Texas Department of Transportation

BOOK 2 – TECHNICAL PROVISIONS

FOR

LOOP 375 - BORDER HIGHWAY WEST EXTENSION

PROJECT

Design-Build Project

ATTACHMENT 13-3
REQUIREMENTS FOR AN ANTI-ICING SYSTEM (FAST)

December 20, 2013

REQUIREMENTS FOR AN ANTI-ICING SYSTEM (FAST)

13.3.1 Introduction

This attachment contains basic information establishing minimum requirements of a fixed automated spray technology (FAST) system and road weather information system (RWIS) site-specific installation. The Developer is ultimately responsible to provide a complete, functioning, and reliable anti-icing system.

13.3.2 Design Considerations

The design, construction and installation of FAST/RWIS systems require specific professional design skills. These disciplines shall be considered at a minimum when selecting a successful vendor for the FAST/RWIS system:

- Architectural design
- Structural design
- Electrical design
- Mechanical design
- Environmental compliance
- Weather and Surface instrumentation

13.3.3 Applicable Codes and References

At a minimum, the following codes and references shall be considered along with all applicable local, state and federal regulations and requirements.

- ARCHITECTURAL

  Buildings shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

  International Building Code

  Texas Accessibility Standards

- STRUCTURAL

  Structural systems shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

  International Building Code

  Manual of Steel Construction

  Building Code Requirement for Structural Concrete – ACI 318

  Building Code Requirement for Concrete Masonry – ACI 530

- ELECTRICAL

  Electrical systems shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

  National Electrical Code with Amendments

  International Building Code with Amendments

International Fire Code with Amendments

International Mechanical Code with Amendments

Uniform Plumbing Code with Amendments

International Energy Conservation Code with 2001 Supplements

Local codes

NFPA 101 Life Safety Code

Applicable NFPA Standards and Codes

Illuminating Engineering Society Design Guidelines

LEED: Leadership in Energy and Environmental Design

- MECHANICAL

Mechanical system shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.) – Fundamentals Handbook

ASHRAE – HVAC Applications Handbook

ASHRAE – HVAC Systems and Equipment Handbook

ASHRAE 52.2 – Method of Testing: General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASHRAE 55 – Thermal Environment Conditions for Human Occupancy

ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality

ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings

ASHRAE Guideline 1 – The HVAC Commissioning Process

ICC International Building Code with local code Addendum

IMC International Mechanical Code with local code Addendum

IPC International Plumbing Code with local code Addendum

LEED® (Leadership in Energy and Environmental Design) NC – Version 3.0 Reference Guide

NFPA 90A – Installation of Air Conditioning and Ventilating Systems

SMACNA (Sheet Metal and Air Conditioning Contractors' National Association, Inc.) – HVAC Duct Construction Standards: Metal and Flexible

SMACNA – HVAC Systems Duct Design

- FIRE ALARM

Fire Alarm Systems shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

NFPA 72

National Electrical Code with Amendments

International Building Code with Amendments

International Fire Code with Amendments

International Mechanical Code with Amendments

Local fire codes

NFPA 101 Life Safety Code

- FIRE PROTECTION

Fire Protection System shall be designed to comply with the requirements of all the latest applicable codes and standards including, but not necessarily limited to, the following:

NFPA 13 and

NFPA 14

Local fire codes

State Fire Marshal's office approval

13.3.4 General Description

Developer shall be responsible for the design, installation and testing of a FAST system including all additional conduit, hardware, storage tanks, pump house design and construction, plumbing, electrical wiring and connections, AC power source and connections and phone/communications source and connections capable of pan, tilt, zoom (PTZ) video for a fully operational state of the art FAST/RWIS System, and any other components necessary to provide a complete, functioning and reliable system.

The anti-icing system shall be a fixed automated system that allows automatic treatment of the traffic lanes.

13.3.5 FAST/RWIS Components

The following criteria shall be used to establish the minimum acceptable standards for the materials, components and control circuitry of the anti-icing system.

13.3.5.1 Pump House – Above-ground

A pre-cast concrete, concrete, or masonry pump house building(s) shall be located within the Site as agreed to by TxDOT and any affected Third Parties. The roof shall be capable of withstanding vertical loading per all applicable codes and regulations, and the structure shall be capable of withstanding wind and precipitation loading as required by applicable codes and regulations.

The doors shall have an opening of adequate size to service and/or replace any equipment or storage tanks required for system operation.

