

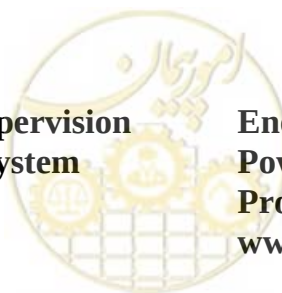
Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Diesel Generator at HV Substations

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Power Industry Technical Criteria
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Technical Specification of Diesel Generators



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1- General Requirements

This specification covers the requirements for the design, manufacturing, factory testing, marking, packing and commission of diesel generator and accessories.

Diesel generator shall be designed, manufactured and tested according to the requirements of the latest edition of the following standards:

IEC 60034-5: Rotating electrical machines

IEC 60034-9: Noise limit

IEC 60364: Electrical installation in building

IEC 60529: Degrees of protection provided by enclosures (IP code)

ISO 3046/II TC70: Test of engine

IEEE std.115: Recommended practices for testing of synchronous machines

IEEE std.446: Recommended practices for emergency and standby power systems for industrial and commercial application

BS 4999: General requirements for rotating electrical machines

ANSI C50.13: Requirements for cylindrical rotor synchronous machines

All amendments, supplements and reference publications of the above mentioned standards shall also be applied.

The packaged diesel generating unit shall consist of an electrical generator directly driven by a diesel engine complete with auxiliary systems. The auxiliary systems shall include lubricating oil systems, engine cooling system, fuel system, daily tank, automatic starting system, exhaust system, excitation auxiliary power and controls.

Diesel generator shall be suitable for use at the specified environmental conditions. Basic equipment data and rating shall be as specified in DG(I).



2- Design and Construction

2-1- General

The diesel generator unit shall be able to start to take up rated load automatically in the event of failure of the normal power supply to the station auxiliary services. All necessary electrical and mechanical interlocks shall be provided.

In the event of main supply failure, after a time delay, a signal will be received and diesel generator shall start immediately. Within 10 seconds after receiving of signal, diesel generator shall be capable of restoring the voltage & frequency to the normal rated values and accepting full load.

Manual start and stop of diesel generator shall be provided by push buttons installed on diesel generator control panel and manual start shall be delayed 1-5 seconds by an adjustable time lag relay.

An auto/ off/ man switch, lockable in off position, shall be installed on diesel generator control panel.

A signal from diesel generator shall be provided to preventing from closing of circuit breaker until the diesel generator has achieved normal speed and voltage.

The neutral point of the generator stator winding will be solidly connected to the substation earthing system.

The engine shall be capable of giving continuously at site not less than the output rating specified and an overload of 10% in excess of this output rating for one hour in any period of 12 hours of consecutive running.

The continuous site output rating of the engine shall be based on the specified site operating conditions.

The site output rating of the generator, irrespective of engine rating, shall also be stated and the site output rating of the diesel generator set will be the lower of these two.

The mounting skid shall be of rigid steel construction, complete with foundation bolt holes and suitable for mounting on a flat concrete foundation. The skid shall have sufficient rigidity to withstand forces due to transportation and dynamic stress during operation of the unit and to maintain alignment of the engine generator assembly under all service conditions. Rubber antivibration should be provided in base of diesel generator unit.

All rotating, moving, electrical and high temperature parts of equipment shall be provided with personal protections such as enclosures, guards, electrical insulation or thermal insulation.

The flywheel shall be made from a casting which shall be shown to be free from defects by means of a 180% overspeed test.

All steel materials for supporting & fixing diesel generator set and accessories including frames to be fixed on the walls & ceiling, pipe & cable ducts frames & covers, anchorbolts & nuts, etc shall be provided.

Overspeed capability of all rotating parts shall be not less than 125% of normal operating speed.

The vibration level should be limited to the tolerable value of the motor and accessories.



2-2- Engine

The engine shall be direct injection, water cooled, 4 stroke diesel engine for maximum 1500 rpm continuous operation.

Cooling shall be effected by means of attached cooling radiators for oil/water cooling plus fans.

The lubricating system shall be designed so that oil is continuously filtered and cooled whilst running.

