SPECIFICATION

FOR

INDUSTRIAL
STATIC VAR COMPENSATOR SYSTEMS

<$ 1,000,000

STATIC VAR COMPENSATOR SYSTEM

[Project NAME]

1. PROJECT INFORMATION

1.1. Purchaser:

1.2. Consulting Engineer:

1.3. Project Name:

1.4. Station Name:

1.5. Station Location:

2. PURPOSE

2.1. It is the intent and desire of the Owner to procure Static VAR Compensators (SVC) systems for [named facilities].

2.2. The purpose of the SVC systems is to maintain the voltage sag at the Point of Common Coupling to a maximum of X.X % of nominal, [12.47 kV] line, during starting of the equipment listed.

2.3. The Owner's Electric load is described in Appendix [A].

2.4. The Utility power system source impedance is described in Appendix [A].

2.5. The Utility power system performance standards are described in Appendix [A].

3. SCOPE OF WORK

3.1. Contractor shall design and furnish one (1) SVC system, each complete with control power transformers, capacitors, filtering and/or harmonic detuning reactors, switching devices, switching controller, disconnecting devices, interconnecting cables, connectors, mounting hardware, supports, etc. as required for a complete system.

3.2. The seller's scope of supply shall include but not limited to the following:

3.2.1. All engineering, fabrication, and supply of the components of the SVC system, their assembly and accessories.

3.2.2. Power transformers, if applicable, for SVC system connection to the power system.

3.2.3. The thyristor valves for reactive power control, including their protection, control and monitoring system.

3.2.4. All filtering reactors and capacitor banks as required by the initial design, and any subsequent changes required by the detailed system study.

3.2.5. Harmonic detuning filters as required by the specified harmonic performance levels.

3.2.6. All power system current and voltage sensing devices as required by the SVC system for proper operation.

3.2.7. Surge protection as required.

3.2.8. All internal support structures as required.

3.2.9. The metal enclosure, including structures, internal insulators, connectors, joints, fittings, etc., as required.

3.2.10. Provisions for Owners :

3.2.10.1. Ground cable connections, minimum two places.

3.2.10.2. Power cable connections, one each for three phases,

3.2.10.3. Neutral cable connection(s) if required by design

3.2.11. Any other equipment and engineering required for the proper functioning of the SVC.

3.3. In addition to the equipment supply, seller shall provide the following services and deliverables:

3.3.1. Power System Study:

3.3.1.1. Load flow study

3.3.1.1.1. Load flow study shall be performed in the initial stage to determine the SCV system equipment sizes and optimum operating point for different system conditions.

3.3.1.2. SVC Performance study

3.3.1.2.1. Harmonic analysis study in accordance with IEEE-519 as each site. The study shall cover the following as a minimum:

3.3.1.2.1.1. Voltage and current distortion analysis

3.3.1.2.1.2. Impedance scan analysis

3.3.2. Drawings and data:

3.3.2.1. Seller shall furnish drawings and all necessary data required for an adequate review of the pad design including cable locations, system layout (plot plan), general arrangements, schematics, wiring diagrams, complete bills of material for all components. Bill of materials shall include material specifications and seller's part number.

3.3.2.2. General arrangement drawings consisting of a composite outline of all equipment and mounting details. These drawings shall show all basic dimensions, tolerances, and required clearances for access, equipment removal and maintenance.

3.3.2.3. Electrical wiring and schematic diagrams showing cable terminations and internal point-to-point wiring.

3.3.3. Installation, Operation and Maintenance Manuals:

3.3.3.1. Seller shall furnish two (2) bound, final sets of complete installation, operating and maintenance manuals for all equipment furnished by Seller.

3.3.3.1.1. The information contained within the manuals shall be separated into logical groups or sections with identifying tabs.

3.3.3.1.2. Each manual shall have an index listing of all leaflets, drawings, sections, etc., in the same order as they appear in the manual.

