01, Ductwork Schedule.

END OF SECTION

DUCTWORK SCHEDULE						23 31 13.01
SYSTEM	SERVICE	SECTION	SMACNA DUCT CONSTRUCTION CRITERIA			APPLICABLE REMARKS
			PRESSURE CLASS (Pa)	MATERIALS OF CONSTRUCTION	SEAL CLASS	
EF-686	EXHAUST AIR	FROM EXHAUST GRILLE TO FAN	-500	GALVANIZED STEEL	A	
EXHAUST FAN	EXHAUST AIR	FROM FAN TO OUTLET	-500	GALVANIZED STEEL	A	
REMARKS:						
A:						
B:						

SECTION 23 34 00

HVAC FANS

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration – Balance Quality Requirement of Rigid Rotors – Part 1, Determination of Permissible Residual Unbalance.
 2. Air Movement and Control Association International (AMCA):
 - a. 99, Standards Handbook.
 - b. 201, Fans and Systems.
 - c. 203, Field Performance Measurement of Fan Systems.
 - d. 210, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
 - e. 300, Reverberant Room Method for Sound Testing of Fans.
 - f. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
 3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
 4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): HVAC Applications Manual.
 - a. 52.2 Method of Testing General Ventilation Air – Cleaning Devices for Removal Efficiency by Particle Size.
 - b. HVAC Applications Manual.
 5. ASTM International (ASTM):
 - a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
 - b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
 - c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
 - d. D3363, Standard Test Method for Film Hardness by Pencil Test.
 - e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
 - f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 6. National Electrical Manufacturers Association (NEMA): MG 1, Motors and Generators.
 7. National Fire Protection Association (NFPA): 45, Fire Protection for Laboratories Using Chemicals.
 8. Occupational Safety and Health Act (OSHA).
 9. Society for Protective Coatings (SSPC):
 - a. SP 3, Power Tool Cleaning.
 - b. SP 5, Joint Surface Preparation Standard White Metal Blast Cleaning.
 - c. SP 6, Joint Surface Preparation Standard Commercial Blast Cleaning.
 - d. SP 10, Joint Surface Preparation Standard Near-White Blast Cleaning.
 10. Underwriters Laboratories Inc. (UL/ULC): 507, Electric Fans.

1.2 DEFINITIONS

A. The following is a list of abbreviations which may be used in this Section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. kW: Kilowatt.
7. ODP: Open Drip Proof.
8. SWSI: Single Width, Single Inlet.
9. TEFC: Totally Enclosed, Fan Cooled.
10. UV: Ultra Violet
11. XP: Explosion Proof.

1.3 SUBMITTALS

A. Action Submittals:

1. Provide for all products specified, as follows:
 - a. Identification as referenced in Contract Documents.
 - b. Manufacturer's name and model number.
 - c. Descriptive specifications, literature and drawings.
 - d. Dimensions and weights.
 - e. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
 - f. Fan Curves:
 - 1) Performance Curves Indicating:
 - a) Relationship of flow rate to static pressure for various fan speeds.
 - b) Brake horsepower curves.
 - c) Acceptable selection range (surge curves, maximum revolutions per minute, etc).
 - d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
 - g. Capacities and ratings.
 - h. Construction materials.
 - i. Fan type, size, class, drive arrangement, discharge, rotation and bearings.
 - j. Wheel type, diameter, revolutions per minute, and tip speed.
 - k. Motor data.
 - l. Power and control wiring diagrams, including terminals and numbers.
 - m. Vibration isolation.
 - n. Factory finish system.
 - o. Color selection charts where applicable.
 - p. Corrosion protection coating product data.
 - q. Fiberglass Material: Statement of resins and reinforcing proposed for use.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions.

3. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Contractor Field Services, for the following:
 - a. Motors specified to be premium efficient type.
 - b. FRP fans.
4. Component and attachment testing seismic certificate of compliance.
5. Test reports.
6. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.4 QUALITY ASSURANCE

- A. Performance Ratings: Tested in accordance with AMCA 210.
- B. Sound Ratings: Tested in accordance with AMCA 300.
- C. Fabrication: In accordance with AMCA 99.

1.5 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts:

Item	Quantity
Vee Belts	One complete set per unit

- B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.1 EQUIPMENT SCHEDULES

- A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Article, Supplements.

2.2 SPARK RESISTANT CONSTRUCTION

- A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.
- B. Alternative fans can also be FRP with graphite liner and grounding.

2.3 NAMEPLATES

- A. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.4 OPERATING LIMITS

- A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408-69.

2.5 ACOUSTICAL LEVELS

- A. Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

2.6 FAN DRIVES

- A. Furnish multiple drive belts where motor horsepower is 1.5 kW or larger.
- B. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
- C. Sheaves shall be capable of providing 150 percent of motor horsepower.
- D. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
- E. Furnish motors for V-belt drives with adjustable rails or bases.
- F. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.
- G. Motors 15 kW or Smaller:
 - 1. Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
 - 2. Final operating point shall be at approximate sheave midpoint.
- H. Motors Larger than 15 kW: Fixed-pitch sheaves.
- I. All motors driven by VFDs to have a shaft grounding ring installed:
 - 1. Current rating: 10 amps high frequency current up to 100 Mhz.
 - 2. Continuous fiber ring with frequency current up to 100 Mhz.
 - 3. Fiber wear: Less than 0.03 mm per 10,000 hours, designed for 200,000 plus hours of operation.
 - 4. Maintenance Requirements: None.
 - 5. Shaft grounding ring may be installed by the motor manufacturer or the fan manufacturer.
 - 6. Shaft grounding ring to be installed in accordance with manufacturer's recommendations.
 - 7. Acceptable Products:
 - a. AEGIS® Shaft Grounding Ring kit.
 - b. Or integral to motor assembly.
- J. Drive Adjustment:
 - 1. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
 - 2. Provide trial and final sheaves, as well as drive belts, as required.
- K. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
- L. Belt and Shaft Guards:
 - 1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA, and Province of Manitoba requirements.
 - 2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.

3. Bright yellow finish.

M. Provide speed test openings at shaft locations.

2.7 FINISHES

- A. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
 - 1. Parts cleaned and chemically pretreated with a phosphatizing process.
 - 2. Alkyd enamel primer.
 - 3. Air-dry enamel topcoat.
- B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
- C. Stainless Steel Parts: Finished smooth and left unpainted.
- D. Fiberglass Parts: Finished in accordance with Paragraph, Fiberglass Material.

2.8 INLINE FAN, CENTRIFUGAL, SQUARE

- A. General:
 - 1. Factory-assembled, centrifugal, inline fan, square housing configuration; including housing, fan wheel, drive assembly, motor and accessories.
 - 2. Bearing AMCA Certified Ratings Seal for sound and air performance.
- B. Housing:
 - 1. Construction: All aluminum.
 - 2. Integral duct collars.
 - 3. Removable side panels, for ease of service.
 - 4. Field convertible for side air discharge configuration.
 - 5. Predrilled universal mounting brackets for vertical or horizontal installation.
 - 6. Inlets: Aerodynamic aluminum venturi.
 - 7. Corrosion-resistant fasteners.
 - 8. Drive belt and bearings separated from air stream by enclosure.
- C. Wheel:
 - 1. Centrifugal backward inclined, 100 percent aluminum construction.
 - 2. Precision machined cast aluminum hub.
 - 3. Die-formed airfoil or backward inclined blades.
 - 4. Matched to inlet venturi.
 - 5. Attached to fan shaft with split taper lock bushing.
- D. Shaft, Bearings, Drive:
 - 1. Shafts:
 - a. Turned, ground and polished carbon steel.
 - b. Keyed for sheave installation.

2. Bearings:
 - a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style, relubricable or sealed type.
 - b. Selected for average life (ABMA 9 L₅₀) of not less than 200,000 hours operation at maximum cataloged operating speed.
 3. Drives:
 - a. In accordance with Article, Drives.
 - b. Factory set to the specified fan revolutions per minute.
 - c. Type: As scheduled in Equipment Schedule.
 - d. Arrangement: As scheduled in Equipment Schedule.
- E. Accessories: Provide as scheduled in Equipment Schedule as follows:
1. Belt Guard: Sheet metal construction, OSHA type.
 2. Motor and Drive Cover:
 - a. Factory fabricated, OSHA type.
 - b. Sheet metal construction, same material as fan housing.
 - c. Vented, openings sufficient size for proper motor cooling.
 - d. Fan speed controller.
 3. Gravity Backdraft Damper: Galvanized steel frame, aluminum blades, brass pivot pins, neoprene seals on damper blade edges, gravity operation, and adjustable counterweight.
 4. Motorized Damper: Galvanized steel frame, aluminum blades, neoprene seals on damper blade edges, 120V operator, minimum NEMA 4X.
 5. Insulated Housing: Fiberglass insulation, 25 mm-thick, neoprene coated, on interior of housing.
 6. Filter Box:
 - a. Refer to Article Filter Housings.
 - b. Attached to fan inlet.
 - c. Box construction to match fan housing.
 - d. Integral duct collars.
 - e. Access Doors: Hinged and latched.
 - f. Filter Media: 25 mm pleated disposable type.
 7. Inlet Screen: Removable 25 mm mesh screen, aluminum construction, overexposed inlets.
 8. Disconnect: NEMA 4X. Supplied and installed on the field by electrical contractor as shown on the drawings.
 9. Single Side Discharge: Package consisting of side duct connection collar and rear-discharge blank-off panel.
 10. Dual Side Discharge: Package consisting of side duct connection collars and rear-discharge blank-off panel.
 11. Bearing Lubrication Lines:
 - a. Extended to outside of fan housing.
 - b. Terminate with zerk fittings.
 12. Spark Resistant Construction Classification: AMCA 99-0401 Type as scheduled.
 13. Corrosion Protection Coating:
 - a. Provide factory-applied corrosion protection coating on these fan components:
 - 1) Wheel.
 - 2) Housing.
 - 3) Accessories.

- 4) Interior surfaces in contact with airstream.
- b. Coating system shall be as scheduled in fan Equipment Schedule, and shall be in accordance with Article, Corrosion Protection Coating.

F. Manufacturers and Products:

1. Greenheck; Model BSQ-HP (Belt); SQ (Direct).
2. Twin City Fan; Model BSI (Belt); Model DSI (Direct).
3. Loren Cook; Model SQNB (Belt); SQND (Direct).
4. ACME; Centri-Master Model XB Series (Belt); XD (Direct).

2.9 CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this Section.
2. Quality Control:
 - a. Verify dry film thickness before final baking.
 - b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning: Clean parts to be coated as follows:
 - a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
 - b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
 - c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Enamel:

1. Material: Alkyd modified urea-melamine single component baking enamel.
2. Surface Preparation: Clean surface to SSPC-SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 149 degrees C.
5. Finished Thickness: 25 microns to 50 microns dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
 - a. Impact Resistance: 0.115 kg meter, ASTM D2794 test method.
 - b. Pencil Hardness: 2H, ASTM D3363 test method.
 - c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - d. Service Temperature: Maximum 110 degree C, continuous.

C. Baked Polyester:

1. Material: Polyester.
2. Surface Preparation: Sandblast surface to SSPC-SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 204 degrees C.
5. Finished Thickness: 38 microns to 62 microns dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - c. Impact Resistance: 1.15 kg meter, ASTM D2794 test method.

- d. Pencil Hardness: 2H, ASTM D3363 test method.
 - e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - f. Service Temperature: Maximum 110 degrees C, continuous.
- D. Air-Dry Epoxy:
- 1. Material: Two-part catalyzed epoxy.
 - 2. Surface Preparation: Clean surface to SSPC-SP 3.
 - 3. Application: Standard air-pressurized spray equipment.
 - 4. Curing: Air dry.
 - 5. Finished Thickness: 100 microns to 150 microns dry film thickness.
 - 6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
 - b. Pencil Hardness: H-2H, ASTM D3363 test method.
 - c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - d. Service Temperature: Maximum 65 degrees C, continuous.
- E. Baked Epoxy:
- 1. Material: Epoxy.
 - 2. Surface Preparation: Sandblast surface to SSPC-SP 10.
 - 3. Application: Electrostatic spray.
 - 4. Curing: Oven baked at a metal temperature not to exceed 204 degrees C.
 - 5. Finished Thickness: 62 microns to 88 microns dry film thickness.
 - 6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - c. Impact Resistance: 1.15 kg meter, ASTM D2794 test method.
 - d. Pencil Hardness: 2H, ASTM D3363 test method.
 - e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - f. Service Temperature: Maximum 110 degrees C, continuous.
- F. Air Dry Phenolic:
- 1. Material:
 - a. Phenolic resin, Heresite VR-500 Series or approved equal in accordance with B8.
 - b. For outdoor applications, apply an UV resistant topcoat, Heresite UC-5500 or approved equal in accordance with B8.
 - 2. Surface Preparation: Sandblast surface to SSPC-SP 6.
 - 3. Application: Standard air-pressurized spray equipment.
 - 4. Curing: Air dry.
 - 5. Finished Thickness: 100 microns to 150 microns dry film thickness.
 - 6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 500-hour duration, ASTM B117 test method.
 - b. Humidity Resistance: Minimum 500-hour duration, ASTM D2247 test method.
 - c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - d. Service Temperature: Maximum 82 degrees C, continuous.

G. Baked Phenolic:

1. Material: Phenolic resin, Heresite P-403 or approved equal in accordance with B8.
2. Surface Preparation: Sandblast surface to SSPC-SP 5.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 204 degrees C.
5. Finished Thickness: 125 microns to 175 microns dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - c. Impact Resistance: 1.15 kg meter, ASTM D2794 test method.
 - d. Pencil Hardness: 2H, ASTM D3363 test method.
 - e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
 - f. Service Temperature: Maximum 121 degrees C, continuous.

H. Baked Epoxy Phenolic:

1. Material:
 - a. Baking cross-linked epoxy-phenolic.
 - b. For outdoor applications, apply an UV resistant topcoat.
2. Surface Preparation: Sandblast surface to SSPC-SP 5.
3. Application: Electrostatic or conventional compressed air spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 204 degrees C.
5. Finished Thickness: 150 microns to 200 microns dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
 - a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
 - b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
 - c. Impact Resistance: 1.84 kg meter, ASTM D2794 test method.
 - d. Pencil Hardness: 3H, ASTM D3363 test method.
 - e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
7. Service Temperature: Maximum 177 degrees C, continuous.

2.10 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.

7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.
9. Service Factor: 1.15.

2.11 ACCESSORIES

- A. Equipment Identification Plates: Furnish 16-gauge Type 304 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 10 mm high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown on Drawings.
- B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 45 kg.

2.12 SOURCE QUALITY CONTROL

- A. General:
 1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
 2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
 3. Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA 203, Appendix L.
- B. Testing Provisions:
 1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
 2. Center punch fan shaft to accommodate tachometer readings.
- C. Acoustical Levels:
 1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
 2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.
- D. Balancing:
 1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
 2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.
- E. Vibration Test:
 1. Each fan furnished with a 3.7 kW or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
 2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
 - a. Belt Drive (except Vane Axial): 0.38 cm per second peak velocity.
 - b. Belt Drive Vane Axial: 0.2 cm per second peak velocity.
 - c. Direct Drive: 0.2 cm per second peak velocity.

3. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install fans level and plumb.
- B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.
- C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- D. Scroll Drains: Pipe drain connection through running trap to floor drain.
- E. Labeling:
 1. Label fans in accordance with Article, Accessories.
 2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.
- F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.
- G. Equipment Support and Restraints:
 1. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment.
 2. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
- H. Connections
 1. Refer to Section 23 31 13, Metal Ductwork and Accessories.
 2. Isolate duct connections to fans.
 3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.2 FIELD QUALITY CONTROL

- A. Functional Tests:
 1. Verify blocking and bracing used during shipping are removed.
 2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
 3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 4. Verify that cleaning and adjusting are complete.
 5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
 6. Reconnect fan drive system; align and adjust belts and install belt guards.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

- B. Performance Tests:
 - 1. Starting Procedures:
 - a. Energize motor and adjust fan to indicated revolutions per minute.
 - b. Measure and record motor voltage and amperage.
 - 2. Operational Test:
 - a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
 - c. Test and adjust control safeties.
 - d. Replace damaged and malfunctioning controls and equipment.

3.3 MANUFACTURER'S SERVICES

- A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Contractor Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of the City's Manitoba personnel for specified component, subsystem, equipment, or system.
- B. Manufacturer's Representative: Present at Site or classroom designated by the City, of Manitoba, for minimum person-days listed below, travel time excluded:
 - 1. One person-day for installation assistance and inspection.
 - 2. One person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
 - 3. One person-day for prestartup classroom or Site training.
 - 4. One person-day for facility startup.
 - 5. One person-day for post-startup training [of the City's personnel.]
 - 6. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by the City and Contract Administrator.
- C. Refer Section 01 43 33, Contractor Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Balancing:
 - 1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
 - 2. Replace fan and motor sheaves as required to achieve design airflow.

- E. Vibration Testing:
 - 1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
 - 2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.5 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.
- B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

3.6 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification.
 - 1. 23 34 00.01, Fans.

END OF SECTION

FANS				23 34 00.01			
SYMBOL				EF-B682			
LOCATION				GENERATOR ROOM			
TYPE				INLINE CENTRIFUGAL SQUARE			
FAN DATA	AIRFLOW	MAX	L/s	925			
		@ SP	Pa	162			
	SPEED	RPM		1298			
	DRIVE TYPE			BELT			
	WHEEL	TYPE		BI			
	MAXIMUM	kW		0.36			
SOUND DATA	SOUND POWER LEVEL dB (RE 10 ⁻¹² W) @ MID OCTAVE BAND FREQUENCY (Hz)		63	83			
			125	81			
			250	76			
			500	69			
			1K	57			
			2K	48			
			4K	41			
			8K	38			
ELECTRICAL DATA	MOTOR		kW	0.56			
			RPM	1725			
			ENCL.	TEFC			
	VOLT			575			
	PH			3			
MAXIMUM DIMENSIONS	LENGTH	mm	558				
	WIDTH	mm	586				
	HEIGHT	mm	586				
	WEIGHT	kg	65				
MANUFACTURER				GREENHECK			
MODEL NO.				BSQ-140			
APPLICABLE REMARKS:				C			
ABBREVIATIONS: FC: FORWARD CURVED BI: BACKWARD INCLINED AF: AIR FOIL							
REMARKS:							
A: AMCA TYPE B SPARK RESISTANT				J: ALUMINUM HOOD			
B: INVERTER DUTY-RATED MOTOR				K: BACK DRAFT DAMPER			
C: DISCONNECT SWITCH				L: MOTOR SPEED CONTROLLER			
D: ROOF CURB & DAMPER TRAY				M: SIDE DISCHARGE			
E: BAKED EPOXY PHENOLIC COATING				N: HOT DIP GALVANIZED			
F: INSULATED FAN HOUSING				O: ALUMINUM CASING			
G: DRAIN WITH PLUG				P: BIRD SCREEN			
H: SUITABLE FOR CLASS I, ZONE 2				Q: SUITABLE FOR CLASS I, ZONE 1			
I: 25mm DEFLECTION INERTIA BASE				R: INSULATED WALKAROUND NOISE ENCLOSURE			

SECTION 23 37 00

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. Air-Conditioning and Refrigeration Institute (ARI): 880, Air Terminals.
 2. ASTM International (ASTM): C636, Standard Practice for Installation of Metal Ceiling Suspension System for Acoustical Tile and Lay-in Panels.
 3. Underwriters' Laboratories of Canada. (ULC): Product Directories.

1.2 DEFINITIONS

- A. NC: Noise Criteria; background sound rating method for indoor sound.

1.3 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings:
 - a. Manufacturer's data and descriptive literature for products specified.
 - b. Furnish the following information for each register, and grille furnished.
 - 1) NC sound data.
 - 2) Static pressure loss data.
 - 3) Throw data.
- B. Informational Submittals:
1. List of recommended spare parts for products specified.

PART 2 PRODUCTS

2.1 EXHAUST GRILLES AND REGISTERS

- A. Louvered Return, Exhaust and Transfer Grilles and Registers (EG, ER):
1. Construction: As follows:
 - a. Material: Aluminum.
 - b. Finish: Aluminum face finish.
 - c. ER Register Accessories:
 - 1) Gang-operated opposed-blade volume control damper.
 - 2) Material to match grille.
 2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
 3. 25 mm minimum flat, rectangular frame.
 4. Manufacturers and Products:
 - a. Krueger; S80/S580H Series.
 - b. Carnes; Type RAAAH.

- c. Titus; 350 Series.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.
- B. Provide appropriate frame to adapt to mounting surface. Provide a 600 mm by 600 mm lay-in ceiling module for diffusers, registers, and grilles in lay-in ceilings.
- C. Support air inlets and outlets where installed in metal suspension systems for acoustical tile and lay-in panel ceilings as specified in ASTM C636 and applicable building code.

END OF SECTION

SECTION 23 46 19

CENTRIFUGAL WATER CHILLERS

EQUIPMENT AND COMPONENT NUMBERS

<u>ID No.</u>	<u>Equipment Description</u>
CHLR-B679	Centrifugal Water Chiller

PART 1 GENERAL

1.1 REFERENCES

- A. The following is a list of standards which may be referenced in this Section:
1. AHRI 350 – Sound Performance Rating of Non-ducted Indoor Air-conditioning and Heat Pump Equipment
 2. AHRI 410 - Standard for Forced Circulation Air-Heating and Air-Cooling Coils
 3. AHRI-550/590-Performance Rating of Water Chilling Packages Using the Vapor Compression Cycle
 4. NECB – National Energy Code for Buildings
 5. NFPA 70 - National Electrical Code (NEC)
 6. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems
 7. CSA B52 - Mechanical Refrigeration Code
 8. CSA C743 – Performance Standard for Rating Packaged Water Chillers
 9. AHRI Standard 550/590 - Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle
 10. ASHRAE Standard 15- Safety Standard for Refrigeration System
 11. ASHRAE Standard 34- Designation and Safety Classification of Refrigerants
 12. ASHRAE Handbook Chapter 3 – Central Cooling and Heating Plants (TC9.1)
 13. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings
 14. Environment Canada, (EC)/Environmental Protection Services (EPS):
 - a. Environmental Code of Practice for Elimination of Fluorocarbons Emission from Refrigeration and Air Conditioning Systems (2015)

1.2 DEFINITIONS

- A. Action Submittals:
1. Submit submittals in accordance with Section 01 33 00- Submittal Procedures
 2. Product Data: Submit rated capacities, weights, specialties and accessories, electrical requirements, wiring diagrams, and control diagrams.
 3. Indicate components, assembly, dimensions, weights and loads, required clearances, and location and size of field connections. Indicate valves, strainers, and thermostatic valves required for complete system.

4. Manufacturer's data including materials of construction details of equipment, wiring diagrams, weight of equipment, mounting, seismic bracing, and support. Information shall include the following:
 - a. Chiller dimensional drawings with elevation overview. Drawings to include required service clearances, location of all field installed piping and electrical connections.
 - b. A summary of all auxiliary utility requirements for normal system operation required. Auxiliary utility requirements include electrical, water, and air. Summary of auxiliary equipment shall include quantity and quality of each specific auxiliary utility required.
 - c. Chiller Control documentation to include Chiller control hardware layout, wiring diagrams depicting factory installed wiring, field installed wiring with points of connection, and points of connection for control/interface points.
 - d. Sequence of operation depicting overview of control logic used.
 - e. Manufacturer certified performance data at full load in addition to either IPLV or NPLV.
 - f. Submit Installation, Operations, and Maintenance.
 - g. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements and include startup instructions.

- B. Information Submittals:
 1. Factory test results, reports, and certifications.
 2. Manufacturer's Certificate of Conformance: Manufactured/commercial products.
 3. Special shipping, storage and protection, and handling instructions.
 4. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Contractor Field Services.
 5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
 6. Service records for maintenance performed during construction.
 7. Submit written certification from Professional Engineer licensed in the Province of Manitoba stating that support systems, anchorage, and equipment have been designed according to requirements of NBC for post-disaster structures, at time of Shop Drawing submittals.
 8. Testing forms in accordance with section 01 91 14.

- C. Delivery: In accordance with Section 01 61 00, Common Product Requirements.
 1. The existing chiller CHLR-B679 is located in the Service Building Boiler Room basement which has an access hatch from above with an opening of 1800 x 1200 mm. Contractor to ensure new chiller dimension will be accessible for final delivery and installation work.
 2. Chiller(s) shall be delivered to the job site with complete components and refrigerant charge.
 3. Deliver materials to site in original factory packing, labelled with manufacturer's recommendations in clean, dry, well-ventilated area.
 4. Store and protect centrifugal water chiller from nicks, scratches, and blemishes.
 5. Store, materials off ground, indoor and in accordance with manufacturer's recommendations in clean dry, well-ventilated area.
 6. Installing contractor to comply with the manufacturer's instructions for transporting, rigging, and assembly of chiller.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable manufacturer shall be product of:
 - 1. SMARDT.
 - 2. Or approved equal in accordance with B7.

- B. Where a manufacturer is approved as equal in accordance with B7, the following additional spare parts shall be provided:
 - 1. expansion valves,
 - 2. safety relief valves,
 - 3. fuse plugs,
 - 4. filters, driers and shells,
 - 5. air filters,
 - 6. pressure switches,
 - 7. Temperature sensors,
 - 8. Flow sensors,
 - 9. electrical contact relays,
 - 10. starters,
 - 11. breakers,
 - 12. fuses/switch disconnects,
 - 13. cable for sensor,
 - 14. cable kit,
 - 15. transformers,
 - 16. relays,
 - 17. capacitors,
 - 18. power supply,
 - 19. user interface,
 - 20. display/screen,
 - 21. controller kits,
 - 22. controller boards and
 - 23. miscellaneous electronics boards.

2.2 GENERAL

- A. Based bid manufacturer is SMARDT.

- B. Chiller shall incorporate a centrifugal compressor with magnetic bearings and consist of a single 145-ton refrigerant circuit. The compressor shall utilize its high-speed variable speed drive in conjunction with the stepless capacity control using vane Chillers shall operate with R-513A refrigerant not subject to phase-out by the Montreal Protocol and the U.S. EPA Phase-out schedule. It is intended that the chiller match existing chiller pipe connections as close as possible with two separate refrigeration circuits and two compressors to provide 50% redundancy. Split circuit with one chiller and condenser barrel.

- C. Provide complete water-cooled centrifugal chiller package CHLR-B679 including compressor, evaporator, condenser, high resolution electronic expansion valve, motors and motor starters, controls, control center, piping, wiring, refrigeration, ready for connection to condenser and

cooling water circuit, interlocks, and electric power source, installed in as welded steel frame with heavy gauge panels and finished to contract standards.

- D. Provide all items not specifically called out which are required to implement specified functions and required for proper system operation.
- E. Design equipment, anchorage, and support systems for vertical and lateral loading in accordance with NBC.

2.3 CONDITIONS OF SERVICE

A. Environmental Conditions:

- 1. Location: Indoors.
- 2. Ambient Air Temperature: 5 to 40 degrees C.
- 3. Relative Humidity: 0 to 100 percent.
- 4. Electrical Area Classification: Unclassified.

B. Operating Conditions:

- 1. Provide Dedicated Water-Cooled Chiller with the capacity as scheduled on drawings at job site elevation listed in the specifications.
- 2. Chiller shall be designed for parallel evaporator water flow.
- 3. Chiller shall be designed to operate using 575 volt, 3-phase, 60 Hz electrical power supply.
- 4. Capacity:
 - a. 145 tons, when cooling 11.6 L/s (184 USGPM) of water from 17.2C to 6.7C (62.9F to 44F). Evaporator pressure drop not to exceed 70.4 kPa (10.21 psi).
 - b. Water cooled condenser supplied for 42/29 degrees C (107/85 degrees F) with a max. pressure drop of 89.1 kPa (12.93 psi) with a minimum ambient temperature of 4.4C (40F).
 - c. Power requirements at 575V/3PH/60hz, including electrical components.
 - d. Refrigerant: The chiller shall operate with R-513A refrigerant. With a 537 kg maximum system refrigerant weight to meet CSA B52.

2.4 CHILLER DESIGN

- A. Chiller modules shall have minimum performance to National Energy Code for Buildings NECB 2020 with Manitoba Code Amendments.
- B. Chiller Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236 and CAN/CSA-C743.
- C. Chiller modules shall be AHRI certified.
- D. Modules shall ship wired and charged with refrigerant. All modules shall be factory run tested prior to shipment on an AHRI certified or 3rd party verified test stand.
- E. Compressors, heat exchangers, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module.

- F. Unit shall consist of one or more magnetic bearing, oil-free centrifugal compressors with integrated variable frequency drive, refrigerant flooded evaporator, water cooled condenser and operating controls with equipment protection.
- G. Acoustics: Sound pressure for the unit shall not exceed the following specified levels, and be less than 81 dBA, measured at 1 meter (3.28 feet). Sound data shall be measured according to AHRI Standard 575-87
- H. Chiller shall be equipped for single-point power connection.
- I. Evaporator shall be designed to allow for the flow rate to be reduced to the rate of 1 gpm per ton without entering laminar flow to allow for variable chilled water flow and facilitate chilled water pump energy savings. The chiller shall be able to operate in a stable fashion at this condition for at least 8 hours continuously independent of condenser water flow rate or condenser water temperature relief.
- J. Condenser shall be designed to allow for the flow rate to be reduced to 1.5 gpm per ton without entering laminar flow to allow for variable condenser water flow and facilitate condenser water pump energy savings. The chiller shall be able to operate in a stable fashion at this condition for at least 8 hours continuously independent of chiller water flow rate or condenser water temperature relief.
- K. Minimum entering condenser water temperature shall be 14-16°F above leaving chilled water temperature. Chiller shall be able to operate in these conditions for at least 8 hours continuously to provide condenser water relief and allow compressor energy savings.
- L. Each compressor shall be electrically and mechanically isolated so that if a compressor fails or needs service it can be serviced or removed from the chiller without disabling the other compressors or the chiller. The chiller shall be able to operate with the remaining compressors with (1) or more compressors removed.
- M. All chillers with (2) compressors or less shall be equipped with a load balancing valve for capacity control and supply chilled temperature stability.

