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Issue 2 Rev 0	2013-03-25	Cancels and replaces KPLC1/3CB/TSP/10/008 Issue 1 Revision 1 dated 2008-03-18 and all previous issues	S. Kimitei	G. Owuor

FOREWORD

This specification has been prepared by the Research and Development Department in collaboration with the Technical Services Department both of The Kenya Power and Lighting Company Limited (abbreviated as KPLC) and it lays down requirements for 132kV Capacitor Voltage Transformers. It is intended for use by KPLC in purchasing the equipment.

1. SCOPE

1.1 This specification is for newly manufactured capacitor voltage transformers for use with electrical measuring instruments, electrical protective devices and similar applications on system highest voltage of 145kV at power frequency of 50Hz.

1.2 The capacitor voltage transformer (CVT) shall be suitable for supplying a low voltage for measurement, control and system protection functions.

1.3 The capacitor voltage transformer shall, when specified on schedule of requirements, be equipped with carrier-frequency accessories for power line carrier-frequency (PLC) application. The details of the accessories appear at ANNEX B of this specification

1.4 The specification also covers inspection and test of the voltage transformer as well as schedule of Guaranteed Technical Particulars to be filled, signed by the manufacturer and submitted for tender evaluation.

The specification stipulates the minimum requirements for 132kV capacitor voltage transformers and accessories acceptable for use in the company and it shall be the responsibility of the supplier to ensure adequacy of the design, good engineering practice, adherence to the specification, applicable standards and applicable regulations as well as ensuring good workmanship in the manufacture of the capacitor voltage transformers for The Kenya Power & Lighting Company.

The specification does not purport to include all the necessary provisions of a contract.

2. REFERENCES

The following standards contain provisions which, through reference in this text constitute provisions of this specification. Unless otherwise stated, the latest editions (including amendments) apply.

IEC 60044-5: Instrument Transformers – Part 5: Capacitor Voltage Transformers

IEC 60815: Guide for the selection of insulators in respect of polluted conditions

3. TERMS AND DEFINITIONS

For the purpose of this specification the definitions given in the reference standards shall apply.

4. REQUIREMENTS

4.1 SERVICE CONDITIONS

4.1.1 Site Conditions

The capacitor voltage transformer shall be suitable for continuous outdoor operation in tropical areas inland, cities and suburbs of cities, along the coast and with the following conditions:

(a) Altitude: upto 2,200 metres above sea level.

(b) Temperature: average of +30°C with a minimum of -1°C and max +40 °C

(c) Humidity: up to 95%,

(d) Pollution: Design pollution level to be taken as "Very *Heavy*" (Pollution level IV) according to IEC 60815.

(e) Isokeraunic level: 180 thunderstorm days per year

4.1.2 System Conditions

The capacitor voltage transformer will be connected between line and earth on overhead system operating at a nominal line voltage of 132kV with maximum system voltage (highest voltage for equipment) of 145kV, 50Hz and exposed to over-voltages of atmospheric origin. The neutral point is solidly earthed.

4.2 MATERIALS, DESIGN AND CONSTRUCTION

4.2.1 The capacitor voltage transformer shall be designed, manufactured and tested to IEC 60044-5 and the requirements of this specification.

4.2.2 All materials used shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperatures and atmospheric conditions arising under working conditions without

undue distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

4.2.3 The design shall ensure satisfactory operation under such sudden variations of load and voltage as may be met with under working conditions on the system, including those due to short circuits.

4.2.4 All parts of the transformer, including insulators with their mountings, shall be designed so as to avoid pockets in which water can collect.

4.2.5 The voltage transformer shall be outdoor; oil insulated and hermetically sealed type. The insulator portion of the voltage transformer shall be made of high-grade brown-glazed porcelain.

4.2.6 The voltage transformer shall be suitable for vertical installation on a steel structure.

4.2.7 All parts, components and accessories of the capacitor voltage transformer shall be resistant to atmospheric corrosion and shall be suitable for specified service conditions.

4.2.8 The voltage transformer shall have primary, secondary and earth terminals.

4.2.9 Primary Terminal

4.2.9.1 The primary terminal shall be of high conductivity copper, tin-plated, suitable for connection of both copper and aluminium conductors.

4.2.9.2 It shall have palm clamp connectors suitable for both stranded conductor and tube connection. Conductor overall diameter shall be 18.3mm to 25mm and busbar tubes of 76.2mm diameter.

