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07-1039

# TYPE TEST CERTIFICATE OF TEMPERATURE-RISE PERFORMANCE

| | |
|---|---|
| **OBJECT** | three-phase $SF_6$ gas/porcelain insulated high voltage circuit breaker |
| **TYPE** | 120-SFM-32B |
| **SERIAL No.'s** | X300650 and X300540 |

| | | | |
|---|---|---|---|
| **Rated voltage ($U_m$)** | **145 kV** | **Rated current** | **3150 A** |
| **Rated frequency** | **50 Hz** | | |

| | |
|---|---|
| **MANUFACTURER** | Crompton Greaves Ltd.<br>Nashik, India |
| **CLIENT** | Crompton Greaves Ltd.<br>Nashik, India |
| **TESTED BY** | KEMA HIGH-VOLTAGE LABORATORY<br>Arnhem, the Netherlands |
| **DATES OF TESTS** | 25 until 27 September 2007 |

The apparatus, constructed in accordance with the description, drawings and photographs incorporated in this Certificate, has been subjected to the series of proving tests in accordance with

**IEC 62271-100** clauses **6.4 and 6.5**

This Type Test Certificate of temperature-rise performance has been issued by KEMA following exclusively the STL Guides.

**The results are shown in the record of Proving Tests and the oscillograms attached hereto. The values obtained and the general performance are considered to comply with the above Standard and to justify the ratings assigned by the manufacturer as listed on page 3.**

The Certificate applies only to the objects tested. The responsibility for conformity of any object having the same designations with that tested rests with the Manufacturer.

This Certificate consists of 20 sheets in total.

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KEMA Nederland B.V.

P.G.A. Bus
KEMA T&D Testing Services
Managing Director

Arnhem, 6 December 2007

Order No: 70770161
Version: 1

## TABLE OF CONTENTS

# 1 IDENTIFICATION OF THE TEST OBJECT

## 1.1 Ratings assigned by the manufacturer

| | | |
|---|---|---|
| Rated highest voltage for equipment ($U_m$) | 145 | kV |
| Rated current | 3150 | A |
| Rated frequency | 50 | Hz |

## 1.2 Description of the test objects

| | |
|---|---|
| Manufacturer | Crompton Greaves Ltd., Nashik, India |
| Type | 120-SFM-32B |
| Serial numbers | X300650 (temperature-rise test and measurements of the resistance of the main circuit before and after)<br>X300540 (temperature-rise test of the auxiliary and control circuits) |
| Rated highest voltage for equipment | 145 kV |
| Rated frequency | 50 Hz |
| Rated current | 3150 A |
| Rated insulation level (AC/LI) | 275/650 kV |
| Rated $SF_6$ gas operating pressure | 0,7 MPa (g) at 20 °C |
| Minimum $SF_6$ gas operating pressure | 0,6 MPa (g) at 20 °C |
| Drawing(s) | see appendix B, drawing no. 3942580 and chapter 1.3 |
| Current transformers | not applicable |
| Spring charging motor | KPT, 230 V a.c., 300 W (elec. power) |
| Closing coil | CGL, 110 V d.c., 605 W |
| Opening coil 1 | CGL, 110 V d.c., 637 W |
| Opening coil 2 | CGL, 110 V d.c., 637 W |
| Year of manufacture | 2007 |

## 1.3 List of drawings

The manufacturer has guaranteed that the equipment submitted for tests has been manufactured in accordance with the following drawings.
KEMA has verified that these drawings adequately represent the equipment tested.

The following drawings have been included in this Certificate:

| Drawing No. | Revision | Title |
|---|---|---|
| 3942580 | 0 | General arrangement for 145 kV, 40 kA SP-SP GCB type-120-SFM-32B |
| 4942581 | 0 | Position of temperature sensors |
| 4942584 | 0 | Rating plate details for 145 kV, 40 kA SP-SP GCB type-120-SFM-32B |

The following drawings are only listed for reference and are kept in KEMA's files:

| Drawing No. | Revision | Title |
|---|---|---|
| 3940645 | 3 | Interrupter porcelain (for 31 mm per kV) 145 kV – 40 kA |
| 2940583 | 7 | Support porcelain (A/S) for 72,5/145 kV, SP-SP GCB |
| 4944297 | 1 | Pole unit assembly 145 kV, 40 kA SP-SP SF6 GCB |
| 4942583 | 0 | Mech. hsg detail for 145 kV, 40 kA SP-SP GCB type-120-SFM-32B |
| 4942343 | 1 | General arrangement for 66/145/170 kV.GO.SP-SP GCB |
| EH3-1947-02 | 0 | Schematic diagram for 145kV, 40kA SP-SP GCB type 120-SFM-32B |
| EH3-1947-09 | 2 | Wiring diagram for 145kV, 40kA SP-SP GCB type 120-SFM-32B |

