Islamic Republic of Iran
Vice Presidency for Strategic Planning and Supervision

General Technical Specification and Execution Procedures for Transmission and Subtransmission Networks Busbar and Conductors at HV Substations

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DESCRIPTION **PAGE**

Technical Specification of Busbar and Conductors

1- General requirements

This specification covers minimum requirement for the design, manufacturing, factory testing, marking and packing of rigid and strain busbars with 63 to 400 kV rated voltage.

Rigid and strain busbars shall be designed, manufactured and tested in accordance with the requirements of this specification and latest revision of ASTM B 317 (for rigid busbars) and IEC 61089, 61889, 61888 and 60104 (for strain conductors), included all amendments, supplements and references publications listed in the above standards unless the cases is specified in the different manner in this technical specification.

Connections between equipments can be strain conductors or appropriate aluminum alloy tubes.

Main characteristic and nominal values of busbars represented in schedule Bus (I) and busbars shall be suitable for mentioned climate at the place of erection.

2- Design and construction

2-1-Strain busbar

Stranded conductors shall be aluminum alloy and the cross section of conductors shall be based on substation's current and environmental conditions.

Conductors shall be free of audible and visible corona. The corona free requirement shall be applicable under all environmental conditions.

Conductors shall be designed for the current carrying capacities specified. Under normal conditions, final temperature of conductor shall be 80 °C.

Conductor shall be able to withstand the short circuit currents specified for 1 second without exceeding a final temperature of 200 °C which initial temperature shall be engineered 80 °C. The design of the conductors shall allow for swinging during short circuits without damaging the connections, busbars and equipments.

All wires making up the conductors shall be free from dust, splints, scratch and all imperfections not consistent with the best commercial practice and that would increase radio interference and corona loss.

Conductor shall be tightly and uniformly stranded with no loose strands and when subjected to 50% of ultimate strength shall show no high wires but shall maintain a true cylindrical form. All conductor furnished shall be substantially free from die grease in accordance with best mill practice.

The conductor shall be supplied wound on a drum. When packing, it is important the conductor does not come into contact with materials which can cause corrosion, e.g. copper or copper alloys. The material which the drum is made shall not attack, or be treated with such substances which does not attack aluminum. Unless otherwise agreed upon, the barrel of the drum shall have a diameter of at least 1m and drum shall have a center hole about 100 mm in diameter. The drum shall be lagged, or covered in some other suitable way.

The drum shall be capable of withstanding all stresses due to breaking and stringing operations. Each end of the conductor shall be equipped with a cap and properly and securely fasted to the drum.

The drum shall be of such design, construction and strength as to guarantee satisfactory delivery of the conductor to its destination without displacement, chafing, or other damage incurring during shipment or field handling.

In addition to marks required for shipping purposes each drum shall be marked to show serial number, type of conductor, length of conductor, arrow showing the end of the conductor and gross, tare and net weights. All markings shall be plainly legible and durable.

Aluminum conductors are only greased by special request and to the extent agreed upon between supplier and purchaser. The grease shall withstand temperatures at which it can be applied, without any noticeable change and also shall be free from component which can corrode aluminum.

2-2- Rigid busbar

Aluminum tubes and A. frames shall be manufactured of hardened aluminum alloy of the Al- Mg-Si type and shall fulfill the demand presented in standard. Aluminum tubes are designed by their nominal outer diameter and wall thickness. Rigid busbar shall be sized to limit specified sag or deflection under dead loads.

Provision shall be made for expansion and contraction of elements due to temperature variations as well as relative displacements of support structures.

In special cases, if for A- frame parts welding method is used, aluminum inserts or weld connectors shall be provided at joint location. Material and mechanical characteristic of this parts shall not changed because of welding. The length of the insert shall not be less than 1.5 times its diameter. Aluminum welding shall be appropriate environmental conditions.

Rigid bus to rigid bus connections shall done so complete connection between connected parts is made.

Jointed tubes shall be had the same electrical and mechanical properties as the unjointed tube.

The minimum factor of safety, considered in the designs of tubular busbar based on the tube yield limit shall be for under load combination without earthquake equal to 1.5 and under load combination with earthquake equal to 1.1.