Filters shall have easily replaceable elements.

Lubricating oil pumps shall be mechanically driven. The lubricating oil capacity shall be sufficient for not less than five days continuous operation.

An electric heater which has thermal controller should be included in the cooling system. This device should keep the motor temperature between 50 to 60 °C.

A dual filter, fitted with a changeover cock, and capable of rejecting particles in excess of 5 microns is to be inserted in the fuel line immediately before the fuel pump.

A suitable asbestos lined metal shield shall be fitted to the engine to cover the exhaust manifolds.

Air filters shall preferably be of the oil bath type. Where dry type air filters are used, these shall be fitted with an approved device to indicate the necessity to renew the filter element.

The noise level at a distance of 7 m from diesel shall not exceed of specified value.

Internal piping and control cables should be provided for the motor.

2-3- Starting system

Electric starting equipment shall be so designed that not more than 3 consecutive attempts to start may be made in any period of one minute, each starting period and the period between such consecutive attempts being automatically time controlled by the equipment. At the failure of the third attempt the starter circuit shall be locked out pending manual resetting.

The equipment shall include a suitable 24 volt starter battery together with a charger of the full wave rectifier type. The battery shall be protected against accidental, mechanical or electrical damage.

Charger should have such characteristic that it should not be damaged, during motor starting. The battery charger shall have a continuous output rating sufficient to recharge the battery from 1.8 V to 2.6 V per cell in a period of 8 hours plus any steady load on the battery. The charger shall be mounted remote from the engine and shall include a battery charge fail alarm.

Without power supply to the charger, the battery shall be capable of providing not less than six starting cycles with in a period of 4 minutes. Upon restoring power supply to the charger immediately there after, the charger shall be capable of restoring the battery, within 20 minutes to a condition in which one more starting cycle can be completed.



The battery shall also be capable of 45 seconds continuous starting attempt. A suitable battery isolating switch, capable of being locked in both the open and closed positions shall be provided on the engine to prevent starting while the diesel generator equipment is under maintenance.

2-4- Fuel system

Daily fuel storage tank complete with necessary supporting structure, pipe connections, valves, gauges, etc and of adequate capacity for 10 hours full load operation of diesel generator shall be provided.

For automatic & manual filling of daily fuel storage tank from main fuel storage tank pumps, float switches, pipes, etc. shall be provided.

Daily tank shall be mounted at a height such that the fuel supply to the engine will always be under gravity. This tank shall be constructed from approved mild steel plate not less than 6 mm thick.

Fuel tank shall be painted externally with a suitable oil resistant aluminum paint. The interior of the tank shall be cleaned by shot blasting and shall then receive a two coat treatment of an epoxy amine.

2-5- Exhaust system

Exhaust system shall be provided with silencers. Extension tubing shall be supplied to enable the exhaust gases to be taken out external to the building. Extension tubing should be covered with the anti- leakage gas insulation for safely and reducing the room temperature. Exhaust pipe runs shall have proper manometer and shall be short and as direct as possible. Bends should be of long radius type.

Provisions shall be made to prevent ingress of moisture in to the exhaust stack and drains shall be provided on the silencer.

Thermal expansion and vibration isolation shall be assured by use of flexible connections.

2-6- Cooling system

The cooling system shall consist of a fan- cooled radiator and a engine driven force flow pump. Steady temperatures shall be maintained by a thermostatically controlled water by- pass system.

The system shall include all components, features and controls necessary to provide for a complete functional system. The whole cooling system shall be manufactured from materials which are suitable for use with anti- freeze solutions.

The radiator shall be constructed from non- ferrous materials.



2-7- Governor and safety devices

The engine shall be provided with electronic type governor, giving maximum error of $\pm 1\%$. The range of adjustment shall be not less than plus and minus 5% of rated speed. Automatic shutdown devices shall be arranged to operate in the event of high water temperature, low lubricating oil pressure and overspeeding of the plant. The overspeed trip shall act directly upon the fuel supply to the engine, independently of the governor.

The maximum variation in speed on full load rejection shall not cause an over speed trip. Steady state speed regulation shall be within $\pm 0.25\%$ of rated frequency.