4.2.9.3 The voltage to be transformed shall be applied to the primary terminal.

4.2.10 Secondary Terminals

4.2.10.1 The secondary terminals of the voltage transformer shall be wired to a terminal box.

4.2.10.2 The terminal box shall be weatherproof with a cable plate at the bottom and shall be covered with removable plate.

4.2.10.3 The secondary shall supply the voltage circuits of measuring instruments, meters, relays or similar apparatus.

4.2.10.4 The secondary terminal box of the voltage transformer shall be complete with protection fuses complete with fuse links.

4.2.11 The voltage transformer shall be designed and constructed to withstand without damage, when energized at rated voltage, the mechanical and thermal effects of an external short-circuit for the duration of 1 s.

4.2.12 At any voltage below rated voltage factor x rated primary voltage and at any burden between zero and rated burden, the ferro-resonance of the CVT incepted by switching operations or transients on the primary or secondary terminals shall not be sustained.

4.2.13 The complete capacitor voltage transformer shall be tight in the full temperature range specified.

4.2.14 The voltage transformer shall have cores and ratings as per clause 4.3.

4.3 Ratings

The ratings of the capacitor voltage transformer shall be as indicated in Table 1.

Table 1: Ratings

Nominal primary voltage		132000/√3 volts
Nominal secondary voltage		110/√3 volts
Rated frequency		50 Hz
Minimum creepage distance of insulator		4495mm
Minimum lightning impulse withstand voltage, primary winding		650kV (peak)
Minimum power frequency withstand voltage, primary winding, dry		275kV (r.m.s.)
Minimum power frequency withstand voltage, secondary winding, r.m.s.		5kV (r.m.s.)
Maximum temperature rise	Windings	65K
	Oil (at top of tank)	55K
Rated voltage factor		1.2 Continuous
		1.5 for 30 sec.
Permissible partial discharges (PD)	PD test voltage (r.m.s) = U_m	10pC
	PD test voltage (r.m.s) = $1.2U_m/\sqrt{3}$	5pC
Transmitted overvoltage limits {peak value of applied voltage(U_p) = $1.6x\sqrt{2}xU_m/\sqrt{3}$, Wave-shape characteristics: conventional front time (T_1) = 0.5µs ±20%, time to half value (T_2) ≥50µs; as per IEC 60044-5		1.6kV (peak value limits)

Radio interference voltage at $1.1U_m/\sqrt{3}$ as per IEC 60044-5			2 500 µV	
Secondary windings core 1, core 2 and core 3				
	Terminal Markings	Voltage Output	Class	VA (pf 0.8 lagging)
Core 1	1a-1n	110/√3	0.5	75
Core 2	2a-2n	110/√3	3P	150
Core 3	da-dn	110/√3	3P	50

Note:
(1) The capacitor voltage transformer shall be installed at altitude of 2200m asl and if tests will be carried out at altitudes below 1000m, the limits of temperature rise given in Table 1 above shall be reduced by 0.4% for each 100m that the altitude at the operating site exceeds 1000m (see clause 6.5 of IEC 60044-5).

(2) The capacitor voltage transformer shall be installed at altitude of 2200m asl, the arcing distance under the standardized reference atmospheric conditions shall be determined by multiplying the withstand voltages required at the service location by a factor k in accordance with Figure 1 and clause 5.2.1 of IEC 60044-5 ($k = e^{m(H-1000)/8150} = e^{(2200-1000)/8150} = 1.16$, with m=1 as per IEC 60044-5 and therefore arcing distance shall be $650kV_p * 1.16 = 754kV_p$, the nearest standard value is $750kV_p$).

4.4 Quality Management System

4.4.1 The supplier shall submit a quality assurance plan (QAP) that will be used to ensure that the transformer design, material, workmanship, tests, service capability, maintenance and documentation, will fulfill the requirements stated in the contract documents, standards, specifications and regulations. The QAP shall be based on and include relevant parts to fulfill the requirements of ISO 9001:2008.

4.4.2 The Manufacturer's Declaration of Conformity to applicable standards and copies of quality management certifications including copy of valid and relevant ISO 9001: 2008 certificate shall be submitted with the tender for evaluation.

4.4.3 The bidder shall indicate the delivery time of the capacitor voltage transformers, manufacturer's monthly & annual production capacity and experience in the production of the type and size of items being offered. A detailed list & contact addresses (including e-mail) of the manufacturer's previous customers for similar type of voltage transformers sold in the last ten years as well as reference letters from at least four of the customers shall be submitted with the tender for evaluation.

5. TESTS AND INSPECTION

5.1 The voltage transformer shall be inspected and tested in accordance with the requirements of this specification and IEC 60044-5. It shall be the responsibility of the supplier to perform or to have performed the tests specified.