2.5 CONDENSER WATER COOLED:

- A. Condenser shall be shell-and-tube type and have separate shells. Heat exchangers shall be designed, constructed, tested, and stamped according to the requirements of the ASME Code, Section VIII Code Case 1518-5. They shall have a copper wall of 0.025 in. wall. In the condenser, refrigerant shall be in the shell and water inside the tubes. The water sides shall be designed for a minimum of 145 psig or as specified. The water connections for the evaporator and condenser shall be grooved suitable for Victaulic couplings or flanged. Vents and drains shall be provided. The refrigerant side of each vessel shall bear the ASME Code stamp, code case section VII. Vessels shall pass a test pressure of 1.1 times the working pressure but not less than 100 psig. Provide intermediate tube supports spaced to enable equal liquid and gas flow across multiple compressor suction ports. The condenser water connections shall also be equipped with right-hand or left-hand connection, interchangeable. Condenser vessel shall be designed for variable flow rate at a minimum turn down ratio of 30%

- B. The condenser shall be provided with dual relief valves equipped with a transfer valve so one valve can be removed for testing or replacement without loss of refrigerant or removal of refrigerant from the vessel. Rupture disks are not acceptable.
- C. Tubes shall be individually replaceable and have internally and externally enhanced surfaces designed for refrigeration duty. Tubes shall have smooth full tube wall landings at the tube-sheet ends and at intermediate tube supports. Tubes shall be mechanically roller expanded into steel tube sheets containing a minimum of three concentric grooves.
- D. Provide factory-mounted and wired, thermal dispersion switches water flow switches on condenser to prevent unit operation with no water flow.

2.6 EVAPORATORS

- A. Evaporator shall be shell-and-tube type and have separate shells. Heat exchangers shall be designed, constructed, tested, and stamped according to the requirements of the ASME Code, Section VIII Code Case 1518-5. They shall have a copper wall of 0.025 in. wall thickness. In the evaporator, refrigerant shall be in the shell and water inside the tubes. The water sides shall be designed for a minimum of 145 psig. Evaporator shall be designed for 30% turn down ratio on flow rate. The water connections for the evaporator and condenser shall be grooved suitable for Victaulic couplings or flanged. Vents and drains shall be provided. The refrigerant side of each vessel shall bear the ASME Code stamp, code case section VII. Vessels shall pass a test pressure of 1.1 times the working pressure but not less than 100 psig. Provide intermediate tube supports spaced to enable equal liquid and gas flow across multiple compressor suction ports. The evaporator water connections shall also be equipped with right-hand or left-hand connection, interchangeable.
- B. The evaporator shall be provided with spring loaded reseating-type pressure relief valves according to ASHRAE-15. Rupture disks are not acceptable.
- C. A perforated plate designed for vapor disengagement shall be installed inside the evaporator above the tubing to assure effective liquid droplet removal to prevent liquid damage to compressors and equalized suction pressure across evaporators with multiple compressors.
- D. Tubes shall be individually replaceable and have internally and externally enhanced surfaces designed for refrigeration duty. Tubes shall have smooth full tube wall landings at the tube-sheet ends and at intermediate tube supports. Tubes shall be mechanically roller expanded into steel tube sheets containing a minimum of three concentric grooves.
- E. Minimum evaporator exiting water temperature shall be 38°F or 15°F with the TTH- low temp compressor, unless otherwise specified.
- F. Total Access Design: Isolation valves shall be installed between the heat exchangers and water supply mains for heat exchanger isolation and removal without the requirement to remove a module or shut down the entire chiller allowing for total access to all serviceable components.

2.7 COMPRESSOR

- A. Compressors shall be of semi-hermetic centrifugal design and operate oil-free with 2 or more compressors or have N+1 redundant chiller, Two-stages of compression, magnetic bearings, movable inlet guide vanes and integrated variable frequency drive system.
- B. Automatically positioned and controlled inlet guide vanes shall operate with compressor speed controls.
- C. Compressor shall be capable of coming to a controlled stop in the event of a power failure. The unit shall be capable of initializing an automatic restart in the case of power failure.
- D. Each compressor shall have integrated microprocessor control capable of capacity and safety control.
- E. Guide Vanes: Modulating with factory mounted electric operator, suitable for capacity reduction down to fifteen (15) percent of specified load without hot gas bypass.
- F. If compressor driver motor uses antifriction bearing with an oil lubricating system, the chiller manufacturer must provide a 20-year warranty of the compressor bearings as well as all preventive maintenance for a period of 20 years. In addition, chillers containing oil must include a 10-year warranty on all systems components and labor. All costs associated with annual oil and oil filter changes plus oil analysis for the whole life cycle of the machine should be at manufacturer expense.
- G. If the compressors contain an atmospheric shaft seal, the chiller manufacturer must provide a 20-year warranty of the shaft seal as well as all preventive maintenance for a period of 20 years. In addition, the manufacturer must provide a 20-year refrigerant replacement warranty for losses due to a failure of the shaft seal.

2.8 COMPRESSOR MOTOR

- A. Permanent magnet, synchronous hermetically sealed motor of enough size to effectively provide compressor horsepower requirements. Motor shall include soft-start capabilities. Motor shall be liquid refrigerant cooled with internal thermal overload protection devices embedded in the winding of each phase.
- B. Compressor motor and chiller unit shall include variable-frequency speed controls to match cooling load demand to compressor speed and inlet guide vane position.
- C. Each compressor shall be equipped with a 5% impedance AC line reactor and a local, individual disconnect or circuit breaker, within the unit.

2.9 CENTRAL CONTROL SYSTEM

- A. The controller fitted to the oil-free centrifugal chiller package shall be an embedded real time microprocessor device that utilizes control software written specifically for chiller applications. User operation shall be accomplished using a panel mounted color touch-screen

interface. The status of the compressors and all system parameters including compressor alarms and temperature trends shall be viewable.

1. Chiller control system shall have the capability to store one year of operational data. No less than 60 points of information shall be sampled at a maximum of 15-minute intervals.
2. Chiller control system shall have digital inputs to be used for interlocks with external equipment.
 - a. Digital input for refrigerant detection to turn off, the chiller and boiler BLR-B651 and B652 shut upon refrigerant detection from the gas detector AIT-B690. The digital input will also start external exhaust fan EF-B682 upon refrigerant detection.
3. Chiller control system shall have full web based remote control capability including the capability for remote operation and software updates.
4. There shall be a backup superheat control on the inlet of the compressor in order to control the EXV in the event of a failure of the primary level sensing device.
5. Selectable control mode – leaving chilled water, entering chilled water or suction pressure control.
6. 10.4-inch or 12 inch, 65,000 colors, touch panel operator interface
7. Chiller documentation shall be viewable via touch panel in pdf format.
8. Operator interface shall be capable of connecting directly to compressors via ModBus RTU communication protocol and display compressor.
9. Chiller control panel user interface shall be capable of remote control and communication via ModBus RTU.
10. Ability to place all outputs in a manual state (hand, off, auto) via graphical user interface.
11. Alarm screen shall be capable of filtering faults into specific categories such as compressor, chiller and system faults in order to provide rapid diagnosis and separation of failure modes.
12. Variable speed cooling tower control.
13. Ability to turn on/off duty standby chilled water pumps.
14. Ability to turn on/off duty standby condenser water pumps.
15. Multiple compressors staging algorithm shall operate at the optimized power curves of each compressor simultaneously and shall reset automatically every second during operation. Compressor staging methods that operates using simple incremental percent of demand shall not be accepted.
16. Continuous data logging for operational trending and bin analysis shall be exportable to “CSV” format. (12 months data stored)
17. Built-in stepper motor controls for EXV’s
18. Ramp rate control - Peak energy demand limiting algorithms.
19. Three levels of alarm safety for minimum chiller down.
20. Chiller control software shall employ an active fault avoidance algorithm to reduce chiller capacity and/or power level in the case the chiller approaches within 10% of any trip limit value such as suction pressure, discharge pressure, chiller amp limit, leaving chilled water temperature limit etc.
21. Store up to 32,000 alarm and fault events stored with date / time stamp.
22. Real time data trending viewable via Touch panel
23. Chiller load profile charts viewable via Touch panel
24. Chiller control graphical user interface shall be capable of displaying data in SI or I-P units without affecting control or BAS protocol units.
25. Controls shall identify within 60 seconds a compressor that is not starting or ramping properly. Upon this identification, the compressor shall be disabled, the remaining

compressors shall be operated in an optimized fashion and an alarm shall be sent to alert the operator.

26. Chiller faults (14) possible conditions
27. Each compressor alarm (9) possible conditions
28. Each compressor fault (13) possible conditions
29. Each compressor bearing fault (8) possible conditions.
30. Each compressor IGV position
31. Control circuit ON/OFF switch.
32. High- and low-pressure safety switch.
33. Water temperature controller.
34. Chilled water flow switch.
35. Compressor short cycling and restart delay timer.
36. Starting sequence switches.
37. Compressor and fan motor circuit breakers.
38. Reset low water temperature cut-out switch.
39. Motor contactors, control relays and indicator lights to include: "start-stop" switch; anti-recycle 30 minute time delay; low chilled water temperature cutout and automatic reset; excess purge signal light and reset switch; manual reset power failure and signal light; chilled water flow interruption light meter to indicate number of compressor starts and elapsed running time.
40. Field power and control circuit terminal blocks.
41. Alarm for refrigerant leakage.
42. BMS interface module for the interface with ModBUS RTU.

B. Data on Main Display Screen shall include (& shall communicate via protocol)

1. Entering and leaving chilled water temperatures
2. Entering and leaving condenser water temperatures
3. Display fault status
4. Display "manual / local mode" when hand switches are activated.
5. (7) states Available
6. Active timers
7. Chiller enable status.
8. Chiller water flow proof status
9. Condenser water flow proof status
10. Indication of compressor readiness
11. Indication of clearance run.
12. Chiller set point.
13. Total chiller KW
14. Total chiller current input
15. Three pages of data trends with Zoom functionality
16. Graphical dial indicators that clearly indicate safe unsafe operation values
17. Graphical representation of evaporator and condenser showing gas movement when chiller is running.
18. Current alarms (announce and manual reset provisions)
19. Compressor actual rpm. Maximum rpm, minimum rpm
20. Compressor alarm description and fault description
21. Compressor percentage motor demand
22. Compressor safety interlock status

23. Compressor Modbus communication health status
24. Compressor suction and discharge pressures
25. Compressor suction and discharge temperature
26. Compressor internal cooling system temperatures and status
27. Compressor motor KW and amps
28. Compressor pressure ratio

C. Liquid level controls

1. Control of refrigerant flow shall utilize a single or multiple 6,000 step electronic expansion valve (EXV), to operate within the full range from full load to the lowest loading capacity for the chiller. Fixed orifice metering devices or float controls using hot gas bypass are not acceptable. The EXV liquid line shall have a sight glass with moisture indicator and temperature sensor connected to control system for validation of sub-cooling.
2. The EXV valve shall be controlled by condenser level float control for better efficiency and to avoid compressor slugging. EXV superheat control shall not be acceptable.
3. Condenser shall be provided with a capacitive type liquid level transducer with a resolution of not less than 1024 discrete steps. Transducer shall be wired to chiller control system. Condenser liquid level measurement shall be used in electronic expansion valve control algorithm with a minimum level set point to ensure adequate liquid seal is maintained in condenser to provide compressor motor cooling during operation. Condenser liquid level shall be clearly displayed on graphical operator interface in a minimum of two screens, chillers without direct level measurement are prohibited due to possible over heating damage that may occur in compressors when liquid seal is lost.

2.10 ACCESSORIES

- A. Lifting Lugs: Provide suitably attached for all equipment assemblies and components weighing over 45 kg.
- B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

2.11 FACTORY FINISHING

- A. Manufacturer's standard coating and finish for corrosive and wet environment.

2.12 SOURCE QUALITY CONTROL

- A. Regulatory Requirements: Comply with the codes and standards as defined in Section 1.1.
- B. Chiller shall be tested at manufacturer's facility to job specific requirements, prior to shipment. Manufacturer shall provide report.

PART 3 EXECUTION

3.1 INSTALLATION

A. Piping System Flushing Procedure

1. Prior to connecting the chiller to the condenser and chilled water loop, the piping loops shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organics. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.
2. During the flushing 30 mesh (max.) Y-strainers (or acceptable Equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on-board chiller strainers shall not be acceptable. The flushing process shall take no less than 6 hours or until the strainers when examined after each flushing are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer's instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.
3. Prior to supplying water to the chiller, the Water Treatment Specification shall be consulted for requirements regarding the water quality during chiller operation. The appropriate chiller manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.
4. Install unit as indicated, to manufacturers recommendations, and in accordance with Environmental Code of Practice for Elimination of Fluorocarbon Emissions from Refrigeration and Air Conditioning Systems.
5. Ensure adequate clearances for servicing and maintenance.

Provide factory supervised start-up on-site for a minimum of two working days ensure proper operation of the equipment. During the period of start-up, the factory authorized technician shall instruct the City's representative in proper care and operation of the equipment.

B. Requirements

1. Supply water for both the chilled water and condenser water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the chiller's heat exchangers, headers and associated piping.

3.2 FIELD FINISHING

- #### A. As specified in Section 09 90 00, Painting and Coating.

3.3 CLEANING

- A. Progress Cleaning: clean in accordance with Section 01 74 00 - Cleaning.
 - 1. Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment in accordance with Section 01 74 00 - Cleaning.

3.4 WARRANTY AND MAINTENANCE

- A. Manufacturer shall provide full parts and labor warranty coverage for entire chiller for a period of two years. All parts shall be warranted against defects in material and workmanship. A parts-only coverage shall be provided for the chiller (s) compressors for a period of five years. The warranty period shall commence either on the equipment start-up date or six months after shipment, whichever is earlier.
- B. Maintenance of the chiller shall be in accordance with Section: 01 78 23.

3.5 MANUFACTURER'S SERVICES

Manufacturer shall provide the services of a local Factory Authorized Service Engineer to provide complete start-up supervision. After start-up a Manufacturer's Representative shall provide a minimum of 8-hours of operator training to the City's designated representative(s).

- A. See Section 01 43 33, Contractor Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.6 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification.
 - 1. Form N: Detailed Specifications Supply, Delivery and On-Site Inspections of SEWPCC Water-Cooled Chiller Equipment

END OF SECTION

SECTION 26 05 01

COMMON WORK RESULTS – ELECTRICAL

PART 1 GENERAL

1.1 RELATED SECTIONS

- A. Requirements specified within this section apply to all sections in Division 26, Electrical. This section supplements requirements of other Divisions.

1.2 CODES AND STANDARDS

- A. Manitoba Building Code (MBC).
- B. The Winnipeg Electrical By-law (WEB)
- C. CSA C22.1 Canadian Electrical Code - Part 1 (CEC)
- D. CSA C22.2 No. 0 General Requirements - Canadian Electrical Code - Part 2
- E. CAN3-C235 Preferred Voltage Levels for AC Systems, 0-50,000 V
- F. Electrical and Electronic Manufacturers Association of Canada (EEMAC)
- G. National Electrical Manufacturers Association (NEMA)
- H. Institute of the Electrical and Electronic Engineers (IEEE)
- I. Insulated Cable Engineers Association (ICEA)
- J. Canadian Standards Association (CSA)
- K. Underwriters Laboratories Canada (ULC)
- L. American National Standards Institute (ANSI)
- M. National Fire Protection Agency (NFPA)
- N. Comply with the most current locally enforced edition of CSA C22.1 Canadian Electrical Code - Part 1, Winnipeg Electrical By-law, Provincial Safety Electrical Authority Codes and Bulletins.
- O. Comply with all laws, ordinances, rules, regulations, codes, and orders of all authorities having jurisdiction relating to this Work. Where these regulations conflict, comply with the most stringent condition.
- P. Comply with latest editions of the CSA Certification Standards and Bulletins.

1.3 DRAWINGS AND SPECIFICATIONS

- A. All materials, equipment, labor, work denoted on the Drawing set is to be considered as new work, to be provided by the Contractor unless specifically noted otherwise. Some of the electrical and automation Drawings show existing systems (with modifications to these systems). These Drawings specifically indicated that there are existing systems shown.
- B. Where Drawings do not specifically indicate that existing systems are depicted, the Contractor shall assume that the materials, equipment, labor, work indicated will form part of his scope, and the Contractor shall include all costs (including materials, labor, etc.) to perform the work.
- C. Prior to installing power and control cabling for process equipment, the Contractor shall review the equipment Shop Drawings, and to ensure that cabling requirements are understood. There may be variations in wiring requirements with process and HVAC equipment, that may require alternate wiring requirements from that shown on the Drawings. Include such wiring and connections in tender at no additional costs.
- D. The electrical Drawings in some cases indicate the size of cables, breakers, conduits, etc. These sizes are based on the supply of specific sizes of equipment. For cases where the Contractor supplies equipment that varies from these assumptions it is the responsibility of the Contractor to provide the correct size of breaker, cable, etc. to suit the installation, at no additional cost to the Contract.
- E. The intent of the Drawings and Specifications is to indicate labor, products, and services necessary for a complete, installed, tested, commissioned and functional installation.
- F. Electrical Drawings may indicate approximate route to be followed by conduits and cables and general location of electrical equipment. They do not show all structural, architectural and mechanical details. In some cases, conduit or wiring is only shown diagrammatically on the Drawings. The details on exact cable or conduit routing, and exact equipment installation location is to be determined on site and coordinated with all other trades.
- G. Where circuit numbers are shown adjacent to equipment, the Electrical Contractor shall provide all wiring, conduit, supports, and any other requirements to provide power to that piece of equipment from the circuit indicated. Where circuit numbers are not shown adjacent to a piece of 575V equipment, refer to the single line drawings for connections details. Provide all wiring, conduit, supports, and any other requirements to provide power to that piece of equipment.
- H. To provide sufficient detail and maximum degree of clarity on the Drawings, symbols used for various electrical devices, particularly wall mounted devices, take up more space on the Drawings than devices physically do. Locate devices with primary regard for convenience of operation, accessibility and space utilization, rather than locating devices to comply with the exact scaled locations of the electrical symbols.
- I. These Specifications along with the Drawings and Specifications of all other divisions shall be considered as an integral part of the Drawing package. Any item or subject omitted from the Specifications or the Drawings but which is mentioned or reasonably specified in the Drawings or Specifications of other divisions, shall be considered as properly and sufficiently specified and shall be provided.

- J. If discrepancies or omissions in the Drawings or Specifications are found, or if the intent or meaning is not clear, advise the Contract Administrator for clarification before submitting a bid.
- K. Provide all minor items and work not shown or specified but which are reasonably necessary to complete the work.
- L. Various package unit types of equipment are included in the work. It is the responsibility of the Contractor to familiarize himself with the requirements of the equipment vendor, and to include all materials and labor for a complete and working installation. In some cases, this means that motors, valves, actuators, etc. need to be wired and connected in the field. The Contractor shall include all costs to perform such services as part of his tender submittal. Coordination between the equipment vendor and the Contractor shall be performed prior to tender bid closing date, and all costs shall be included in the tender. Request for extras due to lack of coordination between the Contractor and the equipment vendors will not be accepted.
- M. In some cases, the plan Drawings indicate the symbol for 1 motor - for package units – when in reality, there are multiple motors, valves, dampers, solenoids, associated with the piece of equipment. It is the responsibility of the Contractor to understand the intricacies of the packaged equipment, and to perform all field connections for a complete and working system.
- N. In some cases, motorized dampers are shown only with one symbol on the Drawings, when in fact multiple motorized dampers are required in order to accommodate the opening size and the actuators. In these cases it is the responsibility of the Contractor to wire and connect all required actuators to allow for correct operation of the system at no additional cost.
- O. Cables schedules / lists where shown do not include all cables required to perform the complete Facility installation. They shall be used as a general guide. Accurate cable lists, quantities, take-offs remain the responsibility of the Contractor. Cable schedules only show cabling where specific cable tags are available on the Drawings. Refer to the cable schedule for specific systems which are not included on the schedule, and include materials, and installation for all remaining cabling.

1.4 CARE, OPERATION AND START-UP

- A. Instruct the Contract Administrator's maintenance and operating personnel in the operation, care and maintenance of systems, system equipment and components.
- B. Where services of a Manufacturer's Factory Service Engineer is required, arrange and pay for services to supervise start-up of installation, check, adjust, balance and calibrate components and instruct operating personnel.
- C. Provide factory service engineer support for such a period, and for as many visits as necessary to put equipment in operation and ensure that operating personnel are familiar and fully trained with all aspects of its care and operation.

1.5 ELECTRICAL COORDINATION

- A. Coordinate work with all other trades to ensure that conflicts do not occur.

- B. Coordinate requirement of mechanical equipment requiring electrical connection with the Mechanical Contractor. Pay specific attention to equipment full load amps, voltage, phase and breaker size.
- C. Verify that all equipment ordered is compliant with the Manitoba Energy Code for Buildings.
- D. Coordinate work with utilities where appropriate, including but not limited to:
 - 1. Incoming overhead lines,
 - 2. Underground buried services,
 - 3. Transformer(s) supplying main electrical service to the Facility,
 - 4. Installation of Supply Authority meter,
 - 5. Installation of incoming telephone / data communication service conductors or cables.

1.6 SUBMITTALS

- A. Permits, Fees and Inspection:
 - 1. Furnish copies of all inspection reports and Certificate of Final Acceptance from Electrical Inspection Authority and any authorities having jurisdiction on completion of work to Contract Administrator and include copies in the O & M manuals.
- B. Site Documentation
 - 1. In each electrical room, provide power distribution system single line diagrams in glazed metal frames.
 - 2. Provide fire alarm riser diagram, plan and building zoning in glazed metal frame at fire alarm control panel and annunciator to meet requirements of Fire Commissioner.
 - 3. Where work includes modification to existing power distribution or fire alarm systems, provide new single line and riser diagrams showing complete modified system. Reinstall diagram into existing frames where feasible or provide new frame and glazing.
- C. Within 15 days of award of the Contract, the Contractor shall submit a completed equipment procurement schedule, which lists the Manufacturer and model of equipment, indicating the projected ordering, Shop Drawing submittal date and delivery dates of all products to meet the required construction schedule.
- D. Prior to delivery of any products to the job site and sufficiently in advance of requirements to allow ample time for checking, submit Shop Drawings for review as specified in Division 01.
- E. Submit Shop Drawings (including product data) for all equipment as required in each section of this Specification.
- F. Prior to submitting the Shop Drawings to the Contract Administrator, the Contractor shall review, date and sign the Shop Drawings to determine that the equipment complies with the requirements of the Specifications and Drawings.
- G. Shop Drawings shall indicate materials, methods of construction and attachment of support, wiring diagrams, connections, recommended installation details, explanatory notes and other information necessary for completion of the work. Where equipment is connected to other equipment, indicate that such items have been coordinated, regardless of the section under which the adjacent items will be supplied and installed. Indicate cross-references to design Drawings and Specifications. Adjustments made on Shop Drawings by the Contract

Administrator are not intended to change the Contract price. If adjustments affect the value of the work, state so in writing to the Contract Administrator prior to proceeding with the work.

- H. Manufacture of products shall conform to the revised Shop Drawings. Failure to supply a product based on the revised, marked up Shop Drawings may require on site product revisions or modifications, which will be at the cost of the Contractor.
- I. Keep one (1) complete set of Shop Drawings at job Site during construction.
- J. Prior to shipping pre-fabricated control panels, photos of completed panels shall be sent to the Contract Administrator of final review. The resolution of the photos should be such that individual wire tags can be read.
- K. Shop Drawings shall have the specific equipment numbers on all pages to clearly indicate which piece of equipment the Shop Drawing refers to. In addition, the entire product part number or catalog number should be adjacent to the tag.

1.7 AS-BUILT DRAWINGS

- A. Refer to Section 01 77 00, Closeout Procedures - for additional requirements for as-built drawings.
- B. The Contractor shall keep one (1) complete set of white prints at the site during work, including all addenda, change orders, site instructions, clarifications, and revisions for the purpose of As-Built drawings. As the work on-site proceeds, the Contractor shall clearly record in red pencil all as-built conditions, which deviate from the original Contract Documents. As-Built drawings to include circuiting of all devices, conduit and feeder runs (complete with conductor size and number) and locations of all electrical equipment.
- C. On completion of the work, minimum of four (4) weeks prior to final inspection, submit As-Built drawings to Contract Administrator for review. The Contractor shall certify, in writing signed and dated, that the As-Built drawings are complete and that they accurately indicate all electrical services, including exposed as well as concealed items.
- D. Comply with all other City of Winnipeg standards and requirements.

1.8 OPERATIONS AND MAINTENANCE (O & M) MANUALS

- A. Provide operation and maintenance manuals as specified herein and in accordance with the general conditions. Refer to Section 01 78 23, Operations and Maintenance Data.
- B. Include in the operations and maintenance manuals a minimum of:
 - 1. Cover page including project name, year, name of City and electrical consultant. Cover page shall be enclosed in a clear plastic cover.
 - 2. Index.
 - 3. List of manufacturers and supplier for all items.
 - 4. Names, address and phone number of all local suppliers for items included in maintenance manual.
 - 5. Stamped and signed Shop Drawings.

6. Details of design elements, construction features, component function and maintenance requirements, to permit effective start-up, operation, maintenance, repair, modification, extension and expansion of portions or features of the installation.
7. Technical data, product data, supplemented by bulletins, component illustrations, exploded views, technical descriptions of items and parts lists. Advertising or sales literature not acceptable.
8. All test results performed. This includes, but is not limited to fire alarm V.I report, grounding system tests, battery bank test results, genset tests, switchgear tests, operation tests, cable tests, MCC tests, load balancing tests, Hi Pot tests, Megger tests, factory tests of all major systems, etc. Submit test results on COW approved test sheets.
9. Panel schedules (hardcopy and Microsoft Excel format).
10. Software copies of relay settings
11. As-Built drawings.
12. Signed and dated warranty certificate.
13. Signed and dated approval by the local Electrical Inspections Department.
All other requirements outlined in the Specifications.

- C. Deliver to the Contract Administrator prior to the scheduled takeover date, five (5) sets of operation and maintenance manuals. Each operation and maintenance manual shall be contained within one or more three “D-ring” binder(s). Each binder shall be labeled directly on the front cover as well as the spine (“ELECTRICAL MAINTENANCE MANUAL – PROJECT NAME – YEAR”). Include memory sticks for required electronic media.
- D. Index plastic divider tabs (with type inserts) shall be provided for each Specification section. Paper dividers, with plastic tabs and typed insertions will not be accepted.
- E. Submit draft document prior to the start of Commissioning.
- F. Comply with all other COW standards and requirements.

1.9 ENVIRONMENTAL CONDITIONS

- A. Equipment and systems are to be rated to correctly operate in the environment in which they re to be installed.
- B. Exterior devices shall be rated to operate in an exterior environment with temperature range of -40 degrees C to +40 degrees C.

1.10 QUALITY ASSURANCE

- A. Qualifications
 1. For work involving specialties, including, but not limited to, the installation of high voltage switchgear, high voltage cables, overhead pole lines, sound and intercommunication systems, fire alarm systems, lightning protection systems, equipment cathodic protection, grounding systems, instrumentation, controls, electronic access, security systems, fibre optics systems, etc. employ only workers fully trained, qualified and experienced in the aspects of such work.

PART 2 PRODUCTS

2.1 ACCEPTED MATERIALS

- A. Materials: approved by and bearing a CSA label. Where there is no alternative to supplying equipment or material that is not approved or certified as indicated, obtain and pay for special approvals from the Office of the Fire Commissioner, Inspection and Technical Services Manitoba.
- B. Factory assemble control panels and component assemblies. Control panels to be CSA certified. Include current interrupting rating on the front panel. Shop Drawings for custom built control panels (which are not designed and sealed as part of the Issued for Construction documents) shall be signed and sealed by an engineer, registered in the Province of Manitoba.
- C. Minimum enclosure type to be NEMA 12 unless otherwise specified. Refer to the Drawings and other Specification section for specific requirements.
- D. Provide materials and equipment in accordance with Section 01 61 00, Common Product Requirements.

2.2 EQUIPMENT FINISH

- A. Where on site finishing is required, prepare and prime surfaces as specified in Section 09 90 00, Painting and Coating.
- B. Shop finish metal enclosure surfaces by application of rust resistant primer inside and outside, and at least two coats of finish enamel.
- C. Paint indoor switchgear and distribution enclosures light grey to ANSI 61 grey enamel, unless otherwise specified.

2.3 EQUIPMENT IDENTIFICATION

- A. Identify electrical equipment with nameplates as described below.
- B. Nameplates:
 - 1. Lamacoid, 3 mm thick plastic nameplates, mechanically attached with self tapping stainless steel screws, white face with black lettering. Note: "Sheet Metal Screws" or other sharp pointed screws are NOT acceptable.
 - 2. Sizes as follows:

NAMEPLATE SIZES

Size 1	10 x 50 mm mm high letters	1 line	3
Size 2	12 x 70 mm mm high letters	1 line	5
Size 3	12 x 70 mm mm high letters	2 lines	3
Size 4	20 x 90 mm mm high letters	1 line	8

Size 5	40 x 90 mm	2 lines	8
	mm high letters		
Size 6	25 x 100 mm	1 line	12
	mm high letters		
Size 7	25 x 100 mm	2 lines	5
	mm high letters		
Size 8	35 x 100 mm	3 lines	5
	mm high letters		
Size 9	45 x 100 mm	4 lines	5
	mm high letters		
Size 10	75 x 160 mm	3 or 4 lines	8
	mm high letters		
Size 11	150 x 250 mm	3 or 4 lines	10
	mm high letters		

- C. Wording on nameplates to be approved by Contract Administrator prior to manufacture.
- D. Allow for average of fifty (50) letters per nameplate.
- E. Identification to be in English.
- F. Provide nameplates for the following, sizes as shown:
 1. Power, voice and data receptacles – Size 1
 2. Panelboards – Size 9
 3. Dry Type Transformer – Size 10
 4. Cabinets – Size 8
 5. Small Junction Boxes (150mm x 150mm or smaller) – Size 1 6. Large Junction Boxes – Size 2
 6. Control panels – Size 8
 7. Contactors – Size 8
 8. Terminal / splitter cabinets – Size 8
 9. MCCs, switchgear, distribution equipment – Size 10
 10. Each cell or bucket in an MCC – Size 7
 11. Each breaker cell located within switchgear – Size 5
 12. Motor starters – Size 8
 13. Light Switches – Size 1
 14. Emergency lighting battery banks – Size 7 or Size 8
 15. Emergency lights – Size 1
 16. Exit signs – Size 3
 17. Disconnect switch – Size 8
 18. Wall mounted fire alarm devices – Size 2
 19. Ceiling mounted fire alarm devices – Size 4
 20. Oil filled padmount transformers – Size 11

2.4 WIRING IDENTIFICATION

- A. Identify wiring with permanent indelible identifying markings, either numbered or coloured plastic tapes, on both ends of phase conductors of feeders and branch circuit wiring.
- B. Maintain phase sequence and colour coding throughout.

