

VOLUME-2
PART- I
Section-3
Governing System

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3. Governing System

3.1 Scope of Work

The intent of these specifications is to define and cover the scope of work under this section which includes the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Purchaser's personnel, handing over to Purchaser and guarantee of digital electro hydraulic governing system for Keyi Hydro Electric Project, Arunachal Pradesh as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

It is not the intention to specify the minute details/smallest items to deliver a functional system or to define the standard manufacturing practice but to outline the performance, constructional, operational and guaranteed requirements. It is the responsibility of the contractor to ensure these requirements.

3.2 Scope of Supply

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

3.2.1 Material

1. Two (2) sets of governing system shall be each complete with:

- Digital Electronic cubicle
- Electro-hydraulic Actuator
- Two motor driven oil pumps mounted on a sump tank
- Leakage oil unit (Separate Leakage unit may not be required. Leakage oil may be drained directly to OPU sump tank. However, the same shall be subject to approval after review during detailed engineering.)
- Oil pressure tank
- Oil piping
- Hot standby (redundant) processing units/controllers
- Speed signal generator (SSG) for supplying a signal to the speed sensing element, and for supplying voltage for the speed relays (covered under Generator)

2. Two (2) sets of oil hydraulic unit consisting of sump tank, pressure tanks, pumps, nitrogen /air accumulator common/independent for Governor and main inlet valve, oil piping, valves, instruments and associated accessories.
3. All parts and accessories required for making a complete operating unit for controlling and regulating the speed of the turbine in conformity with the performance characteristics specified.
4. Controls for Auto/Manual, Local/Remote operation
5. Shielded multi core cables
6. Transducers /sensors / devices along with necessary connections /interfacing for monitoring of operating parameters
7. Coordination & provision of necessary contacts and / or ports for integration with Plant SCADA System
8. Oil for first filling of governor and bearing with 10% extra quantity, in non-returnable drums, for both the units
9. Spare Parts
10. Special tools and instruments for inspection, dismantling and reassembly of elements of supply
11. Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best international practices.

3.2.2 Scope of Services

1. Transportation and delivery to site including all logistics and proper site storage/insurance and preservation as per manufacturer's recommendation.
2. Site installation and commissioning.
3. Field / touch-up painting including all painting materials.
4. Performance and field acceptance testing as per the relevant clause of this section and submission of report.
5. Training of Purchaser's personnel including operation and maintenance staff as defined in "Section 1 - General Information and Requirements".
6. All the technical documentation including preparation and submission of O&M manuals.

3.3 Special Design and Layout Conditions

3.3.1 System arrangement

An individual governor for each unit shall be of the digital electronic-hydraulic type. The electronic regulation system shall be digital PID type of proven design. All equipment shall be suitable for continuous duty and interchangeable between the units.

The operating oil pressure range shall be the manufacturer's standard for the proposed governor and shall have proved satisfactory in similar governors, which have been in operation. However, the normal operating pressure shall not exceed 120 bars. The characteristics of pressure oil system shall be as under

1. Pressure oil system for turbine governor and inlet valve shall be common/independent
2. The pressure oil system shall comprise of a reservoir, two numbers of electrically operated gear oil pumps, one for normal running and other acting as stand by. The system shall be complete with Nitrogen filled accumulator & nitrogen bottles, necessary fittings, mountings, valves, pressure switches, Heat exchangers (if applicable), gauges, control valve (proportional/servo valve) for controlling the guide vane operating mechanism and accessories like pressure line duplex type filters, non-collapsible type return line filter, magnetic particle remover and provision for on line filtration of oil from external source. The bidder shall guarantee that the temperature of the oil shall not exceed 60o C. The bidder shall provide Nitrogen accumulator with the capacity for minimum 3 opening and closing strokes (C-O-C) of Guide Vanes and MIV.
3. Governor shall be fail-safe on the failure of the speed-sensing element, loss of oil pressure or defect in the actuating system so that under any of these conditions, the machine shall be automatically shut down, with alarm and indication.
4. Governor actuator cabinet shall be located near the OPU and electronic cabinet shall be located adjacent to the unit control board. Necessary cabling up to junction box & UCB shall be in the scope of contractor.

3.3.2 Standards

All equipment shall be designed, built, tested and installed to the latest revisions of the following applicable IEC/IS:

Standard	Description
IEC 61362	Guide to specification of hydraulic turbine control systems
IEC 60308	International code for testing of speed governing systems for hydraulic turbines
IEEE 125	IEEE recommended practice for preparation of equipment specifications for speed-governing of hydraulic turbines intended to drive electric generators

3.3.3 Control requirements

The digital governor shall be capable of performing at least the following functions:

1. Speed/frequency control
2. Power control
3. Reservoir water Level control
4. Flow control
5. Turbine creep detection
6. Control sequencing
7. Remote control of unit from the control room at the powerhouse
8. Loading optimisation
9. Joint control for two (2) units.
10. Manual control through the hydraulic actuator

3.3.4 Operation of Governor

The governor shall come into action automatically when the turbine start signal is given from the unit control board/SCADA which shall then regulate the speed of generating unit in operation.

