INDEPENDENT POWER TRANSMISSION OPERATOR S.A.
TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION

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SPECIFICATION SS-97/12

170kV SF_6 OUTDOOR CIRCUIT BREAKERS

I. SCOPE

This hereby specification covers IPTO's requirements with regard the technical characteristics, design features and testing of 170 kV outdoor type circuit breakers.

II. KEYWORDS

Circuit breakers, SF_6 circuit breakers, switching devices.

III. STANDARDS

All technical characteristics and testing of the circuit breakers shall be in
accordance with IEC 62271-100 and IEC 62271-1.

IV. USE

The circuit breakers are to be used in 150kV substations and in extra high voltage substations in conjunction with overhead transmission lines, overhead power plant feeders, cable feeders and autotransformers of 280 MVA to protect them against of all type of faults.

V. ELECTRICAL CHARACTERISTICS OF 150 kV SYSTEM

1. Nominal Voltage	: 150 kV
2. Maximum Operating Voltage	: 170 kV
3. Number of Phases	: 3
4. Number of Conductors	: 3
5. Nominal Frequency	: 50 Hz
6. Short Circuit Level	: 31.5 KA
7. Basic Insulation Level (Impulse Level)	: 750 kV
8. Method of Grounding	: the 150kV system

is solidly grounded

9. Available DC auxiliary supply voltage : 110V DC from substation battery

10. Available AC auxiliary supply voltage : 220/380V AC

VI. OPERATING CONDITIONS

1. Installation : Outdoors

2. Limits of ambient temperature : -25^{o} C, $+45^{o}$ C

3. Altitude : Up to 1000 m above sea level

4. Pollution level : Moderate

5. Other climatic conditions : Snow, ice and fog

VII. REQUIRED DESIGN FEATURES OF THE CIRCUIT BREAKER

1. Type of the Circuit Breaker

SF_6, live tank type, outdoor type

2. Interrupter technology

Puffer or self-puffer or self-blast or self - compression or auto-expansion.

3. Number of Operating Mechanisms

One (1) operating mechanism common for the three poles of the breaker and shared breaker base. Each pole shall be connected to the operating mechanism through a mechanical linkage.

4. Operating Mode

Three poles operated suitable for triple pole auto reclosing.

5. Number of Interrupting Units (chambers)

One (1) interrupter unit per pole.

6. Gas of the breaking chamber

The breaker shall use sulphur Hexafluoride (SF_6) for insulation and arc quenching purposes. The SF_6 gas shall be in accordance with IEC 60376 standard.

7. Operating Mechanism Characteristics

a. Type : stored energy spring type or hydraulic type mechanism consisting of a cabinet which includes both the driving mechanism unit and the control unit or of a control unit cabinet and a separate operating mechanism cabinet.

b. Type of tripping : Trip-free (definition IEV 441-16-31)

c. Auxiliary supply voltages:

1. For the opening and closing circuits : 110 V dc
2. For all other control and signaling circuits : 110 V dc
3. Heating and lighting circuits : 220 V ac
4. For the motor of the operating mechanism : 110 V dc
5. Tolerances of the DC supply voltage except for the tripping coils : +10/-15%
6. Tolerances of the DC supply voltage for the tripping coils : -30%, +10%

8. Structure of the Circuit breaker

The breaker shall consist basically of three (3) poles, one operating mechanism, supports and connecting rod. Each pole shall consist of a hollow insulating column (support column) and on top of it shall be located the interrupting unit housed inside an insulator.

9. Circuit breaker's control and operating mechanism cabinet

The circuit breaker shall be equipped with a control and operating mechanism hot-dip galvanized cabinet of class protection of IP55 as per IEC 60529 which shall be located near the base of the circuit breaker's frame and which shall contain at least the following:

a. The cabinet shall be equipped with anti-condensation heaters controlled via thermostat.

b. The cabinet shall be equipped with a position indicator which will clearly indicate the open and close position of the circuit breaker in accordance with IEC 62271-1.

c. The cabinet shall be equipped with an operations counter which shall indicate the number of operations of the breaker.

d. If it is allowed by the operation of the CBs poles, there should be a pole discrepancy arrangement. This arrangement (circuit) shall use aux NO and NC contacts of the CB in series with a time-delay relay (0-10 sec) and it will provide a tripping command to both tripping coils of the CB in the event that a

CB pole remains closed or open despite the fact that an opponent command was issued.
In addition an alarm signal shall be provided indicating pole discrepancy.

e. The cabinet shall be equipped with a selector switch with three (3) operating positions "Local-Off-Remote" and with as many stages as needed for the control circuits of the breaker. In the "Off" position no circuit breaker operation would be allowed.