The nominal dimensions of the pump house(s) shall be of adequate size to house the minimum number of chemical tanks specified by the vendor to accommodate the need for the chemical agent for this Project, and should include one additional tank for a spare, as recommended by the system supplier. The storage tanks should be sized as described below, or as required by the vendor to accommodate the needs of this Project. The floor of the pump house(s) shall be perfectly level and constructed to support the weight of the filled chemical tanks. The floor design shall serve as a containment area and incorporate a liner to prevent leakage of chemical outside the structure.

Developer shall provide for review, design plans for the pump house(s) that are sealed by a Registered Professional Engineer. The plans shall be provided a minimum of four weeks prior to commencement of construction of the pump house(s). TxDOT will review and provide comments in accordance with the Contract Documents.

Developer shall be responsible for a foundation investigation and foundation design for the pump house(s). A Registered Professional Engineer shall approve the foundation investigation and design in accordance with applicable codes and regulations.

13.3.5.2 Ventilation

Ventilation in the pump house(s) shall meet the requirements to ensure suitability for human occupation and shall ensure that no build-up of deleterious gas is allowed.

13.3.5.3 Power

Electrical service, as required for the FAST/RWIS system, shall be installed by Developer to a breaker box inside the pump house(s) for powering the FAST/RWIS system, up to 150% of actual load. Installation of electrical components within the pump house(s) shall be in accordance with the requirements of the National Electrical Code and any other appropriate codes and regulations, including clearances. Developer shall provide electrical power from the nearest available source. Developer shall be responsible for coordinating with the local electrical utility in order to make all electrical connections between the pumping system and the electrical source.

Additional power source i.e., battery backup, standby generator, etc., shall be available, as deemed necessary by Developer, to ensure functionality of the anti-icing system.

13.3.5.4 Communications

Fiber optic cable shall be provided as part of the ITS to communicate with TransVista.

13.3.5.6 Instrumentation

Instrumentation in the pump house(s) shall include but not be limited to:

- Pressure Gauges;
- Flowmeter Transmitter, to sense flow rate in system and send signal to RPU spray system controller;
- Pressure Switch Transducer, to sense pressure in system and send signal to RPU spray system controller;
- Ultrasonic Level Sensor, to detect the level of chemical in the storage tanks; and
- Additional instrumentation, as needed, for additional specialized equipment.

13.3.5.7 Anti-Icing Chemical Storage

Storage tanks for the anti-icing chemical shall be installed inside a pump house (s) and shall accommodate a minimum of 50 system activations at a rate of 40 gallons per lane mile. Storage tanks shall be sized to fit through available door entries. The tank shall be rated for a maximum fluid specific gravity of 1.5 or greater and shall be made from an approved polymer or glass fiber-reinforced epoxy material. Any metal components of the tank shall be stainless steel. Galvanized steel shall not be used.

13.3.5.8 Flush Water Storage Tank

The flush water storage tank(s) shall be installed inside the pump house(s). Tank capacity shall be sized to accommodate the final system design. The tank(s) shall be rated for a maximum fluid specific gravity of 1.5 or greater and shall be made from an approved polymer or glass fiber-reinforced epoxy material. Any metal components of the tank(s) shall be stainless steel. Galvanized steel shall not be used.

13.3.5.9 System Supply Pump

Developer shall provide a pump of appropriate size to assure proper operation of the designed system. Pump and housing shall be stainless steel with seals and bearings appropriate for exposure to chloride-based chemicals, potassium acetate, calcium magnesium acetate or CMA, CMA with potassium or CMAK, and other anti-icing chemicals. Electric motors shall be of a voltage and cycles appropriate for the system design and use in corrosive environments. Pump shall be capable of refilling any individual accumulator, if applicable, within the finished system within 10 seconds.

13.3.5.10 Valve Units

Valve units shall control the flow of anti-icing chemical from the main supply line to each spray disk. Valve units shall consist of electro-magnetically controlled solenoid valves and electronic solenoid control cards. Each control card shall have the capability to independently control the operation of multiple solenoid valves and through a signal cable. The control cards shall allow each solenoid valve to be remotely activated using different spray programs from the controller. Each control card shall be addressable allowing individual control. The control cards shall have remote fault testing.

13.3.5.11 Solenoid Valve Boxes

All solenoid valves shall be installed in NEMA 3R compliant electrical enclosures that are at a minimum galvanized and firmly attached to the deck and/or curb. Additional valves and diaphragms shall be provided as recommended for FAST/RWIS systems. For each line, the valve box located furthest from the pump shall contain a valve for purging said line with clean water at the end of the season, or when switching chemicals. Purge valves shall also be located at low points in the system as necessary for purging of the system.

