1. SCOPE

This document details the application of SOP 437 (Applicable to ABB / Hitachi Energy VUBB On-load Tap Changers fitted on primary transformers manufactured by ABB / Hitachi Energy Dudullu factory in Turkey) issued by the Energy Networks Association.

2. ISSUE RECORD

This is a Reference document. The current version is held on the EN Document Library.

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Issue Date	Issue No.	Author	Amendment Details
12/12/2023	1	Jose Quintana	Initial issue
18/12/2023	2	Jose Quintana	Appendix 1 updated. 20 additional units identified in SPD
13/02/2024	3	Jon Ruiz de Aguirre	Update according to ALARP
23/05/2024	4	Jose Quintana	Update following completion of RCA. Application revised to ABB Dudullu transformers only. Appendix 1 updated. SOP PowerOn wording improved.

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
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4. REVIEW

This is a Reference document which has a 5-year retention period after which a reminder will be issued to review and extend retention or archive.

5. DISTRIBUTION

This document is not part of a Manual maintained by Document Control and does not have a maintained distribution list. It is published on the SP Energy Networks website.

6. CONTENTS

7. SOP DETAILS

EQUIPMENT TYPE	ABB / Hitachi Energy VUBB On-load Tap Changer fitted on primary transformers manufactured by ABB / Hitachi Energy Dudullu factory in Turkey
ORIGINATING COMPANY	SP Energy Networks
DATE	12th December 2023
NUMBER INSTALLED IN ENERGY NETWORKS NORTH	11
NUMBER INSTALLED IN ENERGY NETWORKS SOUTH	67
REASON	Two identical failures on ABB VUBB on-load tap changers have been experienced to date. Investigations revealed that the lifting lugs, which also act as fixing bolts of the inner tap changer mechanism, had sheared off and fallen to the bottom of the compartment. This additionally allows movement of the inner tap changer structure within its housing which may lead to misalignment of selector contacts. This mechanical issue has the potential to develop into electrical failure by either breach of clearances by the broken metal parts or incomplete tap operation.
STATUS IN INITIATING COMPANY	A Risk Management Zone (RMZ) equivalent to the fire segregation zone of the transformer, as per SUB-01-012, will be established to manage public exposure. That is, 5m from the transformer bund in most circumstances, but 10m to any combustible building (i.e. predominantly made of combustible materials such as timber). Under the restriction, time limited entry to the restricted zone with the equipment live is permissible for staff. The following exposure limits apply for single person entry: • 25 minutes per person per day. Tap changers of the affected type shall be placed on fixed taps in the following situations: 1) On a temporary basis prior to accessing the transformer compound and for the whole duration of any works required. Tapping functionality can be restored on exiting the compound. 2) On a permanent basis on those units where public footpaths, car parks, third-party buildings or high / medium footfall third-party land are within the established RMZ. In these cases, if required due to network performance issues, individual isolated tap operations may be possible subject to risk assessment and adequate control measures being put in place. Notices shall be posted to all access gates / doors into the transformer compounds containing this type of tap changer.

