COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

FEWA STANDARD: S-POC-CAP-OUT-MV	
1 GENERAL This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to site, installation, site testing and commissioning of indoor type MV capacitor banks for improvement of power factor. Further detailed and specific data are contained in the drawings, data sheets and other documents that form part of these Bid Documents. Foundations, supporting structures and all electrical connections shall be provided even if every item is not mentioned particularly in this specification. The capacitor banks shall be connected/installed at MV busbars in primary or distribution substations outdoors as specified. All equipment shall be suitable for use in tropical climatic area and shall be capable of operating at its full ratings in the service conditions as specified. Outdoor capacitor banks shall include metallic enclosure with IP 54 Protection Degree, as specified. However, forced cooling of the container enclosure is not acceptable for heat dissipation. The series reactors of outdoor capacitor banks shall be of air core type separately floor mounted within a GRP enclosure. The outdoor capacitor banks and series reactors shall be installed in separate walled and fenced compounds, the compound gate shall be interlocked with the capacitor bank feeder earth switch. The capacitor banks shall be factory pre-assembled as far as possible to minimise the work required at site. The MV capacitor banks offered shall be complete in all respects necessary for their effective and trouble free operation when connected to the MV system.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

The 3-phase capacitor bank shall be composed of three stages switched by vacuum contactors. The capacitor bank shall not require periodic inspection. Maintenance such as replacement of failed capacitor units or blown fuses shall be done as required, but major maintenance intervals shall not be less than 15 years. The capacitor bank alarm, indication and control system shall be provided with interfacing to the SCMS/DMS. The capacitor banks shall be connected via single core power cables to the concerned switchgear busbar. The cable arrangement for those power cables shall be subject to approval of FEWA. For applicable technical standards, tests and general requirements reference shall be made to latest international standards.	
1.1 Drawings To be provided by the bidder / contractor **Drawing No. Title** 11kV Capacitor Bank Arrangement (Single-Phase)- 3 Stages 11kV Capacitor Bank Arrangement (Three-Phases)-3 Stages 22kV Capacitor Bank Arrangement (Single-Phases)-4 Stages 22kV Capacitor Bank Arrangement (Three-Phases)-4 Stages	
1.2 Equipment Identification and Colour Codes Concerning the MV Capacitor Bank Identification, reference shall be made to latest international standards.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2 TECHNICAL DESCRIPTION **2.1 General** The MV capacitor banks shall be installed indoor or outdoor based upon scope of works, and shall include, but not limited to: • One capacitor bank consisting of three stages as specified in the scope of work and shown in the tender drawings • Capacitor units (Capacitor elements in series and/or parallel connection) • Capacitor elements (internal) fuses • Capacitor elements (internal) discharge resistors • Series detuning reactors • Vacuum Contractors • Stage HRC fuses • Stage Surge arrester • Stage unbalance Current Transformers • Post insulators • Busbars • Protection equipment • Control and Supervision equipment • Interlockings • Tinned Copper busbar /cables • MV and LV cable termination compartments • Terminal connectors • Remote control cubicle, and • Other hardware and accessories required for complete functionally installation.	

2 Capacitor Units **2.2.1 General** Capacitor Units shall consist of: • Capacitor elements • Internal fuses • Discharge resistor • Stainless steel container with two bushings. A common and interchangeable design of capacitor unit shall be utilised for all banks. The Bidder/Contractor shall provide supportive calculations to confirm that the internal ambient temperature will not exceed the maximum operating temperature of the capacitor unit. Where the ambient air temperature, at the proposed location of the capacitor banks, is incompatible with the requirement of the present IEC recommendation, the Bidder/Contractor must agree the unit design with FEWA. The thermal stability test (type test) must then be repeated in order to prove the suitability of the design for the site conditions. Each capacitor units shall be designed to meet the following minimum requirements: a. Permanently connected across the capacitor elements built-in resistor to discharge the unit voltage after disconnecting to a value of 75 V within 10 minutes. b. Suitable for continuous operation at voltage between terminals of 1.10 times the rated voltage, excluding transients. c. Suitable for continuous operation at line current of 1.30 times the current which occurs at rated sinusoidal voltage and rated frequency excluding transients. d. Identically and of the same capacity. The output computed from the measured capacitance, at 25°C, rated voltage and frequency, shall not be less than rated kVAr and not more than 110 % of this value for each capacitor unit. The capacitor	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