13.3.5.12 Valve/Sensor Control Cable

Shielded cable shall be used for all valve and pavement sensor systems.

13.3.5.13 Nozzles

All nozzles shall be removable for cleaning or replacement without the need for removing the entire nozzle assembly and shall be capable of withstanding high-volume interstate traffic and snow plowing procedures conducted with maintenance trucks.

- Face/curb nozzles shall be inset ¼ inch from face of curb/wall, or as recommended by the manufacturer. Nozzles shall be adjusted for cross slope of the roadway as required.
- Puck type nozzles shall be located in the approximate center of the anticipated driving lanes, in the shoulder areas or as recommended by the manufacturer. Puck type nozzles shall be recessed 1/8 inch to ¼ inch from the top of pavement or as recommended by the manufacturer. Overall puck size shall be compatible with the bridge deck design so as to be appropriately encased and seated.

The spray disks shall be made of a durable non-metallic synthetic material that remains stable under exposure to sunlight, weather, and traffic. The spray heads shall be non-metallic, flush mounted, and non-mechanical. The synthetic material shall be comparable in stiffness and rigidity to stainless steel. All metallic components of the spray disk shall be stainless steel.

The spray disks mounted in the bridge deck shall have piping connections located on the underside of the disk. The spray disks shall be fabricated in such a manner that the nozzle directions can be adjusted while the disk is embedded in the bridge deck or roadway surface without removal of the disk assembly.

Puck type nozzles shall be affixed to the surrounding concrete or other bridge deck material with a colored epoxy to match the bridge deck material, or equivalent material as approved by the TxDOT, and care shall be taken during the installation to avoid damaging the underlying waterproofing membrane, if any. A working drawing for the location and pattern of nozzles shall be submitted to TxDOT for approval. The number and pattern of nozzles shall be designed for required coverage per the system's recommendation. The number and pattern of nozzles shall be such that they provide the required coverage. The nozzles shall be capable of being raised for overlay application or lowered for surface removal, without complete unit replacement, to accommodate for roadway or deck surface upgrades.

13.3.5.14 Pressure Piping

The system shall be designed flexibility to use anti-icing chemicals of different specific gravities such as calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), sodium chloride (NaCl), calcium magnesium acetate (CMA), potassium acetate (KAc), CMA/KAc blend (CMAK).

All piping outside of the pump house shall be Polyamide 11, 18/14 pipes or approved equal. All pipe connections, joints, elbows, fixed points, and pipe clamps shall be stainless steel.

Chemical pressure pipe within the pump house shall be beta polypropylene rigid pipe with socket-fused joints, rated for 120% of system pressure. Chemical pressure piping shall be routed within a protective conduit system consisting of non-metallic conduit where embedded in concrete or buried in the ground and schedule 80 PVC where exposed. All embedded or buried conduit must be a minimum of 3-inch diameter, or larger if required.

Conduit pipes shall be secured to bridge and buried conduit pipes to pass a carrier pipe underneath the approaches shall be installed per vendor standard practice. Developer shall coordinate locations of cast-in-place carrier conduits prior to construction. The system shall be designed to mitigate any problems due to water hammer. All valves and valve enclosures shall be labeled to match the piping schematic and operation table.

13.3.5.15 System Controller

A microprocessor-based RPU controller shall control the anti-icing system with capacity for multiple spray disks and the ability to monitor pump functions, system pressure and flow characteristics, and tank fluid levels. The RPU spray system controller shall be able to interpret between various signals from surface and atmospheric sensors to initiate different spray programs to apply measured amounts of liquid anti-icing chemical to the roadway surface.

The control of the application of anti-icing chemical shall be fully automated, with provisions for operator intervention and notification. The automated control system shall include atmospheric sensor capabilities and active and passive pavement sensor technology. The RPU spray system controller shall be capable of storing and running multiple software programs for automatic spray activation sequences. The RPU spray system controller shall vary the length of time each solenoid valve is opened, thus varying the quantity of liquid anti-icing agent that is applied to the roadway surface, and shall change the length of time for pauses between sprays, according to different conditions on the roadway surface.

Fully automatic operation shall have manual override capability, with the options for manual pushbutton operation from the pump house, operation via telephone call with touch tone and/or voice recognition, and computer activation from Window-based PC software. The system shall provide surge protection for the incoming telephone line. The RPU shall detect failures of system components and initiate automatic system shutdown in the event of a failure.

The RPU spray system controller shall be contained within a waterproof stainless steel or aluminum housing with lockable lid. The vendor shall be able to demonstrate a minimum of five years of proven field operation of the RPU spray system controller software in automated liquid anti-icing spray systems.

