TESTS LABORATORY MANUAL OF POWER TRANSFORMERS

(MLETP/01)
INTRODUCTION

Welcome to the Tests Laboratory of Asea Brown Boveri, S.A. Zaragoza. At the moment we want you to meet like your company and we are prepared for the doubts and explanations which you need.

We present this Manual which objective is to aid you for understanding our organization and the tests service.

The Test Laboratory of Asea Brown Boveri has a Quality System accredited by ENAC (National Company of Accreditation and Certification) according to UNE-EN ISO/IEC 17.025 standard, which improve every days the tests service, to satisfy customers and to assure the Quality Management System constituted by the Company Register certificate according to UNE-EN-ISO 9001 and the Environmental certificate which satisfies UNE-EN-ISO 14001 and Regulation CE 761/2001 (EMAS).

We want invite you to state yours complaints and we will be responsible in the organization for achieving the solutions and the elimination of the problems.

Thanks for the confidence puts in our product and we want your staying in Asea Brown Boveri,-Zaragoza be the start point of friendship and collaborations to improve in the near future.
1. QUALITY POLICY ........................................................................................................ 4
2. ORGANIZATION CHART............................................................................................ 5
3. RESPONSABILITIES .................................................................................................... 6
   3.1 Tests Laboratory Technician Manager
   3.2 Tests Laboratory Manager
   3.3 Test Analysts
4. STATEMENT OF INDEPENDENCE, IMPARTIALITY AND INTEGRITY .................. 8
5. TEST TYPES AND CAPACITY .................................................................................. 9
   5.1 Routine Tests
   5.2 Type Tests
   5.3 Special Tests
6. MAIN TESTS INSTALLATIONS ............................................................................... 10
   6.1 Installation I
   6.2 Installation II
7. AMBIENT CONDITIONS FOR THE TESTS EXECUTION ...................................... 12
8. QUALITY SYSTEM SCHEME .................................................................................... 13
9. CERTIFICATES Y ACREDITATES .......................................................................... 14
   9.1 Logos of Quality, Environmental and Tests Certificate.
   9.2 European Accreditation of Laboratories
   9.3 Certificates UNE-EN ISO 9001, UNE-EN ISO 14001 & UNE-EN ISO/IEC 17.025
   9.4 Product certifications
10. GUIDELINES ........................................................................................................... 25
11. DOCUMENTATION AVAILABLE OF QUALITY MANAGEMENT SYSTEM..... 27
12. TEST RECORDS ....................................................................................................... 28
1. QUALITY POLICY

(TEST-ROOM)

The Quality Policy of Asea Brown Boveri, S.A. is our customers’ whole satisfaction.

The strategy in the Quality Department and the final tests laboratory in order to carry out this main objective is:

- To train all the personnel as an appropriate technical capacity for assuring our necessities is assured.
- To have available the appropriate advanced technology equipment that allow us to rise a suitable level of reliability and prestige in front our customers.
- To hold the hard purpose of the company guaranteeing the tests quality, according to the Standards UNE-EN-IEC and other international standards.
- To maintain, facilitate and guarantee the “open doors” of our installations for the customers as they can carry out the appropriate inspection and verification jobs with total impartiality, integrity and clarity.
- To watch over and set an example in the operative Standards, customer’s specifications and the Standards UNE-EN ISO 9001 and UNE-EN ISO 14001, Regulation 761/2001 (EMAS) betting on the continuous improvement and having the perfection as the objective.
- Comply with the Standard UNE-EN ISO/IEC 17.025
- Take part actively in the intercomparison test between the ABB laboratories and between these ones and other laboratories accredited by ENAC.

(General Manager)
Asea Brown Boveri, S.A.
Distribution Transformers
2. ORGANIZATION CHART

(QUALITY AND ENVIRONMENTAL DEPARTMENT)
3. RESPONSIBILITIES DEFINITION IN TESTS LABORATORY

3.1 QUALITY MANAGER

- The Quality Manager is the maximum responsible for the laboratory operation and the representative of this one in the presence of Quality Manager.

3.2 LABORATORY TECHNICAL MANAGER

- Laboratory Technical Manager is directly under the Quality Manager and this one, in turn, on the General Manager.
- He is the maximum responsible for the laboratory maintenance and the representative for the General Management.
- He planes the human, technical and administrative resources according to Quality Manager.
- He is the representative of Laboratory in the presence of customer, registration and accreditation companies.
- He planes and manages the internal audits and checks Tests Laboratory Quality System.
- He is the person in charge for the continuous formation in test subjects.
- He is the maximum responsible of introduction and maintenance of Standard UNE-EN ISO/IEC 17.025 and your accreditation by ENAC.
- In case of his absence he delegates the technical function of this manual to Tests Laboratory Manager with which coordinates the activities of Tests Laboratory.

3.3 TEST ROOM MANAGER

He is responsible of the following duties:

- To confirm the tests protocol and to report the Quality Manager the tests results.
- To plan and execute the receptions with the customers.
- To maintain the calibration plan up to date.
- To plan the tests according to the delivery times requested by the customers.
- To maintain the compliance of the Standard UNE-EN ISO/IEC 17.025
- To check the tests procedures and methods as well as their results.
- To assist in tests analysts training.
- In case of his absence, he delegates the technical duties above mentioned to the technical manager of the laboratory.
3.4 TESTS ANALYSTS

They are responsible of the following duties:

- To prepare the transformers for the tests
- To carry out the tests according to the Standards and test procedures defined.
- To fill in the test protocols, signing in the appropriate box.
- To maintain and keep the devices and equipments destined to the tests.
- To inform about the Non-conformities in the product to the test room Manager.
- To inform about the Anomalies in devices and installations to the Laboratory Manager.
- To clean and keep the devices, equipments, control rooms and the places destined for the tests
- To carry out the Quality, Security and Environmental principles, as well as the Standard UNE-EN ISO/IEC 17.025.
- To assist in new test analysts training
4. STATEMENT OF INDEPENDENCE, IMPARTIALITY AND INTEGRITY OF THE TESTS PERSONNEL

The General Manager of Asea Brown Boveri S.A. Zaragoza declares and certifies in the name of the juridical entity that he represents, that the Quality Department Personnel and the test laboratories are totally independent from other departments of the factory.