On suddenly taking off or apply the full load, permanent speed change should be 4%

2-8- Generator

Three phase, four wire, 400 volts and 50 cycles synchronous generator, complete with main cable box, control multi- core cable box and necessary ancillary equipment shall be delivered.

The generator shall be direct driven by the diesel engine and shall be of the brushless revolving field type, air cooled with rotating exciter and solid state voltage regulator. Damper windings shall incorporated for stable operation under unbalanced loads. Automatic voltage buildup shall be from a permanent magnet generator.

The engine and generator shall be arranged for mounting on a common bedplate.

The stator, rotor and field windings insulation shall be at least class F (measured by resistance of field or armature when the main generator is on continuous rating).

Anticondensation heaters shall be fitted inside the lower part of the stator frame and shall have the connections brought out to a separate terminal box.

Both ends of each stator winding shall be brought out to terminal positions on the stator casing, the phase end terminal box being arranged for 3- phase and neutral connection. The terminal box shall be designed to accept flexible 4- core PVC insulated PVC sheathed cables and shall include a bolted dust- tight cover which can be removed without disturbing the cables.

The generator shall withstand the specified overload continuously and direct short circuit on the output terminals for 3 seconds.

The generator neutral shall be grounded via a high resistance ground fault detector, supplied complete with normally open contacts for a remote alarm device.

An automatic voltage regulator (AVR) of the silicon controlled rectifier type shall be supplied. The AVR shall provided with adjustments for gain and stabilizing.

Total harmonic distortion of the output voltage should be less than 5 percent.



Current transformer with specified characteristics should be considered on neutral point of generator for neutral O/C protection.

2-9- Excitation system

The excitation system shall be brushless with rotating AC exciter and rectifiers, and permanent magnet exciter.

The excitation system shall satisfy the following performance requirements:

- Single running with a voltage regulation of $\pm 2\%$ at generator loads up to continuous rating over the power factor range unity to 0.8 lag.
- Parallel on load operation with the system.
- For conditions above no loss of control or instability shall occur, and kVA and kVAR load sharing shall be within the limits of generator capability.
- Manual and auto control shall be provided.
- Control voltage should be $\pm 5\%$ of set voltage over all specified operating conditions.
- The minimum forcing field voltage capability shall be twice the generator field voltage at full load.
- Maximum transient voltage variation on the sudden application or removal of rated load or on starting of the largest connected motor should be $\pm 20\%$.

2-10- Control panel and junction boxes

Separate panel and junction boxes shall be installed for:

- Control
- Generator power termination and current transformers
- Exciter connections and potential transformers
- DC control wiring
- AC wiring for AC equipments.

All boxes shall be dustproof and IP44 type with proper size and identification. The smallest terminals must be suitable for two 2.5 mm^2 wires each side.

All power and control wiring shall be stranded copper adequately sized.

Each wire shall be "tagged" on both ends with the same number as used on the schematic diagrams.



2-11- Valves, pipes and flanges

The pipes forming the main cooling water circuits shall be steel piping. Tees and bends for piping in materials other than steel shall be to approval. Cast iron is not acceptable for pipes, tees or bends.

Coupling together of pipes and valves of 50 mm diameter and over shall be by means of flanged joints.

Piping under 50 mm diameter may be coupled together with screwed or other approved couplings.

Coupling together of oil and fuel piping shall be by means of flanged joints welded on.

2-12- Controls and indications

Engine instruments mounted on the engine shall be the followings:

- Tachometer
- Lubricating oil pressure gauge
- Lubricating oil thermometer
- Water pressure gauge
- Water temperature thermometer

Generator control panel mounted in the diesel room shall be a free standing control panel type with access doors lockable by padlocks, complete and including the following:

- 1 Selector switch for automatic/ off/ manual
- 1 Set of engine control relays
- 1 Set of alarm equipment
- 1 Set of automatic shut- down
- 1 Mechanically operated hour meter
- 3 ammeter
- 1 Voltmeter with selection switch
- 1 Frequency indicator
- 1 Unbalanced load wattmeter for 3-phase 4-wire supply
- 1 Set of generator field control equipment
- 1 Engine speed controller
- 1 Set of start and "stop" push buttons
- Signal lamp
- 1 Emergency stop push button, shrouded type