13.3.5.16 Logic Controller

The logic controller shall have a data logger and be*)* compatible for connection to future TransVista and/or TxDOT equipment. The controller shall have the capability to record time, pavement sensor data and times of system operation.

The controller shall be able to automatically activate the system when the surface and atmospheric sensors indicate that the temperatures and moisture conditions are appropriate for activation. The system and its operation shall be completely independent of TxDOT's existing or planned road weather information system network.

The system shall be connected via modem to TransVista's wide area network through a central computer located at the TransVista office, from which the system shall be capable of remote control of operation and monitoring. The information from the system sensors shall be available on a web-based system and shall be Microsoft Office compatible. Note: This requirement is necessary at the end of the Term, and to be considered as required immediately in the event there is some crisis and TxDOT wishes to be able to control the system while it is under the Developer's Agreement term.

13.3.5.17 Pushbutton Remote Control Device

The Pushbutton Remote Control device shall be a programmable device similar to a garage door opener. The device shall be able to be set to a desired frequency chosen by TransVista. The device signal shall be strong enough to start the anti-icing system from 1,000 feet away from the pump house.

13.3.5.18 Conduit for Sensor and Power Cable

Sensor control cable and power cable shall be routed within a protective conduit system consisting of non-metallic conduit where embedded in concrete, and galvanized steel conduit where buried or exposed unless in corrosive conditions in which case the conduit provided shall be corrosion-proof. Conduit and all fittings, connections, elbows, and mounting hardware shall be sized and in accordance with vendor's requirements and design.

13.3.5.19 Anti-Icing Chemical

The system shall be able to safely store and apply the commonly encountered liquid de-icing chemicals. Those liquid chemical include but are not limited to: Calcium Chloride ($CaCl_2$),

Magnesium Chloride ($MgCl_2$), Potassium Acetate (KAc), Sodium Chloride (NaCl), Calcium

Magnesium Acetate (CMA), and CMA/KAc blend (CMAK).

13.3.5.20 Road Weather Information System – RWIS

The Developer installed RWIS equipment at the site shall include a tower mounted

Environmental Sensing Station (ESS) with sensors specifically designed for monitoring and displaying pavement surface conditions, pavement temperature, freeze point temperature, chemical percentage, subsurface temperature, and atmospheric temperatures and conditions from the locations as shown in the contract plans.

The RWIS system and associated Remote Processing Units shall allow for total flexibility in the selection of meteorological sensors and the system adaptability. The system shall include the integration of active and passive pavement sensors. The System shall include but not be limited to :

- Air Temperature/Relative Humidity Sensor. Sensors shall have a wind and solar radiation shielded housing and shall be mounted approximately six feet above ground level.
- Optical Precipitation Sensor. Shall be able to detect the rate and type of precipitation by sensing falling particles, and shall be capable of distinguishing between rain, freezing rain, hail, and snow as deemed appropriate for this site by the. False alarm for precipitation and precipitation intensity error rates shall be as recommended by the vendor. The sensor shall be mounted approximately six feet above ground level.
- Wind Speed/Direction Sensor. The sensor shall be installed at the standard meteorological height of approximately 30 feet above ground level at the top of the ESS tower.
- CCTV PTZ Camera. Shall be mounted on the ESS tower approximately 30 feet above ground level, and grab up to 8 preset color video still frame images approximately every 5 to 10 minutes for display at the TransVista Facilities. It shall be fixed mounted, and positioned to take up to eight views of the roadway, bridge and pump house locations to view traffic and weather conditions. It shall be enclosed in an environmental video dome housing to operate in conditions experienced at the site, and withstand common air contaminants found along roadway locations. The camera shall meet the requirements of Section 17.2.3 of the Technical Provisions and/or be compatible with these requirements, subject to TxDOT's approval.
- Environmental Sensing Station (ESS). A remote processing unit (RPU) shall gather data from all connected atmospheric sensors and remote pavement sensors, process, store and transmit this data to the computer monitor at the TransVista Facilities or to a location as determined by the TxDOT. The RPU supplied shall be part of a standard product line and not custom or specially produced for this project. The RWIS RPU shall transmit data to the RPU spray system controller in the required formats when polled. The RWIS RPU shall consist of a microprocessor of current manufacture that is capable of performing all of the required functions. A card cage or other modular layout shall provide the data bus for the microprocessor, and individual components shall be replaceable to perform maintenance and repairs.