SPEN APPLICATION	As detailed above
ADDITIONAL INFORMATION	N/A
UPDATE	The original SOP applied to all ABB VUBB on-load tap changers regardless of the manufacturer of the transformer where these were fitted. However, root cause analysis concluded that the most likely cause of the failures experienced was related to interference and incorrect re-assembly of the internal mechanism of the tap changer at the transformer factory, ABB / Hitachi Energy located in Dudullu (Turkey). Extensive investigation was carried out by the tap changer manufacturer on the actual VUBB product, and no evidence was found to suggest an issue in the design, material selection or manufacturing process. Review of the quality records from the other initially affected transformer manufacturers (Brush Transformers, Winder Power and ABB / Hitachi Energy Monselice Italy) and confirmation of no non-conformances raised against VUBB on-load tap-changer internal mechanism allowed these units to be excluded from the potentially affected list.
REMEDIAL ACTION	Internal inspection of the VUBB on-load tap-changer is required to confirm condition of the internal mechanism fixing arrangements. This inspection shall only be carried out by suitably trained personnel. External authorised transformer service providers certified by Hitachi Energy to carry out work on VUBB tap changers can be used, although training with the tap changer manufacturer for SP Energy Networks staff is also planned to be arranged as required. Methodology for this inspection is described in detail in Hitachi Energy document 1ZSC030598 but summarised in this section. Tap changer compartment oil sample shall be taken for DGA analysis before commencement of works. Sufficient tap changer oil (approx. 10cm) shall be drained to expose the internal mechanism. Protective devices and pipework shall be disconnected as required to allow tap changer cover to be removed. Once access gained, position and condition of the four fixing bolts shall be checked (ie. check for evident damage or deterioration, attempt to rotate and remove bolts by hand…). Applied tightening torque shall be checked and confirmed to match the design value of 24 Nm. DGA analysis of the tap changer compartment oil shall be also reviewed and confirmed within typical values as otherwise it will indicate arcing / discharge activity likely caused by misalignment of contacts. If all fixing bolts appear to be in intact condition and tightening torque confirmed to be as per manufacturer specification, SOP can be removed. Where loose or missing bolts are identified and damage to the casing threads is evident, assistance shall be sought from the tap changer manufacturer.

8. SOP HEADER

Field Name	Field Value		Field Size
Name (SOPXXX) *	**SOP437**		6
The reason for the Operational Restriction *	Failures on ABB VUBB OLTCs		30
Nature of the Operational Restriction *	Tap changer to be placed on fixed taps		50
Comments *	Tap changers shall be placed on fixed taps: 1. On a temporary basis prior to access Tx compound, if total exposure > 25 mins in 24 hrs 2. On a permanent basis where public areas within RMZ		200
Restricted Access to Substation Flag *	**Y**		1
SOP Impact Code * *(highlight or underline the appropriate code)*	0 Temporary/Impact under assessment 1 Very minor operational/network impact 2 Moderate operational/network impact 3 Significant impact on system perf./measurable business costs 4 Inoperable without intervention 5 Inoperable – no cost effective solution/must be replaced		N/A
SOP component type * *(highlight or underline the appropriate code)*	01 Bushing only 02 Circuit Breaker 03 Fixed Portion only 04 Moving Portion only 05 Switch 06 RMU 07 Transformer only 08 Tap Changer only 09 Transformer & Bushing 10 Transformer & Tap Changer		N/A
Search Criteria *	As per list in Appendix 1		N/A

* This denotes a Mandatory Field

9. APPENDIX 1 – LIST OF POTENTIALLY AFFECTED EQUIPMENT

SPD (LIST BY TRANSFORMER)

ENID	Equipment	Description of Technical Object	Description of functional location
20158765	700607003	CRONBERRY T1/PRIMTX/01	CRONBERRY-TRX
20160391	700608038	CRONBERRY T2/PRIMTX/02	CRONBERRY-TRX
20187903	700612981	CREETOWN T1/PRIMTX/01	CREETOWN-TRX
20243198	700624493	DENHOLM NEW TRANFORMER T2/PRIMTX/02	DENHOLM NEW - TRX
20272517	700631708	DENHOLM NEW TRANFORMER T1/PRIMTX/01	DENHOLM NEW - TRX
20277783	700633178	KIRKBANK JOHNS T1/PRIMTX/01	KIRKBANK JOHNS-TRX
20279556	700634562	FAULDHEAD PRIMARY T2/PRIMTX/02	FAULDHEAD PRIMARY - TRX
20344635	700685871	FAULDHEAD PRIMARY T1/PRIMTX/01	FAULDHEAD PRIMARY - TRX
20115841	700578434	T1	MUIRHOUSE 33/11-TRX
20127314	700588007	PINWHERRY 33/11KV PRIMTX SN 1LTR0033335	PINWHERRY 33/11KV-TRX
20240610	700623810	BARRHILL T1/PRIMTX/01	BARRHILL NEW - TRX