unit having output kVAr beyond these limits shall not be accepted. The entire capacitor unit shall not have to be changed due to single capacitor element failure. It shall be able to continue in operation. Isolation of one capacitor unit in a group should not cause voltage unbalance of more than 110% rated voltage on the remaining capacitors in the group. During the design stage contractor shall submit the detailed calculation for selection of the capacitor unit rating and total number of units to be used for each stage of the capacitor bank for the approval of FEWA. The capacitor units shall have a record of production and field experience of not less than three years. Reference lists of supply and failure rate of capacitor of the same design and material shall be submitted with the bid.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.2.2 Capacitor (Elements) The dielectric material of a capacitor element shall consist of an all film material being suitable to operate the capacitors on continuous load under the specified ambient conditions. The capacitor should be completely leakage proof. The impregnant shall be according to IEC 60871 of a hydrocarbon type fluid characterised by high electrical strength (class III B – OSHA classification) and adequate physical and chemical properties and shall be non-PCB (Poly-Chlorinated-Biphenyl), but rapidly biologically degradable, non-poisonous, of trouble-free disposal and have a flash point >150^{o}C. In order to ensure good lonisation performance the aluminium foils shall be folded at the edge.	
2.2.2 Capacitor (Elements) Fuses Each capacitor (element) shall have an internal fuse combined with a secondary solid foil electrode to ensure safe disconnection from the circuit at the end of its normal working life. Fuses shall only rupture in case the related unit is subject to failure and shall be capable of breaking the current following a failure of the capacitor unit without hazard from the fuse or the capacitor. The ruptured fuse of each capacitor (element) shall withstand indefinitely the voltage imposed across it under all operating conditions. The remaining capacitor elements shall be able to operate within the capacitor unit without undue disturbance for a present number of unit capacitors. If one internal capacitor (element) fuse get burnt, this shall not affect the total power and capacitance of the concerned capacitor unit by more than 3 %. During the design stage contractor shall submit the detailed calculation for number of internal fuse element failure to be considered for safe operation and the setting to be adopted for unbalance protection relay alarm and tripping.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.2.4 Capacitor (Element) Container The capacitor elements container shall be constructed as specified in Technical Data Sheets. The capacitor elements shall be enclosed in a stainless steel housing with all joints welded and tested for liquid tightness. Standard corrosion protection of the manufacturer may be acceptable subject to approval of FEWA based upon the submission of the complete factory painting procedure. Further reference shall be made to latest international standards.	
2.2.5 Capacitor Unit Bushings Each capacitor unit shall have two outdoor terminal bushings which shall be hermetically soldered to the case. Terminal bushings shall be with a creepage distance as specified in the Technical Data Sheets. Connections between the bushings and elements and the bushings and container shall not rely on soldered joints for mechanical support. Sealing gaskets shall not be accepted.	
2.2.6 Connections The connection between individual capacitor units in the same block shall be such that a failed capacitor unit can be easily replaced. All interconnections between various components shall be preferably carried out with tinned copper bus bar only to avoid fatigue associated with magnetic forces during bank energisation.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.2.7 Nameplates Capacitor unit nameplate marking shall indicate the corresponding purchase contract number, year of manufacture, type of insulating liquid, rated capacitance, and ratio of measured capacitance to rated capacitance. The nameplate shall be made of stainless steel material. It shall be fixed permanently to the capacitor unit, sticking with glue is not acceptable. The nameplates shall meet requirements as specified in Technical Data Sheets.	
2.3 Series Reactors The transient current that flows on energising shall not exceed the rated making current of the vacuum contactor or circuit breaker controlling the bank. Current limiting/detuning reactors shall be connected in series with each sub-bank to limit the inrush current to an acceptable value and reduce harmonics to an acceptable level. The current which flows upon energising shall be declared and shall take into account the contribution from parallel connected capacitors. The reactors for indoor application at rated voltage 12 KV and below shall be iron -core reactors and shall be provided with supporting insulator including base plate and hardwares ready for installation. For rated voltage 36KV shall be air core reactor. mounted on suitably rated support insulators. The reactor shall be capable of withstanding the inrush currents, which can occur during the life of the capacitor bank. For further reactor requirements, reference shall be made to latest international standards.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.4 Protection **2.4.1 General** Sensitive loss of capacitance and fuse failure detection and alarm facilities complete with indication meters, relays, current transformers, balancing system, auxiliary relays, matching transformers, etc. as well as all related wiring, panels cubicles etc. shall be provided. The unbalance protection shall distinguish between a current unbalance arising as result of imbalanced voltages on the system or temperature variations and differences and the current imbalance caused when the blowing of a fuse or fuses results in loss of capacitance within the capacitor equipment. The unbalance protection for each stage shall comprise two steps with separate alarm and tripping contacts at each stage. The first stage relay is set to operate an alarm when a significant number of capacitor units have failed and the second stage relay shall initiate tripping after a preset time delay via a trip relay (block-close function) before the loss of capacitance has resulted in an unacceptable over-loading of any capacitor. The Bidder/Contractor shall submit a table showing the number of units that can be lost per phase and per series group for a period of 1 month without derating of the capacitor bank and without reduction in the designed life of the capacitor. The minimum number of unit capacitors to satisfy these requirements shall not be less than one.	
The range of settings of the relays shall be adjustable independently to cover the range of sensitivities and relays shall be accompanied by facilities of bias currents or other suitable means to compensate the protection for imbalance arising from variations in capacitance due to temperature variations and other differences occurring at various operating conditions. These features shall be adjustable to permit protection balance to be restored when defective capacitor units are replaced against spare units without requirement of unit selection according to their measured capacitance value.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