This personnel, as the organisation charts show depends directly on the Quality Department and this one depends on the General Management.

The General Management of Asea Brown Boveri S.A., by means of the application of the Quality Assurance Basic Principles, separates this department from the pressures sales, financial and others that can influence on the technical judgement of the test results.

Likewise, it is guaranteed that no member of the Quality Department takes part in activities beyond his department that could endanger the impartiality, independence and integrity of them.

(General Manager)
Asea Brown Boveri, S.A.
Distribution Transformers
5. TESTS TYPES AND TEST LABORATORY CAPACITY

The test laboratory of Asea Brown Boveri, S.A., Zaragoza, is fitted and equipped to carry out final tests based on the Standards IEC, UNE, EN, ANSI and IEEE applicable, until an insulation level of 145 kV in power transformers of until 40 MVA. The tests this laboratory is able to carry out are the following:

5.1 ROUTINE TESTS

- Voltage ratio measurement and check of phase displacement.
- Separate source voltage-withstand test
- Induced over voltage withstand test
- Partial discharges measurements
- No load loss and current measurement
- Measurements of windings resistances
- Load loss and short circuit impedance measurements

5.2 TYPE TESTS

- Temperature rise test
- Lightening impulse test
- Sound level measurement

5.3 SPECIAL TESTS

- Measurement of insulation resistance
- Measurement of zero-sequence impedance
- Measurement of the harmonics of the no-load current
- Measurement of the dissipation factor, tag $\delta$.
- Anti-corrosion protection test
6. MAIN TESTS INSTALLATIONS

6.1 INSTALLATION I (Automated Test Laboratory)

- INSTALLATION FOR INDUSTRIAL FREQUENCY INSULATION TESTS OF 100 kV / 10-20 KVA. (MWB).
- INDUCED VOLTAGE TESTS INSTALLATION 133 Hz
- PARTIAL DISCHARGES MEASUREMENT INSTALLATION. ROBINSON TRADEMARK 100 kV PHASE-EARTH, WITH DETECTOR DDX-9101 TETTEX.
- INSTALLATION FOR THE NO LOAD AND SHORT-CIRCUIT LOSSES MEASUREMENT 50 Hz AND 60 Hz WITH POWER ANALYSER ZIMMER LMG 450.
- TEMPERATURE MEASUREMENT WITH AGILENT AND PT100 PROBES OF 4 WIRES
- VOLTAGE RATIO MEASUREMENT DEVICES TETTEX TYPE 2795.
- DIGITAL RESISTANCES TESTER TETTEX TYPE 2291.
- HARMONIC ANALYSER FLUKE 41.
- INSULATION METER BAKER DS212 PORTABLE.
- ISSUE OF ROUTINE TEST PROTOCOL BY COMPUTER
- CONTROL AND MEASURE OF THE TEST IN AN AUTOMATICAL WAY.

6.2 INSTALLATION II

- LIGHTENING IMPULSE INSTALLATION OF 1000 KV – 30 KJ HAEFELY WITH ANALOGIC OSCILOGRAPH.
- LIGHTENING IMPULSE INSTALLATION OF 300 KV – 7,5 kJ – MWB WITH DIGITAL REGISTER TR-AS 100-10 (Dr. STRAUSS)
- 2 INSTALLATIONS OF INDUSTRIAL FREQUENCY TEST (MWB) OF 100 KV AND HAEFELY OF 300 KV WITH MEASUREMENT OF VOLTAGE WITH DIGITAL VOLTMETERS.
- INDUCED VOLTAGE TEST INSTALLATION 150 Hz.
- PARTIAL DISCHARGES EQUIPMENT, HIPOTRONICS 50 KV PHASE-EARTH WITH A DIGITAL DETECTOR, TYPE DDX-9101.
- PARTIAL DISCHARGES MEASUREMENT INSTALLATION. MPS OF 150 KV PHASE-EARTH, WITH DETECTOR DIGITAL TMG.
- 3 INSTALLATIONS FOR THE NO LOAD MEASUREMENT AND HEATING TEST 50Hz AND 60Hz WITH POWER ANALYSER NORMA D5255T / AV POWER PA 4400 A / ZIMMER LMG 6450.
- 3 WINDING RESISTANCES MEASUREMENT INSTALLATIONS WITH DIRECT CURRENT SUPPLY 18V/20 A & 18v/50 A WITH FLUKE 45 MULTIMETERS, AS HOW DIGITAL MICROMETER OF 50A RAYTECH.
- VOLTAGE RATIO MEASUREMENT DEVICES TYPE TR-MARK/TREX OF RAYTECH.
- INSULATION METERS 5000/10000V KYORITSU AND FLUKE 4450. PORTABLE.
- HEATING TEST INSTALLATION UNTIL 20000 KVA AND 145 KV (50 AND 60 Hz) TEMPERATURES CONTROL WITH DIGITAL REGISTER AGILENT AND PH100 PROBES. LOAD CONTROL WITH POWER ANALYSER NORMA DS255T AND RESISTANCE MEASUREMENT WITH FLUKE 45 MULTIMETERS.

- SOUND LEVEL AND VIBRATIONS MEASUREMENT INSTALLATION WITH DIGITAL SOUND-LEVEL METER BRÜEL KJÆER.
- SOUND INTENSITY MEASUREMENT EQUIPMENT TYPE PULSE OF BRÜEL KJÆER.
- DIGITAL HARMONICS ANALYSER WITH OSCILOGRAPHIC SCREEN CHAUVIN ARNOUX CA8332. PORTABLE.
- EQUIPMENT FOR THE CAPACITY AND TAG $\delta$ MEASUREMENT (SCHERING BRIDGE), PATTERN 2000 V. PORTABLE.
- ISSUE OF ROUTINE TEST PROTOCOL, LIGHTNING IMPULSE TEST, NOISE LEVEL MEASUREMENT AND TEMPERATURE RISE TEST BY COMPUTER.
7. AMBIENT CONDITIONS FOR THE TESTS EXECUTION