# 2 GENERAL INFORMATION

## 2.1 The tests were witnessed by

| Name | Company |
|---|---|
| Mr S.S. Shete | Senior Manager – Design, Crompton Greaves Ltd. |

## 2.2 The tests were carried out by

| Name | Company |
|---|---|
| Mr. P. Kuijpers<br>Mr. H.J. Arnoldus<br>Mr A.H. Minkhorst | KEMA Nederland B.V.,<br>Arnhem, the Netherlands |

## 2.3 Reference to other reports

| Report no. | Tests described |
|---|---|
| 07-1038 | Type test certificate of dielectric performance |
| 07-1398 | Report of performance for wet lightning impulse voltage withstand tests |
| 2110125.01-QUA/INC | Tests of the degree of protection provided by the enclosure (IP55) |
| 470-07 | Mechanical operation test at ambient temperature (class M1, 2000 operations) |

## 2.4 Purpose of the test

Purpose of the test was to verify whether the material complies with the specified requirements.

## 2.5 Measurement uncertainty

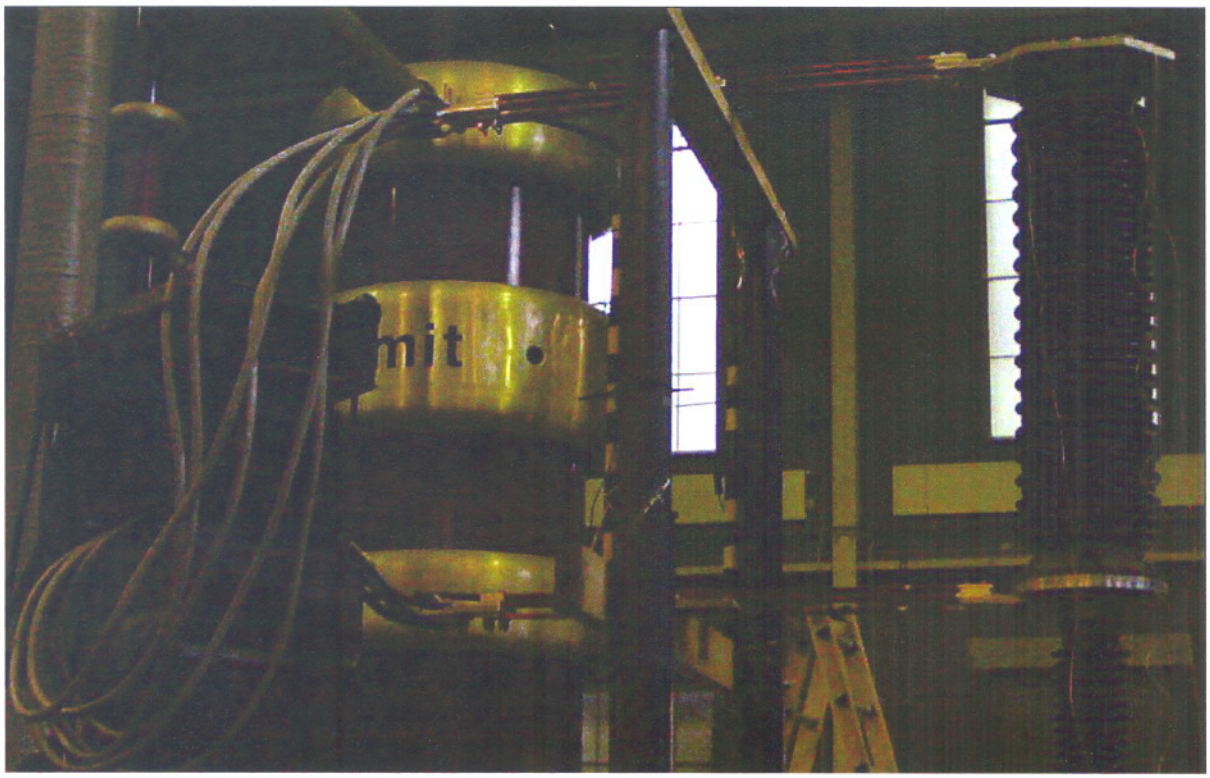
A table with measurement uncertainties is enclosed in appendix A. Unless otherwise indicated in the certificate, the measurement uncertainties of the results presented are as indicated in this table.

