

SECTION 01101 SUMMARY OF WORK

PART 1 GENERAL

1.01 RAW SEWAGE PUMP UPGRADING PROJECT

A. The City of Winnipeg Water and Waste Department is in the process of upgrading its raw sewage pumping system at the North End Water Pollution Control Centre (NEWPCC), and as the first step of the upgrade intends to replace two of its six raw sewage pump and motor assemblies and add variable frequency drives. The upgrades will also include major building renovations with structural, electrical and mechanical modifications. The upgrading will be completed with two or more contracts, with the pump, motor and VFD supply contract being the first. A subsequent contract(s) will be issued for the building renovations and required electrical and mechanical upgrades for the NEWPCC Main Building along with installation of the pumps, motors and VFD equipment.

1.02 WORK COVERED BY CONTRACT DOCUMENTS

- A. A summary of the work to be completed under this supply and delivery contract includes:
1. Inspection of the existing Site for confirmation that the pumps and motors to be supplied will physically fit within the existing dry wells to enable proper operation and maintenance, and review of the suction channel and piping configurations for confirmation the selected equipment will meet the pumping performance requirements.
 2. Design, manufacture, fabrication, factory testing and delivery of two horizontal end suction centrifugal pumps, and two matched medium voltage VFD driven induction motors and two VFDs. Factory unit testing shall include individual equipment testing at the specific equipment manufacturers' locations. Factory string testing at Pump manufacturer's location shall include combined testing of Pump, Motor and VFDs where the motor and VFD will also be tested as a part of the whole pumping system. The Contractor shall include for all pricing in the Bid for making all necessary arrangements for the above tests.
 3. The Contractor shall assume "single source" responsibility for the pump, motor and VFD units.
 4. Arranging for and delivery of the equipment assemblies to temporary storage, unloading and maintaining the equipment to manufacturer's recommendations while in storage.
 5. The equipment will be handed over to the Installing Contractor at the storage facility, at a time determined by the Contract Administrator, with the Installing Contractor to be responsible for pick up and final delivery to the NEWPCC Site for installation.

6. Contractor to provide assistance to the Installing Contractor for installation, operation and troubleshooting during installation, functional testing, commissioning and start-up of the equipment.
7. Provision of operating and maintenance manuals.
8. Provision of training to the City's Operations, Mechanical Maintenance and Electrical/Instrumentation personnel.
9. Provision of required special tools and spare parts.

1.03 MAINTENANCE IN STORAGE AND EMERGENCY USE

- A. The Contractor will be responsible for routine maintenance of the equipment for the entire duration while in storage.
- B. The Contractor is advised that the existing pumps at the NEWPCC are reaching the end of their useful lives and the new equipment is to be available for unplanned emergency use at the NEWPCC if required.

1.04 SITE INFORMATION

The NEWPCC Main Building was constructed in the 1930's, and underwent a major renovation in the 1960's. The Main Building houses three dry wells which each contain two raw sewage pumps. Pump MP-5 which is in the southern dry well (Dry Well No. 1) and Pump MP-4 which is in the central dry well (Dry Well No. 2) are to be replaced with new pumps and motors. The dry wells are only 7.6 m (25 feet) in diameter, which limits the size of equipment that can physically be installed in the locations while allowing room for installation, maintenance and removal.

Raw sewage is fed from the wet well by two suction headers, one on the east side and one on the west side of the dry wells. Pump MP-5 is fed from the East Suction Header, while pump MP-4 is fed from the West Suction Header. Each of these suction headers has different suction and inlet conditions, with the east suction header being immediately adjacent to the dry well, creating a condition in which there is a rapid transition from the suction header to the pump suction line.

During the investigation of pump replacement options, testing of the existing pumps in Dry Well No. 1 was carried out to assess their current performance, with the results reported in NEWPCC – Pump Tests Report (May 3, 2010) which has been included as Additional Information. No unusual operational problems or adverse characteristics were identified from the tests. The Contractor is to consider the system configuration with respect to the pumps being proposed and confirm the new pumps will be suitable for installation in the existing locations.

The East Suction Header which feeds MP-4 was constructed in the 1960's, and was built with a longer straight approach section of suction channel.

The existing electrical room is located immediately south of Dry Well No. 1. It is to be expanded into the former chlorine room which is immediately south of the existing electrical room. The VFDs will be located within this new

electrical room. The space available for the VFDs and other new electrical, control and mechanical equipment along with associated clearance requirements will also be limited in this new electrical room.

The space limitations at the Site for both pump/motor and VFD make the size of the equipment critical to successful installation of the equipment and future maintenance. Accordingly, the specifications have been developed in terms of maximum equipment size limitations.

1.05 DEFINITIONS

A. Further to Supplemental Conditions, D3: Definitions, the following shall apply:

1. General Requirements: Refers to Division 1 of these specifications.
2. Contractor: when reference is made to manufacturer, manufacturer's representative, supplier or subcontractor, (excluding Installer or Installing Contractor) they shall be considered to be a Subcontractor for and representing the Contractor.
3. Engineer: Where the word Engineer appears in reference to contract administration, it shall mean the Contract Administrator
4. Installing Contractor: The entity, under separate contract with the City, whose responsibilities include the installation of the Goods provided under this Contract.
 - a. The Installing Contractor will pick up the pumps, motors and VFDs from temporary storage and deliver to the NEWPCC Site, and take responsibility for their installation. It is anticipated the installation work will be included in a general contract that will include the other Site works, but this general contract work may be split into two or more individual contracts.
5. Owner: Means the City of Winnipeg, as defined in Part C: General Conditions.
6. Surge Well: The facility name and references to Surge Well have been replaced by the term Wet Well, and where Surge Well appears in reference to the NEWPCC structure, it shall be considered interchangeable with Wet Well.
7. Equipment Identification: The pumps have recently been renumbered to the following, and may be referred to by either number interchangeably in these specifications:
 - a. P-M140 (formerly M140-RSP and MP-4)
 - b. P-M150 (formerly M150-RSP and MP-5)

1.06 OWNER FURNISHED PRODUCTS

- A. Contractor to provide all products manufactured with new Material as specified in the Contract Documents.
- B. Installation of the pumps, motors and VFDs including process piping, electrical, control wiring, seal water, etc, will be undertaken by others under a separate installation contract.

END OF SECTION

SECTION 01301 ADMINISTRATIVE REQUIREMENTS

PART 1 GENERAL

1.01 DEFINITIONS

- A. Action Submittal: Written and graphic information submitted by Contractor that requires Contract Administrator's approval.
- B. Informational Submittal: Information submitted by Contractor that does not require Contract Administrator's approval.
- C. Preliminary Operation & Maintenance (O&M) Data: Initial and subsequent submissions for Contract Administrator's review.
- D. Final O&M Data: Data that has been accepted by the Contract Administrator, submitted as specified herein.
- E. Maintenance Operation: As used on Maintenance Summary Form is defined to mean any routine operation required to ensure satisfactory performance and longevity of Goods. Examples of typical maintenance operations are cleaning, lubrication, belt tensioning, adjustment of pump packing glands, and routine adjustments.

1.02 PROJECT COORDINATION

- A. Related Work at Site:
 - 8. One or more contracts will be issued for preparation of the Site, installation of the pumps, motors and VFDs, and other upgrading works prior to delivery of the pumps, motors and VFDs. The new pumps, motors and VFDs are to be turned over to the Installing Contractor for installation. The Contractor will then be required to coordinate subsequent inspections and special services with the Installing Contractor's schedule of activities.
 - 9. The Contractor is advised that although not currently anticipated, there may be other works taking place on-site which may require schedule adjustments and additional coordination of activities.
- B. Facility Operations:
 - 1. Continuous operation of NEWPCC is of critical importance. The NEWPCC is the largest wastewater treatment plant in the City of Winnipeg and processes raw wastewater from two-thirds of the city. All incoming raw sewage is pumped by the raw sewage pumps, and

the pumping operation must be maintained during the pump replacement process.

2. The project has been scheduled for only one pump to be taken out of service at one time to minimize the disruption to the pumping capacity.
3. If the pump replacement work cannot be completed within the intended period because of elevated inflows or high river levels, deferral of the work may be required until suitable conditions exist, and an extended temporary storage period for the pumps, motors and VFDs may be required over this interval.
4. Contractor access to the NEWPCC is generally restricted, except as required for the completion of the specified work or as otherwise approved by the Contract Administrator.

C. Emergency Use of Equipment

1. The pump replacement contract has been planned for an orderly replacement of the pumps without a major disruption in service. Because of the existing pumps nearing the end of their service life and the long lead time required to have the equipment installed from the time of ordering, the City intends to minimize the risk of service reduction by pre-purchasing the pumps and having them in storage and available as soon as practicable.
2. In the event that the pumps are in temporary storage and the City determines one or more pieces of equipment are needed for emergency use, the City reserves the right to make use of the equipment, and if required a change authorization will be issued to the Contractor for delivery of the pumps to the NEWPCC Site.
3. Emergency use of the pumps, if required, will be by separate authorization and is not to be included in the bid price.

D. Onsite Coordination:

1. Contract Administrator shall coordinate Contractor activities with the Installing Contractor and other Site contractors.
2. Contractor shall promptly notify the Contract Administrator of any conflict or coordination problems.

E. Construction Sequencing:

1. Supply and delivery of the pumps, motors and VFDs will commence in advance of the general construction contract at the NEWPCC, but the contracts will proceed simultaneously for most of the duration.
2. Contractor's shop drawing and information submittals must be delivered promptly as they will be used for Site preparation works, including pump base and piping connections.
3. The pumps, motors and VFDs will be delivered to temporary storage while waiting for completion of the NEWPCC Site preparation.

4. When the Contract Administrator anticipates the Installing Contractor will be ready for receiving equipment, the Contract Administrator will notify the Contractor that one pump and motor assembly is to be delivered.
5. The Installing Contractor will pick up the equipment from the temporary storage location, deliver it to the NEWPCC Site and unload.
6. Installing Contractor will install the new pump and motor in the location that has been prepared for its installation.
7. The new pump, motor and VFD will be inspected for conformance to the specifications.
8. The new pump and motor will be commissioned and started up with manufacturers' support in accordance these specifications.
9. All required operations and maintenance manuals and training is to be provided prior to operation by the City. Upon certification of successful start-up and operation, work on replacement of the second pump and motor will commence.
10. A similar sequence will be carried out for the second pump, motor and VFD assembly.
11. After installation, a functional test will be performed to confirm operational performance.

1.03 PROJECT MEETINGS

- A. Contract Administrator will schedule meetings throughout duration of the Work, prepare meeting agendas, preside at meetings, take notes of significant proceedings and decisions, and distribute minutes within 5 working days after each meeting to attendees and parties in attendance and affected by meeting decisions.
- B. Contractor's representative(s) to participate in key project meetings, either in person or by conference call, dealing with design, manufacture, supply, delivery, installation, testing, coordination and performance issues. Meetings will be scheduled monthly, or at key milestones, and will include:
 1. Pre-Construction
 2. Regular Progress Meetings
 - a. Contractor shall be prepared to discuss contractual issues, including schedule, shop drawings, technical issues, performance, Site activities, testing, and all other contractual matters.
 3. Factory Test Meetings
 3. Coordination Meetings with the Installation Contractor
 4. Installation, Site Test, Training Meetings
 5. Special Meetings as called by the Contract Administrator

1.04 SCHEDULES

A. Schedule Submissions:

1. Submit Schedule within time specified in Supplemental Conditions.
2. Scheduled tasks and deliverables shall be in accordance with the requirements specified in the Supplemental Conditions.
3. In addition to requirements of the Supplemental Conditions, provide a Shop Drawing and Sample submittals schedule incorporating the review and processing times identified herein.

B. Progress Reporting

1. Provide monthly progress updates.
2. Submit Notice of Schedule Impact at any time that a Progress Schedule activity is delayed by 5 or more days.
3. Contract Administrator will review progress updates as information.
4. Contract Administrator's review shall not be interpreted as acceptance. Contractor retains responsibility for performing all activities, for task durations, and for task sequences in accordance with the Contract Documents and approved schedules.

C. Schedule Change

1. The Contract Administrator shall determine whether a Change in Work related to the Contract Time or Completion Dates is warranted and whether a corresponding change to the schedule and date for Substantial and Total Performance is required.
2. If a change is approved, the Contractor shall revise the Schedule in accordance with Contract Administrator's formal decision.
4. Update and submit work schedule within 5 days of receiving Contract Administrator's approval of a schedule change.

1.05 SUBMITTAL PROCEDURES

A. Direct all submittals to Contract Administrator, unless specified otherwise.

B. Transmittal of Submittal:

1. Review each submittal and check for compliance with Contract Documents.
2. Stamp each submittal with uniform approval stamp before submitting to Contract Administrator.
 - a. Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with Contract Documents.

- b. Contract Administrator will not review submittals that do not bear Contractor's approval stamp and will return them without action.
- c. Contract Administrator will not review submittals received directly from a Manufacturer, Subcontractor or Supplier and will return them without action.
3. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal form attached at end of this section or in format approved by Contract Administrator.
4. 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 Contract Administrator's project number.
 - d. Date of transmittal.
 - e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
5. Identify and describe each deviation or variation from Contract Documents.

C. 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 labelled tab dividers in orderly manner.

D. Timeliness: Schedule and submit in accordance with schedule of Shop Drawing and Sample submittals, and requirements of individual Specification sections.

E. 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, or if unresolved submit a status update, to Contractor not later than 15 days after receipt, unless otherwise specified. Contract Administrator will endeavour to act upon submittals in accordance with work schedules and contractor identified priorities.
3. Resubmittals will be subject to same review time.

4. No adjustment of Contract Times or Price will be allowed due to delays in progress of Work caused by rejection and subsequent resubmittals.
5. Allow additional review time for complex equipment and systems.

F. Resubmittals: Clearly identify each correction or change made.

G. 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.
 - c. Insufficient number of copies.

H. Submittals not required by Contract Documents:

1. Will not be reviewed and will be returned stamped "Not Subject to Review."
2. Contract Administrator will keep one copy and return all remaining copies to Contractor.

1.06

ACTION SUBMITTALS

A. Prepare and submit Action Submittals required by individual Specification sections.

B. Shop Drawings:

1. Provide a schedule of Shop Drawing delivery in an orderly sequence, in conformance with the Schedule. Allow for Processing Time as stipulated herein, or as otherwise approved by the Contract Administrator.
2. Shop Drawing submission and review by Contract Administrator is to ascertain general conformance to the design intent, and in no way relieves the Contractor of full responsibility for the design content of that portion of the work, or the quality, operation and performance of the Work.
3. Shop Drawings include dimensioned line drawings and related specifications, information and literature for custom fabricated articles and equipment and catalogue drawings.
4. Catalogue Drawings include reprints of catalogue drawings of proprietary articles of standard fabrication and manufacture for the work.
5. Include data sheets for all instruments.

6. Shop Drawing submissions containing design information shall include the seal of a qualified Professional Engineer registered or licensed in the Province of Manitoba.
 7. Copies: Six hard copies and an electronic file in the current version of AutoCAD, or with one reproducible copy, except copyrighted documents, or as otherwise directed by Contract Administrator
 8. 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.
 9. 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.
 10. Product Data: Provide as specified in individual Specifications.
 11. 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.
 12. Units: Submit all Shop Drawings in SI metric units.
- 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.
- D. Action Submittal Dispositions: Contract Administrator will review, mark, and stamp as appropriate, and distribute marked up copies as noted:

1. No Exceptions Taken:
 - a. Contractor may incorporate product(s) or implement Work covered by submittal.
 - b. Distribution:
 - 1) One copy furnished Owner.
 - 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 Taken:
 - 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 Owner.
 - 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 Taken, Resubmit Missing Components:
 - a. Make corrections or obtain missing portions, and resubmit.
 - b. Except for portions indicated, Contractor may begin to incorporate product(s) or implement Work covered by submittal, in accordance with Contract Administrator's notations.
 - c. Distribution:
 - 1) One copy furnished Owner.
 - 2) One copy furnished Resident Project Representative.
 - 3) One copy retained in Contract Administrator's file.
 - 4) Remaining copies returned to Contractor appropriately annotated.
4. Exceptions Taken, Resubmit:
 - a. Contractor may not incorporate product(s) or implement Work covered by submittal.
 - b. Distribution:
 - 1) One copy furnished Resident Project Representative.
 - 2) One copy retained in Contract Administrator's file.
 - 3) Remaining copies returned to Contractor appropriately annotated.

1.07 INFORMATIONAL SUBMITTALS

A. General:

1. Copies: Submit three copies, unless otherwise indicated in individual Specification section, or directed by Contract Administrator.
2. Refer to individual Specification sections for specific submittal requirements.

3. Contract Administrator will review each submittal. If submittal meets conditions of the Contract, Contract Administrator will forward copies to appropriate parties. If Contract Administrator determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Contract Administrator will retain one copy and return remaining copies with review comments to Contractor, and require that submittal be corrected and resubmitted.

1.08 OPERATION AND MAINTENANCE (O&M) DATA

A. Manual Format and Scheduling:

1. Preliminary Data:
 - a. Format: Instructional Manual:
 - 1) Binder 1: Operations
 - 2) Binder 2: Mechanical Maintenance
 - 3) Binder 3: Electrical and Instrumentation
 - b. Submit subsequent to Contract Administrator approval of Shop Drawings, but prior to shipment date.
 - c. Submit two (2) hard copies and two (2) compact disks containing electronic PDF files for Contract Administrator's review.
 - 1) Electronic CD Manual to contain the same information as the hard copy manual as a minimum, but may also include additional reference material.
 - 2) If data does not meet conditions of the Contract:
 - a) All copies will be returned to Contractor with Contract Administrator's comments (on separate document) for revision.
 - b) Resubmit same number of copies, revised in accordance with Contract Administrator's comments.
2. Final Data:
 - a. Submit prior to the shipment of Goods.
 - b. Format: Instructional Manual Electronic Media.
 - c. Data: Submit six (6) hard copies of each Binder and six (6) compact disk electronic copies.