The general prescriptions that determine the ambient conditions for the tests execution, are based in the Standards UNE EN 60076, EN 60076-11, CEI 60076-1 and CEI60076-11, and they are detailed as follows:

- Tests are made at any ambient temperature between 10°C and 40 ºC
- Dielectric tests are made with the transformer at approximately ambient temperature.
- All external components and fittings that are likely to affect the performance during the test are in place.
- The transformer is clean, without dust or other waste.
- The transformer is completely finished, with the enclosure in case it has one.
- Those transformers with two different voltages or provided with tap changers, will be connected to the main voltage unless another connection is specified in the corresponding test chapter or agreed between the manufacturer and the customer.
- The tests results are refereed to a temperature of 120ºC (dry)/75ºC (oil).
- All devices and equipments that take part in the tests execution are subjected to the calibration plan developed by the Quality System implanted in Asea Brown Boveri, according to the standard UNE-EN-ISO 9001 AND UNE-EN ISO/IEC 17.025
- The tests are carried out according to internal procedures and applicable standards.

7.1 TRANSMITTED AND/OR RADIATE DISTURBANCES

The installation, devices and equipments elements which are electromagnetic disturbances transmitters are connected to the mains supply, by means of filters that avoid its propagation and influence in the measurement devices of the tests laboratory, avoiding impurities and harmonics in the waveform used for the tests supply.
8. QUALITY SYSTEM SCHEME

The Quality System is applied to the management, working and tests of the final tests laboratory of Asea Brown Boveri, S.A.

The Quality System is based on the Standard UNE-EN ISO/IEC 17.025.

Our Quality System is written and developed in several documents whose distribution and control is described in the Quality Manual of the tests laboratory and it’s detailed as follows:
9. CERTIFICATES Y ACCREDITATION

9.1 SYMBOLS OF QUALITY, ENVIRONMENTAL AND TESTS CERTIFICATE.

The Asea Brown Boveri, S.A. Company has the Company Register Certificate N°: ER-0046/1/95 by AENOR, which guarantees that our Quality Assurance System satisfies standard UNE-EN-ISO 9001.

AENOR is the register accredited by ENAC and member of IQNet NETWORK (The International Certification Network).

The Asea Brown Boveri, S.A. Company has the Environmental Certificate N°: 023/MA/07/00 of ECA which guarantees that Environmental System satisfies standards UNE-EN-ISO 14001. Also it is adhered to CE regulation 761/2001 (EMAS).

ECA is the register accredited by ENAC.

The tests laboratory of Asea Brown Boveri, S.A. has the accreditations for making routine and type tests on power electric transformers, indicated to the Certificate N°: 262 / LE 591.

The Certification Body is the National Company of Accreditation and Certification (ENAC) signatory of multilateral agreement of mutual recognition established by EA (European Accreditation) in accreditation subject of test and calibration laboratories.
9.2 EUROPEAN ACCREDITATION OF LABORATORIES.

Every member of the EU and EFTA has a national body (or bodies) responsible for a different type of accreditation. Accreditation means:

**Formal recognition by an authoritative body that an organisation is competent**

European cooperation for Accreditation (EA) is an organisation of the national organisations of all the EU / EFTA Member countries that accredit calibration and / or testing laboratories.

The national accreditation bodies evaluate each other at frequent intervals, to ensure that they are all operating correctly to international standards.

National accreditation bodies meeting these criteria can become signatories to the appropriate multilateral agreement (MLA).

In addition, EA has entered into mutual recognition agreements (MRA) with some national accreditation bodies in non-European countries. Certificates and reports issued by bodies accredited by MLA and MRA members are considered to have the same degree of credibility, and are accepted in MLA and MRA countries.

Accredited certificates and reports can be identified because they carry the logo of the accreditation body.

This international acceptance of certificates and reports helps international business by removing barriers to trade.
AUSTRALIE - Australia
National Association of Testing Authorities
7 Leeds Street, Rhodes
NSW 2138 Australia
Tel.: +61 29 736 8222 - Fax: +61 29 743 5311

HONG KONG
HKAS
36/F, Immigration Tower
7 Gloucester Road WANCHAI
Tel.: +852 28 29 4830 - Fax: +852 28 24 13 02

NOUVELLE ZELANDE - New Zealand
International Accreditation New Zealand
630 Great South Road - Greenlane
Auckland 1136
Tel.: +64 9 525 6655 - Fax: +64 9 525 2266

AFRIQUE DU SUD - South Africa
National Laboratory Accreditation Service
P.O. Box 914 2142
Wingate Park - 0153 Pretoria
South Africa
Tel.: +27 12 349 1267 - Fax: +27 12 349 1249

ETATS-UNIS - United States of America
American Association for Laboratory Accreditation
5301 Buckeystown Pike
Suite 350
Frederick, MD21704-8307
United States of America
Tel.: +1 301 644 3212 - Fax: +1 301 662 2974

SINGAPOUR - Singapore
Singapore Accreditation Council
Nº 1 Science Centre Road
SINGAPORE 69077
Tel.: +65 826 3000 - Fax: +65 822 8326

BRESIL - BRAZIL
Inmetro
Rua Santa Alexandrina,
416-90 andar-Rio Comprido
CEP 20261-232
Rio de Janeiro
BRAZIL
Tel.: +55 21 502 6531 - Fax: +55 21 502 6542
9.3 CERTIFICATES UNE-EN ISO 9001, UNE-EN ISO14001 AND (UNE-EN ISO/IEC 17.025)

Registered Firm Certificate: UNE-EN ISO 9001

AENOR Asociación Española de Normalización y Certificación

CERTIFICADO DE REGISTRO DE EMPRESA
REGISTERED FIRM CERTIFICATE
ER-0046/1995

La Asociación Española de Normalización y Certificación (AENOR) certifica que el Sistema de Gestión de la Calidad adoptado por ASEA BROWN BOVERI, S.A. (Transformadores de Distribución) para el diseño, la producción, el servicio, la venta y la reparación de transformadores de distribución y potencia, transformadores de dirección de aceite, transformadores de corriente, transformadores secos, así como otros transformadores especiales, como monofásicos, autotransformadores, trifásicos y reactantes de puesta a tierra.

