


**STANDARDS PUBLICATION**

# KOC STANDARD

# FOR

# VARIABLE SPEED DRIVE (VSD) CONTROLLER

# AND SOFT STARTER

## DOC. NO. KOC-E-014

**(Supersedes 015-PH-1911)**

**STANDARDS TEAM**

شركة نفط الكويت
Kuwait Oil Company
إحدى شركات مؤسسة البترول الكويتية
A Subsidiary of Kuwait Petroleum Corporation

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ISSUING AUTHOURITY:

**STANDARDS TEAM**

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## FOREWORD

This document **"KOC Standard for Variable Speed Drive (VSD) Controller and Soft Starter" (KOC-E-014)** is intended to provide minimum requirements for Variable Speed Drive (VSD) Controller and Soft Starter to be installed at various KOC Facilities in Kuwait.

This Standard has been approved by the Standards Team in consultation with the Standards Technical Committee (STC) for use throughout the Engineering and Operational Functions of Kuwait Oil Company (K.S.C.).

This Standard sets out to achieve the following objectives:

a) To provide technical guidance and establish the base document for developing project / equipment specifications for Variable Speed Drive (VSD) Controller and Soft Starter for motor drives, with a view to achieve uniformity, quality, reliability and efficiency in an economical manner.

b) To assist the designer by providing technical information and engineering practices for establishing the basis for detailed design of Variable Speed Drive (VSD) Controller and Soft Starter to be installed in KOC Facilities to meet the set objectives in projects.

c) To maintain the KOC requirements of safety and protection to plant, personnel and environment established by KOC Health, Safety & Environment Management System (HSEMS) including the Process Safety Management (PSM) requirements.

Feedback as well as any comments or suggestions derived from the application of this Standard at any stage of design, construction, installation, operation etc. are invited and should be directed to:

**Team Leader Standards**
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## 1.0 SCOPE

This Standard specifies the minimum requirements for the design, construction, inspection and testing of Variable Speed Drive (VSD) Controller and Soft Starters, to be installed at various KOC Facilities in Kuwait.

## 2.0 APPLICATION

2.1 The Variable Speed Drive (VSD) Controllers and Soft Starters covered herein are intended for control of Motors driving rotating equipment like pumps, compressors etc.

2.2 The design, construction, performance, inspection and testing of Variable Speed Drive (VSD) Controller and Soft Starter shall comply with all the relevant requirements specified in this Standard and the reference Standards / Codes mentioned herein.

2.3 Any exceptions or deviation from this Standard, along with their merits and justification, shall be brought to the attention of KOC's Controlling Team for their review, consideration and amendment by Standards Team (if required).

2.4 Compliance with this KOC Standard does not of itself confer immunity from legal or statutory obligations.

## 3.0 TERMINOLOGY

### 3.1 Definitions

For the purpose of this Standard, the following definitions apply:

3.1.1 Contractor

A person, persons or firm / company approved and contracted by KOC to undertake the execution of the work defined by the contract.

3.1.2 Converter

Operating unit for electronic power conversion, changing one or more electrical characteristics and comprising one or more electronic switching devices and associated components, such as transformers, filters, commutation aids, controls, protection and auxiliaries, if any.

3.1.3 Electromagnetic Compatibility (EMC)

The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to that environment or to other equipment.

3.1.4 Harmonic Filter

A filter to reduce the flow of harmonic currents into the associated power system.

3.1.5 Intelligent Electronic Device (IED)

Any device incorporating one or more processors with the capability of receiving or sending data / control from or to an external source (for example: electronic multifunction meters, digital relays etc.)

3.1.6 Mean Time Between Failures (MTBF)

Mean Time Between failure refers to the average amount of time that a device or product functions before failing.

3.1.7 Reliability

Reliability of an equipment or device is the ability of the equipment or device to perform its required functions under stated conditions for a specified period of time.

3.1.8 Total Harmonic Distortion (THD)

Total Harmonic Distortion (THD) is the ratio of the R.M.S value of the harmonic content to the R.M.S value of fundamental component or reference fundamental component of an alternating quantity.

3.1.9 Vendor

The System Supplier, who manages with full responsibility, the design, selection of material, manufacturing, assembling, inspection & testing, certification etc. of equipment / system as per the requirements of this Standard / Project Document / Purchase Order.

## 3.2 Abbreviations

For the purposes of this Standard, the following abbreviations apply:

| | |
|---|---|
| DC | Direct Current |
| DOL | Direct On Line |
| EMC | Electromagnetic Compatibility |
| E-SCADA | Electrical Supervisory Control and Data Acquisition |
| FAT | Factory Acceptance Test |
| HRC | High Rupturing Capacity |
| $H_2S$ | Hydrogen Sulphide |
| HSEMS | Health, Safety & Environment Management System |
| HVAC | Heating, Ventilating and Air-Conditioning |

| | |
|---|---|
| Hz | Hertz |
| IEC | International Electrotechnical Commission |
| IED | Intelligent Electronic Device |
| IEEE | The Institute of Electrical and Electronics Engineers |
| IGBT | Insulated Gate Bipolar Transistor |
| IGCT | Integrated Gate Commutated Thyristor |
| IP | Ingress Protection |
| ITP | Inspection & Test Plan |
| JSA | Job Safety Analysis |
| KOC | Kuwait Oil Company (K.S.C.) |
| kW | Kilo Watt |
| LCD | Liquid Crystal Display |
| LV | Low Voltage |
| MCB | Miniature Circuit Breaker |
| MCCB | Moulded Case Circuit Breaker |
| MTBF | Mean Time Between Failure |
| PAT | Performance Acceptance Test |
| PCS | Process Control System |
| PF | Power Factor |
| PPE | Personal Protective Equipment |
| PTW | Permit To Work |
| RFI | Radio Frequency Interference |
| SAT | Site Acceptance Test |
| SPD | Surge Protection Device |
| TDD | Total Demand Distortion |
| THD | Total Harmonic Distortion |

## 4.0 REFERENCE CODES AND STANDARDS

### 4.1 Conflicts

In the event of conflict between this Standard and the Standards / Codes referenced herein or other purchase or contractual requirements, the most stringent requirements shall apply.

### 4.2 List of Standards, Codes and Specification

The design, manufacture, performance and testing of Variable Speed Drive (VSD) Controller and Soft Starter shall conform, except where otherwise specified, to the current issues and amendments of the applicable Codes, Standards and Specifications, including but not limited to the following:

4.2.1 International Standards

| | |
|---|---|
| IEC 60034 (Various Parts) | Rotating Electrical Machines |
| IEC 60051 (Various Parts) | Direct Acting Indicating Analogue Electrical Measuring Instruments and Their Accessories |
| IEC 60076 (Various Parts) | Power Transformers |
| IEC 60146 (Various Parts) | Semiconductor Converters |
| IEC 60204 (Various Parts) | Safety of Machinery - Electrical Equipment of Machines |
| IEC 60255 (Various Parts) | Measuring Relays and Protection Equipment |
| IEC 60269 | Low Voltage Fuses |
| IEC 60282 | High Voltage Fuses |
| IEC 60529 | Degrees of Protection Provided by Enclosures (IP Code) |
| IEC 60947 | Low Voltage Switchgear and Controlgear |
| IEC 61000 (Various Parts) | Electromagnetic Compatibility (EMC) |
| IEC 61071 | Capacitors for Power Electronics |
| IEC 61158 (Various Parts) | Industrial Communication Networks |

| | |
|---|---|
| IEC 61439 (Various Parts) | Low Voltage Switchgear and Controlgear Assemblies |
| IEC TR 61641 | Enclosed Low Voltage Switchgear and Controlgear Assemblies - Guide for testing under conditions of arcing due to internal fault |
| IEC 61800 (Various Parts) | Adjustable Speed Electrical Power Drive Systems |
| IEC 61869 (Various Parts) | Instrument Transformers |
| IEC 62271-200 | High Voltage Switchgear and Controlgear - Part 200: AC Metal Enclosed Switchgear and Controlgear for Rated Voltages above 1 kV and up to and including 52 kV |

4.2.2 National Standards and Codes

| | |
|---|---|
| IEEE 519 | IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems |
| IEEE 1566 | Standard for Performance of Adjustable Speed AC Drives Rated 375 kW and Larger |

4.2.3 KOC Standards and Recommended Practices

| | |
|---|---|
| KOC-E-001 | KOC Standard for High Voltage Induction Motors |
| KOC-E-002 Pt.1 | KOC Standard for High Voltage Switchgear and Controlgear (1 kV to 11 kV) |
| KOC-E-003 Pt.1 | KOC Recommended Practice for Design Basis and Selection of Electrical Systems |
| KOC-E-004 (Various Parts) | KOC Recommended Practice for Selection, Installation and Maintenance of Electrical Equipment in Hazardous Areas |
| KOC-E-005 | KOC Standard for Power Transformers |
| KOC-E-006 | KOC Recommended Practice for Power System Studies, Protection and Control |
| KOC-E-008 | KOC Recommended Practice for the Design, Selection and Installation of Electric Cables, Cable Systems and Wiring |
| KOC-E-009 | KOC Standard for Low Voltage Switchgear |
| KOC-E-020 | KOC Recommended Practice for Electrical Installation on Packaged Equipment |
| KOC-E-023 | KOC Standard for Electrical Power Cables and Wiring |

| | |
|---|---|
| KOC-E-024 | KOC Recommended Practice for Earthing and Bonding |
| KOC-E-027 | KOC Standard for Electrical Supervisory Control and Data Acquisition (E-SCADA) System for Substation |
| KOC-G-002 | KOC Standard for Hazardous Area Classifications |
| KOC-G-004 | KOC Standard for Packing, Marking and Documentation |
| KOC-G-007 | KOC Standard for Basic Design Data |
| KOC-G-009 | KOC Standard for Spare Parts and Maintenance Data |
| KOC-I-001 | KOC Standard for Instrumentation and Control System Design |
| KOC-L-002 | KOC Recommended Practice for the Protection of KOC Services: Clearance Requirements for Buried Pipelines, Cables, Underground Structures, Buildings and Housing Projects |
| KOC-L-028 | KOC Recommended Practice for Plant Layout (Includes Spacing Charts) |
| KOC-L-030 | KOC Standard for Plant and Equipment Noise Control |