B. Instructional Manual Format:

1. Binder: Commercial quality, permanent, three ring or three post binders with durable plastic cover.
2. Size: 8-1/2 inches by 11 inches, minimum.
3. Cover: Identify manual with typed or printed title for each binder and list:
 - a. Project title.
 - b. Designate applicable system, equipment, material, or finish.
 - c. Identity of separate structure as applicable.
 - d. Identity of general subject matter covered in manual.
4. Title Page:

- a. Contractor's name, address, and telephone number.
 - b. Subcontractor, supplier, or maintenance contractor's name, address, and telephone number, as appropriate.
 - 1) Identify area of responsibility of each.
 - 2) Provide name and telephone number of local source of supply for parts and replacement.
5. Table of Contents:
- a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
 - b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
6. Paper: 20-pound minimum, white for typed pages.
7. Text: Manufacturer's printed data, or neatly typewritten.
8. Three hole punch data for binding and composition; arrange printing so that punched holes do not obliterate data.
9. Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.

C. Electronic Media Format:

1. Organize into logical Portable Document Format (PDF), arranged into a directory structure that is similar to the binder hard copies. Organize in a manner to make it easy to find documents from the Table of Contents.
 - a. Files to be exact duplicates of Contract Administrator accepted preliminary data. Arrange by specification number and name.
2. Provide PDF documents in native, searchable format rather than scanned documents.
 - a. Files to be fully functional and viewable in most recent version of Adobe Acrobat.
3. Where comments are required in the manuals to clarify applicable equipment, utilize electronic editing of the PDF files rather than scanning of handwriting comments.
4. Where documents have no electronic origin and must be scanned, they shall be provided at sufficient resolution to prevent distortion.
5. A computer generated paper label shall be affixed to each CD, containing the following information:
 - a. City of Winnipeg Bid Opportunity/Contract Name/Contract Number
 - b. Contractor's project number
 - c. City of Winnipeg Water and Waste Department's project number
 - d. Consulting Engineer's project number
 - e. Title "Operating and Maintenance Instructions"
 - f. Text describing any other documents, presentations, videos, or any other related files included on the CD.
6. Each CD shall be placed in a plastic slim jewel case (not a paper sleeve). The jewel case shall be placed in a CD/DVD three-hole

punched and acid-free, and archival-safe translucent polypropylene storage page for storage in a standard three-ring binder. Each storage page shall have storage for up to four (4) CDs on each page (two on each side). Provide a secure top flap to keep the CDs snug in each pocket and provide a special liner that protects each CD against scratches. The storage page with each CD shall be bound with each paper copy of the manual (one CD per manual).

D. Data Content:

1. Product Data:
 - a. Include only those sheets that are pertinent to specific product.
 - b. Clearly annotate each sheet to:
 - 1) Identify specific product or part installed.
 - 2) Identify data applicable to installation.
 - 3) Delete references to inapplicable information.
 - c. Function, normal operating characteristics, and limiting conditions
 - d. Performance curves, engineering data, nameplate data, and tests.
 - e. Complete nomenclature and commercial number of replaceable parts.
 - f. 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.
 - g. Spare parts ordering instructions.
 - h. Where applicable, identify installed spares and other provisions for future work (e.g., reserved panel space, unused components, wiring, terminals).
1. Color-coded piping diagrams.
2. 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.
3. 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 City's Operating and Maintenance 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 required.
 - 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.
- E. Content for each pump/motor/VFD assembly is to be divided into separate Operations, Mechanical and Electrical binders:
1. Description of Unit and Component Parts:
 - a. Function, normal operating characteristics, and limiting conditions.
 - b. Performance curves, engineering data, nameplate data, and tests.
 2. Operating Procedures:
 - a. Routine and normal operating instructions.
 - b. Sequences required.
 - c. Safety precautions.
 - d. Special operating instructions.
 3. Maintenance Procedures:
 - a. Routine maintenance.
 - b. Guide to troubleshooting.
 - c. Adjustment and checking.
 - d. List of relay settings, control and alarm contact settings.
 4. Manufacturer's printed operating and maintenance instructions.
 5. List of original manufacturer's spare parts, manufacturer's current prices, and recommended quantities to be maintained in storage.
- F. Maintenance Summary:
1. Compile individual Maintenance Summary for each applicable 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.
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.

1.09 SUPPLEMENTS

A. The Supplements listed below, following "End of Section", are part of this Specification:

1. Transmittal of Contractor's Submittal Form (Section 1.05B3).
2. Maintenance Summary Form (Section 1.08F.2(a)).

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION (NOT USED)

END OF SECTION



TRANSMITTAL OF CONTRACTOR'S SUBMITTAL
 (ATTACH TO EACH SUBMITTAL)

CH2MHILL

DATE: _____

TO: _____

Submittal No.: _____
 New Submittal Resubmittal
 Project: _____
 Project No.: _____
 Specification Section No.: _____
**(Cover only one section with each
 transmittal)**

FROM: _____
 Contractor

Schedule Date of Submittal:

SUBMITTAL TYPE: Shop Drawing Sample 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)

MAINTENANCE SUMMARY FORM

PROJECT: _____ CONTRACT NO.: _____

1. ITEM _____

2. MANUFACTURER _____

3. TAG NUMBER(S) _____

4. WEIGHT OF INDIVIDUAL COMPONENTS (OVER 100 POUNDS) _____

5. NAMEPLATE DATA (hp, voltage, speed, etc.) _____

6. CONTRACTOR'S LOCAL REPRESENTATIVE _____

a. Name _____ Telephone No. _____

b. Address _____

7. MAINTENANCE REQUIREMENTS

Maintenance Operation Comments	Frequency	Lubricant (If Applicable)
List briefly each maintenance operation required and refer to specific information in manufacturer's standard maintenance manual, if applicable. (Reference to manufacturer's catalog or sales literature is not acceptable.)	List required frequency of each maintenance operation.	Refer by symbol to lubricant required.

SECTION 01600 MATERIAL AND EQUIPMENT

PART 1 GENERAL

1.01 DEFINITIONS

A. Products:

1. New items for incorporation in the Work, whether purchased by Contractor or Owner 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.

1.02 DESIGN REQUIREMENTS

- ##### **A. Products are to be manufactured, fabricated and supplied in accordance with the specifications and as noted herein.**
- ##### **B. Be responsible for designing seismic attachments, braces, anchors to the structure, and anchors to bases for elements of architectural, mechanical, process, and electrical systems included in the Work in accordance with this Section unless a design is specifically provided within the Contract Documents. Seismic attachments, braces and anchors shall be designed by a qualified professional engineer licensed in the Province of Manitoba.**
- ##### **C. Provide systems, equipment, and components, including supports and anchorages, in accordance with provisions of latest edition of the Manitoba Building Code and National Building Code of Canada.**
1. Importance Category: high
 2. Wind:
 - a. 1 in 50 year hourly pressure of 0.45 kPa.
 - b. Importance factor for wind loads of 1.15.
 3. Snow Load:
 - a. 1 in 50 year ground snow loading of 1.9 kPa.
 - b. 1 in 50 year associated rain loading of 0.2 kPa.
 - c. Importance factor for snow loads of 1.15.

4. Seismic:
 - a. No analysis required.
 - i. According to “Manitoba Building Code Amendment, regulation 4/2008”, registered January 11, 2008, the value of S(0.2) in Manitoba is deemed to be zero. Per National building Code 2010 sentence 4.1.8.1 1), deflection and loading due to earthquake need not be considered if S(0.2) less than 0.12.

1.03 ENVIRONMENTAL REQUIREMENTS

- A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at 220 m above sea level.

1.04 PREPARATION FOR SHIPMENT

- A. When practical, factory assembled 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.
 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. Notify Contract Administrator upon arrival for transfer of materials.
 6. Replace extra materials and special tools found to be damaged or otherwise inoperable.

- D. Where specified, factory test results shall be reviewed and accepted by Contract Administrator before Goods are shipped.
- E. When practical, Goods shall be factory assembled. When impractical:
 - 1. Furnish assembly instructions.
 - 2. Mark or tag the separate parts and assemblies for field assembly.
 - 3. Cover machined and unpainted parts that may be damaged by elements with a strippable protective coating.
- F. Marking: 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.
- G. Spare Parts and Special Tools:
 - 1. Deliver at same time as Goods delivery.
 - 2. Mark to identify associated products by name, equipment, and part number.
 - 3. Package parts for protection against damage from elements during shipping, handling, and storage.
 - 4. Ship in boxes or containers marked to indicate contents and as stated above.
- H. Accessories:
 - 1. Deliver at same time as Goods delivery.
 - 2. Furnish accessories required to place each item of equipment in full operation.
 - 3. Accessories include, but are not limited to, adequate oil and grease as required for first lubrication of equipment (after field testing), special tools, and other items as required for initial operation.

1.05 NOTIFICATION OF SHIPMENT

- A. Provide Notice of Shipment of Goods to Contract Administrator for confirmation of Goods being shipped, manner of shipment and dates, using Contractor's Notice of Shipment of Goods form found at the end of this Section.
- B. Notification for shipment of Goods to be provided for major shipments to and from each factory, as well as final shipment to temporary storage and final destination.

1.06 DELIVERY STORAGE AND INSPECTION

- A. Deliver all products FOB, to temporary storage:

1. Contractor is responsible for arranging and paying for temporary storage location (s) for the equipment, unless authorized otherwise by the Contract Administrator.
2. 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/or CSA labels on products so specified.
3. 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.
4. Delivery of Goods shall be made during regular daytime working hours, Monday through Friday, 8:30am to 3:00pm, unless other arrangements have been made previously.
5. Inspection on Delivery:
 - a. Contractor to record delivery of products and inspect for completeness and evidence of damage during shipment, remove damaged products.
 - b. Upon notification by Contractor of the equipment delivery, Contract Administrator will inspect for completeness and evidence of damage during shipment.
 - c. Should there appear to be incomplete shipment or damage, Contract Administrator will immediately inform the Contractor.
 - d. Damaged or incomplete Goods to be returned for replacement and will not be unloaded, except as necessary to expedite return shipment.
6. Contractor shall expedite replacement of damaged, incomplete, or lost items

1.07 TEMPORARY STORAGE, AND PROTECTION

- A. Contractor shall arrange for temporary storage for all goods and equipment, except as may be otherwise approved under the Contract.
 1. Storage location must:
 - a. Be located in Manitoba, within 250 km of the NEWPCC.
 - b. Meet the storage conditions as specified by the equipment manufacturers. The equipment will have differing minimum storage requirements and may be stored at separate locations.
 2. At least 30 days prior to delivery Contractor to notify Contract Administrator of storage location and arrange for an inspection of the proposed storage location.

- C. Make periodic inspections of stored Goods and products to assure that they are maintained under specified conditions, and free from adverse conditions, damage or deterioration.
 1. 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, maintain and monitor continuous operation of all space heaters furnished for electrical equipment.
 2. store fabricated products above ground on blocking or skids, and prevent soiling or staining. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.
 3. store finished products that are ready for installation in dry and well ventilated areas. Do not subject to extreme changes in temperature or humidity.
 4. Hazardous Materials: Prevent contamination of personnel, storage building, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

1.08 FINAL DELIVERY TO SITE

- A. Final delivery to NEWPCC Site will be by the Installing Contractor.
 1. Goods and products will be delivered to the NEWPCC location:
City of Winnipeg
2230 Main Street
Winnipeg, MB
 2. Delivery of the pump, motor and VFDs to Site will not be permitted until the Site is ready and delivery has been approved by the Contract Administrator.
 3. Contract Administrator will notify the Contractor of a planned date for pickup from temporary storage and turnover to the Installing Contractor based on Site conditions and availability of the Installing Contractor. If the planned date of pickup is later than the specified delivery date, the Contractor shall be responsible, in accordance with the specifications, for:
 - a. extended storage,
 - b. protection of the equipment while in storage
 - c. extended maintenance,
 - d. extension to the schedule for services, and
 - e. extension of the warranty period.
 4. Installation Contractor to carry out an inspection of the pumps, motors and VFDs at the temporary storage Site prior to acceptance and turnover.

5. Inspection on Delivery:
 - a. Contractor to attend the NEWPCC Site upon delivery and inspect Goods for completeness and damage during shipment, notify Contract Administrator of loss or damages.
 - b. Should there appear to be incomplete shipment or damage, Contract Administrator will immediately inform the Installing Contractor.
 - c. Damaged or incomplete Goods will not be unloaded, except as necessary to expedite return shipment.
 - d. Contractor shall assist Installing Contractor to expedite replacement of damaged, incomplete, or lost items.
6. After acceptance by inspecting party, pump, motor and VFD assemblies will be unloaded by Installing Contractor in accordance with manufacturer's instructions, or as otherwise approved by the Contract Administrator.
7. Contractor to provide instructions on any special lifting or unloading requirements in accordance with manufacturer's written instructions and in a manner to prevent damage.
8. Provide Contract Administrator with a Certificate of Equipment Delivery form, as provided at the end of this Section, upon final delivery to the NEWPCC Site.

PART 2 PRODUCTS

2.01 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. 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 provincial and local health and safety regulations.

- F. Regulatory Requirement: Coating materials shall meet federal, provincial, and local requirements limiting the emission of volatile organic compounds and for worker exposure.
- G. Safety Guards: Provide for all 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. Eliminate sharp edges with suitable borders neatly welded.
- H. Special Tools and Accessories: Furnish to Owner, upon acceptance of equipment, all accessories required to place each item of equipment in full operation.
- I. Lubricants:
 - 1. Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, start-up, and operation until final acceptance.
 - 2. Provide Canadian made lubricants readily available in Canada. To the extent possible, provide lubricants compatible with products currently used in Owner's maintenance operations.
 - 3. Furnish lubricants in original sealed containers, correctly identified as to brand and grade.
- J. 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. Pumps, Motors and VFDs: As per specification sections.
 - 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.
- K. Bolted Connections: Project bolt ends minimum of one-half bolt diameter, but not more than one bolt diameter beyond nut faces.
- L. Flanges: Arrange with bolt holes straddling vertical centreline. Provide flanges finished in accordance with MSS SP-6 2007.

- M. Bearings: Unless otherwise specified, provide bearings for rotating equipment suitable for ABMA B-10 life expectancy of minimum 100,000 working hours, without the addition of external cooling, at rated conditions of service.

2.02 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 for anticipated shock and vibratory loads.
4. Use 6 mm minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
5. 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 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. Provide 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. Provide 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 stainless steel drain piping to building drainage system.

2.03 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

3.01 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.

3.02 INSTALLATION

N/A

3.03 ADJUSTMENT AND CLEANING

N/A

3.04 LUBRICANTS

N/A

3.05 SUPPLEMENTS

- A. The Supplements listed below, following "End of Section", are part of this Specification:
 - 1. Contractor's Notice of Shipment of Goods (Section 1.05A)
 - 2. Contractor's Certificate of Equipment Delivery (Section 1.08A8)

END OF SECTION

CONTRACTOR'S NOTICE OF SHIPMENT OF GOODS

Delivery of this notice should be either via fax, email or overnight mail.

TO: _____

ATTENTION: _____

ADDRESS: _____

FAX NO.: _____

RE: Contract No.: _____

Name of Contract: _____

Goods to be Shipped: _____

ATTACH BILL(S) OF LADING FOR ALL SHIPMENTS TO THIS FORM.

Date of Shipment: _____

Manner of Shipment/Name of Carrier: _____

Anticipated Date of Delivery: _____

Special Equipment or Services Required for Unloading/Storage: _____

CONTRACTOR:

Name: _____

Address: _____

City: _____ State: _____ Zip: _____ Telephone: _____

By (Name/Title): _____ Date: _____

CERTIFICATE OF EQUIPMENT DELIVERY

FORM 100

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: _____

Equip. Description _____

Equipment Supply Bid Op # _____

Equipment Install Bid Op # _____

Equipment Tag No. _____

Specification Reference: _____

(Authorized representative of Contractor)

Date _____

(Authorized representative of subcontractor)

Date _____

(Authorized representative of Contract Administrator)

Date _____

SECTION 01701 SPECIAL SERVICES

PART 1 GENERAL

1.01 DEFINITIONS

- A. **Functional Testing:** Tests carried out to demonstrate that installed Goods function as specified and operate in the manner intended.
- B. **Manufacturer's Representative:** A trained service person working for and empowered by the manufacturer to provide installation, testing and commissioning advice, assistance and approval and authorizations in all matters related to the Manufacturer's products.
- C. **Person-Day:** One person for 8 hours within regular Contractor working hours. Where reference to person-day is for attendance at the Site, all travel time and expenses is assumed to be included, and duly compensated for.

1.02 SUBMITTALS

- A. **Informational Submittals:**
 - 1. **Training Schedule:** Submit not less than 40 days prior to start of equipment installation and revise as necessary for acceptance.
 - 2. **Lesson Plan:** Submit proposed lesson plan not less than 40 days prior to scheduled training and revise as necessary for acceptance.
 - 3. **Training Session CD's:** Furnish Owner with two complete sets of video CD's fully indexed and catalogued with printed label stating session and date taped.

1.03 MANUFACTURER'S REPRESENTATIVE

- A. Where Special Services are specified, Contractor shall furnish a qualified representative of each manufacturer.
- B. Each of the major equipment suppliers, including pumps, motors and VFDs shall identify at least one manufacturer's representative.
- C. If manufacturer's representative is found deficient in training or experience by Contract Administrator, furnish replacement representative after acceptance of resume and other qualification documentation of proposed representative.
- D. Authorized representative of the manufacturer shall be 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.

- E. Representative subject to acceptance by Contract Administrator. No substitute representatives will be allowed unless prior written approval by such has been given.