The design, production, selling and repairing of distribution and power transformers, isolated oil transformers, dry type transformers, single phase transformers, such as monophase, auto transformers, three phase, three phase current transformers, and electromagnetic couplers, which are carried out on or from the establishment.


El presente Certificado es válido solo cuando el servicio o servicio no se suspenda o se interrumpa o no se retome a tiempo por AENOR. The Certificate is valid unless it is suspended, cancelled or withdrawn upon AENOR'S written notification.

Cualquier adición adicional relativa al alcance de este certificado como a la aplicabilidad de los requisitos de la norma ISO 9001:2000 puede obtenerse consultando a la organización. Further clarifications regarding the scope of this certificate and the applicability of ISO 9001: 2000 requirements may be obtained by consulting the organization.

Fecha de emisión: 1995-02-21 Fecha de renovación: 2005-03-01
Issued on: 1995-02-21 Revised on: 2005-03-01

AENOR es miembro de la RED IGNet (Red Internacional de Certificación), cuya misión es operar de acuerdo con la norma europea EN 45013. AENOR es a member of the Effo NETWORK (The International Certification Network), which is a member of which operates in accordance with the EN 45013 standard.
Quality Management System Certificate: ISO 9001
Enviromental Management System Certificate: UNE-EN-ISO 14001

ECA CERT, CERTIFICATION, S.A.

Certificates that the environmental management system of the company

ASEA BROWN BOVERI, S.A.

applied to its activities of:

DESING, PRODUCTION AND MAINTENANCE OF ELECTRICAL TRANSFORMERS,

undertaken in the centres
linked to the corresponding contract

conforms to the environmental management regulation
UNE-EN-ISO 14001-04

Certificate nº 073/MA/07/00
Date of application: 14 September 2005
Expiry date: 14 September 2008
Date Issued: 14 September 2005

The General Manager

Virgili Saez Domingo

This certificate is valid without the corresponding contract
(This document is a copy of the original certificate)
Any additional clarifications relative to the implications or the application of the requirements of the regulation can be obtained by contacting the organisation
Organisation of Environmental management Systems accredited by ENAC with accreditation nº 05/MA 003
ENAC is a signatory of the Multilateral Agreement of the IAF (International Accreditation Forum, Inc)
Accreditation Certificate Tests Laboratory: (UNE-EN ISO/IEC 17.025)

Elaboration: ASEA BROWN BOVERI, S.A.

According to the criteria in UNE-EN ISO/IEC 17.025 for the performance of Test of Power transformers as defined in the attached Technical Annex.

Accreditation n°: 262/LE391

Date de entrada en vigor: 09/03/2001

La acreditación mantiene su vigencia hasta notificación en contrario.

En Madrid, a 23 de Noviembre de 2005

El Presidente

[Signature]

Ref: TUE284 La presente documentación sustituye al de ref. TUE1754 por cambio de identidad legal.
**ENAC certification appendix**

Accreditation n\° 262/LE661
Technical Annex 5
Date 1/6/2006
Page 1 de 1

---

(1) The present document is a translation of the Scope of Accreditation n\° 262/LE661, Rev. 6. “Power Transformers”. In case of dispute, the valid is the Spanish version.

**SCOPE OF ACCREDITATION**

**ASEA BROWN BOVERI, S.A.**

Address: Ctra. de Madrid, km. 314, 50012 Zaragoza

Is accredited by the **ENTIDAD NACIONAL DE ACREDITACIÓN**, according to the criteria collected in Standards UNE-EN ISO/IEC 17025: 2005 (CGA-ENAC-LEC), for the performance of the following tests:

**Power Transformers**

Category 0 (Test in the permanent laboratory)

<table>
<thead>
<tr>
<th>PRODUCT/MATERIAL TO TEST</th>
<th>TEST</th>
<th>TEST METHOD</th>
</tr>
</thead>
</table>
| Transformers, auto transformers and reactances three-phase and single-phase of dry type or oil-immersed until 40000 kVA and nominal voltage 145 kV | Measurement of winding resistance               | UNE-EN 60076-1:1998 Cap. 10.2  
IEC 60076-1:1993 Cap. 10.2  
IEC 60076-1/A1:1999 |
|                          | Measurement of voltage ratio and check of phase displacement | UNE-EN 60076-1:1998 Cap. 10.3  
IEC 60076-1:1993 Cap. 10.3  
IEC 60076-1/A1:1999 |
|                          | Measurement of short-circuit impedance and load loss       | UNE-EN 60076-1:1998 Cap. 10.4  
IEC 60076-1:1993 Cap. 10.4  
IEC 60076-1/A1:1999 |
|                          | Measurement of no-load loss and current                 | UNE-EN 60076-1:1998 Cap. 10.5  
IEC 60076-1:1993 Cap. 10.5  
IEC 60076-1/A1:1999 |
|                          | Temperature-rise test (oil transformer)                | UNE-EN 60076-3:2002 Cap. 11  
IEC 60076-3:2000 Cap. 11 |
|                          | Separate source AC withstand voltage test          | UNE-EN 60076-3:2002 Cap. 12  
IEC 60076-3:2000 Cap. 12 |
|                          | Induced AC voltage tests                           | UNE-EN 60076-3:2002 Cap. 12  
IEC 60076-3:2000 Cap. 12 |
|                          | Lightning impulse test                             | UNE-EN 60076-3:2002 Cap. 13-14  
IEC 60076-3:2000 Cap. 13-14 |
|                          | Sound levels tests                                  | UNE-EN 60076-10:2002  
IEC 60076-10:2001 |
|                          | Partial discharge measurement                      | EN 60076-11:2004 Cap. 22  
IEC 60076-11:2004 Cap. 22 |
|                          | Temperature-rise test                              | EN 60076-11:2004 Cap. 22  
IEC 60076-11:2004 Cap. 22 |

The present technical annex is subject to possible modifications. The validity status of the accreditation can be confirmed at the ENAC Web (http://www.enac.es)
9.4. PRODUCT CERTIFICATIONS OBTAINED.

The following product certificates have been obtained by Asea Brown Boveri, S.A (Zaragoza):

- The class C1 "Climatic" certificate in accordance with CENELEC-HD S1 1988/A2:1991 Appendix ZB.2 obtained in ABB Trafo BB GmbH on 29.03.94, test no.: KI 715 W 009.