- 1 ammeter for showing charger current

Complete set of alarms & trips signals including followings shall be provide & indicated on control panel:

- | | |
|--|-------|
| - High water temperature | alarm |
| - High water temperature | trip |
| - Low lubricating oil pressure | alarm |
| - Low lubricating oil pressure | trip |
| - Cooling water pressure | alarm |
| - Cooling water pressure | trip |
| - Lubricating oil temperature | alarm |
| - Lubricating oil temperature | trip |
| - Over speed protection operated | trip |
| - 24 volts control or starting charger failure | alarm |
| - Loss of 24 V control or starting voltage | alarm |
| - Failure to start | alarm |
| - Auto/ off/ man switch not in auto position | alarm |
| - Daily fuel tank low level | alarm |
| - Fire protection faulty or operated | alarm |
| - Ventilation or heating system faulty | alarm |

Six alarm window for protective relays should be considered as a spare.

Following alarms shall be provided to be sent to control building separately:

- Group signaling of above mentioned signals called "diesel generator trouble"
- Main fuel tank low level
- Selector switch not in auto position
- Diesel generator in service

All sensors, trips and indicators shall be powered from the generator battery.

All trip and alarm systems should be reset manually.

Before changing the position of auto/ off/ man selector switch to off position, trip signal should not be reset.



3- Tests

The following tests shall be carry out for diesel generator according to IEEE std. 115 and ISO 3046/JI:

3-1- Mechanical tests

- Mechanical inspection
- Rotor balance
- Rotor overspeed test at 120% of rated speed
- Time of no- load acceleration from no load to full speed

3-2- Electrical tests

- Voltage phase balance and phase sequence
- Polarity of field, CT's and PT's
- No load and full load field current at nominal voltage and frequency
- Synchronous reactance
- Exciter full load and ceiling voltage
- Cold resistance of stator and rotor winding
- Windings insulation resistance

4- Primary inspections and commissioning tests

4-1- Primary inspection

- Oil and fuel filter control
- Water, oil and fuel manometers control
- Control of fuel, water and oil valve adjustment
- Control of fuel, water and oil pump adjustment
- Control of temperature indicating device circuits
- Control of protection panel
- Control of DC and AC circuit breakers and related circuits



- Control and setting (if necessary) of generator exciting current
- Control and setting (if necessary) of governor
- Control of all connections

4-2- Commissioning tests

- Interlocks and alarms tests
- Starting and stop test (manual and automatic)
- Engine and diesel protection relays test

5- Drawings & documents

5-1- Documents to be given by tenderer

- Filled schedule DG (II)
- Catalogue & technical pamphlets
- Summary of test report
- Detailed summary of exceptions to tender specification
- Outline drawing
- List of spare parts
- Reference list
- List of special tools

5-2- Documents to be given by contractor/ supplier

The electrical and mechanical design, fabrication, factory testing, working and packing, transportation, erection, site test, operation and maintenance drawing, documents and manuals shall be submitted not limited to the following:

- Dimensions, weights of the completely assembled diesel generator and all its accessories and dynamic loads of equipment.
- Location, dimensions and heights from level of all relays, instruments, control switches and accessories on control panel.
- Shipping outline showing the dimensions and weights of the shipping sections.
- Foundation dimensions and requirements.
- Cable entrance locations.



- Single line diagram and phasing diagram.
- Wiring diagram of control panel.
- Control schematic of all control circuits.
- Diesel engine performance data and curves.
- Generator performance data and curves.
- General information about diesel engine and generator.
- Vendor's descriptive literature for all component parts of diesel generator.
- Routine test certificates.
- Site test instruction manual.
- Dismantling, reassembling and adjusting manuals.
- Type test documents.
- List of components.
- Drawing list.
- Final as built DOC/DWG.