1.04 INSTALLATION ASSISTANCE

- A. Contractor will provide advice to the Installing Contractor as required during the installation.
- B. Contractor shall attend the Site and inspect the installation prior to operation of the equipment, and provide notification to the Contract Administrator of satisfactory installation.
- C. Provide Contract Administrator with a Certificate of Readiness to Install form for each piece of equipment, as provided at the end of this Section, once the Contactor and Manufacturer's Representatives consider the Site to be ready for equipment installation.

1.05 MANUFACTURER'S CERTIFICATE OF SATISFACTORY INSTALLATION

- A. When so specified, a Manufacturer's Certificate of Satisfactory Installation form, a copy of which is attached to this section, shall be completed and signed by Contractor's representative.
- B. Such form shall certify signing party is a duly authorized representative of Contractor, is empowered by Contractor to inspect, approve, and operate their Goods and is authorized to make recommendations required to ensure that the Goods are complete and operational.

1.06 COMMISSIONING ASSISTANCE

- A. Start-up Assistance: Where specified, furnish representative to assist Installing Contractor with start-up and trouble shooting of furnished Goods:
 - 1. Contractor's representative shall be present during prestart-up meetings.
 - 2. Furnish labour and materials, tools, instruments, and services for checking, testing, and start-up services specified.
 - 3. Develop a standard record of testing. This record shall:
 - a. Be subject to approval of Contract Administrator;
 - b. Include name of Goods and subsystem, if applicable;
 - c. Have provisions for recording dates of completion for checking, inspection by manufacturer, verification of instrumentation and controls, and completion of subsystem tests; and allow space for

describing problems remaining with Goods, and for signature of Contract Administrator indicating acceptance.

1.07 FUNCTIONAL TESTING

- A. A functional test will be performed on each of the installed equipment assemblies, including the pumps, motors and variable frequency drives.
- B. Contractor shall assist in performing functional (or run) testing. Furnish representative to assist with test and necessary adjustments.
- C. General intent of the test is to confirm successful operation of the equipment under various operating conditions. A test protocol will be provided by the Contract Administrator which will include (but not be limited to) testing under the following conditions:
 - 1. Duty Point
 - 2. Low Speed
 - 3. Low Wet Well
 - 4. High Wet Well
 - 5. High Flow (multiple pumps running)
- D. Functional Testing will be for the purpose of confirming successful operation and is not intended to be used for efficiency measurement, and is independent of the specified factory testing.
- E. After the Contractor is satisfied that the equipment meets the functional test requirements, submit the functional test results and a Certificate of Successful Operation, found at the end of this section, to the Contract Administrator for review.

1.08 DEMONSTRATION AND TRAINING

- A. Where specified, furnish Contractor's representative to instruct City's personnel in proper operation and maintenance techniques for the furnished Goods:
- B. Training services may include classroom or on-site instruction, either prestart-up or post start-up, as stated in the Specifications.
- C. Prestart-up Training: shall be completed at least 14 days prior to actual start-up.
- D. Operation and Maintenance Data shall be reviewed and accepted before initiation of prestart-up training.
- E. Post Start-up Training: Furnish and coordinate specified manufacturers' services and Contractor's personnel for post-start-up training of Owner's personnel.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 FULFILLMENT OF SPECIFIED MINIMUM SERVICES

- A. Furnish 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, manufacturer's onsite services shall include:
 - 1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
 - 2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
 - 3. Providing, on a daily basis, copies of all Manufacturers' Representatives field notes and data to the Contract Administrator.
 - 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 functional testing, and facility start-up and evaluation.
 - 7. Training of Owner's personnel in the operation and maintenance of respective product as required.
 - 8. Additional requirements may be specified elsewhere.

3.02 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.

3.03 TRAINING

A. General:

- 1. Furnish manufacturers' representatives for detailed classroom and hands-on training to City's personnel on operation and maintenance of specified product (system, subsystem, component) and as may be required in applicable Specifications.
- 2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Section 01301, Administrative Requirements.
- 3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
- 4. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

B. Training Schedule:

- 1. List specified equipment and systems that require training services and show:
 - a. Respective manufacturer.
 - b. Estimated dates for installation completion.
 - c. Estimated training dates.
- 2. Allow for multiple sessions when several shifts are involved.
- 3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Owner, and to allow full participation by manufacturers' representatives. Adjust schedule for interruptions in operability of equipment.

C. Lesson Plan: When manufacturer or vendor training of Owner personnel is specified, prepare for each required course, containing the following minimum information:

- 1. Title and objectives.
- 2. Recommended types of attendees (e.g., managers, Engineers, operators, maintenance).

3. Course description and outline of course content.
4. Format (e.g., lecture, self-study, demonstration, hands-on).
5. Instruction materials and equipment requirements.
6. Resumes of instructors providing the training.

- D. Post start-up Training: If required in Specifications, furnish and coordinate training of Owner's operating personnel by respective manufacturer's representatives.
- E. Videotape Recordings: The City reserves the right to videotape the training sessions and edit and utilize product information and training material to augment the tapes for use in subsequent internal training sessions.

3.04 MANUFACTURER'S SERVICES

- A. Contractor to coordinate manufacturer's services with Contract Administrator, in accordance with specifications. Combine equipment training sessions where practical to minimize number of sessions.
- B. All services to be provided at Site.
- C. Allow for a minimum of Manufacturer's Representatives time as follows (person-days excluding travel time):
1. Three (3) person-day for advice during installation, installation inspection and completion of Manufacturer's Certificate of Satisfactory Installation (four trips to Site at 0.5 each).
 2. Two (2) person-days for Functional Testing (one test period).
 3. Classroom and hands-on training as required in the specifications, Allow for two separate sessions to accommodate shifts, number of days and trips to be identified by Contractor.

3.05 SUPPLEMENTS

- A. The supplements listed below, following "End of Section", are part of this Specification.
1. Forms: Certificate of Readiness to Install (Section 1.04C).
 2. Forms: Certificate of Satisfactory Installation (Section 1.05A).
 3. Forms: Certificate of Satisfactory Performance (Section 1.07E)

END OF SECTION

Form 101

CERTIFICATE OF READINESS TO INSTALL

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

Project: _____

Equip. Description _____

Equipment Supply Bid Op # _____

Equipment Install Bid Op # _____

Equipment Tag No. _____

Specification Reference: _____

(Authorized representative of Manufacturer) Date _____

(Authorized representative of subcontractor) Date _____

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

(Authorized representative of Contractor) Date _____

Form 102

CERTIFICATE OF PROPER 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: _____

Equip. Description _____

Equipment Supply Bid Op # _____

Equipment Install Bid Op # _____

Equipment Tag No. _____

Specification Reference: _____

Outstanding Defects: _____

_____ Date _____
(Authorized representative of Manufacturer)

_____ Date _____
(Authorized representative of Contractor)

Form 103

CERTIFICATE OF SATISFACTORY PERFORMANCE

We certify that the equipment listed below has been tested and complies with the Functional Test requirements and has been continuously operated for a minimum of three (3) consecutive days and that the equipment operates satisfactorily and meets its specified operating criteria. No defects in the equipment were found and as such is classified as "conforming".

Project: _____

Equip. Description _____

Equipment Supply Bid Op # _____

Equipment Install Bid Op # _____

Equipment Tag No. _____

Specification Reference: _____

(Authorized representative of Manufacturer) Date _____

(Authorized representative of Contractor) Date _____

(Authorized representative of subcontractor) Date _____

(Authorized representative of Contract Administrator) Date _____

Acknowledgement of receipt of O&M Manuals

(Authorized representative of City) Date _____

SECTION 11312 HORIZONTAL END SUCTION CENTRIFUGAL PUMPS

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

- A. This Section covers the work necessary for the design, fabrication, supply, testing and delivery, complete, of two (2) new Horizontal Raw Sewage Pumps. The Works include equipment analysis and all necessary appurtenances and services during fabrication. The Contractor shall also be responsible for product shipment, handling, storage, and protection of all equipment.
- B. Each pump, motor and VFD combination will be considered as a pumping assembly or unit, and tested and delivered together.
- C. The Contractor shall assume “single source” responsibility for the satisfactory operation of the pump, motor and VFD units.
- D. New pumps will be referred to as:
 - 1. P-M140 (formerly M140-RSP and MP-4)
 - 2. P-M150 (formerly M150-RSP and MP-5)

1.02 REFERENCES

- A. Relevant standards and other publications of the organizations listed below form a part of this specification within the indicated subject areas. The applicable issue shall be the one in effect at the time of the invitation to bid:
 - 1. Canadian Standards Association (CSA)
 - 2. American Water Works Association (AWWA)
 - 3. American Gear Manufacturer’s Association (AGMA)
 - 4. American Iron and Steel Institute (AISI)
 - 5. American Society for Testing and Materials (ASTM)
 - 6. Hydraulic Institute Standards (ANSI/HIS), Centrifugal/Vertical General Pump Standards Latest Version.
 - 7. American Society of Mechanical Engineers (ASME)
 - 8. America Bearing Manufacturers Association (ABMA)
 - 9. The Society for Protective Coatings (SSPC)
 - 10. Institute of Electrical and Electronics Engineers (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
 - 11. Manitoba Building Code / National Building Code of Canada (NBCC)
 - 12. ISO 10816-3, 1998; Mechanical vibration-Evaluation of Machine Vibration by Measurements on Non-Rotating Parts

1.03 DEFINITIONS

- A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.04 SUBMITTALS

A. General:

1. Submittals shall be furnished in accordance with Section 01301, Administrative Requirements.

B. Shop Drawings, Samples and Technical Data:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalogue information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data curves showing head, capacity, horsepower demand, NPSH required and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the duty point.
4. The Manufacturer shall indicate the limits on the performance curves recommended for stable operation without surge, cavitation, or excessive vibration. The stable operating range shall be as wide as possible based on actual hydraulic and mechanical tests.
5. Detailed structural, mechanical, and electrical drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment including shaft, mechanical seals, couplings, bearings, anchor bolt plan and template, part nomenclature, material list, outline dimensions, and shipping weights. Template is to include baseplate drawings with levelling jackscrew details, anchor bolt and sleeve details, and minimum foundation installation and levelling requirements.
6. Detailed design and dimensional information for the custom made transition piece from the suction valves to the pump suction flange.
7. The anticipated maximum maintenance weights for shafts, impellers, couplings, and removable casing or housing elements.
8. Paint Finish data include:
 - 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.
 - c. Samples: Furnish additional samples as required until materials, colours and finishes are approved.

9. Specifications for all shop surface preparation, priming and finish coating systems.
10. Pump-motor speed torque curve.
11. Contractor's certification of suitability to meet specified conditions.
12. RTD termination box dimensions, location on pump, and wiring.
13. Schematic wiring diagram for instrumentation devices such as resistance temperature detectors and vibration sensors.
14. Instrumentation datasheets, including but not limited to vibration transducers and RTDs.

C. Quality Control Submittals:

1. Manufacturer's Certification of Compliance that the paint finish system is identical to the requirements specified herein.
2. Manufacturer's Certification: Material Test Certificates, Mill certificates of all materials used in the construction of the pumps.
3. Factory Test Data: Factory Test Reports and Log. Signed, dated, and certified factory test data for each pump.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer's printed installation instructions.
6. Certification of proper installation.
7. List special tools, materials, and supplies furnished with equipment for checking, testing, parts replacement, and maintenance for use prior to and during start-up and for future maintenance.
8. Operation and Maintenance Manual.

1.05 EXTRA MATERIALS

A. Furnish one of each of the following extra pump parts:

1. Complete set bearings.
2. Complete set of gaskets and O-ring seals.
3. Complete set of shaft sleeves.
4. Complete set keys, dowels, pins, etc.
5. Complete mechanical seal.
6. Impeller.
7. Impeller shaft.
8. Impeller wear ring.
9. Casing wear ring.
10. Complete set of any special tools required to dismantle pump.

B. Furnish for each pump assembly:

1. Complete set of anchor bolts
2. Custom designed suction transition from existing knife gate valve to pump suction.

PART 2 PRODUCTS

2.01 GENERAL

- A. Pumps shall be of a standard and industry proven design, designed and sized for the full range of operating duties and conditions specified.
- B. Contractor to coordinate pump requirements with motor and VFD manufacturer and be responsible for the equipment as an assembly.
- C. The pump and motor assembly along with appurtenances must meet physical size limitations for each of the wet wells. The suction valves are not to be replaced and are to be considered fixed points for the installation. The pump and motor when connected to the existing valves must provide for:
 - 1. A clear space of at least 536 mm between the motor and the dry well structure, as predetermined for the Approved Products.
 - 2. The ability to slide the motor laterally or towards the pump for its vertical removal, and the pump laterally or towards the motor for removal without having to remove the other mated equipment.
 - 3. Refer to Dry Well dimensional drawing for the site dimensions.
- D. Pumps, motors and VFD assemblies shall be from the same manufacturer and of the same type.
- E. Design equipment, anchorage, and support systems for vertical and lateral loading in accordance with NBCC.
- F. Approved Products:
 - 1. Flowserve pump 30MN33B.
 - 2. Requests for Substitutes will be considered in accordance with Bidding Instruction B6.

2.02 PUMP DESIGN

- A. The pump design shall consist of a single-stage, solids handling, non-clog, horizontal end suction centrifugal pump with a vertical discharge for raw sewage application. The pump shall incorporate an enclosed or semi-open impeller. See datasheets for details.
- B. Pump design is to allow for use of variable frequency drive (VFD) control of the motor and pump to the flow range indicated in these specifications.
- C. Space limitations in the existing dry wells limit the overall physical dimensions of the new pump and motor assemblies:
 - 1. Existing suction valves will remain in their current position.

HORIZONTAL END SUCTION CENTRIFUGAL PUMPS

2. Existing discharge lines are to be realigned by the Installing Contractor to fit the pumps.
3. Minimum clearance between the pump and motor assembly and the dry well wall or adjacent equipment within the dry well shall be 600 mm.

D. Installation

1. The pumping assemblies are to be installed in a dry well under a separate contract. Each of the pumps discharges into an elevated discharge well, with each of the discharge lines being independent of other pump discharge lines.
2. Contractor shall provide sizing and installation information for design of the installation and preparation of the site, including supports and connection requirements.
3. The existing pumps will be removed and the new pumps and motors will be installed by others, installation shall be inspected and certified by the Contractor prior to operation.

E. Pump Performance Requirements

1. NEWPCC System Curve is identical for MP-4 and MP-5.
2. Duty point: Each pump shall be rated for 140 ML/d (25,700 USgpm) at 18.0 meters (59 feet) TDH.
3. Variable speed control shall be capable of downturn to 80 ML/d (14,700 USgpm) on a continuous basis, as determined from the NEWPCC system curve.
4. Minimum Efficiency at the Duty Point shall be 80%
5. Pump BHP shall not exceed motor nameplate HP at 1.0 service factor at any operating point on the pump curve.
6. The NEWPCC system curve is attached as additional information.
7. Refer to additional information in Pump Data Sheet.

G. Raw sewage pumps require backspin capability (motor non-energized) in order to flush sewage through the impellor for cleaning operations. The pump shall be capable of reverse rotation at speeds up to 1.5 times the rated speed.

H. Pumps shall be capable of passing a sphere diameter of 152 mm (6").

I. Pump casing:

1. Casing shall be designed to permit removal of the rotating assembly without disturbing the suction or discharge connections.
2. Include a large bolted handhole to permit inspection and cleaning of the pump.
3. Casing shall be hydrostatically tested to 1.5 times shut off head.

4. Casing shall be cast iron conforming to ASTM A278 Class 30, with 1.5% nickel.

J. Impellers

1. Impellers shall be ASTM A278 Class 30 cast iron, machined and polished.
2. Impellers shall be secured with locking assembly and cover to prevent loosening.
3. Impellers shall be dynamically balanced.

- K. Provide removable wear Rings of unlike hardened stainless steel on the impellor and suction with wearing surfaces normal to the axis of rotation. Rings shall be fastened by recessed restraining stainless steel screws.

- L. Shafts shall be ASTM A567, GRI 045. Shaft to impellor connections shall be straight. Shaft shall be protected by a 316 stainless steel sleeve. Sleeve shall be keyed to shaft and sealed to prevent leakage between sleeve and shaft.

- M. Bearing shall conform to the standards of the America Bearing Manufacturers Association (ABMA). The bearing shall be designed to provide a minimum L-10 bearing life of 100,000 hours.

- N. The pump shall be provided with a single split mechanical seal.

1. Acceptable products:
 - a. Durametallic
 - b. John Crane
 - c. Chesterton
 - d. Approved Alternate

- O. A custom transition from the exiting 36 inch gate valves shall be provided to the new pump suctions:

1. The transition piece will form part of the overall installation and shall be designed within the constraints of the existing dry well dimensions.
2. Transition piece may be either cast iron, or epoxy coated fabricated steel.
3. Design the transition for smooth flow transition to the pump to minimize head losses.
4. Confirm all field dimensions and valve connection types prior to design and fabrication.

- P. Suction and Discharge flanges shall be ANSI 125 Flat Face type.

- Q. Motor couplings shall be metal flexible with standard guards and designed to withstand short time backspin overspeed of 150% as specified in 2.01H.

- R. Base Plate: Fabricated steel base plate with drip pot for integral mounting of pump and motor.

2.03 ELECTRICAL MOTORS

- A. See Section 16224 MEDIUM VOLTAGE INDUCTION MOTORS.

2.04 SUPPLEMENTS

- A. Refer to Section 01101 for existing Site Information.
- B. The pump installation is to be in existing dry wells in which the installation will not meet the minimum conditions recommended by the Hydraulic Institute Standards. Testing of the existing pumps was carried out with the test results as referenced in Section 01101. The Contactor is to review the report and be satisfied the selected pump will provide proper operation under these conditions.