The following protection should be provided for each Capacitor Bank: • Short Circuit Protection for each Capacitor stage (stage HRC Fuses) • Over-currents due to capacitor bank bus faults and individual capacitor unit failure (numerical protection relay) • Stage Fuse Failure Indication • Capacitor Element Fuses • Over-voltage and under voltage (numerical protection relay). • Thermal Over-load Protection (numerical protection relay shall be suitable for automatic selection of required setting group depending upon number of stages in service or otherwise separate relays to be provided for each stage) • Earth Fault (numerical protection relay) • Stage Unbalance (numerical protection relay) The Bidder/Contractor shall co-ordinate the tripping scheme with main MV switchgear systems. Over-voltage / under-voltage, over-load protections may be combined within a single numerical relay designed specifically for protection of capacitor banks. Relays from the approved Contract Vendor list make only shall be utilised for capacitor bank protection. Protection relays shall be of numerical type with serial port for remote communication with SCMS/DMS.	
The detailed design of the protection scheme and the recommended relay settings with calculations shall be submitted during the engineering stage for approval.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.4.2 Overload Protection A first alarm shall be given at a current of approx. 110 to 120 % of the rated current if applied for more than approx. 30 min. A second alarm (selectable by links for tripping as well) shall be initiated at currents of 120 to 140 % of the rated current suitably time delayed to avoid spurious alarms (trippings) being situated during short time disturbances. Each stage of the overload protection shall be independently adjustable.	
2.4.3 Overcurrent Protection For currents above 140 % of the rated current a time delayed relay shall be provided to initiate tripping. An instantaneous element for initiating tripping at currents above 200 % of rated current and also co-ordinated with HRC fuses. However, properly secured against tripping due to inrush currents shall be added per phase with separate alarm and trip contacts.	
2.4.4 Overvoltage Protection and Surge Arrester The Bidder/Contractor shall propose and provide suitable overvoltage protection devices to control transferred internal and external overvoltages on the capacitor banks.Four Metal oxide surge arrestors for each stage or other specialised voltage limiting devices shall be used, the insulation level to be determined by the Bidder/Contractor, subject to the approval of FEWA. The Bidder/Contractor shall provide, for each proposed surge arrester on the system, details of and justification for the choice of technical data selected. Subsequent to the acceptance of the proposal and prior to the commencement of manufacture or ordering of surge arresters the Bidder/Contractor shall provide studies and calculations to show the correctness of the selected surge arrester.	
Sufficient evidence is to be provided by the Bidder/Contractor subject to the approval of FEWA if no overvoltage protection is considered necessary. In addition to surge Arrester, two stages (for alarm and tripping)over voltage relay are to be provided for each capacitor bank.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.4.5 Undervoltage Protection A three-phase under-voltage relay with a 60% drop-off and time delay of 1-20 sec (in 1 sec steps) shall detect the complete loss of MV supply and trip all MV contactors.	
2.4.6 Capacitor (Element) Fuses (Internal) The fuse shall only operate when the capacitor element it is protecting fails. The fuse shall not operate when the protected element discharges into a parallel connected and faulted element. The fuse shall not operate due to the inrush or outrush currents, which flow when the bank is energised or de-energised, or when a parallel connected bank is energised or de-energised. Facilities shall be provided to allow for safe simple and quick identification of defective capacitor units. Portable capacitance measurement bridge / test equipment or other means shall be supplied being able to defective units without need for breaking any connection of the capacitor banks.	
2.4.7 Stage External HRC Fuses In order to meet the fault level rating stated in data sheets, each contactor shall be protected by a set of HRC fuses. Three phase HRC fuses shall be provided for each stage. They shall be of modern industrial design, current limiting type and with a breaking capacity of over 100 kA. They should have a current rating of not less than 1.6 times the rated three phase capacitor unit current. HRC fuses shall conform to IEC 60282 requirements.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

