

Plant 1.0 MTPA ALUMINA REFINERY STREAM-5	Client NALCO	Contract Code NAL	Document ID 6695-ELT-G00-EC-0024	Contract No. 66-6695	
	TECHNICAL SPECIFICATIONS – VARIABLE FREQUENCY DRIVES			 नेशनल एल्युमिनियम कम्पनी लिमिटेड National Aluminium Company Ltd.	
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INDEX SHEET

The document Cover Sheet indicates revisions made in this document along with the purpose of issue of the revised document. The details of revisions made in the enclosures of this document are listed in the table of *Contents* below and the enclosures listed therein are an integral part of this document.

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Part-IIA	A4	Design Data Sheet (Common Part)	6	0	-
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1.0 SCOPE

The scope of this specification is to define the minimum technical requirement for the design, manufacture, testing and supply of Variable Frequency Drive (VFD). The vendor/LSTK Contractor shall be responsible for engineering and functioning of the drive unit, meeting the intent and the requirement of this specification and data sheet.

In this specification, the word 'drive' shall refer to the power and control module (rectifier - inverter – controller system) along with the associated electrical such as AC / DC link reactor, filter, contactors and other auxiliary panel component / circuitry housed in a metallic enclosure / cabinet.

For design selection of construction & testing of low voltage induction motor, please refer to the relevant Technical Specification of LV Induction motor .

2.0 CODES AND STANDARDS

The equipment shall comply with the requirement of latest revision of codes and standards listed under Part-II of this specification.

- 2.1 The equipment shall also confirm to the provisions of CEA Regulations and other statutory regulation currently force in the country. 
- 2.2 In case Indian standards are not available for any equipment, standards issued by IEC/BS/VDE/IEEE/NEMA or equivalent agency shall be applicable.

3.0 SITE CONDITION

- 3.1 The AC drive shall be designed to operate under site condition as specified in elsewhere in the tender.
- 3.2 The AC drive shall be installed indoor in a non-hazardous location, as specified in data sheets Part-IIA.
- 3.3 All the equipment is intended for continuous duty as per nameplate rating under the specified ambient condition. Derating if any required for service in specified ambient condition shall be clearly indicated. Derated rating of drive shall be suitable for the ambient temperature as per site data irrespective of the ventilation provided for the room.

4.0 GENERAL REQUIREMENTS

- 4.1 The offered equipment shall be brand new state of art technology and with proven track record. No Prototype equipment shall be offered.
- 4.2 Vendor/LSTK Contractor shall ensure availability of spare parts and maintenance support service for the offered equipment for at least 20 years from the date of supply.
- 4.3 Vendor/LSTK Contractor shall give a notice of at least one year to the end user of the equipment before phasing out the product / spares to enable the end user to place the order for spare and services.

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4.4 **Performance Requirement**

4.4.1 **Basic Features**

The drive shall be energy efficient, provide very high reliability, high power factor, low harmonic distortion, wear and noise. It shall be easy to install with minimum time and expense and no special tools shall be required for routine maintenance.

The drive shall be designed to deliver the motor power and torque for the complete speed-torque characteristics of the load. The drive shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses resulting from short –circuit.

The drive shall be designed to operate in one or more of the following operating modes to meet process requirements:

- a) Variable torque, Torque changing as a function of speed i.e Torque \propto Speed²
- b) Constant torque over a specific speed range.
- c) Constant power over a specific range where the torque decreases when speed increases.

The drive controller shall be equipped with microprocessor based digital regulator with programmable functions.

The power control regulator logic shall provide for an acceleration / deceleration current limit curve and shall be capable of field adjustment without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 100 seconds as minimum.

The system shall be suitable for single quadrant and the speed variation shall be with range 1:100 unless otherwise specified with speed set accuracy of $\pm 1\%$ of rated maximum frequency and steady state regulation of $\pm 0.5\%$ of rated frequency.

The total harmonic distortion (THD) of the voltage and current at inverter output shall be as specified in the Part-II of this specification.

The system shall be suitable for operation on a supply system with a short circuit rating as calculated based on the converter transformer(if provided)

The controller / drive output overload capacity shall be 150% of rated current of motor for one minute. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent motor over heating and drive damage.

During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in set point within a time limit of 5-120 seconds

The integrator action of the set point alteration shall be independently adjustable for both an upwards and a down words alteration. The minimum time interval between set point adjustment by the distributed control system shall be considered as 10 seconds.

It shall operate on constant V/F supply with required voltage boost capability in low frequency mode of operation. Short time voltage dips up to 80% of normal shall not cause the control system to stop functioning.

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Drive shall trip in case speed exceeds 105% of the maximum operation speed for more than 10 seconds.

Upon complete loss of the speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to the loss of signal or switch off indicating fault signal. This action shall be user selectable

The drive shall be equipped with an automatic restart facility which will restart the system in case the voltage dips or power interruption for less than 1 seconds with recovery of the voltage to 90% of its nominal value. The drive shall have the facility to block the automatic restart. Upon restart the converter shall be capable of synchronizing onto a rotating motor, so called 'Catch on Fly Start' and develop full acceleration torque within 10 seconds.

Maximum noise level from the drive at 1 meter distance, under rated load with all normal cooling fans operating shall not exceeds 75 dB(A).

Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting.

4.4.2 Control Requirement

The system shall be suitable for number of starts as per specification .

The power controller shall be regulated always to start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

The required provision for the interface with PLC/DCS (located at remote control room) including detail communication module and data transfer facility, I/O detail, shall be furnished, when specified in data sheets.

The communication interface shall be via serial communication link with industry standard open protocol i.e MODBUS RTU. and same shall be coordinated with the interfacing equipment.

The starting, running and stopping logic of the system shall provide potential free contacts wired to terminals for connection to other systems. The interface requirement shall be as indicated in attached scheme for VFD cabinet.

4.4.3 Cooling

Cooling system shall include well-dimensioned panel, adequate cooling air-flow path, module cooling fan and if necessary, panel cooling fan. Vendor/LSTK Contractor shall ensure that the panel dimensions and flow paths have been designed for continuous operation at the specified ambient without overheating. Operation of fans shall be monitored.

Supplier shall ensure that cooling air intake louvers with filter elements are located on front of the panel ONLY. No louvers shall be located on rear or sides as the panels will be kept touching each other or installed back to back or installed touching the wall.