The "local" position and in conjunction with two (2) push-buttons (open-close) or a control switch, will be used to control the breaker locally, that is, from the control cabinet itself for maintenance purpose only. When the circuit breaker is under local control, the bay associated with the circuit breaker will be out of service. The "Remote" position will be used to control (open – close) the breaker from the control building of the substation or from the system's control center and also for tripping purposes.
For the 150 kV bay circuit breakers, the tripping commands from the protection relays will energize both tripping coils of the circuit breaker, via two (2) independent circuits 110 V DC, that is $\pm Q_{bay}$ (control voltage) and $\pm P_{bay}$ (protection voltage).
The stimulation of all the coils inside the circuit breaker (main open and close coils of circuit breaker and the coils of aux relays for the control of the uncharged spring and the SF_6 pressure control) is as shown below:

The <u>tripping coil No1</u> of the circuit breaker will receive:
-tripping local operation, through button locally on the circuit breaker, by $\pm I_{bay}$ voltage, only when the selector switch (L-0-R) is on the "Local" position
-tripping control commands remotely (from the substation control room or System Control Centers) by $\pm Q_{bay}$ voltage, only when the selector switch (L-0-R) is on "Remote" position.
-tripping commands due to the operation of the circuit breaker protection, by $\pm Q_{bay}$ voltage, only when the selector switch (L-0-R) is on the "Remote" position.
-no command or control operation when the selector switch (L-0-R) is on the "Off" position.

The <u>tripping coil No2</u> of the circuit breaker will receive:

-tripping commands due to the operation of the circuit breaker protection, by $\pm P_{bay}$ voltage, when the selector switch (L-0-R) is either on the "Remote" or "Local" position.
-no command, when the selector switch (L-0-R) is on the "Off" position.

The <u>closing coil</u> of the circuit breaker will receive:

-closing local operation, through button locally on the circuit breaker, by $\pm I_{bay}$ voltage, only when the selector switch (L-0-R) is on the "Local" position

-closing control commands remotely (from the substation control room or System Control Centers) by $\pm Q_{bay}$ voltage, only when the selector switch (L-0-R) is on "Remote" position.
-closing commands due to the operation of the auto-reclosing function of the distance protection relay for the circuit breaker, by $\pm Q_{bay}$ voltage, only when the selector switch (L-0-R) is on "Remote" position.
-no command or control operation, when the selector switch (L-0-R) is on the "Off" position.

With respect to the aux relays used for the detection of the SF_6 pressure loss and for the control of the uncharged springs of the circuit breakers, to be noted that their excitation will be, for each case, by the same 110 V DC voltage, which stimulates the corresponding opening or closing circuit breaker coil.

Specifically, four (4) SF6 pressure loss detection relays are required, which will be stimulated only in the case of SF6 pressure and by the same 110 V DC voltage which also stimulates the respective opening or closing coil of the circuit breaker.
For the SF6 pressure loss detection relay which trips the tripping coil No.1 of the circuit breaker, it will be possible to connect its excitation to the appropriate voltage (±Ibay for the "Local" position and ±Qbay for the "Remote" position of the selector switch, while there will be no excitation for the "Off" position).For the SF6 pressure loss detection relay which blocks the operation of the circuit breaker and whose contacts are related to the closing coil and also to the tripping coil No.1 of the circuit breaker, the excitation voltages will be ±Ibay for the "Local" position and ±Qbay for the "Remote" position of the selector switch, while there will be no excitation for the "Off" position.

Similarly, for the SF6 pressure loss detection relay which trips the tripping coil No.2 of the circuit breaker, it will be possible to connect its excitation to the appropriate voltage (±Pbay either for the "Remote" or "Local" positions, while there will be no excitation for the "Off" position of the selector switch). For the relay which blocks the operation of the circuit breaker and whose contacts are related to the tripping coil No.2 of the circuit breaker, the excitation voltage will be ±Pbay either for the "Remote" or "Local" positions, while there will be no excitation for the "Off" position of the selector switch.

As far as the loss of SF6 is concerned, the control circuit should:

-Be able to trip the CB at an appropriate SF6 density level, by implementing some minor cabling (for example, the excitation of the aux relays, which trip the CB in case of SF6 loss, is be connected at a terminal block, and this terminal block can be wired to the appropriate excitation voltage – see also VII/9/f) and
- Block the operation of the CB at a different (than the "trip") density level.

For verifying the expiration of the time required for charging of the circuit breaker springs, an auxiliary time-relay (OFF-delay-ON) will be provided. The auxiliary relay will be excited by the limit switch contact that controls the charging of the springs. The auxiliary relay contacts will change position after a time (t), greater than the time required for charging the springs, giving an alarm.

f. The "Local-Off-Remote" selector switch shall be equipped with an additional number of stages, beyond those which are normally needed for all the control circuits, which shall be used to be inserted to both positive (+) and negative (-) 110V DC buses of the control circuits.

