



SPECIFICATION SS – 106/12
420KV SF6 OUTDOOR CIRCUIT BREAKERS

I. SCOPE

This hereby specification covers IPTO's requirements with regard the technical characteristics, design features and testing of 420KV SF6 outdoor circuit breakers.

II. KEYWORDS

Circuit breakers, SF6 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. The controlled switching characteristics and testing will follow IEC 62271-302.

IV. USE

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

V. ELECTRICAL CHARACTERISTICS OF IPTO's 400KV SYSTEM

1. Nominal Voltage	: 400KV
2. Maximum Operating Voltage	: 420KV
3. Number of phases	: 3
4. Number of conductors	: 3
5. Nominal frequency	: 50Hz
6. Short circuit Level	: 40KA
7. Basic Insulation Level	: 1550KV
8. Method of grounding	: The 400KV system is solidly grounded
9. Available DC auxiliary supply voltage	: 220V DC from substation battery
10. Available AC auxiliary supply voltage	: 230/400 V, AC

VI. OPERATING CONDITIONS

- | | |
|----------------------------------|-------------------------------|
| 1. Installation | : Outdoors |
| 2. Limits of ambient temperature | : -25 ° C, +45 ° C |
| 3. Altitude | : Up to 1000m 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 circuit Breaker

SF6, 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

The circuit breaker shall be equipped with one (1) operating mechanism per pole and the breaker must be suitable for single and triple pole auto-reclosing.

4. Operating mode

Single pole operated suitable for single and triple pole auto-reclosing.

5. Number of Interrupters

Each pole shall contain two (2) interrupting units in series.

6. Gas of the breaking chamber

The breaker shall use Sulphur Hexafluoride (SF6) for insulation and arc-quenching purposes. The SF6 gas shall be in accordance with IEC 60376 standard.

The appropriate quantity of SF6 gas for the operation of the circuit breaker shall be part of the supply.

7. Grading Capacitors

If equal voltage stress across the interrupting units cannot be achieved by the interrupting unit design itself, grading capacitors must be provided (in other words, if it is deemed necessary by the manufacturer).

8. Operating Mechanism characteristics

- a. Type : Stored energy spring driven mechanism consisting of a control cabinet and three (3) operating mechanisms (one per pole).
- b. Type of tripping : Trip-free (definition IEC 441-16-31)
- c. Auxiliary supply voltages
1. For the opening / tripping and closing circuits : 220 V DC
 2. For all other control and signaling circuits : 220 V DC
 3. Heating and lighting circuits : 230 V AC
 4. For the motors of the operating mechanisms : 220 V DC
 5. Tolerances of the DC supply voltages except for the opening / tripping coils : +10, -15%
 6. Tolerance for the DC supply voltages for the opening / tripping coils : +10, -30%

9. Circuit breaker's central control cabinet

The breaker shall be equipped with a central control hot-dip galvanized or aluminum cabinet of weather-proof capability 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 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.** The cabinet shall be equipped with a selector switch with three (3) operating positions "Off-Local-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 for maintenance purposes 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 (opening-closing) the breaker from the control building of the substation or from the system’s control center and also for tripping purposes.

e. The “off-local-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 (-) 220V DC buses of the control circuits.

f. 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 already has been indicated above.

g. The cabinet shall contain the following number of breakers auxiliary free of voltage contacts:

- Ten (10) make contacts
- Ten (10) break contacts

and in addition one (1) passing make contact.

h. The cabinet shall be equipped with terminal blocks suitable to be wired with 2.5mm² size conductors with the exception of the terminal blocks associated with the tripping and closing circuits and the motor of the operating mechanism which must be suitable for 4mm² and the 10 mm² cables respectively. The terminal blocks shall preferably be of the screw type.

i. 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.

j. The cabinet shall contain a circuit for the control of pole discrepancy.

