1ZSC000498-ACM en

Vacuum type on-load tap-changers for use in demanding applications

General for normal operation of an OLTC

A vacuum or a conventional on-load tap-changer (OLTC) can during rated load, when standing in position, be regarded as almost without losses, meaning that the temperature inside the OLTC more or less follow the surrounding transformer oil temperature. An OLTC tested according to IEC 60214-1, 2014-05, will always manage transformer loading according to IEC 60076-7, 2005-12.

For a normal network application, an OLTC can be characterized by the frequency of the OLTC operations are less than 100 operations/day and are most common up to 20 operations/day. In this type of normal network application heating from the OLTC operation does not need to be considered on any OLTC from ABB.

Demanding network application such as HVDC or demanding industrial applications such as arc furnace

Demanding network application such as HVDC are characterized by that the OLTC is frequently operated and also sometimes during this frequent operation maneuvered almost from one end position to the other. Number of operations/day are normally more than 100, all this in the same time as the transformer is fully loaded during a long time giving high ambient temperature for the OLTC. The OLTC is also often planned to operate during emergency situations.

In demanding industrial applications the OLTC operation is characterized by frequently going through a large part of the complete regulating range several times every hour. The load situation of the transformer is rather intermittent and the transformer well cooled, those normally giving the OLTC a lower ambient temperature than in the demanding network application. The industrial process is also normally very costly so the OLTC is not allowed to prolong or disturb this process.

In both these demanding applications the switching losses during operation will contribute to make the internal OLTC temperature higher than the surrounding transformer oil temperature, meaning that special considerations may be needed for OLTC:s in at least the higher rating regions.

ABB has for these applications defined standard operation cycles for OLTC:s as described below; this to be able to make general recommendations when special considerations may be needed. These operation cycles shall not be mixed up with the transformer load cycles since the heating discussed here are almost independent of conduction losses but more depending on switching losses during OLTC operation.

Since the actual case may differ or in some case be unknown regarding actual ambient temperature for the OLTC, load or number of operations, is it recommended to discuss all such unsure cases with ABB.

Standard defined operation cycles

ABB has defined four different standard operation cycles for an OLTC used in demanding applications where the OLTC is frequently maneuvered. The four different operation cycles are:

Demanding network/HVDC:1, see Fig. 1:
The OLTC shall be able to perform 10 op/h at rated current continuously with 90°C ambient temperature in the transformer. This can be regarded to be a rather high switching frequency for a HVDC or a demanding network application running at full load.

Demanding network/HVDC:2, see Fig. 1:
The OLTC shall be able to perform 5 op/h at 1.3 times rated current continuously with 105°C ambient temperature in the transformer. This may be the situation after a longer rather demanding overload situation for a HVDC or a demanding network application.

Demanding network/HVDC:3, see Fig. 1:
The OLTC shall be able to perform 34 operations in a row at 1.5 times rated current with 90°C ambient temperature in the transformer. This can be regarded to be more of an emergency situation for a HVDC or a demanding network application. The minimum time for performing operations is approximately 3 min, this phase can be seen in the far left of this cycle in Fig. 1. After such cycle, if 125°C is reached, operation of the OLTC must be avoided for some hours, letting the OLTC to cool down properly to a more normal temperature.

Arc furnace, see Figs. 1 and 2:
This cycle with both a primary and a secondary meltdown with one re-charge is selected to be one of the arc furnace cycles found, ending up in most OLTC operations/time unit. With an ambient temperature in the transformer of 50°C shall the OLTC shall be able to ramp up 23 steps in two periods with 5 min in-between, see Fig. 2 area (a), where 15 operations at rated load and 8 operations at 1.4 times rated load. The 8 operations at 1.4 times rated load is selected to cover load variations and frequent electrode short circuits during the ramp up phase. This is followed by a 12 min melting time with no operation.

After this is it time for re-charging the oven during 5 min, see Fig. 2 area (b), during this time the OLTC will ramp down with 23 operations with the transformer de-energized.

After the re-charging is done the above ramping up sequence will repeat, see Fig. 2 area (c), followed by 25 min refinery period and at the end ramp down with the transformer de-energized, in the same time the melt will be emptied and a new charge be loaded, see Fig. 2 area (d).

In this arc furnace cycle, during the first 33 min of every new charge the OLTC operation is very intense, see Fig. 2 area (a), (b), and first part of area (c), resulting in totally 46 operations performed with an average operation intensity of approx. 100 op/h.

In the majority of the last 37 min, see Fig. 2 area (d) and last part of area (c), the transformer load is high but no operation are performed during load, making the OLTC temperature to slowly reduce until the oven is ready for melting the next charge.