- C. Colour code: to CSA C22.1.
- D. Use colour coded wires in communication cables, matched throughout system.

2.5 CONDUIT AND CABLE IDENTIFICATION

- A. Colour code conduits, boxes and cables.
- B. Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 5 m intervals.
- C. Colours: 38 mm wide prime colour and 19 mm wide auxiliary colours.

System Band	Prime Aux. Band
Medium Voltage (>750 V)	Orange
347/600 V	Yellow
120/208/240 V Power	Black
UPS 120/208/240 V Power	Black
	Green
Control Wiring (120 V)	Black
	Orange
Fire Alarm	Red
Low Voltage Communication/General	Blue
Low Voltage Control Wiring (<50 V)	Blue
	Orange
Intrinsically Safe	Blue
	White
Ground	Green
Fibre Optic	Purple

- D. Cable Identification: Supply and install lamacoid type cable identification tags for all cables. Install identification tag at both ends.

PART 3 EXECUTION

3.1 PREPARATION AND PROTECTION

- A. Schedule expediting of materials and execution of work in conjunction with associated work of other trades in order to meet the required work schedule.
- B. Post engraved warning signs to meet requirements of local bylaws, Inspection Authority and Contract Administrator.
- C. Protect those working on or in vicinity of exposed electrically energized equipment from physical danger. Shield and mark live parts in accordance with local regulations. Indicate the appropriate voltage.

- D. Arrange for installation of temporary doors, barriers and similar items for access to rooms and areas containing electrical equipment. Keep these doors locked at all times, except when under direct supervision.
- E. Permanently identify with lamacoid nameplate, equipment energized from multiple power sources, noting voltages, power source locations, supply disconnect designations and grounding electrode location.

3.2 WARNING SIGNS

- A. As specified and to meet the requirements of Electrical Inspection Department and the Contract Administrator.
- B. Lamacoid 3 mm thick plastic engraving sheet, red face, white core, mechanically attached with self tapping screws, 20mm text.

3.3 MOUNTING HEIGHTS (as applicable)

- A. Unless otherwise noted, or in contravention of codes and standards, mount equipment replacing existing equipment at the same height.
- B. Mounting height of equipment is from finished floor to centerline of equipment unless specified or indicated otherwise.
- C. If mounting height of equipment is not indicated, verify with the Contract Administrator before proceeding with the installation.
- D. Mount indoor electrical distribution equipment utilizing one of the following:
 - 1. Floor mount on 89mm (3.5") concrete housekeeping pad
 - 2. Surface wall mount to concrete walls (inside electrical rooms).
 - 3. For areas of elevated humidity or moisture (or where a suitable wall is not available) – mount on modular metal support system: Unistrut, Cantruss, or similar.
 - 4. Surface wall mount on 19mm (3/4") thick fire retardant plywood backboard (for non-structural type of walls and to provide a level of fire retardant barrier where needed)
 - 5. Recess mount (as indicated on the Drawings)
- E. Install electrical equipment at the following heights unless indicated or directed otherwise (to bottom of the equipment):
 - 1. Outlets above counters: 150 mm (6"); splashbacks: 100 mm (4").
 - 2. General receptacles & communications outlets: 400 mm (16").
 - 3. Receptacles in mechanical and shop areas: 1 m (40").
 - 4. Switches, dimmers, push buttons: 1.2 m (48").
 - 5. Thermostats: 1.4 m (56").
 - 6. Security alarm bells, horns, speakers: 2.2 m (88").
 - 7. Motor starters: 1675mm (66") to top.
 - 8. Panelboard: 2.0 m (78") to top.
 - 9. Control Panels: 1675mm (66") to top.
 - 10. Clock outlets: 2.15 m (84").
 - 11. Emergency lighting battery bank unit: 2.1m (82").
 - 12. Emergency light remote head: 150mm (6") below ceiling, to a maximum height of 3.0m (118").

13. Wall mount Exit signs: 2.2m (87") or higher as required to coordinate with door height.
14. Pushbutton for power door assist: 900mm (35.4")
15. Intrusion alarm motion detectors: 150mm (6") below ceiling, to a maximum height of 3.0m (118").
16. Intrusion alarm keypad: 1500mm (59")
17. Fire alarm panel: 1650mm (65") to top
18. End of line resistors: 1.6 m (64"),
19. Fire alarm pull stations: 1320mm (52"),
20. Fire alarm horn / strobe: a minimum of 150mm (6") below ceiling to the top edge of the device (for low ceiling areas). Where ceilings allow, mount devices at 2400mm (94.5") (measured to top of device) above finished floor.
21. Coordinate and confirm elevations indicated on the Architectural Drawings. Where discrepancies occur, request clarification from the Contract Administrator.
22. Mounting heights to meet all codes and regulations. Fire alarm devices to be in accordance with CAN / ULC-S524.
23. Coordinate and confirm elevations indicated on the Architectural elevations. Where discrepancies occur, request clarification from the Contract Administrator.

3.4 LOCATION OF DEVICES

- A. Allow for change of location of devices at no extra cost or credit, provided that the distance does not exceed 3000mm (10') from that shown on the Drawings, when the requirement is made known prior to installation.

3.5 CONDUIT AND CABLE INSTALLATION

- A. Sleeves through concrete: schedule 40 galvanized steel pipe, sized for free passage of conduit.
- B. For wall, partitions, and ceilings the sleeve ends shall be flush with the finish on both sides but for floors they shall extend 25 mm (1") above finished floor level.
- C. Fire stop opening with ULC approved assembly for the installation conditions.
- D. Provide a detailed proposed conduit routing plan to the Contract Administrator prior to proceeding with the installation of conduit.
- E. If possible, avoid routing conduits through hazardous area.
- F. Separate cables of different voltage levels when cables are installed parallel to each other.

3.6 CUTTING, PATCHING, DRILLING

- A. Provide all cutting and patching as required.
- B. Return exposed surfaces to an as-found condition.
- C. Exercise care where cutting/drilling holes in existing concrete elements so as not to damage existing reinforcing, or any other systems run in the concrete.
 1. Locate reinforcing and other existing systems using ground penetrating radar, X-Ray or other suitable means. Mark out on the surface of the concrete the locations of rebar and all other systems.

2. For all holes larger than 50mm passing through reinforced concrete, mark the location of the desired hole and all embedded systems. Obtain approval from the Contract Administrator prior to cutting.

- D. Firestop and seal all penetrations.
- E. Ensure that water ingress will not occur.
- F. Provide expansion joints for penetrations where shifting can occur.

3.7 ANCHOR INSTALLATION

- A. The Contractor shall exercise care where installing anchors into existing concrete elements so as not to damage existing reinforcing. All anchors shall be installed utilizing carbide tip drill bits. The existing reinforcing shall be located utilizing a reinforcing bar locator and marked out on the surface of the concrete. The drill holes shall be advanced to the required depth for installation of the anchors. Should reinforcement be encountered while drilling the hole shall be terminated and repositioned to clear the reinforcement. Do not use core bits that can easily intercept and damage/cut the reinforcing during drilling.

3.8 FIELD QUALITY CONTROL

- A. All electrical work to be carried out by qualified, licensed electricians or apprentices as per the conditions of the Provincial Act respecting manpower vocational training and qualification. Employees registered in a provincial apprentices program shall be permitted, under the direct supervision of a qualified licensed electrician, to perform specific tasks - the activities permitted shall be determined based on the level of training attained and the demonstration of ability to perform specific duties. A maximum of one apprentice is permitted per qualified electrician.
- B. The work of this division to be carried out by a Contractor who holds a valid Master Electrical Contractor license as issued by the Province of Manitoba.
- C. Furnish Manufacturer's certificate or letter confirming that entire installation as it pertains to each system has been installed to Manufacturer's instructions.

3.9 LOAD BALANCE

- A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.
- B. Balance electrical load between phases as closely as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.
- C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit panel directory that lists final circuit arrangement.

3.10 TESTS

- A. Test and check electrical, instrumentation and control systems for correct operation and compliance with statutory and regulatory authority requirements.

- B. Perform tests in presence of Contract Administrator. Log, tabulate, sign and include testing and Commissioning results in the O & M manuals.
- C. Testing shall include, but not be limited to, the following:
 - 1. All items indicated in Section 26 08 05, Acceptance Testing and the testing and Commissioning requirements.
 - 2. Electrical power distribution systems.
 - 3. Wire and cable system.
 - 4. Lighting, emergency lighting, photocell, lighting controls and interlocks.
 - 5. Motors, heaters and associated control equipment including sequenced operation of systems where applicable.
 - 6. Communications, control and instrumentation.
 - 7. Fire alarm and intercom systems.
 - 8. Standby genset power systems.
 - 9. All other equipment and systems as indicated in the Drawings and Specifications.
- D. Refer to appropriate Specification sections for specific system or equipment tests.
- E. Supply instruments, meters, consumable parts (such as fuses) and equipment. Arrange for qualified personnel to conduct tests.
- F. In cooperation with mechanical trades, take clamp-on ammeter readings with motors operating at full load. Compare values against the equipment nameplate rating. Log, tabulate and include readings in Maintenance Data and Operating Instructions.
- G. Correct systems which fail any test, correct and re-do tests to ensure proper operation of the system.

3.11 CHECKOUT AND STARTUP

- A. Voltage Field Test:
 - 1. Refer to Section 26 08 05, Acceptance Testing as applicable.
 - 2. Check Supply Utility voltage at point of termination of supply conductors when installation is essentially complete and is in operation.
 - 3. Check voltage amplitude between phases, and phase to neutral for loaded and unloaded conditions.
 - 4. Check voltage drop on at all distribution panels, and ensure that it is less than 3 percent in accordance with CEC requirements.
 - 5. Check voltage drop on equipment loads, and ensure that total voltage drop from the service to the farthest device is less than 5 percent in accordance with the CEC. Adjust transformer taps, and upsize conductors as required to meet the CEC.
 - 6. Unbalance Corrections:
 - a. Make written request to the Supply Utility to correct conditions if the service voltage unbalance exceeds 3 percent.
- B. Current Field Tests:
 - 1. Make line current check after supply utility has made final adjustments to supply voltage.
 - 2. Check current balance at the service demarcation point. Adjust loads to ensure that each phase is appropriately balanced.
 - 2. Check line current in each phase for each piece of equipment.

3. If the phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.12 TOUCH-UP PAINTING

- A. Clean and touch up surfaces of shop painted equipment scratched or marred during shipment or installation, to match original paint.
- B. Obtain necessary touch-up paint of original type and quality from equipment Manufacturer.
- C. Clean surfaces to be painted. Feather out edges of scratch marks. Make patch inconspicuous.
D. Apply one or more coats until damaged surface has been restored to original finish condition. E. Clean and prime exposed non galvanized hangers, racks and fastenings to prevent rusting.
- D. Do not paint nameplates, tags, CSA labels, warning plates and operating instructions. Observe field painting of electrical equipment or raceways. Labels shall be visible and legible after the equipment is installed.

3.13 CLEANING

- A. Clean construction debris and materials from enclosures, before final electrical tests. Vacuum the interior and exterior of enclosures to ensure all equipment is free from debris.

3.14 PROVISION FOR FUTURE EXPANSION

- A. In each location where space for future equipment is indicated, leave such space clean. Install conduit, wiring and other work in such a manner that necessary connections can be made in future without dismantling existing equipment, raceways or wiring. Consult with Contract Administrator whenever necessary.

3.15 BREAKER AND RELAY SETTINGS

- A. The Electrical Contractor shall field adjust and set breaker and relay settings for all breakers, relays, VFDs, etc. in accordance with settings provided by the Contract Administrator. Settings will be provided to the Electrical Contractor after the submission and acceptance of Shop Drawings. Shop Drawing information will be used by the Contract Administrator to calculate the appropriate settings.

3.16 TRAINING

- A. Provide training of COW personnel in all aspects of maintenance, operation, and functionality for all systems.
- B. Training shall be performed at the SEWPCC Facility in Winnipeg, Manitoba. Training shall involve both classroom style of training, as well as practical training with the equipment present.

3.17 UTILITY SERVICES (If Applicable)

- A. It is the responsibility of the Contractor to perform all work related to utility electrical service upgrades, and to coordinate this work with Manitoba Hydro. Coordinate the delivery of utility electrical power to the site at 66kV (2 supply feeders) with Manitoba Hydro.
- B. Construct a new substation along with the required electrical infrastructure to accept the new Manitoba Hydro utility service supply feeders at 66kV. At the same time, maintain operation of the two existing Manitoba Hydro 12.47 kV utility service supply feeders.
- C. The new 66 kV electrical service shall be completely operational, and the majority of the new infrastructure & facilities shall be constructed, installed and commissioned prior to the removal of the existing 12.47 kV MB Hydro utility service feeders to SGR-S701 and SGR-S702 as shown on Drawing 1-0102-ESLD-S001. In summary, construction efforts shall be completed at the Substation, Chemical / Electrical Building, the Grit & Screenings Building, the BNR area, the HRC, Admin, Secondary Clarifiers, the U.V Building, and the construction of the concrete encased duct bank (refer to Drawing 1-0102-EGAD-A001), prior to the disconnection of the two 12.47 kV MB Hydro service cables. The site is intended to run using four (4) electrical services to the site during the construction period. Two new feeders at 66 kV, and two existing feeders at 12.47 kV will run simultaneously, and feed a variety of loads. Running the plant with the redundant services will allow for a smooth and seamless transition, to the new dual service at 66kV with minimal impact to the plant with respect to down-time.
- D. The existing 12.47 kV MB Hydro services currently feed SGR-S701 and SGR-S702 and are shown on Drawing 1-0102-ESLD-S001. The two new 66 kV MB Hydro electric utility services are to feed the Electrical Building SGR-C701 and SGR-C702 – refer to 1-0102-ESLD-C001, ESLD-C002, ESLD-C003).
- E. Once the majority of the construction efforts have been completed, and the two new 66 kV feeders to the site are energizing the Electrical Building, the existing 12.47 kV MB Hydro service cables shall be disconnected and removed by MB Hydro. Coordinate de-energization of the 12.47 kV feeders with MB Hydro. This work shall be performed in accordance with the following general sequence (refer to 1-0102-ESLD-C001 for additional details):
 - 1. Install two 12.47 kV cables from the Electrical Building switchgear SGR-C701 and SGR-C702 (cables C-S701-1 and C-S702-1). Terminate lock-out breakers and terminate cabling at SGR-C701 and SGR-C702. Soft-dig excavate near transformers XFMR-S701 and XFMR-S702 without damaging systems or interrupting power the existing transformers.
 - 2. Assist the City electrical technicians in opening main circuit breaker MCB-S701.
 - 3. Assist the City electrical technicians in closing tie breaker CB-S701-T.
 - 4. Assist the City in re-energizing equipment affected by the momentary interruption as required and as direction by the City.
 - 5. Coordinate utility outage of MB Hydro utility feeder to XFMR-S701. Ensure the correct MB Hydro feeder cable is de-energized.
 - 6. Assist MB Hydro in removing metering equipment as applicable (and where possible).
 - 7. Remove and replace transformer XFMR-S701 ground. Ground cabling shall be run through ground bar to X0 continuously in accordance with code requirements.
 - 8. Remove MB Hydro service cabling from the transformer compartment.
 - 9. Disconnect / remove 12.47 kV tie cable with the assistance of MB Hydro (ensure that the tie cable is de-energized). Isolate and make safe.
 - 10. Install and terminate new cable C-S701-1 into transformer XFMR-S701.

11. Re-energize XFMR-S701 from the new electrical service, via SGR-C701.
 12. Replace and reconnect transformer grounds if disturbed or altered.
 13. Assist the City to open tie breaker CB-S701-T and close MCB-S701.
 14. Perform similar work and take momentary outages to re-feed XFMR-S702 from SGR-C702.
 15. The City has purchased the two 2500 kVA MB Hydro utility transformer XFMR-S701 and XFMR-S702 directly from MB Hydro. These two transformers have Manitoba Department of Labour Special Inspections Certificates.
 16. MB Hydro will be responsible for removing their disconnected 12.47 kV feeder cables as applicable from the site.
- F. Refer to other Contract Documents for additional scope of work and requirements, including but not limited to the Detailed Design Project Commissioning Plan, S0926-01YM-PLA-0001.

END OF SECTION

SECTION 26 05 20

WIRE AND BOX CONNECTORS 0-1000V

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Materials and installation for wire and box connectors.

1.2 RELATED SECTIONS

- A. Section [01 74 21 - Construction/Demolition Waste Management And Disposal].

1.3 REFERENCES

- A. Canadian Standards Association (CSA International)
 - 1. CAN/CSA-C22.2No.18-[98], Outlet Boxes, Conduit Boxes, Fittings and Associated Hardware.
 - 2. CSA C22.2No.65-[93(R1999)], Wire Connectors.
- B. Electrical and Electronic Manufacturers' Association of Canada (EEMAC)
 - 1. EEMAC 1Y-2, 1961 Bushing Stud Connectors and Aluminum Adapters (1200 Ampere Maximum Rating).
- C. National Electrical Manufacturers Association (NEMA)

1.4 WASTE MANAGEMENT AND DISPOSAL

- A. Separate and recycle waste materials in accordance with Section [01 74 21 - Construction/Demolition Waste Management And Disposal].
- B. Remove from site and dispose of all packaging materials at appropriate recycling facilities.
- C. Collect and separate for disposal paper, plastic, polystyrene, corrugated cardboard, packaging material, in appropriate on-site bins for recycling in accordance with Waste Management Plan.
- D. Divert unused wiring materials from landfill to metal recycling facility as approved by Contract Administrator.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Pressure type wire connectors to comply with CSA C22.2No.65, with current carrying parts of [copper] sized to fit copper conductors as required.

- B. Fixture type splicing connectors to comply with CSA C22.2No.65, with current carrying parts of copper, sized to fit copper conductors 10 AWG or less.
- C. Bushing stud connectors: to comply with NEMA requirements and to consist of:
 - 1. Connector body and stud clamp for stranded or round copper conductors.
 - 2. Clamp for stranded or round copper conductors.
 - 3. Clamp for stranded aluminum, or ACSR conductors.
 - 4. Stud clamp bolts.
 - 5. Bolts for copper conductors.
 - 6. Bolts for aluminum conductors.
 - 7. Sized for conductors as indicated.
- D. Clamps or connectors for armoured cable, aluminum sheathed cable, mineral insulated cable, flexible conduit, non-metallic sheathed cable as required to: CAN/CSA-C22.2No.18.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Remove insulation carefully from ends of conductors and:
 - 1. Apply coat of zinc joint compound on aluminum conductors prior to installation of connectors.
 - 2. Install mechanical pressure type connectors and tighten screws [with appropriate compression tool recommended by manufacturer]. Installation shall meet secureness tests in accordance with CSA C22.2No.65.
 - 3. Install fixture type connectors and tighten. Replace insulating cap.
 - 4. Install bushing stud connectors in accordance with [NEMA].

END OF SECTION

SECTION 26 05 21

WIRE AND CABLES (0-1000V) - ELECTRICAL

PART 1 GENERAL

1.1 CODES AND STANDARDS

- A. CAN/CSA-C22.2 No. 38, Thermoset-Insulated Wires and Cables.
- B. CAN/CSA-C22.2 No. 49, Flexible Cords and Cables
- C. CAN/CSA-C22.2 No. 51, Armoured Cables.
- D. CSA C22.2 No. 0.3, Test Methods for Electrical Wires and Cables.
- E. CAN/CSA-C22.2 No. 131, Type TECK 90 Cable.
- F. CAN/CSA C22.2 No. 174 Cables and Cable Glands for use in Hazardous Locations.
- G. CAN/CSA C22.2 No. 230 Tray Cables.
- H. CAN/CSA C21.2 300V Control Cable.
- I. CAN/CSA-C22.2 No. 239, Control and Instrumentation Cables.
- J. CAN/CSA-C22.2 No. 208, Fire Alarm and Signal Cable.
- K. American Society for Testing and Materials (ASTM):
 - 1. B3, Standard Specification for Soft or Annealed Copper Wire.
 - 2. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

1.2 SUBMITTALS

- A. Submit product data in accordance with Section 01 33 00, Submittal Procedures.

PART 2 PRODUCTS

2.1 GENERAL

- A. All conductors (including grounds and bonds) to be high conductivity copper.
- B. Materials to be manufactured to Canadian CSA standards, approved and suitable for -40°C to +90°C operation. Wires and cables shall meet their applicable CSA standard for construction and for testing.

- C. Insulation voltage rating:
 - 1. Conductors carrying 120/208V shall be rated 600V (except as noted otherwise for control cables).
 - 2. Conductors carrying 600V shall be rated 1000V.
- D. Increase conductor sizes to account for loading, cable and conductor spacing with the associated de-rating factors, voltage drop, ambient temperature, equipment termination temperature ratings, and all other requirements in accordance with CEC requirements.

2.2 WIRES (POWER)

- A. Conductors:
 - 1. Stranded for 10 AWG and larger.
 - 2. Minimum size, 12 AWG.
- B. Copper conductors: size as indicated, with insulation of chemically cross-linked thermosetting polyethylene (XLPE) materials, RW90.
- C. Wires sized 2 AWG and smaller to be factory colour coded, taping will not be accepted.

2.3 AC 90 ALUMINUM ARMoured CABLE

- A. Cable: to CAN/CSA-C22.2 No. 38 and CAN/CSA-C22.2 No. 51.
- B. Insulation: chemically cross-linked thermosetting polyethylene (XLPE) type RW90, FT4 rated.
- C. Armour: aluminum interlocked strip.
- D. Fastenings for aluminum armoured AC-90 cables:
 - 1. One hole aluminum straps to secure surface cables 25 mm and smaller. Two hole aluminum straps for cables larger than 25 mm.
 - 2. Channel type supports for two or more cables. Space out cables, minimum 1 cable diameter.
 - 3. Minimum 9 mm diameter threaded rods to support suspended channels.
- E. Connectors:
 - 1. Locknut, screw type, compression style cable connectors, sized as required.
- F. Acceptable Cable Manufacturer: Nexans, General Cable, Southwire

2.4 TECK 90 CABLE

- A. Cable: to CAN/CSA-C22.2 No. 131 and CAN/CSA – C22.2 No. 174
- B. Insulation: chemically cross-linked thermosetting polyethylene (XLPE) type RW90.
- C. Inner jacket: polyvinyl chloride (PVC), 600V or 1000V (as applicable), 100 percent insulation level.
- D. Armour: interlocking aluminum.

- E. Outer jacket: FT4, “HL” rated polyvinyl chloride (PVC) material, black colour.
- F. Fastenings:
 - 1. One hole aluminum straps to secure surface cables 50 mm and smaller. Two hole aluminum straps for cables larger than 50 mm.
 - 2. Channel type or cable tray supports for two (2) or more cables.
- G. Cable Connectors / Fittings:
 - 1. Minimum requirements: Watertight, approved for TECK cable.
 - 2. Hazardous Locations:
 - a. CSA approved.
 - b. Watertight type with:
 - 1) an elastomeric bevelled bushing.
 - 2) a funnel entry, splined gland nut.
 - 3) non-magnetic, stainless steel grounding device with dual grounding action.
 - 4) a taper threaded hub.
 - 5) a hexagonal body and gland nut
 - c. Integral seal type with metal-to-metal contact construction.
 - d. Sealing of multi-conductor cable shall be accomplished with a liquid type polyurethane compound.
 - e. The fitting must:
 - 1) Provide an environmental seal around the outer jacket of the cable and electrically bond the fitting to the cable armour prior to potting the explosion-proof seal.
 - 2) Allow the possibility of disconnection without disturbing the environmental seal, the electrical bonding or the explosion proof seal.
 - f. All metal-clad cable fittings, for jacketed and non-jacketed interlocked armour cable, shall incorporate an easily-removable armour stop (not requiring fitting disassembly) ensuring proper positioning of the cable armour during cable termination.
 - 3. Approved products:
 - a. Teck Cable, (Non-Hazardous Locations):
 - 1) Approved Manufacturers: Thomas & Betts or Cooper Crouse-Hinds
 - 2) Thomas & Betts Star® Teck ST series, aluminum.
 - b. Teck Cable, (Hazardous Locations):
 - 1) Shall meet the requirements of CSA C22.2 No. 174, and be marked accordingly.
 - 2) Approved Manufacturers: Thomas & Betts or Cooper Crouse-Hinds.
 - c. Thomas & Betts, Star® Teck XP (STX) series, explosion proof aluminum, CSA certified Class I, Divisions 1 and 2, Groups A, B, C, D.
- H. Acceptable Cable Manufacturer: Nexans, General Cable, Southwire.

2.5 FIRE ALARM WIRING (if applicable)

- A. Refer to Section 28 31 02, Multiplex Fire Alarm Systems for details.
- B. Low energy, 300 V, FAS 105 shielded cable: minimum #16AWG, with PVC insulation.
- C. Overall aluminum /polyester foil shield, with tinned copper drain wire.
- D. All fire alarm cables shall be installed in a separate, dedicated conduit system.

2.6 INSTRUMENTATION AND CONTROL WIRING

- A. Armoured Control and Instrumentation Cable (ACIC) and Control and Instrumentation Cable (CIC) to: CAN/CSA-C22.2 No. 239 and CAN/CSA C21.2.
- B. Conductors: minimum size, #16 AWG, stranded, annealed (7 strand minimum), tinned copper, unless otherwise specifically noted on the Drawings.
- C. Insulation: chemically cross-linked thermosetting polyethylene (XLPE), rated type RW90, 300V.
- D. Conductor identification: Each grouping (pair, triplet, quad) by consecutive number coding, permanently marked at regular intervals
- E. Construction: twisted pair, triplet and quad grouping with staggered lay.
- F. Shielding shall be in conformance with:
 - 1. Minimum 100 percent coverage aluminum foil or mylar tape shield with minimum 25 percent overlap.
 - 2. Separate drain wire, minimum size 18 AWG, bare, stranded tinned copper. Drain wire to be in direct, continuous contact with the shield.
 - 3. One or more twisted shielded pairs as indicated.
- G. Jacket: PVC (minus 40 degrees C to plus 90 degrees C), low acid gas, minimum FT4 rated flame spread.
- H. Armoured control and instrumentation cable (ACIC), to have aluminum, interlocked armour with overall PVC jacket.
- I. Termination fittings: Type, configuration and gender required to connect cable directly to equipment without additional adapters or fittings.

2.7 FLEXIBLE CABLES

- A. Cable: to CAN/CSA-C22.2 No. 49
- B. Type SOOW, flexible, extra hard usage conductor, watertight, rubber EPDM insulation, with CPE oil resistant outer covering and incorporated ground conductor, 90 degrees C rated.
- C. Instrumentation and control flexible cables, to have braided flexible shield, minimum size 16 AWG.

2.8 ARMORED VARIABLE FREQUENCY DRIVE CABLES

- A. Cable to:
 - 1. CAN/CSA-C22.2 No. 38.
 - 2. CAN/CSA-C22.2 No. 174. 3. CAN/CSA-C22.2 No. 230.
- B. Conductors:
 - 1. Grounding conductors: Three soft bare copper, symmetrically located in continuous contact with the copper tape shield or continuous aluminum armour.

2. Circuit conductors: copper, size as indicated.

C. Armoured cable for VFD application:

1. Designed to reduce high frequency noise interference with data and control signals.
2. Cross-linked polyethylene (XLPE), RW90 insulation on main conductors.
3. Shield: Continuous copper tape shield with 50 percent overlap or continuous (non-interlocked) aluminum armour.
4. Armored, continuously corrugated, corrosion resistant interlocking aluminum sheath.
5. Approved for six-pulse VFD use.
6. Overall PVC outer jacket rated FT4, and hazardous "HL" rated.
7. Acceptable Manufacturer, Nexans DriveRx or approved equal in accordance with B8 Substitutes.

D. Fastenings:

1. One hole aluminum straps to secure surface cables 50 mm and smaller. Two hole aluminum straps for cables larger than 50 mm.
2. Channel type or cable tray supports for two (2) or more cables.

E. Connectors:

1. Nexans, watertight, or hazardous rated cable connectors.

2.9 NON-ARMORED VARIABLE FREQUENCY DRIVE CABLES

A. Cable to:

1. CAN/CSA-C22.2 No. 38.
2. CAN/CSA-C22.2 No. 230.

B. Conductors:

1. Grounding conductors: Three soft bare copper, symmetrically located in continuous contact with the copper tape shield or continuous aluminum armour.
2. Circuit conductors: copper, size as indicated.

C. Cable for VFD application:

1. Designed to reduce high frequency noise interference with data and control signals.
2. Three bonding conductors – soft bare copper.
3. Cross-linked polyethylene (XLPE), RW90 insulation on main conductors.
4. Overall PVC outer jacket rated FT4.
5. Shield: Continuous copper tape shield with minimum 50 percent overlap. Approved for six-pulse VFD use.
6. Acceptable Manufacturer, Belden VFD Cable or approved equal in accordance with B8.
D. All non-armoured VFD cables shall be run in conduit.

2.10 INSULATED GROUND CONDUCTORS

A. Insulated copper ground conductors:

1. Size: as indicated on the Drawings, but in no case smaller than CEC required sizes.
2. Type: soft drawn, stranded, flexible, high conductivity
3. Shall meet the requirements of ASTM B8.
4. Insulation: chemically cross-linked thermosetting polyethylene (XLPE) material, rated RW90

5. Flame Test Rating:
 - a. CSA FT4 (if exposed)
 - b. CSA FT1 (if entirely within conduit)
6. Insulation voltage rating: 600V
7. Colour: green or green with yellow stripes as indicated on the Drawings.

2.11 BARE GROUND CONDUCTORS

- A. Bare copper ground conductors:
 1. Size: as indicated on the Drawings, but in no case smaller than CEC required sizes.
 2. Type: soft drawn, stranded, flexible, high conductivity.
 3. Shall meet the requirements of ASTM B8.