This circuit shall consist of NO and NC auxiliary contacts of the circuit breaker in series for the three poles and these auxiliary contacts shall be connected in series with a time delay relay (0-10sec or 0.1-10sec).

In the event that the circuit breaker has completed its single-pole or triple-pole auto-reclosing function and a command for final tripping has been issued and for some reason pole or poles remain closed, then the above described circuit shall intervene to provide a tripping command to both tripping coils of the circuit breaker. If still some pole remains closed, then an alarm signal shall be provided for pole discrepancy.

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 a light (lamp)
- m.** The cabinet shall be equipped with a socket outlet for 220V AC
- n.** The cabinet shall be equipped with a padlock
- o.** 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, will is connected at a terminal block, and this terminal block can be wired to the appropriate excitation voltage) and
 - Block the operation of the CB at a different (than the “trip”) density level.

10. Operating mechanism cubicles

Each pole of the breaker must include an operating mechanism hot-dip galvanized or aluminum cubicle, of class protection IP55 as per IEC 60529 which shall include among others the following:

- a.** Motor of the operating mechanism, with the motor’s auxiliary supply voltage to be 220V DC, -15%/+10%
- b.** A SF6 density monitor
- c.** Anti-condensation heaters with thermostat

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

a. The isolating housing of the breaker’s column and breaking chambers shall either be of extra strength porcelain or silicon rubber.

The porcelain shall comply in all relevant respects with IEC 62155 “Hollow ceramic and glass insulators for use in electrical equipment”.

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 chambers housing shall be as follows.

- 1. Between live parts and earth (ground) : 25mm/KV
- 2. Across breaker terminals : 25mm/KV

With the voltage used for the determination being that of 420KV (rated voltage).

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

1. Controlled switching

The circuit breaker will be suitable for controlled opening and closing operations of shunt reactor loads, as well as overhead or cable line with connected compensating shunt reactors.

2. Wiring requirements

The wiring of various circuits of the breaker shall be carried out with at least 1.5mm² size conductors, unless, is differently needed by the power requirements of the circuit. Conductors must bear rings with markings.

3. Lifting and moving of the circuit breaker

The offer shall include drawings and instructions which in great detail shall indicate the method or way lifting and moving of the circuit breaker is to be carried out.

The economic offer shall include as an option any possible special tools needed for the lifting of the circuit breaker.

4. Emergency Operation of the Circuit breaker

The circuit breaker must be equipped with a mechanism or other means, for opening and closing for maintenance and emergency situations.

5. 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/s²)

2. Vertical (z axis) : 0.25 g (2,5m/s²)

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.

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 specified 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 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 : 1750N
 - Transversal : 1250N
2. Static vertical force : 1500N

7. Wind speed withstand

The breaker itself shall be able to withstand a wind speed of 150km/h which corresponds to 120kg/m^2 of pressure (with coefficient of dynamic pressure of 1.0).

The breaker's support-structure shall withstand a wind pressure of 180kg/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 $100\text{mm}\times 100\text{mm}\times 25\text{mm}$.

9. Earthing of the circuit breaker

The frame of the circuit breaker shall be provided with a reliable earthing terminal having a clamping screw or bolt for connection to an earthing conductor suitable for 40KA 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.

10. Interconnection cables between poles of the circuit breaker

The installation distance between poles of the circuit breaker will be 6,25m, or 40m, as defined in the Inquiry.

It should be taken into account the length of the cable route for the connection of the circuit breaker operation panels. The estimated length of the horizontal cable route between any pole and the central control cabinet, inside cable trench, will be 12m or 48m long respectively, as above.

The interconnection cables and the suitable hurting plugs wired on the cables, shall be part of the supply.