  The RPU shall include all necessary ports, drivers and inputs to fully support and correctly interpret the pavement and meteorological sensors. The RPU shall be supplied with a host serial port for interfacing to a laptop computer to perform diagnostic and calibration functions. The RPU shall have the capability for future expansion of the number of sensor inputs, serial ports, and shall be capable of adding digital outputs. Any units required for extending the normal operating range of pavement or meteorological sensors shall be compatible with and meet the same requirements as the main RPU. All

RPU units shall be contained in appropriate water tight and durable enclosures capable of continuous operation in the roadside environment and harsh weather conditions.

- RWIS Tower/Pole. The RPU enclosure and atmospheric sensors shall be mounted on a tower/pole approximately 30 feet high. The tower/pole with mounted equipment shall be capable of withstanding all local conditions with an appropriate factor of safety It shall be grounded with four ground rods, each 10 feet in length and connected with 00 ground cable. RWIS mounting tower/pole and foundation drawings shall be submitted for approval in accordance with the local specifications.

13.3.5.21 Pavement Sensors

Pavement sensors are solid-state electronic devices intended to be installed in the bridge deck or roadway pavement. Sensors shall be constructed of materials that have thermal characteristics similar to the bridge deck or pavement materials into which they are installed. They shall be flush-mounted in the bridge deck with an epoxy sealer, and be capable of withstanding high-volume traffic and snow plowing procedures conducted with maintenance trucks.

Pavement sensors shall be of both the active and passive type, installed in such a way to feed information to the EES/RWIS that allows the best detection of conditions.

- Active pavement sensors are defined as surface sensors that measure the freeze point by artificially cooling the surface of the sensor. Active sensors detect the formation of ice at the sensor head with any mixture of anti-icing chemical or liquid used during snow removal operations.

- Passive pavement sensors are defined as surface sensors that measure the physical properties of the pavement surface, or the moisture on the pavement surface without artificially cooling the sensor head and detect specific programmed types of anti-icing chemical used during snow removal operations.

The overall thickness of pavement sensors shall allow for complete encasement in concrete where the sensors are protected and seated for maximum operability. Sensors shall be affixed to the surrounding concrete with a TxDOT approved epoxy and care shall be taken during the installation to avoid damaging any roadway parts or the sensors. Sensors shall be recessed 1/8 inch to ¼ inch from the top of pavement or as recommended by the vendor/manufacturer. Pavement sensors shall be located in the approximate center of the anticipated driving lanes or as recommended by the vendor/manufacturer. A working drawing for the location and pattern of sensors shall be submitted to TxDOT for approval. The pattern, type and number of sensors shall be designed to provide adequate sensing of freezing conditions on the bridge or roadway. Passive sensors shall be calibrated for the anti-icing chemical to be used by the Developer; and recalibrated at Handback, if necessary, for the anti-icing chemical selected by TxDOT.

The Active/Passive surface sensors shall provide the following minimum pavement information, with values appropriate to the site conditions:

- Surface Temperature
- Surface Temperature Accuracy ±0.25°C
- Wet Surface Condition
- Presence of Moisture on Surface
- Presence of Frost or Ice on Surface

- Presence of Chemical on Surface
- Freezing point of the water/ice-control-chemical solution present on the surface
- State of Surface Condition with temperature below 0°C (32°F)
- Surface Sensor performance shall not be degraded by weather conditions, traffic, or road contaminants.

13.3.5.22 System Central Computer

The system shall be supplied with a central computer from a major manufacturer capable of effectively running the supplied TransVista software for remote operation of the anti-icing system.

13.3.5.23 Modem

The system shall be supplied with the necessary modems to provide communications between the RPU spray system controller, RWIS RPU, and central computer over standard telephone lines. The modems shall be industrial grade, intended for exterior installation, capable of operating in a temperature and humidity range appropriate for the site. The system shall be compatible with existing TransVista servers. The RPU shall be able to support communications with the central computer utilizing telephone line autodial/answer modem. Communications between the RPU and central computer shall be verified via user name and password method.

13.3.6 System Requirements

The Developer shall not start construction or installation of any part of the anti-icing system until the complete design and installation working drawings and installation schedule have been received and reviewed, and written approval to begin construction has been issued by TxDOT. Such approval shall not relieve the Developer of responsibility for results obtained by the use of the designs and drawings or any of the Developer's other responsibilities under the contract.

13.3.6.1 General

Developer is responsible to ensure that the System is designed to operate and be fully functional for all conditions at the site. Developer shall submit to TxDOT the parameters for which the system is designed for the following items:

- Ambient Environment. The System shall be able to withstand site temperatures with no permanent loss of function or component failure. The pavement sensors and nozzles shall withstand site temperatures with an adequate factor of safety.
- Operating Environment. The System shall accurately apply liquid anti-icing chemicals to a pavement surface in the site temperature ranges with an adequate factor of safety.