## 2.6 Applicable standards

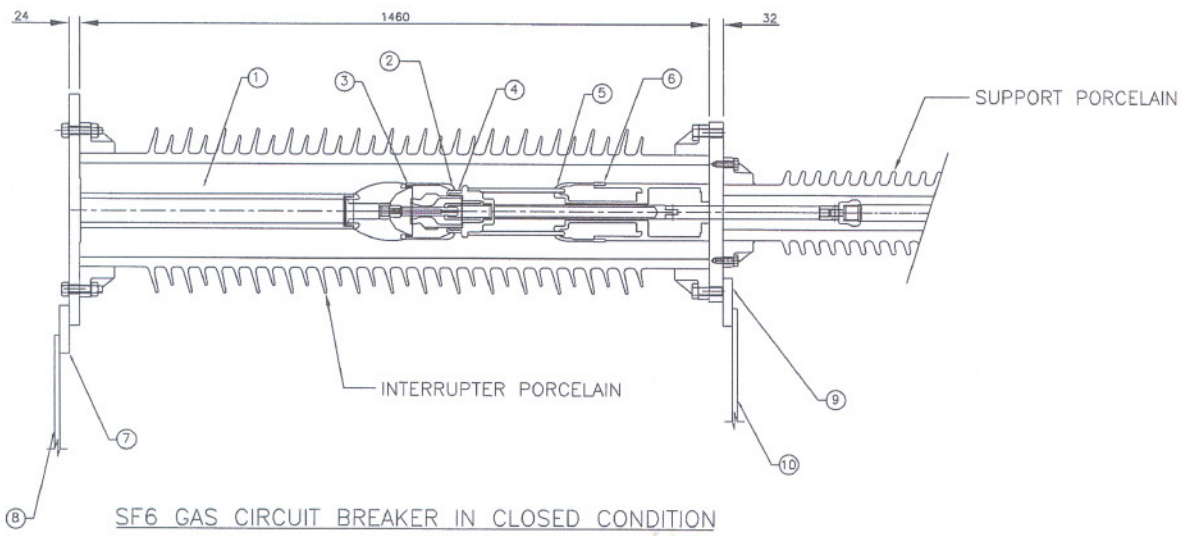
When reference is made to a standard and the date of issue is not stated, this applies to the latest issue, including amendments which have been officially published prior to the date of the tests. Where reference was made in the standard IEC 62271-100 to IEC 60694, it was verified that testing was performed in accordance with both IEC 60694 and the final draft for IEC 62271-1 Ed.1 (17A/799/FDIS), which will cancel and replace IEC 60694 when it will be published in due time.

## 3 GENERAL

For the purpose of the temperature-rise test, one pole of the circuit breaker was assembled by the client on a base frame, which was put on the laboratory floor. The pole was mounted in vertical condition, replicating service conditions.
The current conducting test loop consisted of the circuit breaker and main conductors connected to its terminals. Each of both terminals conducted the full test current. The main conductors consisted of solid copper busbars (3 per terminal) of 75x12 mm (900 $mm^2$ cross-section each) and approximately 1,5 m in length. To the ends of these copper busbars, six insulated cables with flexible, copper conductors with a cross section of 300 $mm^2$ each were connected. These cables were led through an induction transformer, acting as a source, and through a current transformer which was used in combination with an ammeter for current measuring purposes.
The temperatures at various locations inside the circuit breaker were measured by means of thermo-couples of the K type connected to a 30 channel temperature recorder. These thermocouples had been installed inside the circuit breaker pole by the client prior to the test.
The internal thermocouple wiring was brought outside of the circuit breaker compartment by means of specially sealed adapters in order to maintain the $SF_6$ gas pressure inside the compartment during the test. A photograph of the test setup and a drawing of the internal position of the thermocouples inside the circuit breaker are presented on the next page. The thermocouple positions are also shown in the client's drawing no. 4942581, which is included in appendix B of this certificate.
Furthermore, a table is presented with a description of the various measuring points.



Photograph of the test setup during the temperature-rise test




Drawing indicating the position of the various thermocouples in and on the test object

| measuring point | description of measuring point |
|---|---|
| 1 | SF6 gas |
| 2 | stationary main contact tip |
| 3 | stationary main contact base |
| 4 | moving main contact base |
| 5 | fixed finger contact tip |
| 6 | fixed finger contact base |
| 7 | upper terminal pad |
| 8 | temporary connection (upper) – 1 m away from upper terminal |
| 9 | lower terminal pad |
| 10 | temporary connection (lower) – 1 m away from lower terminal |

## 4 MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUIT BEFORE THE TEMPERATURE-RISE TEST

Date of test: 1 October 2007

Before the temperature-rise test was carried out on the test object with serial no. X300650, the d.c. resistance value of the main circuit was determined as a reference in accordance with clause 6.4 of IEC 62271-100. The total resistance of the closed circuit breaker was measured from the upper to the lower flange.
The measurements were performed by injecting a d.c. current of 200 A through the current path and measuring the voltage across the flange locations. For the measurement, the average was taken of three readings.

