A high voltage cable connection (1) for a high voltage device containing insulating liquid comprises a voltage grading shield (8), improving performance and facilitating manufacturing.
before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments

Published:
— with international search report
HIGH VOLTAGE CABLE CONNECTION

FIELD OF INVENTION

The present invention relates generally to high voltage cable connection for connection of a high voltage cable to a high voltage oil immersed device containing insulating liquid.

BACKGROUND

It is known that oil immersed high voltage devices normally connected to the cable system by cable terminations to air and an oil to air bushing on the device or with an oil insulated cable box and a rather complicated cable to oil interface. On lower voltage also rubber/epoxy/oil interfaces or even simpler is used.

High voltage electrical equipment and devices, such as high voltage transformers, are usually equipped with bushings, which are suitable to carry current at high potential through a grounded barrier, e.g. a transformer tank or a wall.

The present invention seeks to provide a high voltage cable connection which has good dielectric and thermal properties, which contains few parts and is easily adapted to different applications.

SUMMARY OF THE INVENTION

According to an aspect of the invention, there is provided a cable connection as specified in claim 1.
The invention is based on the realization that a cable connection with a grounded shielding tube instead of an oil insulated cable box and complicated oil interface can be used in applications wherein part of the device is submerged in oil. This is the case in, for example, in connections to transformers, which are submerged in transformer oil in a transformer tank.

With the inventive cable connection, several advantages are obtained. By using a shielding tube, the cable connection can be made completely dry, i.e., it contains no oil. Also, it has been shown that the electric field pattern in the cable connection is almost identical for both AC and DC applications, making the connection device suitable for both AC and DC.

In a preferred embodiment, an insulating gas, such as SF6 or N2 or mixtures thereof, is used as insulating medium inside the part of the cable connection that is connected to the high voltage device. This provides good thermal properties due to the insulating gas and the open design allowing the gas to circulate inside the cable connection.

The invention makes it possible to use a conventional GIS cable termination. An advantage is that a completely dry arrangement can be made with very few parts in a compact design.

All grounded parts can be made as one part if the detail design shows that this is advantageous. The design will on the device side work similar in both DC and AC applications, this due to the material
relations (between SF6, epoxy, oil) for both permeability and resistivity are similar.

Further embodiments are defined in the dependent claims.

5

BRIEF DESCRIPTION OF DRAWINGS

The invention is now described, by way of example, with reference to the accompanying drawing, in which the sole Fig. 1 is a sectional view of a high voltage cable connection mounted to a high voltage device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the following a detailed description of a preferred embodiment of the present invention will be given. In this description, the term "high voltage" will be used for voltages of 50 kv and higher. Today, the upper limit in commercial high voltage devices is 800 kV but even higher voltages, such as 1000 kV or more, are built or envisaged in the near future.

Also, in this description the term "voltage grading shield" should be read to exclude condenser cores conventionally found in bushings arranged to be submerged in insulating liquid.

Reference is now being made to the figure.

The connection device, generally designated 1, comprises a high voltage conductor 2 that extends through the center of a hollow gas filled cable connection insulator
4a, 4b that forms a housing around the high voltage conductor. The cable connection has two sides, a first side or air side outside the high voltage device to which the cable connection is mounted, and a second side or transformer side submerged in an insulating liquid in the high voltage device to which the cable connection is fitted, in the present example a transformer, generally-designated 20. The transformer contains insulating liquid 22, such as transformer oil, which is enclosed by a tank, designated 24.

The air side of the transformer cable connection is mainly consisting of the high voltage conductor 2 and an air side insulator 4a separating the gas inside the cable connection from the surrounding air. Further, the transformer side of the cable connection is separated from the oil 22 in the transformer by a transformer side insulator 4b.

The insulator, which is preferably made of a composite material, such as epoxy, but could also be made of porcelain, thus comprises two portions: an air side insulator 4a on the air side of the cable connection and a transformer side insulator 4b on the transformer side of the cable connection.