It shall provide stable governing in all possibilities, stages or conditions of operation of the generating units viz.

1. Speed-no-load
2. Isolation mode operation
3. Operation connected with grid power system
4. Black start of the unit.

Further governor shall regulate the generating unit to a uniform speed, free from hunting or instability at all loads.

It shall have provision for optimization of speed governing parameters, servomotor position, parameters and turbine loading rate.

The different controllers when not active shall be tracking the respective actual values for bump-less transfer of control from one mode to another.

The speed governing of the generating unit shall be carried out by a combination of proportional, integral and differential actions and non-linear characteristics in order to provide best quality of control.

The digital governor shall have high sensitivity, quick response to speed / load changes, least possible dead band time and wide adjusting ranges as given below in respect to various parameters.

a)	Sensitivity speed	Not more than 0.01 % of rated
b)	Range of speed changer adjustment (when operating in isolation mode)	Adjustable between (-) 7.5 Hz and (+) 5 Hz of normal 50 Hz (85 % to 110 %) / As per requirement of grid code whichever is higher
c)	Permanent speed droop	Adjustable between 0-10 %
d)	Temporary speed droop	Adjustable between 0-100 %
e)	Speed dead band at rated speed	Shall not exceed 0.02 percent of the rated speed at any gate setting
f)	Governor dead band time	0.2 sec for step load change of 10 % of rated load or more
g)	Guide vane closing time	Adjustable up to 15 sec., having dual rate of closure
h)	Guide vane opening time	Adjustable up to 30 sec
i)	Proportional gain	Adjustable between 0.2-10
j)	Integral time constant	Adjustable 1 sec - 20 sec
k)	Derivative time constant	Adjustable 0 sec - 20 sec

3.3.5 Governor Time Adjustment

1. The governor shall be designed to operate the turbine guide vanes through a full guide vane closing stroke in not less than 6.0 seconds and shall be capable of being adjustable for operation up to a maximum of 15 seconds having dual rate of closure to restrict the pressure rise and speed rise within specified limits mentioned in "Section 2 - Turbine and Accessories"..
2. The governor shall be designed to operate the turbine guide vanes through a full guide vane opening stroke in not less than 12 seconds and shall be capable of being adjustable for operation up to a maximum of 30 seconds.
3. The closing and opening of governor stroke will be guided by the limit of pressure rise and speed rise within specified limit (< 25% and < 50% respectively) on rejection of load.
4. The gate adjustments shall positively restrict the oil flow and shall be arranged to prevent movement of the turbine guide vanes at a faster rate than the maximum rate to which the adjustment is set.

3.3.6 Capacity

The rating of the governor OPU shall not be less than the capacity of the servomotors for operation of the turbine guide vanes and inlet valve operation. The governor shall be capable of supplying sufficient oil to the servomotors to operate the turbine guide vanes to give an effective time from a complete closing or opening stroke for the range of operating times, with a minimum oil pressure under the maximum net head on the turbine. The oil velocity in the pipes shall not exceed 3 m/s. The governor oil pressure system shall be designed for the extreme case of closing, opening and final closing of the guide vanes with both oil pumps and nitrogen / air accumulator in the circuit. The necessary calculation to have sufficient capacity for three (2 "C"+1 "O") operation of the guide vane and one opening operation of MIV (closing operation of MIV being through counter weight) with the nitrogen / high pressure air accumulator shall be supplied for approval.

3.3.7 Transient Immunity

The governing system shall be immune from false operation or failure from high voltage, high frequency transients that may be conducted in the control circuitry and power supplies internal and external to the governor system. To reduce the transients coupled from external sources, shielded cables shall be used for connection to the external equipment and surge suppression devices shall be installed on inductive devices. The governing system shall be designed and tested to be insensitive to radiated high frequency interference such as that coupled from portable radio transmitters.

3.3.8 Electronic equipment

All electronic equipment such as amplifier and logic circuits shall be of solid state design using industrial grade discrete integrated circuits. All components shall be suitable for operation at temperatures between 0°C and 50°C and relative humidity of 98%.

3.3.9 Test facilities

The output of each functional block within the electronic portion of the governor shall be wired to a test jack accessible from the front to facilitate convenient measurement of circuit performance with a portable oscilloscope. The test points shall be isolated electrically to ensure that the grounding of test jack does not cause a change in the output of circuit under test. The controls shall be arranged to permit the electronic circuits to be tested and replaced while the turbine- generator unit is in service.

3.3.10 Power supplies

A reliable power supply shall be provided for powering the governor electronic circuits. The power supply for the governor shall be from two independent 110 V DC station battery sources, one as primary and other as secondary. Switchover from primary to secondary will follow automatically on failure of primary and return to the primary source automatically following restoration of primary supply.