4.2.4 Project Specifications & other KOC Documents

In addition to the KOC Standards and Recommended Practices referenced herein, the Controlling Teams in KOC shall designate other relevant project specifications as required including the following:

| Title / Description | |
|---|---|
| 015-HH-1101 | HVAC Equipment and Installation |

4.2.5 KOC Health, Safety and Environment Management System (HSEMS)

KOC HSE Policy

KOC HSEMS Guide

| | |
|---|---|
| KOC.GE.028 | HSE Training, Awareness and Continued HSE Learning Process |
| KOC.PS.001 | Process Safety Management (PSM) Manual |
| KOC.SA.004 | Permit to Work (PTW) Procedure |
| KOC.SA.010 | Procedure for Personal Protective Equipment |
| KOC.SA.024 | Job Safety Analysis (JSA) Procedure |

KOC.SA.027 Electrical Work Safety Procedure

Any other relevant KOC HSEMS documents as applicable.

## 5.0 ENVIRONMENTAL CONDITIONS

5.1 The environmental conditions in Kuwait are severe and shall be considered carefully while selecting Variable Speed Drive (VSD) Controller and Soft Starter used for outdoor installation. The VSD Controller and Soft Starter intended for outdoor installation shall be suitable for continuous operation at a desert location under high ambient temperature and humidity. The atmosphere shall be considered to be dusty, corrosive and may contain traces of Hydrogen Sulphide ($H_2S$), $SO_x$ / $NO_x$ gases and airborne chemical contaminants.

5.2 Refer to KOC-G-007 "KOC Standard for Basic Design Data", which provides the detailed design information regarding the environmental, site and utility supply conditions prevailing throughout the KOC Facilities.

## 6.0 SERVICE CONDITIONS

### 6.1 General

6.1.1 The Variable Speed Drive (VSD) Controller and Soft Starter are normally installed in substation / room provided with HVAC System, located adjacent to the driven equipment, unless otherwise specified in the project document / Data Sheet. However, it shall be rated for continuous operation at full load and rated speed under the temperature from -3˚ C to 50˚ C and humidity 100%.

6.1.2 Reliability of all components in the VSD Controller / Soft Starter to perform continuously in the service condition specified is essential. The Vendor / Manufacturer shall confirm that VSD Controller / Soft Starter typical of that being supplied shall have been in operational use without problems, elsewhere under similar environmental condition as specified in KOC-G-007, for a minimum period of Two (2) years. Prototype or unproven equipment not having a well-established record shall not be considered.

6.1.3 All components in the VSD Controller and Soft Starter shall have the specified ratings, which shall be their continuous rating as installed in the equipment after being suitably derated for the specified service conditions.

### 6.2 Equipment in Hazardous Area

6.2.1 Any electrical equipment to be installed in a hazardous area shall conform to the relevant parts of "KOC Recommended Practice for Selection, Installation and Maintenance of Electrical Equipment in Hazardous Areas" (KOC-E-004).

6.2.2 The equipment to be installed in a hazardous area shall be certified for use in those areas by a testing authority of an international recognition. The list of testing and certifying agencies acceptable to KOC are given in KOC-E-004 Part 2.

6.2.3 The copies of hazardous area certification documents shall be submitted to KOC for review and approval.

## 7.0 HEALTH, SAFETY AND ENVIRONMENT

7.1 All relevant HSE requirements of KOC's Health, Safety & Environmental Management System (HSEMS) shall be adhered to during design, installation and testing of Variable Speed Drive (VSD) Controller / Soft Starter systems at KOC Facilities.

7.2 The Contractor shall follow necessary Health, Safety & Environment (HSE) procedures to protect personnel, assets and environment during on-site field works.

7.3 Appropriate Permit to Work (PTW) with applicable Job Safety Analysis (JSA) document for the work to be carried out shall be prepared by the Contractor and submitted to KOC Controlling Team for approval prior to commencement of any on-site work. The PTW and JSA documents shall address all relevant HSE requirements for the activities in line with the KOC HSEMS Procedures KOC.SA.004 "Permit to Work Procedure", KOC.SA.024 "Job Safety Analysis (JSA) Procedure" and KOC HSE Policy, which shall be adhered to within KOC areas at all times.

7.4 All personnel utilised for the site works shall have attended the necessary training / awareness course(s) as per the 'Matrix of Identified Categories of Personnel' described in the "HSE Training" and "HSE Awareness" for Contractor's employees and comply with the requirements of HSEMS procedure KOC.GE.028 "HSE Training, Awareness and Continued HSE Learning Process".

7.5 All Personnel carrying out the site work shall use appropriate Personal Protective Equipment (PPE) during the execution of works as identified by the job requirement and in line with the KOC HSEMS procedure KOC.SA.010 "Procedure for Personal Protective Equipment".

7.6 The tools, equipment and machinery to be used for the project shall be periodically inspected and certified for safe use in all KOC Operational Areas.

## 8.0 VARIABLE SPEED DRIVE (VSD) CONTROLLER

### 8.1 Design Requirements and System Description

8.1.1 The VSD Controller shall be a complete package, fully assembled, wired & factory tested, suitable for the load characteristics, operational duty of the driven equipment, number of starts requirement etc. as specified in the project document / Data Sheet.

8.1.2 The design of VSD Controller shall conform to the requirements of IEC 61800-4 (for VSD above 1000 V) and IEC 61800-2 (for VSD up to 1000 V).

8.1.3 The design requirements for VSD Controller specified in this Standard are for general guidance only. The specific requirement for VSD Controller to suit a particular application / operational requirement shall be specified in the project document. The Vendor / Manufacturer shall supply a suitably designed unit, well integrated into the electrical system, to meet specific requirements mentioned in the project document and shall be submitted to KOC for approval.

8.1.4 VSD System shall be designed to achieve the required performance characteristics specified in the project document / Data Sheet. The characteristics shall match with those of the driven equipment with due regard to the operating & transient conditions, critical speed, thermal & dynamic stresses, transient mechanical torque etc.

8.1.5 To ensure the reliability of the complete VSD system, the VSD Controller and motor shall be supplied from the same Manufacturer for all new projects, unless otherwise specified in the project document.

8.1.6 The overall design, manufacture, testing and integration of the complete system, to meet the specific requirements mentioned in the project document / Data Sheet shall be the responsibility of Vendor, where the VSD Controller / Motor / associated driven equipment are included in the scope of the Vendor.

8.1.7 Where, the VSD Controller is to be provided for an existing motor, Vendor shall take into account of the voltage withstanding capacity of the motor. The VSD System shall be suitably designed to perform the normal operations, without any problem with the existing motor.

8.1.8 The Variable Speed Drive (VSD) Controller shall be suitable for operation on a three phase, 50 Hz input supply and without deleterious effect, with variations of input supply voltage and frequency as follows:

a) Voltage ± 6%

b) Frequency ± 2.5%

8.1.9 Variable Speed Drive Controller for drives less than 120 kW shall be rated for 440 volts supply, unless otherwise specified in the project document / Data Sheet. The rated voltage of VSD Controllers for drives more than 120 kW shall be as per the recommendation of Manufacturer, to suit the system requirements and approved by KOC.

8.1.10 VSD Controller shall be suitable for continuous operation, unless specifically called for in the project document / Data Sheet.

8.1.11 Where specified in the project document / Data Sheet, a regenerative breaking system shall be provided for quick stopping of the Motor for specific application.

8.1.12 In cases where the VSD Controller is operated from an independent Generator (where “State Grid” supply is not available) or Standby Generator, it shall be ensured that the harmonics generated by VSD Controller shall not overheat the generator.

8.1.13 The Vendor / Contractor shall conduct a study for evaluating Harmonics, Power Factor (PF), Short Circuit Current, Motor Starting Parameters etc., prior to finalising the design of VSD Controller systems of drive rated above 120 kW, unless otherwise specified in the project document / Data Sheet.

**Note:** The study mentioned above shall be performed at the Substation, from where the power is drawn to the VSD Controller, unless otherwise specified in the project document.

8.1.14 For VSD Controllers used for drive rated up to 120 kW, the requirement of the study mentioned in Sub-Clause 8.1.13 shall be on a case to case basis, as specified in the project document or found necessary by the Vendor / Contractor to ensure a well-integrated stable power system.