For the wiring of the above mentioned circuits, a selector switch (L-0-R), equipped with at least ten (10) pairs of contacts is required.

g. The cabinet shall be equipped with two (2) push – buttons or a two (2) position control switch for local closing and opening of the circuit breaker as all ready has been indicated above.

h. The cabinet shall contain the following auxiliary circuit breaker contacts free of voltage:
- Seven (7) make contacts
- Seven (7) break contacts

i. The cabinet shall be equipped with terminal blocks suitable to be wired with $2.5mm^2$ size conductors with the exemption of the terminal blocks associated with the motor of the operating mechanism which must be suitable for $10mm^2$ cables. The terminal blocks shall preferably be of the screw type.

j. The cabinet shall be equipped with an anti-pumping relay as to prevent constant opening and closing in the event of simultaneously applied."Open" and "Close" commands.

k. Number of closing and tripping circuits:
1. Number of closing circuits : One (1)
2. Number of tripping circuits : Two (2)

l. The cabinet shall be equipped with the operating mechanism of the circuit breaker.

m. The cabinet shall be equipped with the motor of the operating mechanism with the motor's auxiliary supply voltage to be 110 V DC, with tolerance + 10 %, - 15%.
The supply of the circuit breaker motor will be incoming through a bipolar mcb with an aux contact (signaling of the thermal element tripping), while the supply for the local operation of the circuit breaker will be incoming through another independent bipolar mcb.

n. The cabinet shall be equipped with SF_6 density monitors

o. The cabinet shall be equipped with a light bulb (lamp)

p. The cabinet shall be equipped with a socket outlet for 220 V AC

p. The cabinet shall be equipped with a padlock

In case the circuit breaker is equipped with two separate cabinets, one for control and one for the operating mechanism, the cabinet of the operating mechanism shall contain items k, l, m, n and a as indicated above and the control cabinet items, from a to i and items n, o and p. Both cabinets shall be of IP55 protection as per IEC 60529 and hot - dip galvanized.

10. Housing of the isolating column and of the breaking chambers

a. The isolating housing of the breaker's columns and breaking chambers shall either be of extra strength porcelain or silicon rubber. The porcelain housing shall comply in all relevant respects with IEC 62155 "Hollow ceramic and glass insulators for use in electrical equipment" and shall be of grey color. The silicon rubber housing shall be in accordance with IEC 61142 standard "Composite insulators – Hollow insulators for use in outdoor and indoor electrical equipment".

b. The creepage distance of the column and breaking chamber housing shall be as follows:
1. Between live parts and earth (ground) : 25mm / kV (4250mm)
2. Across breaker terminals : 25mm / kV (4250mm)

With the voltage used for the determination being that of 170 kV (rated voltage).

VIII. REQUIRED ADDITIONAL DESIGN AND OTHER FEATURES OF THE CIRCUIT BREAKER

1. Wiring requirements

The wiring of various circuits of the breaker shall be carried out with at least
of the circuit. Conductors must bear rings with markings.

2. Lifting and moving of the circuit breaker

The offer shall include drawings and instructions which in detail shall indicate the method or way of lifting and moving of the circuit breaker.

3. Manual – Emergency Operation of the breaker

The circuit breaker must be equipped with a manual mechanism or other means for opening and closing without the use of DC auxiliary supply voltage for maintenance and emergency situations.

4. Seismic Qualifications Requirements

a. The seismic qualification of the circuit breaker shall be carried out in accordance with IEC 62271-300.

b. Mounting of the breaker : On a steel support structure designed by the manufacturer of the circuit breaker. The use of dampers is not acceptable.

c. Severity levels
   1. Horizontal (x and y axis) : 0.5 g (5m/s^2)
   2. Vertical (z axis) : 0.25 g (2,5m/s^2)

d. Frequency range : 0.1 Hz to 35 Hz

e. Method of seismic qualification : 1. By test or
   2. By combination of test and analysis or
   3. By pure analysis, if sufficient information, on physical parameters (e.g damping coefficient) and on the functional behavior of the breaker, is available.

Pure analysis can be carried out by a) establishing a mathematical model by using vibrational and functional data to assess the breaker's dynamic characteristics and b) by determining the response, in the frequency range stated in paragraph 4 – d above by using one of the methods listed below.

- Acceleration time – history
- Modal analysis using the required response spectrum
- Static coefficient analysis

f. Combination of stresses : The seismic stresses determined by test or by test and analysis or by pure analysis shall be combined with other services loads to determine the total withstand capability of the circuit breaker.