5.2 Copies of previous Type Tests Certificates, Type Tests Reports and Special Tests Reports issued by a third party testing laboratory that is accredited to ISO/IEC 17025 shall be submitted with the tender for the purpose of technical evaluation. The accreditation certificate for the same third party testing laboratory used shall also be submitted with the tender (all in English Language).

Copies of Type Tests Reports and Special Tests Reports to be submitted with the tender shall not be more than five years old and shall include the following as per IEC 60044-5:

5.2.1 Type Tests Reports:

5.2.1.1 Accuracy check;
5.2.1.2 Temperature rise test;
5.2.1.3 Capacitance and tanδ measurement at power-frequency;
5.2.1.4 Chopped impulse test;
5.2.1.5 EMC radio interference voltage (RIV) tests;
5.2.1.6 Short circuit withstand capability test;
5.2.1.7 Lightning impulse test;
5.2.1.8 Wet test for outdoor type transformers with AC voltage;
5.2.1.9 Transient response test;
5.2.1.10 Ferro-resonance test;
5.2.1.11 Tightness of electromagnetic unit;
5.2.1.12 Accuracy tests.

The type test reports shall include the results of the routine tests as per clause 8.1 of IEC 60044-5

5.2.2 Special Tests Reports:

5.2.2.1 Measurement of the transmission factor of high frequency overvoltages;
5.2.2.2 Mechanical strength test;
5.2.2.3 Determination of the temperature coefficient;
5.2.2.4 Tightness design test of capacitor units.

Flow chart test sequence shall be considered mandatory and shall be as per IEC 60044-5.

5.3 Routine test reports for the capacitor voltage transformers to be supplied shall be submitted to KPLC for approval before shipment/delivery of the goods. KPLC Engineers (2) will witness tests at the factory before shipment.

Tests to be witnessed by KPLC Engineers at the factory shall be in accordance with IEC 60044-5 and shall include the following:

5.3.1 Tightness of capacitor voltage divider;
5.3.2 Capacitance and tanδ measurement at power-frequency;
5.3.3 Power-frequency withstand test;
5.3.4 Measurement of partial discharges;
5.3.5 Verification of terminal markings;
5.3.6 Power-frequency withstand tests on the electromagnetic unit;
5.3.7 Power-frequency withstand test on low voltage terminal;
5.3.8 Power-frequency withstand tests on secondary winding;
5.3.9 Ferro-resonance check;
5.3.10 Accuracy check (determination of errors);
5.3.11 Chopped impulse test on primary winding;
5.3.12 Transmitted overvoltage measurement;
5.3.13 Visual inspection of complete voltage transformer;
5.3.14 The protection cores of the CVT shall be tested in accordance with IEC 60044-5 for limits of voltage error and phase displacement as well as transient response.
5.3.15 The measuring core of the CVT shall be tested in accordance with IEC 60044-5 for limits of voltage error and phase displacement as well as tests for accuracy.

5.4 Upon delivery of the capacitor voltage transformers, KPLC will inspect them and may perform or have performed any of the relevant tests in order to verify compliance with the specification. The supplier shall replace/rectify without extra or additional charge to KPLC, capacitor voltage transformers which upon examination, test or use fail to meet any of the requirements in the specification.

6. MARKING AND PACKING

6.1 The voltage transformer shall be fitted with a permanent rating plate indicating the following:

1) Manufacturer's name or abbreviation;
2) Indication: capacitor voltage transformer;
3) Type, designation;
4) Year of manufacture;
5) Serial number;
6) Highest voltage for equipment : U_m [kV];

7) Rated insulation level based on Um: AC/BIL;
8) Rated frequency f_R [Hz];
9) Rated voltage factor F_V: continuous time of operation, short time of operation;
10) Rated capacitance of capacitor divider C_R [pF] ;
11) Rated capacitance of the high voltage capacitor C_1 [pF];
12) Rated capacitance of the intermediate voltage capacitor C_2 [pF];
13) Number of capacitor units;
14) Serial number of capacitor units;
15) Ambient temperature categories;
16) Capacitor divider: Insulation oil (mineral), mass [kg];
17) Magnetic unit: insulation oil(mineral), mass [kg];
18) Mass of complete CVT [kg];
19) Standard edition (year);
20) Current I: connection A1-A2;
21) Rated primary voltage and terminals identification A – N U_{PR} (V);
22) Indication of each secondary winding terminals: 1a -1n, 2a – 2n, da – dn;
23) Voltage of each secondary winding U_{SR} (V);
24) Value of rated output VA;
25) Accuracy class M, P;
26) Maximum simultaneous output for windings of a complete CVT regarding the accuracy class;
27) Thermal limiting output VA;
28) Transient response classes
29) Carrier frequency accessories Drain coil [mH], Voltage limitation device BIL 1.2/50μs [kV]

All the marking shall be by engraving (or superior method) and shall be permanent and legible. The items concerning the carrier frequency accessories may appear in an additional plate.