**Atmospheric conditions**

| | | |
|---|---|---|
| Ambient temperature | 22 | °C |
| Temperature of test object | 22 | °C |

| measurement location | before test (μΩ) | | | average (μΩ) |
|---|---|---|---|---|
| from upper to lower flange | 25 | 28 | 27 | 26,7 |

**Requirement**

No requirements are applicable. The obtained value served as a reference for the measurements after the temperature-rise test.

**Result**

The measurements do not give rise to remarks.

## 5 TEMPERATURE-RISE TEST

The test object with serial no. X300650 was subjected to a temperature-rise test on the main circuit.
The test was carried out in accordance with clause 6.5 of IEC 62271-100.
As mentioned before, the temperature-rise test was performed on a single pole of the circuit breaker.
The test was performed with the circuit breaker filled with $SF_6$ gas at the minimum operating gas pressure of 0,6 MPa (g).
The temperature-rise test was carried out by inducing current into the main circuit as described above under chapter 3.
A current of 3150 A, 50 Hz, was induced into the main circuit by means of the auxiliary cables, led through the induction transformer.
Care was given that no heat transfer to or from the test object was taking place, caused by the feeding circuit or by the auxiliary copper bars. This was done by monitoring the temperature-rise at the terminals of the test object and also at a distance of 1 m from these terminals on the auxiliary copper bars. The difference in temperature-rise between these locations was within 5 K.
The ambient temperature was measured at three locations at a distance of 1 m from the test object and at approximately half its height.
After achieving thermal equilibrium, in accordance with clause 6.5.2 of IEC 60694, the temperature-rise values were determined. For additional information, the temperature of the upper and lower flanges (at the opposite side from the terminal pads) and the temperature on the middle shed of the interrupter porcelain were measured by means of a contact thermometer.
Following this the current was switched off.

**Results of the Temperature-Rise Test**

Date of test: 2 October 2007

**Atmospheric conditions**

Ambient temperature at start of test 22 °C

Temperature of test object at start of test 22 °C

| measuring point | - description of measuring point<br>- classification<br>- material | recorded temperature at thermal equilibrium (°C) | temp. rise (K) | requirement for maximum temp. rise (K) | result |
|---|---|---|---|---|---|
| 1 | - $SF_6$ gas<br>- gas temperature<br>- | 55,6 | 34 | - | ok |
| 2 | - stationary main contact tip<br>- contact in $SF_6$ gas<br>- copper, silver plated | 61,2 | 39 | 65 | passed |
| 3 | - stationary main contact base<br>- contact in $SF_6$ gas<br>- copper, silver plated | 61,6 | 40 | 65 | passed |
| 4 | - moving main contact base<br>- contact in $SF_6$ gas<br>- copper, silver plated | 61,9 | 40 | 65 | passed |
| 5 | - fixed finger contact tip<br>- contact in $SF_6$ gas<br>- copper, silver plated | 54,5 | 33 | 65 | passed |
| 6 | - fixed finger contact base<br>- contact in $SF_6$ gas<br>- copper, silver plated | 57,2 | 35 | 65 | passed |
| 7 | - upper terminal pad<br>- terminal in air<br>- bare aluminium | 55,3 | 33 | 50 | passed |
| 8 | - temporary connection (upper) – 1 m away from terminal<br>- connection bar<br>- bare copper | 56,3 | 34 | -<br>(difference 7 - 8 should be ≤ 5 K) | ok |
| 9 | - lower terminal pad<br>- terminal in air<br>- bare aluminium | 62,0 | 40 | 50 | passed |

**Results of the Temperature-Rise Test** (continued)

| measuring point | - description of measuring point<br>- classification<br>- material | recorded temperature at thermal equilibrium (°C) | temp. rise (K) | requirement for maximum temp. rise (K) | result |
|---|---|---|---|---|---|
| 10 | - temporary connection (lower) – 1 m away from terminal<br>- connection bar<br>- bare copper | 64,2 | 42 | -<br>(difference 9 - 10 should be ≤ 5 K) | ok |
| ambient 1 | - ambient temperature<br>- air temperature<br>- | 21,8 | - | - | - |
| ambient 2 | - ambient temperature<br>- air temperature<br>- | 22,6 | - | - | - |
| ambient 3 | - ambient temperature<br>- air temperature<br>- | 21,4 | - | - | - |
| 11 | - upper flange (opp. from terminal)<br>-<br>- bare aluminium | 47,0 | 25 | for information only | - |
| 12 | - lower flange (opp. from terminal)<br>-<br>- bare aluminium | 47,1 | 25 | for information only | - |
| 13 | - middle shed of interrupter porcelain<br>-<br>- porcelain | 31,0 | 9 | for information only | - |

**Requirements**

The requirements as mentioned in clause 6.5 of IEC 62271-100 and table 3 of IEC 60694.