The following loads are to be considered to occur simultaneously.
1. Internal pressure
2. Static terminal load
3. Wind force of 10m/s on the circuit breaker
4. Seismic forces
5. Dead weight of the complete circuit breaker

The stresses due to the combination of these loads shall be equal to or less than the guaranteed minimum bending stress of each of the critical elements (e.g support insulators).

g. In the offer, bidders are required to submit any test certificates that they may have with the above severity seismic levels. If no test certificates are available, then it could be submitted tests with analysis or pure analysis. Acceptance or not of the test certificates or of the test and analysis or of pure analysis lies on IPTO's judgment. For this reason all bidders are required in the economic offer to include price for the execution of the seismic test, with the above specified severity levels.

5. Circuit breaker 's support structure

Since the breaker is going to be installed on a steel support structure, the successful bidder is required to submit drawings with detail constructional information about the steel support structure. Furthermore, enough information must be provided so that the support structure's concrete steel reinforced base can be calculated. The steel support structure will not be part of the supply.

6. Static terminal load withstand

The circuit breaker shall be able to operate correctly when loaded by stresses resulting from connected conductors as follows:

1. Static horizontal force
   - Longitudinal : 1250 N
   - Transversal : 750 N
2. Static vertical force : 1000 N

7. Wind speed withstand

The breaker itself shall be able to withstand a wind speed of 150 km/h which corresponds to 120 kg/m^2 of pressure (with coefficient of dynamic pressure of
1.0). The breaker's support – structure shall withstand a wind pressure of 180 kg/m^2 (with coefficient of dynamic pressure =1.5).

8. Circuit breakers terminals

The circuit breakers terminals shall be of copper nickel plated or aluminum, rectangular in shape and with dimensions of about 100mm x 100mm x 20mm.

9. Earthling of the circuit breaker

The frame of the circuit breaker shall be provided with a reliable earthling terminal having a clamping screw or bolt for connection to an earthling conductor suitable for 31.5 KA fault current. The diameter of the clamping screw or bolt shall be at least 12mm. The connecting point shall be marked with the "protective earth" symbol.

IX. CIRCUIT BREAKER' S REQUIRED RATE CHARACTERISTICS

1. Rated voltage : 170 kV
2. Rated frequency : 50 Hz
3. Rated normal current : 2000 A
4. Rated insulations level

   a. Rated power frequency withstand voltage (1 min)
   - Phase to earth, between phases and across open circuit breaker contacts (common value) : 325 kV rms

   b. Rated lightning impulse withstand voltage
   - Phase to earth, between phases and across open circuit breaker contacts (common value) : 750 kV peak

5. Rated short circuit breaking current
   AC component, r.m.s value : 31.5 KA
6. Rated transient recovery voltage for terminal faults
   - Peak value : 291 kV
   - Rate of rise of recovery voltage (RRRV) : 2.0 kV/μs
   - First – pole – to- clear factor :1.5
7. Rated transient recovery voltage for short – line faults
   - Peak Value : 194 kV
   - Rate of rise of recovery voltage (RRRV) : 2 kV/ μs
   - First – pole – to – clear factor : 1

8. Rated transient recovery voltage for out – of – phase
   - Peak Value : 434kV
   - Rate of rise of recovery voltage (RRRV) : 1.67 kV/μs
   - First – pole – to – clear factor : 2.5

9. Rated short – circuit making current with time constant 45ms (2.5 times the AC component of short breaking current) : 79 KA peak

10. Rated Operating Sequence : O-0.3s-CO-3 min-CO

11. Rated duration of short -circuit : 3 sec

12. Rated short – time withstand current : 31.5 KA r.m.s

13. Rated peak withstand current : 79 KA peak

14. Rated line – charging breaking current : 63 A r.m.s

15. Rated cable – charging breaking current : 160 A r.m.s.

16. Rated out –of – phase breaking current : 7.875 KA r.m.s.

17. Rated out – of – phase making current : 11 KA peak

18. Mechanical endurance class : M2 (10000 operations)

19. Restrike class during capacitive current breaking : C1

20. Rated break time : ≤ 2,55 cycles (51 ms)

21. Rated closing time : ≤ 3,5 cycles (70 ms)

22. Rated opening time : ≤ 1,8 cycles (36 ms)

23. Shunt reactor load switching current : 100 – 315 A or wider span

X. TESTS

A. Routine tests

Testing shall be in accordance with IEC 62271-100 and IEC 62271-1.
The routine testing shall include the following:

1. Power frequency voltage dry test on the main circuit

Test voltage: 325 kV rms, 50Hz, for 1 minute for phase to earth and phase – to – phase and across open circuit breaker contacts.

2. Tests on auxiliary and control circuits

a. Inspection of auxiliary and control circuits and verification of conformity to the circuit diagrams and wiring diagrams.
b. Functional tests of all low voltage circuits.
c. Verification of protection against electrical shock.
d. Power frequency voltage test.
Test voltage: 1kV, 50Hz with duration of 1 sec.