It is also noticed that in reality each sequence may not be as simple as explained in this standard cycle description. During the times when no operations are performed within the standard cycles normally some operations are performed in reality, but this is regarded to be well compensated by the large number of operations totally included in this standard cycle.

Three different and important temperature levels for an OLTC are also defined, see Fig. 1:

1. 105°C "Max OLTC oil temperature during normal operation". This can be regarded to be a rather normal temperature inside an OLTC mounted in a HVDC transformer that has been running during long time at full load making operations. This temperature can also be reached for an arc furnace OLTC running within a continuous melting process.
2. 115°C "Warning level from temperature guard". The intention of this document is to avoid this temperature from being reached even after a longer rather demanding overload situation for a HVDC or a demanding network application or even an arc furnace application. If selecting the appropriate OLTC for the actual application acc. to this document and still reaching this temperature in a non-emergency situation, it is an indication that the OLTC and the transformer have been operating more heavily than foreseen in this document.
3. 125°C "Temperature lock-out level", if the OLTC is correctly selected acc. to this document, this temperature will normally never be reached, not even during an emergency situation for a HVDC or a demanding network application. This should also never be reached for an arc furnace application with a correctly dimensioned OLTC.

To be able to give a warning signal at 115°C and block the motor drive operation at 125°C shall two temperature guards or an OLTC temperature measurement device be used for this type of applications, at least when an OLTC close to the max. performance data is chosen.

By knowing the actual operation and choosing OLTC according to the recommendations in this product information, normal operation can work safely and smoothly without warnings or operation block from the temperature guards.