- The class F1 "Burning Behaviour" certificate obtained in homologated tests in accordance with CENELEC-HD 464 S1/A3 (November 1992), dated 07.07.97 in the laboratory of C.E.S.I. test number: BC-97/022127.

- The class E2 "Condensation and humidity" certificate, in accordance with CENELEC-HD 464 S1:1988/A2:1991, Appendix ZA.2.2A obtained in ABB Trafo BB GmbH on 29.03.94 test no.: KI 715 W 009.

- Suitability to endure short-circuits according to IEC 60076-5 obtained in C.E.S.I. on 01.03.01, certificate no.: MP-A1/006927.

- The class C2 "Climatic" certificate in accordance with CENELEC HD464 S1:1988/A2:1991, obtained in LGAI on 29.03.01, Certificate no.: 20020462.

- Test Certificate of seismic qualification made by VIRLAB, S.A. with no. 210971, dated on 25.09.01.

- Vibration test Certificate made by VIRLAB, S.A. with no. 221001, dated on 18.06.02.


- Suitability to endure short-circuits according to IEC 60076-5 certified by LABEIN dated on 08.10.04, Certificate no. B125-04-BM-EE-01.

- The class C2 "Climatic" certificate in accordance with EN 60726:2003 Anexo ZB3 method 1, obtained in APPLUS on 29.11.04, Certificate no.: 4039843.

- Vibration test Certificate made by VIRLAB, S.A. with no. 241154, dated on 14.02.05.

- Vibration test Certificate made by VIRLAB, S.A. with no. 251175, dated on 19.09.05.
Suitability to endure short-circuits according to IEC 60076-5 certified by LABEIN dated on 09.01.06. Certificate no. B125-06-AD-EE-01.
### 10. GUIDELINES

**GUIDELINES CONNECTED WITH TRANSFORMERS TESTS**

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>SUBJECT OR TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNE-EN-ISO 9001</td>
<td>Quality System</td>
</tr>
<tr>
<td>UNE-EN ISO/IEC 17.025</td>
<td>Tests Laboratory Quality Management System</td>
</tr>
<tr>
<td>GUIA ISO/CEI - 25</td>
<td></td>
</tr>
<tr>
<td>UNE-EN-ISO 14001</td>
<td>Environmental System</td>
</tr>
<tr>
<td>EC Regulation n° 761/2001, EMAS</td>
<td></td>
</tr>
<tr>
<td>RU 5207-B</td>
<td>UNESA Recommendation</td>
</tr>
<tr>
<td>UNE-EN 60076-1</td>
<td>Measurement of windings resistances</td>
</tr>
<tr>
<td>CEI 60076-1</td>
<td>Voltage ratio measurement</td>
</tr>
<tr>
<td>CENELEC HD 398-1</td>
<td>No load losses and current</td>
</tr>
<tr>
<td></td>
<td>Load loss and short circuit impedance measurements</td>
</tr>
<tr>
<td></td>
<td>Measurement of zero-sequence impedance</td>
</tr>
<tr>
<td>UNE EN 60076-3</td>
<td>Induced voltage</td>
</tr>
<tr>
<td>CEI 60076-3</td>
<td>Voltage withstand</td>
</tr>
<tr>
<td>CENELEC HD 398-3</td>
<td></td>
</tr>
<tr>
<td>EN 60076-11</td>
<td>Partial discharges</td>
</tr>
<tr>
<td>UNE EN 60076-3</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-3</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-11</td>
<td></td>
</tr>
<tr>
<td>CEI 60270</td>
<td></td>
</tr>
<tr>
<td>CENELEC HD 464</td>
<td></td>
</tr>
<tr>
<td>EN 60076-11</td>
<td>Lightning impulse</td>
</tr>
<tr>
<td>UNE EN 60076-3</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-3</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-11</td>
<td></td>
</tr>
<tr>
<td>CENELEC HD 398-3</td>
<td></td>
</tr>
</tbody>
</table>
## GUIDELINES CONNECTED WITH TRANSFORMERS TESTS

<table>
<thead>
<tr>
<th>STANDARD</th>
<th>SUBJECT OR TEST</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNE-EN 60076-2</td>
<td>Temperature rise</td>
</tr>
<tr>
<td>CEI 60076-2</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-11</td>
<td></td>
</tr>
<tr>
<td>EN 60076-11</td>
<td></td>
</tr>
<tr>
<td>CENELEC HD 464</td>
<td></td>
</tr>
<tr>
<td>UNE-EN 60551</td>
<td>Sound level</td>
</tr>
<tr>
<td>UNE 21538</td>
<td>Transformers manufacture</td>
</tr>
<tr>
<td>EN 60076-11</td>
<td></td>
</tr>
<tr>
<td>CEI 60076-11</td>
<td></td>
</tr>
<tr>
<td>CENELEC HD 538 (HD 538.1S1 /HD538.1S1-A1/ HD538.2S1)</td>
<td></td>
</tr>
<tr>
<td>IEEE Std. C57.12.91</td>
<td>Other test standards</td>
</tr>
<tr>
<td>IEEE Std. C57.12.01</td>
<td></td>
</tr>
<tr>
<td>CSA Std. C9-M1981</td>
<td></td>
</tr>
</tbody>
</table>
11. DOCUMENTATION AVAILABLE OF QUALITY MANAGEMENT SYSTEM.