**Result**

The values for temperature-rise of the various points do not exceed the allowed maximum values.
The test was passed.

## 6 MEASUREMENT OF THE RESISTANCE OF THE MAIN CIRCUIT AFTER THE TEMPERATURE-RISE TEST

Date of test: 2 October 2007

After the temperature-rise test had been carried out on the test object with serial no. X300650 and allowing the configuration to cool down to ambient temperature, the d.c. resistance value of the main circuit was determined again in accordance with clause 6.4 of IEC 62271-100. The total resistance of the closed circuit breaker was measured from the upper to the lower flange. The measurements were performed by injecting a d.c. current of 200 A through the current path and measuring the voltage across the flange locations. For the measurement, the average was taken of three readings.
The results were compared with the measurements taken before the temperature-rise test.

**Atmospheric conditions**

| | | |
|---|---|---|
| Ambient temperature | 22 | °C |
| Temperature of test object | 22 | °C |

| measurement location | after test (μΩ) | | | average (μΩ) | difference between measurement before - after (%) |
|---|---|---|---|---|---|
| from upper to lower flange | 26 | 27 | 26 | 26,3 | - 1,3 |

**Requirement**

The difference between the measured resistance values before and after the temperature-rise test shall not be greater than 20%.

**Result**

The measured values are well within the allowed tolerances. The temperature-rise test was passed.

## 7 TEMPERATURE-RISE TEST OF THE AUXILIARY AND CONTROL EQUIPMENT

The auxiliary and control equipment of the test object with serial no. X300540 was subjected to a temperature-rise test. This unit was assembled by the client in a three-pole configuration for the purpose of a mechanical operations test (see chapter 2.3 for a reference to the report regarding this test). Prior to the mechanical operations test, the temperature-rise test of the auxiliary and control equipment was performed.
The test was carried out in accordance with clause 6.5.5 of IEC 62271-100 and reference is made here to IEC 60694 clause 6.5.5.
The auxiliary equipment was tested at its rated supply voltage. All switching devices were equipped with automatic breaking devices for interruption of the auxiliary circuit at the end of the operation. The circuits were energized 10 times, for either 1 second or until the automatic breaking device operated. The interval between the instant of each energizing was the lowest interval possible between two switching operations of the circuit breaker.
Before and immediately after this test sequence, the d.c. resistance of the internal coils of the equipment was measured.

Date of test: 5 October 2007

**Atmospheric conditions**

| | | |
|---|---|---|
| Ambient temperature | 12 | °C |
| Temperature of test objects (at start of test) | 12 | °C |

| equipment | before test sequence (Ω) | after test sequence (Ω) | calculated temperature-rise (K) |
|---|---|---|---|
| closing coil | 20,11 | 20,42 | 4 |
| trip coil 1 | 19,24 | 19,38 | 2 |
| trip coil 2 | 19,48 | 19,56 | 1 |
| spring charging motor | 14,73 | 15,78 | 18 |

**Requirement**

The requirements are as mentioned in clause 6.5.5 and table 3 of IEC60694.

**Result**

The test was passed.

## APPENDIX A MEASUREMENT UNCERTAINTIES

The measurement uncertainties in the results presented are as specified below unless otherwise indicated.

| measurement | measurement uncertainty |
|---|---|
| dielectric tests<br>and impulse current tests | peak value: ≤ 3%<br>time parameters: ≤ 10% |
| capacitance measurement<br><br>tan δ measurement | 0,3%<br><br>± 0,5% ± $5x10^{-5}$ |
| partial discharge measurement | < 10 pC : 2 pC<br>10 - 100 pC : 5 pC<br>> 100 pC : 20 % |
| measurement of impedance<br>ac-resistance measurement | ≤ 1% |
| measurement of losses | ≤ 1% |
| measurement of insulation resistance | ≤ 10% |
| measurement of dc resistance | 1 μΩ - 5 μΩ : 1%<br>5 μΩ - 10 μΩ : 0,5%<br>10 μΩ - 200 μΩ : 0,2% |
| radio interference test | 2 dB |
| calibration of current transformers | 2,2 x $10^{-4}$ Ii/Iu and 290 μrad |
| calibration of voltage transformers | 1,6 x $10^{-4}$ Ui/Uu en 510 μrad |
| measurement of conductivity | 5% |
| measurement of temperature | -50 °C- -40 °C: 3 K<br>-40 °C- 125 °C : 2 K<br>125 °C - 150 °C : 3 K |
| tensile test | 1% |
| sound level measurement | type 1 meter as per IEC 651 and<br>ANSI S1.4.1971 |
| measurement of voltage ratio | 0,1% |

