British Standard

BRITISH STANDARD

BS 5611:1978
IEC 542:1976

Application guide for on-load tap-changers

UDC 621.314.214.332

Cooperating organizations

The Power Electrical Engineering Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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Association of Short Circuit Testing Authorities
British Electrical and Allied Manufacturers Association (BEAMA)
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This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Committee, was published under the authority of the Executive Board on 31 October 1978

The following BSI references relate to the work on this standard:
Committee reference PEL/113
Draft for comment 77/22263 DC

ISBN 0 580 10383 8

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Committee. It is identical with Publication 542 "*Application guide for on-load tap-changers*" of the International Electrotechnical Commission.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards.

Cross-references. The following International Standards are referred to in the text and for each there is a corresponding British Standard; these are as listed below:

International Standard	Corresponding British Standard
IEC 76	BS 171 *Power transformers*
IEC 76-1:1976	BS 171-1:1978 *General* (Identical)
IEC 76-4:1976	BS 171-4:1978 *Specification for tappings and connections* (Identical)
IEC 76-5:1976	BS 171-5:1978 *Specification for ability to withstand short circuit* (Identical)
IEC 214:1976	BS 4571:1978 *Specification for on-load tap changers* (Identical)
IEC 354:1972	CP 1010:1975 *Loading guide for oil-immersed transformers* (Technically equivalent)

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 4, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This application guide is intended to assist in the selection of suitable on-load tap-changers for use in conjunction with the tapped windings of transformers or reactors which, in the following text, are referred to as transformers.

As in the second edition of IEC Publication 214, On-load Tap-changers [revision of Publication 214 (1966)], the designation "on-load tap-changer" is shortened to "tap-changer" in the remainder of this guide and all the tap-changers referred to shall be presumed to comply with the requirements specified in IEC Publication 214.

The recommendations of the application guide are not mandatory and only represent advice to the tap-changer manufacturer and purchaser. The responsibility for the correct application of the fully assembled tap-changer in connection with the transformer is with the manufacturer of the transformer.

2 Selection of a tap-changer

2.1 General remarks

Since the tap-changer represents only a small part of the total cost of the equipment in which it is used, it should be freely chosen to suit the equipment. However, account should be taken of the available standard types of tap-changers.

2.2 Insulation level

The following values occurring on all tapping positions of the transformer should be checked against the tap-changer manufacturer's declared values in accordance with Sub-clause **8.6.4** of IEC Publication 214:

1) Normal power-frequency operating voltages appearing on the tap-changer in service.

2) Power-frequency voltages appearing on the tap-changer during tests on the transformer.

3) Impulse voltages appearing on the tap-changer during tests on the transformer or in service.

NOTE With some winding arrangements, the voltages appearing on the transformer can be abnormally high, e.g.:

— neutral point tappings in auto-transformers,
— line-end tappings, and
— booster transformer arrangements.

These voltages can be affected considerably by the choice of linear, coarse/fine or reversing tapping arrangements. Methods of catering for voltage variation which involve variations in the magnetic flux in the transformer core can also affect the voltages appearing on various parts of the tap-changer (see IEC Publication 76, Power Transformers).

2.3 Current

The tap-changer should satisfy the following conditions:

2.3.1 *Rated through-current*

The rated through-current of the tap-changer as defined in Sub-clause **4.17** of IEC Publication 214 should be not less than that resulting from the highest value of tapping current of the tapped winding of the transformer (in accordance with Sub-clause **4.2** of IEC Publication 76-1, Part 1: General).

2.3.2 *Overload current*

When tap-changers are fitted on transformers which are subjected to overload conditions in accordance with IEC Publication 354, Loading Guide for Oil-immersed Transformers, they should generally be restricted to the occasional overload conditions stated in Sub-clause **4.2** of IEC Publication 76-1, unless specifically ordered for other overload conditions by the transformer manufacturer.

The above requirements are met:

a) If the maximum rated through-current of the tap-changer is at least 1.2 times the highest tapping current of the transformer, or

b) if the tap-changer manufacturer is able to demonstrate that the temperature-rise limits given in Sub-clause **8.1** of Publication 214 are not exceeded when the contacts carry 1.2 times the maximum rated through-current. (The values of current to apply for the other tests of Clause **8** of Publication 214 remain based on the value of the maximum rated through-current.)

The number of tap-changes for each occasional overload period should be limited to the number of operations corresponding to one-half of one complete operating cycle and the peak temperature rise of the transition resistors should not exceed 360 °C for air-environment tap-changers or 300 °C for oil-environment tap-changers.

Where tap-changers are subject to overload conditions not in accordance with the limitations stated in IEC Publication 76-1 with regard to the loading guide for oil-immersed transformers, the tap-changer manufacturer should be consulted and given the current magnitude and duration so that the correct tap-changer can be recommended for the duty required.