External HRC fuses shall have a visual indicator when fuse link is blown HRC fuses shall be shipped separately from fuse holders to avoid any possible mechanical damage. External Fuse Links shall have the following characteristics: a. Accommodate the maximum system voltage. b. Accommodate inrush current due to switching operation. (including back-to-back switching) c. Capable of withstanding discharge current due to short-circuit faults external to the capacitor stage. d. Accommodate the maximum anticipated continuous capacitor-stage current allowing for system overvoltage, capacitor-stage tolerance and harmonic currents Operate as promptly as possible in response to an escalating capacitor-stage failure, and in all cases respond to a completely shorted stage; e. Capable of carrying 130 per cent of rated current of the capacitor stage. f. Include Fuse fails alarm contact for capacitor control panel and SCMS/DMS. Stages external fuses shall be furnished with metal bases and insert plugs. It shall be possible to replace external fuses without removing busbars or bus supports. The fuses should be selected to: i. Accommodate the maximum anticipated continuous capacitor-stage current allowing for system overvoltage, capacitor-stage tolerance and harmonic currents ii. Withstand the transient outrush current from a healthy capacitor stage that occurs when: a. Adjacent capacitor bank is energised (back-to-back switching); and b. When an adjacent capacitor stage fails. iii. Operate as promptly as possible in response to an escalating capacitor-stage failure, and in all cases respond to a completely shorted stage; and protect the capacitor stage from case rupture in accordance with applicable case-ruptures curves.	