## APPENDIX B MANUFACTURER'S DRAWINGS

4 pages

| Drawing no. | Description | Date | Rev. |
|---|---|---|---|
| 3942580 | General arrangement for 145 kV, 40 kA SP-SP GCB type-120-SFM-32B | 19-9-2007 | 0 |
| 4942581 | Position of temperature sensors | 18-09-2007 | 0 |
| 4942584 | Rating plate details for 145 kV, 40 kA SP-SP GCB type-120-SFM-32B | 20-09-2007 | 0 |

## APPENDIX B MANUFACTURER'S DRAWINGS

4 pages

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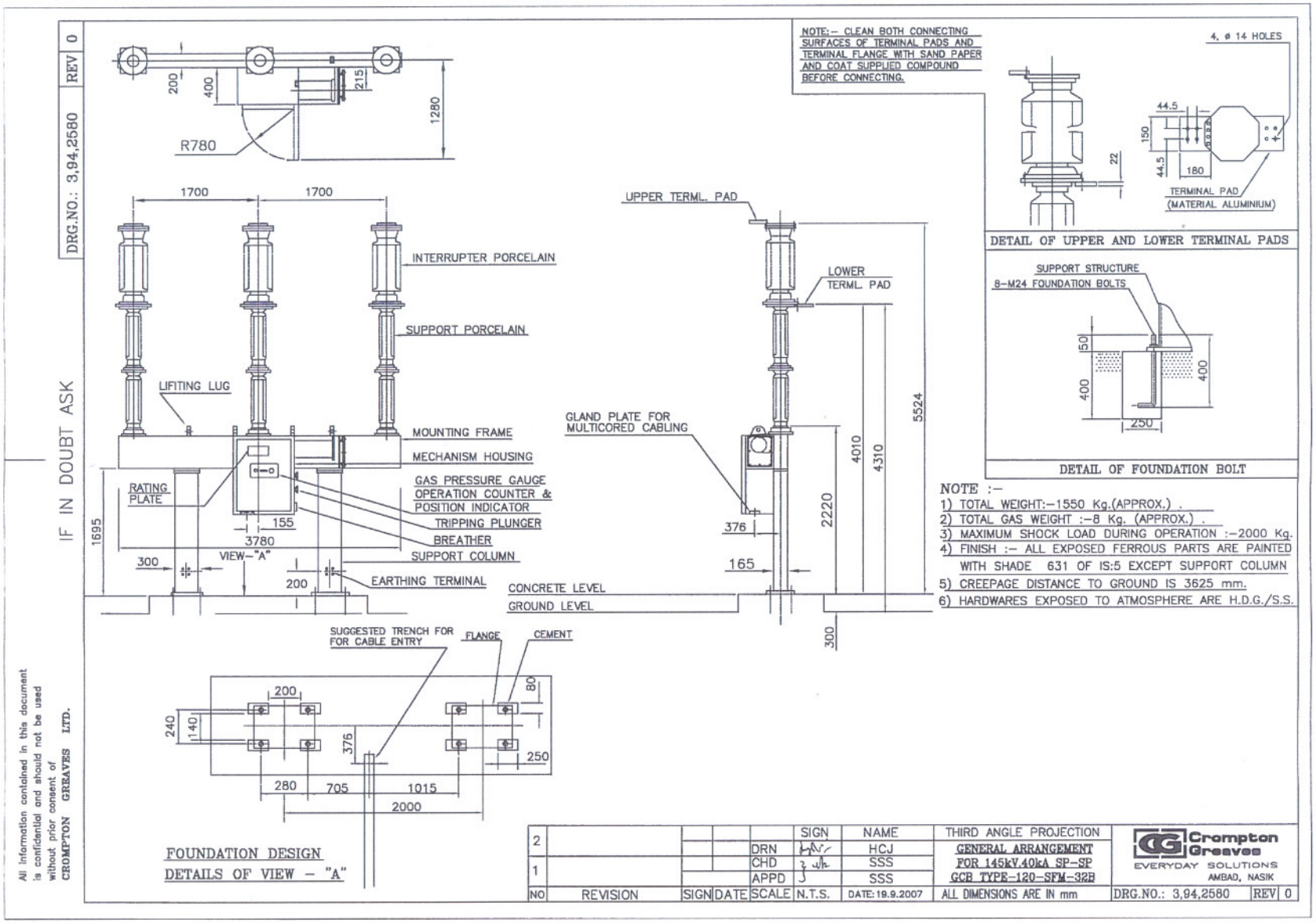
DRG.NO.: 3,94,2580 REV 0
IF IN DOUBT ASK
All information contained in this document is confidential and should not be used without prior consent of CROMPTON GREAVES LTD.
R780
200
400
215
1280
1700
1700
INTERRUPTER PORCELAIN
SUPPORT PORCELAIN
LIFITING LUG
MOUNTING FRAME
MECHANISM HOUSING
RATING PLATE
GAS PRESSURE GAUGE
OPERATION COUNTER &
POSITION INDICATOR
TRIPPING PLUNGER
BREATHER
SUPPORT COLUMN
EARTHING TERMINAL
1695
155
3780
300
VIEW–"A"
200
UPPER TERML. PAD
LOWER TERML. PAD
GLAND PLATE FOR MULTICORED CABLING
5524
4010
4310
2220
376
165
CONCRETE LEVEL