2.12 ACCESSORIES FOR CONDUCTORS 1000 VOLTS AND BELOW

- A. Wiring Accessories
 1. Splice connectors for equipment pig-tail, lighting and receptacle circuits: For wire sizes #12 and #10 AWG inclusive, twist-on compression spring type. Wing-Nut by Ideal, Marrette Type II by Marr Electric Ltd.
 2. Equipment pig-tail power circuit connections: For wire sizes #8 AWG minimum, split-bolt type, sized to suit number and size of conductors. Servit Type KS by Burndy Inc.
 3. Cable grips: To accommodate type and geometry of cable supported, single weave, variable mesh design, by Thomas and Betts Ltd., Crouse Hinds, Woodhead Canada Ltd.
 - B. Identification Devices:
 4. Sleeve: Permanent, PVC, white, with legible machine-printed black markings.
 - a. Manufacturer and Product: Raychem; Type D-SCE or ZH-SCE.
 5. Heat Bond Marker:
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine printed black text.
 - d. Manufacturer: 3M Co.; Type SCS-HB.
 6. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
 7. Tie-On Cable Marker Tags:
 - a. Chemical resistant white tag.
 - b. Size: 13 mm by 51 mm.
 - c. Manufacturer and Product: Raychem; Type CM-SCE.
 8. Grounding conductor: Permanent green heat-shrink sleeve, 51 mm minimum.
- B. Cable ties:
 1. Nylon, adjustable, self-locking.
 2. Use nylon cable ties only in horizontal cable tray runs, to secure cables to the tray. Nylon cable ties are not to be used for cable support.
 3. Manufacturer and Product: Thomas & Betts Ty-Rap.
- C. Heat shrinkable insulation:
 1. Thermally stabilized, crosslinked polyolefin.
 2. Manufacturer and Product: Thomas & Betts Shrink-Kon.

PART 3 EXECUTION

3.1 INSTALLATION OF WIRES AND CABLES

A. Field Quality Control

1. Perform tests in accordance with 26 08 05, Acceptance Testing.
2. Perform megohmmeter testing of all cables (each conductor) for cable sizes 10 AWG and larger - with the following exceptions - megohmmeter testing is not required for: lighting circuit, 120 VAC duplex receptacle cabling. Provide test documentation for all cables tested.

B. Re-use of existing wiring

1. Except where specifically identified or approved, reuse of existing wiring is not permitted.
2. Ensure all existing wiring is tagged prior to disconnection of equipment.
3. Tag spare wires as "Spare" and indicate the location of the other end of the wire. In addition, correlate / identify both ends of each conductor.

C. General requirements

1. Wiring inside walls to drop vertically from above or come up from below. Horizontal cable runs within a wall are not permitted.
2. Branch circuit wiring for surge suppression receptacles and permanently wired computers and electronic equipment to have a dedicated neutral conductor. Do not share neutrals.
3. Conductor length for parallel feeders to be identical.
4. Install wires and cables in a continuous length between termination points. Splices are not permitted, except within junction boxes or where specifically approved by the Contract Administrator. Where splices are necessary and approved utilize the cable Manufacturer approved and recommended kit.
5. For outdoor or exposed installations, make all entries of cables or wires to equipment or panel from the bottom or side to minimize water entry points. Make no entries of cables or wires from the top unless specifically approved by the Contract Administrator.
6. For exterior wall penetrations:
 - a. Utilize Roxtec weatherproof sealing system.
 - b. Install to Manufacturer's recommendations.
 - c. Install flush with exterior of the wall.
 - d. Prior to installation of seals, contractor to submit proof of training to the Contract Administrator. Do not install the cable seal system without equipment Manufacturer training, as work will have to be re-done. Contact Roxtec for training.
 - e. Prior to covering up wall penetration work, arrange for a site inspection of the work with the Contract Administrator. Proof of proper installation is required.
7. Do not pull conductors into conduit or cable tray until rough building construction operations have been completed.
8. Steel armor, steel conduit, and steel cable supports are generally not permitted in order to prevent corrosion due to H₂S gas. Utilize aluminum materials in order to prevent corrosion.
9. Heat shrink insulation shall be used where additional insulation or dressing of connected cables is required. Electrical tape shall not be used for additional insulation or dressing of connected cables. The use of heat shrink tubing and electric heat gun to heat the shrink tubing is the required method.

10. Do not embed cables or conduits in masonry or concrete without written approval from the Contract Administrator. Wiring through conduit sleeves for short, direct wall or floor penetration is accepted.
11. Design wire and cable anchorage and support system for vertical and lateral loading in accordance with the Manitoba Building Code (MBC).
12. Provide non-ferrous GPO (glastic) or aluminum plates for single conductor cable entry into an enclosure. Aluminum entry plate shall be used where conductor armour is required to be bonded to the enclosure. GPO (glastic) materials shall be used where cable armour is not bonded to the enclosure.
13. In some cases the electrical conductor size may be too big to terminate on vendor supplied lugs. In these cases, the Contractor remains responsible for making all cable terminations. The Contractor shall replace the lugs or shall provide reducing compression connectors to make the termination. Alternatively the Contractor may provide appropriate junction boxes to reduce the conductors sizes as required to perform the cable termination.
14. Space out conductors and separate different systems and voltages in accordance with the CEC and the COW requirements. Refer to 26 05 36, Cable Trays for Electrical Systems for cable spacing requirements.

D. Installation of AC-90 cables:

1. To be used only in dry, non-hazardous commercial office type of occupancy.
2. Do not use AC-90 in industrial, wet well, pumping stations, or similar type of facilities.
3. Where AC-90 is permitted to be used, its use is limited as indicated:
 - a. AC-90 is limited to 15A receptacle or lighting circuits only.
 - b. All AC-90 cable runs must be concealed within a wall, or within a drop ceiling. Surface mounted AC-90 runs are prohibited.
 - c. AC-90 drops to recessed light fixtures are permitted but shall not be run horizontally more than 6.5' (2m) from conduit system boxes in ceiling space.
 - d. AC-90 drops from conduit system in the ceiling space to feed outlets in wall stud partitions shall not run more than 6.5' (2 m) horizontally from the ceiling outlet box to the point where the AC-90 drops vertically into the partition.
 - e. Where the total length of AC-90 would be greater than 2 m horizontally in the ceiling, provide conduit to a junction box closer to the drop location.
 - f. Cable runs to receptacles in walls shall be made from an accessible junction box. Do not use receptacles as feed through devices.
 - g. Do not run AC-90 horizontally within enclosed walls.

E. Installation of Teck 90 armored cables:

1. Shall be installed in industrial, hazardous, underground or wet areas and where noted on the Drawings and cable schedules.
2. Where surface mounted, cables shall be securely supported using aluminum cable clamps and cantruss supports. Space supports a maximum of 1 m apart.
3. Where multiple cables are run into an area, install cables on cable tray or on cantruss hangers.
4. Where applicable, de-rate and upsize cables in accordance with the CEC.
5. Minimum bend radius is 12 times, or larger as required by the cable Manufacturer.
6. Avoid damaging outer jacket covering the armor. In some areas, such as the chemical building, exposed armor is not desirable. Replace cables at no additional cost where outer jacket is damaged.

- F. Installation of single RW90 conductors:
 - 1. Install in conduit as per Section 26 05 34, Conduits, Conduit Fasteners and Conduit Fittings.
 - 2. Ensure conduit is dry and clean prior to pulling conductors in. If moisture is present, thoroughly dry and clean conduits.
 - 3. Use pulling lubricant when pulling conductors in conduit to reduce the strain on the wires. Lubricants must be polymer based, and must not adversely affect or degrade cable insulation.
 - 4. Do not combine conductors in a common duct or conduit without regard for de-rating. De-rating is as per the CEC.

- G. Installation of control cables:
 - 1. Install control cables in conduit.
 - 2. Ground shields at one end only. Where possible, ground shields at the end where power is supplied to the cable. Utilize shield grounding bar in panels, where present.
 - 3. Shield drain wires, at the ungrounded end, are to be taped back to the cable. Do not cut the shield drain wire off.
 - 4. CIC cable may not be installed in cable tray. Protection in conduit is required over the entire length.
 - 5. ACIC cable may be installed in cable tray, provided that:
 - a. The cable tray does not contain power cables, unless specifically authorized by the Contract Administrator in writing.
 - b. The ACIC cable voltage rating is equal to or greater than the highest voltage contained in the cable tray.

- H. Installation of fire alarm cabling (if applicable):
 - 1. Install in conduit as per Section 26 05 34, Conduits, Conduit Fasteners and Conduit Fittings.
 - 2. Install conductors to be entirely independent of all other wiring. Do not enter raceway, boxes or enclosures occupied by other wiring except where necessary to connect to power supply, communication circuit, or ancillary devices.

3.2 INSTALLATION

- A. Install terminations, lugs, connectors, and splices in accordance with Manufacturer's instructions.

- B. Wiring and connections should be made within junction boxes, termination cabinets, panels and devices. Use splice kits, only where absolutely necessary, and with specific approval from the Contract Administrator.

- C. Splices shall only be used with specific written approval from the Contract Administrator. Otherwise, connection shall be made using suitable lugs and connectors in approved junction boxes or pull boxes.

- D. Install connector bushings to prevent sharp edges from cutting or damaging conductor insulation.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS

PART 1 GENERAL

1.1 RELATED SECTIONS

- A. Section 26 05 01, Common Work Results – Electrical

1.2 SUBMITTALS

- A. Submit product data in accordance with Section 01 33 00, Submittal Procedures.

PART 2 PRODUCTS

2.1 FRAMING AND SUPPORT SYSTEM

- A. Materials:
 - 1. Conduit support structures shall employ aluminum Unistrut Framing System together with the Manufacturer's connecting components and fasteners for a complete system with exceptions indicated herein.
 - 2. For conduit supports in the Chemical Building, utilize 316 stainless steel Unistrut Framing System together with the Manufacturer's stainless steel connecting components and fasteners for a complete system.
 - 3. Acceptable Manufacturer:
 - a. Unistrut P1000 series or approved equal in accordance with B8 Substitutes.
- B. Finishes:
 - 1. Wet locations: Aluminum.
 - 2. Indoors, dry locations: Aluminum.
 - 3. Corrosive areas (Chemical Building): 316 stainless steel.
 - 4. Wet corrosive areas (exposed to H₂S gasses): Aluminum.
 - 5. Nuts, bolts, machine screws: Stainless Steel.

2.2 CONCRETE AND MASONRY ANCHORS

- A. Materials: 316 stainless steel inserts and anchors for corrosion resistance.
- B. Components: non-drilling anchors for use in predrilled holes, sized to safely support the applied load with a minimum safety factor of four.
- C. Manufacturer: Hilti (Canada) Limited or approved equal in accordance with B8.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Secure equipment to solid masonry, tile and plaster surfaces with anchors.
- B. Secure equipment to poured concrete with expandable inserts.
- C. Secure equipment to hollow masonry walls or suspended ceilings with toggle bolts.
- D. Support equipment, conduit or cables using clips, spring loaded bolts, cable clamps designed as accessories to basic channel members.
- E. Maximum spacing between conduit supports:
 - 1. As per Section 26 05 34, Conduits, Conduit Fasteners, and Conduit Fittings.
- F. Fasten exposed conduit or cables to building construction or support system using straps.
 - 1. PVC Conduit:
 - a. Two-hole straps for all sizes of conduit.
- G. Suspended support systems.
 - 1. Support individual cable or conduit runs with 10 mm diameter threaded rods and spring clips.
 - 2. Support 2 or more cables or conduits on channels supported by 10 mm diameter threaded rod hangers where direct fastening to building construction is impractical.
- H. For surface mounting of two or more conduits use channels, with maximum centre spacing as indicated above.
- I. Provide metal brackets, frames, hangers, clamps and related types of support structures where indicated or as required to support conduit and cable runs.
- J. Ensure adequate support for raceways and cables dropped vertically where there is no wall support.
- K. Do not use wire lashing or perforated strap to support or secure cables.
- L. Do not use supports or equipment installed for other trades for conduit or cable support except with permission of other trade and approval of the Contract Administrator.
- M. Install fastenings and supports as required for each type of equipment cables and conduits, and in accordance with Manufacturer's installation recommendations.
- N. Sand and file sharp edges where members were cut.

END OF SECTION

SECTION 26 05 31

SPLITTERS, JUNCTION, PULL BOXES AND CABINETS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Materials and components for splitters, junction, pull boxes, and cabinets.

1.2 CODES AND STANDARDS

- A. Canadian Standards Association (CSA International)
 - 1. CSA C22.2 No.76, Splitters.
 - 2. CSA C22.2 No. 30, Explosion-Proof Enclosures for Use in Class I hazardous Locations.
 - 3. CSA C22.2 No. 40, Enclosures for Electrical Equipment, Non-Environmental Considerations (Tri-National Standard, with NMX-J-235/1-ANCE-2007 and UL 50).
 - 3. CSA C22.2 No. 94, Special Purpose Enclosures.

1.3 SUBMITTALS

- A. Submit Shop Drawings indicating the components and equipment to be used:
 - 1. Manufacturer's data sheets for each type of junction box, cabinet, splitter, and pull box.
 - 2. Manufacturer's Shop Drawings including:
 - a. Dimensioned layout and general arrangement.
 - b. CSA enclosure rating.
 - c. Voltage, current rating of lugs and termination equipment.
 - d. Accessories and components.
 - e. Material.
 - f. An indication from the Contractor in which area each type of enclosure / box will be installed.

PART 2 PRODUCTS

2.1 SPLITTERS

- A. General
 - 1. Three sets of lugs, minimum, sized and suitable for conductor termination.
 - 2. Main and branch lugs to match required size and number of incoming and outgoing conductors as indicated.
 - 3. Provide ground bar, with a minimum of three terminals.
- B. Splitters installed in dry, non-hazardous, non-corrosive locations to be constructed of sheet metal, with a hinged lockable cover, CSA enclosure type 1, 2 or 12. Use enclosure type 12 for facilities that are sprinklered.
- C. Splitters for wet, exterior application to be constructed of sheet metal, CSA enclosure type 4X.

- D. Do not install splitters in hazardous or corrosive areas. If required install suitable, Class I junction boxes.

2.2 JUNCTION, PULL BOXES AND CABINETS

- A. Junction boxes and pull boxes installed in dry, non-hazardous, non-corrosive office type of locations:
 - 1. CSA enclosure type 1, 2 for dry office type areas. Use sealed, gasketed, CSA enclosure type 12 for sprinklered office areas.
 - 2. To be constructed of sheet metal.
 - 3. For boxes 100 mm square and smaller, screw-on type, flat covers.
 - 4. For boxes larger than 100mm square, box covers are to have a continuous piano hinge and clamps for opening.
- B. Cabinets installed in dry, non-hazardous, non-corrosive process locations:
 - 1. To CSA C22.2 No. 94 and UL 508A
 - 2. CSA enclosure type 12, gasketed.
 - 3. To be constructed of painted, mild steel.
 - 4. Back-plate with offsets for installation of devices.
 - 5. Continuous piano hinge, door with quarter turn latch and handle.
- C. Junction boxes and pull boxes for wet or corrosive locations:
 - 1. CSA enclosure type 4 (aluminum only) or 4X, gasketed.
 - 2. Constructed of cast aluminum with threaded connection.
 - 3. Termination of underground PVC conduit system may be made into an exterior mounted, rigid PVC CSA enclosure type 4X as applicable.
 - 4. Utilize 316 stainless steel bolts, washers and mounting hardware.
- D. For hazardous locations:
 - 1. To CSA C22.2 No. 30 and UL1203.
 - 2. Rated for Class I, Div. 1 & 2 (or Zone 0, 1 and 2), Groups C, D locations.
 - 3. Constructed of cast copper free aluminum with threaded connection.
 - 4. Hinged, bolt-on style aluminum cover with neoprene gasket.
 - 5. Factory installed aluminum mounting plate for terminals, lugs and electrical devices.
 - 6. Factory installed threaded openings for conduit and cable connections.
 - 7. Utilize 316 stainless steel bolts, washers and mounting hardware.

PART 3 EXECUTION

3.1 SPLITTER INSTALLATION

- A. Install splitters and mount plumb, true and square to the building lines.
- B. Extend splitters full length of equipment arrangement except where indicated otherwise.

3.2 JUNCTION BOX, PULL BOXES AND CABINET INSTALLATION

- A. Install pull boxes, pull boxes and cabinets in inconspicuous but accessible locations.

- B. Cabinets shall have a minimum of 1 meter of clearance in front, in accordance with CEC requirements.
- C. If junction boxes are required in inaccessible location, provide a suitable access panel which allows sufficient space for opening the junction box.

3.3 IDENTIFICATION

- A. Provide equipment identification in accordance with Section 26 05 01, Common Work Results - Electrical.
- B. Nameplates for cabinets and splitters, size 8 nameplates engraved as follows:
 - 1. Engrave with the requirements as indicated on the Drawings. If nothing is specified, the minimum is as follows:
 - a. Line 1 is to be the cabinet or splitter identifier as indicated on the Drawings, for example "SPLITTER SPL-M701".
 - b. Line 2 is to be the voltage, for example "600V, 3Ø, 4W".
 - 2. Line 3 is where the panel is fed from, for example "Fed From DP-M702"
- C. Nameplates for junction boxes and pullboxes, size 1 or size 2 engraved with the circuit numbers in the junction box, for example "M703-2" - which corresponds to PNL-M703, circuit 2.

END OF SECTION

SECTION 26 05 34

CONDUITS, CONDUIT FASTENERS, AND CONDUIT FITTINGS

PART 1 GENERAL

1.1 RELATED SECTIONS

- A. Requirements specified within this section apply to all sections in Division 26, Electrical. This section supplements requirements of other Divisions.

1.2 CODES AND STANDARDS

- A. CAN/CSA C22.2 No. 18, Outlet Boxes, Conduit Boxes, and Fittings and Associated Hardware.
- B. CSA C22.2 No. 45, Rigid Metal Conduit.
- C. CSA C22.2 No. 56, Flexible Metal Conduit and Liquid-Tight Flexible Metal Conduit.
- D. CSA C22.2 No. 83, Electrical Metallic Tubing.
- E. CSA C22.2 No. 211.2, Rigid PVC (Unplasticized) Conduit.
- F. CSA C22.2 No. 211.1, Rigid Types EB1 and DB2 / ES2 PVC Conduit
- G. CAN/CSA C22.2 No. 227.3, Flexible, Non-metallic Tubing.

1.3 GENERAL CONDUIT REQUIREMENTS

- A. The Drawings do not show every specific conduit run. Supply and install conduit, and support systems as required for a complete installation.
- B. The materials for each conduit must meet the requirements of the area. Some areas are wet, highly corrosive; other areas have chemicals which may adversely interact with specific materials. Care must be taken in making the proper conduit selection for the particular area.
- C. Design equipment anchorage and support system for vertical and lateral loading in accordance with the MBC.

1.4 SUBMITTALS

- A. Submit written certification from a Professional Engineer licensed in the Province of Manitoba stating that support systems, anchorage, and equipment are structurally sound, and have been designed according to requirements of the MBC.
- B. Submit Shop Drawings indicating the component and equipment to be used:
 - 1. Electric metallic tubing.

2. Rigid aluminum conduit.
3. Rigid PVC conduit.
4. Flexible metal, liquid tight conduit.
5. Flexible non-metallic, liquid tight conduit
6. Conduit fittings, conduit couplings.
7. Hazardous area sealing fittings, coupling and sealing compound
8. Conduit clamps and support systems.
9. Submit information on where each type of conduit will be installed, prior to installation.
10. Submit details of the ULC approved fire stop assembly for approval prior to installation.

PART 2 PRODUCTS

2.1 CONDUITS

- A. Rigid aluminum conduit
 1. Meet requirements of CSA C22.2 No. 45.
 2. Materials: type 6063, copper-free aluminum alloy.
- B. Rigid PVC conduit
 1. Meet requirements of C22.2 No. 211.2.
 2. FT4 rated where installed indoors.
 3. Materials: Polyvinyl Chloride (PVC).
- C. Rigid DB2 PVC conduit
 1. Meet requirements of C22.2 No. 211.1.
 2. Materials: Polyvinyl Chloride (PVC).
- D. HDPE conduit
 1. Meet the requirements of C22.2 No. 211.2
 2. Materials: High Density Polyethylene
- E. EMT conduit
 1. Meet requirements of C22.2 No. 83.
 2. Materials: steel, electroplated outside finish, aluminum painted inside walls.
- F. Flexible liquid tight, metal conduit
 1. Meet requirements of CSA C22.2 No. 56.
 2. Materials: heavy duty, liquid tight, PVC with stainless steel core.
- G. Flexible non-metallic liquid tight conduit
 1. Meet requirements of CSA C22.2 No. 227.3.
 2. Materials: heavy duty, liquid tight, PVC.
- H. Conduits shall be sized in accordance with CEC requirements for wire counts installed. Conductors shall be de-rated according to code requirements. Upsize conductors as required to meet CEC and voltage drop requirements. Minimum conduit size: 21 mm, unless specifically indicated otherwise on the Drawings or specifically approved by the Contract Administrator.

- I. Conduits shall be EMT, rigid aluminum, liquid tight, and rigid PVC, as required to meet the requirements of the installation. Do not use steel conduit for areas where H₂S gas or other corrosive gasses or liquids are present

2.2 CONDUIT FASTENINGS

- A. One hole straps to secure surface conduits 50 mm and smaller. Two hole straps for conduits larger than 50 mm.
- B. Beam clamps to secure conduits to exposed steel work.
- C. Channel type supports for two or more conduits.
- D. Strap material to match conduit material.
- E. Threaded rods, minimum 10 mm diameter, to support suspended channels.

2.3 CONDUIT SPACERS

- A. PVC coated malleable metal spacers, CSA approved for the purpose.
- B. Aluminum channel may be utilized where conduits are grouped, however a non-metallic spacer must be provided between the aluminum channel and concrete.

2.4 CONDUIT FITTINGS

- A. General:
 1. Utilize factory made elbows for 27mm and larger conduits.
 2. All components to be CSA certified for the intended area of use.
 3. Meet all requirements of the CEC with respect to hazardous area sealing fittings.
 4. Utilize insulated grounding bushings at all enclosure entries for metallic conduit.
- B. Electric metallic tubing (EMT):
 1. Meet requirements of CSA C22.2 No. 45.
 2. Type: steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
 3. Electro zinc-plated inside and out.
 4. Raintight.
 5. Coupling Manufacturers and Products:
 - a. Appleton type 95T.
 - b. Crouse-Hinds.
 - c. Thomas & Betts.
 6. Connector Manufacturers and Products:
 - a. Appleton type 86T.
 - b. Crouse-Hinds.
 - c. Thomas & Betts.
- C. Rigid aluminum conduit:
 1. Meet requirements of CSA C22.2 No. 45.

2. Type: threaded, copper-free aluminum. Set screw fittings not permitted.
 3. Insulated bushing:
 - a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
 - b. Manufacturer and Product: O-Z/Gedney Type AB.
 4. Grounding bushing:
 - a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
 - b. Manufacturer and Product: O-Z/Gedney Type ABLG.
 5. Conduit hub:
 - a. Material: cast aluminum, with insulated throat.
 - b. ULC listed for use in wet locations.
 - c. Manufacturers and Products:
 - 1) O-Z/Gedney Type CHA.
 - 2) Thomas & Betts Series 370AL.
 - 3) Meyers Series SA.
 6. Expansion Fitting Manufacturers and Products:
 - a. Deflection/Expansion Movement:
 - 1) Appleton type DF.
 - 2) Crouse-Hinds type XD.
 - b. Expansion Movement Only:
 - 1) Appleton type XJ.
 - 2) Crouse-Hinds type XJ.
- D. Flexible metal, liquid-tight conduit:
1. Meet requirements of CSA C22.2 No. 56.
 2. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
 3. Insulated throat and sealing O-rings.
 4. Manufacturers and Products:
 - a. Thomas & Betts; Series 5331.
 - b. O-Z/Gedney; Series 4Q.
- E. Flexible, nonmetallic, liquid-tight conduit:
1. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
 2. Body/compression nut (gland) design to assure high mechanical pullout strength and watertight seal.
 3. Manufacturers and Products:
 - a. O-Z/Gedney; Type 4Q-P.
 - b. Thomas & Betts; Series 6300 or Carlon; Type LT.
- F. PVC Conduit and Tubing:
1. Meet requirements of NEMA TC-3.
 2. Type: PVC, slip-on.
- G. HDPE Conduit and Tubing:
1. Meet requirements of CSA C22.2 No. 211.2 and UL 651 for electrical cable raceway.
 2. Type: Manufacturer approved

2.5 EXPANSION FITTINGS FOR RIGID CONDUIT

- A. All conduits entering outlet boxes and devices that are located in walls subject to movement shall be terminated by means of liquid-tight flexible conduit, approximately 450 mm in length between the conduit and the outlet box or device which is being supplied. All conduits, bus duct, wireways, etc., passing through or across expansion joints of the building shall be installed with the use of approved expansion fittings.
- B. There are structural expansion joints in the facilities – these are not specifically identified on the electrical Drawings. Review the structural Drawings and note the locations of all expansion joints. Provide expansion couplings and fittings for all conduit crossing the joints. Do not locate rigid devices (for example panels) across or on top of the expansion joints. Add expansion fittings as required to accommodate expansion joints due to temperature variations.

2.6 FISH CORD

- A. Polypropylene.

2.7 CONDUIT BONDING

- A. All conduits shall have a bare or insulated copper bonding conductor run within. The bonding conductor shall be sized as per the CEC, table 16. The conduit itself cannot be used as the only means of bonding. Provide bond jumpers between conduit systems, and to the bond terminals on pull boxes and junctions boxes to ensure electrical continuity of all conduit systems. Not all bond cables are shown on the Drawings or on the cables list. Provide bonds even though not explicitly indicated in other documentation.

PART 3 EXECUTION

3.1 ROUTING

- A. Locate conduits containing communication and low voltage conductors away from conduits containing power wiring.
- B. Run parallel or perpendicular to building lines.
- C. Route conduits on suspended channels where possible.
- D. Avoid routes that would interfere with any potential maintenance activities.
- E. Where not specifically shown in detail on the Drawings, review proposed conduit routing with Contract Administrator prior to installation. Comply with all routing changes requested by the Contract Administrator.
- F. Install conduits to conserve headroom in exposed locations and cause minimum interference in spaces through which they pass.

3.2 INSTALLATION

A. General

1. All conduits shall be cut square and reamed smooth.
2. Provide bonding conductor in all conduit systems. Verify bond continuity of all conduit systems.
3. Metal, threaded conduit to be cut with a cutting tools that provide a 19mm taper per foot.
4. Remove burrs, ream and clean metal conduit before installation of conductors, wires, or cables.
5. Threaded conduit connections shall have a minimum of 5 full threads fully engaged or greater. In general all threaded connections (for both hazardous and non-hazardous areas) shall meet or exceed the requirements set out in CEC Section 18.
6. For metallic conduits, install within a PVC sleeve for holes / penetrations through concrete walls and slabs.
7. Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
8. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
9. Unless otherwise indicated, install conduits surface-mounted on walls and ceilings. Conceal or embed conduits only where indicated.
10. Do not pass conduits through structural members except as specified on the Drawings, or as permitted by the Contract Administrator.
11. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
12. Remove and replace blocked conduit sections. Do not use liquids to clean out conduits.
13. Install pullcords in empty conduit systems.
14. Dry conduits out before installing wire.
15. All conduits exposed in finished areas are to be free of unnecessary labels and trade marks.
16. Seal conduits with duct seal where conduits are run between heated and unheated areas.
17. Where conduits pass through walls, group and install through openings. After all required conduits are installed; close wall openings with material compatible with the wall construction. Perform fire stopping & sealing to ensure integrity of wall.
18. Do not locate conduits less than 75 mm parallel to steam or hot water lines with minimum of 25 mm space at crossovers.
19. Provide a minimum of 1 conduit diameter of space between adjacent conduit runs.
20. PVC conduit sections and fittings shall be connected using watertight PVC conduit cement.
21. Emergency lighting and exit signs shall be connected via a separate and dedicated conduit system.

B. Fire Stop Assemblies

1. Seal and firestop penetration around conduit with ULC approved fire stop assembly for the installation conditions.

3.3 CONDUIT APPLICATION

- A. Interior, exposed:
 - 1. Rigid threaded aluminum.
 - 2. Rigid PVC, FT4.
 - 3. EMT (for office type of areas only).
- B. Interior, concealed (office type of areas):
 - 1. EMT.
- C. Connections to vibrating equipment:
 - 1. Liquid tight, flexible conduit.
- D. Aboveground embedded in concrete walls, ceilings, or floors:
 - 1. Rigid PVC, FT4.
- E. Direct earth burial:
 - 1. Rigid PVC.
 - 2. HDPE horizontal directional drilling conduit – Used where specifically approved by the Contract Administrator.
- F. Concrete Encasement
 - 1. Rigid PVC, type DB2
- G. Under slabs on grade:
 - 1. Rigid PVC.
- H. Wet or Corrosive areas:
 - 1. Rigid threaded aluminum.
 - 2. Rigid PVC, FT4 rated conduit where acceptable by code and where approved on the Drawings.
- I. Hazardous locations:
 - 1. Rigid threaded aluminum.
 - 2. All fittings, couplings and devices shall be rated for Hazardous Class I, Div. 1 & 2 (or Zone 0, 1 and 2), Groups C, D Locations.

3.4 SPACING AND SUPPORTS

- A. WALL SPACING
 - 1. Group conduits wherever possible on suspended or surface mounted channels.
 - 2. Install spacers as required to provide a space between the conduits and the supporting surface, with a minimum space as follows:
 - a. Above grade spaces not classified as CEC Category 1 or 2:
 - 1) Drywall / wood surfaces: no space required
 - 2) Masonry / concrete surfaces: 6 mm
 - 3) Below grade spaces: 12 mm
 - b. Wet locations: 12 mm

- B. Supports for Metallic Conduit
 - 1. Maximum spacing between supports for metallic conduit:
 - a. 16mm conduit: 1.0 m
 - b. 21mm conduit: 1.5 m
 - c. 27mm conduit: 1.5 m
 - d. 35mm conduit: 2.0 m
 - e. 41mm conduit and larger: 2.5 m
- C. Supports for PVC Conduit
 - 1. Maximum spacing between supports for rigid PVC conduit:
 - a. 21mm conduit: 0.75 m
 - b. 27mm conduit: 0.75 m
 - c. 35mm conduit: 0.75 m
 - d. 41mm conduit: 1.2 m
 - e. 53mm conduit: 1.5 m
 - f. 63mm conduit: 1.5 m
 - g. 78mm conduit: 1.5 m
 - h. 91mm conduit and larger: 2.0 m

3.5 CONNECTIONS

- A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
 - 1. Wet or corrosive areas: flexible, non-metallic liquid tight conduit.
 - 2. Dry and non-corrosive areas: flexible, metallic liquid tight conduit.
 - 3. Hazardous areas: flexible liquid tight conduit, with couplings and fittings suitable for Class I, Division 1 and 2 areas.
 - 4. Length: 450 mm minimum, 1500 mm maximum, sufficient to allow movement and adjustment of equipment.
- B. Luminaires in dry areas: flexible, metallic liquid-tight conduit or approved cabling.
- C. Transition from underground or concrete embedded to exposed: rigid PVC to rigid aluminum conduit.
- D. Exterior light pole foundations: rigid PVC conduit.