6.2 The terminals shall be marked clearly and indelibly and in accordance with IEC 60044-5. The terminal marking shall consist of letters followed by numbers.

6.3 Letters A, B, C denote fully insulated primary winding terminals and the lower-case letters a, b, c and n denote the corresponding secondary terminals. Letters da and dn denote the terminals of windings intended to supply a residual voltage.

6.4 Terminals having corresponding capital and lower-case markings shall have the same polarity at the same instant.

6.5 The voltage transformers shall be delivered packed in wooden crates firmly bound and closely together to avoid damage to the CVT and its porcelain insulator during transportation and storage.

7. DOCUMENTATION

7.1 The bidder shall submit its tender complete with technical documents required by Annex A (Guaranteed Technical Particulars) for tender evaluation. The technical documents to be submitted (all in English language) for tender evaluation shall include the following:

a) Guaranteed Technical Particulars;
b) Copies of the Manufacturer's catalogues, brochures, drawings and technical data;
c) Sales records for the last ten years and at least four customer reference letters;
d) Details of manufacturing capacity and the manufacturer's experience;
e) Copies of required type test and special test reports by a third party testing laboratory accredited to ISO/IEC 17025; the Type Test & Special Test Reports shall not be more than five years old.
f) Copy of accreditation certificate for the testing laboratory.

7.2 The successful bidder (supplier) shall submit the following documents/details to The Kenya Power & Lighting Company for approval before manufacture:

a) Guaranteed Technical Particulars,
b) Design Drawings with details of capacitor voltage transformer to be manufactured for KPLC,
c) Quality assurance plan (QAP) that will be used to ensure that the design, material, workmanship, tests, service capability, maintenance and documentation will fulfil the requirements stated in the contract documents, standards, specifications and regulations. The QAP shall be based on and include relevant parts to fulfil the requirements of ISO 9001:2008
d) Detailed test program to be used during factory testing,
e) Marking details and method to be used in marking the voltage transformers,
f) Manufacturer's undertaking to ensure adequacy of the design, good engineering practice, adherence to the specification and applicable standards and regulations as well as ensuring good workmanship in the manufacture of the voltage transformers for The Kenya Power & Lighting Company
g) Packaging details (including packaging materials and their dimensions).

7.3 A set of three (3) original hard cover installation and technical manuals for the voltage transformers shall be supplied with the equipment during delivery.

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ANNEX A: Guaranteed Technical Particulars *(to be filled and signed by the Manufacturer and submitted together with relevant copies of the Manufacturer's catalogues, brochures, drawings, technical data, sales records, four customer reference letters, details of manufacturing capacity, the manufacturer's experience and copies of complete type test certificates and type test reports for tender evaluation, all in English Language)*

Tender No .....

Clause Number	Description	**Bidder's Offer** *(indicate details of the CVT offered)*
-	Name of the Manufacturer, address and Country of manufacture	
	Name & address of Bidder	
	Type/Model Number offered	
Clause Number as per specification *(please refer to the specification)*		
1.	Scope	
	It shall be the responsibility of the supplier to ensure adequacy of the design, good engineering practice, adherence to the specification and applicable standards and regulations as well as ensuring good workmanship in the manufacture of the voltage transformers for The Kenya Power & Lighting Company	
2	Applicable Standards	
3	Terms and Definitions	
4.1.1	Site Conditions	
4.1.2	System Conditions	
4.2.1	Design Standard	
4.2.2	Materials	
4.2.3	Variations of load & voltage	
4.2.4	Rain water	
4.2.5	Outdoor, oil insulated & hermetically sealed type	
	Insulator portion of brown porcelain	
4.2.6	Vertical installation on a steel structure	
4.2.7	All parts & components to be corrosion resistant	
4.2.8	Primary, secondary and earth terminals	
4.2.9.1	Primary terminal to be high conductivity copper, tin plated	
4.2.9.2	Primary terminal to have palm clamp connector clamp suitable for conductor overall diameter of 18.3mm to 25mm and tubes of 76.2mm diameter	