GROUND LEVEL
300
SUGGESTED TRENCH FOR FOR CABLE ENTRY
FLANGE
CEMENT
200
80
240
140
375
250
280
705
1015
2000
FOUNDATION DESIGN
DETAILS OF VIEW – "A"
NOTE:– CLEAN BOTH CONNECTING SURFACES OF TERMINAL PADS AND TERMINAL FLANGE WITH SAND PAPER AND COAT SUPPLIED COMPOUND BEFORE CONNECTING.
4, ø 14 HOLES
22
44.5
150
44.5
180
TERMINAL PAD
(MATERIAL ALUMINIUM)
DETAIL OF UPPER AND LOWER TERMINAL PADS
SUPPORT STRUCTURE
8–M24 FOUNDATION BOLTS
50
400
400
250
DETAIL OF FOUNDATION BOLT
NOTE :–
1) TOTAL WEIGHT:–1550 Kg.(APPROX.) .
2) TOTAL GAS WEIGHT :–8 Kg. (APPROX.) .
3) MAXIMUM SHOCK LOAD DURING OPERATION :–2000 Kg.
4) FINISH :– ALL EXPOSED FERROUS PARTS ARE PAINTED WITH SHADE 631 OF IS:5 EXCEPT SUPPORT COLUMN
5) CREEPAGE DISTANCE TO GROUND IS 3625 mm.
6) HARDWARES EXPOSED TO ATMOSPHERE ARE H.D.G./S.S.
NO REVISION SIGN DATE SCALE N.T.S.
2
1
DRN HCJ
CHD SSS
APPD SSS
DATE: 19.9.2007
THIRD ANGLE PROJECTION
GENERAL ARRANGEMENT FOR 145kV,40kA SP–SP GCB TYPE–120–SFM–32B
ALL DIMENSIONS ARE IN mm
Crompton Greaves
EVERYDAY SOLUTIONS
AMBAD, NASIK
DRG.NO.: 3,94,2580 REV 0

