MATERIAL AND EQUIPMENT STANDARD

FOR

POWER FACTOR IMPROVEMENT CAPACITOR

FIRST EDITION

SEPTEMBER 2006
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1. SCOPE

1.1 This Standard specification covers the minimum requirements for design, manufacture and quality control of power factor correction capacitors.

1.2 Capacitors will be installed in oil, gas and petrochemical industries in Iran under the environmental and service conditions specified herein.

1.3 The general requirements are given in this specification; the specific requirements of individual cases will be given in request for quotation and/or purchase order.

Note: The specification number of the revised version of this standard specification is changed from IPS-M-EL-180 to IPS-M-EL-181(1).

2. REFERENCES

2.1 The equipment under this specification shall be designed, manufactured, inspected and tested in accordance with the applicable sections of the latest edition of the following International Electrotechnical Commission “IEC” standards.

- IEC 60831-1  Shunt Power Capacitor of the Self-Healing Type for a.c. Systems having a rated Voltage up to and including 1000V- General Performance, Testing and Rating, Safety Requirements, guide for Installation and Operation.
- IEC 60831-2  Shunt Power Capacitor of the Self-Healing Type for a.c. Systems having a rated Voltage up to and including 1000V-Ageing Test, Self Healing Test and Destruction Test
- IEC 60871-1  Shunt Capacitors for a.c. Power Systems Having a Rated Voltage above 1000V-General
- IEC 60871-2  Shunt Capacitors for a.c. Power Systems Having a Rated Voltage above 1000V-Endurance Testing
- IEC 60871-3  Shunt Capacitors for a.c. Power Systems Having a Rated Voltage above 1000V-Protection of shunt capacitors and shunt Capacitor banks
- IEC-60871-4  Shunt Capacitors for a.c. Power Systems Having a Rated Voltage above 1000V-Internal fuses
- IEC 60529  Degree of Protection Provided by Enclosures

2.2 Any deviation from this specification and the above mentioned references shall be clearly mentioned in the vendor's proposal.

3. SERVICE CONDITION

3.1 The equipment specified herein will be installed indoor or outdoor as indicated in data sheet.

3.2 The maximum and minimum air temperature, relative humidity and the elevation of the location in which the capacitor will be installed will be indicated in data sheet.

3.3 The atmosphere is saliferrous, dusty and corrosive as commonly encountered in oil, gas and petrochemical installations.
3.4 The supplier shall indicate the capacitor temperature category in the form recommended in IEC 60831-1 or IEC 60871-1 e.g. -40/A, -5/C etc. The number represents the lowest ambient air temperature at which the capacitor may operate and the letter represents the upper limit of temperature range (maximum ambient temperature for category A capacitor is 40°C, category B is 45°C, category C is 50°C and category D is 55°C).

3.5 The system voltages will be three phases symmetrical and the variation will be ±10% of the rated voltage.

3.6 The nominal rated frequency is 50Hz. The system frequency variation will be ±5% of rated frequency, unless otherwise indicated in data sheet.

3.7 The voltage levels adopted in the oil, gas and petrochemical industries of Iran are based on the IEC recommendation No. 60038. The nominal voltage of the system in which the capacitor will be installed will be indicated in data sheet.

3.8 The low voltage power system is 400 volt three phase and 230 volt single phase with solidly earthed neutral. In this standard specification 400 volt three phase or 230 volt single phase capacitors are referred to as low voltage capacitors.

3.9 Capacitors for system voltages of 6 kV three phase are referred to as medium voltage and capacitors with voltages above 6 kV are referred to as high voltage capacitors. Unless otherwise indicated in data sheet the neutral point of medium and high voltage systems are earthed through current limiting resistors.

4. APPLICATION

4.1 Terminologies used in this standard specification, such as capacitor element, capacitor unit and capacitor bank are defined in IEC 60831 and IEC 60871.

4.2 Prior to capacitor selection, the system power factor shall be evaluated, taking into account all the distribution equipment such as transformers, feeder cables and all the loads at rated design values.

4.3 Where the calculated system power factor at full load is less than 85% lagging, capacitor bank/s shall be installed. The capacitor bank/s shall be sized to improve the system power factor to 95% lagging at system full load.

4.4 In case where the calculated system power factor at full load is more than 85% but less than 90% lagging, power factor correction capacitor/s will be required when power is received from outside source/s. In such case the capacitor bank/s shall be sized to improve the system power factor to 95% lagging at system full load.