8.1.15 The major components of VSD Controller shall include, but not limited to Converter Unit, Harmonic Filters, Cooling System etc.

8.1.16 The Vendor / Manufacturer shall design & configure the topology of the VSD System with various components to suit the process / application / operational requirements, as specified in the project document and the details of the same shall be submitted to KOC for review and approval.

8.1.17 VSD Controller shall be suitably designed to limit the Total Harmonic Distortion (THD) to comply with the requirements specified in IEEE 519. For any specific applications, where the THD limits needs to be more stringent (For e.g. VSD application in Hospitals), it shall be specifically mentioned in the project document.

8.1.18 The following shall be considered while designing the Harmonic Filters:

a) The voltage / current harmonics and Total Demand Distortion (TDD) shall meet the requirements of IEEE 519.

b) Voltage and current harmonics shall not exceed the specified limits across the entire speed and load range.

c) Care shall be taken to avoid any resonant condition with existing network.

8.1.19 For safe maintenance of the VSD Controller, suitable measures shall be provided for discharging the static energy in the DC section. The doors of the panel shall be provided with interlock (with time delay) to avoid inadvertent opening of the panel doors until the static energy is completely discharged.

8.1.20 Variable Speed Drive (VSD) Controller shall be rated for 100% full load current with Duty Class-II in accordance with IEC 60146.

8.1.21 VSD Controller shall have provision to independently programme the accelerating and decelerating time setting, in the range from 1 to 250 seconds, unless otherwise specified in the project document / Data Sheet.

8.1.22 VSD Controller shall be provided with a suitably rated circuit breaker for local isolation of incoming power supply, where specifically called for in the project document / Data Sheet. For details of circuit breakers, KOC-E-002 Pt.1 “KOC Standard for High Voltage Switchgear and Controlgear (1 kV to 11 kV) and KOC-E-009 “KOC Standard for Low Voltage Switchgear” shall be referred, as applicable.

## 8.2 Converter Unit

8.2.1 Major components of the Converter Unit shall include, but not limited to the following:

a) Converter Transformer,

b) Rectifier,

c) DC Link,

d) Inverter,

e) Sinusoidal Filter (as required),

f) Any other components required for the normal operation of VSD System.

8.2.2 The following shall be considered while designing the Converter Transformer:

a) The Converter Transformer shall be suitably designed for VSD Controller application and shall be in compliance with IEC 60076 & IEC 60146, as applicable.

b) Converter Transformers shall be of “Dry Type”, for indoor application, unless otherwise specified or approved by KOC.

c) Where Oil Filled Transformers with conservator are considered for VSD application due to specific reasons, it shall be with permission from KOC and shall be located outdoors. Oil filled transformers with conservator shall be provided with accessories such as, gas & oil actuated relays, pressure relief devices, oil level gauge, oil & winding temperature indicators etc.

d) Temperature detectors with alarm and trip features shall be provided for all Converter Transformers.

e) Converter Transformer shall be suitable for continuous operation without failure. Harmonics and other system parameters shall be taken into account, while designing the Converter Transformer.

8.2.3 The Rectifier shall be designed with suitable pulse configuration to limit the Total Harmonic Distortion (THD), as per the requirements specified in IEEE 519.

8.2.4 To reduce dc voltage / current ripples within the acceptable limits, VSD Controller shall be provided with DC Link, between the input rectifier and output inverter.

8.2.5 The inverter shall be semiconductor based, with the “State of the Art Technology”, using IGBT / IGCT or any other advanced technology approved by KOC, to meet the load characteristics / operating duty, as specified in the project document.

8.2.6 In order to ensure a smooth sine wave output voltage to the VSD Motor, VSD Controller shall be provided with a Sinusoidal Filter. While designing the Sinusoidal Filter, the following shall be considered:

a) Length of output cable from the VSD Drive to Motor,

b) Level of Common Mode noise generated by VSD,

c) The ability of Motor insulation level to withstand dv/dt.

8.2.7 Reactors associated with VSD Controller shall be suitably designed in accordance with the requirements of IEC 60076-6.

## 8.3 Cooling System for VSD Controller

8.3.1 The VSD Controller Cooling System shall be Air Cooled type.

8.3.2 The Vendor / Manufacturer shall provide all accessories required for the complete cooling system, such as cooling fans, air ducting etc.

8.3.3 The power supply requirement for the forced cooling system (as applicable) shall be derived from the main power of VSD Controller, without the requirement of separate power supply from an external source.

8.3.4 The forced cooling system provided shall be redundant, such that failure of any of the cooling fans shall not impair the performance of the unit. Due consideration shall be given while designing the ventilation louvers and its arrangement so that dust filters provided on the louvers shall be easily maintainable / replaceable even during operation. The dust filter shall be designed to ensure that the system shall operate satisfactorily even when 50% of dust filter is blocked.

**Note:** In case of large capacity VSD Controllers, where air cooled VSD systems are not in the manufacturing range of any Manufacturers, water cooled systems shall be considered with prior approval from KOC.

## 8.4 Construction Requirements for VSD Controller

8.4.1 Variable Speed Drive (VSD) Controller shall be housed in a free standing, floor mounted, dust & vermin proof, metal enclosure accommodating control, monitoring & indicating equipment, ventilation system etc.

8.4.2 The enclosure shall be constructed from folded and welded mild sheet steel, not less than Two (2) mm thick.

8.4.3 Minimum degree of protection for the enclosure of VSD Controller shall be in accordance with the requirements specified in KOC-E-003 Pt.1 “KOC Recommended Practice for Design Basis and Selection of Electrical Systems”. Where VSD Controller to be installed outdoors, additional weather protection shall be provided to avoid water entry, as specified in the project document.

8.4.4 All cable entry shall be from bottom, unless otherwise specified in the project document. The cable entry shall be via three (3) mm thick removable gland plate(s). Gland plate(s) shall be of adequate size to accommodate all cables.

8.4.5 Door mounted equipment such as selector switches, push buttons, indicating Instruments etc. shall be suitably arranged for ease of operation, inspection and maintenance.

8.4.6 Where specified in the project document / Data Sheet, the VSD Controller shall be designed and constructed for internal arc containment, in accordance with the requirements of IEC 62271-200 (for VSD Controller above 1000 V) and IEC TR 61641 (for VSD Controller up to 1000 V). The VSD Controller, including its structural frame work, sheet steel enclosure, doors etc. shall be capable of withstanding the internal pressures within the structure created by faults such as short circuit or malfunction.

8.4.7 Switchgears associated with the VSD System shall be withdrawable type.

8.4.8 All connections to sub-assemblies, e.g. transformers, semi-conductor heat- sink assemblies, control modules etc. shall be made via centralised termination or connection blocks.

8.4.9 Suitable edge connectors shall be used for inserting Printed Circuit Boards (PCB) for ease of replacement.

8.4.10 Test points shall be suitably located such that it is not necessary to reach past exposed live parts during measurements / testing.

8.4.11 Due consideration shall be given to the accessibility for inspection / repair of various components of the VSD Controller. All exposed live parts shall be shrouded and provided with warning labels. Printed circuit boards shall be tropic proofed.

**8.5 <u>Performance Requirements for VSD Controller</u>**

8.5.1 The speed of VSD Controller shall be maintained within ±1% of set speed, irrespective of variation in load and the speed regulation shall be uniform and bump free.

8.5.2 The speed control shall be calibrated for a range of 0% - 105% in steps of 0.5%, unless otherwise specified in the project document.

8.5.3 The audible noise level of VSD Controller shall not exceed 80 dB (A), measured one (1) metre from the equipment, at any load and speed.

8.5.4 The power factor (PF) of the VSD Controller shall be not less than 0.95 lagging across the entire speed range.

8.5.5 The efficiency of the VSD Controller system including all auxiliaries shall not be less than 95%.

8.5.6 Variable Speed Drive (VSD) Controller shall be designed to provide a minimum Mean Time Between Failure (MTBF) of 50000 hours, unless otherwise specified in the project document.

## 8.6 Control / Auxiliary Power Supply for VSD Controller

8.6.1 All control and auxiliary power supply requirements for VSD Controller shall be derived as an integral part from the main power source of VSD System with suitable control transformer, isolating device etc. to cater for various control and auxiliary supply requirements. This shall include, but not limited to:

a) Control Supply for VSD Controller,

b) Auxiliary power supply for cooling / ventilating system,

c) Any other power supply required for the proper functioning of the VSD System.

8.6.2 VSD Controller shall be equipped with the provision to connect an external power source (for control / auxiliary power supply) to carry out protection checks, testing etc. when the main power to VSD Controller is not available / isolated, unless otherwise specified in the project document / Data Sheet. Suitable interlocks shall be provided between these control supplies to ensure that only one control power supply will be available at a time.

## 8.7 Bypass System for VSD Controller

8.7.1 The provision of a Bypass system for VSD Controller for a particular application shall be based on operational requirements. Where specified in the project document / Data Sheet, the VSD Controller shall be provided with a Bypass arrangement to ensure system availability and reliability. The bypass shall be using Soft Starter, DOL Starter etc. as specified in the project document / Data Sheet.

**Note:** Consideration also shall be given for a redundant VSD System instead of a Bypass arrangement as mentioned above, based on the criticality of operation, approval by KOC.