3. Measurement of the resistance of the main circuit

- The test current : any value between 50 A and 2000A.
- The measured resistance shall not exceed 1.2 Ru, where Ru is equal to the resistance measured before the temperature – rise test.

4. Tightness test

5. Design and visual checks

The following shall be checked:

- The language and data on the name plates.
- Identification of any auxiliary equipment.
- The color and quality of paint and corrosion protection of metallic surfaces.
- The values of the resistors and capacitors connected to the main circuit.

6. Mechanical operating tests

a. At maximum supply voltage of the operating devices and of the auxiliary and control circuits and at maximum pressure for operation.
- Five closing operations
- Five opening operations

b. At specified minimum supply voltage of the operating devices and of the auxiliary and control circuits and at minimum functional pressure for operation.
– Five closing operations
– Five opening operations

c. At rated supply voltage of the operating devices and of the auxiliary and control circuits and at rated pressure for the operation.
- Five close – open operating cycles with the tripping mechanism energized by the closing of the main contacts.
- Moreover, five open – close operating cycles O – t – C where t shall be not more than the time interval specified for the rated operating sequence. Finally for all required operating sequences all inspections, measurements and functional tests shall be performed as specified in IEC 62271-100.

B. Type Tests

Type tests shall be carried out in accordance with IEC 62271-100 and IEC 62271-1.

The following type tests are required.

1. Dielectric Tests

a. *Power frequency voltage tests*

Test voltage : 325 kV rms for 1 minute applied phase – to – earth and across open circuit breaker contacts.

The tests shall be performed in dry and wet conditions.

b. *Lightning impulse voltage tests*

The circuit breaker shall be subjected to lighting impulse voltage tests in dry conditions only.

The tests shall be performed with voltages of both polarities using a lightning impulse of 1.2 / 50 μς.

The test voltage shall be : 750 kV peak, applied phase – to – earth, between phases and across open circuit breaker contacts.

c. *Dielectric tests on auxiliary and control circuits*

The test involves:

- Impulse voltage withstand and
- Power frequency voltage withstand.

Each test shall be performed.

1. Between the auxiliary and control circuits connected together as a whole and the frame of the breaker.

2. If practical, between each part of the auxiliary and control circuits, which in normal use may be insulated from the other parts, and the frame. The other parts are being connected together.

The impulse voltage withstand value shall be 5 kV and the test shall be performed in accordance with IEC 60255-5. The power frequency test shall be performed according to IEC 61180-1. The test voltage shall be 2 kV with duration of 1 min.

2. Radio interference voltage (r. i. v) test

The test voltage shall be applied as follows:

a. In closed position, between the terminals and the earthed frame.

b. In open position, between one terminal and the other terminals which are connected to the earthed framed. The radio interference level at 1.1 Ur $\sqrt{3}$ (108 kV) shall be ≤ 2500 μ V.

3. Measurement of the resistance of the main circuit

The measurement shall be made with a DC by measuring the voltage drop or resistance across the terminals of the each pole.

The current during the test shall have a value between 50A and rated normal current of the breaker.

4. Temperature - rise tests

a. The test shall be made at rated normal current of the breaker in an environment substantially free from air currents and this condition is satisfied when the air velocity is ≤ 0.5 m/s

b. The test shall be made over a period of time sufficient for the temperature rise to reach a stable value. This condition is declared to be obtained when the increase of temperature rise does not exceed 1 K in 1 h.

c. The ambient air temperature during tests shall be more than + 10^{o} C but less than + 40^{o} C.

d. The auxiliary equipment shall be tested at its rated supply voltage or its rated current.

e. The temperature rise of the various parts of the circuit breaker or auxiliary equipment, for which limits are specified, shall not exceed the values specified in table 3 of IEC – 60694.

5. Short –time withstand current and peak withstand current tests

a. The test current shall be equal to the AC component of the rated short–time withstand current of the breaker.
This peak current test shall be equal to the rated peak withstand current of the breaker.

b. The test time shall be 3 seconds.

c. After the test, the switchgear shall not show significant deterioration, shall be capable of operating normally, carrying its rated normal current continuously without exceeding the temperature – rise limits specified in IEC 62271-1 and withstanding the voltages specified under dielectric tests.

6. Tightness test

7. Electromagnetic compatibility test (EMC)

a. The test is only for the secondary systems of the circuit breaker.
For the main circuit of the breaker, without switching operations, the emission level shall be verified by means of the radio interference voltage test.

b. Electronic equipment, which is part of the secondary system, shall fulfill the requirements with regards to emission, as defined in EN 550011 for group 1, class A equipment.

c. Secondary systems of the breaker shall be subjected to electromagnetic immunity tests if they include electronic equipment or components. In other cases no tests are required.

The following immunity tests are specified:

-Electric fast transient / burst test with normal EMC severity class test voltages.

-Oscillatory wave immunity test with normal EMC severity class test voltages.