4.4.4 Fault Diagnostic

Fault diagnostic feature shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available for a minimum 4 days (96 hours) after a shut down even though no supply would be available to the system. The system may be de-energised for maintenance or otherwise. It shall be possible to retrieve the record of prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

4.4.5 Control Circuit

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Control supply for devices external to VFD module i.e. contactors control, space heater supply for Motor /VFD, including lamps etc. shall operate on control power derived from single phase control supply transformer (before the line side contactor), with protection device provided in primary and MCB in secondary, located inside the drive cabinet. The control voltage shall be as specified in data sheets Part II.

Control supply for VFD module shall be as per data sheet Part II.

All the control wiring shall be enclosed in plastic channel. Each wire shall be identified at both ends by PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, copper conductor wire. Minimum conductor size shall be 1.5 sq.mm for control, 2.5 sq.mm for current transformer and other power circuits and 0.7 sq.mm for electronic circuit.

4.4.6 Bypass Arrangement & Output contactor

Bypass feature shall be provided if mentioned in the data sheet. Variable frequency drives (VFD) having bypass feature shall have motor protection relay along with necessary control and metering etc. The Bypass shall be such that when motor is in bypass, the drive shall be accessed for maintenance without any live parts. Bypass components shall meet the requirement of Type-2 co-ordination. All contactor shall be suitable for AC-3 duty. Type of protections to be provided in bypass along with the type of relays shall be as per attached data sheets/scheme.

Output contactor shall be provided in case the VFD has bypass arrangement. Stop PB shall be wired such that drive shall first shutdown (ramp down) and contactor shall switch OFF after complete shutdown of the VFD. Output contactor shall be switched ON before drive is ready for releasing the firing pulses.

In case of VFD does not have bypass arrangement, Isolator shall be provided at output for positive isolation.

4.5 Equipment specification

4.5.1 Power converter

The VFD shall consist of a line side power converter for operation as a rectifier and a load side as a fully controlled inverter.

Drive shall be 6 pulse ~~or 12 pulse~~ or Active front end as specified in the data sheet. Vector group of the input transformer shall be selected to meet the above configuration.

Normally, for all output short circuits, the inverter shall interrupt the current before any semi conductor fuse blows. For internal short circuit, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuse, the converter shall be able to withstand a three – phase short circuit current until interrupted by normal breaker operation. In case of fuse less design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

All power converter thyristors design shall include co-ordination by peak voltage protecting snubber networks and di/dt and dv/dt networks.

The rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing though the element at full load of the VFD throughout the complete speed range.

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The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic current generated by the inverter operation.

The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precaution / tools.

The cooling system of the electronic components, if provided, shall be monitored and alarm shall be generated before occurrence of any consequential damage to the power control devices.

All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuses. I2t particulars of the power controller devices and the fuses shall be supplied along with the calculations in support of the selection of fuse. Inverter shall be of latest technology.

4.5.2 Harmonic

Harmonic at the supply side of the drive shall be restricted to the maximum allowable levels of current and voltage distortion as per recommendation of the latest of IEEE-519 or as per data sheets whichever is stringent. The values of percentage voltage and current harmonics at the input point of drive as the PCC (point of common coupling), shall be furnished.

4.5.3 DC Link and AC Line Reactor

Smoothing reactors for the DC link shall be designed for sufficiently decoupling the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line reactors shall be suitable for harmonic suppression and fault current limitation.

The reactor shall be dry type, air-cooled, and located within the panel.

The reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operating condition of the system without exceeding its temperature.

4.5.4 Output filter

VFD output current waveform shall be inherently sinusoidal, with a total harmonic current distortion not exceeding the value stipulated in relevant standards or data sheets which ever is stringent, over the complete speed range regardless of load. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds after the loss of AC voltage.

VFD shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and shall be housed inside the VFD enclosure.

5.0 ENCLOSURE CONSTRUCTION AND WIRING

Each AC drive module shall be suitably housed in sheet steel panels and shall be fabricated with cold rolled sheet steel and structural steel. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing / wall mounting as specified in data sheet.

Incase of free standing floor mounted panels the maximum and minimum operating height of the switches shall be 1800mm and 300mm respectively. Free standing panels shall be provided with base frames.

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For cable entry removable bolted un-drilled gland plate shall be provided. Clamp type terminals shall be used for connection of all wire up to 10mm² and terminal for higher size shall be bolted. Minimum space for power cable termination shall be 200mm clear.

All the live parts shall be shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered. Minimum 20% spare terminal shall be provided.

All the fuses for power circuit of semi conducting devices shall be fast acting semi conducting type and mounted inside the panel. All the power switches shall be operable externally. All the panel instruments, where ever provided shall be switch board type, back connected, shall have red mark indicating maximum permissible operating rating. Type & size of panel instruments shall be as per data sheets.

Each panel shall be provided with 11W LED illuminating lamp with door switch & protection device. 5/15A, Power socket with switch & MCB shall be provided for the voltage rating specified in data sheets. Each panel shall have space heater with switch, variable setting thermostat & MCB.

All the metallic components / parts shall be connected to the main earth bus bar (PE bus bar) running at the bottom of the panel. PE Bus bar of size as mentioned in data sheets shall be provided with extension on both sides outside the panel and provision for connection to plant earth grid. Material of construction of the PE bar shall be as per data sheets

Panels shall be provided with separate insulated Instrument earthing bus bar (PA bus bar) for connection of screens of instrument cables. PA Bus bar of size as mentioned in data sheets shall be provided. Material of construction of the PA bar shall be as per data sheets

All the metal parts shall be treated so as to ensure efficient anti-corrosive protection. Hard wares shall be zinc – passivated or electrogalvanized. Panel enclosure and structure support shall be thoroughly cleaned and degreased to remove mill scale and rust etc. External surface shall be prepared for final painting of shade specified in the bid document. The paint shall be epoxy based 2 coats by powder coating process.

All panels shall be of same height so as to form a uniform line up, to give good aesthetic appearance.

All the control wiring shall be enclosed in plastic channel.

All electronic modules and components shall be accessible from front of panel only. Modular plug-in / draw-out assemblies for both the system control electronics equipment shall be used.

Suitable removable type hooks shall be provided for lifting the panel.

6.0 SYSTEM COMPONENTS

6.1 General Requirement

The panel shall include suitable main incoming isolation device i.e circuit breaker, MCCB, switch fuse or on load isolator as specified in data sheets for main supply, contactors, diodes or thyristor (converter)/IGBT(inverter) modules with protective devices, reactors for suppressing commutating notches, control circuit ,control accessories, indication and annunciation etc.

Main isolating devices shall also function as a manual disconnecter and Interlock shall be provided between the door so that door cannot be opened unless the Main isolating device is off.