3.3.3.1.3. One (1) set of electronic files of the construction manual material shall be submitted in addition to the final bound sets

3.3.3.2. Each manual shall include the following as a minimum:

3.3.3.2.1. Original Purchase Order (P.O.) and Serial Numbers.

3.3.3.2.2. Names, addresses, telephone numbers and email addresses for the following:

3.3.3.2.2.1. Factory

3.3.3.2.2.2. Engineering

3.3.3.2.2.3. Complete listing of all components and quantities furnished by Seller identified by the original manufacturer's part number as well as by Seller's identification number.

3.3.3.2.2.4. General arrangement drawings consisting of a composite outline of all equipment and mounting details. These drawings shall show all basic dimensions, tolerances, and required clearances for access, equipment removal and maintenance

3.3.3.2.2.5. Complete Bills of Material for all components, including all special appurtenances furnished with the equipment. Bill of Materials shall include Seller's part number

3.3.3.2.2.6. Drawings showing loading and foundation requirements, including dimensions and details of equipment including expansion anchor requirements (location, size, and spacing), base-plate dimensions, and total weight of the equipment

3.3.3.2.2.7. Recommended spare parts with supplier names, part numbers, and prices

3.3.3.2.2.8. Equipment transportation, handling and storage requirements

3.3.3.2.2.9. Recommended trouble-shooting procedures intended for use by owner or owner's representatives.

3.4. Field Services:

3.4.1.1. The Seller shall specify the per diem rates for field engineering personnel during the installation period and testing at each unit to assist and advise others in the erection and installation of the equipment, to resolve field problems due to Seller's design, and to give assistance and guidance in the startup and initial adjustment of all materials and devices provided by the Seller.

3.4.1.2. The Seller shall specify the per diem rates for the necessary engineering services as required to resolve operating problems as they develop until satisfactory operation, as determined by Owner, is achieved. Field engineering services and labor for work resulting from the correction of manufacturing errors shall be paid by the Seller.

3.4.1.2.1. The engineering personnel provided by the Seller shall be qualified to perform the duties required to the satisfaction of the Owner, and shall be capable of escalating decisions within sellers organization to receive responses in a timely manner.

4. MATERIALS AND SERVICES FURNISHED BY OWNER

4.1. Receipt, inspection, unloading and storage of the equipment furnished by the Seller

4.2. All concrete foundations

4.3. Anchor bolts including nuts and washers and other means of anchorage.

4.4. Installation of the equipment

4.5. Grounding materials and connection of same to supplier's equipment.

4.6. Supply of AC and DC power to contractors equipment as required

4.7. Power, control and cable and conduit (excluding interconnect cable by seller).

4.8. Commissioning of all equipment.

4.9. Temporary equipment storage area.

4.10. Storage area for spare parts.

5. CODES AND STANDARDS

5.1. All materials, equipment, products, accessories and essential services supplied under this Contract shall be designed, fabricated or constructed in accordance with the latest recommended practices and standards of all applicable local, state, and federal laws and codes. The codes shall include, but not be limited to:

5.1.1. American National Standards Institute (ANSI)

5.1.2. American Welding Society (AWS)

5.1.3. Insulated Cable Engineers Association (ICEA)

5.1.4. Institute of Electrical and electronics Engineers (IEEE)

5.1.5. Instrument Society of America (ISA)

5.1.6. National Electrical Code (NEC)

5.1.7. National Electrical Manufacturers Association (NEMA)

5.1.8. National Fire Protection Association (NFPA)

5.1.9. Underwriters' Laboratories (UL)

6. SITE CONDITIONS

6.1. Site environmental conditions

6.1.1. [name]

6.1.1.1. ..... Altitude of plant above sea level,

6.1.1.2. ..... Barometric pressure, inches, Hg

6.1.1.3. ..... Maximum outdoor ambient temperature, F (^{0}C)

6.1.1.4. ..... Minimum outdoor ambient temperature, F (^{0}C)

6.1.1.5. ..... Relative humidity, 5 % to 100%

6.1.1.6. ..... Wind: XXX mph basic wind speed and Exposure category [C]

6.1.1.7. ..... Seismic zone

6.1.1.8. ..... Snow loads shall be based on a 5 psf ground snow load.