2.05 ACCESSORIES

- A. Equipment Identification Plate: 1.6 mm stainless steel with 6 mm die-stamped equipment tag number securely mounted in a readily visible location.
- B. Lifting Lugs: Equipment weighing over 45 kg.
- C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.
- D. Vibration Sensor
 - 1. Provide one accelerometer vibration sensor on the pump bearing. Orient the sensor in a horizontal configuration.
 - 2. Vibration sensor to be of consistent type and manufacture with the motor bearing vibration sensor.
 - 3. Requirements:
 - a. Sensitivity: 100mV/g
 - b. Tolerance: +/-5%
 - c. Minimum Frequency Response: 3 Hz – 1.5 kHz, +/- 5%
 - d. Maximum Rated Temperature: at least 120°C
 - e. Stainless steel housing, hermetically sealed.
 - 4. Provide armoured cable – 10m length.
 - 5. CSA Certified.
 - 6. Mounting stud and attachment as per vibration sensor manufacturer's instructions.
 - 7. Acceptable Manufacturer/Model:
 - a. Metrix SA6200A series
 - b. Wilcoxon 786A
 - c. Or approved equal in accordance with B6.

E. RTDs:

1. 100 ohm, 3-wire, platinum, $0.00385\Omega/\Omega/^\circ\text{Cm}$ DIN EN60751, Class B, with shielded cables, pre-wired to terminal junction box.
2. Provide one RTD per bearing.
 - a. Mount detector in the most heavily loaded area of the bearing.

F. Auxiliary Terminal Boxes:

1. Provide separate box for termination of RTDs, attached to pump.
2. Wire devices to auxiliary terminal boxes and terminate on suitable terminal blocks.
3. Provide a separate terminal for termination of each individual RTD shield. Do not “common” the RTD shields.

2.06 PAINT FINISHING

- A. Submit paint and coating selection for approval prior to finishing.
- B. All material labels shall clearly state the name of the manufacturer, name and type of paint, colour and date.
- C. Apply primer within time recommended after surface preparation. Comply with SSPC-PA-1 for application techniques, requirements and precautions.
- D. Apply paint in accordance with SSPC Manual Volume 2 – “Systems and Specifications”, Chapter 5.1.
- E. Protect all coated equipment adequately against damage, dust, moisture, and scratching during shipment, off-loading and storage on-site. If, in the opinion of the Contract Administrator, the coating is damaged during shipment to the extent that touch up would not be satisfactory, return and re-coat the equipment at the Contractor's cost.

PART 3 EXECUTION

3.01 SOURCE QUALITY CONTROL

- A. The following tests shall be conducted on each pump system:
 1. Pump Systems: All pump systems shall be tested at the pump manufacturer's factory. Tests shall be performed using the complete pump system to be furnished, including the motors and VFDs to be supplied with the pumps. Testing of prototype models will not be acceptable.

B. Pumps shall be hydrostatic and performance tested in accordance with the Hydraulic Institute Standard – Latest Version. The acceptance criteria shall be per the standard with the following addendum:

1. Total head and pump efficiency shall meet the specified requirements at rated capacity and rated rpm.
2. Total head and pump efficiency shall meet the specified requirements for the specified flows.
3. An NPSH test shall be performed on the pumps. NPSH required shall be determined for the range of operation specified.
4. The following minimum tests and data shall be performed:
 - a. Hydrostatic test data: The complete pump assembly shall be hydrostatically tested at the pump manufacturer's test facility to not less than two times the pump shut-off head. The test pressure shall be maintained for the time required to conduct a complete visual inspection of the assembly and for not less than 1/2 hour. No leakage shall be permitted during the hydrostatic test and no water may be added to maintain the test pressure. Units and components failing the hydrostatic tests shall be replaced and the tests repeated until satisfactory results are obtained. Certified hydrostatic pressure test reports shall be submitted.
 - b. A minimum of seven hydraulic test points readings between shutoff head and 10 percent beyond the maximum indicated capacity, recorded on data sheets as defined by the Hydraulic Institute. Vibration acceptance limits shall apply to all test points.
 - c. Pump curves showing head, flow, power, efficiency, and NPSH requirements.
 - d. Include curves for reduced speeds at 50 rpm intervals through operating range.
 - e. Certification that the pump horsepower demand did not exceed the rated motor horsepower beyond the 1.0 service rating at any point on the curve.
 - f. A minimum 4-hour continuous running test shall be conducted verifying the drive train stability. Vibration and bearing temperatures shall be recorded at 1/2 hour intervals. The performance test time may be applied towards the total running time. The test duration shall be considered as a minimum and must continue until stable bearing temperatures have been recorded. Rated flow rates shall be used during this test.
 - g. Factory Witnessed Tests: All pumps shall be factory-tested, complete with motor and pump assembled systems and witnessed by the Contract Administrator or their representatives. The Contractor shall give the Contract Administrator a minimum of 28 days notice prior to the test. In the event of an abortive test, all costs for Contract Administrator expenses shall be borne by the Contractor and shall be deemed to be included in the Contract Sum. Such costs shall include travel and subsistence for the

Contract Administrator representatives. Test results shall be submitted to the Contract Administrator and no equipment shall be shipped until the test data have been approved by the Contract Administrator.

- C. Factory Test Report: Include test data sheets, curve test results, performance test logs, certified correct.
- D. At the discretion of the Contract Administrator or their representative, the manufacturer may be required to dismantle the pump unit for internal inspection.
- E. Pump Efficiency Evaluation: An efficiency evaluation shall apply to each of the pumps. The factory test for each pump shall verify compliance with the minimum efficiency quoted and guaranteed at the design flow capacity and design flow pump head specified.
- F. Include vibration test, as follows:
 - 1. Dynamically balance rotating parts of each pump and its driving unit before final assembly.
 - 2. Limits:
 - a. Driving Unit Alone: Less than 80 percent of NEMA MG 1 limits.
 - b. Complete Rotating Assembly Including Coupling, Drive Unit, Less than 90 percent of limits established in the Hydraulic Institute Standards- Latest Version.

3.02 FUNCTIONAL TEST

- A. Refer to Section 01701 for Functional Test requirements
- B. A Functional Test will be required on the installed systems, including pumps, motors and variable frequency drives.
- C. Functional Test is intended to confirm the pumps will operate under a full range of operating conditions. The tests will be evaluated on a pass/fail basis, and not used for determination of efficiency.
 - 1. The equipment will be considered to pass if continuous pumping is demonstrated under the test conditions.
 - 2. A fail condition will occur if the pumps cannot perform under the test condition, or if they perform, but the operation is outside of the normal expected operation, as measured by vibration, noise, temperature, or performance.
 - 3. If in the opinion of the Contract Administrator the pumping system is deemed unsuitable for the application, the Contractor shall make the necessary modification to remedy the problems.

4. If in the opinion of the Contract Administrator the pumping system does not meet the test conditions, but such conditions can be accommodated or avoided in the operation, the failure will be waived and the test considered a pass.

3.03 TRAINING

- A. Training shall be provided in three categories, to three different groups; Operations, Mechanical Maintenance and Electrical/Instrumentation.
- B. Provide Training Schedule and Lesson Plan submittals in advance of training in accordance with Section 01701. All training is to be completed prior to certification of satisfactory performance for first pump assembly installation.
- C. Curriculum and content for each course shall be consistent with operations and maintenance manuals as specified in Section 01301.
- D. Training to be provided on-Site by qualified personnel, and include:
 1. Prestart-up Training: Classroom training completed in advance of equipment start-up.
 2. Post Start-up Training: To be hands-on training after equipment start-up.
- E. Allow for two separate training sessions of three (3) hours each for each type, during different weeks to accommodate shifts and staff availability.
- F. Training sessions may be videotaped, as specified in Section 01701.

3.04 SUPPLEMENTS

- G. The supplements listed below, following “End of Section,” are a part of this Specification.
 3. Horizontal End Suction Centrifugal Pump Data Sheet

END OF SECTION

PUMP DATA SHEET
HORIZONTAL END SUCTION CENTRIFUGAL PUMPS
NO. P-M140 & P-M150

Project: NEWPCC Raw Sewage Pump Replacement Project

Owner: City Of Winnipeg Water & Waste Department

Service: Raw Sewage

Pump Name: Raw Sewage

Equip. Tag Number(s): P-M140 & P-M150

Manufacturer and Model: Flowserve Size and Type 30MN33B
Or Approved Substitute in reference to Bidding Instruction B6

No. Pumps Required: Two (2)

Drive Type: Constant
 Adjustable

Direct-Coupled Belt

LIQUID	OPERATING CONDITIONS	SERVICE CONDITIONS
Name: <u>Raw Municipal Sewage</u> Pumping Temperature (°C): _____ Normal _____ Max <u>20</u> / Min <u>8</u> Specific Gravity @ 8 to 20 (°C): <u>1.0</u> Viscosity (CP) @ 20 (°C): <u>1.002</u> pH: <u>6-8</u> Corrosion/Erosion/Abrasion Caused by: <u>Sand, Grit and Municipal Solids</u> Remarks: <u>Typical Municipal Raw</u> <u>Unscreened Sewage</u> _____ _____	Capacity (l/s): Normal _____ Rated <u>1620.37</u> Discharge Pressure (kPa): _____ Suction Pressure (kPa): Max _____ Rated _____ Diff. Pressure (kPa): _____ Diff. Head (m): <u>18</u> NPSH Available (m): _____ Remarks: <u>Flooded Suction</u> _____ _____	Temp (°C): Max <u>40</u> Min <u>15</u> Rel. Hum (%): Max <u>100</u> Min <u>50</u> Altitude (m): <u>221.76</u> <input checked="" type="checkbox"/> Indoor <input checked="" type="checkbox"/> Heated <input type="checkbox"/> Outdoor <input type="checkbox"/> Unheated Area Classification: <u>Unclassified</u> Other: _____ Remarks: _____ _____ _____

PERFORMANCE REQUIREMENTS (manufacturer to supply missing data)

Proposal Curve No.: _____ Max. Head (kPa): _____ Factory Testing:
 Speed (rpm): Variable Speed 750 max Max. Power (kW): _____ Required Not Required

Efficiency (%): Minimum 80% at Duty Point

Rated Power (kW): 373

Remarks: Suction conditions do not meet the Hydraulic Institute's Standards.
See Additional Information for suction pipe information

Equipment Tag Number(s): P-M140 & P-M150							
PUMP CONSTRUCTION DETAILS (manufacturer to supply missing data)							
Nozzles					Miscellaneous Connections		
	Size	Rating	Facing	Location		Size	
Suction	610 mm or 762 mm (Vendor to Verify)	ANSI B16.5 Class 150	ANSI 125 Flat Face	Vendor to Verify	Drain	2"	Volute Low Point
Discharge	610 mm or 762 mm (Vendor to Verify)	ANSI B16.5 Class 150	ANSI 125 Flat Face	Vendor to Verify	Vent	2"	Volute High Point
					Pres. Gauge	2"	Suction Bell
					Warm Up		
Discharge Orientation: <u>Vertical</u> Impeller Diameter (in.): Rated _____ Radial _____ Thrust _____ Max _____ Min _____ Packing: Manufacturer _____ Lubrication Type: Service Water Type _____ <input checked="" type="checkbox"/> Grease <input type="checkbox"/> Oil Size/No. Rings _____ Coupling: _____ Manufacturer _____ Type _____ Model _____ Mechanical Seal: Single Split Mechanical Seal Driver Half-Coupling Mounted by: API Class Code _____ <input type="checkbox"/> Pump Mfr. <input type="checkbox"/> Driver Mfr. Manufacturer _____ <input type="checkbox"/> Purchaser Model _____ Manufacturer Code _____ Gland Type/Material: _____ Gland Plate Taps Required: <input type="checkbox"/> Quench <input type="checkbox"/> Flush <input type="checkbox"/> Drain <input type="checkbox"/> Vent							
Hydro Test Pressure (kPa): <u>1.5 times</u> <u>maximum shut-off pressure</u> Field Testing: <input type="checkbox"/> Not required <input checked="" type="checkbox"/> Required, functional Remarks: <u>Flange specification for previous MP-1 pump installation (1994) indicates "ANSI B16.5 Class 150 slip-on or weld neck, forged steel. Drilling to ANSI B16.1 raised face." Flange material of both MP-4 and MP-5 to be confirmed by Contractor at Site to ensure proper material selection.</u>							
MATERIALS (manufacturer to supply missing data)							
Case: <u>ASTM A48 Class 30</u>		Impeller: <u>ASTM A48 Class 30</u>		Shaft: <u>ASTM A576 Gr 1045</u>			
Case Wear Rings: <u>ASTM A743 400 Series Stainless Steel Hardened to 450 to 500 BHN</u>		Impeller Wear Rings: <u>ASTM A743 400 Series Stainless Steel Hardened to 400 o 450 BHN</u>		Shaft Sleeve: <u>316 Stainless Steel</u>			
Remarks: _____				Baseplate: _____			
_____				Material _____			
ADDITIONAL REQUIREMENTS							
Provide RTDs on all bearings and one vibration sensor per pump.							

SECTION 16224 MEDIUM VOLTAGE INDUCTION MOTORS

PART 1 GENERAL

1.01 REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. American Bearing Manufacturers Association (ABMA).
 2. Canadian Standards Association.
 - a. C22.1 Canadian Electrical Code – Part I.
 - b. C22.2, No. 100 Motors and Generators
 - c. Z107.51 Procedure for In-Situ Measurement of Noise from Industrial Equipment
 3. Institute of Electrical and Electronics Engineers (IEEE):
 - a. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
 - b. 85, Test Procedure for Airborne Sound Measurements on Rotating Electrical Machinery
 - c. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
 4. National Electronics Manufacturers Association (NEMA):
 - a. MG 1, Motors and Generators.
 - b. MG 2, Safety Standard for Construction and Guide for Selection, Installation, and Use of Electric Motors and Generators.
 5. Underwriters Laboratory (UL):
 - a. UL1730 Electric Motors

1.02 DEFINITIONS

- A. CT: Current Transformer.
- B. DE: Drive End
- C. ODE: Opposite-to-Drive End
- D. PIV: Peak Inverse Voltage.
- E. RMS: Root Mean Squared
- F. RTD: Resistance temperature detector.
- G. VFD: Variable Frequency Drive

1.03 SUBMITTALS

- A. Action Submittals:

MEDIUM VOLTAGE INDUCTION MOTORS

1. Submit complete motor data with driven equipment Shop Drawings.
2. Induction motor name and specification number of driven equipment.
3. Rated motor horsepower.
4. Voltage, phase and frequency ratings.
5. Design full load current at rated horsepower for utilization (motor) voltage.
6. Number of poles and full-load speed.
7. Service factor (Direct Start and VFD).
8. Power factor at full, 3/4-load and 1/2-load.
9. Locked rotor, pull-up, breakdown, and full-load torque.
10. Guaranteed minimum full-load efficiency, include nominal efficiencies at 1/2-load and 3/4-load.
11. Maximum number of successive cold and hot starts (Direct-start and VFD operation).
12. Code letter for locked-rotor kVA/HP.
13. Locked-rotor inrush in percent of full-load current.
14. Motor thermal performance—hot and cold start curves.
15. Winding insulation class and temperature rise class.
16. Frame size.
17. Enclosure.
18. Motor type/model and dimension drawing. Include motor component weights.
19. Motor terminal box, RTD box, vibration detector box and space heater box dimensions, location on motor, and wiring.
20. Motor lead termination support insulators.
21. Schematic wiring diagram for motor and for devices such as resistance temperature detectors, vibration sensors, and space heaters as applicable.
22. Bearing Data:
 - a. Identify type and manufacturer of antifriction bearings to be installed.
 - b. Specify proposed bearing insulation materials and methods and recommended bearing lubricant(s).
 - c. Bearing protection data including resistance temperature detectors as applicable.
23. Anticipated maximum maintenance weights for rotors and removable housing elements.
24. Assembly clearances; this requirement includes, but is not limited to diametrical bearing clearances, air gap, coupling interference fit to shaft and bearing housing interference fit.
25. Shaft radial and axial runout tolerances at various lateral locations.
26. Instrumentation, including but not limited to vibration transducers and RTDs.

B. Informational Submittals:

1. List demonstrating manufacturer's requisite experience, as well as location of manufacturer and number of years of production.

2. Driven equipment and motor manufacturers' detailed mass elastic data.
3. Name, address, telephone number, and contact name for factory-trained and authorized service organization representing motor manufacturer.
4. Written installation, connection, and commissioning instructions for specific motor(s) to be furnished.
5. Operation and Maintenance Data as specified in Section 01301, Operation and Maintenance Data.
6. Factory test results.
7. Sound test report.

1.04 QUALITY ASSURANCE

- A. Production Facility: Motor manufacturer shall produce the medium voltage, induction motors at a facility manufacturer owns or operates under its own supervision.
- B. Requisite Experience: Induction motor manufacturer shall be experienced in manufacture of medium voltage induction motors for at least 10 years. At least 10 of manufacturer's induction motors of comparable capacity and complexity shall have been successfully operating in similar condition as ones specified in this section for at least 5 years in North America.
- C. Service Organizations: Motor manufacturer shall have a factory-owned or authorized service organization.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 1. U.S. Electrical Motors (Nidec Motor Corporation)
 2. Or approved equal in accordance with B6.

2.02 GENERAL

- A. Electric motors driving identical machines shall be identical.
- B. The motor shall be designed, manufactured, rated, and guaranteed for starting and continuous operation when electrically driven by a medium voltage VFD.
- C. Maximum motor loading at any point on driven load operating curve shall in no case exceed nameplate horsepower rating, exclusive of service factor

and as verified with approved submittal data of driven machinery. Motor shall be required to conform to NEMA standard ratings.

D. Lateral and Torsional Analysis:

1. Driven equipment supplier with system responsibility shall perform a complete lateral and torsional analysis of each distinct equipment-coupling motor system provided on Project.
2. Identify lateral critical(s) plus torsional critical(s) speeds.
3. Produce critical speed maps; no active critical speed shall be allowed within 20 percent of operating speed range.
4. Perform the analysis and submit for review. Wait for approval of the Contract Administrator prior to fabrication of machinery.
5. Mass Elastic Data: Used for independent evaluation of lateral and torsional natural frequency analysis. Encroachment by plus or minus 20 percent of any active critical speeds upon operating speed range must be eliminated to satisfaction of the Contract Administrator.