8.7.2 The Bypass system shall be complete with switchgear, protection and safety interlocks, as required.

8.7.3 The Bypass system (where provided), shall have the provision for automatic and manual transfer of Motor from VSD Controller to Bypass and vice versa, as specified in the project document / Data Sheet.

# 9.0 SOFT STARTER

## 9.1 Design Requirements and System Description

9.1.1 The Soft Starter system shall be fully assembled, wired and factory tested. It shall be designed to suit the operational duty of the driven equipment, number of starts required etc. as specified in the project document / Data Sheet.

9.1.2 Soft Starter shall be semiconductor based, with the “State of the Art Technology” approved by KOC. It shall be provided with starter module, cooling system, harmonic filters (as required) and all necessary accessories.

9.1.3 Soft Starter shall limit the inrush current during starting and the inrush current limit shall be as specified in the project document.

9.1.4 Soft Starter shall be suitably designed to limit the Total Harmonic Distortion (THD), to comply with the requirements specified in IEEE 519.

9.1.5 There shall be provision in the Soft Starter to connect the motor to the Normal Supply using integrated bypass unit, when the motor reaches its rated speed at rated voltage.

9.1.6 In case where Soft Starter is operated from an independent Generator (where “State Grid” supply is not available) or Standby Generator, it shall be ensured that the harmonics generated by Soft Starter shall not overheat the generator.

9.1.7 Soft Starter shall be provided with programmable Ramp Up / Ramp Down facility to suit the application, as specified in the project document / Data Sheet.

9.1.8 Soft Starter shall be provided with a suitably rated circuit breaker for local isolation of incoming power supply, where specifically called for in the project document / Data Sheet. For details on circuit breaker, KOC-E-002 Pt.1 “KOC Standard for High Voltage Switchgear and Controlgear (1 kV to 11 kV) and KOC-E-009 “KOC Standard for Low Voltage Switchgear” shall be referred, as applicable.

## 9.2 Cooling System for Soft Starter

9.2.1 The Soft Starter Cooling System shall be Air Cooled type.

9.2.2 The Vendor / Manufacturer shall provide all accessories required for the complete cooling system, such as cooling fans, air ducting etc. as applicable.

9.2.3 The forced cooling system provided shall be redundant, such that failure of any of the cooling fans shall not impair the performance of the unit. Due consideration shall be given while designing the ventilation louvers and its arrangement so that dust filters provided on the louvers shall be easily maintainable / replaceable even during operation. The dust filter shall be designed to ensure that the system shall operate satisfactorily even when 50% of dust filter is blocked.

## 9.3 Construction Requirements for Soft Starter

9.3.1 The Soft Starter shall be housed in a free standing, floor mounted, dust & vermin proof metal enclosure, accommodating control, monitoring & indicating equipment, ventilation system etc.

9.3.2 The enclosure shall be constructed from folded and welded mild sheet steel of not less than Two (2) mm thick.

9.3.3 Minimum degree of protection for the enclosure of Soft Starter shall be in accordance with the requirements specified in KOC-E-003 Pt.1 "KOC Recommended Practice for Design Basis and Selection of Electrical Systems". Where Soft Starter to be installed outdoors, additional weather protection shall be provided to avoid water entry, as specified in the project document.

9.3.4 The Switchgear associated with the Soft Starter shall be withdrawable type.

9.3.5 Where specified in the project document / Data Sheet, the Soft Starter shall be designed and constructed for internal arc containment, in accordance with the requirements of IEC 62271-200 (for Soft Starter above 1000 V) and IEC TR 61641 (for Soft Starter up to 1000 V). The Soft Starter, including its structural frame work, sheet steel enclosure, doors etc. shall be capable of withstanding the internal pressures within the structure, created by faults such as short circuit or malfunction.

## 9.4 Control / Auxiliary Power Supply for Soft Starter

9.4.1 All control and auxiliary power supply requirements for Soft Starter shall be derived as an integral part from the main power source of Soft Starter, with suitable control transformer, isolating device etc. to cater for various control and auxiliary supply requirements. This shall include, but not limited to the following:

a) Control Supply for Soft Starter.

b) Auxiliary power supply for cooling / ventilating system.

c) Any other power supply required for the proper functioning of the Soft Starter.

9.4.2 Soft Starter shall be equipped with the provision to connect an external power source (for control / auxiliary supply) to carry out protection checks, testing etc. when the main power to Soft Starter is not available / isolated, unless otherwise specified in the project document / Data Sheet. Suitable interlocks shall be provided between these control supplies to ensure that only one control power supply will be available at a time.

## 10.0 CONTROL WIRING AND TERMINATION

10.1 The control wiring of the VSD Controller / Soft Starter panel shall be carried out using stranded copper conductor.

10.2 Minimum cross sectional area of the cables used for power supply connection / distribution within the panel shall not be less than 1.5 $mm^2$. (The Manufacturer shall submit cable sizing calculation for KOC review and approval). A minimum of 2.5 $mm^2$ shall be used for current transformer wiring.

10.3 The panel internal wiring / termination cables for data and signal shall be suitably sized, taking into account of the requirements of the connected circuits and the future spare requirements. The conductor size shall be selected based on the maximum continuous current ratings, length of circuit etc. Minimum conductor size shall be 0.75 $mm^2$, unless otherwise approved by KOC.

10.4 Any other Vendor specific cables provided (Termination cables, Ribbon cables etc.) shall be subject to verification of assurance provided by the Manufacturer regarding the integrity of the system functionality, current carrying capacity, maintainability and continued operation of the cable system throughout the life cycle of the VSD Controller / Soft Starter.

10.5 Panel wiring shall be identified with numbers allocated in accordance with approved drawings. The wiring diagrams shall clearly identify the reference numbers and the wires shall be terminated with approved type terminations.

10.6 Terminal blocks shall be logically grouped, indelibly marked in accordance with the approved Manufacturer's drawings. Segregation of different voltage levels within terminal blocks shall be achieved by barriers and be clearly identified by labels. Rail mounted terminals shall be identified according to approved Manufacturers drawings.

10.7 Terminal blocks associated with external sources of supply shall be fully shrouded and fitted with a danger warning label.

10.8 Terminals associated with external current monitoring signal shall be provided with easily removable shorting plugs.

10.9 Wiring looms crossing from fixed to hinged panels shall be mechanically supported on both panels, adjacent to the hinged side, by means of saddles or compression type supports.

## 11.0 CABLE TERMINATIONS

11.1 VSD Controller / Soft Starter shall have undrilled removable gland plates provided for cable termination compartments. For termination of single core cables, gland plates of non-magnetic material shall be used.

11.2 The clearance between the gland plate and any internal equipment shall be minimum 300 mm to permit easy cable installation and connection, unless otherwise specified in the project document.

11.3 The terminals shall be suitably arranged to facilitate the dressing and safe connection of cables, without exposure to adjacent live functional units.

11.4 Inside the VSD Controller, separate terminals of adequate dimensions, one for each cable, shall be fitted for cable armour earthing purposes.

## 12.0 VSD MOTOR

### 12.1 General

Motor used with VSD Controller / Soft Starter shall comply with the requirements of this Standard and KOC-E-001 "KOC Standard for High Voltage Induction Motors" & KOC-E-010 "KOC Standard for Low Voltage Induction Motors", as applicable. The Motors for use in hazardous areas shall be certified for use within the area classification applicable (For details, refer Sub-Clause 6.2).

**12.2 Specific Requirements for VSD Motor**

The Motor used with VSD Controller shall be suitably designed for VSD application. The following shall be considered while design / installation of motors, used with VSD Controller:

a) The motor shall operate satisfactorily in all respects to suit the process requirements across the entire range of speed, power and torque.

b) It shall be designed to operate at lower speed range without being overheated.

c) Motor shaft shall be provided with grounding brushes / other suitable measures to reduce induced voltages in the motor shaft.

d) The motor bearings shall be insulated from the rotor shaft at one end.

e) The body of the Motor, VSD Controller shall be interconnected and grounded.

f) Any other specific requirement as recommended by the Vendor / Manufacturer, for the proper operation of the complete VSD System.

## 13.0 CONTROL AND PROTECTION SYSTEM

### 13.1 General

13.1.1 VSD Controller / Soft Starter control panel shall be provided with all necessary indicating meters, such as Voltmeter, Ammeter, Power Factor (PF) meter, Active Power meter etc. unless otherwise specified in the project document. Panel shall be provided with internal illumination.

13.1.2 Indicating instruments shall be flush type, Class-I in accordance with relevant IEC Standard.

13.1.3 Voltage and current transformers for metering & protection shall be suitable for VSD / Soft Starter application.

13.1.4 Voltage Transformers for VSD controller / Soft Starter shall be double wound with earth screen between primary & secondary windings and the earth screen shall be connected to the main earth bar. The Voltage Transformer used shall comply with the requirements of IEC 61869.

13.1.5 Current Transformers shall comply with the requirements of IEC 61869. The secondary winding of Current Transformers shall be earthed at one point through a removable link, with the provision for attaching test links. Current Transformers shall be rated to withstand the thermal and magnetic stresses resulting from fault current.

13.1.6 All control circuits and internal components shall be adequately protected by means of suitable MCCB / MCB, fuses and double pole breaker / switch for DC circuits. Miniature Circuit Breakers (MCB) used shall be fitted with thermal and magnetic trips according to IEC 60947. The protective devices shall be suitably located for ease of access.