7. POWER SYSTEM CHARACTERISTICS

7.1. Short circuit levels and impedances;

7.1.1. .....See Appendix A,

7.2. Fault Clearing Time:

7.2.1. The following clearing times are anticipated for faults on the [XXX] kV system.

7.2.1.1. Initiating relaying Time

7.2.1.1.1.1.1. ..... Primary Line ??? Cycles

7.2.1.1.1.1.2. ..... Back-up line ??? Cycles

7.2.1.1.1.1.3. ..... Breaker failure ??? Cycles

7.3. Voltage and frequency:

7.3.1. [Facility]

7.3.1.1.	Nominal distribution line voltage (L-L), 12.47 kV (1.0 pu)
7.3.1.2.	Maximum continuous voltage (L-L), 1.05 pu
7.3.1.3.	Minimum continuous voltage(L-L), 0.97pu
7.3.1.4.	Normal frequency, ... 60 Hz
7.3.1.5.	Maximum continuous frequency, 60.05 Hz
7.3.1.6.	Minimum continuous frequency, 59.95 Hz
7.3.1.7.	Minimum transient frequency, ?? Hz for ?? seconds
7.3.1.8.	Maximum transient frequency, ?? Hz for ?? seconds

7.4. Existing Insulation Levels

7.4.1.1.	12.47 kV system, ... 110 kV BIL
7.4.1.2.	4.16 kV system, ... 75 kV BIL

8. STATIC VAR SYSTEM SPECIFICATION REQUIREMENTS

8.1. SVC system General requirements

8.1.1. The SCV system shall be designed for outdoor installation on a concrete pad.

8.1.2. The SVC shall be designed for connection to the [**12.47**] kV line. See appendix A, SK-AF-01 for connection.

8.1.3. All enclosures furnished for the system shall have a NEMA 3R rating.

8.1.4. The following types of equipment may be furnished to perform the functions required by the specification:

8.1.4.1. Thyristor-controlled reactor, thyristor-switched capacitor (TCR-TSC)

8.1.4.2. Thyristor-switched capacitor (TSC)

8.1.5. SVC system shall utilize solid-state switches to apply capacitors, reactors, etc, in a stepped manner to automatically maintain system voltage, on a single cycle-response basis in order to mitigate sags caused by inductive loading by motors during start-up, operation and during stalls. Alternatively, the SVC system shall use a combination of harmonic filters, capacitors and phase controlled inductors to provide a variable supply of VARS.

8.1.6. SVC system shall have the appropriate number of solid –state semiconductor switches per phase for the required number of compensation combinations from 0 to the maximum required KVAR per phase. Each phase shall have independent compensation.

8.1.7. The SVC system shall be designed for [**15 kV**] Class, to limit the voltage sags, to a voltage resolution of no more than + or – designed delta V of 2.5% with a maximum response time of 1.1 cycles.

8.1.8. The SVC system shall be furnished complete with all required controls, and with the ability to interface with Owner's plant control system, if desired by Owner.

8.1.9. The existing system presently uses a soft start to start the 1750 hp compressor motor. The soft start is set for a maximum inrush current of 350% of full load current. Seller shall include the following as part of the bid:

8.1.9.1. For 2.5% Sag Limit

8.1.9.1.1. Base Bid I

8.1.9.1.1.1. SVC system design with 1750 hp compressor motor starting with the soft start set at 350% inrush current.

8.1.9.2. For 2.0% Sag Limit

8.1.9.2.1. Alternate Bid II

8.1.9.2.1.1. SVC system design with 1750 hp compressor motor starting with the soft start set at 350% inrush current.

8.2. Harmonics

8.2.1. The SVC system shall be designed to avoid resonance between capacitor banks, filter branches, any solid state devices shown on drawings provided, including variable frequency drives and reduced voltage soft starters and the remainer of ac system. The harmonic level on the 12.47 kV bus and the 4.16 kV bus shall not exceed the IEEE 519 limits, under worst case conditions of ambient temperature, frequency, unbalanced system voltage, and parameters of the SVC such as the valve firing variations, capacitors, reactors, etc.