IX. CIRCUIT BREAKER'S REQUIRED RATED CHARACTERISTICS

1. Rated Voltage : 420KV
2. Rated frequency : 50Hz
3. Rated normal current : 3150A
4. Rated insulations level
 - a. Rated power frequency withstand voltage (1 min)
 - Phase to earth and between phases : 620 KV rms
 - Across open circuit breaker contacts : 800 KV rms
 - b. Rated switching impulse withstand voltage
 - Phase to earth : 1175 KV peak
 - Across open circuit breaker contacts : 1175 KV peak
 - Between phases : 1760 KV peak

c. Rated lightning impulse withstand voltage	
• Phase to earth and between phases	: 1550kV peak
• Across open circuit breaker contacts	: 1550 (+315) KV peak
5. Rated short circuit breaking current	
AC component, r.m.s. value	: 40 KA
6. Rated transient recovery voltage for terminal faults	
•Peak Value	: 624 KV
•Rate of rise of recovery voltage (RRRV)	: 2.0 KV/ μ s
•First-pole-to-clear factor	: 1.3
7. Rated transient recovery voltage for short-line faults	
• Peak Value	: 480 KV
• Rate of rise of recovery voltage (RRRV)	: 2 KV/ μ s
• Fist-pole-to-clear factor	: 1
8. Rated transient recovery voltage for out-of-phase	
• Peak Value	: 857 KV
• Rate of rise of recovery voltage (RRRV)	: 1.54 KV/ μ s
• First-pole-to-clear factor	: 2
9. Rated short-circuit making current with time constant 45ms (2.5x the AC component of the short circuit breaking current)	:100 KA peak
10. Rated Operating Sequence	: O-0.3s-CO-3min-CO
11. Rated duration of short-circuit	: 3sec
12. Rated short-time withstand current	: 40 KA rms
13. Rated peak withstand current	: 100 KA peak
14. Rated line- charging breaking current	: 400A rms
15. Rated cable- charging breaking current	: 400A rms
16. Rated out-of-phase breaking current	: 10 KA rms
17. Rated out-of-phase making current	: 14 KA peak
18. Mechanical endurance class	: M2 (10000 operations)

19. Restrike class during capacitive current breaking	: C1
20. Rated break time	: ≤ 2.5 cycles (50ms)
21. Rated closing time	: ≤ 5.5 cycles (110ms)
22. Rated Opening time	: ≤ 2 cycles (40ms)
23. Shunt reactor load switching current	: 100 – 315 A or wider span
24. Rated making window of a single pole	: ≤ 4 ms
25. Rated opening window of a single pole	: ≤ 3 ms
26. Simultaneity difference on closing between poles	: ≤ 1/4 cycle (5 ms)
27. Simultaneity difference on opening between poles	: ≤ 1/6 cycle (3.3 ms)
28. Simultaneity difference on closing between breaking chambers of same pole	: ≤ 1/6 cycle (3.3 ms)
29. Simultaneity difference on opening between breaking chambers of same pole	: ≤ 1/16 cycle (1.3 ms)

X. TESTS

A. Routine Tests

Testing shall be in accordance with IEC 62271-100 and IEC62271-1.

The routine testing shall include the following:

1. Power frequency voltage dry test on the main circuit

Test voltage: 620kV 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 50A and 3150A
 - The measured resistance shall not exceed 1.2 R_u , where R_u 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 operation
 - c. At rated supply voltage of the operating devices and of the auxiliary and control circuits and at rated pressure for 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 voltages : 620kV rms for 1 minute applied phase-to-earth
: 800kV rms for 1 minute applied across open
circuit
breaker contacts

The tests shall be performed in dry conditions only.

Both the preferred and alternative methods are acceptable for the insulation across the open circuit breaker contacts.

b. Switching impulse voltage tests

The tests shall be performed with voltages of both polarities and the standardized switching impulse 250/2500 μ s under dry and wet conditions.

The test voltages shall be : 1175kV peak, for phase-to earth and across open
circuit breaker contacts
: 1760kV peak, between phases

The second test series, with the test voltages 900(+450) KV is not required, because the circuit breaker does not provide isolating gap between open contacts.

c. Lightning impulse voltage tests

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

The tests shall be performed with voltages of both polarities using a lighting impulse of 1.2/50 μ s

The test voltages shall be : 1550kV peak, applied phase-to-earth with
the breaker closed and 1550 (+315) KV peak,
applied across open circuit breaker contacts

d. 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 practicable, 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 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 frame.