2.4.8 Discharge Devices If particularly specified, additional rapid discharge reactor shall be provided to recharge the stage within reduced time instead of the normal time of 5 minute duration to control the voltage during fluctuating load conditions.	
2.4.9 Unbalance Protection Each capacitor bank stage shall be provided with an unbalanced protection scheme to initiate an alarm when a number of elements in an internally fused type are lost. The scheme shall switch the stage out of service when there is an overvoltage of 10% or more on the remaining parallel unit after a fuse (or fuses) is blown. The selected unbalanced protection scheme shall be based on the following characteristics: • Shall not be sensitive to harmonics • Shall not be sensitive to normal phase voltage and phase impedance unbalance • Shall not operate due to switching transient • Shall not trip before the fuse has time to clear. The unbalanced protection equipment shall include current transformer with two stage-unbalance relays. The range of settings of the relays shall be adjustable independently to cover the range of sensitivities and relays shall be accompanied by facilities of bias current or other suitable means to suitable means to compensate the protection for unbalance arising from variations in capacitance due to temperature variations and other differences occurring at various operating conditions.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.5 Capacitor Bank Control **2.5.1 General** Automatic and manual switching control shall be provided for the individual stages. Switching itself shall be provided by means of vacuum contactors as specified below. The operating mode of each Capacitor bank shall be selectable via an Auto/Manual/Off switch. There shall be ON/OFF push buttons for manual Close/Trip. Manual closing shall only be possible with the selector switch in Manual position. In automatic mode a numerical type of reactive power regulator including harmonic current supervision shall provide automatic control to switch in/out the individual stages depending on the measured power factor and respective set values. Time delay facilities shall be provided in the control circuit to inhibit any contactor reclosing within a set time delay. The delay shall be adjustable over the range 0-10 minutes. Switching on of the MV incoming circuit breaker or isolator/earthing switch shall also be prevented during up to 10 minutes to allow for discharging of the capacitors. Paralleling of MV busbars and any necessary interlocking schemes shall be considered in the control scheme. Provision should be made to integrate the capacitor bank control/alarm/indication into the SCMS/DMS by use of approved protocols, preferably IEC. It should include switching from manual to automatic modes and manual control. The detailed design of the complete control system including the type of numerical power factor control unit shall be subject to FEWA approval.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.5.2 Control Panel For Control Panel requirements, reference shall be made to latest international standards.	
2.6 Vacuum Contactors (11kV) Each capacitor bank stage shall be controlled by a suitable vacuum contactor for switching in and out the respective capacitor rack, according to the capacitive demand required by the system operating conditions. The contactor shall be of three-pole type. The contactors shall have a good record of production and experience of not less than five (5) years. The interrupter shall be completely sealed utilizing vacuum as the interrupting dielectric. The contactor shall be restrike-free and shall not produce excessive transient overvoltage. Tripping mechanism shall be of quick-trip type within 5 cycles after applying a trip signal. At least four NO/NC mechanically operated auxiliary contacts each shall be provided, rated not less than 5A, 230 V AC. The contactors shall be provided with operation counter and position indicator to indicate the closed or open position. The contactor shall be supplied with undervoltage relay and associated control circuit in order that the contactor shall be opened when loss of MV bus voltages occurs. Complete control circuit for the contactor / controller and protection relays shall be fed from the station D.C supply only. The contactors shall be maintenance free. All mounting hardwares shall be supplied.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.7 Vacuum Circuit Breaker (22kV) Each capacitor bank stage shall be controlled by a suitable vacuum circuit breaker for switching in and out the respective capacitor rack, according to the capacitive demand required by the system operating conditions. The circuit breaker shall be of three-pole type. The circuit breakers shall have a good record of production and experience of not less than five (5) years. The interrupter shall be completely sealed utilizing vacuum as the interrupting dielectric. The circuit breaker shall be restrike-free and shall not produce excessive transient overvoltage. Tripping mechanism shall be of quick-trip type within 5 cycles after applying a trip signal. At least four NO/NC mechanically operated auxiliary contacts each shall be provided, rated not less than 5A, 230 V AC. The circuit breaker shall be provided with operation counter and position indicator to indicate the closed or open position. The circuit breaker shall be supplied with undervoltage relay and associated control circuit in order that the contactor shall be opened when loss of MV bus voltages occurs. Complete control circuit for the contactor / controller and protection relays shall be fed from the station D.C supply only. The circuit breaker shall be maintenance free. All mounting hardwares shall be supplied.	
2.8 Capacitor Bank Feeder Circuit Breaker For Capacitor Bank Feeder Circuit Breaker requirements, reference shall be made to latest international standards	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.9 Interlocking and Earthing Interlocking scheme shall be provided for: • Prevent closing the capacitor bank feeder circuit breaker when any gate/door of the capacitor bank compound / room is open • Prevent closing any grounding switch of the energised capacitor bank, and • Prevent opening of any gate/door directly to the capacitor bank . Compound / room unless the capacitor bank feeder earth switch is closed. • Design of the control scheme shall be such that, all stages of vacuum contactors shall be closed automatically to ensure earth continuity of the complete bank for safe maintenance. . The vacuum contactors shall close automatically with time delay of 10 minutes after the capacitor bank feeder earth switch is closed. After de-energising, and closing the capacitor bank feeder earth switch an interlocking time delay of 10 minutes shall be provided before access to the capacitor bank room or compound can be achieved. Portable, insulated earthing equipment shall also be provided to earth and ensure discharge of the capacitor units before handling. This portable earth to be of special design equipped with insulated stick to enable the operator for safe earthing, more over there should be leads from the capacitors to facilitate connection of the earth .	
2.10 Warning Signs Warning signs to prevent closing the grounding switch when capacitors are not fully discharged shall be provided.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.11 Losses and Temperature Rise Losses shall not exceed the value stated in Technical Data Sheets under rated conditions. The guaranteed minimum value of losses of the capacitor unit shall include the losses of the internal discharge resistor. The temperature rise any part of the capacitor bank and associated equipment shall not exceed the maximum permissible temperatures specified in the associated IEC Standards for the various components when operating under site conditions.	
2.12 Capacitor Bank Enclosure **2.12.1 General** The enclosure design shall be such that there is adequate dissipation by radiation and convection of the heat generated by capacitor losses. The arrangement shall be naturally ventilated and the maximum temperature of all components shall not exceed the specified values under all site conditions. The arrangement of the enclosure and its equipment shall be such as to provide easy access for replacement of the equipment units and safety of operating staff shall be ensured. Each stage of the capacitor bank must be completely segregated from the other stages. The busbars must pass through bushing insulators in between the cubicles. The metallic enclosure for shall meet the requirements as specified in the Technical Data Sheets.	
2.12.2 Corrosion Protection For Corrosion Protection/Painting measures, reference shall be made to latest international standards.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