8.3. Reliability and Availability:

8.3.1. Definitions

8.3.1.1. Forced outages: Outages caused by the SVC equipment which result in loss of essential functions of the SVC. These outages are initiated by protective devices.

8.3.1.2. Scheduled outages: Outages necessary for the preventive maintenance to assure continued and reliable operation of the SVC.

8.3.1.3. Outage duration: The elapsed time from the instant the SVC is out of service to the instant it is returned to service. If partial SVC capacity is available for service during non-working time spans, such time will not be included in the outage duration.

8.3.1.4. The following will be excluded in the outage duration:

8.3.1.4.1. The time required by system operators/technicians for disconnection and grounding of equipment in preparation for repair work, and for removal of grounds and reconnection of equipment after repairs are complete.

8.3.1.4.2. Delays caused by unavailability of qualified Customer personnel will be excluded from the outage duration

8.3.1.4.3. Delays caused by Customer failure to maintain recommended spares will be excluded from the outage duration

8.3.2. Partial outage: If partial SVC outage is available, the duration of equivalent outage shall be calculated as the product of the de-rated condition duration and the proportion of the nominal output range which cannot be achieved during this period.

8.3.3. Annual availability: The annual equivalent availability for forced outages in %, is defined as follows:

8.3.3.1.1. $$\left[1-\sum\left(\frac{Duration-of\ -equivalent-outage}{8760}\right)\right]*100$$

8.3.4. Required availability

8.3.4.1. The annual equivalent availability for forced outages for the SVC shall be at least 96%.

8.3.4.2. The Seller shall guarantee the quoted availability performance for the applicable warranty period.

8.3.4.3. If the actual performance is below the values above, the Seller shall provide corrections and modifications to meet the availability guarantees at no extra cost to the Owner.

8.4. Main SVC Components:

8.4.1. Thyristor Valves

8.4.1.1. Capacitor thyristor valves shall switch the AC current by allowing full current conduction or zero current conduction, thereby providing step changes in VAR output, and shall maintain the capacitors at negative peak line voltage while the thyristors are not conducting.

8.4.1.2. Thyristor valves shall be designed for maximum overvoltage and overcurrent stresses due to system faults and switching.

8.4.1.3. Thyristor valve design shall include an appropriate allowance for unequal voltage distribution across individual thyristors in the thyristor valve. A minimum of 10% redundant series thyristors, but no less than one redundant series thyristor, are required in each single-phase thyristor valve.

8.4.1.4. Thyristor valves shall be designed to ensure satisfactory operation to the overall performance requirements and including all accessories

8.4.1.5. The thyristor valves shall be designed to permit the Owner to easily determine the overall state from the customer interface.

8.4.1.6. The thyristor valves shall be designed to permit the Owner to easily determine the overall condition of the entire valve using quick field measurements.

8.4.1.7. Thyristor triggering means: redundant triggering systems shall be provided.

8.4.1.8. Thyristor ratings: Seller shall supply a standard data sheet of ratings for the thyristor proposed to be supplied.

8.4.1.9. Minimum valve protection shall include the following protective function:

8.4.1.9.1. Capacitor Valve: multiple firing circuits for each thyristor shall be provided.

8.4.1.9.2. Capacitor Valves: System shall be designed to sense over-and-under voltage conditions and respond to avoid damage to valve, capacitor, SVC, and electrical system.

8.4.1.9.3. Capacitor Valves: System shall have hardware and software to prevent firing of valves at the incorrect point on the waveform.

8.4.2. Capacitor Banks

8.4.2.1. The purpose of the capacitor banks shall be to provide the required leading VAR supply.

8.4.2.2. All banks shall be designed to avoid resonance with the AC power system.

8.4.2.3. Shunt capacitor banks shall include units and protective fuses, suitably connected in series and parallel, and an unbalanced protection scheme in each capacitor bank to provide alarms for possible capacitor failure.