E. Motors driven by VFDs shall be rated and labelled as suitable for inverter duty, and rated for continuous operation at 40 degrees C ambient temperature running on VFD output at any frequency from 30 Hz to 60 Hz, or lower frequency as required to achieve the specified pumping rates.

1. Motor CSA approved for inverter duty

2.03 DESIGN REQUIREMENTS

A. Electric motors shall be in accordance with NEMA MG 1

B. Motor Voltage Ratings: 4,000 volts, three-phase, 60 Hz, for use on a 4,160-volt (nominal), three-phase, 60-Hz system as indicated.

C. Operating speed range: Coordinate with pump manufacturer.

D. Torque Loading: Coordinate with pump manufacturer.

E. Service Factor:

1. Minimum service factor:
 - a. when direct started: 1.15
 - b. when operated from a VFD: 1.0
2. Note that while this application is for VFD operation, the motor shall be rated at 1.15 service factor in a direct FVNR start application.

F. Windings and Insulation:

1. All windings and terminal leads to be copper.

2. Furnish motors with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C, and at an altitude of 1000m above sea level, without exceeding Class B temperature rise limits stated in NEMA MG 1-20.8 at rated full load and service factor.
3. The stator coils shall be form wound, vacuum pressure epoxy impregnated, in open slots. Designs incorporating semi-closed slots, closed slots or random wound coils are not acceptable.
4. The design of the stator winding shall be consistent with the requirements of long life, taking into account the stress associated with starting and being powered by a VFD.
5. Provide epoxy coating on windings and leads to provide enhanced moisture and corrosion protection.
6. All coil manufacturing to be performed in a clean room environment.

G. Motor Leads and Terminations:

1. Provide three main leads fitted with solderless lug terminals with two holes minimum each.
2. Hole spacing and size shall meet NEMA standards (12mm holes 44.45 mm apart).
3. Leads shall be brought out to main terminal box for all motors.
4. Leads to be rated at 155°C insulation, with maximum allowable terminal box temperature not to exceed 90°C.
5. Incoming cables will be shielded. Allow liberal space for accommodating stress cones inside the terminal box. The terminal box should be capable of being rotated in 90° steps.

H. Rotor Bars:

1. Designed to meet starting and accelerating torque characteristics of NEMA MG 1-20.4.3.2 for Variable Torque Square applications.
2. Size to assure tight bar construction to eliminate bar vibration.
3. Replaceable without damage to air passages or laminations.

I. Stator:

1. Iron laminations shall utilize C5 core-plate minimum, on both sides, capable of withstanding 1,400 degrees F without deterioration.
2. Brace and support to eliminate any detrimental winding movement.

J. Shafts:

1. Material: Hot-rolled C1045, minimum.
2. Stiff-shaft design.
3. Shaft Dimensions: Manufacturer's standard.
4. Provide extended shaft, tapered shaft, double shaft, or short shaft as required.
5. Include reference measurement to locate magnetic center in the event of a broken pointer on motor outline drawing.

6. Provide drive shaft extension with open-ended keyway and key.
 7. Provide a shaft grounding brush at the mechanical output end of the motor shaft.
- K. Number of Starts: Each motor shall be capable of two successive cold starts or one hot start according to NEMA MG 1, in the event of a full voltage start (not primary application)
- L. Power Factor: 75.0 minimum at 60 Hz, full load.
- M. Motor Efficiency:
1. Guaranteed Minimum Efficiency: 94% @ 60 Hz, full load.
 2. Stamp nameplate with tested efficiency.
 3. In accordance with IEEE 112.
- N. Capable of rotating at 150 percent of full-speed in reverse rotation direction, with no power applied to motor and without any damage to the motor.
- O. Starting:
1. Motors shall be suitable for full-voltage starting and VFD starting. Primary application is VFD starting.
 2. Starting frequency shall be as defined in NEMA MG 1 Section 20.12.
- P. Enclosures:
1. Mechanical protection and method of ventilation or cooling as listed below and as defined in NEMA MG 1-25 for Open Machines.
 2. Weather Protected, Type II (WP II):
 - a. Check spaces, dimensions, and arrangement to ensure heat exhaust of one motor is not fed as air intake on an adjacent motor.
 - b. Provide reusable, washable, stainless steel inlet air filters and stainless steel screens.
 - c. Provide differential pressure gauges for indication of dirty inlet air filters.
 3. Cooling Air:
 - a. Internal cooling air shall circulate from end(s) of motor towards center of rotor and stator lamination stacks, then through vents in rotor and stator laminations (symmetrical cooling) to exhaust openings or heat exchanger.
 - b. Internal air shall circulate through rotor and stator in a symmetrical manner to minimize hotspots.
 4. Hardware: Stainless steel hardware for screens and associated fasteners.
 5. Provide openings in stator endplates with access covers for checking motor air gap.
 6. Provide condensate drains in the lowest part of the motor.

Q. Reverse Rotation:

1. The motor shall be designed for withstanding non-energized 150% overspeed condition in the reverse direction without suffering mechanical damage.

R. Noise Level

1. Maximum noise level:
 - a. 80 dBA at 1 meter.

2.04 MOTOR NAME PLATES

A. General:

1. Shall conform to NEMA MG-1 and CSA standards.

B. Metal:

1. Material: Specification grade, one-piece, 1 mm nominal thickness stainless steel.
2. Finish: ASTM A167, Type 316 SS, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

C. Include, at minimum, the following on the nameplate in addition to any other requirements included elsewhere in the specification:

1. Manufacturer's name, mark, or logo.
2. Manufacturer's plant location.
3. Manufacturer's machine code.
4. Manufacturer's model number or catalog number.
5. Serial number.
6. Date of manufacture.
7. Maximum momentary overspeed.
8. Motor service factor.
9. Bearing information, type, size, and part number.
10. Total weight and individual weights of the rotor and stator.
11. Heater rating and connection details.
12. Recommended grade of lubricant.
13. The motor shall bear a "CSA Approved" or "cUL Approved" designation.

D. Provide the following information on a starting capability nameplate:

1. Maximum number of starts/hour and wait times from cold for full voltage starting.
2. Maximum number of starts/hour and wait times from hot for full voltage starting.
3. Running "cool down time" for line operation.

4. Maximum number of starts/hour from cold for VFD starting.
5. Maximum number of starts/hour from hot for VFD starting.
6. Running “cool down time” for VFD operation.
7. Stopped “cool” time.

2.05 WIRE MARKERS

- A. Clearly label all wire terminations using shrink-on sleeve type wire markers approved for terminal wiring at each terminal point. Wire and terminal numbers shall be identical on equipment and on all drawings and diagrams where they are shown.
- B. Mark terminals and leads as per NEMA MG 1-2.

2.06 ACCESSORIES

- A. Connection Box:
 1. Cast or fabricated steel connection box.
 2. Fabricated steel connection boxes shall have hinged covers secured by knurled screws.
 3. Gasketed and provisions for grounding.
- B. Main Terminal Boxes:
 1. Size:
 - a. For three main leads, incoming cable glands, and accessories.
 - b. To accommodate components and accept power supply conductors, all per NEMA requirements.
 - c. At minimum, motor lead terminal box to be one size larger than standard size terminal box for the rated motor size.
 2. NEMA 4 construction. Cast iron or steel. Sheet steel terminal boxes shall have a minimum thickness of 3 mm (1/8”).
 3. Allot space for mounting of auxiliary devices such as stress cones.
 4. Allow for top, side, or bottom entry of the supply cable.
 5. Terminal box shall not restrict the ventilating air flow or interfere with any other motor accessory.
- C. Equipment Grounding Lugs:
 1. Provide within main terminal box, suitable to terminate equipment ground wire, sized 6 AWG. Ground path shall be direct to stator frame.
- D. Auxiliary Terminal Boxes:
 1. Provide separate boxes for termination of space heaters, stator and bearing RTDs.

2. Space heater terminations shall be in a terminal box that is separate from control signal terminations.
3. Install a suitable nameplate with the heater rating and connection details.
4. Wire devices to auxiliary terminal boxes and terminate on suitable terminal blocks.
5. RTD Terminal box:
 - a. Provide a separate terminal for termination of each individual RTD shield. Do not “common” the RTD shields.

E. Vibration Sensor

1. Provide accelerometer vibration sensor on the drive-end (DE) motor bearing. Orient the sensor in a horizontal configuration.
2. Vibration sensor to be of consistent type and manufacture with the pump bearing vibration sensor.
3. Requirements:
 - a. Sensitivity: 100mV/g
 - b. Tolerance: +/-5%
 - c. Minimum Frequency Response: 3 Hz – 1.5 kHz, +/- 5%
 - d. Maximum Rated Temperature: at least 120°C
 - e. Stainless steel housing, hermetically sealed.
4. Provide armoured cable – 10m length.
5. CSA Certified.
6. Mounting stud and attachment as per vibration sensor manufacturer’s instructions.
7. Acceptable Manufacturer/Model:
 - a. Metrix SA6200A series
 - b. Wilcoxon 786A
 - c. Or approved equal in accordance with B6.

F. Filter Pressure Switch(es):

1. Provide filter differential pressure switch(es), in addition to pressure gauges, across all filters.
2. Pressure switches to actuate when filters require maintenance.
3. Requirements:
 - a. SPDT
 - b. Contact Ratings: 5A @ 120VAC or 24VDC

G. Space Heaters:

1. Provide to keep motor windings at least 5 degrees C to 10 degrees C above dew point during de-energized conditions.
2. Grid type in base of stator with easy access for maintenance.
3. Rated for 240V ac, single-phase power.
4. Design and size heater for 120V ac, single-phase power.

5. Pre-wired to terminal junction box mounted on motor.
 6. Provide warning label on space heater junction box and motor indicating space heater wiring is energized when motor is not running.
 7. The maximum sheath temperature of space heaters shall not exceed 150°C based on an ambient temperature of 40°C.
- H. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 10mm (3/8-inch) high engraved block type black enamel filled equipment identification number indicated in this Specification.
- I. Frame Grounding Pads: Provide two stainless steel faced grounding pads and locate on opposite sides of motor frame diagonally apart. Each grounding pad shall feature two tapped 12mm (1/2-inch) national coarse (NC) thread holes drilled into the motor frame, spaced 44.45 mm (1.75") apart in a NEMA standard 2-hole pattern.
- J. Lifting Lugs: Provide suitably attached lifting lugs. If concealed lugs are used, attach data plates to both sides of the motor enclosure, warning against improper lifting.

2.07 MOTOR BEARINGS

- A. Bearings shall conform to provisions of driven equipment Specification, except as supplemented or modified by requirements of this Specification.
- B. Bearings for the motors shall be extra heavy duty anti-friction type, designed and constructed to provide a running lifetime of one hundred thousand (100,000) hours according to the requirements of the Anti-Friction Bearing Manufacturers Association (AFBMA).
- C. Bearing Insulation:
1. Provide double insulated bearing at the non-drive end to prevent shaft current, with provision for checking the insulation during operation;
 2. Provide insulated bearings at both the drive end and non-drive end, with provision for checking the insulation during operation.

2.08 SHAFT GROUNDING DEVICE

- A. Provide grounding device on drive end.
- B. Requirements:
1. Fibre-based grounding ring.
 2. Split mounted.
 3. Treat shaft with corrosion protection.

2.09 MOTOR TEMPERATURE DETECTION

A. RTDs:

1. 100 ohm, 3-wire, platinum, $0.00385\Omega/\Omega/^\circ\text{C}$ DIN EN60751, Class B, with shielded cables, pre-wired to terminal junction box mounted on motor base.
 - a. The temperature detector leads shall be shielded from the terminal box to the slot, but not necessarily in the slot.
 - b. Design mounting arrangements for the embedded stator RTDs such that the RTD operates below its Corona Inception Voltage (CIV) taking into consideration the capacitive or inductive coupling of the displaced neutral voltage on the detector casing.
 - c. Install all temperature detector elements in the stator windings and temporarily ground to the frame during the performance of the high potential tests on the stator windings.
2. Provide one RTD per bearing.
 - a. Mount detector in the most heavily loaded area of the bearing.
3. Provide six stator winding RTDs (two per phase).

2.10 FACTORY TESTING

A. General:

1. Factory test motors in conformance with IEEE 112, IEEE 43, and NEMA MG 1.
2. Notify Contract Administrator a minimum of 5 weeks prior to test.
3. No equipment shall be shipped until Contract Administrator has approved test data.
4. Acceptance:
 - a. In the event motor fails to meet above requirements or efficiencies make necessary modifications, repairs, or replace entire motor.
 - b. Retest motor until found satisfactory.
5. Test Reports:
 - a. Include documentation and results.
 - b. Indicate test procedure and instrumentation used to measure and record data.
 - c. Certified, signed, and dated by motor manufacturer's test personnel and responsible engineers.
 - d. The test report shall be certified by the equipment manufacturer and shall be forwarded to, and accepted by, the Contract Administrator prior to the equipment being shipped from the factory.
 - e. The test report shall be included in the O&M Manual.

B. Tests:

1. Routine:
 - a. Measurement of winding resistance.

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- b. No-load motoring readings of current, power, and speed at rated voltage and frequency.
 - c. Measure and record air gap during assembly.
 - d. Visually inspect bearing and bearing insulation.
 - e. High potential test in accordance with NEMA MG 1-20.17.
2. Load testing
 - a. Complete with the rated load including motoring readings of current, power, and speed at rated voltage and the following speeds:
 - i. Minimum speed (as per pumping requirements)
 - ii. Maximum speed (60 Hz)
 - iii. And one intermediate point
 3. Surge: Test stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no turn-to-turn shorts. Repeat surge test after coil-to-coil connections are complete.
 4. High Potential: High pot stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no turn-to-turn shorts. Repeat high potential test after all coil-to-coil connections are complete.
 5. Efficiency and Loss: Use IEEE 112 Method F. Include the following in determining efficiency per NEMA MG 1–20.21.
 - a. Stator I^2R .
 - b. Rotor I^2R .
 - c. Core loss.
 - d. Stray load losses.
 - e. Friction and windage loss.
 6. Phase Rotation:
 - a. Apply phase sequence as called for an outline drawing and check for correct direction of rotation.
 - b. Record direction of rotation and phase sequence.
 7. Temperature:
 - a. Perform heat run tests on motors via embedded detector, using either of the IEEE 112 8.2.3 methods of loading.
 - b. Record stator and bearing temperatures every 10 minutes or less until machine reaches a constant temperature equilibrium.
 - c. Determine temperature rise for service factor loading.
 8. Blocked Rotor Test: With rotor blocked, take the following readings at highest voltage possible: line voltage, current, kW, torque, and induced field current.
 9. Noise:
 - a. In accordance with NEMA MG 1, Part 9.
 - b. Mean A-weighted sound pressure level measured at one meter from major machine surface shall not exceed 85 dB (A) with motor operating at no-load, and rated frequency and voltage applied.

10. Vibration:

- a. Radial Shaft at Full Operating Speed: 2.0 mils peak-to-peak, maximum.
- b. Take vibration data at cold and hot operating conditions, at no-load during factory testing.
- c. Transient Shaft Vibration: 3.5 mils peak-to-peak, maximum, throughout normal startup and shutdown speed range.
- d. Values shall include shaft surface runout sensed by probes.
- e. Shaft Runout: At slow roll speeds of less than 100 rpm shall be less than 0.5 mils peak-to-peak, maximum.
- f. Bearing Housing Vibration:
 - i. At full operating speed shall be 0.15 inches per second (RMS), maximum.
 - ii. Take vibration data at cold and hot conditions, at no-load.
 - iii. Transient Vibration: 12.7mm/s RMS, maximum, throughout normal startup and shutdown speed range.
- g. Vibration Frequency:
 - i. Record during vibration testing at cold and hot conditions.
 - ii. Record frequencies up to seven times line frequency.
 - iii. When operated uncoupled at rated speed, machinery shall not exhibit unusual or abnormal frequency components on either shaft or casing vibration measurements.
 - iv. Normal frequency components are defined as excitations such as rotational speed, synchronous and multiples of synchronous frequency or blade passing frequency that is inherent with mechanical construction of machinery.
 - v. Unusual or abnormal frequency components are excitations that are non-synchronous or not related to known geometry of machinery.

13. Final Insulation Resistance: Take reading of armature insulation with mega-ohmmeter for one minute after high potential test has been completed.

2.11 PAINT FINISHING

- C. Submit paint and coating selection for approval prior to finishing.
- D. All material labels shall clearly state the name of the manufacturer, name and type of paint, colour and date.
- E. Apply primer within time recommended after surface preparation. Comply with SSPC-PA-1 for application techniques, requirements and precautions.
- F. Apply paint in accordance with SSPC Manual Volume 2 – “Systems and Specifications”, Chapter 5.1.
- G. Protect all coated equipment adequately against damage, dust, moisture, and scratching during shipment, off-loading and storage on-site. If, in the
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opinion of the Contract Administrator, the coating is damaged during shipment to the extent that touch up would not be satisfactory, return and re-coat the equipment at the Contractor's cost.

2.12 MOUNTING

- A. Horizontal mounting.
- B. All motors are to be supplied with the related equipment.
- C. Factory align and balance motors with the related equipment to minimize vibration and undue stresses.