2.13 Cable Connections **2.13.1 MV Cables** For the MV XLPE cables reference shall be made to latest international standards.	
2.13.2 LV Multicore Auxiliary Cables For LV power & control cables reference shall be made to latest international standards.	
2.14 Labels and Plates Rating plates, labels and other markings shall be clear, indelible, in the English language, and in accordance with IEC 60871. Drawings of stainless steel rating plates shall be submitted for approval.	
2.15 Busbars and Connections The spacing between busbar phases shall provide the necessary clearance for the voltage rating and shall be completely insulated in an approved manner (i.e. coat insulation or shrinkable tube). Taping of busbars will not be accepted.	
The main busbar connections and their supports shall be of an approved type and shall be capable of carrying the rated short circuit duty of the installation. All connections (copper conductor, cable, flat busbar etc,) from HRC fuses to the remaining part for each stage shall have a minimum continuous current rating of not less than 200% of the respective stage rating.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3 TESTING AND INSPECTION

3. 1 Type Tests

Type tests may be omitted if acceptable test records can be submitted, unless specified otherwise. The design tests shall conform with IEC and must include at least the following:

a. If applicable, complete assembled capacitor banks according to IEC 62271-200 and IEC 60694 recommendations. In all cases the design of the completed equipment shall be verified by Temperature Rise Tests, LI Withstand Test and Ingress Protection Test.

b. Capacitor Units

   i. Thermal stability test
   ii. Capacitor loss angle
   iii. A.C. voltage test between terminals and container
   iv. Lightning impulse voltage test between terminals and container
   v. Short circuit discharge test

a. Capacitor Stage Contactors

   m) Insulation (dielectric) test
   n) Short time current test
   o) Rated making current test
   p) Operating duty test
   q) Temperature rise test
   r) Radio influence voltage test
   s) Mechanical life test
   t) Control wiring test.

b. Fuses according to IEC 60549 / 60282 recommendations

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3.2 Routine Tests Routine tests shall be performed according to IEC Standards and shall be witnessed by FEWA unless otherwise waived in writing:	
3.3 Site Tests **3.3.1 General Requirements** Not less than one month prior to the commencement of site testing, the Bidder/Contractor shall submit to FEWA the Site Test and Commissioning procedure (SAT). The tests shall be carried out as per approved SAT document. No testing shall commence until the format and test procedures are agreed and all results shall be submitted on the approved form. Testing shall be carried out during normal working hours as far as practicable. Tests, which involve existing apparatus and outages, may be carried out outside normal working hours. The Bidder/Contractor shall give sufficient notice to allow for the necessary outage arrangements to be made in conformity with the testing programme. The Bidder/Contractor shall advise FEWA in writing at the time of commencement of site erection of the site supplies, which will be required for the operation of the test equipment.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