3.6 BENDS

- A. Conduit runs shall not exceed four 90 degrees bends (for a total of 360 degrees) between pullboxes.
- B. Bend conduit cold. Replace conduit if kinked or flattened more than 1/10th of its original diameter. Bends are to be symmetrical.
- C. Avoid field-made bends and offsets, but where necessary, make with an acceptable bending machine. Do not heat metal raceways to facilitate bending.

- D. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
- E. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.
- F. Use factory made elbows for conduits over 27 mm in diameter.
- G. Install concealed raceways with a minimum of bends in the shortest practical distance.
- H. PVC Conduit:
 - 1. Bends 30 degrees and larger: provide factory made elbows.
 - 2. Use Manufacturer's recommended method for forming bends.
- I. Do not make bends that exceed allowable conductor or cable bending radius; or that significantly restrict cable pulls.

3.7 PENETRATIONS

- A. Prior to coring, drilling or cutting through wall, roof or floor members: perform scan of the surface, mark the intended location, and confirm acceptability with the Contract Administrator.
- B. For circular penetrations, provided steel pipe (galvanized or stainless to suit the environment). Provide 88.9mm high concrete curb around floor penetrations that are subject to regular clean up or wash down.
- C. Make at right angles, unless otherwise shown.
- D. Notching or penetration of structural members, including footings and beams, is not permitted unless specifically approved by the Contract Administrator.
- E. Firestop openings around penetrations to maintain fire-resistance rating.
- F. Apply single layer of wraparound duct band to all metallic conduit protruding through concrete floor slabs to a point 50 mm above and 50 mm below concrete surface.
- G. Concrete walls, floors, or ceilings (above ground): provide non-shrink grout dry-pack, or use watertight seal device.
- H. Entering Structures:
 - 1. General: seal raceway at the first box or outlet with oakum or expandable plastic compound to prevent the entrance of gases or liquids from one area to another.
 - 2. Exterior wall penetration:
 - a. Utilize Roxtec weatherproof sealing system.
 - b. Install to Manufacturer's recommendations.
 - c. Install flush with exterior of the wall.

- d. Prior to installation of seals, Contractor to submit proof of training to the Contract Administrator. Do not install the cable seal system without equipment Manufacturer training, as work will have to be re-done. Contact Roxtec for training.
- e. Prior to covering up wall penetration work, arrange for a site inspection of the work with the Contract Administrator. Proof of proper installation is required.
3. Concrete roof or membrane waterproofed floor:
 - a. Provide a watertight seal.
 - b. Without concrete encasement: Install watertight entrance seal device on each side.
 - c. With concrete encasement: install watertight entrance seal device on the accessible side.
 - d. Securely anchor watertight entrance seal device into construction with one or more integral flanges.
 - e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
4. Heating, ventilating, and air conditioning equipment:
 - a. Penetrate equipment in area established by Manufacturer.
 - b. Connect equipment using liquid tight flexible conduit.
5. Corrosive sensitive Areas:
 - a. Seal all conduit passing through corrosive room walls.
 - b. Seal conduit entering equipment panel boards and field panels containing electrical equipment.
6. Existing or precast wall (underground): core drill wall and install a watertight entrance seal device.
7. Nonwaterproofed floor (underground, without concrete encasement):
 - a. Provide watertight entrance seal device.
 - b. Fill space between raceway and sleeve with expandable watertight compound or oakum and lead joint, on each side.
8. For exterior installations, conduit entry shall be from the bottom, unless approved otherwise by the Contract Administrator.

3.8 UNDERGROUND CONDUIT INSTALLATIONS

- A. Minimum burial depths shall be as detailed on the Drawings, but in no case less than the requirements indicated in the CEC.
- B. Conduits shall have a red plastic warning tape placed above, buried at a depth of 305mm below grade. The plastic tape is to completely cover all conduits, and overlap the width of all conduits by at least 150mm on either side. Provide mechanical protection, planking in accordance with the U.G trenching specifications.
- C. All underground direct buried conduits shall be rigid PVC.
- D. Provide rigid PVC conduit, type DB2 for encasement in concrete for duct banks. HDPE conduit can be used only where specifically approved by the Contract Administrator.
- E. Maintain a minimum of 1200mm horizontal clearance distance from underground structures such as buildings and equipment foundations.

- F. Maintain a minimum of 600mm horizontal clearance distance from underground equipment such as piping and other underground conduit runs.
- G. All clearances in strict accordance with the MBC, CEC, and all other bylaws.
- H. Provide Universal GPS coordinates of all underground conduit runs at every bend, and at every 6000mm intervals. Include coordinates on the As-Built drawings.
- I. Provide man-holes and hand-holes as required to accommodate the conductor pull.
- J. Slope conduits away from building and enclosures entry points, to provide drainage.

3.9 INSTALLATIONS IN CATEGORY 1 LOCATIONS

- A. Arrange to provide drainage at frequent intervals to suitable locations.
- B. Equip with approved fittings to permit the moisture to drain out of the system.
- C. Install the conduit with a minimum of 12 mm space from the supporting surface.
- D. Every joint, coupling and fitting to be water-tight.
- E. Where conduit leaves a warm room and enters a cooler atmosphere, seal the conduit and arrange the conduit in a manner to avoid condensation accumulation at the seal.

3.10 INSTALLATIONS IN CATEGORY 2 LOCATIONS

- A. Comply with all requirements of Category 1 locations.

3.11 INSTALLATIONS IN CATEGORY 2 WET LOCATIONS

- A. Comply with all requirements of Category 1 locations.

3.12 INSTALLATIONS IN HAZARDOUS LOCATIONS

- A. Install conduit system, complete with explosion proof conduit sealing fittings:
 1. Install cables in conduit system – maximum permitted conduit / conduit fitting fill for hazardous areas is 25 percent.
 2. Provide sealing fittings to suit the area classification, and to meet the CEC requirements.
 3. Install sealing compound following Manufacturer's instructions.

END OF SECTION

SECTION 26 08 05

ACCEPTANCE TESTING

PART 1 GENERAL

1.1 REFERENCES

- A. NETA Acceptance Testing Specifications, 2009 (ATS-2009)
- B. CSA C282, Emergency Electrical Power Supply for Buildings.
- C. City of Winnipeg inspection / test forms, Appendix Y – Sample Electrical Test Forms.

1.2 SUBMITTALS

- A. Provide submittals in accordance with Section 01 33 00, Submittal Procedures.
- B. Submit:
 - 1. Test equipment to be utilized with last calibration date.
 - 2. Qualifications of lead electrical inspections technician.
 - 3. Test forms that will be utilized. These will be based on the COW test form format.

1.3 QUALIFICATION

- A. Provide competent lead electrical inspection technician thoroughly familiar with all aspects of electrical testing. It is expected that the technician will have a CET, Journeyman Electrician's certificate, or other equivalent designation. The designated technician is to be on-site and lead all electrical testing.
 - 1. The Contract Administrator reserves right to approve the lead electrical inspection technician, and request an alternate technician if deemed to be unqualified.
 - 2. The Contract Administrator reserves the right to request documentation and proof from the Contractor that their lead electrical inspections technician is qualified to perform the work. The documentation and proof can include the following:
 - a. A request for references from past previous projects.
 - b. A request for a list of past previous projects.
 - c. A request for an interview and seminar to be given by the lead electrical inspection technician demonstrating in-depth knowledge of the subject matter.
 - 3. In the circumstance where the Contract Administrator rejects the lead inspection technician, the Contractor will be responsible for providing a suitably qualified individual to perform the work, at no additional cost to the City of Winnipeg. Qualifications will be specifically analyzed by the Contract Administrator, based on the following:
 - a. The qualified lead electrical inspection technician will have performed similar work at other similar installations.
 - b. The qualified lead electrical inspection technician will be trained in using the instruments and measuring devices; and adjusting the settings or programming the devices.

- c. The qualified lead electrical inspection technician will have experience in analyzing the results obtain from the instruments or measuring devices.
 - d. The qualified lead electrical inspection technician will have sufficient experience to immediately recognize erroneous measurements based on past work experience and expected results.
 - e. The qualified lead electrical inspection technician will be familiar with the settings and methodologies required to perform the work.
4. In the circumstance where the Contractor cannot provide a competent lead electrical inspection technician, the Contract Administrator reserves the right to hire a qualified individual separate from this Contract and to back charge the Contractor for services and costs performed in order to complete the work.

1.4 TESTING EQUIPMENT

- A. All test equipment shall be in good mechanical and electrical condition.
- B. Accuracy of metering in test equipment shall be appropriate for the test being performed.
- C. Wave shape and frequency of test equipment output waveforms shall be appropriate for the test and the tested equipment.
- D. The test equipment shall be calibrated as specified below:
 1. The testing organization shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.
 2. The testing organization will have calibration certifications for test equipment, and a copy will be made available to the Contract Administrator.
 3. The firm providing calibration service shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.
 4. Instruments shall be calibrated in accordance with the following frequency schedule:
 - a. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum.
 - b. Laboratory instruments: 12 months maximum.
 - c. Leased specialty equipment: 12 months maximum.
 - d. Dated calibration labels shall be visible on all test equipment.
 - e. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date.
 - f. Calibrating standard shall be of higher accuracy than that of the instrument tested.
- E. Specific requirements of insulation resistance meters.
 1. Must be digital units. Crank-type analog insulation resistance meters will not be acceptable.
- F. Ensure suitable power supply is available for test equipment, be this 120Vac or battery powered devices. Record make, model, and calibration date of test instrument.
- G. Test to be conducted with full safety requirements in force, including “barrier” of conductor ends, proper bonding, “flag-person” as necessary.
- H. All test equipment to have valid calibration stickers displayed on the equipment.

- I. DC High Pot (dielectric strength) Units:
1. Test instrument to have minimum output of 60 kV dc capacity.
 2. 120Vac powered.
- J. AC High Voltage (dielectric strength) Units:
1. Use AC High voltage units for insulation tests and other tests as indicated, at voltage levels indicated, or required by Manufacturers recommendations.
- K. Low Resistance Test Units (Ductor):
1. Low resistance test units to have 10A output.
 2. Digital display and accuracy to 1 micro-ohm, with a range from 1 $\mu\Omega$ to 1000 Ω . Standard electrician multimeters will not be accepted.
- L. Insulation Resistance Tests (Megohmmeter/Megger):
1. Use a megger with 20,000 M-ohm resolution for megger tests.
 2. Output voltages on DC megger units to be 250V, 500V, 1000V, 2500V or other as required.
 3. Record ambient temperature and adjust the measured M-ohms to 20C ambient.
 4. Use 2.5kV megger for 5 kV and 15 kV equipment and 1000 V megger range for power equipment of 600 V and below.
 5. For 10-minute megger tests, record M-ohm values in M-ohm at 30 seconds, 60 seconds, 5 minutes and 10 minutes. Plot M-ohm against time for each connection, calculate and record the ratio of measured M-ohm as follows:
 - a. 60 sec M-ohm/30 sec M-ohm = dielectric absorption.
 - b. 10 min M-ohm/1 min M-ohm = polarization index.
 - c. Report the 1 minute M-ohm as the insulation resistance value.
 6. Submit tabulated measure M-ohm figures for 10-minute insulation tests, submit a graph.
 7. Apply megohmmeter dc voltage in accordance with the equipment Manufacturer's recommendations or NETA ATS-2009 Table 100.1.
- M. VLF Test:
1. Use a VLF tester capable of 40 kV peak that is capable of testing 1.1uF of cable load at 0.1 Hz up to 5.5 uF at 0.2 Hz.
- N. Relay Test Equipment:
1. Relay test equipment to be designed for relay testing, secondary current injection.
 2. Current output to a minimum of 60Amps for testing of instantaneous features.
 3. Indicators to detect open signals, pick-up signals and other required signals.
 4. Timers to 1 millisecond.
 5. MultiAmp or approved equal in accordance with B8 relay test units. Specifically designed relay testers for specific relays should be used if available.
 6. For equipment required on three phase systems, have a three phase voltage and relay output test unit.
 7. For equipment required on three phase differential tests, have a six phase voltage and relay output test unit.

- O. Ground Resistivity Tester:
 - 1. Ground resistivity tester to measure earth impedance in variable distances from the source.
 - 2. Unit to be capable of plotting ground resistivity from 0.1 ohms and up.
- P. Other test equipment as required in order to satisfy the requirements of this section as detailed herein.

1.5 TESTING REPORT

- A. Prepare an overall inspection and test report that details all investigations and tests.
- B. The Contractor shall furnish five paper copies and two electronic copies on USB of each final report.
 - 1. The electronic copies of the report, including the test forms, shall be provided in PDF format.
 - 2. Sample City test forms are included for reference. The Contractor shall modify the forms, and create new forms as needed to meet all the test requirements described herein.
 - 3. A Microsoft Word version of the all completed test forms provided to the City shall also be included on the USBs.
- C. The report shall be neat and organized. Any omissions, inconsistencies, or incomplete work identified by the Contract Administrator shall be corrected and incorporated into the report in the appropriate section, and completely resubmitted.
- D. A draft of each report shall be completed and sent to the Contract Administrator for review a maximum of one month after the completion of the inspections at the Site.
- E. The final report shall be submitted a maximum of two weeks after the Contractor receives the mark-up of the draft report from the Contract Administrator.
- F. The report shall include the following:
 - 1. Summary of project.
 - 2. Testing Equipment.
 - 3. Detail the type, manufacturer, model, last calibration date and test certificate for all testing equipment used.
 - 4. Description of equipment tested.
 - 5. Description and methodology of all tests performed.
 - 6. Typed inspection forms including:
 - a. Identification of the testing organization.
 - b. Equipment identification.
 - c. Humidity, temperature, and other conditions that may affect the results of the tests/calibrations.
 - d. Date of inspections, tests, maintenance, and/or calibrations.
 - e. Identification and signed initials of the testing technician.
 - f. Indication of inspections, tests, maintenance, and/or calibrations performed and recorded, along with charts, and graphs as applicable. All measurements and readings taken shall be noted for inclusion in the report. Where repairs are made, measurements and readings before and after the repair shall be included.

- g. Indication of expected results, when calibrations are to be performed.
- h. Indication of “as-found” and “as-left” results, as applicable.
- 7. Itemized list of all repaired deficiencies which shall include:
 - a. Detailed description of the deficiency.
 - b. Detailed description of the deficiency repair.
- 8. Itemized list of all un-repaired deficiencies encountered which shall include:
 - a. Detailed description of the deficiency.
 - b. Recommended action to be taken to repair the deficiency.
 - c. Reason for not performing the recommended repair (such as equipment or component not available).
 - d. Schedule and subsequent follow up and documentation of the repair of the deficiency.

PART 2 PRODUCTS

2.1 EQUIPMENT

- A. Provide all tests results with typed test reports and signed field test sheets.
- B. All test sheets to include equipment nameplate data, customer identification, time and date of tests, environmental conditions during tests, and test results.
- C. Provide testing equipment, lifts, man-baskets, temporary connections, cabling, lugs, leads, clips, and all other devices and equipment as required to perform the required tests and complete the required documentation.

PART 3 EXECUTION

3.1 TEST PLAN

- A. Prior to performing testing, the lead electrical inspection technician shall submit written test procedures indicating details of the work to be performed to the Contract Administrator for review and approval prior to proceeding.
- B. As a minimum, the test plan shall include the following:
 - 1. Type of tests.
 - 2. Equipment being used to perform the test.
 - 3. Equipment settings for each test.
 - 4. Test sheets.
 - 5. Safety checks and safety plan.
 - 6. An indication of expected results.
- C. The cost of any damage to equipment due to improper test methods or procedures will be borne by the Contractor performing the tests.

3.2 SCOPE OF TESTING

- A. Perform testing and Commissioning of electrical devices, in accordance with the Drawings and Specifications to suit the actual project. Scope of work for testing includes the following devices:
1. Motor Control Centers (MCCs), including:
 - a. Surge Protector
 - b. Power Meter
 - c. Voltage Monitor
 - d. CTs
 - e. PTs (if present)
 - f. Main and Tie Breakers
 - g. Branch Circuit Breakers
 - h. Motor Starters
 - i. VFDs
 - j. Interlocks
 - k. Kirk keys
 2. Panelboards and distribution panels, greater than 225A, including:
 - a. Surge Protector
 - b. Power Meter
 - c. Voltage Monitor
 - d. CTs
 - e. PTs
 - f. Branch Circuit Breakers
 3. Air circuit breakers
 4. Vacuum circuit breakers.
 5. Static Uninterruptible Power Supply (UPS)
 6. Molded case circuit breakers, greater than or equal to 250A frame.
 7. Contactors, greater than or equal to 100A.
 8. Protective relays
 9. Medium voltage and low voltage switchgear, including:
 - a. Surge Protector
 - b. Power Meter
 - c. Voltage Monitor
 - d. CTs
 - e. PTs
 - f. Relays
 - g. Switches, pushbuttons
 - h. Lock-out relays
 - i. Interlocks
 - j. Kirk keys
 10. Power factor correction, including:
 - a. Metering
 - b. Capacitors
 - c. Branch Circuit Breakers
 - d. Contactors
 11. Dry type transformers, 15 kVA and greater.
 12. Oil filled transformers.

13. Motors, 0.5 HP and greater.
 14. Gensets.
 15. Transfer switches.
 16. Safety switches, greater than 200A.
 17. Battery systems.
 18. Surge arrestors.
 19. Soft starters.
 20. VFDs.
 21. Cables:
 - a. Test all 120 V / 208 V / 240 V / 600 V power cables and wires No. 10 AWG or larger (except for lighting and 15A duplex receptacle circuits)
 - b. Test all 15 kV cables
 22. Grounding system.
 23. Perform harmonics measurements and analysis at all main distribution panels, and at all MCCs at all available voltage levels at the Facility.
- B. All new equipment which fails the tests shall be replaced, repaired and corrected at no additional charge. These items are deemed to be under warrantee, and the warrantee shall not be affected or voided as a result of the testing performed.
- C. The calibration, check out, testing and Commissioning activities specified in other sections, of the overall Specifications are to be considered as supplemental to the requirements of this section. Those requirements are to be completed for each particular part of the work described prior to the execution of the overall requirements described herein. Where any duplication in requirements may exist the more stringent requirement will take precedent.
- D. Perform Commissioning of all systems, to ensure a complete and functional installation. Perform Commissioning work in accordance with Appendix A – Commissioning Specification and Objectives (CSO), and Appendix B – Commissioning Procedures (CP), of this document.

3.3 INSPECTION, TESTING AND MAINTENANCE PROCEDURES

- A. General
1. All tests are based on NETA (InterNational Electrical Testing Association) standard ATS-2009. Where Manufacturer's Specifications, tolerances, and/or published data are not available, refer to the appropriate tables in ATS-2009. Confirm with the equipment Manufacturer that the test will not damage the equipment or void the warrantee prior to proceeding with tests.
 2. Torque all accessible bolted electrical connections. Additional requirements apply as specified.
 3. Utilize the Drawings for reference while performing the specified electrical inspection work. Where the existing installation deviates from that shown on the Drawings, mark-up the Drawings with red pen as required to reflect the installation. Include the marked-up Drawings in the report.
 4. The scope of required Drawing checks is limited to the equipment and components that are part of the electrical inspection work.
 5. Any repairs made that affect the accuracy of the Drawings shall be marked up on the Drawings.

6. All inspection values, readings, corrections, and assessments shall be clearly recorded for inclusion within the report.
7. Where corrections or repairs are made, record both as found/as left test readings on the inspection sheet. If space is not provided on the inspection form, record the readings in the Note fields or on a separate sheet.

B. Inspection Forms

1. The inspection forms are to be provided, and completed by the Contractor. These shall be typewritten (in Microsoft Word or Excel format) and submitted the Contract Administrator for format approval.
2. Make appropriate print-outs of the inspection forms and utilize for entry of data and test results on site.
3. Utilizing the Microsoft Word form templates, enter the data recorded manually into the forms electronically.
4. Complete the inspection forms in their entirety and include them in the report.
5. Submit electronic PDF copies of the inspection forms.
6. The scope of work required in the Specifications is in no way limited by the inspection forms, or spaces provided. Provide additional pages, documents, and forms as required to provide a complete report.
7. The inspection forms may be updated during the by the Contract Administrator. Utilize the latest forms.
8. Perform insulation resistance temperature correction calculations utilizing the following:
 - a. To correct to 20 degrees C, utilize Table 260805-1.
 - b. To correct to 40 degrees C, utilize Table 260805-2.

Table 260805-1		
Insulation Resistance Correction Factors (20 °C)		
Measured Temperature (°C)	Oil Immersed Insulation	Solid Insulation
-10	0.125	0.25
-5	0.18	0.32
0	0.25	0.40
5	0.36	0.50
10	0.50	0.63
15	0.75	0.81
16	0.80	0.85
17	0.85	0.89
18	0.90	0.92
19	0.95	0.96
20	1.00	1.00
21	1.08	1.05

Table 260805-1		
Insulation Resistance Correction Factors (20 °C)		
Measured Temperature (°C)	Oil Immersed Insulation	Solid Insulation
22	1.16	1.10
23	1.24	1.15
24	1.32	1.20
25	1.40	1.25
30	1.98	1.58
35	2.80	2.00
40	3.95	2.50
45	5.60	3.15
50	7.85	3.98
55	11.20	5.00
60	15.85	6.30

Table 260805-2		
Insulation Resistance Correction Factors (40 °C)		
Measured Temperature (°C)	Oil Immersed Insulation	Solid Insulation
-10	0.03	0.10
-5	0.04	0.13
0	0.06	0.16
5	0.09	0.20
10	0.13	0.25
15	0.18	0.31
16	0.19	0.33
17	0.21	0.34
18	0.22	0.36
19	0.24	0.38
20	0.25	0.40
21	0.27	0.42

Table 260805-2		
Insulation Resistance Correction Factors (40 °C)		
Measured Temperature (°C)	Oil Immersed Insulation	Solid Insulation
22	0.29	0.44
23	0.31	0.46
24	0.33	0.48
25	0.35	0.50
30	0.50	0.63
35	0.71	0.79
40	1.00	1.00
45	1.41	1.26
50	2.00	1.59
55	2.83	2.00
60	4.00	2.52

C. Perform winding resistance temperature correction calculations utilizing the following:

1.
$$R_C = R_M \frac{T_C + T_K}{T_M + T_K}$$

2. Where, RC = Resistance at corrected temperature.
 RM = Resistance at measured temperature.
 TC = Temperature to correct to in degrees C.
 TM = Measured temperature in degrees C.
 TK = Temperature Resistance Constant
 (234.5 degrees C for copper, 226.0 degrees C for aluminum)

3.4 CABLES (ALSO FEEDERS IN CONDUIT), UP TO 600 V

- A. Perform inspection and tests on cables prior to installing sealing compound in the conduit system. This applies to hazardous areas and to weatherproof penetration sealant.
- B. Inspection and testing shall be comprised of the following:
1. For cables/wires 4/0 AWG or larger, inspect bolted electrical connections for high resistance using a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate and correct values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 2. Torque all accessible bolted electrical connections.
 3. Inspect compression applied connectors for correct cable match and indentation.
 4. Inspect grounding and cable/conduit support.

5. Verify that visible cable bends meet or exceed the minimum allowable bending radius.
6. Measure length of cable/conduit and record in meters. Record and adjust all cable lengths included in the cable schedules. Other building base building cabling such as lighting, fire alarm, public address, 15A duplex receptacles do not need to be recorded. Record cable lengths based on conductor distance markings where ever possible, for accurate lengths.
7. If cables/wires are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
8. Perform an insulation-resistance test on each conductor. Individually test each conductor with all other conductors and shields grounded. The test duration shall be one minute. Investigate resistances less than 1 Gigohms for power cabling. The voltage applied shall be 1000 Vdc for 600 V or 1000 V rated cables.

3.5 CABLES, MEDIUM VOLTAGE (5 kV AND 15 kV) – if applicable

- A. Inspection and testing shall be comprised of the following:
 1. Inspect exposed sections of cables for physical damage and evidence of overheating and corona.
 2. Proper connections in accordance with single-line diagram.
 3. Proper circuit and phase identification.
 4. Inspect terminations and splices for physical damage and evidence of overheating and corona.
 5. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 6. Inspect compression applied connectors for correct cable match and indentation.
 7. Check for proper lug installation.
 8. Confirm bolt torque levels are in accordance with Manufacturer's recommendation.
 9. Inspect shield grounding and cable support.
 10. Verify that visible cable bends meet or exceed the minimum allowable bending radius.
 11. Measure and record the length of cable.
 12. If cables are terminated through window-type current transformers, inspect to verify that neutral and ground conductors are correctly placed and that shields are correctly terminated for operation of protective devices.
 13. Perform a shield-continuity test on each power cable by ohmmeter method. The shielding must exhibit continuity. Investigate resistance values in excess of 10 ohms per 1000 feet of cable.
 14. Perform an insulation-resistance test on each conductor utilizing a megohm-meter:
 - a. Utilize 2,500-volt megohmmeter for 5 kV, 8 kV, 15 kV conductors in accordance with NETA standards.
 - b. Individually test each conductor with all other conductors and shields grounded. The test duration shall be one minute. Investigate resistances less than 5 Gig-ohms for 5 kV cable, and 15 Gig-ohms for 15 kV.
 15. Perform a Very Low Frequency (VLF) ac high-potential test on cables. Adhere to all precautions and limits as specified in the applicable NEMA / ICEA Standard for the specific cable. Perform tests in accordance with IEEE Standard 400.2. Test procedure

shall be as follows, and the results for each cable test shall be recorded as specified herein. The test voltage shall be sinusoidal with a frequency of 0.1 Hz, and shall not exceed cable Manufacturer's test values or IEEE 400.2 values as indicated:

Cable rating phase to phase (RMS)	Acceptance test phase to ground	Maintenance test phase to ground
5 kV RMS	10 kV RMS (14 peak)	7 kV RMS (10 peak)
15 kV RMS	20 kV RMS (28 peak)	16 kV RMS (22 peak)

- a. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the over-potential test, the test specimen is considered to have passed the test.
 - b. Ensure that the input voltage to the test set is regulated.
 - c. Current-sensing circuits in test equipment shall measure only the leakage current associated with the cable under test and shall not include internal leakage of the test equipment.
 - d. Record wet and dry-bulb temperatures or relative humidity and temperature.
 - e. Test each section of cable individually.
 - f. Individually test each conductor with all other conductors grounded. Ground all shields.
 - g. Terminations shall be adequately corona-suppressed by guard ring, field reduction sphere, or other suitable methods as necessary.
 - h. Ensure that the maximum test voltage does not exceed the limits for terminators specified in IEEE Standard 48 or Manufacturer's Specifications.
 - i. Raise the conductor test voltage to the specified maximum test voltage and hold for five minutes. Record leakage current.
 - j. Apply grounds for a time period adequate to drain all insulation-stored charge.
16. Perform a Dissipation Factor (Tangent Delta) test on all cables.
- a. Perform tests in accordance with IEEE Standard 400.2.
 - b. The test voltage applied shall be a 0.1 Hz sinusoidal waveform.
 - c. The dissipation factor shall be calculated for an applied voltage of 1 U_o RMS.
 - 1) Test 5 kV cable to 1 U_o (1 U_o is defined as 1 x line to ground operating voltage; which is 2400V RMS for 5 kV cable, and 4.16 kV phase to phase distributions).
 - 2) Test 15 kV cable to 1 U_o or 7,200V RMS for 15 kV cable, and 12.47 kV phase to phase distributions.
 - d. Provided that the dissipation factor does not rise significantly while raising the voltage, the dissipation factor shall also be calculated for an applied voltage 2 U_o RMS.
 - 1) Test 5 kV cable to 2 U_o or 4800V RMS for 5 kV cable, and 4.16 kV phase to phase distributions.
 - 2) Test 15 kV cable to 2 U_o or 14,400V RMS for 15 kV cable, and 12.47 kV phase to phase distributions.
17. In the event of a cable failure discovered during testing, replace the cable.

3.6 CIRCUIT BREAKERS, INSULATED-CASE/MOLDED CASE, UP TO 600 V

- A. Inspection and testing shall include the following:
 1. Note the equipment nameplate data for inclusion in the report.
 2. Record all adjustable settings.

3. Inspect physical and mechanical condition.
 4. Inspect anchorage and alignment.
 5. Clean the unit.
 6. Torque all accessible bolted power connections.
 7. Operate the circuit breaker to insure smooth operation.
 8. Test all breakers utilizing the "Push-To-Trip" button, if equipped.
 9. Move operating handle to the off and on position.
 10. Restore breaker position to original position.
- B. For cables 4/0 AWG and larger, inspect bolted electrical connections for high resistance using a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- C. For breakers with a frame size greater or equal to 250A, or as specified elsewhere in the Specification:
1. Perform an insulation resistance test.
 2. Breakers rated less than 600V, test voltage is to be 500 VDC.
 3. Breakers rated at 600V, test voltage is to be 1000 VDC.
- D. Perform a contact/pole-resistance test.