USED ON :– 145kV, 40kA SF6 GCB

DRG. NO:– 4,94,2581 R0

IF IN DOUBT ASK

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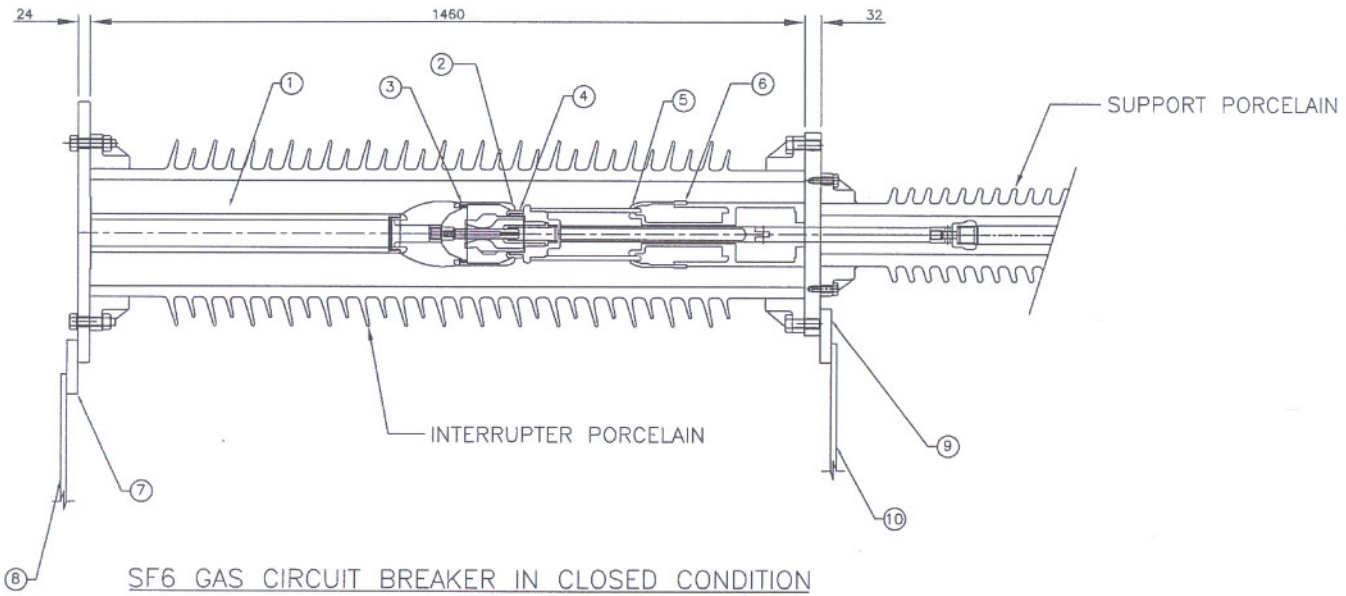
| ITEM | DESCRIPTION OF TEMPERATURE SENSORS |
|---|---|
| 1 | SF6 GAS |
| 2 | STATIONARY MAIN CONTACT TIP |
| 3 | STATIONARY MAIN CONTACT BASE |
| 4 | MOVING MAIN CONTACT BASE |
| 5 | FIXED FINGER CONTACT TIP |
| 6 | FIXED FINGER CONTACT BASE |
| 7 | UPPER TERMINAL PAD |
| 8 | TEMPORARY CONNECTION (UPPER) – 1 MTR. AWAY |
| 9 | LOWER TERMINAL PAD |
| 10 | TEMPORARY CONNECTION (LOWER) – 1 MTR. AWAY |




SF6 GAS CIRCUIT BREAKER IN CLOSED CONDITION

| NO | REVISION | SIGN | DATE |
|---|---|---|---|
| 4 | | | |
| 3 | | | |
| 2 | | | |
| 1 | | | |

| | SIGN | NAME |
|---|---|---|
| DRN | | HCJ |
| CHD | | SSS |
| APPD | | SSS |
| DATE | 18.09.07 | |

POSITION OF TEMPERATURE SENSORS (145 kV,40 kA SP–SP GCB)

Crompton Greaves
EVERYDAY SOLUTIONS
AMBAD, NASIK

ALL DIMENSIONS ARE IN mm

DRG.NO.: 4,94,2581 R0

DRG.NO.:4,94,2584 REV 0

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Crompton Greaves

EVERYDAY SOLUTIONS

# GAS CIRCUIT BREAKER

| | |
|---|---|
| TYPE 120–SFM–32B | SR. NO. : YEAR 2007 |
| RATED VOLTAGE 145 kV | RATED FREQUENCY 50 Hz |
| RATED NORMAL CURRENT 3150 A | RATED MAKING CAPACITY 100 kAp |
| RATED SHORT CIRCUIT BREAKING CURRENT 40 kA | RATED SHORT TIME CURRENT 40 kA FOR 3 SECONDS |
| RATED LIGHTNING IMPULSE WITHSTAND VOLTAGE 650 kVp | FIRST POLE TO CLEAR FACTOR 1.5 |
| | RAT.OPR.SEQ. O–0.3SEC–CO–3MIN–CO |
| RATED SF6 GAS PRESSURE 7 kg/cm$^2$–g(AT 20°C) | GAS WT 8 Kg / TOTAL WT. 1550 Kg |
| RATED COIL VOLTAGE – CLOSING 110 V DC ,TRIPPING 110 V DC | |
| MOTOR VOLTAGE 230 V AC | AUX CIRCUIT VOLTAGE 1ø,230V AC,50 Hz |

MATERIAL: STAINLESS STEEL 0.5THK

| NO | REVISION | SIGN | DATE |
|---|---|---|---|
| 2 | | | |
| 1 | | | |

| | SIGN. | NAME |
|---|---|---|
| DRN | | HCJ |
| CHD | | SSS |
| APPD | | SSS |
| SCALE | N.T.S. | DATE 20.09.07 |

THIRD ANGLE PROJECTION

RATING PLATE DETAILS FOR 145kV,40kA SP–SP GCB TYPE–120–SFM–32B

ALL DIMENSIONS ARE IN mm

Crompton Greaves EVERYDAY SOLUTIONS AMBAD, NASHIK

DRG.NO.:4,94,2584 REV 0

KEMA