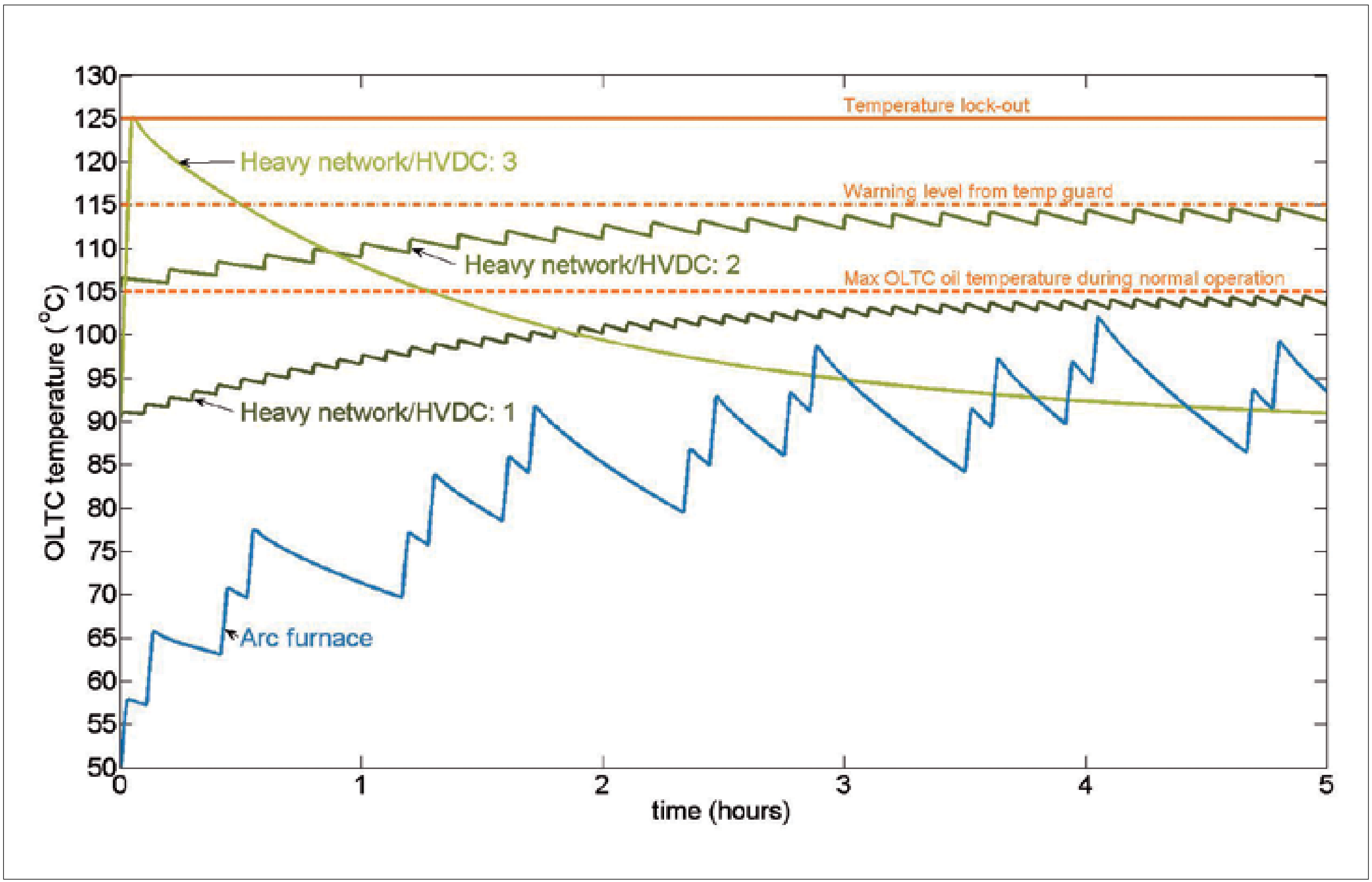

Fig. 1. Reference switching cycles for demanding network applications such as HVDC and for industrial applications such as arc furnace. This is a general picture of the cycles during startup, for a specific type of OLTC the time constants may differ.

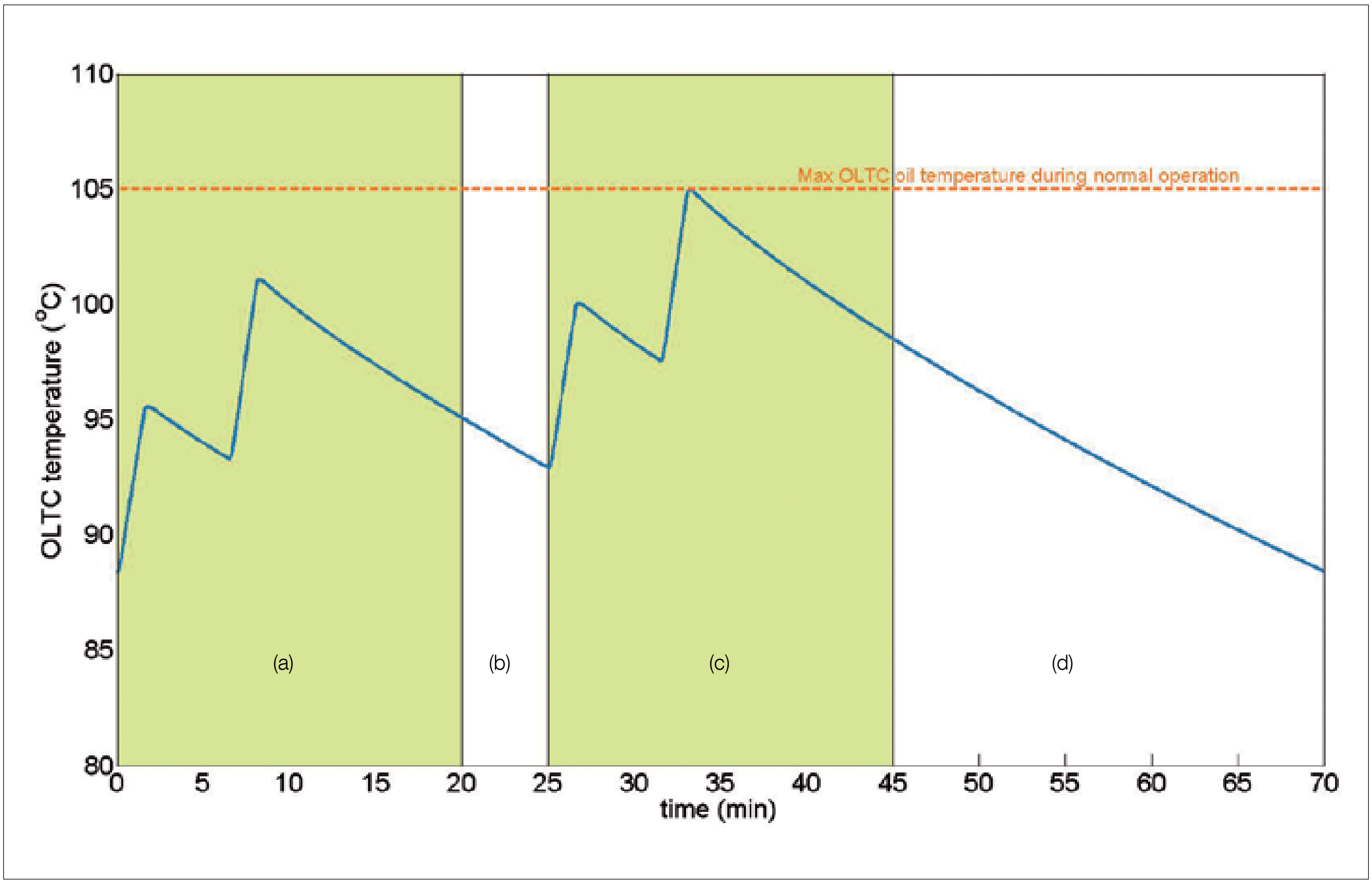

Fig. 2. Cycle with both a primary and a secondary meltdown and one recharge is selected as reference switching cycle for industrial applications such as arc furnace. This figure shows the situation after many repeating melting cycles in a row when the maximum temperature inside the OLTC rises no more. Area (a) includes the first melting cycle, area (b) includes recharging of the oven, area (c) shows second melting cycle, area (d) includes the refinery, emptying and recharge period.