SCHEDULE DG(I)
RATING AND CHARACTERISTICS OF
EMERGENCY DIESEL GENERATOR

ITEM	DESCRIPTION	TECHNICAL Particular
1	Service conditions	
1.1	Max. ambient temperature °C	40/ 45/ 50/ 55
1.2	Min. ambient temperature °C	-25/ -30/ -35/ -40
1.3	Altitude above sea level m	1000/ 1500/ 2000/ 2500
1.4	Seismic acceleration m/s ²	0.2g/ 0.25g/ 0.3g/ 0.35g
2	DG characteristic	
2.1	Net output of diesel generator set at site conditions and power factor 0.8 lagging kW	*
2.2	Rated voltage and variation V	400/ 230,±5%
2.3	Voltage adjustment range/ step (%)	±5/1
2.4	Max. rated speed rpm	1500
2.5	Rated frequency and variation Hz	50
2.6	Number of phases/ connection	3/Y
2.7	Maximum steady state change in voltage from full load to no load or from no load to full load (%)	±2
2.8	Maximum steady state change in speed from full load to no load or from no load to full load (%)	±5
2.9	Transient reactance of generator (%)	<20
2.10	Overload capability of D.G. set (%)	10
2.11	Protection degree of boxes & control panels	IP44
2.12	Starting & control battery voltage V	24
2.13	Noise level at a distance of 7m from diesel without barrier dB	75

* These will be specified by engineer.



SCHEDULE DG (II)
GURANTEED TECHNICAL INFORMATION OF EMERGENCY DIESEL GENERATOR
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION	TECHNICAL Particular
1	General	
1.1	Max. design ambient temperature	°C
1.2	Min. design ambient temperature	°C
1.3	Design altitude above sea level	m
1.4	Design seismic acceleration	m/s ²
1.5	Documents (test reports/ outline/ drawings/ catalogues/ maintenance & installation manuals/ instruction manuals/ references/ list of spare parts)	
2	Diesel engine	
2.1	Manufacturer/ country	
2.2	The first year that this type of engine has been committed in international market	
2.3	Continuous rated engine output at ISO standard reference conditions	kW
2.4	Continuous rated engine output at site conditions	kW
2.5	Prime rating	kVA
2.6	Standby rating	kVA
2.7	Protection degree (IP)	
2.8	Crank- shaft speed	rpm
2.9	Number of cylinders & arrangement	
2.10	Diameter of cylinders	mm
2.11	Mean piston speed	m/min
2.12	Fuel consumption:	
2.12.1	100% load	Lit/kW/hr
2.12.2	50% load	Lit/kW/hr
2.13	Maximum firing pressure	Kg/cm ²
2.14	Lubricating oil consumption	Lit/hr
2.15	Maximum temporary speed change during load shedding from full load to no load	(%)
2.16	Maximum permanent speed change after load to no load	(%)
2.17	Governor manufacturer/ country	
2.18	Range of governor remote adjustment	(%)
2.19	Type of cooling system	

SCHEDULE DG (II)
GURANTEED TECHNICAL INFORMATION OF EMERGENCY DIESEL GENERATOR
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION	TECHNICAL Particular
2.20	Cooling water temperature through cylinders:	
2.20.1	Inlet °C	
2.20.2	Outlet °C	
2.21	Lubricating oil temperature at engine:	
2.21.1	Inlet °C	
2.21.2	Outlet °C	
2.22	Air consumption of engine	Lit/sec
2.23	Engine dimensions (w×l×h)	mm
2.24	Engine total weight	kg
2.25	Overall efficiency of diesel	%
3	Generator	
3.1	Manufacturer/ country	
3.2	Rated continuous output at IEC conditions	kW
3.3	Rated continuous output at site	kW
3.4	Rated power factor (lagging)	
3.5	Rated terminal voltage/ connection	V
3.6	Rated phase current at rated power factor	A
3.7	Maximum continuous rating at zero power factor and rated voltage	kVAR
3.8	Maximum permissible negative phase sequence current as a percentage of rated current	(%)
3.9	Over load rating for each hours	(%)
3.10	Rated frequency	Hz
3.11	Rated speed	rpm
3.12	Short circuit ratio at rated excitation current	
3.13	Enclosure protection (IP code)	
3.14	Stator insulation:	
3.14.1	Class	
3.14.2	Material	
3.15	Calculated resistance of winding at 20 °C	Ω/phase