The Bidder/Contractor shall provide the requisite experienced test personnel and all relevant test equipment, unless otherwise agreed by FEWA or stated in the Schedules. On completion of any group of tests the Bidder/Contractor shall submit two clean copies of the test results recorded on the approved form. FEWA shall countersign the test sheets found to be satisfactory and retain one copy. The Bidder/Contractor shall subsequently provide to FEWA six bound copies of all site test sheets as final records. The test sheets shall be grouped by substation sub-divided by plant type and further on a circuit-by-circuit basis. So that the records may be used for maintenance tests the final records shall be provided as soon as possible after completion of testing. No tests as agreed under the programme of tests shall be waived except upon the instruction of FEWA in writing. All tests shall be carried out in the presence of FEWA unless otherwise agreed. The Bidder/Contractor shall carry out all the necessary tests for the Capacitor bank units, cables and other associated equipment and submit a report that they are ready for commissioning. Tests on the Capacitor Bank Units will be carried out by the Bidder/Contractor under the supervision of the manufacturer and energised by the Engineer from FEWA, after witnessing necessary commissioning tests carried out by the Bidder/Contractor. Any defects noticed during commissioning due to poor workmanship, wrong phasing or any other reason shall be made good by the Bidder/Contractor immediately. Any defects noticed due to poor workmanship in the guarantee period must be rectified by the Bidder/Contractor to the satisfaction of FEWA. The Site Tests include but not limited to:	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3.3.2 Tests on Capacitor Bank Units and Auxiliary Equipment **3.3.2.1 General Checks** A general check of all the main switchgear, labelling and ancillary equipment shall be made and shall include a check of the completeness, correctness and condition of earth connections, painted surfaces, cables, wiring, plates and all other auxiliary and ancillary items. Checks shall be made for any leaks, and that insulators are clean and free from external damage. A check shall be made that loose items which are to be taken over by FEWA, e.g. tools, spares, are in order and are correctly stored for taking over. Shutters, interlocking, earthing procedures and the interchangeability of components shall be checked.	
3.3.2.2 Continuity of Cable Connections and Phasing Continuity of cable connections and phasing sequence to be checked.	
3.3.2.3 Insulation between Phases, Insulation to Earth Insulation resistance between phases and to earth shall be measured.	
3.3.2.4 Testing of Current Transformers on the Capacitor Bank The Bidder/Contractor shall be responsible for performing all required tests on the Current transformers installed in the Capacitor Bank Unit.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3.3.2.5 Protection The Bidder/Contractor will be responsible for carrying out required tests to prove the correct operation of the following equipment under the manufacturers supervision. • Capacitor Bank Feeder Circuit Breaker • Capacitor stage Contactor • Short Circuit Protection (3 phase) • External HRC Fuse Failure Indication • Overvoltage Protection • Undervoltage Protection • Overload Protection • Earth fault Protection • Unbalance Protection • Relay service settings will be provided by the Manufacturer of the capacitor bank.	
3.3.2.6 Mechanical Inspection All relays are to be examined to ensure that they are in proper working condition and correctly adjusted, correctly labelled and that the relay case, cover, glass and gaskets are in good order and properly fitting.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3.3.2.7 DC Operations Tests are to be carried out to prove the correctness of all dc polarities, the operating levels of dc relays and the correct functioning of dc relay schemes, selection and control switching, indicating and alarms.	
3.3.2.8 Wiring Inter-relay, inter-unit and cubicle wiring, if carried out at site is to be checked to the appropriate circuit wiring diagram. Where it is found necessary during pre-commissioning work, to effect site modifications to the secondary wiring, site copies of the appropriate schematic and wiring diagrams shall be suitably marked as agreed with FEWA before the circuit is commissioned. Loop resistance measurements are to be made on all current transformer circuits.	
3.3.2.9 Secondary Injection Secondary injection test shall be carried out on all relays, meters using voltage and current of sinusoidal waveform at rated power frequency.	
3.3.2.10 Operation of Power Factor Regulator Functional testing of the numerical power factor regulator shall be carried out.	
3.3.2.11 Interlocking and Trip Tests All interlocking arrangements both electrical and mechanical shall be fully checked and tested. Tripping of MV Capacitor Bank Feeder Circuit Breaker ensured by operation of all associated protections.	
3.3.2.12 System Measurements of Harmonics In order to ensure that installation of the Capacitor Banks has not affected the system, System measurement of harmonics shall be carried out by the Bidder/Contractor.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

3.3.2.13 Power Factor Measurement power factor after capacitor bank commissioning.	
3.3.2.14 On Load Tests In view of the hazards inherent in these tests, they shall be carried out under the direct supervision of FEWA. An operation and stability test shall be carried out for on load commissioning of each bank. On load checks shall be made after the protection gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed as well as to confirm the integrity of the current transformer circuits. Where necessary voltage and current readings shall be taken at the terminals on each relay to ensure that loop connections between the relays are complete.	
4 LOSS EVALUATION **4.1 General** Evaluated cost of the capacitor bank shall be based on the following equation: A = B + 1530 C * total bank kVAR where A = Evaluation cost of capacitor bank and equipment in DIRHAM. B = Cost of capacitor bank and equipment in DIRHAM. C = Capacitor loss tan δ of capacitor unit with discharge resistor, measured at evaluated temperature in %.	

COMMENTS TO FEWA STANDARD: S-POC-CAP-OUTD-MV FEWA-CB6.3-OUT-COMM-0

4.2 Compensation for LOSS Beyond Quoted Value Bidders/Contractors shall quote capacitor losses measured at elevated temperature otherwise such offer shall be rejected. If the quoted value is lower than the average value witnessed by FEWA during FAT, compensation to FEWA shall be made at the rate of 300 DIRHAMs per % for the exceeding loss tan δ times total purchased KVAr.	