The power supply shall include redundant converter (dc-dc) connected to station battery source such that failure of any regulated output voltage shall cause instantaneous transfer to a redundant converter without affecting normal governor operation in any way. Contacts shall be provided to give an alarm on

power supply failure and local indication shall be provided to identify the failed functional block. The Contractor shall provide full details of the proposed power supply system for approval by the Purchaser.

In case AC supply is required for any control function, same shall be sourced from the on line UPS with automatic change over facility.

If 24 DC supply is required then the same shall be supplied/arranged by the contractor.

3.3.11 Actuator lock

An automatic locking device shall be supplied that will cause the turbine control mechanism to lock at its last position in the event of speed sensor failure, power failure, removal/failure of electronic component or operation of other protective devices. The device shall allow the turbine control servomotors to close under action of the servomotor limit and automatic shutdown devices.

3.3.12 3.3.12 Hydraulic system

The governor hydraulic system shall perform in accordance with the requirement of this specification, using oil of same specification as used for lubrication of generator pedestal bearing.

Filter element shall be paper mesh type, which needs to be replaced with new element in case of clogging.

3.3.13 Software programme features

The governor shall have auto test programme for checking permanently for correct operation of the main governor components.

3.3.14 Emergency shutdown valve

An independent emergency solenoid valve shall be provided which shall operate in emergencies and catastrophic conditions and send the pressurized oil directly to the guide vane servomotors by bypassing the governor.

3.4 Design and Construction

3.4.1 Type and description

The governor controls for the hydraulic turbines shall be of the oil-pressure, cabinet-actuator, digital-electronic-hydraulic type. The fundamental speed-governing functions including speed sensing, development of the governing control signal, its modification with stabilizing terms, insertion of speed changer signal (speed/load level), and speed droop shall all be developed digitally. Physical control of the turbine guide vane servomotors is to be accomplished hydraulically. The transmission of control from the governor electronics to the turbine guide vane servomotor system shall be in the form of a guide vane position set point signal. This guide vane position set point control signal shall be electronic. The turbine guide vanes are to be controlled by the hydraulic servomotors via a proportional valve

(electro-hydraulic interface) and feedback system so as to correspond exactly to the position called for by the governor guide vane position set point signal.

The governor controls and auxiliary equipment shall be of a type having an established reputation for satisfactory and reliable hydroelectric service, and their operation shall be guaranteed by the Contractor.

The unit governor controls shall be complete with proportional (pilot) valves for the guide vane main distributing valves to servomotors providing the required electro-hydraulic interface with the digital controls, a speed signal generator (SSG) device for providing speed sensing for speed-rated switching functions and tachometer indication, interconnecting oil piping, wiring, instrumentation, controls, and indicating devices with all parts and accessories required to make a complete unit for regulating the speed and controlling the guide vane opening of the turbine.

The actuator proportional (pilot) valves for each governor shall be installed on the oil sump tank on or near the guide vane main distributing valve in the actuator cabinet. The proportional (pilot) valve ports shall be connected by piping to the main distributing valves to form a complete and operational hydraulic control system for interfacing with the digital governor controls.

All gauges and indicating and control devices for the governor shall be mounted on the front of the actuator cabinet. All panels that are provided shall be hinged so that they may be easily swung open to give ready access to all electro-hydraulic components and control devices.

Each governor shall be capable of interfacing with automatic synchronizing equipment and be adaptable for Automatic Generation Control (AGC) through direct interaction with the SCADA system.

3.4.2 Digital electronic controller

The redundant digital controller shall have provisions for setting / adjusting and indication display of the set values of various governor characteristics / parameters with the help of the key board/HMI viz.

1. Permanent speed droop,
2. Temporary speed droop,
3. Temporary speed droop decay time constant,
4. Sensitivity,
5. Frequency dead band,
6. Speed regulation,
7. Power regulation,
8. Opening limitations,
9. Speed set point,
10. Output set point,

11. Monitoring and supervision of speed, power and position feedback signals,
12. Other essential devices for smooth operation protection and safety of the units.

3.4.2.1 Electronic cubicle

All electronic components of digital governor shall be housed in an electronic cubicle. The cubicle shall be a dust tight steel cabinet with doors for convenient adjustment, test and maintenance and shall be mounted at a suitable location along with unit control board panels.

3.4.3 Hydraulic actuator unit

3.4.3.1 Actuator control system

The actuator control system shall consist of a proportional (pilot) valve used in conjunction with the main oil distributing valve with gate position and gate velocity feedback and electronic circuitry constituting a closed-loop control system or an equivalent control system for positioning the gate servomotors to an electronic set-point.

The actuator control system shall position the turbine servomotors to equal the set-point output signal from the digital controller. The actuator control system shall be designed in a failsafe manner such that loss of either its power source or its set-point signal shall cause an immediate closure of the turbine gate servomotors to the shutdown position with full squeeze and an immediate operation of the governor shutdown and lockout relay.

3.4.3.2 Auto clean strainer

Filter element shall be paper mesh type, which needs to be replaced with new element in case of clogging.