SCHEDULE DG (II)
GURANTEED TECHNICAL INFORMATION OF EMERGENCY DIESEL GENERATOR
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION	TECHNICAL Particular
3.16	Rotor insulation:	
3.16.1	Class	
3.16.2	Material	
3.17	Calculated resistance of rotor winding at 20 °C	ohm
3.18	Overspeed test value	rpm
3.19	Direct axis subtransient reactance (X''_d)	(%)
3.20	Direct axis transient reactance (X'_d)	(%)
3.21	Direct axis synchronous reactance unsaturated (X_{du})	(%)
3.22	Negative sequence reactance (X_2)	(%)
3.23	Zero sequence reactance (X_0)	(%)
3.24	Generator efficiency at rated power factor	
3.24.1	Full rated output	(%)
3.24.2	50% rated output	(%)
3.25	Generator waveform distortion factor at rated voltage (No load):	
3.25.1	Phase to phase	(%)
3.25.2	Phase to neutral	(%)
3.26	Temperature rise above ambient at rated values of output, voltage & power factor (IEC conditions):	
3.26.1	Stator conductor	°C
3.26.2	Rotor conductor	°C
3.26.3	Coolant	°C
3.27	Rotor excitation current:	
3.27.1	No load & rated voltage	A
3.27.2	Rated output & power factor	A
3.27.3	Rated output at zero power factor	A
3.28	Total losses at rated output & power factor lagging	kW
3.29	Generator dimensions (L×W×h)	mm
3.30	Generator weight	kg



SCHEDULE DG (II)
GURANTEED TECHNICAL INFORMATION OF EMERGENCY DIESEL GENERATOR
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION	TECHNICAL Particular
4	Diesel generator set	
4.1	Guaranteed period	year
4.2	Start- up time from initiation until rated voltage and speed	Sec
4.3	Minimum room temperature for automatic starting	°C
4.4	The load which could be applied after start- up time:	
4.4.1	Room temperature 15°C	kW
4.4.2	Room temperature same as value stated for above item 4.2	kW
4.5	The time after starting when full load could be applied:	
4.5.1	Room temperature 15°C	Sec
4.5.2	Room temperature same as value stated for above item 4.2	Sec
4.6	Noise at 7 m distance:	
4.6.1	Maximum intensity	dB
4.6.2	Frequency of max intensity	Hz
4.7	Vibration of diesel generator set:	
4.7.1	Maximum peak to peak intensity	µm
4.7.2	Frequency of max. intensity	Hz
4.8	Transport dimension of D.G. set (L×W×h)	mm
4.9	Real dimension of D.G. set (L×W×h)	mm
4.10	Transport weight of D.G. set	kg
4.11	Net weight of D.G. set	kg
5	Automatic voltage control equipment	
5.1	Type/ manufacturer	
5.2	Maximum variation in generator terminal voltage between no load and rated power	(%)
5.3	Response to rejection of maximum continuous load at rated power factor:	Sec
5.3.1	Momentary overvoltage	(%)
5.3.2	Time to restore voltage to preset value	Sec

SCHEDULE DG (II)
GURANTEED TECHNICAL INFORMATION OF EMERGENCY DIESEL GENERATOR
(TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION	TECHNICAL Particular
6	Starting battery	
6.1	Manufacturer/ country	
6.2	Type designation	
6.3	Rated voltage	V
6.4	Capacity	AH
6.5	Number of cells	
6.6	Resistance of complete battery (Internal & connections)	Ω
7	Starting battery charger	
7.1	Manufacturer/ country	
7.2	Type designation	
7.3	Rated input power	kW
7.4	Rated input voltage	V
7.5	Rated output DC current	A
7.6	Max. designed input voltage variation	(%)
7.7	Max. designed frequency variation	(%)
7.8	Max. ripple to DC voltage ratio	(%)
8	Neutral current transformer	
8.1	Type of current transformer	
8.2	Number of core	
8.3	Accuracy	
8.4	burden	VA