Cast aluminum alloy corona bells shall be so installed to prevent the intrusion of moisture.
Rigid busbar shall be arranged in a manner such that it can be extended without difficulty.
Aluminum damping wire shall be inserted in the tubes to damp the wind vibrations.
Expansion connectors shall be provided to accommodate the effects of thermal expansion of the busbars without including stress on connectors and equipments.
Under normal Conditions, final temperature shall be 85°C for aluminum tubes.
Tubes shall be able to withstand the short circuit currents specified for 1 second without exceeding a final temperature of 200 °C while initial temperature shall be considered 85°C.
Tubes shall be packed in wooden box. The side walls of these boxes shall be covered such that without opening the box dimensions of tubes could be inspected. Plastic caps shall be installed in each end of tubes in order to prevent entering dust and insects.

3- Tests

Strain busbar shall be tested according to latest revision of IEC 61809,61889, 61888, 60104, 60468 and ISO 6892 and 7802. Strain busbars and connectors shall be tested to ensure that the correct tensions, sags and clearances will be maintained over the range of environmental conditions and load without stress to other equipments. If dynamometers are used to check the sags and tensions, they shall be checked both before and after use.
Rigid busbar shall be tested according to latest revision of IEC 60468 and ASTM B317 and B557.
Rigid busbar and connections shall be tested to ensure that the busbars will not cause over loading of the supporting insulators under load conditions and under the range of climate variations applicable to the site.

4- Drawing and documents

4-1- Documents to be given by tenderer

- Filled schedule BUS (II)
- Catalogue and technical pamphlets
- Outline drawing

- Detailed summary of exceptions to tender specifications
- Reference list
- Special tools list
-Spare part list

4-2- Documents to be given by contractor /supplier

The electrical and mechanical design, fabrication, factory testing, marking, packing, transportations, warehousing, erection and site testing, operating and maintenance drawings, documents and manuals shall be submitted not limited to the followings:

- Calculation sheets to establish adequacy of busbars in any respect
- Loading on supports and structures
- Mounting details
-Packing details
- Shipping, warehousing, assembly, erection, operating and maintenance instruction manuals
- Work schedules and monthly progress report
- List of components
- Test certificates
- Drawing list
- Final asbulit documents and drawings

5- Commissioning

The manufacturer shall produce a program of site commissioning checks and tests. Repetition of the full program of routine tests which have already performed in the factory, shall be avoided. The purpose of commissioning tests is for confirmation of:

- Absence of damage
- Compatibility of separate units
- Correct assembly
- Correct performance

For this purpose the commissioning tests shall include, but not limited to the following items. The results of the tests shall be recorded in a test report.

- Visual inspection of installation, correct assembly and electrical connections
- Assurance of direct connection of metal bodies to ground grid

- Control of busbar deflection
- Control of allowable electrical clearances
- Visual control of busbar connection points
- Control of correct phase connection
- Measurement of electrical resistance of connections for minimum 5 connections of any type
- Assurance of correct usage of turn buckle and firm on suitable situation
- Assurance of correct placing of conductor and tension string for two or multi bundle systems
- Assurance of correction of busbar connections

SCHEDULE BUS (I)

RATING AND CHARACTERISTIC OF BUSBAR & CONDUCTORS

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	**63/66 kV**	**132 kV**	**230 kV**	**400 kV**
1	**Particular of systems**						
1-1	Nominal system voltage	kV_{rms}	20	63/66	132	230	400
1-2	Max. system voltage	kV_{rms}	24	72.5	145	245	420
1-3	Nominal system frequency	Hz	50	50	50	50	50
1-4	Lightning impulse withstand voltage level of equipments	kV_{peak}	125/170	325	550/650	850/950/ 1050	1050/1175/1300/1425
1-5	Switching impulse withstand voltage level of equipments	kV_{peak}	-	-	-	-	850/950/1050
1-6	Max. initial symmetrical short circuit current	kA_{rms}	*	*	*	*	*
1-7	Peak value of short circuit current	kA_{peak}	*	*	*	*	*
1-8	Steady state short circuit current	kA	*	*	*	*	*
1-9	Max. duration of short circuit current in system	sec	1-3	1-3	1-3	1	1
1-10	Protection system is included autorecloser?	Yes/No	*	*	*	*	*
1-11	Duration of first fault where system is included atuorecloser	sec	*	*	*	*	*