Diagram of the documentation available for the customers in the Quality and Environmental Department.
12. TEST RECORDS

Test Records
# INDEX OF TESTS PROCEDURES

## ROUTINE TESTS

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Pag.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 623.001/R 30</td>
<td>Voltage ratio measurement and check of phase displacement.</td>
</tr>
<tr>
<td>E 623.002/R 31</td>
<td>Separate source voltage—withstand test</td>
</tr>
<tr>
<td>E 623.003/R 32</td>
<td>Induced over voltage withstand test</td>
</tr>
<tr>
<td>E 623.004/R 33</td>
<td>Partial discharges measurements in dry—type transformers</td>
</tr>
<tr>
<td>E 623.005/R 34</td>
<td>No load loss and current measurements</td>
</tr>
<tr>
<td>E 623.006/R 35</td>
<td>Measurements of windings resistances</td>
</tr>
<tr>
<td>E 623.007/R 36</td>
<td>Load loss and short—circuit impedance measurements</td>
</tr>
</tbody>
</table>

## TYPE TESTS

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Pag.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 623.008/R 37</td>
<td>Temperature rise test</td>
</tr>
<tr>
<td>E 623.009/F 38</td>
<td>Lightning impulse test</td>
</tr>
<tr>
<td>E 623.010/F 39</td>
<td>Sound level measurement</td>
</tr>
</tbody>
</table>

## SPECIAL TESTS

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Pag.</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 623.011/R 40</td>
<td>Measurements of insulation resistance</td>
</tr>
<tr>
<td>E 623.012/R 41</td>
<td>Measurements of zero—sequence impedance</td>
</tr>
<tr>
<td>E 623.013/R 42</td>
<td>Measurements of the harmonics of the no—load current</td>
</tr>
<tr>
<td>E 623.014/R 43</td>
<td>Measurements of the dissipation factor, ( \delta ), of the insulation resistance capacitances</td>
</tr>
<tr>
<td>E 623.016/R 44</td>
<td>Anti—corrosion protection test</td>
</tr>
</tbody>
</table>

**NOTE:** Accredited Tests by **ENAC** are identifies by the letter **E**
DENOMINATION:
TRANSFORMATION RATIO MEASUREMENT AND CONNECTION CHECKING

SIMPLIFIED SCHEME:

See tables in the procedure nº 623.001

EQUIPMENT AND TEST APPARATUS:
- BAUR VMG 50 oscillograph
- Three-phase ratio measuring instrument (TETTEX)
- Three-phase ratio measuring instrument (UM1B UNITRONICS)
- Three-phase ratio measuring instrument type TR-MARK (RAYTECH)
- Three-phase ratio measuring instrument type TREX (RAYTECH)

TEST PURPOSE:
Measure the transformation ratio (relation between the primary and secondary turns) and check the connection unit for which the transformer has been designed.
The equipment is connected as indications and tables given by the manufacturer.

STANDARDS AND PROCEDURES APPLICABLES:
- UNE EN 60.076-1
- CEI 60.076-1
- CENELEC HD 398-1
- Test procedure nº 623.001

EVALUATION:
Tolerance (the lower of the following values): A) 0,5% of the specific ratio
B) 1/10 of the impedance voltage, as a %
Not applicable to autotransformers nor to LV/LV transformers.
DENOMINATION:

SEPARATE SOURCE VOLTAGE-WITHSTAND TEST

SIMPLIFIED SCHEME:

V: Operation and control module
E: Step-up transformer
D: Voltage divisor
U: Digital peak voltmeter with value $\hat{U}/\sqrt{2}$ y $U_{\text{eff}}$

TEST PURPOSE:

To check the insulation between the different windings and between the windings and the earth.
The test will last 1 minute and the windings not being tested and the metallic elements must be earthed.

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60076-3
- CEI 60076-3
- CENELEC HD 398-3
- Test procedure nº 623.002

EVALUATION:

The transformer should withstand the voltage applied for 1 minute as the standards. See table of the section “Evaluation” of the test procedure nº 623.002.
The test is satisfactory when there is no sudden drop of the test voltage during the test.
DENOMINATION:

INDUCED OVER VOLTAGE WITHSTAND TEST

SIMPLIFIED SCHEME:

M-G: Rotative converter
A: Control ammeters
E: Step-up transformer
T:T: Class 0.2, voltage measurement transformer
U: Digital measurement voltmeter
R: serial-parallel reactances (connect if it’s necessary)

EQUIPMENT AND TEST APPARATUS:

TEST PURPOSE:

To check the insulation between windings and between the sections of a winding, and to check the insulation between windings and earth in not uniform insulate transformer.

The test time is: \( t = \frac{120f_n}{f_e} \) sec. \( f_n \): rated frequency; \( f_e \): test frequency.

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60076-3
- CEI 60.076-3
- CENELEC HD 398-3
- Test procedure nº 623.003

EVALUATION:

For the duration of the test, the transformer should withstand a phase voltage equal to twice the suitable voltage.

The test is considered satisfactory when neither dramatic variations are observed in the intensity absorbed by the transformer nor sudden drops in the test voltage.
DENOMINATION:

PARTIAL DISCHARGES MEASUREMENTS IN DRY-TYPE TRANSFORMERS

SIMPLIFIED SCHEME:

![Simplified Scheme Diagram]

T: TEST OBJECT

EQUIPMENT AND TEST APPARATUS:

- M-G: rotative converter
- F₁ and F₂: Filters in LV and in MV
- E: Step-up transformer.
- T.T.: Class 0,2 voltage measurement transformer
- U: digital measurement voltmeter
- C: coupling capacitor
- U.S.: Secondary measurement units
- D: partial discharge detector

TEST PURPOSE:

To ensure that the internal insulation of a transformer is free of air or gas bubbles or that the discharges that occur in them are under a specified value.

The test voltage is the following:                                           (Ur: Rated frequency)
1st Increase to 1,8 Ur between HV phases- Maintain 30 seconds and observe
2nd Decrease to 1,3 Ur between HV phases - Maintain 3 minutes and measure

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60076-3
- CEI-60270
- CEI 60076-3
- EN 60076-11
- CEI 60076-11
- CENELEC HD 464
- Test procedure no. 623.004

EVALUATION:

The maximum value of partial discharges expressed in pC (unit of apparent charge), is 10 pC or according to the agreement between the customer and Asea Brown Boveri.
DENOMINATION:

NO LOAD LOSS AND CURRENT MEASUREMENTS

SIMPLIFIED SCHEME:

\[ 50 \text{ Hz} \]

\[ 60 \text{ Hz} / 50\text{Hz} \]

M: MAINS

G: \(\Phi\)

T: TEST OBJECT

E: Step-up transformer

T.I.: Class 0,2 current measurement transformers

T.T.: Class 0,2 voltage measurement transformers

N: Digital power analyser > class 0,2

EQUIPMENT AND TEST APPARATUS:

- M-G: Rotative converter
- V: Regulating transformer
- E: Step-up transformer
- T.I.: Class 0,2 current measurement transformers
- T.T.: Class 0,2 voltage measurement transformers
- N: Digital power analyser > class 0,2

TEST PURPOSE:

To determine the value of the losses in the transformer’s magnetic circuit as well as the intensity of the exciting current, feeding with the rated voltage and frequency, by the LV or HV and keeping opened the HV or LV.