3.7 AIR CIRCUIT BREAKERS

- A. Visual and Mechanical Inspection:
1. Proper cell fit and element alignment.
 2. Proper operation of cubicle shutters and racking mechanism.
 3. Bolt torque level in accordance with Manufacturer's recommendations and NETA ATS-2009, Table 100.12. Where conical washers (Belleville or other) are used, consult with the Contract Administrator prior to tightening or applying pressure to connections.
 4. Proper contact condition.
 5. Perform mechanical operator and contact alignment tests on breaker and it's operating mechanism in accordance with Manufacturer's instructions.
 6. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operations are correct.
 7. Ensure that maintenance devices are available for servicing and operating breaker.
 8. Check for adequate lubrication on contact, moving, and sliding parts.
 9. Check condition of brushes and limit switches on charging and lifting motors.
 10. With Breaker in TEST Position:
 - a. Trip and close breaker with control switch.
 - b. Trip breaker by manually operating each protective relay.
 11. Perform breaker travel and velocity analysis in accordance with Manufacturer's instructions; values shall be in accordance with Manufacturer's acceptable limits.
- B. Electrical Tests:
1. Insulation Resistance Tests:
 - a. Utilize:
 - 1) 1,000 volt megohmmeter for 600V circuit breakers
 - b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute

- c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
- d. Test values to comply with NETA ATS-2009 Table 100.1.
2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each pole.
 - b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Dielectric Withstand Tests:
 - a. Maximum applied voltage for equipment in accordance with NETA ATS-2009, Table 100.2 and Table 100.19
 - b. Each pole-to-ground with other poles grounded and contacts closed.
 - c. Test results evaluated on pass/fail basis.
4. Minimum pickup voltage tests on trip and close coils.

3.8 VACUUM CIRCUIT BREAKERS

- A. Visual and Mechanical Inspection:
 1. Check for proper element alignment.
 2. Check for proper operation of cubicle shutters and racking mechanism.
 3. Bolt torque level in accordance with Manufacturer's recommendations and NETA ATS-2009, Table 100.12. Where conical washers (Belleville or other) are used, consult with the Contract Administrator prior to tightening or applying pressure to connections.
 4. Perform mechanical operational tests on breaker and it's operating mechanism in accordance with Manufacturer's instructions, plus check:
 - a. Pull rod adjustment.
 - b. Trip latch clearance.
 - c. Overtravel stops.
 - d. Wipe and gap setting.
 5. Perform breaker travel and velocity analysis in accordance with Manufacturer's instructions; values shall be in accordance with Manufacturer's acceptable limits.
 6. Check contact erosion indicators in accordance with Manufacturer's instructions.
 7. With Breaker in TEST Position:
 - a. Trip and close breaker with control switch.
 - b. Trip breaker by manually operating each protective relay.
- B. Electrical Tests:
 1. Insulation Resistance Tests:
 - a. Utilize 2,500-volt dc megohmmeter for 5 kV and 15 kV circuit breakers.
 - b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute
 - c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
 - d. Test values to comply with NETA ATS-2009, Table 100.1
 2. Contact Resistance Tests:
 - a. Between the line and load stab of closed contact resistance in microhms across each pole.
 - b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
 3. Dielectric Withstand Tests:
 - a. Maximum applied voltage in accordance with NETA ATS-2009, Table 100.19.
 - b. Each pole-to-ground with other poles grounded and contacts closed.
 - c. Test results evaluated on pass/fail basis.
 4. Minimum pickup voltage tests on trip and close coils.

3.9 CONTACTOR PANELS, UP TO 600V

- A. Inspection and testing shall be comprised of the following:
 - 1. Note the equipment nameplate data for inclusion in the report.
 - 2. Inspect physical and mechanical condition.
 - 3. Inspect anchorage, alignment, and grounding.
 - 4. Verify the unit is clean.
 - 5. Torque all accessible bolted power connections.
 - 6. Inspect unit for evidence of overheating or stress.
 - 7. Visually inspect and exercise transfer switch.
- B. If power and/or control fuses are present, record fuse size and type. Measure the resistance of each fuse. Investigate inconsistent resistance values.
- C. Perform an insulation resistance tests.
 - 1. Units rated less than 600V, test voltage is to be 500 VDC.
 - 2. Units rated at 600V, test voltage is to be 1000 VDC.
- D. Perform a contact/pole-resistance tests.
- E. Perform functional testing to verify operation of unit.

3.10 CONTROL POWER TRANSFORMERS, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
 - 1. Record the equipment nameplate data for inclusion in the report.
 - 2. Inspect physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 3. Verify that primary and secondary fuse ratings or circuit breakers match available Drawings. Where Drawings are not available, note fuses that appear to be sized incorrectly, based upon application of the Canadian Electrical Code. Mark fuse sizes and type on the Drawings, where not shown.
 - 4. Perform insulation-resistance tests. Perform measurements from winding-to-winding and each winding-to-ground. Test voltages shall be:
 - a. windings less than 250 V: 500 Vdc
 - b. windings greater than 250 V: 1000 Vdc

3.11 CURRENT INSTRUMENT TRANSFORMERS

- A. Inspection and testing shall be comprised of the following:
 - 1. Inspect physical and mechanical condition.
 - 2. Record the equipment nameplate data for inclusion in the report.
 - 3. Ensure that CT shorting bars are removed or installed as required.
 - 4. Verify that current circuits are grounded and have only one grounding point in accordance with ANSI/IEEE C57.13.3.
 - 5. Perform an insulation resistance test of the current transformer primary and secondary windings, and wiring to ground at 1000 Vdc. Do not perform this test on solid-state devices. Investigate any resistance values less than 25 megohms.

6. Perform a polarity test of each current transformer in accordance with ANSI/IEEE C57.13.1.
7. Perform a ratio-verification test using the voltage or current method in accordance with ANSI/IEEE C57.13.1. Note any ratio accuracies not within 0.5 percent of nameplate or Manufacturer's published data.
8. Perform an excitation test on transformers used for protection or relaying applications in accordance with ANSI C57.13.1.

3.12 GROUNDING SYSTEM

- A. Inspection and testing shall be comprised of the following:
 1. Perform resistance tests between the main grounding electrode and grounded points in the electrical distribution system located in the switchgear, transformers, and MCCs. Investigate and correct connections with a resistance greater than 0.5 milliohms.
 2. Perform resistance tests between the main grounding electrode and grounded points in the isolated ground system points in all control / PLC cabinets connected to the isolated ground system. Investigate and correct connections with a resistance greater than 0.5 milliohms.
 3. Perform resistance tests between the lightning protection terminals (at roof level) and the grounding electrode. Investigate and correct connections with a resistance greater than 0.5 milliohms.

3.13 HARMONICS MEASUREMENTS – if applicable

- A. Testing shall be comprised of the following:
 1. Connect to existing CTs and PTs, if provided. If not provided, supply appropriate CTs and PTs as required.
 2. Test duration at each location is to be one hour.
 3. Coordinate with operations personnel to ensure the loads run during the test are representative of normal and maximum plant operation.
 4. Monitor the following for all three phases:
 - a. Voltage, current, and power factor
 - b. Harmonic voltage level for 1st (base) through 15th harmonics.
 - c. Harmonic current level for 1st (base) through 15th harmonics, expressed in percent of current.
 - d. Total harmonic distortion (THD)
 - e. Total demand distortion (TDD)
 5. Record samples as one (1) minute intervals for a period of 24 hours for each required operating scenario. Included in the period, ensure all loads are running.
 6. Provide Microsoft Excel files of the test results. Provide graphical representations of levels. Provide overall systems report and analysis.
 7. Provide a summary page in the report indicating the THD, and maximum, average, and minimum for each voltage and current harmonic.
 8. Perform harmonics recording, measurements, and analysis / report for each of the following operating scenarios:
 - a. On 600 VAC MCCs / 600 Switchgear
 - 1) Normal operation with tie breaker open
 - 2) Normal operation with tie breaker closed, and all systems fed from one supply.

- b. On 12.47 kV Switchgear
 - 1) Normal operation with tie breaker open
 - 2) Normal operation with tie breaker closed, and all systems fed from one supply.

3.14 PROTECTIVE RELAYS

- A. Visual and Mechanical Inspection:
 - 1. Visually Check Each Relay For:
 - a. Tight cover gasket and proper seal.
 - b. Unbroken cover glass.
 - c. Condition of case shorting contacts if present.
 - d. Circuit wiring and connections
 - 2. Mechanically Check Each Relay For:
 - a. Freedom of movement.
 - b. Proper travel and alignment.
 - c. Trip plunger mechanism.
 - 3. Verify That Each Relay:
 - a. Complies with Contract Documents and application.
 - b. Is set in accordance with recommended settings.
- B. Electrical Tests:
 - 1. Tests on Nominal Recommended Setting For:
 - a. Perform tests to suit the type of relay and the type of protection in accordance with NETA ATS-2009.
 - b. Pickup parameters on each operating element.
 - c. Timing at three points on time-current curve.
 - d. Pickup target and seal-in units.
 - e. Special tests as required to check operation of restraint, directional, and other elements in accordance with Manufacturer's instruction manual and NETA standards.
 - 2. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
 - 3. Current Injection Tests:
 - a. For entire current circuit in each section.
 - b. Secondary injection for current flow.
 - c. Test current at each device.
 - 4. For Motor protection Relays and similar relays, use 3-phase current injection for unbalanced protection testing, unless recommended otherwise by the Manufacturer.
 - 5. Use 6 phase current injection and voltage relay (3 phase line, 3 phase load) test units for differential protection relays.

3.15 METERING DEVICES, DIGITAL

- A. Inspection and testing shall be comprised of the following:
 - 1. Inspect physical and mechanical condition.
 - 2. Torque all bolted connections.
 - 3. Record the equipment nameplate data for inclusion in the report.
 - 4. Verify accuracy of voltage and current at a minimum of two points each.
 - 5. If required, calibrate meters in accordance with Manufacturer's published data.

3.16 PANELBOARDS, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
1. Note the equipment nameplate data for inclusion in the report.
 2. Inspect physical and mechanical condition.
 3. Inspect anchorage, alignment, and grounding.
 4. Clean the unit.
 5. Inspect breakers and verify mechanical operation by exercising all circuit breakers.
 - a. Record breaker data on the inspection form.
 - b. Test all breakers utilizing the “Push-To-Trip” button, if equipped.
 - c. Move operating handle to the off and on position.
 - d. Restore breaker position to original position.
 6. Test with current injection, main and feeder/load breakers with a frame size greater than or equal to 250A, or with long, short, or ground fault settings and complete a separate inspection form for each.
 7. Torque all accessible bolted power connections including incoming, load neutral and ground connections.
 8. Perform insulation-resistance tests on each bus phase with all other phases grounded.
 - a. The main breaker, if present, is to be open for the test. If no main breaker is present, disconnect the supply conductors.
 - b. Open all load breakers.
 - c. Test voltage for all 600/347 V panelboards to be 1000 Vdc.
 - d. Test voltage for all 120/208 V panelboards to be 500 Vdc.

3.17 MOTOR CONTROL, UP TO 600 V

- A. Visual and Mechanical Inspection:
1. Proper barrier and shutter installation and operation.
 2. Proper operation of indicating and monitoring devices.
 3. Proper overload protection for each motor.
 4. Improper blockage of air cooling passages.
 5. Proper operation of drawout elements.
 6. Integrity and contamination of bus insulation system.
 7. Check Door and Device Interlocking System By:
 - a. Closure attempt of device when door is in OPEN position.
 - b. Opening attempt of door when device is in CLOSED position.
 8. Check Key Interlocking Systems For:
 - a. Key captivity when device is in CLOSED position.
 - b. Key removal when device is in OPEN position.
 - c. Closure attempt of device when key has been removed.
 - d. Correct number of keys in relationship to number of lock cylinders.
 - e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
 9. Check Nameplates for Proper Identification Of:
 - a. Equipment title and tag number with latest one-line diagram.
 - b. Pushbuttons.
 - c. Control switches.
 - d. Pilot lights.

- e. Control relays.
 - f. Circuit breakers.
 - g. Indicating meters.
 10. Verify that fuse and circuit breaker sizes and types conform to the Drawings.
 11. Verify that current and potential transformer ratios conform to the Drawings.
 12. Check Bus Connections for High Resistance by Low Resistance Ohmmeter, Calibrated Torque Wrench Applied to Bolted Joints and Thermographic Survey:
 - a. Ohmic value to be zero.
 - b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by Manufacturer.
 - c. Thermographic survey temperature gradient of 2 degrees C, or less.
 13. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
 - a. Closure attempt for locked open devices.
 - b. Opening attempt for locked closed devices.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
 14. Verify performance of each control device and feature furnished as part of the motor control center.
 15. Control Wiring:
 - a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - b. Check for proper conductor lacing and bundling.
 - c. Check for proper conductor identification.
 - d. Check for proper conductor lugs and connections.
 16. Exercise active components.
 17. Inspect Contactors For:
 - a. Correct mechanical operations.
 - b. Correct contact gap, wipe, alignment, and pressure.
 - c. Correct torque of all connections.
 18. Compare overload heater rating with full-load current for proper size.
 19. Compare, fuse, motor protector, and circuit breaker with motor characteristics for proper size.
 20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.
- B. Electrical Tests:
1. For units with solid state components, follow Manufacturer's recommendations prior to performing any tests.
 2. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage.
 - b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
 - c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
 - d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
 - e. Test values to comply with NETA ATS-2009, Table 100.1.
 3. Current Injection Through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
 - a. Trip time in accordance with Manufacturer's published data.
 - b. Investigate values in excess of 120 seconds.

4. Control Wiring Tests:
 - a. Apply secondary voltage to control power and potential circuits.
 - b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational test by initiating control devices to affect proper operation.
6. Verify the correct operation of the network cabling, network switch, and associated components within Smart MCCs.
 - a. Verify I/O and metering data from each Intelligent Overload.

3.18 DISTRIBUTION SWITCHBOARDS / SWITCHGEAR, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
 1. Switchgear dimension verification.
 2. Inspect the switchboard physical, electrical, and mechanical condition. Inspect the main bus compartment.
 3. Verify appropriate anchorage, required area clearances, physical damage, and correct alignment.
 4. Inspect all doors, panels, and sections for dents, holes, fit, and missing hardware.
 5. Verify that fuse and / or circuit breaker sizes and types correspond to Drawings and coordination study as well as to the circuit breaker's address for microprocessor-communication packages.
 6. Verify that current and potential transformer ratios correspond to Drawings.
 7. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 8. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 9. Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 10. Make key exchange with all devices included in the interlock scheme as applicable.
 11. Vacuum debris from interior of switchboard. Clean off all dust and adhesive residue from switchboard.
 12. Use appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 13. Inspect insulators for evidence of physical damage or contaminated surfaces.
 14. Verify correct barrier and shutter installation and operation.
 15. Operational testing of all circuit breakers (close, open, charging, racking, etc). Exercise all active components.
 16. Inspect all mechanical indicating devices for correct operation.
 17. Verify that filters are in place and / or vents are clear.
 18. Test operation, alignment, and penetration of instrument transformer withdrawal disconnects, current-carrying and grounding contacts.
 19. Perform point to point ground-resistance tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and / or derived neutral points. Investigate point-to-point resistance values which exceed 0.5 ohm.
 20. Perform insulation-resistance tests each bus section, phase-to-phase and phase-to-ground.
 - a. Test voltage for 600/347 V equipment to be 1000 Vdc.
 - b. Test voltage for 120/208 V equipment to be 500 Vdc.
 21. Inspect all surge arrestors if available.

22. Inspect control power transformers.
23. Inspect all current instrument transformers. Verify the position of any C.T shorting pins.
24. Inspect potential transformers.
25. Inspect all metering devices.
26. Inspect and test air circuit breakers.
27. Inspect and test protective relays.
28. Inspect and test all moulded case feeder breakers. Feeder breakers with a frame size less than 250A, and without long, short, or ground fault settings, may be recorded on the Switchboard inspection form. Record test results on other breakers on the appropriate inspection form.
 - a. Inspect and test all capacitors.
 - b. Perform a system function test to prove the correct interaction of all sensing, processing, and action devices. Perform system function tests upon completion of the maintenance tests defined, as system conditions allow.
29. Perform tests for the purpose of evaluating performance of all integral components and their functioning as a complete unit within each cell.
30. Verify the correct operation of all interlock safety devices for fail-safe functions in addition to design function.
31. Verify the correct operation of all sensing devices, alarms, and indicating devices.
32. Verify the correct operation of the network cabling, network switch, and associated components.

3.19 MEDIUM VOLTAGE SWITCHGEAR AND MOTOR CONTROL CENTERS (5 kV AND 15 kV)
– if applicable

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Bolt torque level in accordance with Manufacturer's recommendations and NETA ATS-2009, Table 100.12. Where conical washers (Belleville or other) are used, consult with the Contract Administrator prior to tightening or applying pressure to connections.
4. Proper operation of indicating devices.
5. Proper overload protection.
6. Blockage of air cooling passages.
7. Proper operation of drawout elements.
8. Integrity and contamination of bus insulation system.
9. Check Door and Device Interlocking System By:
 - a. Closure attempt of device when door is in OPEN position.
 - b. Opening attempt of door when device is in CLOSED position.
10. Check Key Interlocking Systems For:
 - a. Key captivity when device is in CLOSED position.
 - b. Key removal when device is in OPEN position.
 - c. Closure attempt of device when key has been removed.
 - d. Correct number of keys in relationship to number of lock cylinders.
 - e. Existence of other keys capable at operating lock cylinders; destroy duplicate sets of keys.
11. Check Nameplates for Proper Identification of Each:
 - a. Equipment title and tag number with latest one-line diagram.

- b. Pushbutton.
 - c. Control switch.
 - d. Pilot light.
 - e. Control relay.
 - f. Circuit breaker.
 - g. Indicating meter.
12. Verify that fuse sizes and types conform to the Drawings.
 13. Check Bus Connections for High Resistance by Low Resistance Ohmmeter, Calibrated Torque Wrench Applied to Bolted Joints and Thermographic Survey:
 - a. Ohmic value to be zero.
 - b. Bolt torque level in accordance with Manufacturer's recommendation.
 - c. Thermographic survey temperature gradient of 2 degrees C, or less.
 14. Check Operation and Sequencing of Electrical and Mechanical Interlock Systems By:
 - a. Closure attempt for locked open devices.
 - b. Opening attempt for locked closed devices.
 - c. Key exchange to operate devices in OFF-NORMAL positions.
 15. Verify performance of each control device and feature furnished as part of the motor control center.
 16. Control Wiring:
 - a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
 - b. Check for proper conductor lacing and bundling.
 - c. Check for proper conductor identification.
 - d. Check for proper conductor lugs and connections.
 17. Exercise active components.
 18. Verify performance of charging mechanisms.
 19. Inspect all surge arrestors if available.
 20. Inspect control power transformers.
 21. Inspect all current instrument transformers. Verify the position of any C.T shorting pins.
 22. Inspect potential transformers.
 23. Inspect all metering devices.
 24. Inspect and test air circuit breakers.
 25. Inspect and test protective relays.
 26. For motor starters:
 - a. Inspect magnetic contactors for:
 - 1) Correct mechanical operations.
 - 2) Correct contact gap, wipe, alignment, and pressure.
 - 3) Correct torque of connections.
 - b. Perform phasing check on motor control centers to ensure proper bus phasing from each source.
- B. Electrical Tests:
1. For units with solid state devices follow Manufacturer's recommendations prior to performing any tests.
 2. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections
 3. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage.

- b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
 - c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
 - d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
 - e. Test values to comply with NETA ATS-2009, Table 100.1
4. Overpotential Dielectric Tests:
 - a. Maximum applied voltage in accordance with NETA ATS, Table 100.19.
 - b. Phase-to-phase and phase-to-ground for 1 minute for each phase of each bus section.
 - c. Test results evaluated on pass/fail basis.
 5. Bottle integrity test for vacuum contactors in accordance with Manufacturer's procedure.
 6. Test by Primary Current Injection:
 - a. Overload units at sensors using 300 percent of motor full-load current.
 - 1) Overload trip times to be in accordance with Manufacturer's published data.
 - b. Check voltage levels at each point on terminal boards and each device terminal.
 7. Control Wiring Tests:
 - a. Apply secondary voltage on control power and potential circuits.
 - b. Check voltage levels at each point on terminal boards and at each device terminal.
 8. Test indicating and monitoring devices for proper operation.
 9. Perform setup and testing of solid state relays and multifunction protective devices in accordance with Manufacturer's instructions. Relays and electronic components to be tested by means of secondary current injection test.
 10. Measure Contact and Power Fuse Resistances:
 - a. Contact resistance shall not exceed Manufacturer's recommended values.
 - b. Resistance of power fuses not to deviate more than 15 percent between identical fuses.
 11. Verify the correct operation of the network cabling, network switch, and associated components.
 - a. Verify I/O, communications, metering data from relays or other solid state devices.

3.20 MOTORS, INDUCTION, AC, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
 1. Note the equipment nameplate data for inclusion in the report.
 2. Inspect physical and mechanical condition.
 3. Inspect anchorage, alignment, and grounding.
 4. Inspect air baffles, filter media, cooling fans, slip rings, brushes, and brush rigging. Air baffles and filter media should be clean. Cooling fans should operate. Slip ring wear and brushes should be within Manufacturer's tolerances for continued use. Brush rigging should be intact.
 5. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 6. Verify the application of appropriate lubrication and lubrication systems.
 7. Verify the absence of unusual mechanical or electrical noise or signs of overheating.
 8. Perform a rotation test to insure correct shaft direction.

9. Perform insulation-resistance tests in accordance with ANSI/IEEE Standard 43. Test voltage shall be in accordance with Manufacturer's published data or 500 Vdc.
 - a. Where possible, test each winding separately. Ground all windings not under test.
 - b. Ensure all cables and accessories are disconnected during the test.
 - c. For motors less than or equal to 150kW (200 HP), the test duration is to be one (1) minute. Calculate the dielectric absorption ratio.
 - d. For motors greater than 150kW (200 HP), the test duration is to be ten (10) minutes. Calculate the dielectric absorption ratio and polarization index.
 - e. Correct test results to 40 degrees C.
 - f. Investigate readings below 100 megohms. Investigate dielectric absorption ratios less than 1.4 and polarization index ratios less than 2.0 for Class B insulation and Class F insulation.
10. Where it is not possible to perform an insulation resistance test separately on each winding, perform a winding resistance test on each winding using a low-resistance ohmmeter.
11. Measure running voltage and current and evaluate relative to load conditions and nameplate full-load amperes. Utilize a true RMS meter.
 - a. Where powered by a VFD with bypass, perform test with the motor powered by the VFD and by the bypass starter.
12. Perform insulation-resistance test on insulated bearings in accordance with Manufacturer's published data, if applicable.
13. Perform resistance tests on resistance temperature detector (RTD) circuits. RTD circuits should conform to design intent and/or machine protection device Manufacturer's Specifications.

3.21 SAFETY SWITCHES, UP TO 600 V

- A. Visual and Mechanical Inspection:
 1. Proper blade pressure and alignment.
 2. Proper operation of switch operating handle.
 3. Adequate mechanical support for each fuse.
 4. Proper contact-to-contact tightness between fuse clip and fuse.
 5. Cable connection bolt torque level in accordance with NETA ATS-2009, Table 100.12.
 6. Proper phase barrier material and installation.
 7. Verify that fuse sizes and types correspond to one-line diagram.
 8. Perform mechanical operational test and verify electrical and mechanical interlocking system operation and sequencing where installed.
- B. Electrical Tests:
 1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage.
 - b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
 - c. Insulation resistance values equal to, or greater than, ohmic values established by Manufacturer.
 2. Contact Resistance Tests:
 - a. Contact resistance in microhms across each switch blade and fuse holder.
 - b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.22 MOTOR STARTERS, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
1. Note the motor / equipment nameplate data for inclusion in the report.
 2. Record all adjustable settings, size of overload, etc.
 3. Ensure overloads are set in accordance with the motor nameplate data, and the electrical code requirements.
 4. Inspect physical and mechanical condition.
 5. Inspect anchorage, alignment, and grounding.
 6. Verify the unit is clean.
 7. Torque all accessible bolted power connections.
 8. Inspect contactors for evidence of overheating or stress.
 9. Visually inspect and exercise circuit breaker.
 10. If power fuses are present, record fuse size and type. Measure the resistance of each fuse. Investigate inconsistent resistance values.

3.23 MOTOR STARTERS, SOFT STARTER, UP TO 600 V

- A. Inspection and testing shall be comprised of the following:
1. Note the motor / equipment nameplate data for inclusion in the report.
 2. Confirm soft starter parameters.
 3. Ensure all parameters are correct for the specific motor nameplate.
 4. Record size and setting of overload.
 5. Inspect physical and mechanical condition.
 6. Inspect anchorage, alignment, and grounding.
 7. Verify the unit is clean.
 8. Torque all accessible bolted power connections.
 9. Inspect contactors for evidence of overheating or stress.
 10. Perform resistance measurements with a low-resistance ohmmeter for each pole of the following:
 - a. Bypass contactor.
 - b. Capacitor contactor, if applicable.
 - c. Main disconnect/circuit breaker.
 - d. Main fuses.
 11. Perform power cable insulation resistance measurements. Test voltage for 208V or 240V to be 500V, 600V rated equipment is to be 1000V. Disconnect the power cables from the soft starter module and control power fuses prior to test. Test to include:
 - a. Bypass contactor line and load to GND.
 - b. Bypass contactor line to load with contactor open.
 12. Perform an operational inspection while starting, running, and stopping the motor at normal load. Include:
 - a. Measurement of ramp up time.
 - b. Measurement of motor current.
 - c. Recording of soft starter, ammeter, and remote displayed current readings.
 - d. Measurement of ramp down time.

3.24 VARIABLE FREQUENCY DRIVE, LOW VOLTAGE (LESS THAN 37.5 kW)

- A. Inspection and testing shall be comprised of the following:
1. Inspect physical and mechanical condition.
 2. Inspect anchorage, alignment, and grounding.
 3. Clean the unit.
 4. Check the air filters.
 5. Ensure vent path openings are free from debris and that heat transfer surfaces are not contaminated by oil, dust, or dirt.
 6. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 7. Visually inspect VFD grounding to ensure continuity.
 8. Inspect condition and connections of line reactors, and load reactors / load filter if present.
 9. Inspect DC bus capacitors for bulging and leakage.
 10. Cooling fans and heat sinks:
 - a. Visually inspect and listen for any abnormal noises or vibration.
 - b. Verify that fans rotate freely.
 - c. Verify correct direction of airflow.
 - d. Clean and verify integrity of heat sinks.
 - e. Verify the operation of the grounding switch, if present.
 11. Perform all other work in accordance with the Manufacturer's instructions.
- B. Record the following VFD Parameters:
1. Motor voltage, current, frequency, nominal speed, nominal power.
 2. Control mode / method.
 3. Minimum and maximum control frequency.
 4. Acceleration and deceleration time.
 5. Compare drive overcurrent set points with motor full-load current rating to verify correct settings.
- C. Power fuses:
1. Record fuse data. Confirm that the fuses are of the correct type and rating. Utilize Manufacturer's published data where available.
 2. Measure fuse resistance.
- D. Bolted connections:
1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 2. Torque all bolted connections.
- E. Inverter / Supply Module Power Connections:
1. Remove each power module and visually inspect the contacts.
 2. Torque all cable connections.
 3. Clean all contact surfaces and apply suitable joint compound as recommended by Manufacturer.

- F. Operator Interface:
 - 1. Check the display and keypad for proper operation and communication.
 - 2. Retrieve fault history log and note any faults.
 - G. Grounding/Bonding measurements:
 - 1. Measure the resistance of the ground bonding connection between the VFD and the main grounding bus in the corresponding electrical room.
 - H. Control Wiring:
 - 1. Check for tightness of all accessible control wiring and torque any loose connections.
 - I. Perform operational tests by initiating control devices.
 - 1. Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 - 2. Verify operation of drive from local start/stop and speed control signals.
 - 3. Verify operation of all local pilot lights.
 - 4. Verify the operation of any emergency stop switches.
 - 5. Perform all other tests in accordance with the Manufacturer's instructions.
 - 6. Perform all tests in accordance with the Manufacturer's recommendations and instructions.
 - J. Voltage and Current Testing:
 - 1. With the VFD under load, measure and record the following:
 - a. Incoming AC voltage and currents.
 - K. With the VFD output in START/RUN mode, and at zero speed:
 - 1. Measure and record the AC output voltage. Voltages above 40 VAC should be investigated.
- 3.25 VARIABLE FREQUENCY DRIVE, LOW VOLTAGE (GREATER THAN 37.5 kW AND LESS THAN 150 kW)
- A. Inspection and testing shall be comprised of the following:
 - 1. Inspect physical and mechanical condition.
 - 2. Inspect anchorage, alignment, and grounding.
 - 3. Clean the unit.
 - 4. Check the air filters.
 - 5. Ensure vent path openings are free from debris and that heat transfer surfaces are not contaminated by oil, dust, or dirt.
 - 6. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
 - 7. Visually inspect VFD grounding to ensure continuity.
 - 8. Inspect condition and connections of line reactors, if present.
 - 9. Inspect condition and connections of DC Link Reactors, if present.
 - 10. Inspect condition and connections of load reactors or load filter, if present.
 - 11. Inspect condition of isolation transformers, if present.
 - 12. Inspect DC bus capacitors for bulging and leakage.
 - 13. Cooling fans and heat sinks:
 - a. Visually inspect and listen for any abnormal noises or vibration.
 - b. Verify that fans rotate freely.

- c. Verify correct direction of airflow.
 - d. Clean and verify integrity of heat sinks.
 - e. Verify the operation of the grounding switch, if present.
- B. Record the following VFD Parameters:
1. Motor voltage, current, frequency, nominal speed, nominal power.
 2. Control mode / method.
 3. Minimum and maximum control frequency.
 4. Acceleration and deceleration time.
 5. Compare drive overcurrent set points with motor full-load current rating to verify correct settings.
- C. Power fuses:
1. Record fuse data. Confirm that the fuses are of the correct type and rating. Utilize Manufacturer's published data where available.
 2. Measure fuse resistance.
- D. Bolted connections:
1. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 2. Torque all bolted connections.
- E. Inverter / Supply Module Power Connections:
1. Remove each power module and visually inspect the contacts.
 2. Torque all cable connections.
 3. Clean all contact surfaces and apply suitable joint compound as recommended by Manufacturer.
- F. Operator Interface:
1. Check the display and keypad for proper operation and communication.
 2. Retrieve fault history log and note any faults.
- G. Grounding/Bonding measurements:
1. Measure the resistance of the ground bonding connection between the VFD and the main grounding bus in the corresponding electrical room.
- H. Control Wiring:
1. Check for tightness of all accessible control wiring and torque any loose connections.
- I. Perform operational tests by initiating control devices.
1. Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.
 2. Verify operation of drive from local start/stop and speed control signals.
 3. Verify operation of all local pilot lights.
 4. Verify the operation of any emergency stop switches.