SPM (LIST BY TRANSFORMER)

ENID	Equipment	Description of Technical Object	Description of functional location
20118460	700580655	33/11/T2	DARESBURY NPL-TRX
20120991	700582813	33/T1	LLANBEDROG-TRX
20125381	700586466	33/11/T1	GRANTHAM CLOSE-TRX
20131091	700591122	33/11/T1	WEST FELTON-TRX
20131833	700591684	33/T1	HASKAYNE-TRX
20133835	700593331	33/6.6/T1	MOBIL OIL WALLASEY-TRX
20133842	700593335	33/11/T2	IFTON-TRX
20133847	700593336	33/11/T1	PENYGROES-TRX
20155510	700604184	33/T1	LLANILAR-TRX
20157173	700605573	33/T1	LLANFAELOG-TRX
20160375	700608023	33/6.6/TRANSFORMER	EVERTON ROAD-TRX
20173339	700610128	33/11/T1	EGREMONT-TRX
20179672	700611575	33/T1/PRIMTX	SHERDLEY ROAD-TRX
20179674	700611577	33/11/T1/PRIMTX	MANOD-TRX
20199826	700614831	33/33/11/T1	CIVIC CENTRE-TRX
20202069	700615334	33/11/T1	LOSTOCK GRID-TRX
20202653	700615540	33/11/T2	DUCKINGTON-TRX
20202656	700615545	33/11/T1	CREWE GRID A-TRX
20212212	700617692	33/11/T1	MINFFORDD-TRX
20236302	700622879	33/T1	STONEYCROFT-TRX
20246146	700625415	33/T1	HAWLEYS LANE-TRX
20265320	700630376	33/T1	CHURCH LAWTON-TRX
20279906	700634831	33/T2	CHOWLEY-TRX
20279940	700634857	33/T1	CHESHIRE GREEN - TRX
20284691	700636887	33/T1	NANT-Y-GAMAR-TRX
20285163	700637259	SINGLETON AVE/PRIMTX/33/6 T1	SINGLETON AVE 6-6KV-TRX
20285164	700637260	33/T2	CADBURYS-TRX
20287948	700639357	33/T1	PADDINGTON PLACE-TRX
20287949	700639358	33/T2	PADDINGTON PLACE-TRX
20290890	700641465	33/T1	CAERNARFON-TRX
20290980	700641506	ABERYSTWYTH/PRIMTX/33/11 T1	ABERYSTWYTH -TRX
20291004	700641528	33/T1	MERES EDGE-TRX
20295992	700645300	33/T2	CHALON WAY-TRX
20311395	700658246	33/T1	CHESTER ST CREWE - TRX
20311396	700658247	33/T2	CHESTER ST CREWE - TRX

20318207	700664299	33/T1	FERODO-TRX
20318350	700664400	33/T1	VAUXHALLS-TRX
20290922	700641483	33/T1	LLANDYRNOG-TRX
20212216	700617697	33/11/T1	BUCKLEY CROSS-TRX
20111386	700574601	33/11/T1	ORION BOULEVARD-TRX
20120968	700582799	33/T2	ST JAMES-TRX
20129135	700589562	33/11/T1	MDHB EGERTON DOCK-TRX
20130731	700590820	33/11/T1	LYMM-TRX
20134013	700593459	33/11/T1	GREENFIELD-TRX
20191355	700613552	33/T1	FOUR CROSSES-TRX
20197295	700614345	33/T1	MARSH BROWS-TRX
20236738	700622947	33/T2	BEAUMARIS-TRX
20243796	700624688	33/33/11KV/T1	WHITBY -TRX
20247753	700625815	33/T2	COEDPOETH-TRX
20250245	700626402	33/T1	BROOK BRIDGE-TRX
20282397	700635501	33/T1	ST HELENS WWTW-TRX
20290006	700640814	33/T1	OAK ROAD GAS GEN - TRX
20290746	700641380	33/T1	HOLMES CHAPEL-TRX
20295705	700645052	33/T1	GREAT SUTTON-TRX
20325628	700669970	LISTER DRIVE/PRIMTX/T3	LISTER DRIVE -TRX
20331618	700675132	33/T1	BETHESDA-TRX
20156494	700605017	33/T1	NEWHALL-TRX
20157345	700605701	33/PRIMTX/T1/33-11KV TRANSFORMER	SOUTHDENE-TRX
20179673	700611576	33/11/T1/PRIMTX	CAERGEILIOG -TRX
20194440	700613985	33/11/T1	ALMATEX-TRX
20205661	700616188	LLANDUDNO JUNCTION/PRIMTX/T1	LLANDUDNO JUNCTION-TRX
20230891	700622094	33/T2	LISTER DRIVE 6KV-TRX
20250357	700626508	WEAVER IND EST/PRIMTX/T1	WEAVER IND EST-TRX
20285772	700637721	33/T1	CONWY-TRX
20287291	700638866	33/T1	PALL MALL PRIMARY - TRX
20320269	700665927	33/T1	IND EST EARLSFIELD PK - TRX
20335367	700678107	RINGWAY/PRIMTX/T2	RINGWAY-TRX