13.1.7 Semiconductors for VSD Controllers / Soft Starters shall be protected by high speed fuses with fully insulated carriers and bases.

13.1.8 Safety interlocks and protective covers shall be provided for VSD Controller / Soft Starter to prevent incorrect or unsafe operation and to prevent access to live parts.

13.1.9 VSD Controller / Soft Starter shall be provided with both visual & audible alarm and shall have Test, Accept and Reset pushbuttons.

13.1.10 Alarm indications shall have provision to check their operation by simulation. Volt-free contacts shall be provided for remote alarm purpose.

13.1.11 VSD Controller / Soft Starter shall be provided with “Lightning and Surge Protection Devices (SPD)”.

13.1.12 Space heaters, controlled by thermostats, shall be provided for each compartment of VSD Controller / Soft Starter. Heaters with isolating switch fuse and neutral link shall be suitable for 250 V, single-phase supply. Surface temperature of all heaters shall not exceed 160°C.

## 13.2 Control and Protection Requirements for VSD Controller

13.2.1 The Control and protection system provided for the Variable Speed Drive (VSD) Controller shall be microprocessor based and shall have facilities for monitoring & fault diagnostics. The VSD Controller shall be provided with various controls / functions, as specified in the project document / Data Sheet, which shall include, but not limited to the following:

a) Emergency stay-put stop pushbutton (lockable at “Off” position),

b) VSD Bypass Transfer Switch (as applicable),

c) “Raise” and “Lower” speed control pushbuttons / joystick in the VSD Control Panel. (This Speed control shall be only for maintenance and commissioning purpose and the access for the same shall be limited to authorised personnel),

d) Automatic sequence control for Start-up of cooling system, Interlock checking, Automatic start & run-up of drive etc.

e) Provision for testing the VSD Controller without the motor running, for start-up check, troubleshooting / maintenance etc.

13.2.2 VSD Controller shall be provided with programmable control unit with keypad and sufficiently large LCD display unit, to display alarm, self-diagnostic & fault messages and it shall have the provision for data logging with battery backed memory. Appropriate keypad and navigation facility shall be provided for programming, display, diagnosis etc. and key settings shall be password protected. The LCD Monitor shall display all relevant data, which shall include, but not limited to the following:

a) Status (running, ready, stop, fault, auto / manual).

b) Hours run (cumulative & since last fault).

c) Event / Fault log (VSD / Motor).

d) Process control set points.

e) Motor speed.

f) Motor current.

g) Motor Active Power in kW.

h) Motor Reactive Power in kvar.

i) Power Factor (PF).

j) Trends / curves of parameters (line / load voltage & current, DC voltage, frequency, speed, torque, active & reactive power, power factor (PF), VSD temperature etc.).

k) Any other relevant data as specified in the project document / Data Sheet or recommended by the Manufacturer for maintaining and ensuring the reliable operation of the VSD Controller.

13.2.3 VSD Controller shall be provided with various set points which shall include, but not limited to the following:

a) Maximum and minimum speed setting.

b) Maximum and minimum torque settings.

c) Time to reach set Speed / torque.

d) Current limit setting.

13.2.4 VSD Controller shall be provided with various protection, which shall include, but not limited to:

a) Under voltage, overvoltage, over current, earth fault, over-frequency.

b) Over temperature protection for internal components.

c) Alarm and trip for oil & winding over temperature, Low oil level and high oil pressure for Converter Transformer & Reactor (as applicable).

d) Over temperature alarm and trip in case of “Dry Type” transformers.

e) Any other protection as specified in the project document / Data Sheet or recommended by the Manufacturer for ensuring the reliable operation of the VSD System.

13.2.5 Variable Speed Drive (VSD) Controller shall be provided with voltage dip protection to protect the VSD System from damage, with the provision to ride through short voltage dip down to 80% system voltage for a duration up to Four (4) seconds (minimum).

**13.3 <u>Control and Protection Requirements for Soft Starter</u>**

13.3.1 The control and protection system provided for Soft Starter shall be microprocessor based and shall have facilities for monitoring & fault diagnostics functions.

13.3.2 The Soft Starter shall be provided with various controls / functions, as specified in the project document / Data Sheet.

13.3.3 The Soft Starter control panel shall be provided with programmable control unit with keypad and sufficiently large LCD display, to display alarm, diagnostic and fault messages and it shall have the provision of data logging with battery backed memory. Appropriate keypad and navigation facility shall be provided for programming, display, diagnosis etc. and key settings shall be password protected. The LCD Display shall display all relevant data, which shall include, but not limited to the following:

a) Status (running, ready, stop, fault), control status (Auto / Manual).

b) Event / Fault log (drive / motor protections).

c) Trends / curves - line / load voltage & current, torque, power, internal temperature etc.

d) Motor vibration and temperature.

e) Other relevant data.

13.3.4 Soft Starter shall be provided with various protections, which shall include, but not limited to:

a) Under voltage, overvoltage, over current, earth fault, over-frequency.

b) Over temperature protection for internal components.

c) Any other protection as specified in the project document / Data Sheet or recommended by the Manufacturer for ensuring the reliable operation of the Soft Starter.

## 13.4 Control and Protection Requirements for VSD Motor

13.4.1 Motor associated with VSD Controller / Soft Starter shall be provided with all necessary protection, as specified in project document in accordance with KOC-E-002 Pt.1 “KOC Standard for HV Switchgear and Controlgear” and KOC-E-009 “KOC Standard for LV Switchgear” for HV and LV motors respectively. Any additional protection required for the reliable operation of the motor as recommended by the Manufacturer shall also be provided.

13.4.2 A selector switch with local / off / remote positions shall be provided on the Local Control Station.

13.4.3 An Emergency Stop push button shall be provided at the Local Control Station of the motor and it shall operate irrespective of the position of any selector switch.

13.4.4 The control of the VSD Motor shall be through PCS / E-SCADA. In addition, a control unit with LCD display shall be provided adjacent to the VSD Motor to raise and lower the speed, where specifically called for in the project document.

## 14.0 INTERFACE WITH E-SCADA AND PCS

14.1 VSD Controller / Soft Starter shall be provided with necessary outputs as required to interface with E-SCADA and PCS for various control / monitoring etc., as specified in the project document.

14.2 The functional units associated with VSD Controller / Soft Starter shall be provided with Intelligent Electronic Devices (IED) / relays / interface modules as required for communication with E-SCADA for control, monitoring, diagnostic etc. as specified in the project document.

14.3 The communication protocol used in VSD Controller / Soft Starter shall be compatible with the E-SCADA system. For more details on E-SCADA, KOC-E-027 “KOC Standards for Electrical Supervisory Control and Data Acquisition (E-SCADA) System for Substation”, shall be referred.

14.4 VSD Controller / Soft Starter shall be provided with PCS interface, as specified in the project document, which shall include, but not limited to the following:

a) Start / Stop control.

b) Speed / Torque control (For VSD).

c) Motor running (Status).

d) Motor available (Status).

e) Motor tripped (Status).

## 15.0 ELECTROMAGNETIC COMPATIBILITY (EMC)

All components of VSD Controller / Soft Starter shall be designed and manufactured, such that, under normal operating conditions, the associated systems shall be unaffected by electromagnetic disturbances likely to be encountered and shall not radiate Radio Frequency Interference (RFI) which shall affect the normal operation of other electronic devices. The VSD Controller / Soft Starter shall meet the EMC requirements of IEC 61800-3.

## 16.0 EARTHING

16.1 A fully fault rated earth busbar of sufficient size shall be provided along the full length of the VSD Controller / Soft Starter panels with provision for earth cable connection at each end to the common earthing system. All metallic non-current carrying parts shall be bonded together and connected to the earth bar at minimum Two (2) points.

16.2 All panel-mounted equipment with exposed metal parts such as indicating lights, pushbuttons, relays etc. shall be separately earthed.

16.3 Doors and hinged parts shall be bonded to the panel structure by means of a flexible copper connection having minimum cross-sectional area of 6 $mm^2$, suitably arranged so as to avoid trapping of the connection when the door is opened or closed.

16.4 Connections from the main earth bar to components shall consist of copper strips or green / yellow PVC-sheathed stranded copper conductors. Termination lugs shall be of the compression type.

16.5 The cross section area of the earthing and bonding conductors provided for exposed conductive parts shall be such that they are capable of carrying the earth fault current for the duration of the fault without damage to the conductor or associated insulation.

16.6 Earthing switches provided for VSD Controller / Soft Starter shall be appropriately interlocked with the respective circuit breakers.

16.7 Provision shall be made for bonding of all earth conductors to the main earth bar, including the cable glands, armouring at cable termination, gland plates etc.

16.8 For more details on earthing and bonding, KOC-E-024 “KOC Recommended Practice for Earthing and Bonding” shall be referred.

## 17.0 NAME PLATE AND LABELS

17.1 All major components and sub-assemblies of VSD Controller / Soft Starter shall be provided with name & rating plates, clearly and indelibly marked. Nameplates shall be fixed with non-corrodible screws or rivets.

The information on the Nameplate shall include, but not limited to the following:

a) Name of the Manufacturer.

b) Tag Number of VSD Controller / Soft Starter.

c) Year of Manufacture.

d) Rated Voltage & Frequency.

e) Rated Current.

f) Rated Power.

g) Degree of Protection.

h) Total Mass of Each Unit.