8.4.2.4. Shunt capacitor banks operating as part of SVC systems shall include diagnostics to both alarm and deactivate system if unbalance exceeds a software-settable threshold.

8.4.2.5. Capacitors shall be capable of continuous operation at maximum working voltage up to 110% of rated voltage, as specified in IEEE std. 18.

8.4.2.6. Capacitor banks may be used in conjunction with reactors for the purpose of harmonic filtering. In this event, the bank rating shall be designed with adequate margins for the anticipated harmonic loading and the increased voltage stress due to the voltage rise across the filter reactor.

8.4.2.7. Series reactors to limit the peak inrush/outrush currents shall be supplied where necessary to stay within the rating of the new and existing switching devices.

8.4.2.8. The Seller shall submit information about the reactor impedances, as well as the harmonic overvoltage factor, that have been used for the calculating rated voltage and reactive power for the capacitor banks.

8.4.3. TSC Reactors

8.4.3.1. Air-core reactors in a form suitable for outdoor use shall be provided for dI/DT filtering. All air core reactors shall include over-temperature sensors.

8.4.3.2. If required harmonic reactors shall be provided utilizing either air-core or iron-core reactors provided in a form suitable for outdoor use. All harmonic filters shall include over-temperature protection.

8.4.3.3. Seller shall provide detailed reactor specifications with the proposal.

8.4.4. Surge Arresters

8.4.4.1. Seller shall supply all necessary surge arresters for protecting the SVC system equipment.

8.4.4.2. Surge arresters shall be of the metal oxide type.

8.4.5. Control Equipment

8.4.5.1. The primary purpose of the control of the SVC is to control the system voltage by having the SVC supply reactive power in response to measured system parameters.

8.4.5.2. The structure and function of the active SVC control shall consist all of the following:

8.4.5.2.1. Voltage, current, and reactive power measurements shall be measured at least 20 x per cycle.

8.4.5.2.2. SVC control by generation of the appropriate firing pulses to the thyristor valves. This shall be determined by the reactive power measurements and shall occur no less than once per cycle.

8.4.5.2.3. Supplementary control modules for damping and VAR control

8.4.5.2.4. Monitoring and protection of the control itself and the components it controls including but not limited to:

8.4.5.2.4.1. Orderly start-up and shutdown sequence, including auto-restart after a power outage.

8.4.5.2.4.2. Automatic voltage control, operative during start-up to prevent unnecessary switching of the reactive elements.

8.4.5.3. The control system components shall be housed in a NEMA 3R enclosure.

8.4.5.4. Control system protection: The control system protection shall include as a minimum the following:

8.4.5.4.1.1. Power supply failure

8.4.5.4.1.2. Cooling system failure (if applicable)

8.4.5.4.1.3. Over-temperature protection for all components

8.4.5.4.1.4. Capacitor loss/ current imbalance within an acceptable level

8.4.5.4.1.5. Loss of control power

8.4.5.4.1.6. Loss of synchronism including change in phase sequence or phase angle

8.4.5.4.1.7. Loss of system voltage (any phase)

8.4.5.4.1.8. System voltage above or below software pre-set levels.

8.4.5.4.1.9. Control system self monitoring alarms

8.4.5.5. Meter and control switches: Control of the SVC shall be possible from a local control panel, with provisions for remote data acquisition, monitoring and supervisory control. The local control and indication panel shall contain as a minimum the following items:

8.4.5.5.1. “On-Off” switch

8.4.5.5.2. “Trip” switch

8.4.5.5.3. SCV “On” indication

8.4.5.5.4. SVC “Off” indication

8.4.5.5.5. SVC “Trouble” Indication

8.4.5.5.6. Total reactive power generated/absorbed by the compensator

8.4.5.5.7. Currents through each thyristor valve

8.4.5.5.8. Primary voltage, single phase

8.4.5.5.9. Voltage reference setting

8.4.6. Disconnect Switches

8.4.6.1. As a minimum, the SVC shall be provided with a means of being visible disconnected from the power system for maintenance and repair. A fused disconnect switch or a removable circuit breaker shall provide this function. Provisions for grounding shall be provided. In addition, individual components shall be able to be disconnected by switches, removable links, or other means to facilitate testing.