PART 3 EXECUTION

3.01 SITE ACCEPTANCE TESTING

- A. Site Acceptance Testing will be the responsibility of the Installing Contractor.
- B. The motor supply Contractor is responsible for addressing all issues with the motor supply that are identified during the Site Acceptance Test.
- C. The Site Acceptance Test will include, but is not necessarily limited to, the following:
 - 1. 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.
 - 2. Inspect and test shaft grounding device.
 - 3. 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.
 - 4. Verify the application of appropriate lubrication and lubrication systems.
 - 5. Verify the absence of unusual mechanical or electrical noise or signs of overheating.
 - 6. Verify that resistance temperature detector (RTD) circuits conform to drawings.
 - 7. Perform space heater insulation resistance at 500 VDC.
 - 8. Perform winding insulation-resistance tests in accordance with ANSI/IEEE Standard 43. Test voltage shall be in accordance with manufacturer's published data or 2500 Vdc. Test duration shall be for ten minutes. Calculate polarization index. The dielectric absorption ratio or polarization should not be less than 1.0. The recommended minimum insulation resistance (IR 1 min) test results in megohms should be corrected to 40° C and read as follows:

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- a. IR 1 min = $kV + 1$ megaohms for most windings made before 1970, (kV is the rated machine terminal-to-terminal voltage, in rms kV)
 - b. IR 1 min = 100 megohms for most ac windings built after 1970 (form-wound coils).
9. Perform dc overpotential tests in accordance with ANSI/IEEE Standard 95 on each winding. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the overpotential test, the test specimen is considered to have passed the test.
- a. Test each winding individually.
 - b. Ground windings not under test.
 - c. Test voltage to be incremented gradually to 7.0 kV.
 - d. Test duration to be one minute after the target test voltage is reached.
 - e. Record leakage current in microamps.
 - f. Perform phase-to-phase stator resistance test.
 - g. Investigate phase-to-phase stator resistance values that deviate by more than 10 percent.
 - h. Perform resistance tests on resistance temperature detector (RTD) circuits. Utilize a 500VDC test voltage for one minute.
10. Test insulation resistance of insulated bearings in accordance with manufacturer's information.
11. Perform a rotation test to insure correct shaft direction.
12. Measure running current and evaluate relative to load conditions and nameplate full-load amperes.
13. Perform vibration baseline test.

3.02 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification.
1. Medium Voltage Induction Motors Data Sheet

END OF SECTION

MEDIUM VOLTAGE INDUCTION MOTORS DATA SHEET

Project Name: _____

Equipment Tag Number: **P-M140.MTR AND P-M150.MTR** _____

Item Name: **Raw Sewage Pump Motors**

GENERAL

1. Volts 4160
2. Phase 3Ø
3. Hertz 60
4. Duty Continuous
5. Other _____
6. Nameplate HP, kW Contractor to Specify
7. Service Factor 1.15 (Direct) 1.0 (VFD)
8. Synchronous RPM Contractor to Specify
9. Rated PF >= 0.75
10. Insul. Class Class F Other _____
11. Voltage and Freq. Variations +/- 10% As per NEMA MG 1
12. Stator Temp. Rise _____ °C Above _____ °C by _____
13. Rotor Temp. Rise _____ °C Above _____ °C by Resistance
14. _____
15. **Site Data:**
16. Area Classification Class _____ Group _____
17. Division _____ Nonclassified
18. _____
19. Zone _____ Class _____
20. Group _____ Temp. Code _____
21. Ignition Temp., if less than 250°C _____
22. Site Elevation (ft/m) ~215m ASL
23. Ambient Temp. Max. 40°C Min. 5°C
24. Relative Humidity Max. 99% Min. 10%
25. Motor Location Indoor Outdoor
26. Roof Over Motor No Roof Over Motor
27. Building Temp. Controlled Not Controlled
28. **Unusual Conditions:**
29. Dust _____
30. Chemicals _____
31. Seismic Loading _____
32. Corrosive Agents Some corrosive gases (H2S) present
33. Other _____
34. **Enclosure:** Explosion Proof TEFC
35. Open-Drip-Proof
36. Weathered Protected: Type I Type II
37. TEPV TEWAC Other _____
38. TEAAC, Tubes:
39. Copper Aluminum Stainless Steel
40. Stainless Steel Fasteners
41. Provision for Purging _____
42. Degree of Protection IP _____
43. Cooling System _____
44. _____
45. _____
46. _____
47. _____
48. _____
49. _____

51. **Mounting:** Horizontal Vertical
52. Shaft Down Shaft Up
53. Flange Mounted Pedestal Foot Mounted
54. Engine Type: _____
55. **Motor** Full Voltage Reduced Voltage _____
56. Type _____
57. Other Starting Method VFD
58. Volt. Dip @ Locked Rotor-Max % ___ at KVA Inrush
59. Loaded Unloaded Partially Loaded _____

BEARING DATA

60. **Bearings:**
61. Type Required Hydrodynamic
62. Oil Rings Required
63. Antifriction
64. Thrust Bearings Max. _____
- Connected Equipment _____
- Thrust _____

LUBRICATION SYSTEM

65. **Lubrication:** Pressure of Flood Lube:
66. System Supplied By _____
67. Common With Drive Equipment
68. Per API 614
69. Manufacturer's Standard
70. Self-Lube:
71. Bearing Housing Headers Required
72. Bearing Constant-Level Sight Feed Oilers Required
73. Oil Mist for Antifriction Bearings

CONTROLS

74. **Motor Vendor to Furnish:**
75. _____
76. _____
77. Separate Monitoring and Control Devices, as Listed Below, for Mounting In:
78. Purchaser's Switchgear
79. Vendor Furnished Control Panel
80. _____
81. _____
82. _____
83. _____
84. _____
85. _____
86. _____
87. _____
88. _____
89. _____
90. _____
91. _____
92. _____
93. _____

MEDIUM VOLTAGE INDUCTION MOTORS DATA SHEET

Project Name: _____
Equipment Tag Number: P-M140.MTR AND P-M150.MTR _____
Item Name: Raw Sewage Pump Motors _____

ACCESSORY EQUIPMENT

1. **Main Conduit Box**
2. **Sized For:** Feeder Cable:
 - 3. Conductor Size _____
 - 4. Type Tape Shielded TECK 90 _____
 - 5. Insulation XLPE 15 kV _____
 - 6. Quantity Per Phase 1 _____
 - 7. Entering From:
 - 8. Top Bottom Side
 - 9. Both Ends of Stator Winding Brought Out to Terminal Box
 - 10. Terminations and Interior Jumpers:
 - 11. Insulated Uninsulated
 - 12. Current Transformers for Differential Protection:
 - 13. Type: Core Balance Full Differential
 - 14. Accuracy Class _____
 - 15. Quantity _____ Ratio _____
 - 16. Supplied by _____ Mounted by _____
 - 17. Surge Capacitors: _____ Microfarads
 - 18. Supplied by _____ Mounted by _____
 - 19. Surge Arresters: _____ kV Rated
 - 20. Supplied by _____ Mounted by _____
 - 21. Current Transformers for Ammeter
 - 22. Quantity _____ Ratio _____
 - 23. Accuracy Class _____
 - 24. Supplied by _____ Mounted by _____
 - 25. Potential Transformers for Voltmeter
 - 26. Quantity _____ Ratio _____
 - 27. Accuracy Class _____
 - 28. Fuses Required _____
 - 29. Supplied by _____ Mounted by _____
 - 30. Bushing Studs or Receptacles _____
 - 31. Space for Stress Cones _____
 - 32. Thermal Insulation _____
 - 33. Maximum Sheath Temperature, _____ °C or Temperature Code _____
 - 34. Breathers
 - 35. Drain Holes
 - 36. Provision for Purging
 - 37. Ground Bus _____
 - 38. Other Terminal Box Requirements _____
 - 39. _____
 - 40. _____
 - 41. _____
 - 42. _____
 - 43. _____
 - 44. _____
 - 45. _____
 - 46. **Stator Space** _____ 120 Volts _____ 1 _____ Phase
 - 47. _____
 - 48. **Bearing Heaters:** _____ Volts _____ Phase

49. **Vibration Detectors:**
 - 50. Noncontacting Probes
 - 51. Installed Provisions Only
 - 52. Qty/Bearing: Two Four
 - 53. Probe Type _____
 - 54. Model _____
 - 55. Probe Furnished By _____
 - 56. Bearing Housing Seismic Sensors
 - 57. Installed Provisions Only
 - 58. Qty/Bearing: 1 (on DE)
 - 59. Location (H,V,A): H
 - 60. Sensor Type: Accelerometer
 - 61. Model: as per spec
 - 62. Sensor Furnished By: Motor Mfg _____
 - 63. Motor Casing Seismic Sensors
 - 64. Qty/Motor _____
 - 65. Location (H,V,A) _____
 - 66. Sensor Type _____
 - 67. Model _____
 - 68. Sensor Furnished By _____
 - 69. Vibration Switch:
 - 70. Manual Reset Electric Reset
 - 71. Switch Type _____
 - 72. Model _____
 - 73. Terminal Head or Box _____
 - 74. **TEWAC Heat Exchanger:**
 - 75. **Exchanger Location** _____
 - 76. **Redundant Coolers Req.** Yes No
 - 77. Air Temperature Sensor Required
 - 78. Description _____
 - 79. Flow Sensor Local Indicator Required
 - 80. Lead Detection Required
 - 81. Provision Only Required
 - 82. Differential Pressure Switch:
 - 83. Provisions Only Differential Pressure Gauge
 - 84. **Hydrodynamic & Thrust**
 - 85. **Bearing Temp. Devices:**
 - 86. Provision Only Manufacturer's Standard
 - 87. RTD: _____ Detector Material
 - 88. _____ ohms @ _____ °C
 - 89. Type: 3-Wire 2-Wire
 - 90. Thermocouple: Type _____
 - 91. Dial Type Thermometers: Alarm Contacts
 - 92. RTD: Qty/Phase 2 _____ Material
 - 93. _____ Pt _____
 - 94. _____ 100 _____ ohms @ _____ °C
 - 95. Type: 3-Wire 2-Wire
 - 96. Ground One Lead Yes No
 - 97. Thermocouples: Type _____
 - 98. Qty/Phase _____
 - 90. **Winding Temperature**
 - 91. **Detectors:**

NOTES:

SECTION 261923 MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE

PART 1 GENERAL

1.01 GENERAL REQUIREMENTS

- A. This specification defines the technical requirements related to the design, fabrication, factory testing, supply, and delivery to Site of fully enclosed, CSA approved and/or C-UL listed, medium voltage, indoor type Variable Frequency Drive (VFD).
- B. This specification shall be read in conjunction with the other documents forming part of the Tender/Purchase Order documents.
- C. Nothing in this specification shall be interpreted as relieving the Vendor of the responsibility for complete compliance with the codes and standards.
- D. The issues and revisions of these documents in effect on the date of the contract award shall apply.
- E. In the event that this specification conflicts with any of the above referenced documents, or any attached specifications, the Vendor shall notify the Contract Administrator in writing prior to proceeding.
- F. Any applicable laws, rules, regulations or codes of the province or other local regulating bodies having jurisdiction over the Site shall apply.
- G. The VFD shall be designed for operating a raw sewage pump in a wastewater treatment facility.
- H. The VFD shall be suitable for mounting on a concrete floor.

1.02 REFERENCES

- A. Relevant standards and other publications of the organizations listed below form a part of this specification within the indicated subject areas. The applicable issue shall be the one in effect at the time of the invitation to bid:
 - 1. Canadian Standards Association (CSA)
 - a. CSA 22.1 Canadian Electrical Code
 - b. CSA 22.2 No 253
 - 2. American Water Works Association (AWWA)
 - 3. American Iron and Steel Institute (AISI)
 - 4. American Society for Testing and Materials (ASTM)
 - 5. American Society of Mechanical Engineers (ASME)
 - 6. America Bearing Manufacturers Association (ABMA)
 - 7. The Society for Protective Coatings (SSPC)
 - 8. Institute of Electrical and Electronics Engineers (IEEE)
 - a. IEEE 519 Guide for Harmonic Control and Reactive Compensation of Static Power Converters

- b. IEEE 1100 – Powering and Grounding Sensitive Electronic Equipment (Emerald Book)
- 9. Electrical and Electronic Manufacturers Association of Canada (EEMAC)
- 10. Manitoba Building Code / National Building Code of Canada (NBCC)
- 11. ISO 10816-3, 1998; Mechanical vibration-Evaluation of Machine Vibration by Measurements on Non-Rotating Parts
- 12. International Electrotechnical Commission (IEC)
- 13. International Society of Automation (ISA)
- 14. International Organization for Standardization (ISO)
- 15. National Electrical Manufacturer Association (NEMA)
 - a. NEMA ICS 6 – Industrial Control and Systems Enclosures
 - b. NEMA ICS 7 – Industrial Control Systems Adjustable Speed Drives
- 16. Underwriters Laboratories Inc (UL)
 - a. UL 347A – Medium Voltage Power Conversion Equipment

1.03

DEFINITIONS

- A. CPT – Control Power Transformer
- B. Converter — a device that changes electrical energy from one form to another (AC to DC or from AC to DC to AC). A semiconductor converter is a converter that uses semiconductors as the active elements in the conversion process. Generally a converter consists of three power sections together with their required auxiliaries:
 - 1. An input “rectifier” section consisting of semiconductor devices, together with optional line side filters and isolation transformer(s);
 - 2. A DC filter (dc bus) section consisting of reactors, capacitors, or combinations of reactors and capacitors; and
 - 3. An output “inverter” section consisting of semiconductor devices, together with optional line side filters, switchgear, controls, auxiliary devices and cooling systems.
- C. Commutation Failure — during converter operation is the failure to achieve forward blocking of an arm of a thyristor or transistor at the end of its normally conducting period, thus enabling the direct current to pass during the period when the thyristor is normally in the off state.
- D. FAT - Factory Acceptance Test
- E. FLA – Full Load Amps
- F. HCT – Hall effect Current Transformer
- G. IGBT - Insulated Gate Bipolar Transistor, a high speed electrical switching power device.
- H. LCD – Liquid Crystal Display
- I. Neutral Point Clamp (NPC) — VFD topology used to control/reduce the neutral voltage at the load with reference to ground, (reduces dv/dt and THD in the output voltage).

- J. Operational Speed Range — is the entire speed range over which the connected motor is required to operate the driven mechanical equipment.
- K. Point of Common Coupling (PCC) — for the purposes of this Specification the Point of Common Coupling with the supply network shall be defined as the input terminals of the VFD.
- L. Root Sum Square (RSS) — the sum of the squares of amplitude of all harmonic voltages (or currents), thus
- M. Total Current Harmonic Distortion (I_{THD}) — the ratio of the square root of the sum of the squares of amplitude of all harmonic voltages to the amplitude of the fundamental voltage, thus

$$I_{THD} = \frac{\sqrt{\sum_{h=2}^{50} I_h^2}}{I_1} \times 100\%$$

$$= \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 \dots + I_{50}^2}}{I_1} \times 100\%$$

- N. Total Voltage Harmonic Distortion (V_{THD}) — the ratio of the square root of the sum of the squares of amplitude of all harmonic voltages to the amplitude of the fundamental voltage, thus

$$V_{THD} = \frac{\sqrt{\sum_{h=2}^{50} V_h^2}}{V_1} \times 100\%$$

$$= \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 \dots + V_{50}^2}}{V_1} \times 100\%$$

- O. Telephone Influence Factor (TIF) — for a voltage or current wave in an electric supply circuit, the ratio of the square root of the sum of the squares of the weighted root-mean-square (RMS) values of all the sine wave components (including alternating waves, both fundamental and harmonic) to the root-mean-square (RMS) value (unweighted) of the entire wave. Thus the Voltage Telephone Influence Factor (VTIF) is defined by

$$V_{TIF} = \frac{\sqrt{\sum_{h=1}^H (T_h Z_h I_h)^2}}{V_1}$$

IEEE 519 (8-4)

- Where:
- V1 = fundamental line-to-neutral voltage (RMS)
 - Ih = harmonic current into power system
 - Zh = power system impedance at harmonic order h
 - Th = telephone interference weighting factor

H = upper limit of harmonics (5000 Hz)

P. Variable Frequency Drive (VFD) — a system consisting of a medium voltage power converter and its associated control and protection equipment that used to vary the speed of a previously fixed speed motor.

Q. CT: Current Transformer.

R. PIV: Peak Inverse Voltage.

S. RMS: Root Mean Squared

T. RTD: Resistance Temperature Detector.

1.04 SUBMITTALS

A. General:

1. Submittals shall be furnished in accordance with Section 01301, Administrative Requirements.

B. Qualification Submittals

1. To determine the qualifications of the proposed VFD, the Contract Administrator may request as part of the evaluation process the following:
 - a. Equipment Layout Drawing:
 - b. List demonstrating manufacturer's requisite experience, as well as location of manufacturer and number of years of production.
 - c. Manufacturers proposed after sales support service for the VFD.
 - d. Other information as required to evaluate the suitability of the VFD for the given application.