2.3.3 *Short-circuit current*

The short-circuit current of the tap-changer as given in Sub-clause **8.3** of IEC Publication 214 should be not less than that resulting from the overcurrent of the associated transformer as given in Sub-clause **1.2** of IEC Publication 76-5, Part 5: Ability to Withstand Short Circuit.

NOTE Particular care should be taken to check this current on low-impedance and booster transformers. In some instances, the fault-current value could dictate the choice of tap-changer.

2.4 Breaking capacity

The highest tapping current and the voltage per step of the transformer should be within the values of rated through-current and relevant rated step voltage declared by the tap-changer manufacturer for the particular tap-changer.

For values outside of those declared, the tap-changer manufacturer should be consulted.

For application to transformers with several different currents and step voltages, the transition impedance should be designed so that the switched current and recovery voltage in the tap-changer do not exceed those covered by the type tests.

NOTE In certain applications, such as furnace transformers, the tap-changer may be called upon, if required, to operate during periods of momentary overloads of two to three times the transformer continuous maximum rating. The diverter switch or selector switch should be chosen so that it is capable of meeting this condition.
Where appropriate, consideration should be given to the effect on the step voltage, and in consequence on the breaking capacity, of methods of voltage variation giving variations in the magnetic flux in the transformer core.

2.5 Number of tapping positions

The number of inherent tapping positions of the tap-changers is generally standardized with various manufacturers' equipment. The selection of the number of service tapping positions should preferably be made within that range.

As the extent of the tapping range increases, the voltages to be catered for also increase and it is essential that precautions be taken to avoid excessive voltages over the tapping range when operating or testing at minimum winding positions. The effect can be very marked on furnace and rectifier transformers feeding electrolytic plants where wide tapping ranges are often necessary and the tap-changer is in the constant voltage winding, i.e. wide variations in the magnetic flux in the transformer core occur.

2.6 Discharge problems with change-over selectors

It should be noted that, under certain conditions, tap-changers with change-over selectors can allow momentary disconnection of the tapped winding. In such cases, discharges between the opening and closing contacts can occur during the operation of the change-over selector, and in order to avoid difficulties with regard to the dielectric stress and the formation of gases which could arise when the tap-changer operates under high voltage to earth, special precautions will be necessary. There are many different methods of overcoming the problem but some examples are the use of two-way change-over selectors, control resistors, or capacitive control between the main winding and the tapped portion of the winding.

2.7 Mechanical life

The mechanical duty may need consideration if the expected number of operations per annum exceeds 20 000, for example, this can occur on transformers for use on rolling-mills, electrolytic plants or furnace supplies.

2.8 Motor-drive mechanism

If the motor-drive mechanism is purchased from a manufacturer other than the manufacturer of the tap-changer, then it is the purchaser's responsibility to ensure that the motor-drive mechanism is suitable for all its necessary duties.

2.9 Pressure and vacuum tests

Where applicable, the tap-changer when fully assembled has to withstand all the pressure and vacuum tests of its associated transformer. In such cases, all the relevant information should be given in the order to the manufacturer of the tap-changer.

2.10 Low-temperature conditions

Should the tap selectors, diverter switches or selector switches be located in separate containers outside the transformer tank, in air, and the ambient temperature can be lower than – 25 °C, it is advisable to specify the quality of the insulating and/or lubricating oils.

Should the tap selectors, diverter switches or selector switches be located inside the transformer tank and the oil temperature can be lower than – 25 °C during operation, the tap-changer manufacturer shall be consulted, taking the quality of the transformer oil into consideration.

If necessary, automatically controlled heating devices could be provided or, alternatively, means of preventing tap-change operation at abnormally low temperatures may be considered.

2.11 Continuous operation

If the tap-changer is required to operate continuously, the temperature conditions may need to be checked and the tap-changer manufacturer should be consulted.

3 Location of oil-immersed tap-changer components

3.1 Tap selectors

Unless otherwise agreed between the manufacturer and the purchaser, the tap selectors may be located within the main transformer oil.

3.2 Diverter and selector switches

To prevent contamination of the main transformer oil, oil-immersed diverter or selector switches should be in a separate container which may be located inside or outside the main transformer oil. When located in the main transformer oil, it is not necessary for the container to be absolutely oil-tight, providing that precautions are taken to avoid any mixture of the switch oil with the transformer oil and that the oil in the container can be changed easily without lowering the oil level in the transformer tank. Where appropriate, arrangements should be made for it to be made clear in the transformer maintenance instructions that the main transformer oil should not be drained until all of the oil has been removed from the diverter switch container.

If an oil-tight container is required, it should be specified by the purchaser.

3.3 Oil level alarm contacts

If oil level alarm contacts are required, they should be specified by the purchaser.

4 Field service

4.1 Safety of operation

1) Such protective devices as may be considered necessary should be connected in accordance with the manufacturer's instructions.

2) In order to minimize switching under excessive overload or short-circuit conditions, it is recommended that, in the case of motor control, a protective device should be fitted to prevent, or if initiated interrupt, an operation of the motor-drive mechanism when the transformer load exceeds the agreed value.