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The fuse used for semiconductor device protection shall be semi conductor type. Other fuse shall be HRC type mounted inside the panel. All switches shall be rotary type and fitted on front of the panel.

All the electronics circuit cards shall preferably be modular for easy replacement. In case of thyristor application, test point shall be provided for testing the thyristor firing pulse in control circuit and at the thyristor gate terminals.

Acrylic transparent insulating materials shall be used for covering live components. Drive keypad shall be provided outside the panel.

6.2 Reliability Features

The expected life time of the VFD shall be 20 years. The VFD including all individual components forming part of the system shall have an availability of minimum 0.997 and MTBF of 3200 hrs.

The design shall incorporate the following reliability features:

- a) Pre-tested components with power components to be 100% tested under dynamics conditions.
- b) Printed circuit boards shall be computer tested and adjusted.
- c) Printed circuit boards shall be temperature cycled for minimum of 40 hours.
- d) Printed circuit boards shall be treated for tropical, humid and corrosive environment.

6.3 Maintenance Feature

The design shall incorporate the following maintenance features:

- a) Modular construction.
- b) Printed circuit Boards shall be plug connected.
- c) All componests shall be easily accessible from the front of the enclosure.
- d) Standard diagnostics to aid maintenance personnel. This shall include alphanumeric displays, test or measurement points.

7.0 PROTECTION, CONTROL, METERING, INDICATION & ANNUNCIATION

The manufacturer shall provide all necessary system control, protection, alarm equipment and metering for the entire drive unit and its auxiliary equipment. Automatic sequence control shall include start-up of cooling system, interlock checking, automatic start and run up of drive, planned energy shutdown. The same shall be processed through microprocessor based system.

Bypass along with the motor protection relay shall be provided to bypass the VFD when BYPASS mode is selected.

Manufacturer shall review the requirement of control & interfacing with owner's DCS, LCS etc. as indicated below develop a control scheme & submit the same for review & approval. Supplier shall also refer the attached control scheme for reference.

Operator control panel

Each drive shall be equipped with a front mounted operator control panel consisting of backlit alphanumeric display and a keypad with keys for Run/Stop, Increase/decrease, menu navigation and parameter select/save. All parameter names, fault message, warning and other information

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shall be displayed in complete English words or standard English abbreviations to allow the user to understand what is being displayed without the use of a manual or cross reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameter, application and activity function access, fault, local controls adjustment storage, self test and diagnostics.

7.1 Protective Features

The system offered shall incorporate adequate protective features, properly co-ordinated for the drive and motor but not limited to Part-II of the this specification.

Separate Thermistor / RTD relay shall be considered. Refer data sheet.

7.2 Protective Alarms

The system shall generate protection alarms, for various fault conditions of the drive motor, supply cables, converter Transformer, DC Reactor and the converter. Alarm shall also be indicated for the failure of various auxiliaries together with identification of the failing unit and type of fault/trouble.

7.3 Control

The following controls shall be provided as a part of the operator control panel or through separate selector switches.

The VFD Panel shall be suitable to receive Start / Stop signals and speed Raise/ Lower signal (In Drive mode only) either from Local Control Station (LCS) located near motor (LOCAL Mode) or from DCS (REMOTE Mode) or from both based on the Process Logic requirement as specified in the data sheet.

Local-Remote switch shall be either provided on the VFD panel front door if specified in the datasheet or an external command from DCS/ LCS shall be used for control.

Speed Raise/Lower signal shall be accepted either from DCS or from the LCS. Separate selector switch shall provided on the panel door or external selection command shall be used as specified in the datasheet.

Forward/reverse facility shall be provided if specified in the Data sheet .

In case of failure of VFD drive, it should be isolated from both sides automatically. VFD/Bypass mode selector switch shall be provided on the panel front door for Bypass mode selection to start the motor through bypass starter. Type of Bypass starter shall be as specified the data sheet.

VFD MODE

Motor shall receive power supply through VFD module & motor start, stop, speed variation shall be either possible from LOCAL or REMOTE mode.

BY-PASS MODE

Motor shall be started using a Direct-On-Line (DOL) starter incase VFD module is down for repairs. Motor start shall be selectable in LOCAL or REMOTE mode. Motor stop shall be possible irrespective of Local/Remote mode of operation.

Arrangement for feeding the motor space heater as specified in the data sheets shall be provided.

7.4 Audio Visual Indications

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The indications and Audio–Visual alarms shall be as per the design data sheet (Part-II) of this specification. Hooter for audio annunciation shall be provided with test, accept & reset push button. Hooter shall be electronic type & have oscillating tone.

7.5 Metering

Digital display of all parameters specified in part-II of this specification shall be as a part of the operator control panel, selectable by the operator or by separate meters as specified in data sheets.

Provision for remote metering on the LCS, DCS if specified in datasheet shall be provided. Associated transducers shall be considered as specified in data sheets. All remote signals shall be wired upto the remote terminal box for customer cable connection

7.6 Annunciations & Indications

Potential free contact shall be provided for remote annunciations and shall be wired upto terminal block for the owner’s use.

All analog signals (4-20mA) shall be provided with galvanic isolation barrier.

Supplier shall provide the arrangement in the VFD panel for supplying the control voltage to the speed indicator located on the LCS in field

8.0 PAINTING

All metal surfaces shall be thoroughly cleaned and de–greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be provided with epoxy based powder coating. The colour shade of the final paint shall be as per data sheets. Panel finish shall be free from imperfections like pinhole, orange peels, runoff paint, etc.

All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion.

9.0 INSPECTION & TESTING

Inspection and testing shall be carried out based on latest revision of this specification and approved vendor drawings certified for construction. Testing procedure shall be as specified in Part-IV. In case of ambiguity between vendor drawings and technical specifications, the requirement indicated in technical specifications shall govern.

Owner / Consultant/ LSTK Consultant shall have the right to carry out stage inspection and shop visit to review the manufacturing progress. However manufacturer need not hold any of the manufacturing activity for Owner / Consultant/ LSTK Consultant stage inspection.

Supplier shall furnish the type test certificates as requested in data sheets, Supplier shall ensure that the VFD modules as well as the VFD cabinets are duly type tested & type test certificates are valid & not more than 5 years old at time of placing order.

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For combined testing of VFD with along with the motor, if specified in data sheets, the VFD shall be delivered to Motor vendor's works. VFD supplier's representative shall also be available along with LSTK Contractor / Owner / Consultant inspectors at motor vendor's works to witness the testing. The arrangement will be mutually coordinated during the detailed engineering after the order placement.