C. Review Submittals Prior to Manufacture:

1. Dimensions
 - e. VFD width
 - f. VFD depth.
 - g. VFD height (without cooling fans)
 - h. VFD height (with fans)
 - i. Clearance required above the fans- for maintenance or operational purposes
 - j. Shipping weight
2. Detailed Bill of Material
3. Calculated VFD availability (support with calculations)
4. Manufacturers proposed after sales support service for the VFD.
5. Installation Manuals
6. Operation Manuals
7. Programming Manuals

8. Maintenance Manuals.
9. Equipment Layout Drawing, showing:
 - a. Plan, elevation, and section drawings indicating the dimensions, physical arrangement of major components, and the degree of compartmentalization and physical segregation provided between components,
 - b. Front layout of the local operator controls (panel),
 - c. Mimic panel layout,
 - d. Outline drawings,
 - e. Location and sizing of all cable entry and exit points,
 - f. For air-cooled systems show:
 - i. Air inlet and outlet passages,
 - ii. Location and size of cooling fans,
 - iii. Location and size of inlet and outlet filters,
 - iv. Minimum clearances required at air inlet(s) and outlet(s) external to the VFD enclosure required to ensure proper cooling airflow.
10. Connection Wiring Diagrams
11. Single Line Diagrams identifying all equipment, including:
 - a. Power connections, medium and low voltage,
 - b. Metering, alarms and protective relaying,
 - c. Type of converter and method of commutation,
 - d. Filters for reduction of harmonics,
 - e. Auxiliary power supplies.
12. Three-Line Diagrams for all power systems.
13. Control Schematics, complete set including internal controls.
14. Complete listing of jumpers and programmable settings, and the proposed setting for this application.
15. Equipment Ratings
 - a. Voltage, frequency/speed range, amperes and volt-amperes
 - b. Breaker, contactor, and fuse ratings,
 - c. Converter kVA rating,
 - d. Transformer data including kVA rating, % impedance, winding arrangement, and grounding, transformer K-factor,
 - e. Minimum efficiency and power factor curves for the operating speed range on the maximum load torque/speed curve,
 - f. Maximum steady-state frequency deviation at any load from zero to rated,
 - g. The percentage current harmonics and amplitudes of all harmonics (up to and including 35th harmonic) produced when running at minimum, mid-range, three quarter, and maximum speeds on the maximum load/torque speed curve,
 - h. Voltage telephone influence factor (V_{TIF})
16. VFD heat rejection rate at various loads,
17. The allowable ambient operating temperature range,
18. Driven Equipment Capability Data, showing:
 - a. Torque speed capability curves for the VFD from zero to maximum speed. The curves shall clearly identify any points where the torque is reduced as a result of electrical resonance or other causes (Coordinate with the motor vendor as required to obtain the motor torque-speed curves),

- b. The response time of the speed control system to bring the VFD to the design conditions, for a suddenly applied load of 50% and 100% of load according to the maximum load torque/speed curve at minimum and maximum designed speeds, respectively (four response times required).
19. Submit calculated values and expected values for all factory tests prior to construction, including, but limited to:
 - a. Noise levels.
 - b. Efficiency.
 - c. Power factor.
 - d. The percentage current harmonics and amplitudes of all harmonics (up to and including 35th harmonic) produced when running at minimum, mid-range, three quarter, and maximum speeds on the maximum load/torque speed curve.

D. Submittals Required After Factory Testing

1. Complete set certified factory test results, for all specified tests.
2. Final certified, as-built versions of all review submittals.
3. As-built versions of all submittals to be provided within two weeks of shipment.

E. Other Submittals

1. Regular renewal frequency for the following components
 - a. Cooling fans
 - b. Air/Dust filter.
 - c. Electrolytic capacitors on circuit boards
 - d. DC link oil filled capacitor
2. Vendor to provide cooling fans expected operating life data.
3. Submit training proposal a minimum of 40 Working Days prior to the start date of training, including:
 - a. Name and qualifications of trainer. Identify how the trainer will be familiar with the project, and training qualifications and experience.
 - b. List type of visual and audio aids to be used, including simulation equipment.
 - c. Hour-by-hour schedule including brief overview of content.
 - d. Copy of training manual.

F. Closeout Submittals

1. Provide a complete set of all prior submittals to be included as part of the O&M manuals specified in Section 01301.

1.05 QUALITY ASSURANCE

- A. Production Facility: VFD manufacturer shall produce the medium voltage variable frequency drive at a facility manufacturer owns or operates under its own supervision.
- B. Requisite Experience: Variable frequency drive manufacturer shall be experienced in manufacture of variable frequency drives for at least ten years.
 - 1. At least fifty (50) of manufacturer's drives of comparable capacity and complexity shall have been successfully operating in similar condition as ones specified in this section for at least ten years in North America.
- C. Service Organizations: VFD manufacturer shall have a factory-owned or authorized service organization within a reasonable service distance from Site.
- D. Spare Parts Availability: VFD manufacturer shall have a factory-owned or authorized service organization that maintains a full set of spare parts for the proposed VFD within Canada.
- E. The VFD Vendor/Manufacturer shall be capable of providing start-up service, emergency call service, repair work, maintenance and troubleshooting training of customer personnel. Emergency service shall be available within a twenty-four (24) hour response time.
- F. Training
 - 1. Provide a factory trained, competent trainer fully familiar with the operation and maintenance of the VFD.
 - 2. Instructor to have qualifications, acceptable to the Contract Administrator, regarding training. Expectations will be completion of a certified training course, and/or demonstrated experience, proficiency, and quality of training.
 - 3. The Contract Administrator reserves right to approve instructors.
- G. The VFD Manufacturer shall be certified to ISO 9001-2000 and ISO 14001.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 - 1. Toshiba International Corporations;
 - 2. Or approved equal in accordance with B6.

2.02 GENERAL

- A. Prohibited Materials

1. Asbestos (either friable or non-friable form), asbestos containing materials, other fibrous materials of equal hazard, or materials which are known or suspected of being carcinogenic shall not be used or incorporated into in any part or portion of the VFD.

B. VFDs driving similar machines shall be identical.

C. Complete Package

1. The VFD shall be provided as a complete package in a single enclosure, with the following:
 - a. Incoming Disconnect
 - b. Input Vacuum Contactor
 - c. Multisecundary Isolation Transformer
 - d. Rectifier
 - e. Frequency Converter/Inverter
 - f. Protective System / Devices
 - g. Output filter or reactor (when required)
 - h. Diagnostics and Control Circuits

D. Design Requirements

1. VFD Basic Ratings:
 - a. Variable Torque Type (VT)
 - b. Input Voltage 4160V nominal, 60Hz
 - c. Load Ratings:
 - i. Voltage: 4160V, 3ph
 - ii. RPM: As per motor supply.
 - iii. Horsepower: As per motor supply or 500HP, whichever is greater.
 - iv. Full Load Amps: As per motor supply or 86 A, whichever is greater.
 - v. LRA As per motor supply.
 - vi. Overload Rating: 115% of rated current for one minute.
 - d. VFD speed control range 10:1
2. The VFD shall be designed to provide output requirements dictated by the speed/torque characteristics of motor and driven equipment over the entire speed range. The VFD manufacturer must coordinate with the pump and motor vendors to collect all the information.
3. The VFD shall convert the line input voltage to adjustable AC voltage and frequency output power. The output power shall be controlled such that permissible Volts/Hertz ratio is not exceeded throughout the specified operating speed range, over an input voltage range of +/-10% and input frequency variation of +/- 5%.
4. The VFD shall continue operation without coming to a standstill or resulting in a process shutdown, following any momentary voltage dips in the input power supply, auxiliary power supply, or both, of less than 20% rated voltage, which last for less than 0.5 second.

5. The VFD shall be capable of re-accelerating the driven equipment, following voltage dips greater than 20% of the rated input power supply, of up to 5 seconds duration, without the need to come to a complete stop. Indicate the maximum time delay before re-acceleration begins following restoration of the supply voltage.
6. The VFD shall be capable of safe operation under the short time condition when the pump is back-spinning at 150% overspeed condition with its motor non-energized.
7. Environmental
 - a. Ambient Temperature: 5°C to 40°C

E. Input Power Quality

1. The complete VFD efficiency from the input terminals to the output terminals, including all control and auxiliary power shall be as follows:
 - a. At 100% speed, 100% VFD rated load: 96% minimum
 - b. At 75% speed, 50% VFD rated load: 95% minimum
 - c. At 50% speed, 25% VFD rated load: 93% minimum

F. Input Power Quality

1. The VFD current harmonic distortion (I_{THD}) at its input terminals shall comply with IEEE 519 current harmonic limits:

I_{sc} / I_L	Individual Harmonic Order (Odd Harmonics)					TDD
	<11	$11 \leq h \leq 17$	$17 \leq h \leq 23$	$23 \leq h \leq 35$	$h \leq 35$	
<20 *	4.0	2.0	1.5	0.6	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

- a. The VFD current input harmonics shall be less than the IEEE 519 table referenced above for all speeds and loads.
 - b. Vendor to provide voltage and current harmonic data spectrum for the offered VFD for different load /speed combinations.
2. VFD Manufacturer shall calculate, and provide as a review submittal prior to manufacture, the value of the Total Harmonic Distortion (V_{THD}) of the input voltage, Voltage Telephone Influence Factor (V_{TIF}) and the Total Current Harmonic Distortion (I_{THD}) and Individual Harmonic Current Distortion at the VFD input terminals.
3. The calculated Harmonics and V_{TIF} shall be based on the specified network short-circuit level. At VFD input terminals the short circuit level is 10.9kA (Interrupting) and 17kA (momentary). The 4160V system neutral is solidly grounded.
4. The VFD fundamental power factor shall be greater than 0.97. The total power factor at the VFD input shall be greater than 0.95, for the load range of 50 to 100%. The VFD including power factor correction and/or harmonic filter shall never have a leading power factor.

G. Output Power Quality

1. For supply voltage limits of $\pm 10\%$, the VFD shall be capable of developing the following torques:
 - a. Maximum steady torque required by the load torque/speed curve for the specified motor and pump,
 - b. 115% of maximum load torque/speed curve for 20 seconds,
 - c. For constant torque loads 150% of maximum load torque for 60 seconds,
2. Pulsating torques shall not exceed 0.8 RMS times the value of the maximum steady state for speed range from zero to 105% of rated speed.
3. The transient output voltage shall not exceed the peak voltage insulation level of the motor or cause insulation stress.
4. Provide output filter in the VFD output section, as required to meet specified requirements.

H. Thermal and Mechanical Withstand Capability

1. All medium voltage portions of the VFD and converter shall be manufactured and braced to withstand the thermal and mechanical forces caused by a short-circuit of the specified level (see 2.02E4).

I. Speed Control

1. The converter output frequency shall not deviate more than $\pm 1\%$ of any given set point within the operating frequency range.
2. Over-speed protection shall immediately shutdown the converter if the output frequency exceeds 105% of maximum design frequency.
3. Wherever required, under-speed protection shall shutdown the converter if the output frequency falls below 90% of minimum design frequency for a programmable period (not to exceed 60 seconds).
4. The speed control shall have adjustable dead bands to prevent the pump drive train from operating in any critical speed range and an alarm shall be initiated if the deviation between set point and measured value exceeds 5% for a programmable period (not to exceed 60 seconds).
5. The VFD shall be equipped with both V/F as well as Sensorless Vector control. It shall be possible to select in field either V/F control or S-vector control.

J. Reliability

1. The VFD unit shall be designed and built for continuous full load operation under the specified environmental conditions. Redundant cooling fans shall be provided where necessary to meet this requirement.
2. The VFD system shall be capable of operating at least 40,000 hours between failures.
3. All power semiconductors and passive power components in both the rectifier and inverter section shall be medium voltage rated components. Low voltage inverter section components are acceptable only where a "Cascaded H Bridge" (CHB) inverter configuration is employed.
4. The DC link capacitors must be based upon a long lasting oil filled design. Electrolytic capacitors are not acceptable for the DC link

5. The Vendor/Manufacturer shall list any control or power components preferably selected from IGBT, IGCT or SGCT that require recommended maintenance or replacement before 40,000 hours of operation. Information must be available in Vendor/Manufacturer's maintenance manual and available for submittal.
6. The calculated Mean Time Between Failures (MTBF) of the complete VFD shall be greater than 40,000 hours. All components of the VFD shall be considered for MTBF calculations. The Vendor/Manufacturer shall provide separate calculated values for MTBF for:
 - a. Medium voltage converter power semi-conductors including "on-module" gating, firing, and snubber circuits,
 - b. Power circuit, medium voltage converter including transformer, input filter, dc link, and output filter as may be applicable,
 - c. Low voltage, controls, and auxiliaries, including fans and pumps,
 - d. Complete VFD as a unit.
7. The Vendor/Manufacturer shall also provide calculated Mean Time to Repair (MTTR) values for the above items.
8. The calculated availability of the VFD based on the above MBTF and MTTR data. The calculated availability shall be greater than 99.97%.

2.03

DESIGN REQUIREMENTS

A. VFD topology/Pulse Number

1. The VFD shall be a Voltage Source Inverter (VSI) type.
2. The front end rectifier section pulse count shall be 24 pulse minimum.
3. The VFD waveform modulation shall be Pulse Width Modulation (PWM), Neutral Point Clamp (NPC) type, with a minimum of five output levels.
4. The VFD shall be equipped with input pre-charging reactor, pre-charge bypass contactor, and its associated controls supplies all integral to the VFD.

B. Inverter Requirements

1. Isolation between the controller and inverter to be fibre optic.
2. It shall be possible to replace each phase inverter power module as a separate component, without replacing all other phases.
3. Utilize a minimum of eight IGBTs (or equivalent in accordance with B6) per phase (24 total) to generate a five level or better output voltage waveform.
4. Provide neutral point clamping diodes to avoid neutral point voltage shift.
5. Utilize inverter firing patterns that avoid neutral shift.

C. Harmonic filters and Power factor correction

1. The VFD Manufacturer shall provide all necessary input and output filtering equipment to meet the specified harmonic limits.
2. Power factor correction equipment shall be provided if necessary to maintain a constant input power factor of greater than 0.95 lagging throughout the entire load range.

3. Filters shall be mounted within the VFD enclosure. The VFD Manufacturer shall provide all components of the filter, including but not limited to: installation, cabling, bus work, supports, surge protection, lugs, mounting bolts, capacitors, reactors, resistors, construction drawings, service, and maintenance instructions.
4. Capacitors shall be environmentally safe, equipped with self discharge resistors and a method of shorting the phases shall be provided. Capacitors shall be equipped with fuse protection.
5. Filter inductors may be air or iron core. Inductors shall have Class F insulation with Class B temperature rise.
6. There shall be annunciation of failure of each filter section.

D. Radio and Controls Interference

1. The VFD shall be provided with radio interference suppression.

E. Control/Protection Power Supplies

1. Power required for protective logic and I/O circuits and low voltage controls shall be supplied from an integral supply to VFD. Provide necessary control transformer.
2. The control power transformer ratings shall allow for a minimum of 25% spare capacity.
3. Minimum interrupting rating of the CPT primary fusing: 100,000 kA
4. CPT secondary to have one leg grounded.
5. Control power for the VFD shall be:
 - a. Integral 120V AC 1Ø power supply.
 - b. Integral 24V DC regulated power supply (if required).

F. Auxiliary Power Supplies

1. Power source for other required auxiliary systems (cooling fans, pumps, etc.) shall be supplied internally to the VFD.
2. Where the Manufacturer's standard design requires auxiliary systems to operate independently of the medium voltage input to the VFD power shall be 600VAC 3Ø.
3. Where voltages other than 600VAC 3Ø are required the Manufacturer shall incorporate an auxiliary transformer in the VFD to transform the 600VAC 3Ø to the voltage(s) required.

G. Motor Space Heaters

1. Provide contactor and control circuit to power 120VAC, 1Ø motor space heaters. 120VAC power to be provided from an external source. Switch heater power off when motor is in operation. Coordinate ratings with motor vendor as required.

H. Fault Current Protection

1. Over-current protection shall be provided for the converter. The Vendor/Manufacturer shall identify types of faults for which the over-current protection is designed.
2. The protection for the driven induction motor shall include:
 - a. Overload protection,
 - b. Short-circuit fault,
 - c. Ground-fault,
 - d. Locked rotor (motor stalled),
 - e. Mechanical jam
3. Manually reset “lockout” functions shall be provided for all faults resulting in tripping.
4. Manufacturer to propose for provisions to locate ground faults without shutting down the motor.
5. Manufacturer to provide data/ description for:
 - a. Maximum short circuit fault interrupting capacity of the VFD
 - b. Maximum short-circuit fault withstand capacity of the VFD
 - c. VFD behavior in case a ground-fault occurs on motor side
 - d. VFD behavior in case a fault occurs on the DC link section
 - e. VFD behavior in case a fault occurs in the front end (rectifier section)
 - f. VFD behavior in case a fault occurs in the output (Inverter) section

I. Over-voltage Protection

1. Vendor/Manufacturer shall provide magnitude and duration of maximum external voltage surge which the VFD is capable of withstanding.
2. The converter shall not be damaged for any internal or external over-voltages.
3. Semiconductor devices shall be rated above the maximum crest, repetitive and non-repetitive voltage peaks.
4. Over-voltage protection devices required for the converter power circuits, auxiliary power circuits, and motor and motor feeder cables shall be included in the scope of supply of the VFD.

J. Under-voltage Protection

1. The converter shall have capability to supply all rated current values without “commutation-failure”, with a 10% voltage dip conditions in the MV supply circuit.

K. System Control Interface

1. The VFD shall be equipped with a front mounted local operator control panel consisting of a LCD display, VFD control keypad, pushbuttons, and pilot lights with the following functions:
 - a. Minimum of a 4 x 20 character LCD display, with adjustable backlighting.
 - b. In the event that the LCD display is disconnected, the drive shall be able to function.
 - c. Settings and parameters to be password protected.
 - d. All indicating pilot lights to be LED based.
 - e. “Run” and “Stop” pushbuttons complete with guards.

- f. Note: the local “Run” pushbutton shall be active only with the VFD “Local/Remote” selector switch in “Local” mode. A remote “Run” function (via Purchaser’s plant DCS) shall be available only in “Remote” mode of the VFD LOR selector. All “Stop” and “Emergency Stop” functions whether local or remote shall be active at all times.
- g. A two position (twist to release) maintained contact “Emergency Stop” red mushroom pushbutton.
- h. A “Local Speed Setting Device” which shall be active only with the “Local/Remote” selector switch in “Local”, complete with setting matching and “bump less” transfer capability.
- i. A “Local/Remote” control selector switch.
- j. Local “Start” and “Stop” pushbuttons, for use while in Local mode.
- k. The local operator control panel shall include the following long life LED pilot lights:
 - i. “Ready”, blue (stand-by condition, medium voltage power available, control and auxiliary power available, no faults, all safety interlocks “normal”)
 - ii. “Running”, green (VFD in operation, motor powered)
 - iii. “Local”, blue
 - iv. “Remote”, blue
 - v. “Fault”, red (VFD or motor “tripped” by a protective device)
 - vi. “Alarm”, amber (abnormal condition but VFD/motor not “tripped”).
- l. Elapsed time meter.
- m. Display and adjustment of drive parameters
- n. Display and reset drive and motor faults and alarm conditions.
- o. Display of actual drive operating parameters, including (but not limited to):
 - i. Local Speed Setting (selectable - Hz, RPM, or mA),
 - ii. Remote Speed Setting (selectable - Hz, RPM, or mA),
 - iii. Metering:
 - Actual output motor speed (selectable - Hz, RPM, or mA),
 - Input Volts,
 - Input Currents,
 - Input Power Factor (Pf)
 - DC Link (bus) Volts,
 - Output (Motor) Volts
 - Output (Motor) Currents.
2. Parameters names, fault/alarm messages and other information shall be displayed in plain text to allow the user to understand what is being displayed. The language on the panel shall be English.
3. Password protection shall be provided to provide security against unauthorized parameter access.
4. Hardwired inputs and outputs shall be provided to interface with remote control equipment (operator, supervisory control and monitoring systems):
 - a. Analogue inputs: two x 4–20 mA.
 - b. Analogue outputs: three x 4–20 mA.
 - c. Digital inputs: eight x 24Vdc.