4.5 Capacitor banks shall be installed in the main power plant or in individual substations to compensate the reactive power globally. The main power plant is where the power is generated by in house generators or where the power is received from outside sources. Substations receive power from the main power plant and feed the electrical consumers.

4.6 Capacitor banks shall be connected to distribution switchgear or motor control centers by means of suitable switching devices.

4.7 The switching devices shall be approved for such duty and shall be rated for 1.5 times of rated current of the capacitor banks. They shall be able to withstand transient inrush currents of up to 100 times of rated current of the capacitor banks. The switching devices shall be equipped with suitable over current protections.

4.8 Connecting cables between the switching device and the capacitor bank shall have a continuous current rating of 1.5 times the nominal current rating of the capacitor bank.
4.9 Each capacitor bank shall be installed as an independent equipment. Installation of capacitor or capacitor bank parallel to individual motor which is switched on and off together with the motor is not desirable, and can only be adopted for special applications when approved by Company representative. For such application, the power of the capacitor shall be less than the power required for the self excitation of the motor at no load.

4.10 Medium and high voltage capacitor banks shall be fixed which can be applied as one bank or two banks, and shall be energized manually. In case of installing two banks in parallel, the inrush current of the capacitor bank in parallel with the energized one shall be investigated and current limiting reactors shall be used when necessary (refer to Annex B of IEC 60831-1 and Annex D of IEC 60871-1 for Inrush Transient Current).

4.11 In low voltage systems, automatically controlled capacitor bank which regulates reactive power may be adopted in order to keep the power factor at 90% to 100% lagging. Automatically controlled scheme can be adopted when the capacitor kVAR is more than 15% of the size of upstream transformer in kVA. In such case a power factor controller can be included to connect or disconnect capacitors as required. The number of steps for connecting capacitors shall be approved by company representative.

4.12 The power factor controller includes power factor sensor (or regulator) together with appropriate contactors and protective devices. Devices used in the power factor controller shall be according to IPS-M-EL-143(1) (low voltage switchgear and controlgear).

4.13 Three phase medium and high voltage capacitor banks can be connected Delta, star or double star. The supplier shall indicate the connection mode in data sheet.

4.14 Three phase low voltage capacitor banks shall be connected Delta.

4.15 Medium and high voltage capacitor banks of 1000 kVAR and above shall be connected as double star. Double star capacitor banks shall be equipped with unbalance protection monitoring the current flowing between the two neutrals of the star connections.

4.16 When a network or a transformer supplies power to devices which generate harmonics such as variable speed drives or big battery chargers, UPSs, etc. The capacitor voltage shall be increased and detuning reactors shall be connected in series with the capacitor bank/s.

4.17 When the harmonic generating load is less than 20% of the total load, the voltage of the power factor correction capacitors shall be increased by at least 10%. In case where more than 20% of the total load is harmonic generating, detuning reactors shall additionally be supplied with the capacitor bank.

4.18 The detuning reactors shall be sized so that the resonance frequency of the detuned capacitor bank shall be at the frequency of the 5th harmonic.

4.19 When reactor is used in series with capacitor bank as detuning reactor or current limiting reactor, the kVAR rating of the capacitor at 50 Hz shall be increased so that the kVAR of the combined capacitor plus reactor shall be equal to the required kVAR indicated in data sheet. More over the voltage rating of the capacitor shall be increased proportional to reactor voltage.

5. CONSTRUCTION REQUIREMENTS

5.1 Enclosure

5.1.1 The capacitor bank shall be metal enclosed self supporting, free standing, floor mounted made of sheet steel with minimum thickness of 2 mm. In case of special applications such as capacitors which operate parallel to individual motor or other equipment the enclosure need not be floor mounted. Modular design enclosure/s is preferred.
5.1.2 The enclosure shall be suitably subdivided into separate compartments, such as power entrance compartment, capacitor compartment and when required switching compartment. The internal partitions shall be metallic and shall be earthed.

5.1.3 Unless otherwise specified in data sheet, the degree of protection of indoor enclosure shall be IP 41 and that of outdoor enclosure shall be IP 54 according to IEC 60529 without using the floor as part of the enclosure. Outdoor enclosure shall be provided with sloping sun shade.

5.1.4 The capacitor compartment and the switching compartment shall be equipped with a wide view window to facilitate checking of capacitors, capacitor fuses and switching devices without opening the doors or de-energizing the capacitor bank.

5.1.5 The capacitor compartment shall be properly ventilated. When forced ventilation is required, thermostatically controlled fan/s shall be supplied.