Vendor/LSTK Contractor shall ensure that all meters and instruments associated with testing of the equipment are calibrated by a competent testing authority and the calibration certificates are valid at the time of carrying out the testing of equipment.

After completion of inspection and testing, vendor shall furnish all as-built documents in required number of sets. Only after receipt of final documents by the LSTK Contractor, release order for dispatch of material will be issued.

10.0 PACKING AND DISPATCH

The equipment shall be divided in to a several shipping section for protection and ease of handling during transportation. The equipment shall be properly packed for transportation by ship /rail or trailer. The panel shall be wrapped in polyethylene sheet before being placed in wooden crates / cases to prevent damage to the finish. Crates /cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particular's, 'PO nos' etc shall be clearly marked on the package together with other details as per the LSTK Contractor order.

The equipment may be stored outdoor for long period before installation. The packing should also be suitable for outdoor storage areas with heavy rain and high ambient temperature unless otherwise agreed.

11.0 PERFORMANCE GUARANTEE

All performance figures for VFDs furnished along with the specification shall be guaranteed within the tolerances permitted in relevant standards.

If actual performance figures of the drive, as per test reports witnessed by Owner, are not within the limits of guaranteed values, including tolerance limits indicated in relevant standards, then the drive shall be liable for rejection. However LSTK Contractor / Owner reserves the right to use the rejected drive till a new drive is supplied.

If any drive supplied by the vendor fails at site, due to manufacturing defects, during erection, commissioning or service (within guarantee period), the vendor shall repair and put back into successful operation. The failed equipment within the time frame and procedure of repair agreed with the Owner / LSTK Contractor, depending on nature of failure, at no extra cost to Owner and the Guarantee period shall be suitably extended.

 नालको NALCO नेपाल एल्युमिनियम कम्पनी लिमिटेड National Aluminium Company Ltd.		VARIABLE FREQUENCY DRIVES		Code	NAL	
		PART - IIA		Contract no.	66-6695	
DESIGN DATA SHEET				Doc.	6695-ELT-G00-EC-0024	
				Rev.	0	Page 1 OF 6
GENERAL	001	Make of VSD	: As per Vendor List			
	002	Application :	: 3 Ph, Squirrel Cage Induction Motor			
	003	Collaboration Arrangement	:			*
	004	Standard product or Manufactured against this order	:			*
	005	Panel Location	: Indoor			
	006	Ambient conditions specified under site conditions	: Refer Site data sheet			
	007	Air conditioned / Pressurised Room	:			*
	008	Drives to be enclosed in common cabinet	: NO			
	009	Common Cabinet to be supplied	: NO			
	010	Derating required for the design ambient temp.	:			*
	011	Control Cable type, Size and max. loop (to and fro) length	: VFD/MCC to DCS :			*
		VFD/MCC to LCS :			*	
CODES & STANDARDS	012	IEC 60146- Semiconductor Converters				
	013	IS 6619 : Semiconductor Safety Code				
	014	IS 1885: Static Converters				
	015	IS 6553: Environmental Requirements for Semiconductor Devices & Ics				
	016	IS 14901 :Essential ratings and characteristics of semi-conducting devices				
	017	IS 3715 Letter symbols for semi conducting devices				
	018	IS/IEC-60947 General requirement of switchgear & control gear for voltage not exceeding 1000V				
	019	IS 4411 Code of designation of semi-conducting devices				
	020	IS 5001 Guide for preparation of drawing for semi-conducting devices				
	021	IS 5469 Code of practice for the use of semi-conductor junction devices				
	022					
	023	IEC 61000 Radiated Electromagnetic Field Requirements				
	024	IEEE 519 Recommended practices and requirements for harmonic control in electrical power system.				
	025	IEC 61800-8 Adjustable Speed Electrical Power Drive systems - Part 8: Specification of voltage on the power interface				
	026	IEC 60034-18-41 Partial discharge free Electrical Insulation systems (Type I)				
027						
INPUT DATA	028	Voltage & variation	: 415 Volts, 3 Phase, ± 10 %	690 Volts, 3 Phase, ± 10 %		
	029	Frequency & variation	: 50 Hz + 3%, - 5 %	50 Hz + 3%, - 5 %		
	030	Combined Voltage & Frequency variation	: ± 10 %	± 10 %		
	031	Isolation Device at LSTK switchboard	: SFU			
	032	Power factor at full load (min-0.85)	:			*
	033	Short circuit level	: 65 kA for 1 sec			
	034	THD (current) feedback to source	: %			*
	035	Input side choke to reduce harmonics	: Required for 6 pulse, * %			*
			for 12 pulse and Active front end based on line side harmonic values to be limited to source			
	036	DC link inductor on both +ve & -ve limb required	: YES			
	037	VFD panel design to be "FUSELESS"	: NO			
038	Type of converter	: a. Rectifier – Thyristor For 6 Pulse, 415 V. IGBT For Active front end , 690V. b. Inverter – IGBT				
039	Type of Incoming Isolation Device in VFD panel	: SFU				
INVERTER DATA	040	Type of Inverter	: Voltage Source Inveretr, sine wave PWM			
	041	Devices used for Construction	: IGBT (Third Generation)			
	042	a) MAKE	:			*
	043	Max. Hot spot temp. for semiconductor devices	: 80 °C			
	044	PIV Rating of Diodes	: 2.5 times rated voltage			
	045					