The radio interference level at $1.1 \frac{U_r}{\sqrt{3}} = 267 \text{ kV}$ shall be $\leq 2500 \mu\text{V}$.

3. Measurement of the resistance of the main circuit

The measurement shall be made with DC current, by measuring the voltage drop or resistance across the terminals of 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 $\leq 0.5 \text{ m/s}$.
- 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 1K in 1h.
- c. The ambient air temperature during tests shall be more than $+10^\circ\text{C}$ but less than $+40^\circ\text{C}$.
- 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.
The 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 tests are 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 55011 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 security class test voltages
 - Oscillatory wave immunity test with normal EMC severity class test voltages.

8. Mechanical operation test at ambient temperature

The mechanical operation test shall consist of 10000 operating sequences. The circuit breaker should be tested preferably as a complete multipole 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 multipole 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. Short-circuit current making and breaking tests

- 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 (400A) at a voltage level of $\frac{420KV}{\sqrt{3}} \times 1.2=291$ KV (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 whole or in part from one or more separate sources (synthetic tests).
- e. Synthetic testing shall be in accordance with IEC 62271-101.
- f. Since the circuit breaker consists of three independent single-poles, it can be tested single-phase

10. Line-charging current switching test

- 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 400 A rms.
- c. For direct single-phase laboratory tests, the test voltage shall be $\frac{420KV}{\sqrt{3}} \times 1.2=291$ 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 restrike class capability (C1 classification of a breaker means low probability of restrike during capacitive current breaking).

11. Out-of-phase making and breaking tests

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

- b. The out-of-phase making current shall be 14KA peak
- c. The out-of-phase breaking current shall be 10KA rms
- d. The applied voltage and the power frequency recovery voltage shall have the following values
 - Applied voltage and the power frequency recovery voltage of 485kV rms at breaking current of 10KA.
- e. The transient recovery voltage shall be 857kV peak.
- f. The test-duty shall be OP2 with operating sequence CO – O – O and breaking current 10KA

12. Cable – charging current switching test

- a. Any of the following test possibilities is acceptable:
 - Three-phase tests with use of parallel cables or concentrated capacitors
 - Single-phase tests
 - Single-phase laboratory tests with concentrated capacitors.
- b. The line charging breaking current shall be 400 A rms.
- c. For direct single-phase laboratory tests, the test voltage shall be $\frac{420KV}{\sqrt{3}} = 242 \text{ kV}$.
- d. In laboratory tests, the cables may be partly or fully replaced by artificial circuits with lumped elements of capacitors, reactors or resistors.
- e. 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 : 1750N
 Transversal : 1250N
 The static vertical force shall be 1500N.

Ice coating and pressure shall be in accordance with IEC 62271-1.
Calculations can be used to prove the circuit breakers capability to with stand the stresses instead of tests

15. High temperature tests

High temperature = +45°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 lightning impulse withstand voltage in KV
5. Rated switching impulse withstand voltage in KV
6. Rated frequency in Hz
7. Rated normal current in A
8. Rated duration of short circuit in sec
9. Rated short circuit breaking current in KA
10. DC component of the rated short circuit breaking current in %
11. First-pole-to-clear factor
12. Rated out-of-phase breaking current in KA
13. Rated line-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. Rated operating sequence
18. Year of manufacture
19. Temperature class
20. Relevant standard with date of issue