Other general requirements are:

- Chemical Environment. The System shall be able to safely store and apply the commonly encountered liquid anti-icing chemicals. Those liquid chemicals include but are not limited to: Calcium Chloride, Magnesium Chloride, Potassium Acetate, Sodium Chloride, Calcium Magnesium Acetate, and Calcium Magnesium Acetate/Potassium Acetate blend. The entire permanent anti-icing spray system components shall consist of materials that are resistant to corrosion from whatever chemical is selected by the Developer, and at Handback by TxDOT, for use in the system.

- Communications and Software. The System communication software delivered shall meet standard communication protocol specifications. The System shall communicate functions such as automatic system operation and display, the system software programs in the controller, tank level, pressure and fluid flow control along with manual operation of the system. The system data collection software shall run as a background service on the central computer. The central computer need not be logged on to the TransVista's network to continue to log data from the anti-icing system.
- Operating System. Latest Microsoft Business OS and minimum true 32-bit operating system or approved equivalent. The Engineer shall approve operating system at the time of installation.
- Software/Firmware. Client software shall not require OS administrative privilege to operate. Software/Firmware manufacturer shall support bug fixes and maintenance upgrades for a minimum of one year after system acceptance.
- Software Licensing. Developer shall provide a minimum of three remote access licenses and one license for the software on the central computer or a web based system.
- Users. The system shall permit a minimum of five simultaneous users with user configurable and changeable web access.
- Security. All communication to and from the RPU shall be verified by user name and password. The system shall provide two levels of password security, one with administrative configuration abilities, and the other user as read-only access. All passwords shall be stored in an encrypted format with no clear text. User accounts names and passwords shall be user definable and changeable. The system shall support a minimum of two user accounts within the RPU.
- Regulatory Requirements. The System shall comply with all applicable national, state, and local construction and safety codes.
- The System provided shall be capable of two-way communication using any or all of the following methods:

    - Computer Network. The System provided shall be capable of networking with wide area networks. The System provided shall utilize a current state of the art Windows Server approved by TxDOT. The server provided shall network with standard computers via modem, network router, and frame relay, etc.
    - Telephone Modem. The System provided shall be capable of supporting conventional telephone modem operation. This capability shall include the ability to originate, or receive, calls to remote control sites.
    - Onsite Hook-up. The System provided shall provide the capability for local onsite connection of a portable computer to the RPU spray controller and RWIS RPU compatible with TransVista's and TxDOT's equipment.

13.3.6.2 Control Options

The System provided shall provide for the control of the liquid chemical application with full automation. The system provided shall be capable of the following control modes:

- Fully Automated. The System operation shall be automatic utilizing user defined parameters and the pavement and weather conditions sensed by the RWIS.

- Manual Override. The System provided shall allow for manual override of the automated mode locally, at the site, or remotely.
- Fully Manual. The System provided shall respond only to a user generated command.

  Manual control options shall include the override ability by networked computers, modem, manual on-site locking pushbutton, or telephone.

13.3.6.3 Detection and Remediation

The System provided shall detect problems and compensate for these problems and notify the user of the problems by the following methods:

- Self-Check. The System provided shall detect chemical leakage and restrictions within the entire spray system. Additionally, the System provided shall detect hardware failures in all other connecting systems and alert the system user of the problem.
- Remediation. The System delivered shall provide for a single push button reset of normal functions upon completed system repairs or inspections. The system shall automatically detect system defects and take action without operator intervention to prevent system damage or environmental damage.
- User Notification. The System shall automatically notify system user through the central computer of detected problems including location of abnormalities and actions taken. The notification system shall include user definable and configurable alarms and notifications.

13.3.6.4 Inventory Tracking and Control

The System shall automatically provide tracking of material used by the anti-icing system.

The system shall provide inventory control. The system shall detect and report liquid levels in the tank throughout the range from full tank to empty tank. The status of the tank level shall be reported to the user using the communications system. The system also shall have alarms for full tank, low level refilling required, and low level-not sufficient chemical to operate the system. The system shall provide an alarm to the operator and an automatic shut-off to prevent system damage. All alarm levels shall be settable by system user.