VUCG.E and VUCG.T

All VUCG.E and VUCG.T tap-changer types can be used during all types of cycles described in this document. If however the breaking capacity is in the highest region, a BIL 1050 design shall be used for allowing more energy to be stored in the larger oil volume and for its improved cooling towards the surrounding transformer oil. VUCG.E and VUCG.T short versions has less oil volume and should normally not be used for any demanding application without contacting ABB for verification of suitability for the actual demanding application.

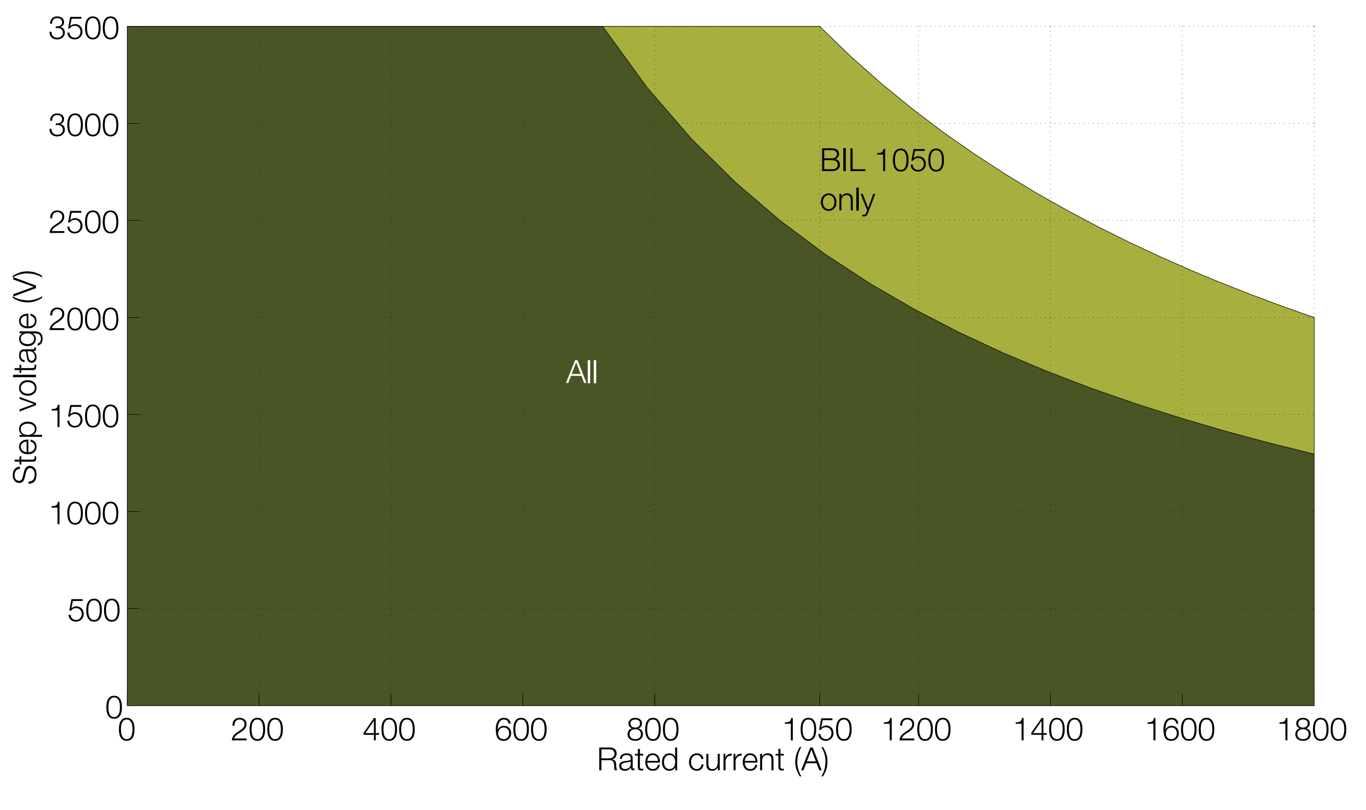

Fig. 3. Possible ratings for different BIL levels for VUCG.E or VUCG.T on demanding network applications, such as HVDC and for industrial applications such as arc furnace.