3.4.3.3 Actuator cabinet

The electro-hydraulic interface components and accessories necessary for the hydraulic actuator like transducers, relay valve, solenoid valves, switches, terminal blocks shall be housed in actuator cabinet located near OPU.

The controls and instrumentation including indication as defined here in shall be mounted on the actuator cabinet.

3.4.4 Control and indicating devices

The hydraulic actuator units shall have various devices, controls, indications as given below:

3.4.4.1 Gate position and gate limit control and indication

A mechanical gate limit indicator and gate position indicator of the duplex type shall be mounted on the actuator. These indicators shall be designed for field adjustment to obtain correct indication of turbine gate position.

Manufacturer shall supply current transducers and wiring in the cabinet for remote indication of gate position and gate limit at the unit control board.

The gate limit control device shall limit the degree of guide vane opening at any position within the full range of guide vane travel. The control device shall be suitable for manual adjustment from actuator cabinet, local adjustment from unit control board and remote adjustment from powerhouse control room through SCADA system.

3.4.4.2 Speed adjustment control and indication

A device for adjusting the speed set point of the governor when the generator is isolated from the system shall be provided, operated manually at the actuator and electrically controlled by the unit synchronizing equipment.

The control device shall be suitable for manual adjustment from actuator cabinet, local adjustment from unit control board and remote adjustment from powerhouse control room through SCADA system.

The speed changer position shall be displayed on an indicator located on governor at the actuator cabinet and on the unit control board.

The limit switches shall be suitable for switching power to the speed adjustment motor and shall be connected to prevent over-travel and to return the speed set to the synchronous speed after the main breaker has closed.

3.4.4.3 Indicating lights

The following indicating lights shall be mounted on the front face of the actuator cabinet:

- Servomotor gate lock "On" or "Off" indication,
- Generator brake switch in "Auto" position,
- Generator brake "On" or "Off" indication,
- Actuator lock "On",
- "Auto"/"Manual", light on to indicate "Auto" or "Manual",
- Speed sensor failure indicating light,
- Governor electronics power supply test and failure indication

3.4.4.4 Load adjustment control and indication

A device for adjusting the output set-point of governor when the main breaker is closed and the unit is synchronized with the system shall be provided. A feedback selector switch shall be provided to supply

the load adjustment control with a feedback signal from either the guide vane opening or generator output load. Provision shall be made for easy selection between the two feedback signals in the field.

3.4.4.5 Manual gate control

It shall be possible to manually control the guide vanes from the control cabinet for local control for testing and in order that the unit can continue in operation should the electronic circuitry, transducer or transducer pilot valve be inoperative. Transfer of control shall be bump-less from automatic to manual control and vice versa while the unit is in operation.

Manual or automatic control shall be selected using a solenoid controller from the actuator cabinet or from the remote control system at the unit control board and in the powerhouse control room. Automatic shutdown protection shall be available under manual control also.

3.4.4.6 Automatic start, shutdown and speed-no-load

A device to automatically start the turbine, shut down the turbine, and for emergency and catastrophic shutdown of the turbine or operation of automatic protection devices for the generator, turbine and governor, shall be provided.

The automatic speed-no-load device, when actuated, shall limit the turbine guide vanes slightly above the speed-no-load position. This device shall be designed to permit manual or automatic shutdown of the unit to speed-no-load at any time, and shall be such that the guide vanes are again governed by the speed responsive element on reaching the speed-no-load position.

The automatic start-up (from the operator's work station in powerhouse unit control board or control room) will be initiated by momentary closure of contacts. Synchronizer action shall then be initiated from the governor when the unit attains 90 percent of the speed. The speed-no-load shutdown solenoid shall be energized after the main breaker closes.

Automatic shutdown will follow momentary closure of contacts (from the powerhouse control room).

3.4.4.7 Generator brake control

Generator brakes shall be hydraulically operated through the dedicated solenoid operated valve mounted on OPU. The operation of the solenoid of the air valve shall be selected by means of a control switch with "Manual", "Off" and "Automatic" positions. The control switch shall be provided with spring return to "Off" from the "Manual" position and shall maintain the "Automatic" position when so placed.

Gate position switches and speed switches as specified herein shall prevent the application of the brakes until the guide vanes are fully closed and the unit speed has decreased to less than 30 percent

of the rated speed. It shall be possible, below 30 percent speed, to apply the brakes continuously/intermittently after an adjustable period of time by means of the automatic control. The brakes shall be automatically released after the adjustable period of time sufficient to assure that the unit has been brought to a complete stop.

3.4.4.8 Oil pressure gauge

A pressure gauge shall be mounted on the actuator, graduated in bars, to indicate the pressure in the governor oil pressure tank.

3.4.4.9 Gate position switches

A twelve (12) or more contact switch assembly operated by the servomotor position transducer shall be provided. Each contact shall be adjustable to open or to close at any point from zero to full gate opening, as desired. Contacts shall be electrically separate, ungrounded, and suitable for 110 V DC.