B. Operating Mechanisms

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 of the offered equipment for the type tests specified in this hereby specification.
Acceptance or not of these certificates lies on IPTO's judgment. In any case, for the technical evaluation purposes, IPTO reserves the right to demand from the Bidders to confirm any stated values of specific technical features by the submission of related test certificates. Congruency failure between values will be reason for the offer's rejection.
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 (3sets). The drawings will include the connection of the point-on-wave controller to the circuit breaker.
2. Complete physical drawings of the breaker indicating all dimensional 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, commissioning and assembly instructions in detail.
6. The commissioning instructions will also describe the on-site measurements, which are required in order to determine the operating (opening-closing) times of the circuit breaker. Recommendations should be also included, regarding when the on-site measurement of the operating times should be repeated during the lifetime of the circuit breaker.
7. 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

Each circuit breaker must be delivered packaged inside entirely closed robust wooden boxes, palet type of at least 20mm thickness, with all of its parts numbered and easily identifiable. The operating mechanisms and supporting insulators will be in separate boxes, as above, protected internally by an insulating material (e.g. nylon), meaning seaworthy packing.

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

ATTACHMENT "A"
420KV SF6 OUTDOOR CIRCUIT BREAKER

All bidders must provide the following data. Failure to comply in full shall constitute sufficient reason for rejection of 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 SF6 gas in accordance with IEC 60376? :
9. Are grading capacitors used across the interrupting units? :
 - a. If yes, then indicate
 - grading capacitors voltage :
 - grading capacitors capacitance :
 - grading capacitors lightning impulse withstand voltage :
 - reactive power of the grading capacitors: :
10. Type and description of the operating mechanism :
.....
.....
.....
.....
11. Is the mechanism of free-trip? :
12. 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
13. Is the circuit breakers central control cabinet in accordance with the requirement of paragraph VII-9-a to m :
- a. If no, indicate deviations :
 -
 -
 -
14. Are the circuit breakers operating mechanism cubicles equipped with the following?
- a. motor :
 - b. SF6 density monitor :
 - c. Anti-condensation heaters with thermostat :
 - d. Class protection of the cubicles :
15. Type of housing of the Isolating column and of the breaking chambers and indicate compliance with the relevant IEC standard :
-
-
-
-
16. Creepage distance of the isolating column and breaking chambers housing
- a. Between live parts and earth :
 - b. Across breaker terminals :
17. Size of wires (cables) used in the circuits of the breaker's operating mechanisms. :
-
18. Is a drawing provided in which the method of the breaker lifting is indicated? :
19. If special tools are needed for the lifting of the breaker, are they included in the economic offer? :
20. Means for opening and closing of the circuit breaker in case of maintenance and emergency operation? :

21. Can the offered type of circuit breaker withstand successfully the seismic severity levels of 0.5g horizontal (x and y axis) and 0.25g vertical? :
22. Which method has been used to seismic qualify the offered type of breaker? :
23. Static terminal load withstand capability
- a. static horizontal force
 - Longitudinal :
 - Transversal :
 - b. static vertical force :
24. Wind speed and pressure capability of the breaker
- a. wind speed in km/h withstand :
 - b. pressure in kg/m² withstand with cdp of 1.0 :
25. Wind pressure withstand capability of the breaker's steel supporting structure: :
26. Material, shape and dimensions of the circuit breaker's terminals :
27. Rated characteristics
- a. Rated voltage :
 - b. Rated frequency :
 - c. Rated normal current :
 - d. Rated power frequency withstand voltage
 - Phase to earth and between phases :
 - Across open circuit breaker contacts :
 - e. Rated switching impulse withstand voltage
 - Phase to earth :
 - Across open circuit breaker contacts :
 - Between phases :
 - f. Rated lightning impulse withstand voltage