VUCL.E and VUCL.T

Most VUCL.E and VUCL.T tap-changer types can be used during all types of cycles described in this document. If however the breaking capacity is large, a larger insulation class towards ground shall be used for allowing more energy to be stored in the larger oil volume and for its improved cooling towards the surrounding transformer oil. For the highest region or if not longer diverter switch housing with higher BIL level is possible, please contact ABB for further advice.

BIL 750 is thermally equivalent with BIL 650. BIL 1175 is thermally equivalent to BIL 1050.

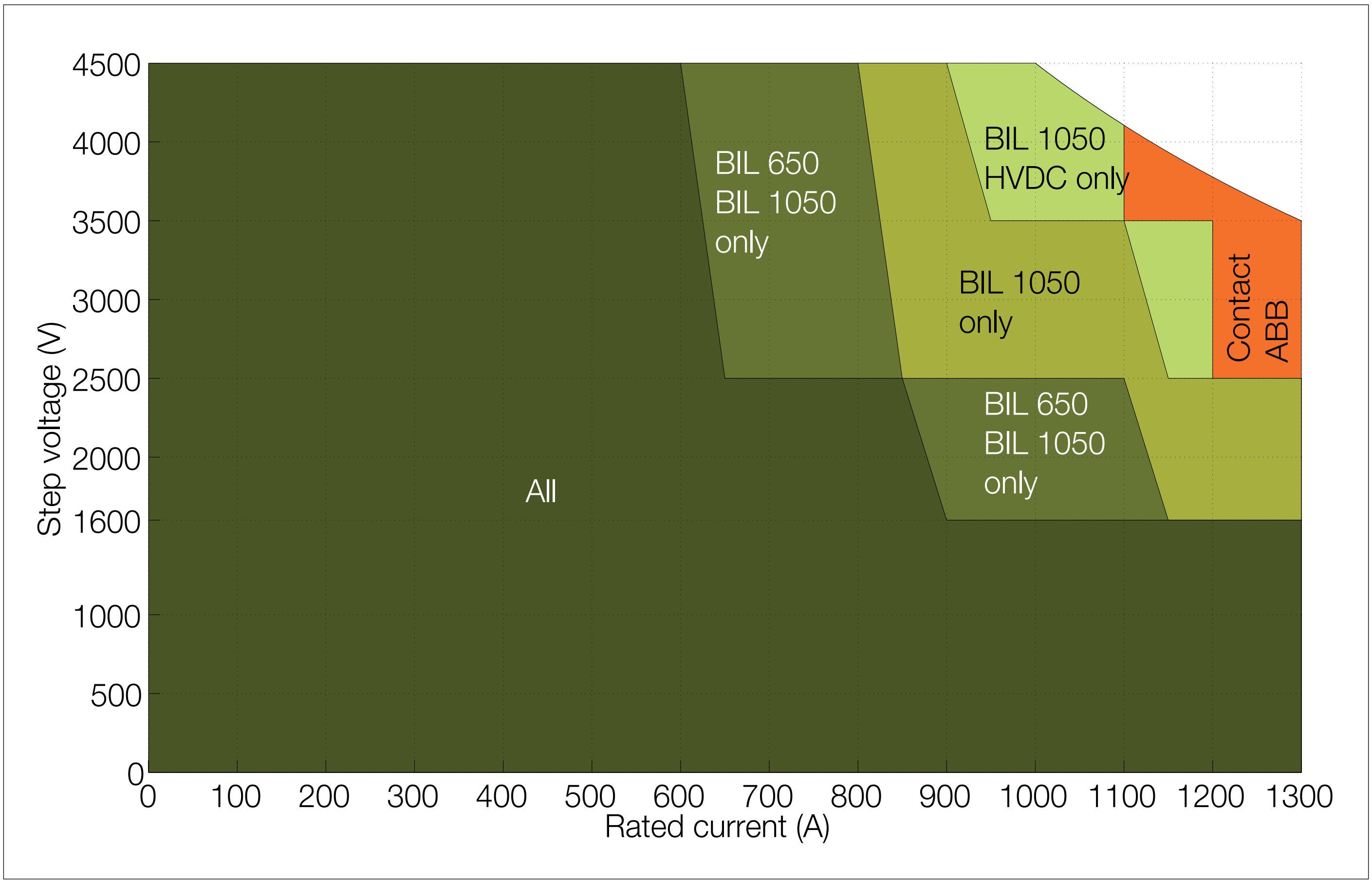

Fig. 4. Possible ratings for different BIL levels for VUCL.E or VUCL.T on demanding network applications, such as HVDC and for industrial applications such as arc furnace.