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60.076-1
- CEI 60076-1
- CENELEC HD 398-1
- Test procedure nº 623.005

EVALUATION:

Tolerances:
Iron losses: limit \(W_o + 15\%W_o\), when the offered total losses \(W_T\) are \(< W_T + 10\%W_T\), or according to the agreement between the customer and Asea Brown Boveri.
No load current 30% increase of the specified No-Load.
DENOMINATION:
MEASUREMENTS OF WINDINGS RESISTANCES

SIMPLIFIED SCHEME:

\[ \text{T: TEST OBJET} \quad \text{IS: value of the current of Shunt} \]

\[ \text{RT} = \frac{U_2 \cdot 150}{U_1 \cdot \text{Is}} \quad (\Omega) \]

EQUIPMENT AND TEST APPARATUS:
- F.A.: d.c. power supply
- S: Current measurement Shunts.
- RL: Limiting resistance
- U₁: Voltage measurement in Shunt
- U₂: Voltage measurement at test object’s terminals
- t: Temperature measurement probe (°C)

TEST PURPOSE:
To measure the ohmic resistance of the windings of the transformer. This value will be applied to calculate ohmic losses and additional losses by calculating the difference between the load measured and the ohmic losses calculated.

STANDARDS AND PROCEDURES APPLICABLES:
- UNE EN 60.076-1
- CEI 60076-1
- CENELEC HD 398-1
- Test procedure nº 623.006

EVALUATION:
The ohmic losses value is limited by the load guaranteed losses. See test record nº 623.007/F.
DENOMINATION:
LOAD LOSS AND SHORT-CIRCUIT IMPEDANCE MEASUREMENTS

SIMPLIFIED SCHEME:

\[ \begin{align*}
&\text{50 Hz MAINS} \\
&\text{50 Hz} \\
&\text{M-G: Rotative converter} \\
&\text{V: Regulating transformer} \\
&\text{E: Step-up transformer} \\
&\text{T.I.: Class 0,2 current measurement transformers} \\
&\text{T.T.: Class 0,2 voltage measurement transformers} \\
&\text{N: Digital power analyser > class 0,2}
\end{align*} \]

TEST PURPOSE:
To determine the value of the losses which occur in the windings (load losses) and the impedance voltage when the rated current flows through the windings, feeding normally by the HV and short-circuiting the LV.

STANDARDS AND PROCEDURES APPLICABLES:
- UNE EN 60.076-1
- CEI 60076-1
- CENELEC HD 398-1
- Test procedure nº 623.007

EVALUATION:
Tolerances:
Load losses at 120ºC or to the reference temperature: limit \( W_c + 15\% W_c \), when the offered total losses (\( W_T \)) are \( W_T + 10\% W_T \), or according to the agreement between the customer and Asea Brown Boveri.
Impedance voltage referred to the principal tapping and 120ºC or to the reference temperature \( \pm 10\% \) of the offered.
DENOMINATION:
TEMPERATURE RISE TEST

SIMPLIFIED SCHEME:

EQUIPMENT AND TEST APPARATUS:

M-G: Rotative converter
V: Regulating transformer
E: Step-up transformer
T.: Test object
C: Capacitors (connect if it is necessary)
T.I.: Class 0,2 current measurement transformers
T.T.: Class 0,2 voltage measurement transformers
N: Digital power analyser>class 0,2
D:C::Power supply
S: Shunts
U1-U2: Digital multimeters
PT100: Thermoresistance / °C analogic thermometers
HP: Data acquisition unit HP (20 channels)

TEST PURPOSE:
To determine the temperature that the transformer will reach in real working conditions when supplied with the rated power.

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60.076-2 and UNE 20178
- CEI 60.076 and CEI 60.076 parts 1&2
- EN 60076-11
- CEI 60076-11
- CENELEC HD 464
- Test procedure nº 623.008-623.008/A-623.008/B

EVALUATION:
The medium heating in the winding must be lower than 100K (F class)(dry-type) and 60/65 heating sup. Oil/medium winding in oil case or according to the agreement between the customer and Asea Brown Boveri.
**DENOMINATION:**

LIGHTENING IMPULSE TEST

**SIMPLIFIED SCHEME:**

![Simplified Scheme Diagram]

**EQUIPMENT AND TEST APPARATUS:**

- V: Regulating transformer
- R: DC rectifier
- G: Impulse generator
- S: Shunts of appropriate resistance
- D: Capacitive voltage divisor
- O/SM: Analogical oscilograph /Digital System
- U: Digital impulse voltmeter.
- C: Chopping gap (lightning impulse chopped)

**TEST PURPOSE:**

To deduce the behaviour of transformer when it is subjected to over voltage in the form of a standard wave similar to those produced in lines as a result of atmospheric discharges.

- Standard wave: 1,2 ± 30% / 50 ± 20% (µ sec)
- Impulses per phase: 1 to 50% and 3 to 100%
- No-tested windings and metallic parts will be earthed through the shunt S.

**STANDARDS AND PRECEDURES APPLICABLES:**

- EN 60076-11
- CEI 60076-11
- UNE EN 60076-3
- CEI 60.076-3
- CENELEC HD 398-3
- Test procedure nº 623.009

**EVALUATION:**

The transformer should resist the test voltage, according to the list given in the section “Evaluation” of the test procedure nº623.009 or according to the agreement between the customer and Asea Brown Boveri.