HITACHI
Inspire the Next

Inspection of VUBB

Contents

Hitachi Energy

1 Purpose

The purpose of this instruction is to describe how inspection of the installed VUBB should be done, and what actions should be taken depending on inspection result.

2 Preparation

2.1 Tools & disposables needed.

- Torque wrench, calibrated for 24 Nm.
- Hexagon socket, 13 mm to be used with torque wrench for the bolts (M8).
- New bolts; Hexagon M8x60 8.8, partly threaded, 4 pcs per tap-changer, 9ADA56-22
- Rags
- Oil drum, for temporary storage of oil.
- Oil, of same type as used in existing OLTC.
    - To replace the one in conservator needed to open the top cover.

      (Oil can be re-used or refurbished if handled well and fulfilling the requirements)

2.2 Health & safety

Make sure transformer is de-energized and grounded as per local regulations before accessing the top of the transformer.

Lifting of tap-changer insert should only be done by qualified personnel trained in the procedure.

During drilling moments, care should be taken so that a minimum number of *burrs* falls into the tap-changer housing.

2.3 Nomenclature

Figure 1 below show the different parts referred to in this inspection instruction. (Top cover is already removed)

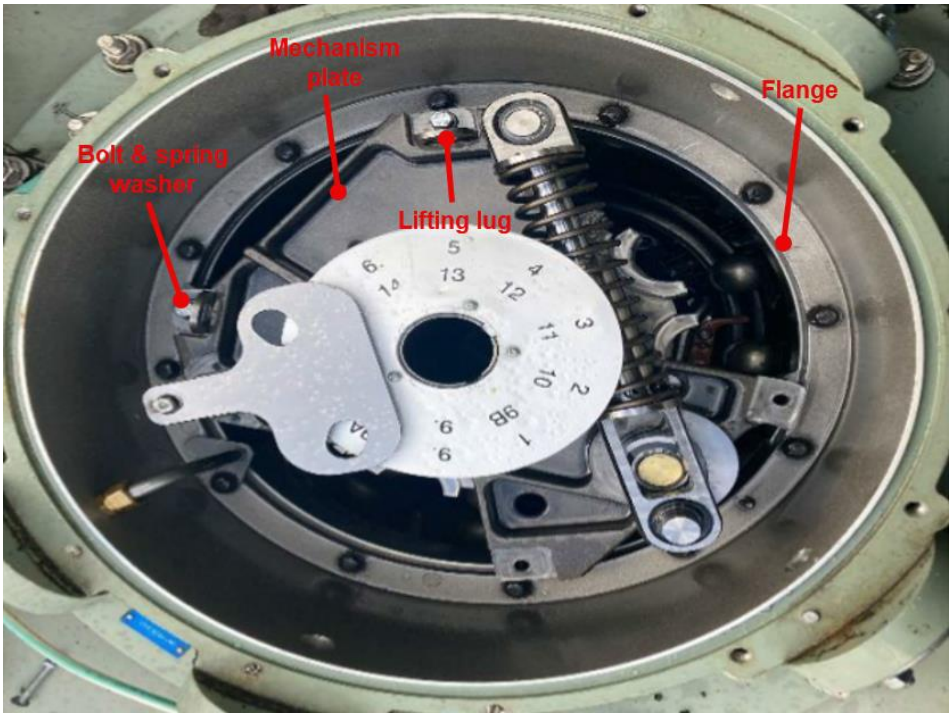

Figure 1: Nomenclature for relevant parts

3 Work tasks, step by step

3.1 DGA

Prior to accessing site for draining oil from the conservator and open the top cover of the tap-changer, it is recommended to take oil sample and perform DGA.