- J. Voltage and Current Testing:
1. With the VFD under load, measure and record the following:
 - a. Measure and record incoming AC voltage and currents.
 - b. Measure and record DC and AC bus voltages.
 2. Utilize a recording oscilloscope to capture the input voltage waveform and verify correct operation.
 3. Utilize a recording oscilloscope to capture the output voltage waveform and verify correct operation.
 4. Include input and output waveforms with the report.
- K. With the VFD output in START/RUN mode, and at zero speed:
1. Measure and record the AC output voltage. Voltages above 40 VAC should be investigated.

3.26 SURGE ARRESTORS, UP TO 600V

- A. Inspection and testing shall be comprised of the following:
1. Inspect physical and mechanical condition.
 2. Inspect anchorage, alignment, grounding, and required clearances.
 3. Clean the unit.
 4. Verify that arrestors are electrically connected in their specified configuration.
 5. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 6. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
 7. Verify that stroke counter, if present, is correctly mounted and electrically connected.
 8. Perform insulation-resistance tests for one minute from each phase terminal to the case.
 9. Equipment rated greater than or equal to 600V, utilize a test voltage of 1000 VDC.
 10. Equipment rated less than 600V, utilize a test voltage of 500 VDC.
 11. Test the grounding connection. Resistance between the arrester ground terminal and the ground system should be less than 0.5 ohm.

3.27 TRANSFORMERS, DRY-TYPE, UP TO 600V – if applicable

- A. Inspection and testing shall be comprised of the following:
1. Note the equipment nameplate data for inclusion in the report.
 2. Inspect physical and mechanical condition.
 3. Inspect anchorage, alignment, and grounding.
 4. Clean the unit.
 5. Torque all accessible bolted power connections.
 6. Record the tap setting.
 7. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Duration of the test is to be one minute. Calculate the dielectric absorption ratio.
 - a. 600 V windings shall be tested at 1000 Vdc.
 - b. 120/208 V windings shall be tested at 500 Vdc.

3.28 TRANSFORMERS, DRY-TYPE, MEDIUM VOLTAGE - if applicable

- A. Inspection and testing shall be comprised of the following:
1. Note the equipment nameplate data for inclusion in the report.
 2. Inspect physical and mechanical condition.
 3. Inspect anchorage, alignment, and grounding.
 4. Clean the unit.
 5. Verify that alarm settings on temperature indicators are as specified and operate within Manufacturer's recommendations for specified settings.
 6. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values which deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 7. Record tap setting. Confirm the tap setting appears reasonable by measuring the voltage during normal Facility operation.
 8. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Calculate polarization index. Minimum insulation-resistance values of transformer insulation should be 1000 megohms for the 4160 V windings and 100 megohms for the 600 V windings. Values of insulation resistance less than the values stated should be investigated. The polarization index should not be less than 1.0.
 - a. The test duration shall be 10 minutes for each winding.
 - b. 4160 V windings shall be tested at 2500 Vdc.
 - c. 600 V windings shall be tested at 1000 Vdc.
 9. Perform turns-ratio tests at the designated tap position. Turns-ratio test results should not deviate more than one-half percent from either the adjacent coils or the calculated ratio.
 10. Measure the resistance of each winding at the designated tap position.
 11. Measure core insulation resistance at 500 Vdc if the core is insulated and if the core ground strap is removable.
 12. Verify correct secondary voltage phase-to-phase and phase-to-neutral after energization and prior to loading. Phase-to-phase and phase-to-neutral secondary voltages should be in agreement with nameplate data.

3.29 LIQUID FILLED TRANSFORMERS – if applicable

- A. Inspection and testing shall be comprised of the following:
1. Physical and insulator damage.
 2. Conduct external inspections in accordance with layout Shop Drawings. Check nameplates and vector diagrams against test results.
 3. Inspect silica gel breathers, oil gauge, temperature gauge and similar devices where fitted. For devices with settings, record the settings in use. Record actual reading of all gauges and ambient temperature.
 4. Proper winding connections.
 5. Bolt torque level in accordance Manufacturer's recommendations.
 6. Defective wiring.
 7. Proper operation of fans, indicators, and auxiliary devices.
 8. Effective core and equipment grounding. Review neutral grounding device wiring and connections (if present).
 9. Removal of shipping brackets, fixtures, or bracing.

10. Inspect for oil leaks, correct oil level, and sign of rusting.
11. Integrity and contamination of bus insulation system.
12. Verify that tap-changer is set at correct ratio for rated voltage under normal operating conditions.
13. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.
14. Exercise the manual tap changer to check its functions and ease of access.
15. Operate and simulate alarm and trip conditions of each protective device.

B. Electrical Tests:

1. As a minimum, perform the following transformer tests:
 - a. Perform high voltage AC insulation tests on high voltage windings to ground, low voltage windings to ground, high voltage windings to low voltage windings. Perform dooble test on transformer, approved equal in accordance with B8 Capacitance and Dissipation Factor tests.
 - b. Inspect bushings, and measure insulation resistance with use of high voltage AC insulation test.
 - c. Winding resistance measurement on all windings (standard test protocol).
 - d. Oil analysis and gas analysis.
 - e. H.V. test on oil samples from transformer tank for each transformer.
 - f. Voltage ratio three phase, for each tap (Transformer Tap ratio).
 - g. Relay and protective devices operation.
2. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage for each:
 - 1) Winding-to-winding.
 - 2) Winding-to-ground.
 - b. 10-minute test duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes. Results temperature corrected in accordance with NETA ATS-2009, Table 100.14 or Tables 260805-1 and 260805-1.
 - c. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by Manufacturer.
 - d. Insulation resistance test results to compare within 1 percent of adjacent windings.
3. Perform tests and adjustments for fans, controls, and alarm functions as suggested by Manufacturer.

3.30 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding and bonding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that moulds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-Of-Potential Test:
 - a. In accordance with IEEE 81, Section 8.2.1.5, perform measurements of the ground system resistance, at each Facility, and at the substation.
 - b. The ground system resistance shall not exceed 0.5 ohms in summer soil conditions.
 - c. Test point shall be at the North-West corner of the substation, plus at each of the individual buildings.
 - d. Perform resistance testing of the connections between each ground rod and ground cabling, to ensure proper connection.

3.31 GROUND FAULT SYSTEMS

A. Inspection and Testing Limited To:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral Main Bonding Connection to Assure:
 - a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
 - b. Ground strap sensing system is grounded through sensing device.
 - c. Neutral ground conductor is solidly grounded.
2. Verify that control power has adequate capacity for system.
3. Manually Operate Monitor Panels For:
 - a. Trip test.
 - b. No trip test.
 - c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

3.32 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Note the equipment nameplate data for inclusion in the report.
3. Record all adjustable settings, setpoints, delays, etc.
4. Inspect physical and mechanical condition.
5. Inspect anchorage, alignment, and grounding.
6. Verify the unit is clean.
7. Torque all accessible bolted power connections.
8. Visually inspect and exercise transfer switch.
9. Check connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
10. Check positive mechanical and electrical interlock between normal and alternate sources.
11. Check for Proper Operation:
 - a. Manual transfer function switch.
 - b. Generator under load and nonload conditions.
 - c. Auto-exerciser of generator under load and no-load conditions.

12. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
 - a. Applied megohmmeter dc voltage for each phase with switch CLOSED in both source positions.
 - b. Phase-to-phase and phase-to-ground for 1 minute.
 - c. Test values in accordance with Manufacturer's published data.
2. Contact Resistance Test:
 - a. Contact resistance in microhms across each contact for both source positions.
 - b. Investigate values exceeding 100 microhms.
 - c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and Calibrate in Accordance with Specifications:
 - a. Voltage and frequency sensing relays.
 - b. Time delay relays.
 - c. Engine start and shutdown relays.
4. Perform Automatic Transfer Tests By:
 - a. Simulating loss of normal power.
 - b. Return to normal power.
 - c. Simulating loss of alternate power.
 - d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and Verify Operation and Timing Of:
 - a. Normal and alternate voltage sensing relays.
 - b. Engine start sequence.
 - c. Timing delay upon transfer and retransfer.
 - d. Engine cool down and shutdown.
 - e. Interlocks and limit switch functions.
 - f. Engine cool down and shutdown feature.
6. If power and/or control fuses are present, record fuse size and type. Measure the resistance of each fuse. Investigate inconsistent resistance values.

3.33 BATTERY SYSTEM

A. Visual and Mechanical Inspection:

1. Physical damage and electrolyte leakage.
2. Evidence of corrosion.
3. Intercell bus link integrity.
4. Battery cable insulation damage and contaminated surfaces.
5. Operating conditions of ventilating equipment.
6. Visual check of electrolyte level.

B. Electrical Tests:

1. Measure:
 - a. Bank charging voltage.
 - b. Individual cell voltage.
 - c. Electrolyte specific gravity in each cell.
 - d. Measured test values to be in accordance with Manufacturer's published data.
2. Verify During Recharge Mode:
 - a. Charging rates from charger.

- b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with ANSI 450.

3.34 STANDBY AND EMERGENCY GENERATOR SYSTEMS

- A. Perform tests and Commissioning in accordance with CSA C282 (latest) Section 10 – Initial Installation Performance Test. Tests include, but are not limited to the requirements below.
- B. Visual and Mechanical Inspection:
 1. Proper grounding.
 2. Blockage of ventilating passageways.
 3. Proper operation of jack water heaters.
 4. Integrity of engine cooling and fuel supply systems.
 5. Excessive mechanical and electrical noise.
 6. Overheating of engine or generator.
 7. Proper installation of vibration isolators.
 8. Proper cooling liquid type and level.
 9. Operate Engine-Generator and Check For:
 - a. Excessive mechanical and electrical noise.
 - b. Overheating.
 - c. Correct rotation.
 - d. Check resistance temperature detectors or generator inherent thermal protectors for functionality and proper operation.
 - e. Excessive vibration.
 10. Verify that voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
 11. Proper operation of meters and instruments.
 12. Compare generator nameplate rating and connection with one-line diagram.
 13. All other tests in accordance with the Manufacturer’s recommended testing and Commissioning requirements.
- C. Electrical and Mechanical Tests:
 1. Alternator insulation shall be tested (“megger”) in compliance with IEEE standard 43-2000 (200kW and above).
 2. Ensure the engine starts (both hot and cold) within 15 seconds.
 3. Cold start test by interrupting normal power source with test load consisting of connected system load to verify:
 - a. Transfer switch operation.
 - b. Automatic starting operation.
 - c. Operating ability of engine-generator.
 - d. Overcurrent devices capability to withstand inrush currents.
 - e. Verify no load frequency and voltage to be as specified
 4. Phase rotation tests.
 5. Test Engine Protective Shutdown Features For:
 - a. Low oil pressure.
 - b. Overtemperature.
 - c. Overspeed.
 6. Vibration levels in accordance with Manufacturer’s recommendations.

7. Load bank test or system load tests as required by the Contract Administrator:
 - a. 25 percent applied load for 30 minutes.
 - b. 50 percent applied load for 30 minutes.
 - c. 75 percent applied load for 30 minutes.
 - d. 100 percent applied load for 4 hours.
 - e. Load test results to demonstrate ability of unit to deliver rated load for test period.
8. One-Step Rated kW Load Pickup Test:
 - a. Perform test immediately after performing load bank test.
 - b. Apply rated load, minus largest rated hp motor, to generator.
 - c. Start largest rated hp motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
 - d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.
9. Record the following items at first load acceptance, and at 15 minute intervals:
 - a. Time delay on start.
 - b. The cranking time until the engine starts and runs.
 - c. The time required to come up to operating speed.
 - d. The time required for each life safety equipment transfer switch to be transferred to the emergency position.
 - e. The time required to achieve steady-state condition, with all switches transferred to the emergency position.
 - f. The time delay(s) for the connection of any loads arranged to be connected to the emergency supply later than the life safety equipment.
 - g. The voltage, frequency and amperes at start-up, at any observed change in load, and at full load.
 - h. The engine oil pressure, water temperature, and the battery charge rate 1 minute after start, at 5 minute intervals for the first 15 minutes, and at 15 minute intervals thereafter.
 - i. The time delay on retransfer for each transfer switch.
 - j. The time delay on engine cool-down and shutdown.
10. Cycle crank test shall be demonstrated by preventing the engine from running (any method recommended by the Manufacturer may be used). The mode selector shall then be placed in the "Manual" position to cause the engine to crank.
11. All safety shutdowns and alarms as specified in CSA C282 Table 1 shall be verified and tested.
12. Factory authorized Manufacturer's Representative shall deliver operator training to ensure that appropriately qualified personnel are trained to operate the emergency power systems.
13. The test results shall be saved for comparison with future routine scheduled analyses.
14. All other tests in accordance with the Manufacturer's testing and Commissioning requirements.

3.35 STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS)

- A. Testing configuration shall not interfere with the supply of power to the load ultimately supplied by the UPS.

- B. Provide a complete UPS testing report in accordance with the Manufacturer's recommendations and these documents.
- C. Test equipment:
 - 1. Instruments used during testing are to have been calibrated within one year prior to the test date. Include a copy of the calibration certificate
 - 2. Load bank for testing, adjustable to 110 percent of system rated output power.
 - a. Load bank to be CSA, ULC approved or approved equal in accordance with B8.
- D. Provide competent field personnel to perform test, adjustments and instruction on UPS equipment.
- E. Perform a visual inspection and identify deficiencies. Inspection to include:
 - 1. Materials, workmanship, and assembly conform with design requirements.
 - 2. Parts are new and free of defects.
 - 3. Accessories are present.
 - 4. Inspect equipment for signs of damage.
 - 5. Verify installation per Drawings.
 - 6. Inspect cabinets for foreign objects.
 - 7. Verify neutral and ground conductors are properly sized and configured.
 - 8. Battery and components are not damaged.
 - 9. Battery cells are of identical construction.
 - 10. Inspect battery for proper polarity.
 - 11. Confirm polarity of connections to inverter are correct.
 - 12. Verify all printed circuit boards are configured properly.
- F. Mechanical Inspection
 - 1. Check all control wiring connections for tightness.
 - 2. Check all power wiring.
 - 3. Check all terminals screws, nuts, and/or spade lugs for tightness.
- G. Electrical Inspection
 - 1. Confirm input voltage and phase rotation is correct.
 - 2. Verify control transformer connections are correct for voltages being used.
 - 3. Verify UPS control wiring and terminations.
 - 4. Assure connection and voltage of the battery string(s).
 - 5. Verify neutral and ground conductors are properly landed.
 - 6. Inspect external maintenance bypass switch for proper terminations and phasing.
- H. Demonstrate System Operation:
 - 1. System start-up and shut down.
 - 2. Verify proper firmware control functions.
 - 3. Verify proper firmware bypass operations.
 - 4. System switchover to and from internal and external bypass.
 - 5. Simulate utility power failure.
 - 6. Verify proper charger operations.
 - 7. Adjustable settings.

- I. UPS Measurement Test:
1. Test and record all UPS internal measurements against calibrated test instruments for 50 percent and 100 percent output load. The tests shall include:
 - a. Output voltage, current, frequency, and power.
 - b. Battery voltage and current.
 - c. Input voltage, current, and power.
 - d. Bypass voltage and frequency.
- J. Steady Load Test:
1. Switch system onto AC mains, start UPS and connect load bank at UPS rated load.
 2. Operate system at full rated load for one (1) hour.
 3. Record data, utilizing UPS display, at start of test and every 10 minutes thereafter, including:
 - a. Output voltage phase to phase, phase to neutral.
 - b. Output current each phase.
 - c. Output frequency.
 - d. Output kW.
 - e. Battery voltage and current
- K. Battery Testing:
1. Charge battery to ensure cells are fully charged. When voltage reaches steady value at end of charge, record:
 - a. Ambient Temperature.
 - b. Temperature of each cell.
 - c. Voltage of each cell.
 - d. Voltage of overall battery string.
 - e. Charger output voltage and current
 - f. AC ripple current and voltage imposed on the battery.
 - g. Internal ohmic values of each cell and battery.
 - h. Measure intercell connection resistances for all cells.
- L. Battery Load Test
1. Charge battery to ensure cells are fully charged.
 2. Connect the load bank to the UPS output, configured for the UPS rated output power.
 3. Record data, utilizing UPS display, at start of test and every 5 minutes thereafter.
Including:
 - a. Output voltage phase to phase, phase to neutral
 - b. Output current each phase.
 - c. Output frequency.
 - d. Output kW.
 - e. Battery voltage and current.
 4. Upon the Battery Low Alarm, record:
 - a. The test time expired.
 - b. Battery voltage and current.
 5. Allow the UPS to automatically shutdown on low battery. Record the time of automatic shutdown

- M. PLC Alarms
 - 1. With the assistance of City of Winnipeg personnel, test the UPS alarms transmitted to the PLC system.
- N. Document, sign, and date test results. Include all documentation in the O & M manuals.

3.36 POWER FACTOR CORRECTION / HARMONICS FILTERS

- A. Factory tests required
 - 1. Capacity testing, to ensure proper capacity, filter ratings.
 - 2. All other normal tests to ensure a complete and operating system
- B. Visual and Mechanical Inspection:
 - 1. Note the equipment nameplate data for inclusion in the report.
 - 2. Record all adjustable settings.
 - 3. Inspect physical and mechanical condition.
 - 4. Inspect anchorage, alignment, and grounding.
 - 5. Torque all accessible bolted power connections.
 - 6. Verify capacitors are connected in proper configuration.
- C. System Setup:
 - 1. Enter system parameters in accordance with the Manufacturer's recommended Commissioning and start-up manual. This includes but is not limited to the following
 - a. Adjust and set date and time.
 - b. Check the fans(s).
 - c. System integrity test – inject leading and lagging vars for 15 minutes to confirm system operation and capacity.
 - d. Parallel system setup (as applicable).
 - e. External transformer.
 - f. C.T configuration.
 - g. System mode setup.
 - h. Password setup.
 - i. Test run.
 - j. All other requirements in accordance with the Manufacturer's recommendations.
- D. Electrical Tests:
 - 1. With the circuit breaker open perform insulation resistance testing, each pole-to-pole and pole-to-ground; values in accordance with Manufacturer's recommendation.
 - 2. With the circuit breaker closed, perform insulation resistance testing pole-ground only (otherwise the voltage will energize the DC buswork).
 - 3. Megger units rated less than 600V, test voltage is to be 500 VDC.
 - 4. Perform a contact/pole-resistance test.
 - 5. DC bus discharge time.
- E. If power and/or control fuses are present, record fuse size and type. Measure the resistance of each fuse. Investigate inconsistent resistance values.
- F. Perform functional testing to verify operation of unit.

- G. All testing, Commissioning, shall be documented, and shall be performed in the presence of a factory trained service engineer.

3.37 THERMOGRAPHIC INSPECTION

- A. Camera
1. Minimum IR resolution: 320 x 240 pixels.
 2. Minimum visible resolution: 640 x 480 pixels.
- B. Thermographic inspections and photographs shall be completed in accordance with the recommendations of the Standard for Infrared Inspection of Electrical Systems and Rotating Equipment published by the Infrasppection Institute.
- C. Provide a thermographic survey of connections associated with incoming service conductors, bus work, and branch feeder conductors and larger at each:
1. Medium voltage switchgear.
 2. Low voltage switchgear, greater than 225A
 3. Panelboards greater than 225A.
 4. Motor control centers
 5. Transfer switches
 6. All other equipment specified herein which requires a thermographic survey.
- D. Provide a thermographic survey of feeder conductors terminating at:
1. Motors rated 50 HP and larger
 2. Transfer switches.
 3. Engine-generators.
- E. Inspection and testing shall be comprised of the following:
1. Remove all necessary covers prior to thermographic inspection.
 2. Equipment to be inspected shall include all current-carrying devices.
 3. Test Parameters:
 - a. Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1 degrees C at 30 degrees C.
 - b. Equipment shall detect emitted radiation and convert detected radiation to a visual signal.
 - c. Thermographic surveys should be performed during periods of maximum possible loading but not less than 40 percent of rated load of the electrical equipment being inspected. Coordinate with City as required.
 - d. Note all temperature differences larger than 1 degrees C. Investigate all temperature differences larger than 4 degrees C.
 - e. Re-inspect deficient areas with the thermographic camera following repairs and corrections, for deficient areas identified.
- F. Provide a report which shall include the following:
1. Description of the equipment tested.
 2. Discrepancies found.
 3. Temperature difference between the area of concern and the reference area.
 4. Probable cause of temperature difference.

5. Identify any repairs made during the thermographic inspection. If no repairs were made, provide recommended action for repair.
6. Areas inspected. Identify inaccessible and / or unobservable areas and / or equipment.
7. Identify load conditions at time of inspection.
8. Provide photographs and thermograms of all areas investigated, with deficient areas identified. Visible light photographs and thermograms shall align in a manner to allow for easy identification of the components shown on the thermograms.
9. Provide thermograms of all deficient areas corrected, and identify the load conditions at the time of re-inspection.

3.38 SUPPLEMENTS

- A. The Supplements listed below, following “End of Section”, are part of this Specification.
 1. Appendix A – Commissioning Specification and Objectives Figure 2 – Temporary RAS Line Modifications.
 2. Appendix B – Commissioning Procedures

END OF SECTION

SECTION 26 28 14
FUSES – LOW VOLTAGE

PART 1 GENERAL

1.1 RELATED SECTIONS

- A. Section 01 33 00, Submittal Procedures.
- B. Section 26 05 01, Common Work Results - Electrical.
- C. Section 26 28 23, Disconnect Switches – Fused and Non-Fused.

1.2 CODES AND STANDARDS

- A. CSA, Canadian Standards Association.
 - 1. CSA C22.2 No. 248 – Low Voltage Fuses.

1.3 SUBMITTALS

- A. Provide Submittals in accordance with Section 01 33 00, Submittal Procedures and Section 26 05 01, Common Work Results – Electrical.
- B. Product Data:
 - 1. Submit Manufacturer’s printed product literature, Specifications and datasheets and include product characteristics, performance criteria, and limitations.
- C. Submit Shop Drawing to indicate:
 - 1. Time-current curves for all fuse types and sizes.

PART 2 PRODUCTS

2.1 FUSES – VFD DRIVES

- A. CSA approved
- B. Size as indicated on Drawing.
- C. Class J, Fast Acting.
- D. Interrupting rating: at least 200 KAIC.
- E. Approved Manufacturer: As recommended by the VFD Manufacturer.

2.2 FUSES – FUSED DISCONNECTS

- A. As required, provide fused disconnects when the interrupting rating at disconnect switches is required to exceed 10 kA (higher fault level applications).
- B. CSA approved.
- C. Size as indicated on Drawing
- D. Class J, time delay fuses, Class R fuses, or other types as required.
- E. Interrupting rating: at least 200 KAIC

2.3 FUSES – CONTROL CIRCUITS

- A. CSA approved
- B. Size as indicated on Drawing
- C. Provide Class CC, time delay or fast acting, as indicated on the Drawings.
- D. Interrupting rating. At least 200 KAIC.

2.4 EQUIPMENT IDENTIFICATION

- A. Provide equipment identification in accordance with Section 26 05 01, Common Work Results – Electrical.

2.5 SPARE PARTS

- A. Provide spare fuses for each size and type required in accordance with the following:
 - 1. Where there are up to 10 fuses of a specific type and size installed, provide 3 spares.
 - 2. Where there are up between 11 and 50 fuses of a specific type and size installed, provide 6 spares.
 - 3. Where there are 51 and greater quantity of a specific type and size installed, provide 10 spares.
 - 4. Turn over all spares to the Contract Administrator at completion of the project.

2.6 APPROVED MANUFACTURERS

- A. Manufacturers:
 - 1. Ferraz Shawmut or approved equal in accordance with B8 - Substitutes.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Installation of fuses for VFD drives and motor control circuits will be done during MCC fabrication.
- B. Prior to energizing, Contractor is to confirm correct fuse size and type are installed.

END OF SECTION

SECTION 26 28 23

DISCONNECT SWITCHES – FUSED AND NON-FUSED

PART 1 GENERAL

1.1 GENERAL

- A. This section is specifically applicable to fused disconnect switch rated at 600 VAC and below. This section does not apply to high voltage disconnect switches.

1.2 RELATED SECTIONS

- A. Section 01 33 00, Submittal Procedures.
- B. Section 26 05 01, Common Work Results - Electrical.
- C. Section 26 28 14, Fuses – Low Voltage

1.3 CODES AND STANDARDS

- A. Canadian Standards Association.
 - 1. CSA-C22.2 No. 4-M89 (R2000), Enclosed Switches.

1.4 SUBMITTALS

- A. Provide Submittals in accordance with Section 01 33 00, Submittal Procedures and Section 26 05 01, Common Work Results - Electrical.
- B. Product Data:
 - 1. Submit Manufacturer's printed product literature, Specifications and datasheets and include product characteristics, performance criteria (including interrupting rating), enclosure rating, and limitations.

PART 2 PRODUCTS

2.1 DISCONNECT SWITCHES

- A. CSA approved.
- B. Size to accommodate the required loads. Minimum sizes as indicated on Drawings.
- C. Disconnect switches shall be in NEMA 4 enclosures (or higher). All disconnects exposed to weather or moisture shall be NEMA 4x rated (minimum). Disconnects in hazardous areas shall be rated for the classification of the area.
- D. All disconnect switches located in the Chemical Building shall be NEMA 4X, 316 stainless steel.

- E. Unless otherwise indicated on the Drawings, motors in hazardous locations will not utilize disconnect switches. They will be locked out at the MCC (in order to locate disconnecting means outside of the hazardous areas).
- F. For VFD driven loads provide early break contact in order to signal the VFD drive that operation of the disconnecting means is underway. The VFD drive will be wired and connected in a manner that the early break contactor will shutdown the system.
- G. Any disconnect switch installed in hazardous areas shall be rated for the space they are installed in.
- H. Mechanically interlocked door to prevent opening when handle in ON position.
- I. Disconnects for motor loads to be heavy duty, motor rated.
- J. Disconnect switches shall have the appropriate interrupting rating (kAIC). Minimum rating is 10 kAIC. For interrupting ratings greater than 10 KAIC, utilize fused disconnects. For fuses refer to Section 26 28 14, Fuses – Low Voltage.
- K. Provide fuses as indicated on the Drawings. Provide 3 spare fuses for every disconnect switch.
- L. Provision for padlocking in on-off switch position.
- M. Switch mechanism: quick-make, quick-break action with self-wiping contacts.
- N. For switches 100A and over, provide non-tracking arc shrouds.
- O. Solderless pressure lugs for cable connectors.
- P. All switch poles to operate together, simultaneously with a common operating bar.
- Q. Highly visible ON-OFF switch position indication on switch enclosure cover.
- R. For 120V non-hazardous areas, where indicated on the Drawings, provide type K manual motor disconnect switches. If not specifically indicated as type K on the Drawings, utilize, Nema, full size, fully rated heavy duty disconnect switches.

2.2 ACCESSORIES

- A. Provide 2 spare disconnect switches of each size and type. Turn over to the Contract Administrator.
- B. One spare handle for each type of disconnect switch. Turn over to the Contract Administrator.
- C. For fused disconnects, provide spare fuses in accordance with Section 26 28 14, Fuses – Low Voltage.

2.3 APPROVED MANUFACTURERS

- A. Schneider Electric, Eaton, Hubbell or approved equal in accordance to B8 - Substitutes.

- B. All disconnect switches to be of one Manufacturer for the entire project. Split packages (multiple vendors) will be rejected.

2.4 EQUIPMENT IDENTIFICATION

- A. Provide equipment identification in accordance with Section 26 05 01, Common Work Results - Electrical.
- B. Nameplate to be size 8, example as followed:



PART 3 EXECUTION

3.1 INSTALLATION

- A. Install disconnect switches plumb and true. Provide structural supports, including cantruss and other steel members for disconnect supports.
- B. Supports to be installed rigid, affixed (bolted) to structural members.
- C. Provide lamacoid labels to disconnect switch enclosure.

END OF SECTION

SECTION 40 05 15

PIPING AND CABLE TRAY SUPPORT SYSTEMS

PART 1 GENERAL

1.1 WORK OF THIS SECTION

- A. Work of this Section includes design, furnishing, and installation of pipe support systems and cable tray supports. Comply with support concepts where shown on the Drawings and complete with additional design as necessary to provide complete support systems.

1.2 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Society of Mechanical Engineers (ASME):
 - a. B31.1, Power Piping.
 - b. B31.3, Process Piping.
 - c. B31.9, Building Services Piping.
 2. American Society for Testing and Materials (ASTM):
 - a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
 - c. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
 3. Canadian General Standards Board (CGSB):
 - a. 1-GP-181, Ready-Mixed Organic Zinc-Rich Coating.
 4. Canadian Standards Association (CSA):
 - a. B51, Boiler, Pressure Vessel, and Pressure Piping Code.
 - b. C22.2 No. 126.1, Metal Cable Tray Systems.
 - c. C22.2 No. 126.2, Nonmetallic Cable Tray Systems.
 5. Manufacturers' Standardization Society (MSS):
 - a. SP-58, Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation.
 6. National Electrical Manufacturers Association (NEMA):
 - a. VE 1, Metal Cable Tray Systems.
 - b. VE 2, Cable Tray Installation Guidelines.
 7. 2010 National Building Code of Canada, with 2011 Manitoba Amendments (NBC).

1.3 DEFINITIONS

- A. Design Differential Temperature: Temperature differential between piping design temperature and outdoor winter one percent design temperature as defined by governing building code.

1.4 SUBMITTALS

A. Shop Drawings:

1. Drawings of piping and cable tray support systems, locating each support, brace, hanger, guide, component, expansion joint, and anchor on piping or cable tray. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number. Indicate point load reactions from pipe and cable tray supports on supporting structure in vertical, lateral, and longitudinal directions.
2. If computer piping stress analyses are used, submit piping isometric drawings with nodal numbers consistent with analyses.
3. Catalog information on piping and cable tray supports.
4. Details of piping and cable tray supports for custom designed items.
5. Revisions to support systems resulting from changes in related piping and cable tray system layout or addition of flexible joints.
6. Submit computer piping stress analyses in accordance with CSA B51 and ASME B31.1, B31.3, or B31.9, as applicable, for all piping support systems for piping subject to any of the following design conditions:
 - a. Pipe sizes 100 mm and larger and design differential temperature exceeding 205 degrees C.
 - b. Pipe sizes 200 mm and larger and design differential temperature exceeding 150 degrees C.
 - c. Pipe sizes 300 mm and larger and design differential temperature exceeding 90 degrees C.
 - d. Pipe sizes 500 mm and larger and any design differential temperature.
 - e. Pipe sizes 75 mm and larger and design pressure exceeding 3450 kPag.