3.4.4.10 Governor time adjustment

The actuator shall be equipped with means to adjust the opening and closing times of the guide vanes between minimum of 5 seconds and maximum of 15 seconds for a full gate closing and maximum of 30 seconds for a full gate opening stroke, and with secure means to lock these adjustments. The adjustment for guide vanes closing and opening times shall be possible without dismantling the main distribution valves of the actuator.

3.4.5 Speed droop control and indication

A speed droop control device which operates when the main breaker is closed and determines the change in output if the speed deviates from the synchronous speed, shall be provided. The device shall be manually adjusted at the actuator over a range of 0 to 10 %. A speed droop indicator shall also be provided on the actuator and shall be fitted with a calibrated dial to indicate the speed change for which the unit is adjusted.

3.4.6 Joint control system

A system shall be provided to set the load adjustments controls of the governors to provide equal loading of the units on joint control and to permit remote control of station output. It shall include joint/independent control output control device with provision for remote operation. Indicating lights for joint control and independent control shall be provided on the actuators of each governor and unit control board. When joint control is selected for a unit, the load adjustment control shall be adjusted to the same setting as the joint output control.

3.4.7 Speed switches

Suitable number of electronic speed switches shall be mounted in the regulation cubicle of the governor. These switches shall be used as follows:

1. Over speed protection:
 - To cause unit shut down through the shutdown solenoid via protection circuits at 150% (or more) of rated speed,
 - To cause emergency shutdown of the unit through certain specific protection circuits and/or when unit speed increases beyond 150%,

- In the event of catastrophic conditions and speed rising to 150 % and above, simultaneous command to go to emergency solenoid valve and the MIV control cabinet for closure
- 2. Two sets of contacts shall be arranged to close at and above 90 per cent of the rated speed,
- 3. Brake control: to activate the generator brake when the unit speed is approximately 30 per cent of rated speed,
- 4. Zero speed: to close the contacts at zero speed indicating unit stopped,

Any other speed switch required under Start/Stop logic shall be deemed included in the scope of supply.

3.4.8 Speed sensing devices

Speed of the unit for governor operation shall be measured both from the prime frequency signal from a voltage transformer on generator terminal, (taken at the potential transformers) and back up signal taken from inductive transducer actuated by toothed wheel located on the generating unit shaft.

These two fully independent speed sensing systems shall be installed as main and back-up respectively, with automatic switch-over in case of loss of signal of the main system.

The toothed wheel type speed signal generator (SSG) mounted on the generator shaft and a magnetic pick-up mounted near the toothed wheel shall provide a redundant source of speed signal for the governing system. This output shall also be used for detection of creep and shall have the provision for an alarm to apply brakes. The speed signal generator shall be complete with toothed wheel and magnetic pick-up and internal wiring up to the terminal box on the generator barrel shall be carried out/up to the governor electronic cabinet.

If either speed signal fails or goes out of range, an alarm shall be generated and control shall be transferred to the other signal without affecting the normal operation of the governor. If both speed signals fail, immediate closure of the turbine gate servomotors to the shutdown position and an immediate operation of the governor shutdown and lockout relay shall occur in automatic mode.

The capacity and characteristics of the SSG shall fully match with the requirement of speed responsive elements and governor regulation and control system. It shall be designed to withstand satisfactorily the maximum runaway speed of the turbine.

3.4.9 Load Follower for Manual-Automatic Change-Over

Change of the governor operating modes initiated either automatically or manually shall result in a bump-less transfer by means of a load follower device. The magnitude of the power output fluctuation shall not exceed 5% of rated load when manual-automatic change-over is operated.

3.4.10 Frequency-Phase Follower

To facilitate synchronizing the unit with the network, the governor shall be provided with a frequency-phase follower which shall control the opening of the wicket gates until the frequency of the generator matches closely with the frequency of the network.

3.4.11 Emergency stop

The hydraulic actuator units shall have various devices, controls, indications as given below:-

Two remotely controlled shut down devices for normal and emergency closure of wicket gates. For normal shut downs and some trips closure shall be with electrical/hydraulic interface which will act in response to wicket gate setting instructions from the PID electronics and the governor start/stop valve. There shall also be an emergency closure hydraulic circuit which shall be completely independent of the electrical/hydraulic interface. In the event of emergency closure both the electrical/hydraulic interface and the emergency shut down circuit will operate. The emergency circuit and governor start/stop valve will be fed from independent 110V DC sources.

3.4.12 Hydraulic panel and control at UCB

The governor shall have provision to monitor & control all the parameters of turbine manually or electronically at the front face of governor control panel and hydraulic panel i.e. either from touch screen or push buttons.

3.4.13 Oil pressure system

3.4.13.1 General

Each unit shall have an independent oil pressure system serving the turbine guide vanes for operation of the governor for the operating mechanism, servomotor and controls. If common pressure oil system is provided for governor and inlet valve, the former shall also be able to meet the operating requirements of inlet valve in addition to governor. The oil pressure system shall consist of a sump tank, two (2) A.C. motor driven screw pumps and nitrogen / compressed air accumulator. The design shall be compact, and there shall be easy access to all the components for maintenance and replacement. All the components shall be selected to assure high reliability, long life, low noise and minimum heating of the oil.