8. <u>Mechanical operation test at ambient temperature</u>

The mechanical operation test shall consist of 10000 operating sequences. The circuit breaker should be tested preferably as a complete multi-pole circuit breaker. However, for convenience or owing to limitations of the dimensions of the test bay, one single-pole unit of the circuit breaker may be tested, provided that it is equivalent to the complete multi-pole circuit breaker over the range of tests, for example in respect of

-reference mechanical travel characteristics

-power and strength of closing and opening mechanism

-rigidity of structure.

The circuit breaker shall be tested as follows:

Operating sequence	Supply voltage and operating pressure	Number of operating sequences
		Circuit breaker for auto – reclosing
C – ta – O- ta	Minimum	500
	Rated	500
	Maximum	500
O – t- CO- ta – C – ta	Rated	250
O = opening C = closing CO = closing followed immediately by an opening ta = time between two operations which is necessary to restore the initial conditions and /or to prevent undue heating of parts of the breaker t = 0.3 s Repetition rate of the operating sequence = 5 times		

9. <u>Short – circuit current making and breaking tests</u>

a. The circuit breaker shall be capable of making and breaking the specified three - phase symmetrical and asymmetrical currents between 10 % and 100 % of the rated short - circuit breaking current at rated voltage.

b. The breaker shall be capable at making and breaking single-phase short-circuit currents between 10% and 100 % of the rated short – circuit breaking current at phase-to-earth voltage.

c. The breaker shall be capable of switching the capacitive current 160 A at a voltage level of $170kV\sqrt{3} \times 1.2 = 118kV$ (for direct single-phase laboratory test).

d. The applied voltage, current, transient and power frequency recovery voltages may all be obtained from a single power source (direct tests) or from several sources where all of the current, or a major portion of it, is obtained from one source, and the transient recovery voltage is obtained wholly or in part from one or more separate sources (synthetic tests). Synthetic testing shall be in accordance with IEC 62271-101.

10. <u>Line – charging current switching test</u>

a. Any of the following test possibilities is acceptable :

- Three – phase tests with use of parallel lines or concentrated capacitors
- Single – phase tests
- Single – phase laboratory tests with concentrated

capacitors b. The line charging breaking current shall be 63 A r.m.s

c. For direct single – phase laboratory tests, the test voltage shall be
170 kV / $\sqrt{3}$ x 1.2 = 118 kV

d. In laboratory tests, the lines may be partly or fully replaced by artificial circuits with lumped elements of capacitors, reactors or resistors.

e. The line – charging breaking current test shall be carried out according to C1 restrict class capability (C 1 classification of a breaker means low probability of restrict during capacitive current breaking).

11. <u>Out – of – phase making and breaking tests</u>

a. This test shall be carried preferably in a single – phase test circuit.

b. The out – of – phase making current shall be 11 KA peak.

c. The out – of – phase breaking current shall be 7.875 kA r.m.s

d. The applied voltage and the power frequency recovery voltage shall have the following value :

- Applied voltage and the power frequency recovery voltage : 196 kV rms at breaking current of 7.875 KA.

e. The transient recovery voltage shall be 434 kV peak.

f. The test - duty shall be OP2 with operating sequence CO – O – O and breaking current of 7.875 KA

12. <u>Cable – Charging current switching test</u>

a. The cable – charging breaking current shall be 160 A rms at a test voltage of
170 kV / $\sqrt{3}$ x 1.2 = 118 kV

b. Capacitors may be used to simulate screened and belted cables.

c. The cable – charging breaking current test shall be carried out according to C1 restrike class capability (C1 classification of a breaker means low probability of restrike during capacitive current breaking).

13. Shunt reactor current switching tests

a. Two tests will be carried out, following the provisions of IEC 62271-110. The one test will be performed with 315 A inductive breaking current and the other with inductive breaking current lower or equal to 100 A.

b. The shunt reactors in the tests will have earthed neutral nodes.

14. Static terminal load tests

The static horizontal force withstand shall be:

Longitudinal	: 1250 N
Transversal	: 750 N
The static vertical force shall be	: 1000 N

Ice coating and pressure shall be in accordance with IEC 62271-1

Calculations can be used to prove the circuit breakers capability to withstand the stresses instead of tests.

15. High temperature tests

High temperature = $+45^{o}C$

XI. NAMEPLATES

The circuit breaker and its operating mechanisms shall be equipped with name plates of no corrosive material, which shall bear on them the following information.