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CONTROL CHARACTERISTICS	046	Overload Capacity	:	150 % for 1 minute				
	047	DC Injection Braking Required	:	YES				
	048	Acceleration / Deceleration time / ramp selection	:	YES Ramp down time setting : *				
	049	Auto tuning	:	YES				
	050	Slip Compensation	:	YES				
	051	Momentary Power Loss Ride through (1 sec.)	:	YES *				
	052	Catch on Fly Start	:	YES				
	053	Multi Speed Operation	:	YES				
	054	Switching Frequency Range(2-16kHz)	:	*				
	055	Frequency Accuracy(min-0.1Hz)	:	*				
	056	Starting Torque	:	*				
	057	Torque Boost	:	YES *				
	058	Jump Frequency	:	YES				
	059	Bumpless transfer during changeover from Manual to Auto	:	YES				
PROTECTION	060	Thermal Overload	:	YES				
	061	Short Circuit Protection	:	YES				
	062	Overvoltage	:	YES				
	063	Undervoltage	:	YES (auto reset)				
	064	Motor Temperature Monitoring (Alarm/Trip)	:	YES (Using Thermistors)				
	065	Single Phasing / Unbalance	:	YES				
	066	Earth Leakage Protection	:	YES, sensitivity 100 mA				
	067	Stall Protection	:	YES				
	068	Motor O/L and single phasing in By-Pass	:	YES				
	069	Motor Earth leakage protection in By-Pass	:	YES 5.5 kW & Above				
	070	Heat Sink Overheat	:	YES				
	071	Cooling System Failure	:	YES				
	072	VFD Module Internal Failure	:	YES				
	073	DC link Over voltage	:	YES				
	074	Incoming line surge protection	:	YES				
CONTROL, METERING & INDICATIONS ON PANEL	075	Metering						
	076	Type of Meter :	:	Digital				
	077	Accuracy Class / Burden	:	1.0 / 5 VA				
	078	Size	:	96 x 96mm (Tautband 240 degree deflection)				
	079	Panel Meters shall be provided for	:					
	080	Incoming Voltage	:	YES Thru Selector Switch				
	081	Incoming Current	:	YES Thru Selector Switch				
	082	Running Hours	:	YES				
	083	Motor kWh	:	YES				
	084	Visual Indications						
	085	Type of Indiacating Lamps	:	Clustered Chip LED				
	086	Motor running (Any either VFD or By Pass mode) - RED						
	087	Motor stopped - GREEN						
	088	Common Fault (Combined for VFD mode or Bypass mode) - AMBER						
	089	By Pass Protection Fault - AMBER						

 नालको NALCO नेपाल एल्युमिनियम कम्पनी लिमिटेड National Aluminium Company Ltd.	VARIABLE FREQUENCY DRIVES		Code	NAL		
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CONTROL, METERING & INDICATIONS ON PANEL (CONT...)	090	AC mains ON – RED, YELLOW, BLUE	:	YES		
	091	VFD MODE 'ON' - RED	:	YES		
	092	By PASS MODE 'ON' - RED	:	YES		
	093	System ready to start / Healthy – GREEN	:	YES		
	094	Hooter for Audio Indication	:	YES		
	095					
	096	Interface with DCS (REMOTE Mode)				
	097	Indications to DCS				
	098	Motor Running (either in VFD or Bypass Mode)	:	Pot, Free Contact	:	YES
	099	Motor Fault (either in VFD or Bypass Mode)	:	Pot, Free Contact	:	YES
	100	Local / Remote Selected	:	Pot, Free Contact	:	YES
	101	Speed Indication	:	4-20 mA Analog active	:	YES
	102	Current Indication (VFD and Bypass mode)	:	4-20 mA Analog active	:	YES
	103	VFD/BYPASS Indication	:	Pot, Free Contact	:	YES
	104	Commands From DCS				
	105	Start	:	Pulsed Pot. Free Contact	:	YES
	106	Stop / Process interlock	:	Latched Pot. Free Contact	:	YES
	107	Local / Remote Selection (Optional)	:	Latched Pot. Free Contact	:	YES
	108	Speed Set Point	:	4-20 mA Analog active	:	YES
	109	Soft Link Communication with DCS / PLC / SCADA				
	110	Communication Card required for VFD	:		:	YES
	111	Communication Link	:	RS-485		
	112	Communication protocol	:	Modbus RTU		
	113	Communication Media	:	Copper cables		
	114					
	115	Interface with LCS (LOCAL Mode)				
	116	Indications to LCS				
	117	Motor Current (for VFD and bypass mode)	:	4-20 mA Analog active	:	YES
	118	Motor Speed	:	4-20 mA Analog active	:	YES
	119	Arrangement for feeding control supply to digital indicator shall be provided in VFD Cabinet				
	120	NOTE : 20 mA shall correspond to the values required as per each VFD - Motor application requirement				
	121	Commands from LCS				
	122	Start	:	Start Push Button - Pulsed	:	YES
123	Stop / Emergency Stop Command	:	Press to Stop twist to release	:	YES	
124	Speed Raise	:	Pot, Free Contact	:	YES	
125	Speed Lower	:	Pot, Free Contact	:	YES	
126	Supplier shall interrogate all pot. Free contacts from LCS /DCS with relay in VFD cabinet & contact of this relay shall then be given to VFD module electronics to avoid nuisance operation.					
127	Capacitance effect of long control cable length shall be considered while designing the control circuit. If required special measures like special auxiliary relays,R-C circuits shall be implemented. Actual loop length,cable type for each circuit shall be informed during detail engineering.					
128	Functions on Panel					
129	Emergency Stop	:	Press to stop twist to release with shroud	:	YES	
130	VFD / BYPASS Mode Selection	:	Key Switch	:	YES	
131	Reset	:	Push Button	:	YES	
132	Local / Remote Selection	:	Key Switch	:	YES	
133	Location of Local / Remote Selection Switch	:	DCS			

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CONTROL, METERING & INDICATIONS (CONT...)	134	Control Supply for devices external to VFD module : Thro. Control transformer, Tapped before line side of incoming contactor , Control voltage 240 V AC.				
	135	Control supply for VFD module : External power supply from UPS. UPS voltage is 230 V AC.				
	136	Provision for feeding Motor Space Heater				
	137	To be provided for motors	:	30 kW & Above		
	138	Typical Rating	:	W		*
	139	Space heater Voltage	:	Volts		*
CABINET DETAILS	140	Make of Panel	:	As per Vendor List- Electrical		
	141	Cabinet Type	:	Free Standing		
	142	Degree of Protection	:	IP 41 (min.)		
	143	Access	:	Front only		
	144	Cable Entry	:	Bottom		
	145	Sheet Steel Material	:	CRCA		
	146	a) Thickness of Sheet Steel	:	2 mm		
	147	b) Thickness of Gland Plate	:	3 mm		
	149	c) Thickness of Structural members	:	3 mm		
	150	Base Frame required	:	YES		
	151	Main Busbar	:			
	152	a) Material	:	Aluminium		
	153	b) Busbar size	:	mm X	mm	*
	154	PE Busbar (for electrical earthing)	:			
	155	a) Material	:	Copper		
	156	b) PE Busbar size	:	mm X	mm	*
	157	PA Busbar (for instrument earthing)	:			
	158	a) Material	:	Copper		
	159	b) PE Busbar size	:	mm X	mm	*
	160	Overall Dimensions(HXWXD)	:	mm X	mm X	mm *
	161	Overall Weight:	:	kg		*
	162	Material of wire mesh to cover louvers	:	Brass		
	163	Gasket Material	:	Neoprene Rubber		
	164	Name Plate details	:			
	165	a) Material:	:	METAL PHOTO BLACK & SILVER		
	166	b) Thickness	:	2 mm		
	167	c) Inscription	:	White letter engreaved on black background		
	168	AC Power Socket required inside the panel	:	YES		
	169	Panel Space Heater with thermostat	:	YES		
	170	Control Voltage for socket & panel space heater	:	240 Volts, 1Phase AC		
171						
172						
173						