13.3.6.5 Operating Capabilities

The System shall have the following basic operating capabilities as a minimum:

- Automatic system tests on a preprogrammed and/or timed basis. The system shall measure system pressure and quantity of liquid flow and prevent system operation if parameters exist outside of acceptable operating conditions.
- The system shall monitor and alarm for tank levels of low and or empty.
- Ability to activate a warning device before the spraying operation commences.
- The system shall be capable of going through a system evaluation before activating the spraying operation. This system evaluation shall check for system leaks, low chemical reservoir levels, and other system defects and shall not activate the system if any of these conditions exist. During system activation, the system shall evaluate if individual spray valves do not activate and shall document in the system log and alert the operator of these conditions.
- Autonomous operations based on various weather parameters in the RWIS.

The RWIS and pavement sensor technology shall include the following:

- The sensor technology must insure that the sensor shall work with any anti-icing chemical, multiple chemicals, varying water depths, oils, dirt, and other remaining residuals on the road surface that can change the freezing point temperature. This includes any potential chemical applied on the surface by maintenance trucks. Sensor technology must allow the system to have total user flexibility in system operation.

Pavement and atmospheric sensors shall allow the following detection of the system:

- Comparison of active and passive pavement sensors utilizing the advantages of each;
- Detection of accurate Freeze Point Pavement Temperature on the pavement which does not require re-calibration with each chemical used;
- Able to operate with multiple chemicals, for example when exposed to various combinations of truck-applied chemicals;
- Allows for system activation at different thresholds before freezing, for example, 1, 2, or 3 degrees before freezing, and provides accurate detection of freeze point temperature to –4 degrees F.
- The System provided shall allow for software logic programs that utilize all of the capabilities of the RWIS remote processor to properly interface with the anti-icing spray system controller. The System provided shall have user settable thresholds for adjusting automatic operation of the system;
    - System activation when road moisture is at or near freezing via user settable thresholds;
    - System activation when freeze point temperature sensors detect when pavement surface moisture is near freezing via user settable thresholds;
    - System activation when chemical dilution is occurring via user settable thresholds;
    - System activation and accurate freeze point temperature measurements even when multiple chemicals are used via user settable thresholds;
    - Accurate system activation without calibration of pavement sensors with changing chemicals;
    - Immediate system activation when falling snow or freezing precipitation is detected and surface temperatures is below user settable threshold;
    - The ability to include other weather parameters in the system logic such as low pavement temperature lockout according to different anti-icing chemicals for minimum temperature, relative humidity, etc. or high wind lockout, via user settable thresholds.

The system shall have a minimum number of different spray programs as recommended by the vendor, available for activation of the various nozzles, separate timed sequences, or separate circuits. A circuit is defined as a pump, supply lines, valve units and controlling device. These programs shall be capable of operating a minimum number of valves as specified by the vendor and as necessary for this site. Programs shall be capable of spraying each nozzle through its electromagnetic valve for a specific length of time, selectable from 1 to 10,000 milli-seconds. Programs shall be capable of changing the length of pauses between nozzle spraying, selectable from 1 to 10,000 seconds.

Manual override of system operations shall be available from any of the manual options. The system shall include the following manual operating capabilities:

- Manual pushbutton at the site;
- Remote (line of site from the roadway) pushbutton from hand held device, similar to a garage door opener;
- Activation from telephone voice or data transmission;
- Computer activation from a state of the art Web or Windows based PC software approved by the Engineer.

13.3.7 Commissioning, Testing, and Training

A qualified representative shall provide for the installation of the automatic anti-icing system including the start-up, alignment, and testing of the entire system. The chemical storage tanks and the entire system shall be filled to capacity with anti-icing chemical at commissioning of the system. The flush water storage tank shall be filled to capacity with clean, potable water at commissioning of the system.

13.3.8 Testing Requirements

An installation test of the system shall be conducted at the conclusion of installation in the presence of TxDOT. The installation test shall simulate the full range of functions the anti-icing system is intended to provide. A successful installation test is required before acceptance by TxDOT.

13.3.9 Training

A qualified representative shall provide a minimum of one eight hour day of on-site training.

This training shall cover operation, seasonal commissioning and decommissioning, and preventive maintenance of the fixed automatic anti-icing system. An allowance for up to five TxDOT and/or TransVista personnel shall be invited to the training. A TxDOT training session for up to twenty people will be given at the end of the Term.

13.3.10 Warranty

The system shall be warranted to meet the manufactures specifications and for defects in material and workmanship for a period of one year starting on the date of system acceptance. Both material and labor shall be covered by this warranty.

13.3.11 Submittals

The Developer shall submit the following for review and approval in accordance with the Contract Documents:

- Detailed design and installation working drawings for the complete anti-icing spray system with sufficient detail to allow review of all power and communications for compliance with the Specifications. Working drawings shall clearly indicate any and all deviations from the contract documents. The working drawings shall include specific details and exact locations of all system components including proprietary equipment.
- Compliance Traceability Matrix for all components including computer and electronic device hardware and software that give evidence of the compliance of each component or function with the requirements in these specifications and the vendors specifications.
- Communications Infrastructure Plan showing routing of electronic communications between devices in the field, between devices and computers, between systems, and between the field computers/systems and remote users.