17.2 Suitable instruction notice shall be affixed to the equipment in a prominent location. The notice shall list procedures to be employed for start-up, shutdown, maintenance and test operations.

17.3 Warning labels shall be provided in all locations where necessary to warn personnel of potentially dangerous situations.

17.4 All instruments, selector switches, indicators, etc. shall be provided with descriptive labels.

17.5 All solid-state or other equipment which can be damaged when subjected to high voltage shall be provided with a warning label stating “NOT TO BE HIGH VOLTAGE TESTED”.

17.6 Labels shall have black characters on a white background, except warning labels which shall have white characters on a red background.

17.7 All labels inside the panels shall be engraved on plastic-laminated material and all nameplates and labels on the outside surface of panels shall be engraved on stainless steel. The nameplate / labels shall be secured with non-corrodible screws. Adhesive or self-tapping screws are not acceptable.

17.8 All components incorporated within the unit shall be indelibly marked with the component circuit reference. Handwritten stickers or dymo-tape labels are unacceptable.

17.9 All programmable parts such as PROM, EPROM and similar components shall be marked with software programme identifier along with its version.

## 18.0 PAINTING

18.1 Painting of the Variable Speed Drive (VSD) Controller / Soft Starter shall be in accordance with KOC-P-001 “KOC Standard for Painting and Coating of External Metal Surfaces” and the Manufacturer’s standard, approved by KOC. The Manufacturer shall provide details including type and number of coatings of primer and final paint.

18.2 Colour shall be selected to match with the switchboard installed in the same location (if any), as specified in the project document.

## 19.0 INSPECTION AND TESTING REQUIREMENTS

Inspection and Testing of VSD Controller / Soft Starter shall comprise of Shop Inspection at Manufacturers works, Factory Acceptance Test (FAT), Site Acceptance Test (SAT) and Performance Acceptance Test (PAT). Vendor / Manufacturer shall develop specific Inspection & Test Plan (ITP) and test report formats for VSD Controller & Soft Starter and submit to KOC for approval. All inspection and testing shall be as per approved Inspection and Test Plan (ITP).

## 19.1 Shop Inspection

While performing the inspection at Manufacturers works, the following shall be verified as a minimum:

a) Perform visual inspection to verify the details, features and materials of build as specified in the project document.

b) Complete dimensional check in accordance with KOC approved drawings.

c) Check for completeness of Vendor's work and / or availability of all component parts and accessories in accordance with this Standard, Data Sheet and drawings.

d) Verification of correctness of the assembly and soundness of all active and passive components of the Printed Circuit Boards.

e) Check for door restraints can effectively prevent damage of wiring to equipment mounted on the door.

f) Check the various interlocking arrangements for doors, functional units etc.

g) Check fuses and other protective devices for rating, labelling, accessibility etc.

h) Verify functioning of the selector switches, indicating lamps etc.

i) Check nameplates, labelling etc. are in accordance with this Standard.

## 19.2 Testing

### 19.2.1 General

a) The VSD Controller shall be tested in accordance with the requirements of IEC 61800-2 (for VSD up to 1000 V) and IEC 61800-4 (for VSD above 1000 V).

b) All components / sub-systems shall be routine tested.

c) Assembled sub-systems shall be function tested prior to incorporation into the package.

d) "Burn-in Test" shall be carried out on all electronic cards prior to integration into the package and the test certificates shall be submitted to KOC for review.

19.2.2 Factory Acceptance Test (FAT)

VSD Controller / Soft Starter shall be tested in accordance with the relevant IEC Standards and the requirements of this Standard. During the FAT, the following Tests / Verification shall be carried out at the Manufacturers works, unless otherwise specified in the project document:

a) General

i) Routine tests on the complete assembly.

ii) Functionality checks of system as per approved design.

iii) Function test on all protective devices.

iv) The complete assembly shall be subject to dielectric tests (high voltage AC / DC test and measurement of insulation resistance).

v) Verification of "current / voltage transformer" ratios.

vi) Testing of the control and communication systems.

b) Specific requirements for VSD Controller

In addition to the tests mentioned in Sub-Clause 19.2.2 (a), the following tests shall also be carried on VSD Controller:

i) Speed control tests over the entire operating range.

ii) Load test on VSD Controller at 10%, 25%, 50%, 75%, 90% and 100% load setting for a minimum period of Four (4) hours on each load setting. During the load test, the following shall be carried out as a minimum:

- The internal temperature of various locations of the panel shall be monitored and recorded at set loads.
- Function / control tests on VSD controller shall include all relevant controls such as start, stop, speed, torque, power control, ramp up, ramp down, (forward, reverse, braking, regeneration as applicable) etc. to verify intended performance as per approved design.
- Electrical parameters on the input and output sides such as voltage, current, power, Power Factor (PF), frequency, voltage & current harmonics and DC voltage & current shall be measured and recorded.
- Testing of bypass systems (as applicable) for proper changeover / interlocks.

- Monitoring of the Temperature rise at various set loads and recording the results.
- Noise level shall be measured & recorded.
- Operation of all protective devices and alarms including remote signalling.
- Operation of cooling systems.
- Any other functional tests as specified by KOC.

**Notes:**

1. The load test mentioned above shall be carried out using cable of similar electrical characteristics, as used at KOC Facility for connecting VSD Controller with Motor, (where VSD Controller and Motor are included in the scope of supply), unless otherwise specified in the project document.

2. For VSD Controller of smaller rating (e.g. less than 120 kW), the applicability of the load test as mentioned in Sub-Clause 19.2.2.b. (ii) of this Standard shall be limited to that specified in the project document / approved by KOC.

c) Specific requirements for Soft Starter

In addition to the tests mentioned in Sub-Clause 19.2.2 (a), the following tests shall also be carried on Soft Starter:

i) Function / control tests such as start, stop, ramp up, ramp down, etc. to verify intended performance as per approved design.

ii) Measurement and recording of Noise level.

d) Specific requirements for VSD Motor

The following tests / verification shall be carried out on the motor, where VSD Controller and Motor are included in the scope of supply:

i) Check for any electrical discharges at motor bearings.

ii) Measurement and recording of bearing current.

iii) Testing of torsional & lateral vibrations and record the result.

iv) Measurement and recording of Noise level.

v) In addition to various tests mentioned above, Motors for VSD (HV &LV) shall be tested in accordance with the requirements specified in KOC-E-001 “KOC Standard for High Voltage Induction Motors” and KOC-E-010 “KOC Standard for Low Voltage Induction Motors” respectively.

19.2.3 Site Acceptance Test (SAT)

All the tests carried out during FAT shall be repeated during SAT, to ensure the performance of the VSD Controller / Soft Starter, unless otherwise specified in the project document.

In addition, the following tests shall also be carried out at site, prior to commissioning of the system:

a) Instrument loop checks from field to VSD Controller / Soft Starter.

b) Dielectric tests on complete system.

c) Secondary injection tests on protective relays and meters.

d) Verification of all programmed set points and control parameters.

e) Verification of control functions of bypass transfer systems (as applicable), alarms, programs, communication functions, protections, interlocks, set points etc.

f) VSD Controller / Soft Starter shall be operated with the motor and connected load to check proper operation of interlocks, control functions etc.

g) String Tests shall be performed connecting VSD / Soft Starter (as applicable), motor and Load (driven equipment) together, unless otherwise specified in the project document / Data Sheet.

During the String Test, electric discharges at motor bearings shall be checked and various parameters, such as noise levels of VSD / Soft Starter / motor, voltages, currents, frequency, power factor, kW, vibration etc. shall be measured.

19.2.4 Performance Acceptance Test (PAT)

a) On satisfactory completion of the Site Acceptance Test (SAT), the complete system, including VSD Controller, Soft Starter (as applicable), Motor and load (driven equipment) shall undergo a Performance Acceptance Test (PAT) for Ninety-six (96) hours of operation in VSD Controller mode and Twenty-four (24) hours of operation in Bypass mode (where a Bypass system is provided), unless otherwise specified in the project document / Data Sheet.

b) During the PAT, all the parameters shall be measured and checked against approved design, which shall include, but not limited to the following:

i) Voltage, current, frequency, speed,

ii) Power, power factor,

iii) Line harmonics (voltage, current),

iv) Load harmonics,

v) Internal temperatures,

vi) VSD & Soft Starter noise levels, motor noise and vibration level.

## 20.0 TRAINING

20.1 The Vendor / Manufacturer shall provide training related to operation and maintenance of VSD Controller / Soft Starter at the Factory / KOC site for KOC personnel, as specified in project document / Data Sheet. The training shall be conducted in English language.

20.2 Training shall cover the following as a minimum:

a) General description of various components used.

b) Details of design of the various components / systems and its operation.

c) Details of control & communication systems.

d) Safety features / various interlocks provided.

e) Installation procedures.

f) Start-up procedures and operational requirements.

g) Trouble-shooting & diagnostics.

h) Routine & preventive maintenance strategy.

i) Programming, adjustments of set points.

## 21.0 QUALITY ASSURANCE

21.1 The Vendor / Manufacturer shall operate a quality system to ensure that the requirements of this Standard are achieved. The quality system shall be preferably based on ISO 9000, certified by internationally reputed inspection agencies.