 NALCO नालको नैपलार सुपुर्माणिकार कम्पनी लिमिटेड National Aluminium Company Ltd.		VARIABLE FREQUENCY DRIVES		Code	NAL		
		PART - IIB DESIGN DATA SHEET (SPECIFIC)		Contract no.	66-6695		
				Doc.	6695-ELT-G00-EC-0024		
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GENERAL	001	VFD Tag No. (for tag plate)	:	As per tagging philosophy			*
	002	Service Description (for tag plate)	:				*
	003	Motor Cable Size	:	mm ²	Cu/Al conductor,A		*
	004	Power and control Cable Length (from VFD to Motor, minimum 250 mtrs)	:	mtrs.			*
	005	Power Cable recommendation (screened/unscreened/PE	:				*
	006	Parameters expected at Motor terminals based on selected VFD, Cable details and Motor	:				*
		Phase to Phase peak Voltage between Phases	:	Voltage			*
		Phase to ground/frame peak voltage	:	Voltage			*
		dv/dt	:	kV/ microseconds			*
		minimum time between pulses	:	micro seconds			*
		minimum pulse duration	:	micro seconds			*
		Rise time	:	micro seconds			*
		Values estimated above shall be suitable for motor insulation with stress category C of IEC 60034-18-41					
	If the values do not meet the reqmt. of standards, than suitable filter at the output shall be provided by VFD vendor. Same shall be installed inside the VFD panel.						
007	VFD Parameters	:				*	
	Carrier frequency	:	kHz			*	
008	Output Choke required	:	Yes, *	% Impdeance		*	
009	Input Choke considered	:	Required for 6 pulse			*	
	Vendor to confirm for Active front end based on line side harmonics						
010	DC link inductor on both +ve & -ve limb considered	:	Required for 6 pulse , Vendor to confirm for Active Front end			*	
011	Bypass arrangement required	:	YES			*	
012	Type of Bypass starter	:	DOL Bypass starter similar to LV switchgear, except fixed type			*	
013	Braking required	:	YES			*	
MODULE DETAILS	014	Model/Type No.	:				*
	015	Make / Country of Origin	:				*
	016	Rated Voltage	:	415 V			*
	017	Rated Current (at switching frequency)	:	_____ Amp at _____ kHz switching freq			*
	018	Input (kVA)	:				*
	019	Output (KVA)	:				*
	020	Efficiency (at full load)	:				*
	021	Output frequency range	:				*
	022	Power dissipation (kW)	:				*
	023	Degree of protection for Module	:				*
	024	Module Cooling	:	Air (By fan)			*
	025	THD of Output Voltage	:	% (No Load)			*
	026	THD of Output Current	:	% (Full load)			*
	027	Dimensions (HXWXD)	:				*
	028	Control Method	:	OPEN LOOP/CLOSED LOOP CONTROL			*
	029	Tacho generator feedback required	:	YES / NO (Application Based)			*
	030	Type of braking	:	Regenerative / DC injection / Resistive (Application Based)			*
031	External Braking Resistor required	:	YES / NO / To be recommended by supplier (Application Based)			*	
032	Time for motor - driven equipment to decelerate	:	seconds			*	
033	Time for Drive to boot after control supply powerup	:	seconds			*	
034	Speed reversing provision required	:	YES/NO (Application Based)			*	
MOTOR DETAILS	035	Motor Tag No	:				*
	036	Motor kW Rating	:	kW			*
	037	Motor Type	:	SQIM			*
	038	No. Of Phases	:	3 Ph.			*
	039	Rated Voltage	:	415 Volts			*
	040	Rated Frequency	:	50 Hz			*
	041	Rated speed	:	rpm			*
	042	Full load current	:	Amps			*
	043	GD ² value	:	Kg-m			*
	044	Located in Hazardous Area	:	YES / NO			*
	045	Hazardous area classification	:				*
	046	Explosion Protection of the motor	:				*
	047	Combine testing of Motor and VFD	:	Yes / No (if applicable)			*
LOAD DETAILS	048	Equipment Tag No.	:				*
	049	Service Description	:				*
	050	Type of driven equipment	:	Centrifugal, positive displacement / Fan / Blower/ Agitator etc.			*
	051	Application	:	Variable Torque/ Constant Torque/ Constant Power			*
	052	GD ² value	:	Kg-m			*
	053	Breakaway Torque of load	:	Kg-m			*
	054	Range of Speed Variation required	:	rpm			*

Plant 1.0 MTPA ALUMINA REFINERY STREAM-5	Client NALCO	Contract Code NAL	Document ID 6695-ELT-G00-EC-0024	Contract No. 66-6695	
	VARIABLE FREQUENCY DRIVES Part-III - Drawings & Documents Enclosed			 नेशनल एल्युमिनियम कम्पनी लिमिटेड National Aluminium Company Ltd.	
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Following drawing(s)/document(s) is/are enclosed:

Sr. No.	Dwg. No./ Doc. No.	Description	Size	No. of Sheets
1.	Annexure-I	SCHEME FOR VFD CABINET	A3	1 of 1