A. Circuit Breaker

1. Manufacture
2. Type designation and serial number
3. Rated voltage, in kV
4. Rated lighting impulse withstand voltage in kV
5. Rated frequency in Hz
6. Rated normal current in A
7. Rated duration of short circuit in sec
8. Rated short circuit breaking current in KA
9. DC component of the rated short circuit breaking current in %
10. First – pole – to clear factor
11. Rated out – of – phase breaking current in KA
12. Rated line – charging breaking current in A

13. Rated cable – charging breaking current in A
14. Rated filling pressure for interruption in MPa
15. Rated filling pressure for operation in MPa
16. Mass of the breaker in kg
17. Rates operating sequence
18. Year of manufacture
19. Temperature class
20. Relevant standard with date of issue

B. Operating mechanism

1. Manufacturer
2. Type designation and serial number
3. Rated supply voltage of closing and opening devices
4. Rated supply voltage of auxiliary circuits
5. Relevant standard with date of issue

XII. DATA WHICH MUST BE SUBMITTED BY ALL BIDDERS

1. Outline drawing of the breaker, in which the physical dimensions of the breaker are clearly depicted.

2. Brochures, technical pamphlets and any other information which is deemed necessary for the technical evaluation process.

3. All bidders are required to answer all items of Attachment A. Failure to comply or partial filling of the attachment will constitute sufficient reason for rejection of the offer.

4. Any test certificates for the type tests specified in this hereby specification. Acceptance or not of these certificates lies on IPTO's judgment

5. Any seismic test certificates or tests and analysis or pure analysis. Acceptance or not lies on IPTO's judgment.

6. A preliminary drawing for the steel support structure of the circuit breaker.

7. A drawing indicating method of lifting of the circuit breaker.

XIII. DATA WHICH MUST BE SUBMITTED BY THE SUCCESSFUL BIDDER

1. Complete schematic and wiring drawings of the breaker for approval before the construction of the breaker (3 sets).

2. Complete physical drawings of the breaker indicating all dimension details of the breaker for approval before the construction of the breaker (3 sets).

3. Technical brochures describing in detail the breaker itself, its operating mechanism and its operation
4. Detail drawings of the breakers steel support structure so that IPTO can construct it and also to be able to construct its concrete steel reinforced base.

5. Maintenance and assembly instructions in detail.

6. A drawing indicating method of lifting of the breaker.

XIV. WARRANTY

The supplier must provide a warranty of three (3) years, beginning from the date of delivery of the circuit breaker for damages by faulty design or by unreliable components or by combination of the two.

XV. PACKING

The circuit breakers shall be delivered in entirely closed and robust wooden boxes of at least 20mm thickness. The boxes will be of ΄΄pallet type΄΄, with strengthened base. The poles and the mechanism of each circuit breaker shall be delivered in separate boxes. The boxes will be protected internally by an insulating material (e.g.nylon).

XVI. The circuit breaker must be delivered filled with the appropriate, for its operation, quantity of SF6 gas.

ATTACHMENT "A"

SPECIFICATION SS-97/12

170 kV SF_6 OUTDOOR CIRCUIT BREAKERS

All bidders must provide the following data. Failure to comply in full shall constitute sufficient reason for rejection if the offer

1. Type and manufacture : ……

2. Ambient temperature range : ……

3. Type of interrupter technology : ……

……

……

4. Number of operating mechanisms : ……

……

5. Operating mode : ……..

……

6. Number of interrupting units : …….

……

7. Type of gas used in the breaking chamber : …….

8. Is the SF_6 gas in accordance with IEC – 60376? : …….

9. Type and description of the operating mechanism : …….

……...

……...

……...

10. Auxiliary supply voltages
    a.For the opening and closing circuits : …….

    b. For all other control and signaling circuits : …….

    c. For the heating and light circuits : …….

    d. For the motor of the operating mechanism : …….

11. Describe the basic elements of the circuit breaker's structure : …….

……...

……...

12. Is the circuit breakers control and operating mechanism cabinet in accordance with the requirement of paragraph VII – 9 –a to p : …….

a. If no, indicate deviations : …….

……...

……...

……...

13. Is the circuit breaker equipped with two separate cabinets? One for control and the other for the operating mechanism? : …….

……...

a. If yes, then does the control cabinet contain items a to j and n to p of paragraph VII – 9? : ….....

……...

And does the operating mechanism cabinet contain items k, l ,m, n and a of paragraph VII – 9? : …….

……...

14. Type of housing of the isolating column and of the breaking chamber and indicate compliance with the relevant IEC standard : ……

……..

……...

……..

15. Creepage distance of the isolating column and breaking chambers housing

    a. Between live parts and earth : …….

    b. Across breaker terminals : …….

16. Size of wires (cables) used in the circuits of the breaker's operating mechanisms : ……

    ……..

17. Is a drawing provided in which the method of the breaker lifting is indicated ? : ……

18. Are special tools needed for the lifting of the breaker? : ……

19. Can the breaker be operated without the use of the DC auxiliary supply voltage? :…….

20. Can the offered type of circuit breaker withstand successfully the seismic severity levels of 0.5 g horizontal (x and y axis) and 0.25 g vertical? : ……

    ……...