3.4.13.2 Operating pressure

The normal operating pressure of the hydraulic oil pressure system shall be 80-120bars.

The operating pressure shall be achieved through nitrogen accumulator / compressed air to cater the requirement of governor oil pressure system.

3.4.13.3 Oil pumps/Gear pumps

Two oil pumps/Gear pumps shall be provided, one acting as "main" and the other as "standby". Each oil pump for the oil pressure supply system shall be independently driven by a 3-phase 415V AC electric motor and each shall have a capacity sufficient to operate the complete governor oil pressure system. It shall be possible to run one main pump continuously so that it discharges to the sump or accumulator tank without overheating the oil. A complete pump logic control system shall be provided that will permit the selection of either pump, as the main unit with the other pump acting as a standby, which will cut in automatically to supply the oil and close a set of alarm contacts.

Each oil pump shall be of the screw type, with a capacity (l/ minute) of not less than 1.1 times of the total oil volume of both the servomotors per minute or higher when operating under the pumping pressure recommended by the Contractor in worst conditions. Each pump shall be self-priming under maximum oil pressure.

A suitable oil strainer shall be fitted in the suction line of each pump.

The motor/pump units shall be mounted on the oil sump tank. Control switches and indicating lamps shall be mounted on the front panel of the actuator.

Each pump shall be direct-connected to a 415 V, 3 phase, 50 Hz, squirrel-cage, low starting current, induction type motor designed for full voltage across the line starting and conforming to IEC standards, with class F insulation. The motor shall have windings with moisture and oil-resistant insulation. The windings shall be braced for line start application. The capacity and torque shall be suitable for the pump requirements and the temp of motor shall not increase beyond B class insulation.

Automatic pressure-operated motor controls shall be furnished on the governor cabinet as well as unit control panel with each main pump, which will start the pump when the oil pressure in the accumulator tank drops to a predetermined point and which will stop the pump when the oil pressure rises to a predetermined point.

The starting control equipment shall be arranged so as to start the motor and permit it to reach full speed before the pump loads, and to unload the pump before the motor is disconnected from the power supply. Combination heavy-duty magnetic starting contactors with fused disconnecting switches and three thermal overload devices shall be furnished and shall be mounted on or adjacent to the pump units.

A 415/240 V control circuit transformer shall be provided within each magnetic starter enclosure, of suitable size for control of the starter and supply to the starter accessories. Suitable terminal blocks with marking strips shall be provided in accessible places for the control wiring. All control equipment shall be suitable for operation from the 110 V AC control circuit transformer. The control equipment shall include a timer, adjustable from 0 to 60 seconds which shall prevent simultaneous closing of the magnetic starters when the power supply is removed and then restored.

Each governor pump shall be provided with an adjustable temperature switch with two (2) electrically separate contacts suitable for operation at 110 V DC located in the pump suction side for governor oil high temperature alarm.

The connections to all pumps shall be arranged so that any pump may be removed for repair or replacement without interfering with the continuous operation of the system.

3.4.13.4 Oil sump tank

The governor system shall be supplied with a sump tank of sufficient capacity to hold at least 10 per cent more than the total quantity of oil in the entire governor & inlet valve system including oil pressure tank. The sump tank shall be designed and have connections for venting and overflow.

The sump tank shall be provided with a manhole of 600 mm diameter with a suitable oil resistant gasket for access to the interior of the tank. A suitable oil level glass shall be provided to indicate the level of

the oil in the tank, marked with low and high level marks, complete with both hand shut-off valves and automatic means of shutting off oil discharge in the event of breakage.

Suitable connections for filling and draining the tank, and connections for an oil purifier shall be provided. The oil purifier connections shall consist of two pipe outlets and valves, one located near the bottom on one side and the other near the top on the opposite side. A vertical filter screen shall be arranged to divide the sump tank into "clean" and "dirty" oil compartments. All strainers shall be readily removable for cleaning. The outlets of all oil pipes to the sump shall be below low oil level. Any component that requires adjustments shall not be located inside the sump tank. Low and high level switches shall be provided for sump tank, suitable for 110 V DC, which operate alarms whenever the oil level reaches the present level. An oil temperature switch wired to cut off power supply to the oil pumps in the event of high temperature shall also be provided.

3.4.14 Oil pressure piping

All piping shall be of stainless steel seamless as per DIN 2391C/ EN 10305-4. The entire piping system shall be welded, insofar as practicable, leaving only such flanged connections as may be necessary for erection or possible subsequent dismantling for repair. Whenever straight pipes are provided, tapered flanged connections shall be introduced to ensure leak proof connection.

Gate valves shall be provided in the pressure line between the pressure tank and the actuator tank. The valves shall be located near the tank. Valves shall be cast or forged steel valve with rising spindle type and having flanged ends.