- Installation schedule that shall outline the steps the Contractor intends to make to complete the contract. The installation schedule shall be revised and resubmitted if there is a significant change to the schedule.
- Contractor qualifications and resumes in accordance with the Contract Documents.
- Documentation of five years of proven field operation of the active pavement sensors in automated liquid anti-icing spray systems.
- Documentation of five years of proven field operation of the programmable system controller software in automated liquid anti-icing spray systems.
- Structural engineering design calculations and shop drawings for the pump house precast concrete building prepared and sealed by a Professional Engineer.
- Electrical engineering design calculations and shop drawings for the system prepared and sealed by a Professional Engineer.
- Mechanical engineering design calculations and shop drawings for the system prepared and sealed by a Professional Engineer.
- Working drawings and product data for doors, louvers, frames and all accessories and hardware for the pump house.
- Design calculations and working drawings for the pump house stair framing that have been prepared and sealed by a Professional Engineer.
- Working drawings for RWIS mounting pole and foundation.
- Product data sheets and certificates of conformance with the Specifications, and Quality Assurance reports for the following system components:

    1. Spray disks;
    2. Pavement sensors;
    3. Chemical pressure piping;
    4. Conduit for chemical pressure piping;
    5. Valve and valve controller;
    6. Pressurized accumulator tanks;
    7. System control cable;
    8. Sensor control cable;
    9. Conduit for sensor control cable and RPU slave unit power cable;
    10. Anti-icing chemical;
    11. Anti-icing chemical storage tanks;
    12. Flush water storage tank;
    13. Pump and motor;
    14. RPU spray system controller;
    15. RWIS RPU and all meteorological sensors;
    16. Modems;
    17. Uninterruptible power supply;
    18. Standby electric generator set;
    19. Automatic transfer switch for standby electric generator set;

20. TxDOT concrete, in accordance with the Standard Specifications, for cast-in-place building foundation;

21. TxDOT concrete, in accordance with the Standard Specifications, for precast building;

22. Epoxy resin waterproofing for concrete surfaces;

23. Deformed steel reinforcing bars, epoxy-coated;

24. 7-wire steel post-tensioning strand for precast building;

25. Silicone sealant and bond breaking tape for building joints;

26. Floor grating for building;

27. Removable handrail for building.

13.3.12 Operations and Maintenance Manual

The Developer shall furnish an Operations and Maintenance Manual, or O&M Manual, for the anti-icing system. The O&M Manual shall include detailed operation and maintenance instructions for all systems and items of equipment provided under the contract. The O&M

Manual shall be in the form of neatly formatted bound ring binders and electronic format in the form of CD-ROM disks. Prior to completion of the work, the Developer shall furnish for TxDOT's review five O&M Manual draft copies. At the end of the Term, the Developer shall furnish ten updated copies of the final O&M Manual.

The O&M Manual shall consist of product data sheets, brochures, bulletins, charts, schedules, approved working drawings corrected to as-built conditions, assembly drawings, wiring diagrams, operation and maintenance information for equipment, and other information necessary for TxDOT to establish an effective operating maintenance program. Oversized sheets and working drawings larger than 8.5 inches by 11 inches shall be neatly folded to that size with title block exposed along one edge, and bound or placed in pockets within the Manual.

The O&M Manual shall include:

- Title page giving the name and location of the facility, bridge plan numbers, and Project Numbers;
- Performance curves for all pumps and equipment;
- Approved working drawings of each component;
- Approved product data sheets and dimensioned drawings of each piece of equipment, and details of all replacement parts;
- Manufacturer's installation, operation, and maintenance instructions for each piece of equipment and complete listing of nameplate data;
- Complete wiring diagrams of all individual pieces of equipment and systems including one line diagrams, schematic or elementary diagrams, and interconnection diagrams;
- Complete piping and interconnection drawings;
- Complete parts list with parts assembly drawing preferably by exploded view, names and addresses of spare parts suppliers, recommended list of spare parts to be kept on hand by the Department, and sample order forms for ordering spare parts. Lead time required for ordering spare parts shall be estimated;

- Instructions with easily understood schematics or diagrams for disassembling and assembling the equipment for overhaul or repair.

Delivery of O&M Manual at initial operation and again at the end of the Term is an essential part of project delivery.