B. Information Submittals:

1. Submit written certification from Professional Engineer licensed in province of Manitoba stating that support systems, anchorage, and equipment have been designed in accordance with requirements of NBC for post-disaster structures, at time of Shop Drawing submittals.
2. Maintenance information on piping and cable tray support systems.

1.5 QUALIFICATIONS

- A. Piping and cable tray support systems shall be designed, and Shop Drawings prepared and sealed, by Professional Engineer licensed in province of Manitoba.

1.6 DESIGN REQUIREMENTS

A. General:

1. Review requirements of Section 23 21 13, Hydronic Piping; Section 40 42 13, Piping Insulation; and Contract Drawings.
2. Piping and cable tray supports shall be designed and constructed to meet the requirements of NBC. Specifically, the design shall meet the requirements of NBC for post-disaster structures, where the piping shall be installed.
3. Design, size, and locate piping and cable tray support systems throughout facility, whether or not shown on Drawings. Shop Drawings will not be reviewed for structural

adequacy. Full responsibility for design and installation of piping and cable tray support systems rests with the Contractor.

4. Cable Tray Design Loads: Use working load adequate for actual cable installed plus 20 percent additional weight allowance for future cables, plus 100 kg concentrated static load applied between side rails and mid-span. Use safety factor of 2 in accordance with NEMA VE 1, Table 3-1.
5. Locate piping and cable tray support systems such that they will not interfere with any doors, windows, or other openings. Locate to clear headroom requirements.
6. Locate and select material of pipe and cable tray support systems such that all valves and flow meters can be removed in future for maintenance.
7. Select piping and cable tray support systems such that they incorporate existing and new expansion joints in pipes and structures.
8. Locate piping and cable tray supports such that they will not interfere with any existing, proposed, or future equipment and its clearance requirement around them.
9. Support Arrangement from Floor, Roof, or Wall: Locations of piping and cable tray supports shall be either from floor, wall, or roof based on best option and to suit field condition unless otherwise noted in Contract Documents.
10. Supports may be shown on Drawings only where specific types and locations are required; additional supports are required in addition to those shown.
11. Meet requirements of MSS SP-58 or as modified by this section.
12. Design anchorage and support piping and cable tray systems for vertical and lateral loading in accordance with NBC.
13. All supports shall be laterally restrained.

B. Piping Support Systems:

1. Support Load: Dead loads imposed by weight of pipes filled with water, except air and gas pipes, plus insulation.
2. Prevent contact of two dissimilar metals per manufacturer's recommendations.
3. Maximum Support Spacing and Minimum Rod Size:
 - a. Steel and Ductile Iron Piping (note that following spacing may require use of higher load pipe clamps and more than single anchor point in concrete):

Nominal Pipe Size (mm)	Maximum Support/Hanger Spacing (m)	Minimum Rod Size Single Rod Hangers (mm)
25 & smaller	1.8	6.25
32 through 65	2.4	6.25
75 & 100	3.0	9.5
150	3.6	9.5
200	3.6	12.5
250 & 300	4.3	15.9
350	4.8	19.1
400 & 450	4.8	22.2
500	5.4	25.4

SEWPCC B679 CHILLER REPLACEMENT PROJECT
 BID OPPORTUNITY NO. 929-2023

Nominal Pipe Size (mm)	Maximum Support/Hanger Spacing (m)	Minimum Rod Size Single Rod Hangers (mm)
600	5.4	31.7
750 & larger	As shown on Drawings	45

- b. Copper Piping:
 - 1) Maximum Support/Hanger Spacing: 0.61 m less than specified above for steel piping, with 25 mm and smaller piping supported every 1.5 m.
 - 2) Minimum Hanger Rod Size: Same as specified above for steel piping.
- c. Plastic and Fiberglass Piping:
 - 1) Maximum Support/Hanger Spacing: As recommended by manufacturer for flow temperature in pipe.
 - 2) Minimum Hanger Rod Size: Same as specified above for steel pipe.
- d. Stainless Steel Piping:

Nominal Pipe Size (mm)	Maximum Support/Hanger Spacing (m)	Minimum Rod Size Single Rod Hangers (mm)
25 & smaller	1.8	6.25
32 through 100	2.4	6.25
150	2.4	9.5
200 & 250	3.0	12.5
300	3.0	12.5
350 & 400	3.6	15.9
450 & 500	4.3	19.1
600	4.3	22.2
750 & larger	As shown on Drawings	45

- C. Cable Tray Support Systems:
 - 1. Prevent contact of two dissimilar metals per manufacturer’s recommendations.
 - 2. Maximum Support/Hanger Spacing: In accordance with manufacturer’s recommendations and applicable code requirements.
- D. Framing Support Systems:
 - 1. Beams: Size such that beam stress does not exceed 172,000 kPa and maximum deflection does not exceed 1/240 of span.
 - 2. Column Members: Size in accordance with manufacturer’s recommended method.
 - 3. Support Loads: Calculate using weight of pipes filled with water.

4. Maximum Spans:
 - a. Steel and Ductile Iron Pipe 75 mm Diameter and Larger: 3 m centers, unless otherwise shown.
 - b. Other Pipelines and Special Situations: May require supplementary hangers and supports.
5. Electrical Conduit Support: Include in design of framing support system.
- E. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.
- F. Vertical Sway Bracing: 3 m maximum centers, or as shown.

PART 2 PRODUCTS

2.1 GENERAL

- A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated by catalogs.
- B. Materials: In accordance with Tables 1 and 2, attached as supplements to this section.
- C. Customized pipe supports shall be supplied by the manufacturers listed in this specification section or by Taylor Pipe Supports.

2.2 PIPE HANGERS

- A. Clevis Type:
 1. MSS SP-58 Type 1.
 2. Manufacturers and Products:
 - a. Anvil; Figure 260.
 - b. Cooper B-Line; Figure B3100.
- B. J-Hanger:
 1. MSS SP-58 Type 5.
 2. Manufacturers and Products:
 - a. Anvil; Figure 67.
 - b. Cooper B-Line; Figure B3690.
- C. Adjustable Split-Ring Type:
 1. MSS SP-58 Type 6.
 2. Manufacturers and Products:
 - a. Anvil; Figure 104.
- D. Adjustable Split-Ring Type with Turnbuckle:
 1. MSS SP-58 Type 11.
 2. Manufacturers and Products:
 - a. Anvil; Figure 108 with Figure 230.

- E. Extension Split Pipe Clamp:
 - 1. MSS SP-58 Type 12.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 138R.
 - b. Cooper B-Line; Figure B3198R or B3198H.
- F. Adjustable Yoke Pipe Roll:
 - 1. MSS SP-58 Type 43.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 181.
 - b. Cooper B-Line; Figure B3110.

2.3 SADDLE SUPPORTS

- A. Pedestal Type – Non-Adjustable:
 - 1. MSS SP-58 Type 37.
 - 2. Schedule 40 pipe stanchion, non-adjustable saddle with U-bolt, and anchoring flange.
 - 3. Manufacturers and Products:
 - a. Anvil; Figure 259.
 - b. Cooper B-Line; Figure B3090.
- B. Pedestal Type – Adjustable:
 - 1. MSS SP-58 Type 38, with U-bolt.
 - 2. Schedule 40 pipe stanchion, adjustable saddle with U-bolt, and anchoring flange.
 - 3. Manufacturers and Products:
 - a. Anvil; Figure 265.
 - b. Cooper B-Line; Figure B3092.

2.4 ROLLER SUPPORTS

- A. Roller Chair:
 - 1. Manufacturers and Products:
 - a. Anvil; Figure 175.
 - b. Cooper B-Line; Figure B3120.
- B. Adjustable Roller Support:
 - 1. MSS SP-58 Type 41.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 177.
 - b. Cooper B-Line; Figure B3122.
- C. Pipe Roll:
 - 1. MSS SP-58 Type 44.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 271.
 - b. Cooper B-Line; Figure B3117SL.
- D. Adjustable Pipe Roll:
 - 1. MSS SP-58 Type 46.

2. Manufacturers and Products:
 - a. Anvil; Figure 274, 274P, or 275.
 - b. Cooper B-Line; Figure B3118SL.

2.5 BOLTED SUPPORTS

- A. Flange Type:
 1. Bolts directly to pipe flange.
 2. Adjustable pipe stanchion, single or double pipe supports.
 3. Manufacturers and Products:
 - a. Cooper B-Line; Figure B3094.
 - b. Standon; Model S89.

2.6 WALL BRACKETS

- A. Welded Steel Bracket (medium duty):
 1. MSS SP-58 Type 32.
 2. Manufacturers and Products:
 - a. Anvil; Figure 195.
 - b. Cooper B-Line; Figure B3066.
- B. Welded Steel Bracket (heavy duty):
 1. MSS SP 58 Type 33.
 2. Manufacturers and Products:
 - a. Anvil; Figure 199.
 - b. Cooper B-Line; Figure B3067.

2.7 PIPE CLAMPS

- A. Riser Clamp:
 1. MSS SP-58 Type 8.
 2. Manufacturers and Products:
 - a. Anvil; Figure 261.
 - b. Cooper B-Line; Figure B3373.
- B. Offset Pipe Clamp:
 1. Manufacturers and Products:
 - a. Anvil; Figure 103.
 - b. Cooper B-Line: Figure B3148.
- C. Pipe Strap:
 1. MSS SP-58 Type 26.
 2. Manufacturers and Products:
 - a. Anvil; Figure 262.
 - b. Cooper B-Line: Figure B2400.

2.8 CHANNEL TYPE SUPPORT SYSTEMS

- A. Pre-Engineered Support System:
 - 1. Channel Size:
 - a. Steel: 12-gauge, 41.3 mm wide minimum.
 - b. FRP: 38.1 mm wide minimum.
 - 2. Members and Connections: Design for all loads with safety factor of 5.
 - 3. Pipe Clamps: Two-piece clamps for all pipes unless otherwise noted.
 - 4. Manufacturers and Products:
 - a. Anvil; Power-Strut.
 - b. Cooper B-Line; Strut System.
 - c. UBS Industries; Unistrut.
 - d. Tyco; Aickinstrut (FRP system).

2.9 FLOOR-MOUNTED PIPE AND CABLE TRAY SUPPORT SYSTEMS

- A. W, H, or HSS shapes steel sections conforming to Section 05 50 00, Metal Fabrication (Basic). Hot-dip galvanize after fabrication.
- B. MI Industrial Modular Support System supplied by Hilti may be used as an alternative support system.
- C. Support system shall be placed at locations not to interfere with equipment maintenance and walkways.

2.10 ACCESSORIES

- A. Hanger Rods, Clevises, Nuts, U-bolts, Sockets, and Turnbuckles: In accordance with MSS SP-58.
- B. Concrete Inserts:
 - 1. MSS SP-58 Type 18.
 - 2. Continuous channel insert with load rating not less than that of hanger rod it supports.
 - 3. Manufacturers and Products:
 - a. Cooper B-Line; Figure B22I, B32I, or B52I.
- C. Beam Clamps:
 - 1. MSS SP-58 Type 21, 28, 29, or 30.
 - 2. Concentric loading type which engage both sides of flange.
 - 3. Manufacturers and Products:
 - a. Anvil; Figure 133 or 292.
 - b. Cooper B-Line; Figure B3050 or B3054.
- D. Insulation Protection Saddles:
 - 1. MSS SP-58 Type 39.
 - 2. Manufacturers and Products:
 - a. Anvil; Figure 160 through 166A.
 - b. Cooper B-Line; Figure B3160 through B3165.

- E. Insulation Protection Shields:
 - 1. MSS SP-58 Type 40.
 - 2. Galvanized steel or stainless steel.
 - 3. Manufacturers and Products:
 - a. Anvil; Figure 167.
 - b. Cooper B-Line; Figure B3151.
- F. Vibration Isolation Pads:
 - 1. Type: Neoprene waffle.
 - 2. Manufacturers and Products:
 - a. Mason Industries; Type W.
 - b. Korfund; Korpad 40.
- G. Flush Type Insert Channels: As specified in Section 05 50 00, Metal Fabrications (Basic).

2.11 PIPE GUIDES

- A. Intermediate Guides:
 - 1. Piping 150 mm and Smaller:
 - a. Type: Pipe clamp with oversized pipe sleeve to provide minimum 3.2 mm clearance.
 - b. Manufacturers and Products:
 - 1) Cooper B-Line; B3148 or B3180.
 - 2) Anvil; Figure 103.
 - 2. Piping 200 mm and Larger:
 - a. Type: Specially formed U-bolts with double nuts to provide 6.4 mm minimum clearance around pipe.
 - b. U-Bolt Stock Size:
 - 1) 200 mm Pipe: 15.9 mm.
 - 2) 250 mm Pipe: 19.1 mm.
 - 3) 300 mm Through 400 mm Pipe: 22.2 mm.
 - 4) 450 mm Through 762 mm Pipe: 25.4 mm.
- B. Alignment Guides:
 - 1. Piping 200 mm and Smaller:
 - a. Spider or sleeve type.
 - b. Manufacturers and Products:
 - 1) Anvil; Figure 255 or 256.
 - 2) Cooper B-Line; Figure B3281 through B3287.
 - 3) Flexonics; Series PGT.
 - 2. Piping 250 mm and Larger:
 - a. Adjustable double roller type.
 - b. Manufacturers and Products:
 - 1) Anvil; Figure 177 with Figure 171.
 - 2) Cooper B-Line; Figure B3122A.

2.12 PIPE ANCHORS

- A. Anchor Chairs:
 - 1. Type: Anchor chair with U-bolt strap.

2. Manufacturers and Products:
 - a. Cooper B-Line; Figure B3147A or B3147B.

2.13 ANCHORING SYSTEMS

- A. Size: Sized by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications (Basic).

PART 3 EXECUTION

3.1 INSTALLATION

- A. General:
 1. Install support systems in accordance with MSS SP-58 unless shown otherwise.
 2. Support piping connections to equipment by pipe support and not by equipment.
 3. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
 4. Support no pipe from pipe above it.
 5. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
 6. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
 7. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
 8. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
 9. Repair mounting surfaces to original condition after attachments are made.
- B. Standard Pipe Supports:
 1. Horizontal Suspended Piping:
 - a. Single Pipes: Adjustable swivel-ring, split-ring, or clevis hangers.
 - b. Grouped Pipes: Trapeze hanger systems.
 - c. Furnish galvanized steel insulation protection shield and oversized hangers for insulated pipe.
 - d. Furnish precut sections of rigid insulation with vapor barrier at hangers for insulated pipe.
 2. Horizontal Piping Supported From Walls:
 - a. Single Pipes: Wall brackets or wall clips attached to wall with anchors. Clips attached to wall mounted framing also acceptable.
 - b. Stacked Piping:
 - 1) Wall mounted framing system and clips acceptable for piping smaller than 75 mm minimal diameter.
 - 2) Piping clamps that resist axial movement of pipe through support not acceptable.
 - c. Wall mounted piping clips not acceptable for insulated piping.
 3. Horizontal Piping Supported From Floors:
 - a. Stanchion Type:
 - 1) Pedestal type, adjustable with stanchion, saddle, and anchoring flange.

- 2) Use yoked saddles for piping whose centerline elevation is 450 mm or greater above floor and for exterior installations.
 - 3) Provide neoprene waffle isolation pad under anchoring flanges, adjacent to equipment or where otherwise required to provide vibration isolation.
 - b. Floor Mounted Channel Supports:
 - 1) Use for piping smaller than 75 mm nominal diameter running along floors and in trenches at piping elevations lower than can be accommodated using pedestal pipe supports.
 - 2) Attach channel framing to floors with anchor bolts.
 - 3) Attach pipe to channel with clips or pipe clamps.
 - c. Concrete Cradles: Use for piping larger than 75 mm along floor and in trenches at piping elevations lower than can be accommodated using stanchion type.
 4. Vertical Pipe: Support with wall brackets and base elbow or riser clamps on floor penetrations.
 5. Standard Attachments:
 - a. To Concrete Ceilings: Concrete inserts.
 - b. To Steel Beams: I-beam clamp or welded attachments.
 - c. To Wooden Beams: Lag screws and angle clips to members not less than 62.5 mm thick.
 - d. To Concrete Walls: Concrete inserts or brackets or clip angles with anchor bolts.
 6. Existing Walls and Ceilings: Install as specified for new construction, unless shown otherwise.
- C. Intermediate and Alignment Guides:
1. Provide pipe alignment guides (or pipe supports that provide same function) at expansion joints and loops.
 2. Guide piping on each side of expansion joint or loop at 4- and 14-pipe diameters from each joint or loop.
 3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.
- D. Accessories:
1. Insulation Protection Shield: Install on insulated non-steel piping. Oversize rollers and supports.
 2. Insulation Protection Saddle: Install on insulated steel pipe. Oversize rollers and supports.
 3. Vibration Isolation Pad: Install under base flange of pedestal type pipe supports adjacent to equipment, and where required to isolate vibration.
 4. Dielectric Barrier:
 - a. Install between carbon steel members and copper or stainless steel pipe.
 - b. Install between stainless steel supports and non stainless steel ferrous metal piping.
 5. Electrical Isolation: Install 6.4 mm by 75 mm neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.2 FIELD FINISHING

- A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

Table 1 Nonchemical Areas	
Exposure Conditions	Hanger Material
Office areas	Galvanized steel or precoated steel
Shops and warehouse areas	Galvanized steel or precoated steel
Pipe Galleries	Galvanized steel or precoated steel
Headworks	Stainless steel or FRP
Primary Clarifiers	Stainless steel or FRP
Fermenter	FRP
Biofilter	FRP
Process areas: high humidity or hydrogen sulfide	Stainless steel or FRP
Process areas: wetted or submerged	Stainless steel or FRP
Outside	Galvanized steel

Notes:

1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 304.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M. Repair galvanized coatings damaged by welding, cutting, or rough handling during shipping, installation or otherwise, in accordance with ASTM A780/A780M using organic zinc-rich primer, CGSB 1-GP-181M, Sealtight Galvafruid Zinc-Rich Coating by W.R. Meadows Ltd., or approved equal in accordance with B8. Dry film thickness on repairs to exceed original coating thickness by minimum 25 percent.

Table 2 Chemical Areas		
Exposure Conditions	Hanger for Direct Exposure	Hanger for Remote Exposure
Ferric Chloride	FRP	Precoated steel
Polymers	FRP	Precoated steel
Sodium Hydroxide	FRP	Precoated steel
Sodium Hypochlorite	FRP	Precoated steel
Sodium Bisulphite	FRP	Precoated steel

Notes:

1. Direct exposure includes entire area within the chemical room including both basement and ground floors.
2. Remote exposure is area beyond area defined as direct exposure, but within designated building.
3. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
4. Stainless steel to be Type 304.

SECTION 40 42 13

PIPING INSULATION

PART 1 GENERAL

1.1 REFERENCES

- A. Comply with the latest edition of the following statutes codes and standards and all amendments thereto.
1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Efficient Design of New Buildings Except Low-rise Residential Buildings.
 2. ASTM International (ASTM):
 - a. C177, Standard Test Method for SteadyState Heat Flux Measurements and Thermal Transmission Properties by means of the Guarded Hotplate Apparatus.
 - b. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
 - c. C518, Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
 - d. C533, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
 - e. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
 - f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
 - g. C552, Standard Specification for Cellular Glass Thermal.
 - h. C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
 - i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
 - j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
 - k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
 - l. E96, Test Methods for Water Vapor Transmission of Materials.
 3. International Code Council (ICC) International Energy Conservation Code (IECC).
 4. Underwriters Laboratories Inc. (UL).
 5. Underwriters Laboratories of Canada (ULC).

1.2 SUBMITTALS

- A. Action Submittals:
1. Shop Drawings: Manufacturer's descriptive literature.
- B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.1 PIPE INSULATION

A. Type 1:

1. Material: Flexible elastomeric pipe insulation, closed cell structure in accordance with ASTM C534.
2. Temperature Rating: Minus 40 degrees C to 82 degrees C.
3. Nominal Density: 96 kg/m³.
4. Conductivity in accordance with ASHRAE 90.1 and minimum of 24 degrees C per ASTM C177 or ASTM C518.
5. Minimum water vapor transmission of 5.75 ng/Pa·s·m² per ASTM E96.
6. Joints: Manufacturer's adhesive.
7. Flame Spread Rating: Less than 25 per ASTM E84.
8. Manufacturers and Products:
 - a. Rubatex; Insul-Tube 180 or Insul-Sheet 1800.
 - b. Armstrong; Armaflex AP.

B. Type 2:

1. Material: UL rated-, preformed, sectional rigid fiberglass with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure sensitive, -self-sealing- lap.
2. Temperature Rating: Minus 18 degrees C to 455 degrees C.
3. Conductivity in accordance with ASHRAE 90.1 and minimum of 0.039 w/m·degrees C.
4. Minimum water vapor transmission for jacket of 1.15 ng/Pa·s·m² per ASTM E96.
5. Joints: Matching pressure sensitive butt strips for sealing circumferential joints.
6. Manufacturers and Products:
 - a. Owens Corning Fiberglass; ASJ/SSL11.
 - b. Manville; Micro-Lock 650 with AP-T Jacket.

C. Type 2A – Flexible Blanket, Non jacketed, High Temperature:

1. Description: Roll form complying with ASTM C553.
2. Thermal Conductivity: 0.27 at 24 degrees C mean temperature.
3. Non jacketed.
4. Density: 2 pcf.
5. Maximum Operating Temperature: 538 degrees C.
6. Acceptable Manufacturers:
 - a. Johns Manville HTB 23.
 - b. Owens Corning – Fiber Glass TTW Type 1.
 - c. Knauf Fiber Glass GmbH Type ET.

D. Type 3:

1. Material: Cellular glass.
2. Temperature Rating: Minus 179 degrees C to 482 degrees C.
3. Following manufacturer's direction based upon temperature of piping to be insulated.
4. Manufacturer and Product: Pittsburgh Corning; FOAMGLAS.

- E. Type 4:
1. Material: Calcium silicate, minimum density of 192 kg/m³, maximum K factor of 0.066 W/m·degrees C at 149 degrees C mean (ASTM C533), without factory-applied jacket.
 2. Temperature Rating: 649 degrees C, maximum.
 3. Manufacturers and Products:
 - a. Owens/Corning Fiberglass; Kaylo 10.
 - b. Schuller (Manville); Thermo-12.
 - c. Calsilite; 1,200-degree thermal insulation.

- F. Type 5 Noise Insulation for Pipes and Ducts:
1. Material: Foil faced mass loaded vinyl noise barrier bonded to 50 mm
 2. quilted fiberglass sound absorber. 2 pounds per square foot noise
 3. barrier.
 4. Temperature Rating: Minus 25 degrees C to 150 degrees C.
 5. Class A Fire Rating.
 6. Sound Reduction: 20 decibels.
 7. Manufacturers: Sound Seal Corp.

2.2 ROOF DRAIN AND OVERFLOW DRAIN SUMPS INSULATION

- A. Type 1: 25 mm thick.

2.3 FITTING INSULATION

- A. Type 1: Same as pipe.

- B. Type 2:
1. Wired in place premolded insulation or mitered segments, or soft fiberglass insulation inserts covered with premolded 20mil minimum thickness PVC fitting covers.
 2. Manufacturers:
 - a. Manville Zeston.
 - b. CEEL-CO.
 - c. Knauf-Proto.

- C. Type 3: Same as pipe.

2.4 INSULATION AT PIPE HANGERS AND SUPPORTS

- A. Refer to Section 40 05 15, Piping Support Systems.

- B. Type 1:
1. Copper and Nonmetallic Pipe 50 mm and Smaller and Steel Pipe 40 mm and Smaller: Use insulation shields.
 2. Larger Sizes: Use insulation saddles or Type 3 rigid insulation insert 250 mm long.

- C. Type 2: UL rated-, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 250 mm in length, with factory applied, vinyl coated and embossed vapor barrier jacket with -self sealing- lap.

2.5 INSULATION FINISH SYSTEMS

- A. Type F1 – PVC:
 - 1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 70 degrees C.
 - 2. Manufacturers and Products:
 - a. Knauf; Proto.
 - b. Johns Manville; Zeston.

- B. Type F2 – Paint:
 - 1. Acrylic latex paint, white, and suitable for outdoor use.
 - 2. Manufacturers and Products:
 - a. Armstrong; WB Armaflex finish.
 - b. Rubatex; 374, white finish.

- C. Type F3 – Aluminum:
 - 1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, minimum 0.4 mm thickness, with smooth mill finish.
 - 2. Vapor Barrier: Provide factory applied vapor barrier, consisting of kraft paper with 1 mil thick low density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
 - 3. Fitting Covers: Material as for aluminum roll jacketing, pre-molded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, specialty fittings, etc.
 - 4. Manufacturers:
 - a. RPR Products; Insul-Mate.
 - b. Childers.
 - c. Pabco.

- D. Type 4 – Buried for Type 3 Insulation: Jacket system to be foam glass manufacturer's standard Pittwrap bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, heat-sealed at overlap.

PART 3 EXECUTION

3.1 APPLICATION

- A. General:
 - 1. Insulate valve bodies, flanges, and pipe couplings.
 - 2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
 - 3. Do not insulate flexible pipe couplings and expansion joints unless they are located outdoors.

4. Service and Insulation Thickness: Refer to Insulation Schedule below and to Process Piping Schedule in Section 40 27 00, Process Piping – General.

Insulation Schedule								
Service Type	Pipe Legend	Thickness	Fluid Temperature (degrees C)*	Insulation	Finish Systems			
					Concealed from View	Indoors Exposed	Outdoors	Buried
Cooling Systems (Condensate chilled water, and refrigerant)	CWS, CWR, R, CHS, CHR	40 mm CWS, CWR, CHS, CHR (up to 100 mm pipe) 50 mm CWS, CWR, CHS, CHR (above 100 mm pipe)	4 to 15	Type 1	N/A	F1	F3	N/A
<small>*Use these fluid temperatures unless otherwise noted in the Process Piping Schedule. †Based upon insulation with glass fiber per ASTM C547, outdoors with 9 L/s wind with 10% safety and no value assigned to cladding or air space at cladding. ‡Matches the watts per meter in Section 40 41 13, Pipe Heat Tracing</small>								

3.2 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install insulation after piping system has been pressure tested and leaks corrected.
3. Apply insulation over clean finish painted and dry surfaces.
4. Do not allow insulation to cover nameplates or code inspection stamps.
5. Run insulation continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
6. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
7. Use insulating cement, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

B. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

C. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier jackets on pipe insulation and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

E. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

F. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

- G. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.
- H. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.
- I. Insulate valve bodies, flanges, and pipe couplings.
- J. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
- K. Do not insulate flexible pipe couplings and expansion joints.
- L. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.
- M. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.
- N. Placement:
 - 1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
 - 2. Insulate valves and fittings with sleeved or cut pieces of same material.
 - 3. Seal and tape joints.
- O. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.
- P. Heat Traced Piping: Apply insulation after heat tracing work is completed and approved.
- Q. Vapor Barrier:
 - 1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
 - 2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
 - 3. Do not use staples and screws to secure vapor sealed system components.
- R. Aluminum Jacket:
 - 1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
 - 2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
 - 3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
 - 4. Do not use screws or rivets to fasten the fitting covers.
 - 5. Install removable prefabricated aluminum covers on exterior flanges and unions.
 - 6. Caulk and seal all exterior joints to make watertight.
- S. PVC Jacketing:
 - 1. Overlap jacketing minimum 50 mm. Seal and band longitudinal and circumferential joints and seams with sealing compound and pre-formed aluminum or stainless steel straps and fasteners.

2. Make special provision, according to manufacturer's instructions, to allow uniform expansion on jacket to avoid joint opening on piping with 50 mm or greater layer of insulation.
3. Provide removable sections at inspection openings, arranged to allow removal and replacement without cutting cover or retaining system.
4. Design covers for flanges, fittings and expansion pieces with hinged locking arrangement to allow removal and replacement without cutting cover or retaining system.

3.3 FIELD FINISHING

- A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.
- B. Where pipe labels or banding are specified for a piping system they shall be applied to the finished insulation and not to the pipe.
- C. Painting Piping Insulation (Exposed to View):
 1. Metal or PVC jacketing does not require painting.
 2. If an insulated piping system is indicated to be painted in Section 40 27 00, Process Piping—General, the piping shall receive the following:
 - a. Prime coat in accordance with Section 09 90 00, Painting and Coating.
 - b. Finished insulation (and not the piping) shall be painted in accordance with Section 09 90 00, Painting and Coating.

END OF SECTION

SECTION 40 80 01

PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.1 SUBMITTALS

- A. Informational Submittals:
 - 1. Testing Plan: Submit prior to testing and include at least the information that follows.
 - a. Testing dates.
 - b. Piping systems and section(s) to be tested.
 - c. Test type.
 - d. Method of isolation.
 - e. Calculation of maximum allowable leakage for piping section(s) to be tested.
 - 2. Certifications of Calibration: Testing equipment.
 - 3. Certified Test Report.

PART 2 PRODUCTS (Not Used)

PART 3 EXECUTION

3.1 PREPARATION

- A. Notify Contract Administrator in writing 5 days in advance of testing. Perform testing in presence of Contract Administrator.
- B. Pressure Piping:
 - 1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
 - 2. Prior to testing, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
 - 3. New Piping Connected to Existing Piping:
 - a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Contract Administrator.
 - b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Contract Administrator.
 - 4. Items that do not require testing include: equipment seal drains, tank overflows to atmospheric vented drains, tank atmospheric vents.
 - 5. Test Pressure: As indicated on Piping Schedule or as specified by equipment manufacturer as applicable.
- C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

3.2 HYDROSTATIC TEST FOR PRESSURE PIPING

- A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.
- B. Exposed Piping:
 - 1. Perform testing on installed piping prior to application of insulation.
 - 2. Maximum Filling Velocity: 0.76 meter per second, applied over full area of pipe.
 - 3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
 - 4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
 - 5. Examine joints and connections for leakage.
 - 6. Correct visible leakage and retest as specified.
 - 7. Empty pipe of water prior to final cleaning or disinfection.

3.3 FIELD QUALITY CONTROL

- A. Test Report Documentation:
 - 1. Test date.
 - 2. Description and identification of piping tested.
 - 3. Test fluid.
 - 4. Test pressure.
 - 5. Remarks, including:
 - a. Leaks (type, location).
 - b. Repair/replacement performed to remedy excessive leakage.
 - 6. Signed by Contractor and Contract Administrator to represent that test has been satisfactorily completed.

END OF SECTION