 नालको NALCO नेशनल एल्युमिनियम कंपनी लिमिटेड National Aluminium Company Ltd.		VARIABLE FREQUENCY DRIVES PART- IV INSPECTION TEST PLAN			Code	NAL	
					Contract no.	66-6695	
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Tests		Reference Documents	Sample size	Scope of Inspection			
				Vendor	Owner / Consultant / LSTK Contractor	Remark	
A	Type Tests						
i	Temp. rise Test (at full load)	IEC 60146	Note-3	P _{PROTO}	R		
ii	Measurement of Efficiency at 50 % & full load		Note-4	P _{PROTO}	R		
iii	Noise level Test	IEC 60146	Note-3	P _{PROTO}	R		
iv	Power loss determination(By Cal. method)	IEC 60146	Note-4	P _{PROTO}	R		
v	Degree of Protection for Cabinet		Note-3	P _{PROTO}	R		
vi	Rated Output test	IEC 60146	Note-3	P _{PROTO}	R		
vii	Overcurrent Test	IEC 60146	Note-3	P _{PROTO}	R		
B	Routine Tests						
i	Visual Inspection	Approved drawings	100%	P	W		
ii	Dimensional Checks			P	W		
iii	Light load test & Functional Tests including external interfaces	IEC 60146 & App. Drawings		P	W		
iv	Insulation Test	IEC 60146		P	W		
v	Checking of Auxiliary devices	IEC 60146		P	W		
vi	Checking of Protective devices	IEC 60146		P	W		
vii	Measurement of output voltage	IEC 60146		P	W		
viii	Confirmation of output voltage adjustment range	IEC 60146		P	W		
C	Combined testing for motor and VFD (if applicable)	As per Part V		P	W		
D	Site Tests						
i	Functional Tests including external interfaces						
ii	Load test with actual load						
iii	Harmonic measurement						
a.	- THD (I) at input and output						
b.	- THD (V) at input						
	Notes:						
	1) R = Review; W = Witness, P = Perform (on project equipment), P _{PROTO} = Perform (on prototype).						
	2) Type / special test TCs shall be valid, i.e. less than 5 years old, otherwise vendor shall get the tests performed by accredited / recognised test agency without any additional cost and within agreed time schedule.						
	3) These tests shall be conducted on similar rating / prototype						
	4) These tests shall be conducted on identical rating : Calculation to be submitted.						

Plant 1.0 MTPA ALUMINA REFINERY STREAM-5	Client NALCO	Contract Code NAL	Document ID 6695-ELT-G00-EC-0024	Contract No. 66-6695	
	Combined Testing Of Motor And VFD Part-V			 नेशनल एल्युमिनियम कम्पनी लिमिटेड National Aluminium Company Ltd.	
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Responsibility matrix for combined testing of Squirrel cage Motor with Variable frequency drive (VFD)

Details of Motor Vendor works:

Name and Address :
Contact person (Email and telephone number) :

Details of VFD Vendor works:

Name and Address :
Contact person (Email and telephone number) :

LSTK Contractor:

Name and Address:

Scope matrix for VFD Vendor :

a. Work envisaged at VFD vendor's work:

- Factory Acceptance Test (FAT) of VFD at VFD vendor shop as per approved QAP/Order Specification. FAT shall be performed on VFD Panels, identified for combine testing before the same are ready for despatch to motor vendor works.
- Packing and forwarding of VFD panels (identified for combine testing as per Order Specification) to Motor vendor works.

b. Work envisaged at motor vendor's works:

- Supervision of unloading, unpacking of VFD Panels and shifting to test setup at Motor Vendor works.
- Supervision of cable termination and arrangement of test setup for the combine testing.
- Visual inspection, Control and Power cable termination checks, Earthing checks and performing the required cold / safety checks before energising the VFD.
- Energising the VFD and setting the required parameters in the VFD.
- Transportation of VFD Panels back to VFD vendor works as applicable.

Notes :

- 1) VFD vendor shall be present throughout the heat run test and assist the Motor vendor wherever required.
- 2) VFD vendor to ensure the availability of VFD throughout the heat run test by supervising the VFD performance/operation.
- 3) VFD vendor to ensure that manpower (technicians) and special tools/test instruments/meters required for the combine testing is organised.
- 4) VFD vendor shall follow all the Safety, Security and other administrative rules and regulations of Motor vendor works.
- 5) Required documentation for the transport of VFD to motor vendor works and from Motor vendor works to site/VFD works shall be organised by VFD vendor.

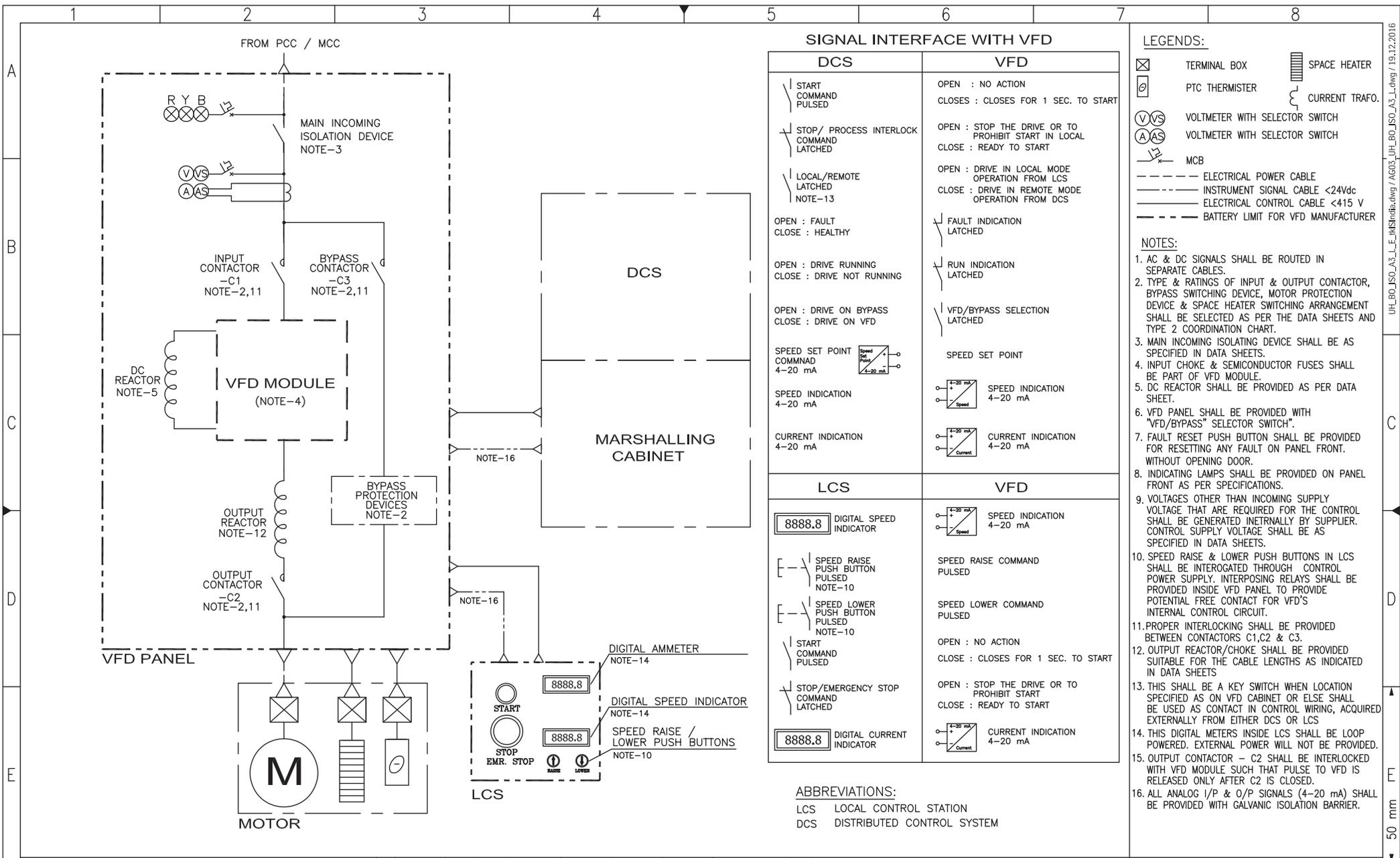
Plant 1.0 MTPA ALUMINA REFINERY STREAM-5	Client NALCO	Contract Code NAL	Document ID 6695-ELT-G00-EC-0024	Contract No. 66-6695
	Combined Testing Of Motor And VFD Part-V			
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Scope matrix for Motor Vendor :