Other proven designs and arrangements of pressure accumulator can be accepted, subject to approval of the Purchaser, provided that the performance is equivalent and that is an established design already used by the contractor successfully in other similar applications.

3.4.15 Quality Control and Assurance

To ensure quality during each stage of work, the Contractor shall establish a system defining quality assurance plan/procedures during various stages of work with due regard to general technical specification.

The Contractor shall maintain quality control during manufacturing of equipment as per the approved quality assurance plan. Inspections and tests shall be carried out by the Contractor as per approved quality assurance plan with due regard to stipulations in "General Technical Specification" at various stages of manufacturing for assuring the full compliance of supply with the requirements of specification.

3.5 Drawings, Documents and Design Calculations

3.5.1 Design memorandum

The Contractor shall prepare and submit to the Purchaser a "Design Memorandum" of the proposed equipment/system fulfilling the contract specification/requirement for approval prior to submission of drawings and documents. The memorandum shall include the design philosophy, methodology, system

description, input parameters for design, standard and codes, design and selection criteria, equipment data, material specification, major technical features, basic arrangement/ layout etc.

3.5.2 Drawings and documents to be submitted with bid and after award of contract

The Contractor shall submit all the drawings and documents in accordance with requirements stipulated in "General Technical Specification (GTS)". The drawings and documents shall include at least the following:

1. General arrangement, outline and foundation drawings,
2. A complete and detailed description of the governor operation explaining various safety, protective and regulation features of electro-hydraulic governor, actuator, cabinet, etc. The description shall be written in coherent narrative form, shall be indexed, and shall provide a complete step-by step explanation of the operation of the governor circuits through the sequence: normal start-up, normal shutdown, emergency shutdown (load rejection) and operation of and recommended settings and programming for all auxiliary circuits, such as brakes, and protective circuits, in the manual and automatic mode,
3. Functional block diagram of governor control system,
4. List of tests to be conducted in shop, and at site, during commissioning,
5. Instruments offered, with catalogues/pamphlets,
6. Governor opening and closing characteristics,
7. Drawings, showing general arrangement, sections of all major assemblies, sub-assemblies and major components,
8. Control schematic drawing showing provision of all instruments, devices, and functioning of governor regulating functions,
9. Electrical drawings,
10. Cable schedule up to governor electronic cabinet.
11. Erection, commissioning, operation and maintenance instructions for digital governor system and other accessories, air compressor, nitrogen battery etc.

3.5.3 Design calculation

The Contractor shall submit the design calculation as per "General Technical Specification (GTS)" covering at least the following, for approval.

1. Structural analysis of different parts of governor,
2. Governor closing and opening time,

3. Calculation of capacity of nitrogen /air accumulator oil pressure system,
4. Calculation of size of oil pressure tank,
5. Calculation for capacity of pump and motor.

The Contractor shall also provide other calculations as required by the Engineer for his approval of the Contractor's design.

3.6 Delivery, Installation and Commissioning

3.6.1 Site installation and commissioning

3.6.1.1 General

The Contractor shall follow the requirements of installation elaborated in "General Technical Specification (GTS)" and "Clause - 1 - General Information and Requirements".

The Contractor has to do all the work related to assembly, erection, testing and commissioning complete in all respects. All necessary tools, plants, labour, materials including consumables for performing installation, testing, pre-commissioning and commissioning shall be provided by the Contractor.

The Contractor shall submit the necessary data/information, layout and foundation/support drawings well in advance.

The Contractor shall provide and install the concrete inserts / embedment, support steels and/or components for foundation/supports purposes as per approved erection drawings and coordinate the activities with civil contractors to keep his activities in synchronism with civil work. All installation for foundation shall be verified and accepted by the Engineer.

The Contractor shall use anchor fasteners for installation of piping, fixtures, mountings, conduits, cabling, panels etc.

The Contractor shall supply sufficient number of erection and commissioning spares based on their experience so that erection, testing and commissioning work progresses smoothly and is not hampered for want of such spares. These spares shall be in addition to the spare parts described under clause "Spare Parts".

3.6.1.2 Installation procedure

The Contractor shall submit six copies of all detailed programs and the procedures to be adopted for erection / installation, testing and commissioning, at least six (6) months before start of erection activities/ installation, for approval of the Purchaser.

The installation procedure shall also have a section "site quality assurance plan" containing erection data sheets for various components. These sheets should specify site measurements/ inspections required to be made for ensuring proper installation.

3.7 Field Tests

All field tests including tests during installation, pre-commissioning, commissioning, shall be conducted by the Contractor, in the presence of representative of the Purchaser.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, shall be submitted well in advance, at least three (3) months before start of relevant testing, for approval of the Purchaser.

The equipment / system shall be considered commissioned and ready for trial run only after successful operation for a "test service period" specified in sub clause "Performance Testing". In the event of any failure, this period shall be repeated for any number of times till the successful operation as described above is achieved.