    ……...

21. Which method has been used to seismic qualify the offered type of breaker? : ……....

    ……...

    ……...

    ……...

22. Static terminal load withstand capability
    a. Static horizontal force
       Longitudinal : …….

       Transversal : …….

    b. Static vertical force : ……

23. Wind speed and pressure capability of the breaker
    a. Wind speed in km/h withstand : …….

    b. Pressure in kg/m^2 withstand with c.d.p of 1.0 : ……

24. Wind pressure withstand capability of the breaker's steel supporting structure : ……

25. Material, shape and dimensions of the circuit breaker's terminals : ……

……...

……...

……...

26. Rated characteristics

a. Rated voltage : …….

b. Rated frequency : ……

c. Rated normal current : …….

d. Rated power frequency withstand voltage
-Phase to earth, between phases and across open circuit breaker contacts : …….

e.Rated lightning impulse withstand voltage
-Phase to earth, between phases and across open circuit breaker contacts : ……

f. Rated short circuit breaking current
-AC component, rms value : ……

-DC component, % value : ……

g. Rated transient recovery voltage for terminal faults
-Peak value : ……

-Rate of rise of recovery voltage (RRRV) : ……

-First – pole – to – clear factor : ……

h. Rated transient recovery voltage for short – line faults
-Peak value : ……

-Rate of rise of recovery voltage (RRRV) : ……

-First – pole – to – clear factor : ……

i. Rated transient recovery voltage for out – of – phase
-Peak value : …….

-Rate of rise of recovery voltage (RRRV) : …….

-First – pole – to – clear factor : …….

j. Rated short – circuit making current : ……

k. Rated operating sequence : ……

l. Rated duration of short circuit : ……

m. First –pole – to – clear factor : ……

n. Rated short – time withstand current : ……

o. Rated peak withstand current : ……

p.Rated line – charging breaking current : ……

q.Rated cable – charging breaking current : ……

r. Rated out – of – phase breaking current : ……

s.Rated out – of – phase making current : ……

t. Mechanical endurance class : ……

u. Restrike class during capacitive current breaking : ……

v. Rated break time : ……

w. Rated closing time : …….

x. Rated opening time : ……

27. Shunt reactor load switching current : ……

28. Dead time between closing and opening or vise – versa : ……...

……..

29. Simultaneity difference between poles (ON/OFF) : …….

……...

30. Is the circuit breakers frame equipped with an earthling terminal as described in paragraph VIII – 9 : ……

31. Type of main contacts : …….

32. Material of the main contacts : …….

33. Arc quenching medium (SF_6)

a.Rated pressure of SF_6 in bar or MPa : …….

b.SF_6 alarm pressure in bar MPa : …….

c.SF_6 lockout pressure in bar or MPa : …….

d.SF_6 loss – rate /year : …….

e.Mass of SF_6 for the entire breaker : …….

f. Minimum SF_6 operating pressure : …….

34. Number of auxiliary free contacts : ……

……..

……...

35. Number of tripping coils : …….

36. Number of closing coils : …….

37. Power consumption

a. Closing coil (DC) : …….

b. Trip coil (DC) : ……

c. Heaters : ……

d. Light bulb : ……

38. Spring type operating mechanism data (if applicable)

a. Motor voltage : …….

b. Motor power when running : …….

c. Voltage operating tolerance : …….

d. Motor power during starting : …….

39. Hydraulic type operating mechanism data (if applicable)

a. Type of hydraulic liquid : ……

b. Volume of hydraulic liquid : …….

c. Rated pressure : …….

d. Minimum operating pressure : …….

e. Maximum operating pressure : …….

f. Rated voltage of the pump motor : …….

g. Voltage tolerance of the pump motor : …….

h. Power of the pump motor when running : …….

i. Power of the pump motor when starting : …….

40. Weight of the entire breaker complete with SF_6 : …….

41. Weight of the entire breaker complete with SF_6 and all fittings as in service : …….

42. Is the breaker of the live tank type? : …….

43. IP class protection of breaker's control and operating mechanism cabinet : ……

……...

44. If applicable, IP class protection of

a.Control cabinet : …….

b.Operating mechanism cabinet : …….

45. Minimum bending stress of the most critical elements of the circuit breaker : …….

……...

……...

46. Is the mechanism trip-free? (as per IEV 441-16-31) : …….

47. Dimensions of the breaker : …….

48. Is the porcelain housing of grey color? : …….

49. Is the operating mechanism equipped with a pole discrepancy arrangement? : …….

…….

…….

50. Tolerance of the DC supply voltage for the tripping coils : …….

51. Is the circuit breaker delivered filled with the appropriate for its operation quantity of SF6 gas? : …….

52. Is the packing according the requirements of par. XV? : …….