A flange 6 is provided to electrically connect the housing of the cable connection to ground through the tank 24 of the transformer 20.

A so-called throat shield or voltage grading shield in the form of a concentric grounded tube 8 is provided inside the hollow cable connection insulator 4a, 4b around the portion of the cable connection going into the
This shield 8, which is made of a suitable conductive material, such as aluminum, accomplishes grading of the electrical field in the connection device and is used instead of a condenser core. The voltage grading shield 8 is surrounded by the insulating gas, such as SF6 or N2 or mixtures thereof, which is provided in the space 10a inside of the air side insulator 4a and the space 10b inside of the transformer side insulator 4b. It is preferred that these two spaces 10a, 10b are in communication with each other to provide circulation of the insulating gas, thereby improving cooling of the transformer side of the cable connection 1.

In DC applications, the inside of the transformer side insulator 4b, i.e., the surface of the transformer side insulator facing the insulation gas inside the insulator, may be covered with a dielectric material (not shown) with a relatively low resistivity, such as silicone rubber, composite material or varnish. Since the resistivity of silicone rubber is almost of the same order of magnitude as that of the oil inside the transformer, improved electric field distribution is obtained. This layer minimizes internal radial field stresses in the transformer side insulator 4b separating the gas in the cable connection 1 from the oil 22 in the transformer 20 and provides a smooth grading of the potential along the transformer side insulator 4b between the high voltage and the grounded flange 6 and increases thereby the dielectric strength of the insulator 4b.

Optimal performance is obtained by a geometrical design of the transformer side insulator 4b. In the preferred embodiment, the transformer side insulator has an essentially frusto-conical shape. This could be
supplemented by the thickness of the coating on the inside of the connection device or the thickness of the insulator 4b housing. In order to further improve the performance, the thickness of the coating can vary along the transformer side of cable connection.

A shielding ring 12 provided at the end of the transformer side of the cable connection and a corresponding barrier system 26 in the transformer connection can further enhance the performance.

In both AC and DC applications, in order to achieve a smooth grading of the potential along the transformer side insulator 4b between the high voltage and the grounded flange, the geometry of the transformer side insulator 4b is optimized. Also, in DC applications the geometry of the barrier system 26 in the transformer is taken into account when optimizing the cable connection.

A preferred embodiment of a high voltage cable connection and a high voltage device according to the invention has been described. A person skilled in the art realizes that these could be varied within the scope of the appended claims. Thus, although the high voltage device to which the inventive high voltage cable connection is attached has been described as a transformer, it will be appreciated that this could be other devices containing insulating liquid, such as reactors or breakers.

The inventive cable connection has been described as an air-oil connection device, i.e., wherein the first side of the connection device is surrounded by air outside a transformer, for example. It is realized that this first
side can be provided in other environments, such as in gas in a gas-oil connection device.

The transformer 20 has been described with a barrier 26. It is realized that this barrier is optional.
CLAIMS

1. A high voltage cable connection for connection of a high voltage cable (200) to a high voltage oil immersed device containing insulating liquid, the high voltage cable connection (1) comprising: a cable termination (201), a hollow insulator housing comprising a first side insulator (4a) arranged to be provided outside of the high voltage device and a second side insulator (4b) arranged to be submerged in the insulating liquid of the high voltage device, and a high voltage conductor (2) provided in the hollow insulator housing; characterized by that the cable termination (210) is arranged in the housing (4a) and a voltage grading shield (8) provided between the high voltage conductor and the insulator housing and that the voltage grading shield (8) is a concentric grounded tube.

2. The high voltage cable connection according to claim 1, wherein the voltage grading shield (8) is made of a conductive material such as aluminum.

3. The high voltage cable connection according to any of claims 1-2, comprising a flange (6) arranged to electrically connect the housing of the connection device to ground.