VUCG.N

Most VUCG.N tap-changer types can be used during all types of cycles described in this document. If however the breaking capacity is large, a higher BIL rating can be required for allowing more energy to be stored in the larger oil volume and for its improved cooling towards the surrounding transformer oil. For the highest region or if not longer diverter switch housing with higher BIL level is possible, another type of optimization or another type of tap-changer may be required, please always contact ABB for further advice when VUCG.N shall be used for demanding applications with very frequent OLTC operation. VUCG.N short version has less oil volume and should normally not be used for any demanding application without contacting ABB for advice.

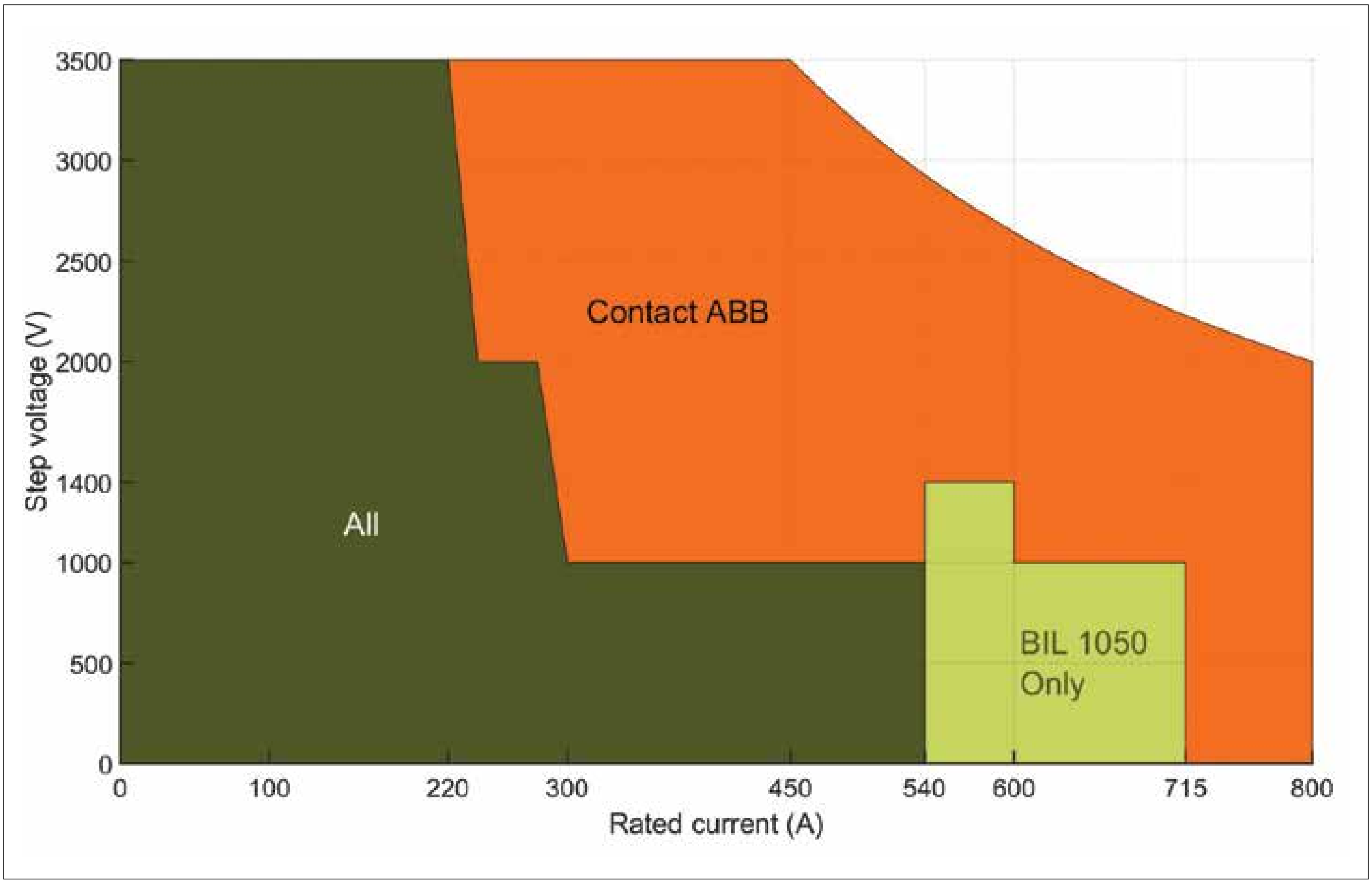

Fig. 5. Possible ratings for different BIL levels for VUCG.N on demanding network applications, such as HVDC and for industrial applications such as arc furnace.