In dry-type transformers, the impulse test can give rise to partial capacitive discharges in the air, which does not mean that the insulation is damaged. Said discharges has as a result the modification of the current wave whilst the voltage wave only varies very slightly or it isn’t at all.
DENOMINATION:
SOUND LEVEL MEASUREMENT

SIMPLIFIED SCHEME:

EQUIPMENT AND TEST APPARATUS:
- V: Regulating transformer
- E: Step-up transformer
- T.T: 0.2 class voltage measurement transformers
- U: Digital voltimeter
- S: Digital sound-level meter as per DIN and UNE 21314
- Sound level calibrator
- Sound level measuring equipment accessories

TEST PURPOSE:
To measure the level of noise emitted by the transformer’s magnetic core.
The transformer is fed with its no load rated voltage and frequency. The sound level is measured at the 4 transformer’s faces, at half-height and at a distance of 0.3 or 1 m.

STANDARDS AND PROCEDURES APPLICABLES:
- UNE EN 60076-10
- IEC 60076-10
- UNE 21.538-1
- Tests procedures nº 623.010 and 623.010/A

EVALUATION:
The acoustic power measurement will be the indicated in the table of the test procedure nº623.010 and 623.010/A or according to the agreement between the customer and Asea Brown Boveri.
DENOMINATION:

MEASUREMENT OF INSULATION RESISTANCE

SIMPLIFIED SCHEME:

![Simplified Scheme]

T: TEST OBJECT

EQUIPMENT AND TEST APPARATUS:

M.A.: Insulation measuring instrument

TEST PURPOSE:

To determine the insulation resistance expressed in MΩ. (Room temperature)

Three readings should be taken: HV/Earth and HV/LV, at the room temperature, being its metallic parts earthed. The test voltage value should be 5000v and the application time should be 1 minute.

In dry-type transformers the test voltage value should be 2000v in low voltage part.

STANDARDS AND PROCEDURES APPLICABLES:

- Test procedure nº 623.011

EVALUATION:

The insulation resistance measuring should be higher than 1 MΩ per KV in H.V./L.V. and H.V./Earth, and 2 MΩ per KV in L.V./Earth for dry type transformers.
DENOMINATION:

MEASUREMENT OF ZERO-SEQUENCE IMPEDANCE

SIMPLIFIED SCHEME:

![Simplified Scheme Diagram]

EQUIPMENT AND TEST APPARATUS:

- M-G: Rotative converter
- V: Regulating transformer
- E: Step-up transformer
- T.I.: Class 0,2 current measurement transformers
- T.T.: Class 0,2 voltage measurement transformers
- N: Digital power analyser

TEST PURPOSE:

To determine the zero-sequence impedance of a three-phase neutral reactor or of a three-phase transformer.

The test is carried out by applying, between the three united phases and neutral, a single-phase voltage at the rated frequency.

The value of $Z_0 = \frac{V}{I_f}$

STANDARDS AND PROCEDURES APPLICABLES:

- UNE EN 60.076-1
- CEI 60076-1
- Test procedure nº 623.012

EVALUATION:

The value of the zero-sequence impedance expressed in ohms per phase at the rated frequency will be that agreed by the customer and Asea Brown Boveri.

The acceptable tolerance in the reactors will be that expressed in the standard: +20% of the agreed value and –0%.
**DENOMINATION:**

MEASUREMENT OF THE HARMONICS OF THE NO-LOAD CURRENT

**SIMPLIFIED SCHEME:**

![Electrical Circuit Diagram]

T: TEST OBJECT

**EQUIPMENT AND TEST APPARATUS:**

- M-G: rotative converter
- V: regulating transformer
- E: Step-up transformer
- T.I.: class 0,2 current measurement transformers
- T.T.: class 0,2 voltage measurement transformers
- N: Digital power analyser
- A: Harmonics analyser
- P: Current probe.

**TEST PURPOSE:**

To measure the harmonics of the no-load current which are produced as a result of the non-linear magnetic characteristic of transformers.

The transformer is fed by one of its windings, with its rated voltage and frequency, keeping the other one no-loaded.

**STANDARDS AND PROCEDURES APPLICABLES:**

- Test procedure nº 623.013

**EVALUATION:**

Revised: Test Chief
Approved: Quality Manager
DENOMINATION:
MEASUREMENT OF PARALLEL CAPACITY AND TAG $\delta$

SIMPLIFIED SCHEME:

![Diagram](image)

EQUIPMENT AND TEST APPARATUS:

- V: Operation control module (Regulating transformer)
- E: Step-up transformer
- D: Capacitor voltage divisor
- U: Digital measurement voltmeter
- CP: 100pF 2000 v. pattern capacitor
- PS: Schering bridge
- CN-CX-E: Connection terminals in Schering bridge

TEST PURPOSE:
To determine the insulation ageing rate by controlling its tag $\delta$.
The measuring will be carried out with 1500 v. In each case.

STANDARDS AND PROCEDURES APPLICABLES:

- Test procedure nº 623.014

EVALUATION:
See section 7 “Evaluation” of the test procedure nº 623.014
DENOMINATION:
ANTI-CORROSION PROTECTION TEST

SIMPLIFIED SCHEME:

No applicable.

EQUIPMENT AND TEST APPARATUS:

- QUANIX 4500 thickness measuring instrument
- QUANIX thickness measuring instrument
- S/DIN 53151, ISO2409 AND ASTM D3359 INTA Scorer (2mm gap between blades)

TEST PURPOSE:

To check if the transformer’s enclosure and metallic parts are painted correctly. According to this, the thickness and the painting adherence or galvanized, and its aspect, should be checked with the indicated apparatus.

STANDARDS AND PROCEDURES APPLICABLES:

- ISO 2808 and ISO 2409
- Test procedure nº 623.016
- Supplier production procedure
- Production procedure nº614.014-613.022-613.023

EVALUATION:

Average thickness ($E_m$)-higher than 70 micra (no single reading will be lower than 50 ) or according to the agreement between the customer and Asea Brown Boveri.

Adherence.- Grade 1 when $E_m < 120$ micra

        Grade 4ª S/ASTM 3359 (method A) when $E_m>125$ micra

Aspect.- Smooth, glossy and of a uniform colour, without imperfections ( peelings, granulating, marks, puckering, etc…)

Galvanized—See procedure nº 614.014
Dear customer:
The Customer's Complaints Book is at your disposal in order to express your complaints with respect to the tests laboratory.
Please use your right
A COMPLAINT IS A PRESENT!