SCHEDULE BUS (I)

RATING AND CHARACTERISTIC OF BUSBAR & CONDUCTORS

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	**63/66 kV**	**132 kV**	**230 kV**	**400 kV**
1-12	Class	Indoor/outdoor	*	*	*	*	*
2	**Service condition**						
2-1	Max. ambient temperature	°C	40/45/50/55	40/45/50/55	40/45/50/55	40/45/50/55	40/45/50/55
2-2	Min. ambient temperature	°C	-25/-30/-35/-40	-25/-30/-35/-40	-25/-30/-35/-40	-25/-30/-35/-40	-25/-30/-35/-40
2-3	Max. value of average daily temperature	°C	*	*	*	*	*
2-4	Altitude above sea level	m	1000/1500/2000/2500	1000/1500/2000/ 2500	1000/1500/2000/ 2500	1000/1500/2000/ 2500	1000/1500/2000/ 2500
2-5	Solar radiation	W/m^2	*	*	*	*	*
2-6	Relative humidity	%	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95	90/95/more than 95
2-7	Seismic acceleration	m/s^2	0.2g/0.25g/0.3g/0.35g	0.2g/0.25g/0.3g/0.35g	0.2g/0.25g/0.3g/0.35g	0.2g/0.25g/0.3g/0.35g	0.2g/0.25g/0.3g/0.35g
2-8	Max. wind velocity	m/s^2	30/40/45	30/40/45	30/40/45	30/40/45	30/40/45
2-9	Wind velocity in ice condition	m/s	20	20	20	20	20
2-10	Ice coating thickness	mm	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25	5/10/20/25
2-11	Pollution level		Low/medium/high /very high/special	Low/medium/high /very high/special	Low/medium/high /very high/special	Low/medium/high /very high/special	Low/medium/high /very high/special

SCHEDULE BUS (I)
RATING AND CHARACTERISTIC OF BUSBAR & CONDUCTORS

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
3	**Busbar characteristics**						
3-1	Strain busbars:						
3-1-1	Bus arrangement and relevant information		*	*	*	*	*
3-1-2	Space between phases	m	*	*	*	*	*
3-1-3	Height of conductors from ground level	m	*	*	*	*	*
3-1-4	Bus material		Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy
3-1-5	Max. allowable temperature of continuous operation of conductors	°C	*	*	*	*	*
3-1-6	Cross section of conductors	mm^2	*	*	*	*	*
3-1-7	Continuous allowable current of conductors in design	A	*	*	*	*	*
3-2	Rigid busbars:						
3-2-1	Bus arrangement and relevant information		*	*	*	*	*
3-2-2	Space between phases	m	*	*	*	*	*
3-2-3	Height of tubular conductors from ground level	m	*	*	*	*	*
3-2-4	Tubular conductor material		*	*	*	*	*
3-2-5	Max. allowable temperature of continuous operation of conductors	°C	*	*	*	*	*

SCHEDULE BUS (I)
RATING AND CHARACTERISTIC OF BUSBAR & CONDUCTORS

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
3-2-6	Cross section of tubular conductors	mm^2	*	*	*	*	*
3-2-7	Outer diameter of tubular conductors	mm	*	*	*	*	*
3-2-8	Wall thickness of tubes	mm	*	*	*	*	*
3-2-9	Continuous allowable current of conductors in design	A	*	*	*	*	*
3-2-10	Damping wire required?	Yes/No	*	*	*	*	*
3-2-10-1	Damping wire material		Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy	Aluminum alloy

*These will be specified by designer engineer.

BUS SCHEDULE (II)
GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
1	**General**						
1-1	Manufacturer's name and country						
1-2	Manufacturers type & designation						
1-3	Class	Indoor/outdoor					
1-4	Environmental condition:						
1-4-1	Max. design ambient temperature	°C					
1-4-2	Min. design ambient temperature	°C					
1-4-3	Max. design value of average daily temperature	°C					
1-4-4	Design altitude above sea level	m					
1-4-5	Design solar radiation	W/m^2					
1-4-6	Relative humidity						
1-4-7	Design seismic acceleration	m/s^2					
1-4-8	Max. wind velocity in ice condition	m/s					
1-4-9	Max. design ice thickness	mm					
1-4-10	Pollution level						