VUCL.N

Most VUCL.N tap-changer types can be used during all types of cycles described in this document. If however the breaking capacity is large, a higher BIL rating can be required for allowing more energy to be stored in the larger oil volume and for its improved cooling towards the surrounding transformer oil. For the highest region or if not longer diverter switch housing with higher BIL level is possible, another type of optimization may be required. Please always contact ABB for further advice when VUCL.N shall be used for demanding applications with very frequent OLTC operation.

BIL 750 is thermally equivalent with BIL 650. BIL 1175 is thermally equivalent to BIL 1050.

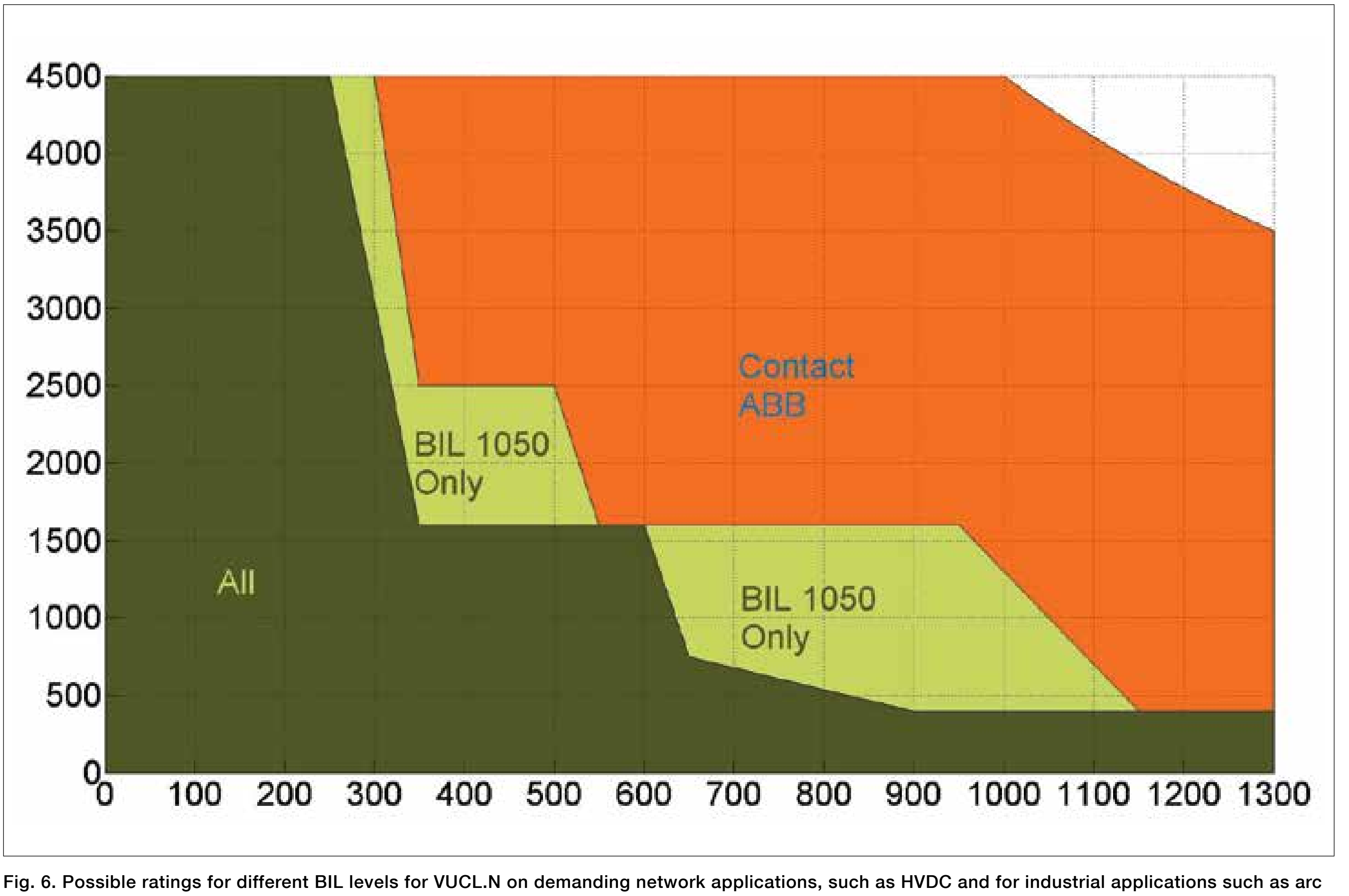

Fig. 6. Possible ratings for different BIL levels for VUCL.N on demanding network applications, such as HVDC and for industrial applications such as arc furnace.