4. The high voltage cable connection according to any of claims 1-3, comprising an insulating gas, such as SF6 or N2 or mixtures thereof, inside the hollow
insulator housing (4a, 4b) and surrounding the voltage grading shield (8) and the cable termination (201).

5 The high voltage cable connection according to claim 4, wherein a space (10a) inside of the first side insulator (4a) and a space (10b) inside of the second side insulator (4b) are in communication with each other.

6 The high voltage cable connection according to any of claims 1-5, comprising a layer of dielectric material with a relatively low resistivity provided on the inner surface of the second side insulator (4b).

7 The high voltage cable connection according to claim 6, wherein the layer of dielectric material comprises any of silicon rubber, composite material or varnish.

8 The high voltage cable connection according to any of claims 1-7, wherein the second side insulator (4b) has essentially frusto-conical shape.

9 The high voltage cable connection according to any of claims 1-8, wherein the second side insulator (4b) comprises an insulating material, such as a composite material or porcelain.

10 The high voltage cable connection according to any of claims 1-9, wherein the first side insulator (4a) is arranged to be surrounded by any of the following: air, oil, and gas.
**INTERNATIONAL SEARCH REPORT**

**International application No**

PCT/EP2008/057355

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. H02G15/22 H01F27/04 H01B17/42

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H02G H01F H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>US 6 951 987 B1 (HANSEN PEDER M [US] ET AL) 4 October 2005 (2005-10-04) column 1, line 6 - column 2, line 5 column 2, line 56 - column 4, line 29; figures 1,2</td>
<td>1-10</td>
</tr>
<tr>
<td>Y</td>
<td>US 2 790 842 A (NICOLAS JAMES H) 30 April 1957 (1957-04-30) the whole document</td>
<td>1-10</td>
</tr>
<tr>
<td>A</td>
<td>US 4 584 429 A (RAKETTI RAYMOND [US] ET AL) 22 April 1986 (1986-04-22) column 5, line 53 - column 8, line 38; figure 1</td>
<td>1-10</td>
</tr>
<tr>
<td>A</td>
<td>US 4 159 401 A (KAMATA ISAO [JP]) 26 June 1979 (1979-06-26) the whole document</td>
<td>1-10</td>
</tr>
</tbody>
</table>

**X** Further documents are listed in the continuation of Box C

**X** See patent family annex

* Special categories of cited documents

'Y' later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

'X' document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

'Y' document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

'A' document member of the same patent family

Date of the actual completion of the international search: 27 October 2008

Date of mailing of the international search report: 06/11/2008

Name and mailing address of the ISA/

European Patent Office
P B 5818 Patentlaan 2
NL-2280 HV RUSSEL
Tel (+31-70) 340-2040
Fax (+31-70) 340-3016

Authorized officer

Hermann, Robert
**INTERNATIONAL SEARCH REPORT**

**DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document with indication where appropriate of the relevant passages</th>
<th>Relevant to claim No</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EP 1 577 904 A (ABB RESEARCH LTD [CH]) 21 September 2005 (2005-09-21) paragraphs [0002] - [0007], [0022], [0023]; figure I</td>
<td>1-10</td>
</tr>
<tr>
<td>P5A</td>
<td>WO 2007/078237 A (ABB TECHNOLOGY LTD [CH]; HARTINGS RALF [SE]; JACOBSON BJOERN [SE]; HEY) 12 July 2007-(2007-07-12) the whole document</td>
<td>1-10</td>
</tr>
</tbody>
</table>

Forri PCT/ISA/210 (continuation of second sheet) (April 2005)
<table>
<thead>
<tr>
<th>Patent document cited in search report</th>
<th>Publication date</th>
<th>Patent family member(s)</th>
<th>Publication date</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 6951987 B1</td>
<td>04-10-2005</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 2790842 A</td>
<td>30-04-1957</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td>US 4159401 A</td>
<td>26-06-1979</td>
<td>NONE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EP 1966806 A1</td>
<td>10-09-2008</td>
</tr>
</tbody>
</table>