• Phase to earth and between phases	:
• Across open circuit breaker contacts	:
g. Rated short circuit breaking current	
• AC component, rms value	:
• DC component, % value	:
h. Rated transient recovery voltage for terminal faults	
• Peak value	:
• Rate of rise of recovery voltage (RRRV)	:
• First-pole-to-clear factor	:
i. Rated transient recovery voltage for short-line faults	
• Peak value	:
• Rate of rise of recovery voltage (RRRV)	:
• First-pole-to-clear factor	:
j. Rated transient recovery voltage for out-of-phase	
• Peak value	:
• Rate of rise of recovery voltage (RRRV)	:
• First-pole-to-clear factor	:
k. Rated short-circuit making current	:
l. Rated operating sequence	:
m. Rated duration of short circuit	:
n. First-pole-to-clear factor	:
o. Rated short-time withstand current	:
p. Rated peak withstand current	:
q. Rated line-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. Break time (min-max) of a single pole	:
w. Opening time (min-max) of a single pole	:
x. Arcing time (min-max) of a single pole	:
y. Make time (min-max) of a single pole	:

z. Closing time (min-max) of a single pole	:
aa. Pre-arcing time (min-max) of a single pole	:
28. Shunt reactor load switching current	:
29. Dead time between closing and opening or vise - versa	:
30. Rated making window of a single pole	:
31. Rated opening window of a single pole	:
32. Rate of decay of dielectric strength (RDDS)	:
33. Rate of rise of dielectric strength (RRDS)	:
34. Simultaneity difference on closing between poles	:
35. Simultaneity difference on opening between poles	:
36. Simultaneity difference on closing between breaking chambers of same pole	:
37. Simultaneity difference on opening between breaking chambers of same pole	:
38. Ambient temperature sensitivity of	
- closing time (+/-)	:ms/K
- opening time (+/-)	:ms/K
39. Control voltage sensitivity of	
- closing time (+/-)	:%
- opening time (+/-)	:%
40. Idle time (≥ 7 days) sensitivity of	
- closing time (+/-)	:ms
- opening time (+/-)	:ms
41. Is the circuit breakers frame equipped with an earthing terminal as described in paragraph VIII-9	:
42. Type of main contacts	:
43. Material of the main contacts	:

- 44. Arc quenching medium (SF6)
 - a. Rated pressure of SF6 in bar or MPa :
 - b. SF6 alarm pressure in bar or MPa :
 - c. SF6 lockout pressure in bar or MPa :
 - d. SF6 loss-rate/year :
 - e. Mass of SF6 for the entire breaker :
 - f. Minimum operating pressure :

- 45. Class protection of central control cabinet and of the operating mechanism cubicles :

- 46. Number of auxiliary free contacts :
.....

- 47. Number of tripping coils :

- 48. Number of closing coils :

- 49. Number of wiping contacts :

- 50. Power consumption
 - a. closing coil (D.C) :
 - b. Trip coil (D.C) :
 - c. Heaters :
 - d. Light bulb :

- 51. Spring type operating mechanism data
 - a. Motor voltage :
 - b. Motor power when running :
 - c. Voltage operating tolerance :
 - d. Motor power during starting :

- 52. Weight of the entire breaker complete with SF6 :

- 53. Weight of the entire breaker complete with SF6 and all fittings as in service. :

- 54. Is the breaker of the live tank type? :

- 55. IP class protection of breaker's central control cabinet :

- 56. Minimum bending stress of the most critical elements of the circuit breaker :
.....

- 57. Dimensions of the breaker :

- 58. Are the central control cubicle and the operating mechanism cubicle of aluminum or hot-dip galvanized? :
- 59. Is the mechanism trip-free as per IEV 441-16-31? :
- 60. Is the central control cubicle of the operating mechanism equipped with pole discrepancy scheme? :.....
- 61. Tolerances of the supply voltage of the tripping / opening coils :.....
- 62. Is part of the supply the appropriate quantity of SF6 gas for the operation of the circuit breaker ? :.....
- 63. Is the circuit breaker equipped with the suitable fast connection plugs for the interconnection of the poles? :.....
- 64. Are the calculations or relevant test reports requested in parag. VIII.5g submitted with the bid? :.....
- 65. Is each circuit breaker to be delivered packaged in accordance with the paragr. XV of this hereby specification? :.....