21.2 Verification of the Vendor's / Manufacturer's quality system is normally part of the pre-qualification procedure and is therefore not detailed in the core text of this document.

## 22.0 PACKING, MARKING AND DOCUMENTATION

### 22.1 General

22.1.1 All correspondence, drawings, instruction manuals, data sheets or any other written information shall be in English language. In case of dual language, one language shall be English.

22.1.2 All dimensions, units of measurements, physical constant etc. shall be in SI Units.

### 22.2 Documentation

The Vendor shall provide all documents related to VSD Controller / Soft Starter, Motor etc. to KOC for review / approval / records. The submission shall include Drawings, Manuals for Installation / Testing / Operation & Maintenance etc. as detailed below:

a) Drawings shall include block diagrams, panel elevations, schematics and wiring diagrams. Block diagrams shall describe overall system architecture showing all connected equipment / systems.

b) Installation documentation shall include outline drawings, details of mounting requirements, connection details, size, weight and any other information needed for installation, including but not limited to the following:

i) Electrical power, data, control & communication interface wiring details and installation procedures,

ii) Floor, drilling and bolting details required to secure the equipment,

iii) Safety Precautions,

iv) Earthing and Bonding procedures,

v) Clearance for access and ventilation,

vi) Installation of various components, alignment and testing details.

c) The Operation and Maintenance documentation shall describe how to operate the VSD Controller and Soft Starter and carry out various available functions. This shall include, but not limited to the instructions for the safe operation of the system, routine / emergency operation, maintenance procedures, safety precautions and quantitative & qualitative limits to be observed while starting, running and shutting down of the system.

### 22.3 Deliverables

22.3.1 The documents / drawings to be provided by the Vendor / Manufacturer while submitting the offer shall include, but not limited to the following:

a) General arrangement drawing showing VSD Controller / Soft Starter.

b) Block diagrams of the complete system.

c) Typical schematic diagram for power, control & protection and details of Topology used.

d) Functional details of VSD Controller / Soft Starter.

e) Supply record for identical VSD Controller / Soft Starter.

f) Report of project specific study conducted earlier for VSD System design.

g) Completed Data Sheet.

h) Descriptive and illustrative catalogues and literature on VSD Controller / Soft Starter and associated devices / components.

i) Proposed test on all equipment and components.

j) Complete technical description of the system indicating the design, operation, construction, performance and maintenance aspects.

k) Details of Rated power of the equipment and auxiliaries.

l) Efficiency of the system.

m) Heat dissipation calculation.

n) Details of communication protocols used.

o) Type Test Certificates of various equipment / components, as applicable.

p) Installation guidelines.

q) FAT, SAT and PAT Procedures with details of all tests to be carried out showing description of each test.

r) Project specific Inspection & Test Plan (ITP) to be carried out at various stages.

s) Quality plan and Certificates.

t) Documents supporting the Manufacturer's capabilities for carrying out the installation work.

u) List of all documentation / submittals delivered with the system.

v) List of recommended spare parts.

w) Location of all service centres.

x) Training Plans.

22.3.2 The following documents of VSD Controller / Soft Starter shall be submitted for KOC's review / approval, record and use as a minimum:

a) Detailed drawing showing general arrangements with dimensions, cable termination details, weight and all other details.

b) Drawings showing the locations of individual components in various compartments.

c) Panel Internal Components layout drawing.

d) Floor plan with foundation / fixing details.

e) Schematic and wiring diagrams showing cable size, terminal strip arrangement with identification numbers.

f) Functional design specification.

g) Inspection and test plan (ITP).

h) Test Certificates.

i) Inspection & Test Reports (FAT, SAT & PAT).

j) Parts list of all components used with all technical details, Maker's Name, type, Serial Number etc.

k) Catalogues of all items included in the system.

l) Paint specification.

m) List of spare parts for Two (2) years of normal operation.

n) Installation, Testing & Commissioning, Operation & Maintenance, Service Manuals.

o) Complete details including quantity, rating, type and catalogue number of all components used.

p) Completed Data Sheets of various equipment, sub-systems and components.

q) Packing details.

r) **"As Built"** Drawings of all drawings listed above.

22.3.3 Drawings supplied by the Vendor / Manufacturer shall have the following information as a minimum:

a) Drawing Title.

b) Manufacturer's Name and address.

c) Name of the project.

d) Manufacturer's order or contract number.

e) Purchaser's order number.

f) Manufacturer's drawing number with revision number & dates.

g) Evidence of quality checks in the form of dated signatures of the Manufacturer's Engineering Team.

22.3.4 Vendor / Manufacturer shall submit all drawings and documents in hard copies and in electronic files.

22.3.5 For more details on packing, marking and shipping documentation, KOC-G-004 "KOC Standard for Packing, Marking and Documentation" shall be referred.

## 23.0 SPARE PARTS AND MAINTENANCE REQUIREMENTS

23.1 The Vendor shall supply all spare parts and consumables required for pre-commissioning, commissioning and performance testing activities.

23.2 The Vendor shall supply critical spare parts, which shall include, but not limited to the following:

a) Set of cooling fans - each size & type.

b) Set of dust filters - each size & type.

c) Set of fuses - each size & type.

d) Any other spare parts recommended by the Manufacturer.

23.3 The Vendor shall submit the list of spare parts required for maintenance.

23.4 The Vendor shall supply special equipment for the maintenance of the system, which shall include, but not limited to:

a) Portable data logger / Pocket PC.

b) Communication cables and adaptors.

c) Voltage & Current Harmonics analyser (where specified).

d) Any other specialized instruments for maintenance.

23.5 A complete set of special tools and devices necessary for installation, operation & maintenance of VSD Controller / Soft Starter shall be provided. The purpose of each tool and device shall be labelled and tools shall be kept in a suitable lockable cabinet.

23.6 The Vendor / Manufacturer shall provide the updates / support for the applicable Software for VSD Controller / Soft Starter.

23.7 For more details on spare parts and maintenance requirements, KOC-G-009 “KOC Standard for Spare Parts and Maintenance Data” shall be referred.

## 24.0 APPENDIX - I DATA SHEET FOR VSD CONTROLLER

| Data Sheet No. | DATA SHEET FOR VSD CONTROLLER | REV. | |
|---|---|---|---|

| A | GENERAL INFORMATION / DESIGN DATA -To be completed by Purchaser | | |
|---|---|---|---|
| **1.0** | **GENERAL** | | |
| 1.1 | APPLICABLE KOC STANDARD | | KOC-E-014 |
| 1.2 | INSTALLATION SITE | | |
| 1.3 | TOTAL NUMBER OF UNITS | | |
| 1.4 | TAG NUMBER (EQUIPMENT NUMBER) | | |
| 1.5 | REFERENCE SINGLE LINE DIAGRAM NO. | | |
| 1.6 | FACILITY PLOT PLAN DRAWING NO. | | |
| 1.7 | SERVICE CONDITIONS OF VSD CONTROLLER INSTALLATION, IF OTHER THAN SPECIFIED IN THE STANDARD | | |
| **2.0** | **INPUT POWER SUPPLY** | | |
| 2.1 | SOURCE OF POWER | | □ MAINS □ GENERATOR |
| 2.2 | SUPPLY VOLTAGE | | |
| 2.3 | SYSTEM GROUNDING | | |
| 2.4 | INPUT SYSTEM FAULT LEVEL (kA) | | |
| 2.5 | SUPPLY SWITCHGEAR IDENTIFICATION TAG NO. | | |
| 2.6 | REQUIREMENT OF CIRCUIT BREAKER FOR LOCAL ISOLATION | | |
| **3.0** | **APPLICATION** | | |
| 3.1 | LOAD TYPE | | |
| 3.2 | NO. OF STARTS | | |
| 3.3 | REQUIREMENT REGENERATIVE BREAKING | | |
| 3.4 | TIME SETTING | RAMP UP | |
| | | RAMP DOWN | |
| 3.5 | DRIVEN EQUIPMENT MANUFACTURER DETAILS (FOR EXISTING EQUIPMENT) | | |
| 3.6 | SPECIFIC REQUIREMENT, IF ANY? | | |
| **4.0** | **MOTOR** | | |
| 4.1 | MOTOR TYPE | | |
| 4.2 | MOTOR VOLTAGE | | |
| 4.3 | MOTOR RATED KW | | |
| 4.4 | MOTOR RATED FREQUENCY | | |
| 4.5 | HAZARDOUS AREA CLASSIFICATION OF THE LOCATION OF DRIVE (MOTOR) | | |
| 4.6 | MOTOR MANUFACTURER DETAILS (FOR EXISTING MOTORS) | | |
| **5.0** | **OPERATING MODES** | | |
| 5.1 | DUTY CYCLE | | |
| **6.0** | **BYPASS SYSTEM** | | |
| 6.1 | BYPASS SYSTEM REQUIRED | | |
| 6.2 | BYPASS SYSTEM TRANSFER MODE | | |
| 6.3 | TYPE OF STARTER (SOFT STARTER, DOL, OTHERS) | | |
| 6.4 | REQUIREMENT OF REDUNTANT VSD SYSTEM | | |
| **7.0** | **INTERNAL ARC TESTING** | | |
| 7.1 | REQUIREMENT INTERNAL ARC CONTAINMENT TESTING FOR VSD ENCLOSURE (SPECIFY) | | |
| **8.0** | **CONTROL AND PROTECTION** | | |
| 8.1 | REQUIREMENT PROGRAMMABLE CONTROLLER WITH LCD DISPLAY | | |
| 8.2 | PROVISION FOR CONNECTING ADDITIONAL EXTERNAL CONTROL SUPPLY FOR TESTING ETC. | | □ REQUIRED □ NOT REQUIRED |