A potential issue with un-due arcing/sparking due to issues with mechanism is captured and preparations can be started in advance for the future actions required, i.e will a crane be needed to lift out the tap-changer insert for replacement?

3.2 Preparations

- Document the number of operations on the motor drive unit counter.
- Document the position indicated on the motor drive unit.
- Document the article number of the tap-changer.

3.3 Oil drainage

- Lower oil level a few cm (~10), down to the transformer cover, so that the mechanism at the top of the OLTC is visual and the bolts for the lifting lugs are accessible.
- The method depends on transformer design, i.e will the conservator connection to the OLTC be through a valve or not?

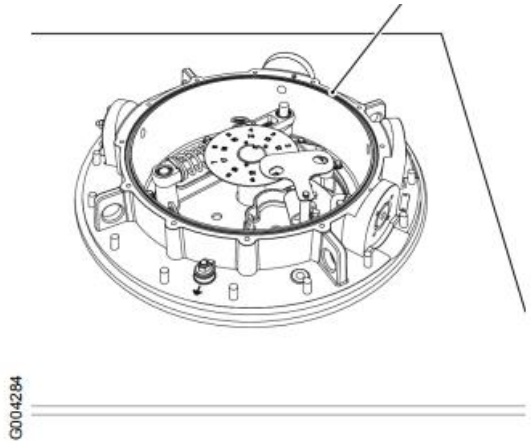

Figure 2: Top flange of VUBB with top cover removed.

3.4 Removal of OLTC top cover

- Disconnects protective devices attached to top cover (i.e PRD)
- Remove fasteners for top cover (1) and lift off the top cover (2).
- Place the top cover in a suitable location without scratching or damaging the sealing surface.

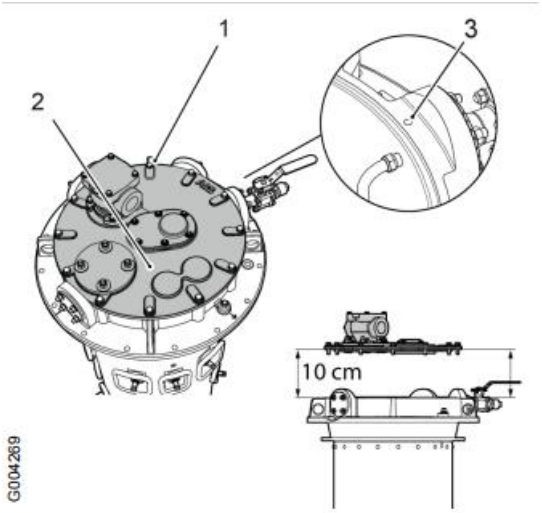

Figure 3: Removal of VUBB top cover

3.5 Inspection

After lowering the oil level and removing the top cover, four lifting lugs should be seen in the locations indicated by photo below in Figure 4.

Try to rotate the lifting lugs by hand. They should remain in position and not be able to move.