NOTE In the case of manual control, protective devices are not considered necessary as it is not normal practice to tap-change manually during periods of overload and the probability of coincidence of a tap-change operation under short-circuit conditions is negligible.

4.2 Parallel operation

In the case of parallel operation of transformers with tapped windings, care should be taken by the manufacturer and the user of the transformer to ensure that the currents circulating between the transformers are limited to an acceptable value.

4.3 Contact erosion and oil contamination

Tap-changers have expendable items in their construction and the manufacturer's figures should be noted for maintenance periods in terms of time and in numbers of operations. Generally, expected contact life for a particular tap-changer is given at maximum rated through-current. If the load current of the transformer is less than this value, contact life is increased.

The number of operations before oil-change is necessary is conditional on the oil being in good condition originally and maintained in a dry state.

For good utilization of the tap-changer, it is necessary to follow the maintenance instruction book of the tap-changer manufacturer, which generally gives the above as a function of:

1) rated through-current;

2) the service duty of the transformer.

5 Information required with enquiry or order

In order that the correct tap-changer can be specified, the following information should be given by the transformer manufacturer:

5.1 Rating and general data

1. Relevant specification.
2. Number of tap-changers required.
3. Single or polyphase units.
4. Number of phases in system.
5. Frequency.
6. Rated power, in kilovoltamperes, of apparatus to which the tap-changer is to be connected.
7. Rated voltage of the winding to which the tap-changer is to be connected.
8. Winding connections.
9. Tapping range required, given in per cent above and below the rated voltage of the winding. (See Sub-clause **2.3** of ICE Publication 76-4, Part 4: Tappings and Connections.)

10. Number of service tapping positions required, the numbering of these positions and their identification with reference to the transformer tappings.

11. Tapping arrangement (i.e. linear, reversing or coarse/fine).

12. Position of tappings in winding (e.g. line end, middle, neutral point).

13. Highest tapping current of the winding to which the tap-changer is to be connected (see IEC Publication 76-1, Sub-clause **3.5.3.5**).

14. Maximum value and duration of short-circuit current passing through the tap-changer.

15. Phase voltage per step (if the step voltage varies over the range, give full details, together with associated currents).

16. On neutral-point tap-changers, whether one neutral terminal or three separate neutral terminals are required.

17. The power-frequency voltage appearing between the opening and closing contacts of the change-over selector. (See Sub-clause **2.6** of this guide.)

NOTE The power-frequency voltage has two components, i.e. an inductive component and a capacitive component, during the time the winding is disconnected.

5.2 Insulation level

The following impulse voltage and power-frequency voltage test values should be given:

1. Highest voltage between the extreme tappings and, where applicable, the highest voltage between the ends of the coarse tapping winding section and the fine tapping section.

2. Highest voltage between the most onerously stressed tapping and earth.

3. Highest voltage between tappings of adjacent phases.

4. Highest voltage between the diverter switch and earth.

5. Highest voltage between phases of the diverter switch.

6. Highest voltage between open diverter switch contacts.

NOTE If applicable, partial discharge and switching impulse levels should be given.

5.3 Pressure, vacuum and temperature requirements

1. Maximum working pressure when oil-filled.

2. Maximum pressure during oil tests on the apparatus.

3. Maximum vacuum to be applied.

4. Type of processing, maximum temperature, vacuum and duration if the tap-changer is fitted before this operation.

5. Temperatures in special environments, e.g. noise enclosures, etc.

6. Minimum operating temperatures and details of any special low-temperature requirements if below – 25 °C.

5.4 Special

1. Details of periods of overload, value and duration (see IEC Publication 354, Clause **3**, and see Sub-clause **2.3.2** of this guide).

2. Details of duty of apparatus, e.g. distribution transformer, arc furnace transformer, etc.

3. Details of transport of transformer.

4. Any special requirements of the specification.

5.5 Fittings

Items not covered by the tap-changer manufacturer's standard, e.g. valves, etc., should be specified.

5.6 Motor-drive mechanism

To enable the correct control devices to be included in the motor-drive mechanism, the fullest possible details of the control scheme should be given by the purchaser, including which, if any, of the following basic control functions are required, together with the type of device necessary for the function.

1. Local electrical control and indication.

2. Remote electrical control and indication.

3. Local automatic control and indication, with or without line drop compensation.

4. Remote automatic control and indication, with or without line drop compensation.

5. Parallel control of two or more transformers.

6. Supervisory control and indication.

7. In the case of remote and supervisory control and indication, the approximate distance between the tap-changer and the control point should be stated.

8. Supplier of controlgear.

9. Auxiliary supply details for electrical motor and control equipment, i.e. normal voltage, maximum and minimum voltage limits if not within the standard limits given in IEC Publication 214, Sub-clause **11.2**, a.c. or d.c. If a.c., frequency, number of phases and availability of neutral point.

Publications referred to

See national foreword

BS 5611:1978
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