5.1.6 The enclosure shall be properly degreased, phosphatized, cleaned and painted from inside and outside. The painting shall be done by means of electrostatic powder coating based on epoxy and polyester resins. The color of the enclosure will be decided by company representative. Manufacturer’s standard painting system, if different from above shall be agreed by company representative.

5.1.7 Door/s of the enclosure/s shall be equipped with proper danger and warning sign.

5.1.8 The enclosure/s shall include provisions to be effectively grounded at two locations.

5.2 Capacitor Units

5.2.1 Low voltage capacitors shall be of the self-healing type and shall comply with the requirements of IEC 60831 and may be of either three phase or single phase construction.

5.2.2 Medium voltage and High voltage capacitors shall comply with the requirements of IEC 60871.

5.2.3 Capacitor units may consist of one or more capacitor elements. The electrodes and dielectric materials of the capacitor elements shall be indicated in data sheet.

5.2.4 Each capacitor unit shall be enclosed in a sealed case. The case of low voltage capacitor unit shall be aluminum. The case of medium voltage and high voltage capacitor unit shall be welded steel.

5.2.5 The leads of each capacitor unit shall be brought out through sealed connectors or bushings made of high quality resin or porcelain. The complete assembly shall be a sealed unit.

5.2.6 The insulating medium of low voltage capacitor units shall be according to IEC recommendation and shall be indicated in data sheet. Dry type air insulated capacitor is acceptable for low voltage application. The insulating medium shall be suitable for the maximum ambient temperature or room temperature indicated in data sheet.

5.2.7 Medium and high voltage capacitor units shall be oil filled. The units shall not contain polychlorinated biphenyl (PCB). The supplier shall indicate the insulating medium of the capacitor units in data sheet.

5.2.8 Suitable means shall be provided on the metal case of each capacitor unit for connecting the metal case to ground.

5.3 Internal Fuses

5.3.1 Internal fuses shall be provided to effectively remove a capacitor unit from the circuit in case of capacitor unit failure. Operation of a capacitor fuse shall be indicated by a suitable visible means.
5.3.2 For low voltage capacitor units, internal over pressure disconnectors can be supplied instead of fuses.

5.3.3 Internal fuses shall comply with IEC 60871-4.

5.4 Discharge resistor

5.4.1 Low voltage capacitor unit shall be provided with a discharge resistor to discharge the stored energy of the capacitor and reduce the voltage of the unit from the peak voltage of \(\sqrt{2}\) times the rated voltage to 75 volt or less in 3 minutes after disconnection. The method of connection of the resistors to capacitor units shall be according to IEC 60831-1 with a K factor of 1.

5.4.2 Medium voltage and high voltage capacitor unit shall be provided with a discharge resistor to discharge the stored energy of the capacitor and reduce the voltage from the peak voltage of \(\sqrt{2}\) times the rated voltage to 75 volt or less in 10 minutes after disconnection.

5.4.3 There shall be no fuse, switch or any other disconnecting device between the capacitor unit and the discharge resistors.

5.4.4 The resistance of the discharge resistors shall be calculated according to the formulas given in IEC 60831-1 or IEC 60871-1. The supplier shall indicate in data sheet, the size of discharge resistors in ohm.

5.4.5 In order to meet the requirements of paragraphs 5.4.1 and 5.4.2, additional discharge resistors or reactors may be installed at the capacitor contactor/s or at the power supply switching device located in the station switch room. Such scheme shall be approved by company representative.

5.4.6 The supplier of the capacitor bank may propose, as an option, the application of discharge reactors instead of discharge resistors for each capacitor unit.

5.5 Grounding Switch

5.5.1 On the capacitor enclosure, a load break switch shall be provided for grounding the capacitors. The operating handle of this grounding switch shall be outside the enclosure. The grounding switch shall be closed after the elapse of the times specified in paragraphs 5.4.1 or 5.4.2.

5.5.2 For medium voltage and high voltage capacitor banks, a grounding switch safety relay shall be included when necessary to prohibit the operation of the grounding switch before the elapse of the above mentioned times.

5.5.3 The grounding switch, when in closed or ground position shall short circuit and ground the capacitor leads and discharge the remaining energy left on the capacitors. This switch shall be key interlocked with the power supply switching device located in the station switch room.

5.5.4 It shall not be possible to close the grounding switch before opening the power supply switching device, and the power supply switching device may only be closed after the grounding switch is opened.

5.6 Safety Requirement

5.6.1 Safety interlocks shall be provided between the power supply switching device located in the station switch room and the grounding switch specified in clause 5.5.

5.6.2 The power supply switching device shall be opened and locked in open position before operating the handle of the grounding switch.