- Receiving, unloading, unpacking of VFD Panels and shifting of VFD panels to test setup.
- Power, Cable termination, Earthing and arrangement of test setup for the combine testing.
- Connecting thermistor to VFD panels with cables where applicable. Arranging external control supply if required.
- Factory Acceptance Test (FAT) of Motors including combine testing as per approved QAP/Order Specification.
- LSTK Contractor shall be one point responsible to Co-ordinate with the Motor vendor and VFD vendor
- Arranging statutory authority to witness the test and certification of motor enclosure.
- Packing of VFD Panels, shifting and loading for transportation.

Notes :

1. Motor vendor to coordinate with VFD vendor personnel for organise his gate pass and other administrative requirements.
2. LSTK Contractor shall ensure that combine testing is performed in his presence.



- LEGENDS:**
- TERMINAL BOX
 - SPACE HEATER
 - PTC THERMISTER
 - CURRENT TRAF0.
 - VOLTMETER WITH SELECTOR SWITCH
 - VOLTMETER WITH SELECTOR SWITCH
 - MCB
 - ELECTRICAL POWER CABLE
 - INSTRUMENT SIGNAL CABLE <24Vdc
 - ELECTRICAL CONTROL CABLE <415 V
 - BATTERY LIMIT FOR VFD MANUFACTURER

- NOTES:**
- AC & DC SIGNALS SHALL BE ROUTED IN SEPARATE CABLES.
 - TYPE & RATINGS OF INPUT & OUTPUT CONTACTOR, BYPASS SWITCHING DEVICE, MOTOR PROTECTION DEVICE & SPACE HEATER SWITCHING ARRANGEMENT SHALL BE SELECTED AS PER THE DATA SHEETS AND TYPE 2 COORDINATION CHART.
 - MAIN INCOMING ISOLATING DEVICE SHALL BE AS SPECIFIED IN DATA SHEETS.
 - INPUT CHOKE & SEMICONDUCTOR FUSES SHALL BE PART OF VFD MODULE.
 - DC REACTOR SHALL BE PROVIDED AS PER DATA SHEET.
 - VFD PANEL SHALL BE PROVIDED WITH "VFD/BYPASS" SELECTOR SWITCH".
 - FAULT RESET PUSH BUTTON SHALL BE PROVIDED FOR RESETTING ANY FAULT ON PANEL FRONT. WITHOUT OPENING DOOR.
 - INDICATING LAMPS SHALL BE PROVIDED ON PANEL FRONT AS PER SPECIFICATIONS.
 - VOLTAGES OTHER THAN INCOMING SUPPLY VOLTAGE THAT ARE REQUIRED FOR THE CONTROL SHALL BE GENERATED INTERNALLY BY SUPPLIER. CONTROL SUPPLY VOLTAGE SHALL BE AS SPECIFIED IN DATA SHEETS.
 - SPEED RAISE & LOWER PUSH BUTTONS IN LCS SHALL BE INTEROGATED THROUGH CONTROL POWER SUPPLY. INTERPOSING RELAYS SHALL BE PROVIDED INSIDE VFD PANEL TO PROVIDE POTENTIAL FREE CONTACT FOR VFD'S INTERNAL CONTROL CIRCUIT.
 - PROPER INTERLOCKING SHALL BE PROVIDED BETWEEN CONTACTORS C1,C2 & C3.
 - OUTPUT REACTOR/CHOKE SHALL BE PROVIDED SUITABLE FOR THE CABLE LENGTHS AS INDICATED IN DATA SHEETS
 - THIS SHALL BE A KEY SWITCH WHEN LOCATION SPECIFIED AS ON VFD CABINET OR ELSE SHALL BE USED AS CONTACT IN CONTROL WIRING, ACQUIRED EXTERNALLY FROM EITHER DCS OR LCS
 - THIS DIGITAL METERS INSIDE LCS SHALL BE LOOP POWERED. EXTERNAL POWER WILL NOT BE PROVIDED.
 - OUTPUT CONTACTOR - C2 SHALL BE INTERLOCKED WITH VFD MODULE SUCH THAT PULSE TO VFD IS RELEASED ONLY AFTER C2 IS CLOSED.
 - ALL ANALOG I/P & O/P SIGNALS (4-20 mA) SHALL BE PROVIDED WITH GALVANIC ISOLATION BARRIER.

ABBREVIATIONS:
 LCS LOCAL CONTROL STATION
 DCS DISTRIBUTED CONTROL SYSTEM

BAR-Code		00	23.10.17	RDK	PDW	23.10.17	MSD	23.10.17	MSD	FIRST ISSUED	Contract No.	Document ID	Part	Rev.	 © thyssenkrupp Industrial Solutions (India) Private Limited 2017 Description SCHEME FOR VFD CABINET
Rev.	Date	Name		Date	Name		Date	Name		Description	Acc. Code	66-6695	ANNEXURE-1	79	
Pro. Unit	TON		Group	Cat. Code	Acc. Code	Status	Date	Name		Drawn	23.10.17	RDK			
Con. Unit	Type of Document	Order No.	Scale	Sheet	1 / 1		Prepared	23.10.17	PDW	Checked	23.10.17	MSD			
Approved	23.10.17	MSD													
Store Location: Server/Share :VAP 0 60.00 0 Electrical		Store Location: Folder :VAP_0_60.00_0_Electrical\VAP_0_60.04_0_Specification\Variable_Frequency_Drives		Store Name VFD.DWG											

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