VUCL.E and VUCL.T of the two pole versions (often used for HVDC)

Two pole versions of VUCL.E and VUCL.T tap-changer types can be used during all types of cycles described in this document. If however the breaking capacity is large, a higher BIL rating can be required for allowing more energy to be stored in the larger oil volume and for its improved cooling towards the surrounding transformer oil. For the highest region or if not longer diverter switch housing with higher BIL level is possible, another type of optimization may be required. Please always contact ABB for further advice when VUCL.E and VUCL.T of two pole versions shall be used for demanding applications with very frequent OLTC operation.

BIL 750 is thermally equivalent with BIL 650. BIL 1175 is thermally equivalent to BIL 1050.

VUBB.T and VUBB.N

ABB shall always be contacted for verification of suitability for the actual demanding application.

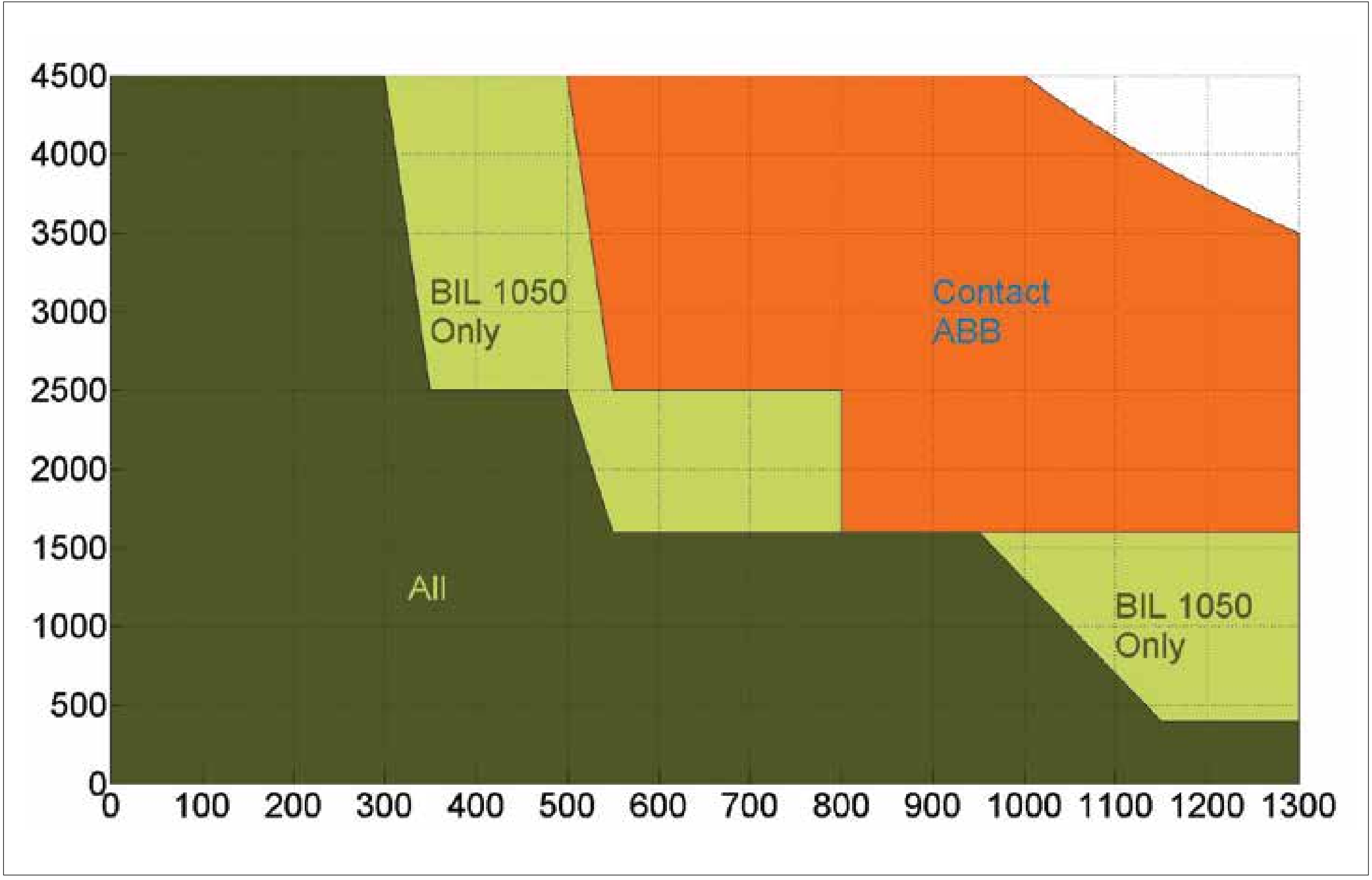

Fig. 7. Possible ratings for different BIL levels for VUCL.E or VUCL.T on demanding network applications, such as HVDC and for industrial applications such as arc furnace.

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