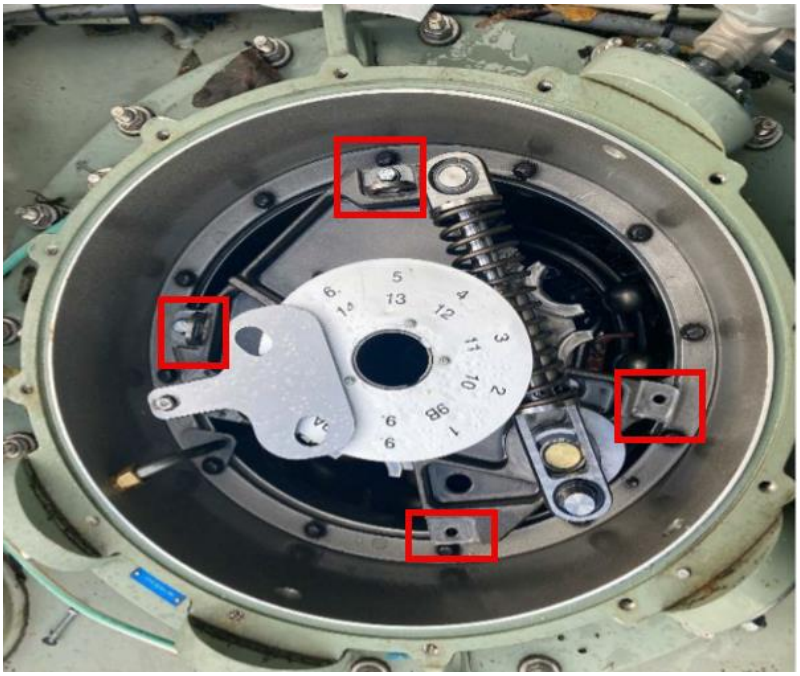

Figure 4: Photo of VUBB with top cover removed, two lifting lugs missing.

If all lifting lugs are intact and appear to be properly attached, continue to section 3.6.1.
If all lifting lugs are in proper position and bolts appear intact, but the lifting lugs can easily be rotated, continue to section 3.6.2.

If one or more lifting lugs are missing together with their bolts, continue to section 3.7.

3.6 Minor corrections

3.6.1 Re-tightening of intact fasteners

With the calibrated torque wrench, re-tighten the bolts to the stipulated torque. [24Nm]

Take notice of the angle β required to reach set torque. This is valuable information for the continuing investigation.

Figure 5: Illustration of tightening angle

3.6.2 Control of poorly tightened lugs

First, it needs to be assessed if the existing threads in the flange can be re-used.
This procedure is applicable if it is possible to rotate the lifting lugs by hand, but the bolts appear intact:

- By hand, apply pressure to bolt head in all directions (X and Y) and see if the bolt is allowed to move.
  If it remains in proper position, the threads are not *significantly* damaged and can be re-used, but bolts might have been subjected to fatigue stressing oscillations and should be replaced.
  If the bolt is easily tilted, and appears to be loose in its threads, continue to section 3.7.

  If bolt is rigid in position;

- Replace the bolts and tighten them with the torque tool to the stipulated torque [24Nm]

3.7 Extensive correction

3.7.1 Missing lifting lugs & bolts

If one or more lifting lugs are missing, the bolts have sheared off and the threads have been damaged to some degree. This might require a special mitigation beginning with:

- Drainage of full oil volume
- Lifting of selector switch insert
- Removal of lifting lugs from the OLTC bottom.
- Clean the housing (after corrective actions on the threads)
- Inspect the OLTC for arcing damages in proximity to moving contacts.
    - *Here it is valuable to have a DGA taken before maintenance work begins.*

A method to repair the threads is being evaluated and will be distributed once completed.
If actions described in 3.6 is not enough, tap-changer should remain in fixed tap position until arrangements are done to repair the threads. The DGA will be valuable for knowing if full or parts of the tap-changer need to be replaced.

4 Additional Information

4.1 Listing of related documents

Ref #	Document Kind, Title	Document No

5 Addendum

[Text.]

6 Revisions

Rev.	Page (P) Chapt. (C)	Description	Date Dept./Init.