- i. Digital inputs to be isolated from VFD internal control logic, and utilize 24 VDC signal level. Signals to be input include:
 - E-stop
 - Run Cmd
 - Signals as required to meet specified local control requirements
 - d. Digital outputs (Relay Outputs):
 - i. Five dry-contact relay outputs rated 5 A @ 230 VAC, 5 A @ 24 VDC, with the following signals:
 - Run
 - Alarm
 - Fault
 - Ready (Power present and ready to operate)
 - Programmable relay
5. All external interfaces to be connected to clearly identified, accessible, terminal blocks. Terminal blocks to be screw compression type, capable of terminating two 14 AWG wires under each screw.
 6. Control wiring to be segregated from power wiring to avoid interference.
 7. An Ethernet based Modbus –TCP communication interface shall be provided to interface with the City’s control system. All VFD control parameters, settings, alarms, faults, operational measurements (metering), and status shall be available for remote display/logging, and trending on the City’s control system via this interface.

L. Alarms and Trips

1. Standard alarm detection and indication arrangement shall be proposed. Acknowledgement/reset of all alarms shall be possible from the local operator interface.
2. The following “typical” VFD fault trip and alarms shall be provided and annunciated on the local operator interface:
 - a. Converter failure,
 - b. Converter power circuit,
 - c. Ground fault (VFD),
 - d. Ground fault on converter output,
 - e. Converter over-current,
 - f. Supply system over or under voltage,
 - g. Supply system phase voltage unbalance,
 - h. DC link fault,
 - i. Voltage/frequency ratio incorrect,
 - j. 5% frequency deviation from the set point,
 - k. Auxiliary device fault and indicating the failed device,
 - l. Loss of analogue control signal (i.e. speed order),
 - m. Control electronics fault,
 - n. Motor overload,
 - o. Motor stalled,
 - p. Motor winding over temperature,
 - q. Manually tripped,
 - r. Enclosure high temperature

- s. Cooling fan failure,
 - t. Cooling water supply high temperature (water cooled units only),
 - u. Internal cooling loop circulating pump failure (water cooled units only).
3. Alarm conditions shall be detected and indicated independently from trip conditions. Alarms shall cause the “alarm” pilot light to illuminate; faults shall cause the “fault” pilot light to illuminate.
 4. Faults shall be further categorized into “critical” and “non-critical”, “critical” faults being those requiring a protective shutdown of the VFD, “non-critical faults being those causing a reduction in capacity or involving failure of duplicated equipment.
 5. Separate digital output contacts shall be provided for “common alarm” and “common fault”, contacts shall be wired to separate terminal blocks.

M. VFD Cooling Arrangement

1. Air Cooled VFD shall meet the following:
 - a. 100% redundant cooling fans shall be provided, c/w provision for supply from integral power supply.
 - b. Failure of any fan shall automatically start the standby and initiate a “non-critical” fault alarm.
 - c. In the event of a complete ventilation failure, the VFD shall stop prior to thermal damage to any internal component.
 - d. Cooling fan system shall include provisions, to enable the customer to duct exhaust hot air outside of building.
 - e. Provide screens for all openings exceeding 6 mm. The maximum screen opening not to exceed 6 mm.
 - f. Exhaust to be at the top of the VFD enclosure.
2. Cooling fans requirements:
 - a. A ten year design life.
 - b. Three phase, squirrel cage, ball bearing fan.
 - c. Provide internal protection for fan motor.

N. Incoming Power Isolating Device/Main Fusing

1. The Purchaser will provide medium voltage power to the VFD from a 4160V, Fused Load Break disconnect switch.
2. Manufacturer shall include in its VFD an HP rated incoming line disconnect switch (non-load break type) with current limiting fuses. Provide a door mounted viewing window for visual confirmation of isolation of line disconnect contacts.
3. Alternatively if required by the Vendor/Manufacturer’s standard design, the VFD shall include a main circuit breaker instead of a fused disconnect, complying with Canadian Electrical Code.
4. Where a dedicated fused vacuum type contactor or main circuit breaker is incorporated into the VFD:
 - a. The VFD shall provide the open/close commands for this device.
 - b. Contactor shall be draw-out type, or an isolation switch with an auxiliary contact shall be included. The isolation switch, circuit breaker, or contactor shall be lockable in the open or withdrawn position.

- c. The switchgear shall be suitable rated for 115% of the VFD full load current.
- d. An electronic protection relay shall be provided for instantaneous and time over-current protection (50/51) of the transformer.
5. VFDs requiring an external circuit breaker or external line contactor will not be accepted. All components shall be integral to the VFD unit.
6. Provide surge arrestors to enable VFD to withstand BIL of 50kV at its input terminals. Provide details.
7. Provide following interlocks in the VFD:
 - a. Front door interlock preventing door opening when VFD is in operation.
 - b. Vacuum contactor/disconnect interlock as required.
 - c. Standard safety interlocks

O. Input Power Transformer

1. The input power transformer shall be an integral part of the VFD and shall meet the following requirements:
 - a. Transformer(s) shall be specially designed to supply power to the VFD and shall meet all applicable requirements of IEEE C57 and / or equivalent CSA standards,
 - b. Contain 12 three-phase windings
 - c. Transformer(s) shall be thermally rated to allow a 150% overload for five minutes with the drive previously operating at 100% load for an extended period of time,
 - d. Transformer(s) shall be designed to withstand the specified short circuit conditions at the input of the VFD,
 - e. Transformer(s) shall maintain electromagnetic symmetry when only one secondary winding is in short circuit in order to minimize the resulting short circuit forces,
 - f. Transformer(s) shall be capable of thermally withstanding a short circuit for 2 seconds,
 - g. Transformer(s) shall be of a high efficiency type with full load losses < 2%,
 - h. Transformer winding material shall be copper,
 - i. Transformer shall be built for a design life of 25 years.
 - j. The transformer shall include electrostatic shielding between the windings to carry high frequency capacitive currents to ground,
2. Transformer Protection
 - a. Dry-type transformer(s) shall be protected with an over-temperature protection device with alarm and trip contacts,
 - b. Liquid-type transformer(s) shall include pressure relief device, pressure / vacuum gauge, gas evolution relay (slow and fast gas) with alarm and tripping contacts, liquid level gauge with alarm contacts, and liquid thermometer with alarm and tripping contacts,
 - c. Each primary winding shall be provided with 4 off-load 2.5% taps 2-FCAN, 2-FCBN, liquid-type transformers may incorporate an off-load manual tap adjusting switch or tap-changer.
3. Transformer Temperature Class
 - a. Temperature Class 220°C and average winding temperature rise by resistance of 115°C (above a 40°C ambient),

P. Power Bus

1. Requirements for all power bus bars:
 - a. Tin plated copper.
 - b. Braced for short circuits up to 50 kA.

Q. Reactors

1. Reactors shall not exceed their temperature limit under all operation conditions.
2. Reactors shall be protected with an over-temperature protection device with alarm and tripping contacts.

R. VFD Enclosure

1. The VFD enclosure shall be front access only for operations, cable handling, maintenance etc. No rear or side access is available at Site.
2. The maximum size of the enclosure at the largest point, including all fans and other accessories, is to be:
 - a. 2812mm High.
 - b. 2400mm Wide
 - c. 1300mm Deep
 - d. VFDs exceeding any one of these dimensions will not be accepted.
3. The maximum depth of the VFD, including the required minimum front service access clearance, is to be 3000 mm.
4. The VFD shall be constructed to NEMA-1A gasketed/EEMAC enclosure Type 12 (IP51).
5. The layout of the VFD drive cubicles shall include all necessary compartmentalization with segregation between compartments to enable routine maintenance to be carried out safely with the VFD in operation.
6. Cable entry/exit shall be:
 - a. Incoming cable: 3C, 2 AWG, HVTECK, 15kV, 100% insulation, shielded, top entry.
 - b. Motor cable: 3C, 2 AWG HVTECK, 15kV, 100% insulation, shielded, bottom entry.
 - c. VFD to Motor cable length is approximately 50m.
 - d. Provide NEMA Std 2-hole or 4-hole cable termination points.
 - e. Cable routing space shall be sufficient to exceed all code cable bending requirements.
7. Air intakes shall be equipped with replaceable dust filters. Dust filters shall be replaceable from the exterior of the VFD while the VFD is in operation without requiring the opening of any door or panel (excepting the retaining panel for the filter itself). Fasteners for filter compartment covers shall be captive. Replacing of filters shall not expose the operator or maintenance person to hazardous conditions or to contact with any energized component.
8. VFD compartment or section doors (with the exception of doors to “low voltage” control compartments) shall be secured by captive bolts. Low voltage compartment doors shall be secured by three point latches and equipped with lockable “automotive” type handles.

9. Medium voltage section or compartment doors shall be mechanically interlocked to prevent access to any medium voltage equipment within the VFD, unless the incoming voltage to that section or compartment has been isolated at the source and the disconnecting means locked. Where the VFD is equipped with an integral lockable disconnecting means, opening or withdrawing that device and locking it in its opened or withdrawn state, may be used to permit access to downstream sections of the VFD.
10. External access panels and external covers for termination compartments, etc. shall be secured from within the structure and shall only be removable from within the VFD structure.
11. The VFD enclosure shall be designed for an unclassified area.
12. All enclosure openings exceeding 6mm width shall be provided with mesh screen (opening size not exceeding 6mm).

S. Noise Level

1. Maximum noise level:
 - a. 80 dBA at 1 meter.

T. Nameplates

1. Provide engraved lamacoid nameplates with lettering ½ inch high, or larger. The nameplates shall have black lettering on white background.
2. Provide red DANGER signs on VFD enclosure.
3. Provide manufacturers details on a lamacoid nameplate with full order reference details and manufacturer's contact details.
4. Identify all front door mounted meters, relays, touch screen panel, keypad, lamps, switches and other devices with lamacoid nameplates using the same tag as used on VFD shop drawings.

U. Software

1. Supply two full working copies of VFD setup, control and monitoring and HMI graphic display (Operator interface) setup software.
 - a. Copies to be supplied on CD or DVD media, with all required licenses, instruction manuals, interface/communications cards/adaptors, connecting cables, software/hardware keys, as may be required to properly and fully interface with the drive.
2. Software computer requirements:
 - a. Microsoft Windows XP /Windows 7 compatible
 - b. Suitable for installation on a laptop computer with an "Intel" or "AMD" processor.
3. The software shall be capable of a minimum of the following functions:
 - a. Parameter setup,
 - b. Fault log viewing,
 - c. Diagnostic analysis,
 - d. Monitoring and control,

- e. Download, upload, and backup of drive setup and operating parameters,
- f. Real time graphical display of the VFD performance.

2.04 SPECIAL MAINTENANCE TOOLS AND EQUIPMENT

- A. Supply all special tools and equipment required for maintenance and service, including, but not limited to:
 1. Tools to rack out and remove rectifier including lifting mechanism
 2. Tools to rack out and remove inverter including lifting mechanism
 3. Other tools as may be required.

2.05 SPARE PARTS

- A. Supply the following spare parts (total, not per VFD):
 1. DC Power Supply, Qty 1
 2. Gate Signal Board, Qty 1
 3. Control Logic Board, Qty 1
 4. Differential External I/O Board, Qty 1
 5. Display Board, Qty 1
 6. Interface Board, Qty 1
 7. Gate Drive / Hall Transformer Board, Qty 1
 8. PDM Board, Qty 1
 9. Fan, 460V, 3PH, Qty 1
 10. Fuse, 4.8KV, 2A, Qty 4
 11. Fuse, E, 5.5KV, Qty 3
 12. Diode Bridge Fuse, Qty 18
 13. Diode Pack, 2200V, Qty 12
 14. Power Module Assembly, Qty 1
- H. Where the above are not applicable to the VFD being supplied, the equivalent component or module applicable to the supplied VFD is required.

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. The VFD unit shall be completely fabricated, assembled and tested at the manufacturing facilities and pump manufacturer's facility prior to being shipped to Site, where it shall be further Site tested and commissioned along with associated switchgear and protection to verify functionality.

- B. The equipment shall be completely fabricated, assembled, factory tested and CSA and/or cUL certified at the Vendor's manufacturing facilities and shipped to Site ready for field installation and energization.
- C. The VFD shall be shipped in a weatherproof packaging, suitable for extreme weather conditions expected to be encountered during its transportation to pump manufacturer's facility or to Customer's Site.

3.02

FACTORY ACCEPTANCE TEST

- A. Perform a complete factory acceptance test on the complete assembled VFD including its component transformers and reactors. The requirements of this section are for the tests that are to be performed at the VFD manufacturer's facility. An additional factory string test of the complete system including pump and motor is required as specified in other sections at the pump manufacturer's premises.
 - 1. Utilize calibrated instruments only, and provide calibration certificates for all instruments indicating calibration within six months prior to testing.
- B. Perform a full-load functional test of the VFD. The test shall prove the correct operation of all control functions, auxiliaries, protective systems, alarms and metering, including:
 - 1. A heat run of the VFD when loaded according to the maximum load torque/speed curve and operating at the lowest, mid-range and highest design speeds. The heat run shall last for four hours at each of the lowest, mid range speeds and maximum speeds,
 - 2. Efficiency (including all auxiliaries), input power factor and harmonic measurements at the following pump operating points:
 - a. 100% speed, 100% load.
 - b. 75% speed, 50% load.
 - c. 50% speed, 25% load.
 - d. 100% speed, 75% load
 - e. 90% speed, 61% load
 - f. 80% speed, 48% load
 - g. 70% speed, 37% load
 - 3. Harmonic measurements to include V_{THD} (Voltage), I_{THD} (Current), and measurement of individual harmonics from 1 to 49 at the various speeds and loads indicated.
 - 4. All VFD unit testing at VFD manufacturer's premises shall be performed using Dynamometer test beds. Use of stationary load banks for VFD testing is not acceptable.
 - 5. Confirm stable operation of the VFD over the complete operating speed range, when suddenly applying and removing full load,
 - 6. Confirm VFD capability to continue operation without coming to a standstill, following any momentary voltage dips in the input power

supply, auxiliary power supply or both of less than 20% rated voltage, which last for less than 0.5 seconds,

7. Confirm VFD capability to automatically re-accelerate following loss of voltage for up to five seconds,
8. Measurement of input and output (motor) current harmonics with rated motor connected at VFD test facility and at varying load/speed runs.
9. Include for following tests:
 - a. Maximum/minimum load operation test.
 - b. Noise level test.
 - c. Current/Torque limit test.
 - d. Power outage ride thorough test
 - e. Test simulation of alarm and trip functions
 - f. Transformer losses testing
 - g. Transformer efficiency testing

C. Provide coordination and services to include for transporting reach VFD to and from pump manufacturer's factory for a combined VFD and pump testing at their premises. Include for manufacturer trained VFD technician to be present at the time of combined test at the Pump manufacturer's premises.

D. Provide written, signed results of all factory acceptance tests.

3.03 TESTING AND COMMISSIONING

- A. Provide a factory trained service engineer(s) for the start-up of the VFD. The service engineer shall be an employee of the manufacturer. All travel expenses and time shall be included.
- B. Perform functional testing, commissioning and initial parameter setting. This shall be performed by, or under the supervision of, the factory trained service engineer.
- C. Acceptance testing, final parameter adjustment and performance tests of the VFD, motor and combined VFD/motor as a unit shall carried out by the factory trained service engineer(s) with the Contract Administrator and designated representatives present.
- D. Upon completion of functional testing and commissioning provide a full and comprehensive acceptance testing report including a listing of all adjustments/corrections made and all drive parameter settings in their "as left" state.

3.04 TRAINING

- A. Provide Training Schedule and Lesson Plan submittals in advance of training in accordance with Section 01701. All training is to be completed prior to certification of satisfactory performance for first pump assembly installation.

- B. Curriculum and content for each course shall be consistent with operations and maintenance manuals as specified in Section 01301.
- C. Training sessions may be videotaped, as specified in Section 01701.
- D. Provide hands-on maintenance and operation training to the City's maintenance personnel at the Site.
- E. Provide a paper copy of training materials to all course participants.
- F. Operations Training
 - 1. Location: At a facility provided by the City.
 - 2. Duration: One hour minimum.
 - 3. Number of Sessions: Two (on separate days)
 - 4. Number of trainees: Coordinate with Contract Administrator prior to training.
 - 5. Audience: Operations and maintenance personnel.
- G. Maintenance Training - Classroom
 - 1. Location: At a facility provided by the City.
 - 2. Duration: Two hours minimum.
 - 3. Number of Sessions: Two (on separate days)
 - 4. Number of trainees: Coordinate with Contract Administrator prior to training.
 - 5. Audience: Electrical and instrumentation maintenance personnel.
- E. Maintenance Training – Hands-on
 - 1. Location: NEWPCC
 - 2. Duration: Two hours minimum.
 - 3. Number of Sessions: Three (on separate days)
 - 4. Number of trainees: Coordinate with Contract Administrator prior to training.
 - 5. Audience: Electrical and instrumentation maintenance personnel.

END OF SECTION

E2. ADDITIONAL INFORMATION