| | | |
|---|---|---|
| 8.3 | ADDITIONAL CONTROL REQUIRED, IF ANY | |
| 8.4 | ADDITIONAL PROTECTION REQUIRED, IF ANY | |
| 8.5 | ADDITIONAL INDICATING INSTRUMENTS REQUIRED, IF ANY | |
| **9.0** | **TESTING** | |
| 9.1 | STRING TEST REQUIRED - Ref. Sub-Clause 19.2.3 (g) | |
| 9.2 | DETAILS OF CABLES TO MOTOR (TYPE & LENGTH)- Ref. Sub-Clause 19.2.2.b.ii.Note 1 | |
| 9.3 | VSD TYPE TEST CERTIFICATE REQUIRED | |
| 9.4 | REQUIREMENT OF SPECIAL TESTS, IF ANY | |
| **10.0** | **TRAINING** | |
| 10.1 | REQUIREMENT OF FACTORY / ON SITE TRAINING | |
| **11.0** | **SPARE PARTS** | |
| 11.1 | REQUIREMENT OF ADDITIONAL SPARE PARTS, IF ANY | |
| | | |
| **B** | **DATA TO BE SUBMITTED BY VENDOR / MANUFACTURER (Provide additional sheets, if required)** | |
| **1.0** | **DRIVE ARCHITECTURE** | |
| 1.1 | TYPE OF TOPOLOGY of VSD SYSTEM SUPPLIED | |
| 1.2 | TYPE OF TECHNOLOGY / SEMICONDUCTOR USED | |
| **2.0** | **MOTOR** | |
| 2.1 | MOTOR VOLTAGE | |
| 2.2 | MOTOR RATED KW | |
| 2.3 | MOTOR BEARING / COUPLING DETAILS | |
| **3.0** | **COMMUNICATION PROTOCOL USED** | |
| **4.0** | **VENDOR SERVICE SUPPORT (PERSONNEL, STOCKING OF SPARES) AVAILABILITY** | □ **YES** □ **NO** |
| **5.0** | **COMPLIANCE WITH THIS KOC STANDARD AND DATA SHEET** | □ **YES** □ **NO** |
| 5.1 | IF NO, SPECIFY | |

## 24.0 APPENDIX - II: DATA SHEET FOR SOFT STARTER

| Data Sheet No. | DATA SHEET FOR SOFT STARTER | REV. | |
|---|---|---|---|
| | | | |

| A | GENERAL INFORMATION / DESIGN DATA- To Be Completed By Purchaser | | |
|---|---|---|---|
| **1.0** | **General** | | |
| 1.1 | APPLICABLE KOC STANDARD | | KOC-E-014 |
| 1.2 | INSTALLATION SITE | | |
| 1.3 | TOTAL NUMBER OF UNITS | | |
| 1.4 | TAG NUMBER (EQUIPMENT NUMBER) | | |
| 1.5 | REFERENCE SINGLE LINE DIAGRAM NO. | | |
| 1.6 | FACILITY PLOT PLAN DRAWING NO. | | |
| 1.7 | SERVICE CONDITIONS, IF OTHER THAN SPECIFIED IN THE STANDARD | | |
| **2.0** | **INPUT POWER SUPPLY** | | |
| 2.1 | SOURCE OF POWER | | □ MAINS □ GENERATOR |
| 2.2 | SUPPLY VOLTAGE | | |
| 2.3 | SYSTEM GROUNDING | | |
| 2.4 | INPUT SYSTEM FAULT LEVEL (kA) | | |
| 2.5 | SUPPLY SWITCHGEAR IDENTIFICATION TAG NO. | | |
| 2.6 | REQUIREMENT OF CIRCUIT BREAKER FOR LOCAL ISOLATION | | |
| **3.0** | **APPLICATION** | | |
| 3.1 | LOAD TYPE | | |
| 3.2 | NO OF START / STOP OPERATION | | |
| 3.3 | INRUSH CURRENT DURING RAMP UP | | |
| 3.4 | TIME SETTING | RAMP UP | |
| | | RAMP DOWN | |
| 3.5 | DRIVEN EQUIPMENT MANUFACTURER DETAILS (FOR EXISTING EQUIPMENT) | | |
| 3.6 | SPECIFIC REQUIREMENT, IF ANY? | | |
| **4.0** | **MOTOR** | | |
| 4.1 | MOTOR TYPE | | |
| 4.2 | MOTOR VOLTAGE | | |
| 4.3 | MOTOR RATED KW | | |
| 4.4 | MOTOR RATED FREQUENCY | | |
| 4.5 | HAZARDOUS AREA CLASSIFICATION OF THE LOCATION OF DRIVE (MOTOR) | | |
| 4.6 | MOTOR MANUFACTURER DETAILS (FOR EXISTING MOTOR) | | |
| **5.0** | **INTERNAL ARC TESTING** | | |
| 5.1 | INTERNAL ARC TESTING OF SOFT STARTER ENCLOSURE REQUIRED | | |
| **6.0** | **CONTROL AND PROTECTION** | | |
| 6.1 | REQUIREMENT PROGRAMMABLE CONTROLLER WITH LCD DISPLAY | | |
| 6.2 | PROVISION FOR CONNECTING ADDITIONAL EXTERNAL CONTROL SUPPLY FOR TESTING ETC. | | □ REQUIRED □ NOT REQUIRED |
| 6.3 | ADDITIONAL CONTROL REQUIRED, IF ANY | | |
| 6.4 | ADDITIONAL PROTECTION REQUIRED , IF ANY | | |

| | | |
|---|---|---|
| **7.0** | **TESTING** | |
| 7.1 | STRING TEST REQUIRED - Ref. Sub-Clause 19.2.3 (g) | |
| 7.2 | REQUIREMENT OF SPECIAL TESTS, IF ANY | |
| **8.0** | **TRAINING** | |
| 8.1 | REQUIREMENT OF FACTORY TRAINING / ON SITE TRAINING | |
| **9.0** | **SPARE PARTS** | |
| 9.1 | REQUIREMENT OF ADDITIONAL SPARE PARTS, IF ANY | |
| | | |
| **B** | **DATA TO BE SUBMITTED BY VENDOR / MANUFACTURER (Provide additional sheets, if required)** | |
| **1.0** | **STARTER ARCHITECTURE** | |
| 1.1 | TYPE OF TECHNOLOGY / SEMICONDUCTOR USED | |
| **2.0** | **COMMUNICATION PROTOCOL USED** | |
| **3.0** | **VENDOR SERVICE SUPPORT (PERSONNEL, STOCKING OF SPARES) AVAILABILITY** | □ **YES** □ **NO** |
| **4.0** | **COMPLIANCE WITH THIS KOC STANDARD AND DATA SHEET** | □ **YES** □ **NO** |
| 4.1 | IF NO, SPECIFY | |

## ACKNOWLEDGEMENT

This KOC Standard has been approved by the Standards Technical Committee (STC) consisting of the following Members:

| | | |
|---|---|---|
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| Mr. A. Unnikrishnan | Standards Team | Secretary / Member |
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The Draft of this Standard had been circulated to the KOC User Teams for review and responses were received from the following Teams:

**AHMADI PROJECTS GROUP**

Team Leader Corporate Proj. I

**CORP. INFO. TECH. GROUP**

Team Leader Tech. Systems

**EXPORT OPERATIONS GROUP**

Team Leader Export Tech. Svcs.
Team Leader HSE-Exp. Opns. & Mar. Opns.

**FIRE TEAM**

Team Leader - Fire (Supp. Svcs)

**GAS OPERATIONS GROUP**

Team Leader Consumer Networks
Team Leader Gas Opns. (S&EK)

**HS&E GROUP**

Team Leader Safety

**OPERATIONS GROUP (EK)**

Team Leader Maint. (EK-II)

**OPERATIONS GROUP (NK)**

Team Leader Maint. (NK)

**OPERATIONS GROUP (SK)**

Team Leader Maint. (SK)

**OPERATIONS SUPPORT GROUP**

Team Leader Maint. Supp. & Relia. (S&EK)
Team Leader HSE (S&EK)

**OPERATIONS SUPPORT GROUP (WK)**

Team Leader Maint. (WK)

**PROJECTS SUPPORT SERVICES GROUP**

Team Leader PMC Management
Team Leader Tech. Expertise
Team Leader Tech. Pers. Dev. & Admin.

**SECURITY GROUP**

Team Leader Security (S&EK)

**SUPPORT SERVICES GROUP (NK)**

Team Leader Proj. Mgmt. (NK)

**TECHNICAL SUPPORT GROUP**

Team Leader Drilling & W/Over Tech. Svcs. II

**SUPPORT SERVICES GROUP (WK)**

Team Leader Proj. Mgmt. (WK)

**The Task Force Responsible for Development of this Standard:**

The development of this Standard has been entrusted by the Standards Technical Committee (STC) to the Task Force (TF-EE/16) comprising of the following Members:

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