3.7.1 Tests during installation and pre commissioning

At least following tests shall be conducted:

1. Tightness tests on all pressure oil and nitrogen / air piping,
2. Hydrostatic tests on all pressure oil piping and all pressure piping systems at a pressure 50 % greater than the maximum operating pressure after installation,
3. Tests on oil pressure system to verify:
 - Loading and unloading valve settings,
 - Pressure and level control in oil pressure tank in auto/manual mode,
 - Tests to verify pump capacity,
 - Low and high level alarms/shutdown,
 - Low and high pressure alarm,
 - Pressure relief valve setting,
 - Operation of pressure switches.
4. Dielectric and Insulation Resistance Tests on electrical circuits as per relevant standards,
5. Test to verify logic control scheme from local/remote including start/stop, load control, emergency shutdown, controlled action shutdown, locking and other feature,
6. Calibration of instruments, switches and controllers provided in the governing system, oil pressure system and nitrogen / compressed air systems,
7. Tests to verify number of close/open operations with oil pump off,
8. Test to measure guide vanes opening and closing times and servomotor cushioning time.

3.7.2 Commissioning tests

At least following tests shall be conducted:

1. Tests to verify stability and response of governor for 10% to 20% step change,
2. Tests to verify governing of turbine during load rejection and load acceptance,
3. Tests to verify performance of digital governor regulation and control system,
4. Tests to verify parallel operation of unit as per droop settings selected,
5. Other test to verify performance as per applicable IEC code 60308 for testing of speed governing systems for hydraulic turbines.

3.7.3 Performance testing

If nothing unusual has been observed in load run and load rejection tests, the test service period of 72 hours shall follow. During this test service period, the digital governing system must operate continuously without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the test service period.

The Contractor shall be responsible for the equipment during test service and also for the way it is operated. However, the Purchaser's personnel will operate the equipment under the Contractor's guidance during test service period.

3.7.4 Field acceptance tests

All acceptance tests in accordance with provision in latest edition of IEC 60308 shall be conducted at site before acceptance of digital governor by the Purchaser. Spare Parts

The spare parts mentioned here under are meant for use by the Purchaser during operation and maintenance stage and shall not be used as erection spares required during installation.

3.8 Mandatory spare parts

The Contractor shall supply the general spare parts as per clause no. 1.3.2 of "General Technical Specification (GTS)". The supply of these spares shall be as per the list of spares for each component / equipment / item approved during detailed engineering.

3.8.1 Specified spare parts

The following specified spares shall be included for supply:

S. No	Description	Quantity
1	Complete proportional valve assemblies	1 no. of each type

2	Main distributing valve	1 no.
3	Solenoid valve	1 set of each type
4	Speed sensing device complete with pickups, amplifiers, etc.	1 set of each type
5	Transducers of all type used in the system	1 set of each type
6	Signal conditioners	1 set of each type
7	Printed circuit card/module	1 no.of each type
8	Power supply unit	1 no.of each type
9	filter element of each type used in the electro-hydraulic actuator, and pumping set	1 no. of each used type
10	Safety relief valve complete assembly	1 no.each type used
11	Level switches and relays	1 no of each used type
12	Pressure switches and relays, limit switches	1 no. of each used type
13	RTDs, Thermometers, pressure gauges used in the system	1 no. of each used type
14	Complete set of gaskets, O-rings, sealing rings and packing	1 set of each type used

3.8.2 Recommended spare parts

The Contractor shall furnish the list of recommended spare parts as per clause no. 1.3.3 of “General Technical Specification (GTS)”and annexure.

3.9 Special Tools

The Contractor shall propose the list of recommended special tools (other than those included under “Tools and Appliances” above) including their make and detailed specification as recommended by manufacturer(s) and to be accepted by the Purchaser.

3.10 Quality Assurance and Testing

The bidder shall submit the quality assurance plan along with bid for approval of the purchaser. The Contractor shall follow the quality assurance and testing requirements as per quality assurance plan approved by the purchaser.

3.11 Guaranteed and Technical Particulars

Guaranteed and Technical Particulars shall be furnished along with the bid. Bids lacking in this may be considered unresponsive. Particulars subject to guarantees shall be clearly marked

3.12 Completeness of Equipment

All fittings and accessories of the Governing System and associated auxiliary & ancillary equipment which may not have been specifically mentioned in these specifications, but are usually necessary for completion of the above equipment, shall be deemed to be covered by the specification; and shall be indicated and furnished by the supplier without any charges to the purchaser.

3.13 Deviation from Specifications

While the purchaser does not bind himself to accept any deviation, due consideration will be given to any special devices or equipment put forward by the supplier with a view to increase the efficiency of the equipment and minimize the maintenance cost of the equipment as a whole.

Should the supplier wish to depart from these specifications, he shall submit a complete and itemized list of such deviations, together with full particulars of the reasons for the deviations in a separate schedule with special reference to clause and paragraph nos. of this specification. Unless this is done and also the purchaser's concurrence in respect of such deviations is obtained in writing, the equipment offered shall be deemed to comply in every respect with these specifications.