BUS SCHEDULE (II)

GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
1-4-11	Average velocity of wind	m/s					
1-4-12	Max. ultimate temperature of busbar	°C					
1-5	Documents (test reports/ drawings/ catalogues/ maintenance & installation manuals/ reference list of spare parts)	Yes/No					
2	**Rated value & characteristics**						
2-1	Strain busbars:						
2-1-1	Bus arrangement and relevant information						
2-1-2	Bus material						
2-1-3	Type of aluminum alloys						
2-1-4	Diameter of conductors						
2-1-5	Rated cross section	mm^2					
2-1-6	conductors mass per unit length	kg/m					
2-1-7	Max. working tension	kN					
2-1-8	Ultimate tensile strength of conductor	kN					
2-1-9	Min. breaking strength	kN					
2-1-10	Electrical resistance of conductor at 20 °C	Ω/km					

BUS SCHEDULE (II)
GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
2-1-11	Max. radio influence voltage level	μV					
2-1-12	Visible corona inspection voltage	kV					
2-1-13	Conductors greased?	Yes/No					
2-1-14	Grease type (if is used)						
2-1-15	Allowable continuous current capability at ambient temperature (wind velocity 0.6 m/s and ultimate conductor temperature 80 °C):						
2-1-15-1	50°C	A					
2-1-15-2	45°C	A					
2-1-15-3	35°C	A					
2-1-15-4	-25°C	A					
2-1-16	Temperature rise during specified short circuit in design with initial conductor temperature 80 °C	°C					
2-1-17	Modulus of elasticity	N/mm^2					
2-1-18	Coefficient of linear thermal expansion	mm/°C					
2-1-19	Max. horizontal displacement of conductor to be caused by mechanical forces resulting from short circuit	m					

BUS SCHEDULE (II)

GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
2-1-20	Max. dynamic forces because of short circuit (F_t,F_f,F_{pi})	N					
2-1-21	Reference standards						
2-2	Rigid busbars:						
2-2-1	Bus arrangement and relevant information						
2-2-2	Bus material						
2-2-3	Outer diameter of tubular conductors	mm					
2-2-4	Wall thickness of tubular conductors	mm					
2-2-5	Cross section of tubular conductors	mm^2					
2-2-6	Mass per unit length of tubular conductors	kg/m					
2-2-7	Min. ultimate tensile strength	N/mm^2					
2-2-8	Resistance at 20 °C	Ω/km					
2-2-9	Max. radio influence voltage level	μV					
2-2-10	Max. deflection of installed busbar	mm					
2-2-11	Min. conductivity at 20 °C	mm^2/Ω.km					

BUS SCHEDULE (II)
GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
2-2-12	Allowable continuous current capability at ambient temperature (wind velocity 0.6 m/s and ultimate conductor temperature 85 °C):						
2-12-2-1	50°C	A					
2-12-2-2	45°C	A					
2-12-2-3	35°C	A					
2-12-2-4	-25°C	A					
2-2-13	Temperature rise during specified short circuit in design with initial conductor temperature 80 °C	°C					
2-2-14	Modulus of elasticity	N/mm^2					
2-2-15	Coefficient of linear thermal expansion	mm/°C					
2-2-16	Inertia moment of conductor cross section	cm^4					
2-2-17	Section modulus	cm^3					
2-2-18	Max. safely factor under load combination without earthquake						
2-2-19	Max. safely factor under load combination with earthquake						

BUS SCHEDULE (II)

GUARANTEED TECHNICAL INFORMATION OF BUSBAR (TO BE SUPPLIED WITH TENDER)

ITEM	DESCRIPTION		TECHNICAL SPECIFICATION FOR SYSTEMS WITH FOLLOW WING NOMINAL VOLTAGES				
			20/33 kV	63/66 kV	132 kV	230 kV	400 kV
2-2-20	Damping wire required?	Yes/No					
2-2-20-1	Length of damping wire	mm					
2-2-20-2	Material of damping wire	Aluminum alloy					
2-2-20-3	Cross section of damping wire	mm^2					
2-2-21	Max. dynamic forces on each busbar supports because of short circuit	kN					
2-2-22	Reference standards						