5.6.3 The grounding switch shall be closed and locked in ground position before opening the door of the capacitor compartment/s.
5.6.4 The power supply switching device is not in the scope of this specification. The purchaser will provide the interlock elements in the form of electrical interlock and/or key interlock.

5.6.5 The interlock system and the type and location of the grounding switch shall be approved by Company representative.

5.7 Marking

5.7.1 The information outlined in IEC 60831-1 or IEC 60871-1 shall be marked on each capacitor unit either directly or on a rating plate attached to each unit.

5.7.2 Each capacitor bank shall have a rating plate. At least the information outlined in IEC 60831-1 or IEC 60871-1 shall be engraved or indelibly marked on such rating plate.

6. TEST AND INSPECTION

6.1 The equipment under this specification shall be factory tested. Certified copies of test reports and/or certificates shall be submitted to the purchaser. The numbers of certified copies required will be specified by the purchaser in the purchase order.

6.2 Routine tests shall be performed according to the requirements of IEC 60831-1 or IEC 60871-1 and the relevant IEC publications referred to therein.

6.3 Type tests shall be performed on selected capacitors according to the recommendations of IEC 60831-1 or IEC 60871-1. The results of such tests on identical equipment are acceptable.

6.4 The purchaser’s inspectors shall be granted the right for inspection at any stage of manufacture and testing.

6.5 Purchaser will require the presence of his nominated representative to witness the final inspection and tests. The supplier shall inform the date of such tests at least four weeks in advance.

7. SPARE PARTS

7.1 Together with the supply of equipment under this specification, a complete set of spare parts for commissioning and special tools, if required shall be supplied. The supplied spare parts shall comply with the same specifications as the original parts and shall be fully interchangeable with the original parts without any modification. Spare parts shall be preserved to prevent deterioration during transport and storage in a humid tropical atmosphere.

7.2 The vendor shall also supply a list of recommended spare parts for two years of operation.

8. DOCUMENTATION

8.1 The vendor shall supply the necessary information with the quotation to enable evaluation of the submitted proposal. General documents/drawings are not acceptable unless they are revised to show the equipment proposed.

The documents to be supplied with the quotation shall at least include the following:

a) Completed enquiry data sheet/s.

b) Summary of exceptions/deviations to this standard specification.

c) Brochures and catalogues containing description of typical capacitor banks.

d) Preliminary dimensional drawings.

e) Type of packaging and approximate shipping weights.
8.2 The documents which shall be supplied at ordering stage shall at least include the following:

- a) Updated and completed enquiry data sheet/s.
- b) Drawings showing main dimensions and arrangement of components.
- c) Wiring diagrams of all accessories, or devices.
- d) List of components or accessories, showing complete reordering information for replaceable parts.
- e) Installation, operation and maintenance instruction/s.
- f) Recommended spare parts list for two years of operation.
- g) Test reports and/or certificates for routine tests, type tests and special tests.

9. SHIPMENT

9.1 The supplier of the equipment under this specification is the sole responsible for packaging and preparation for shipment.

9.2 The packaging and preparation for shipment shall be adequate to avoid mechanical damage during transport and handling.

9.3 Each shipping package shall be provided with permanently attached identification tag containing necessary information together with the capacitor identification number indicated in data sheet Appendix A.

9.4 Shipping documents with exact description of equipment for custom release shall be supplied, with the equipment.

10. GUARANTEE

10.1 The supplier of the equipment under this specification shall guarantee the equipment and shall replace any damaged equipment/parts resulting from poor workmanship and/or faulty design.

10.2 The supplier shall replace any equipment/part failed under the following condition:

- Failure under start up and commissioning tests performed according to IEC recommendations.
- Failure under normal usage for a period of 12 months, not exceeding 18 months from the date of dispatch from the manufacturers works.
APPENDIX A

POWER FACTOR IMPROVEMENT CAPACITOR DATA SHEET

The vendor shall complete and submit this data sheet with his proposal.

Items marked with asterisk will be specified by purchaser.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Name of project or plant</td>
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<tr>
<td>2</td>
<td>Capacitor bank identification No</td>
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<tr>
<td>3</td>
<td>Site elevation above sea level (m)</td>
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<td>4</td>
<td>Maximum ambient temperature, outdoor</td>
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<td>10</td>
<td>Nominal three phase system voltage phase to phase (or phase to neutral)</td>
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<td>45.</td>
<td>accessories</td>
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<td>46.</td>
<td>Deviation from this specification if any</td>
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</table>

*by purchaser*