8.4.6.2. Disconnect devices shall be adequately sized to carry the maximum steady-state current that can flow in (rms of the fundamental and harmonics), as well as the momentary currents due to faults.

9. STATIC VAR SYSTEM TESTS

9.1. General Requirements

9.1.1. Factory testing shall be performed in accordance with the latest applicable standards and any additional requirements in this specification

9.1.2. The Owner reserves the right for itself and/or his representative to be present and witness all tests.

9.1.3. Seller shall furnish all labor, materials, instrumentation and testing facilities for all tests in this specification

9.2. Notification of Tests

9.2.1. Seller shall give the Owner advanced notice of routine and factory acceptance tests two weeks before the actual testing date.

9.2.2. Seller shall furnish an inspection and test plan for the commissioning and fields verification two weeks before the beginning of the testing.

9.3. SVC system Commissioning Tests

9.3.1. The SVC commissioning tests are those tests performed at the site on the fully assembled SVC system, without having the SVC system connected to the power system. The test shall include but not be limited to the following:

9.3.1.1. Testing of the control and monitoring system.

9.3.1.2. Check of operation and indication of circuit breakers, disconnect switches, etc.

9.3.1.3. Capacitance check of capacitor banks

9.3.1.4. Inductor rating check

9.3.1.5. Thyristor valve measurement.

9.3.1.6. Check current and voltage transformers and devices.

9.3.1.7. Overall check of trip operations from protections to breakers

9.3.1.8. Check of circuits through interface.

9.4. Field Verification Tests

9.4.1. Upon satisfactory completion of the commissioning test, energizing of the SVC system and field verification tests shall be performed. These tests are performed at the site on the fully assembled SVC system with the SVC operating and connected to the power system. The tests shall include but not be limited to the following:

9.4.1.1. Measure and verify the compensator operation at nominal power system properties.

9.4.1.2. Verify start, stop, close loop, open loop and trip sequences.

9.4.1.3. Verify change of controls reference point and gain settings.

9.4.1.4. Verify the function of the manual control mode, and secondary voltage limiter.

9.4.1.5. Harmonic voltage measurements on the SVC system.

9.4.1.6. Check of supplementary control functions.

10. SPARE PARTS

10.1. Seller shall submit a Recommended Spare Parts List with its proposal. The parts, which Owner should carry in stock to properly maintain the equipment and minimize its outage time for a period of one year, shall be identified with an asterisk. The Recommended Spare Parts List shall

10.1.1. Be identified with Specification Number, equipment name, and facility name.

10.1.2. Be inclusive of, and applicable to all equipment components, auxiliaries, accessories, and materials being furnished under the contract.

10.1.3. Include for each recommended spare part the supplier's name, the unit price (which shall be firm for one year), quantity, description, part number, drawing references, etc., to completely identify the item and the equipment component for which it is recommended.

10.1.4. Be based upon furnishing the parts Ex-works, freight PPA. Contractor shall indicate the point of shipment, the amount included for freight charges and the lead-time required for delivering the spare parts after an order is placed.

10.2. Seller's proposal shall include a list of recommended test equipment and special tools for each site. The test equipment list and special tools list shall indicate the cost of each component for each site.

10.3. All requirements regarding quality control and documentation that apply to the original parts of the specified equipment shall apply equally to the spare parts of the specified equipment.

11. DELIVERY AND DESTINATION

11.1. Items shall be shipped free from contamination prior to packaging and shipping.

11.2. The weight, lifting points or center of gravity shall be indicated on the crate, skid or package by the shipper and shall be utilized to provide proper handling during loading, transfer between carriers and unloading.

11.3. Shipments by truck shall be marked for delivery to:

12. REFERENCE DRAWINGS

12.1. Drawings listed in Appendix A are part here of

APPENDIX A

DRAWING LIST

Drawing No.	Revision	Description

APPENDIX B

APPENDIX C