Clause Number	Description		Bidder's Offer *(indicate details of the CVT offered)*
4.2.9.3	The voltage to be transformed shall be applied to the primary terminal		
4.2.10.1	Secondary terminals wired to terminal box		
4.2.10.2	Terminal box shall be weather-proof with cable plate at bottom		
4.2.10.3	The secondary shall supply the voltage circuits of measuring instruments, meters, relays or similar apparatus		
4.2.10.4	The secondary terminal box of the voltage transformer shall be complete with protection fuses complete with fuse links		
4.2.11	Short-circuit withstand, 1 s		
4.2.12	Ferro-resonance		
4.2.13	Tightness		
4.3	**RATINGS**		
a)	Nominal Primary Voltage		
b)	Nominal Secondary Voltage		
c)	Rated Frequency		
d)	Minimum Creepage Distance of Insulator		
e)	Lightning impulse withstand voltage, primary winding (kV_p)		
f)	Power frequency withstand voltage, primary winding, r.m.s, dry		
g)	Power frequency withstand voltage, secondary winding, r.m.s.		
h)	Maximum temperature rise	Windings	
		Oil (at top of tank)	
i)	Rated Voltage Factor	Continuous	
		30 seconds	
j)	Permissible partial discharges (PD)	PD test voltage (rms) = U_m	
		PD test voltage (rms) = $1.2U_m/\sqrt{3}$	
k)	Transmitted overvoltage limits: peak value of applied voltage(U_p) = $1.6x\sqrt{2}xU_m/\sqrt{3}$, Wave-shape characteristics: conventional front time (T_1) = 0.5µs ±20%, time to half value (T_2) ≥50µs; as per IEC 60044-5 (peak value limits)		

Clause Number	Description		Bidder's Offer *(indicate details of the CVT offered)*
l)	Radio interference voltage at $1.1U_m/\sqrt{3}$ as per IEC 60044-5		
m)	Secondary Windings (indicate terminal markings, voltage output, class & VA rating at 0.8pf lagging)	Core 1	
		Core 2	
		Core 3	
4.4.1	Quality Assurance Plan to be based on ISO 9001:2008		
4.4.2	Declaration of conformity to IEC 60044-5		
	Copy of ISO 9001:2008 certificate submitted		
4.4.3	Customer reference list for last ten years and four customer reference letters		
	Manufacturer's experience		
	Manufacturer's capacity (number of units per month)		
5.1	Test Standard		
	Responsibility of testing of transformer & manufacturer's capability to test		
5.2	Copies of type test and special test reports to IEC 60044-5 submitted with tender for evaluation shall not be more than five years old and shall include: -Accuracy check; -Temperature rise test; -Capacitance and tanδ measurement at power-frequency; -Chopped impulse test; -EMC radio interference voltage (RIV) tests; -Short circuit withstand capability test; -Lightning impulse test; -Wet test for outdoor type transformers with AC voltage; -Transient response test; -Ferro-resonance test; -Tightness of electromagnetic unit; -Accuracy tests. -Measurement of the transmission factor of high frequency overvoltages; -Mechanical strength test; -Determination of the temperature coefficient; -Tightness design test of capacitor units.		

Clause Number	Description		Bidder's Offer *(indicate details of the CVT offered)*
	The type test reports shall include the results of the routine tests as per clause 8.1 of IEC 60044-5.		
5.3	Tests to IEC 60044-5 to be carried out during Factory Acceptance Testing shall include: -Tightness of capacitor voltage divider; -Capacitance and tanδ measurement at power-frequency; -Power-frequency withstand test; -Measurement of partial discharges; -Verification of terminal markings; -Power-frequency withstand tests on the electromagnetic unit; -Power-frequency withstand test on low voltage terminal; -Power-frequency withstand tests on secondary winding; -Ferro-resonance check; -Accuracy check (determination of errors); -Chopped impulse test on primary winding; -Transmitted overvoltage measurement; -Visual inspection of complete voltage transformer; -The protection cores of the CVT shall be tested in accordance with IEC 60044-5 for limits of voltage error and phase displacement as well as transient response. -The measuring core of the CVT shall be tested in accordance with IEC 60044-5 for limits of voltage error and phase displacement as well as tests for accuracy.		
5.4	Inspection and test by KPLC during delivery by supplier before acceptance to stores		
6.1	Marking	Items to be marked to include those required by clause 6.1 of this specification	
		Method of marking to ensure it is permanent and legible	
6.2	The terminals shall be marked clearly and indelibly and in accordance with IEC 60044-5. The terminal marking shall consist of letters followed by numbers.		

Clause Number	Description	**Bidder's Offer** *(indicate details of the CVT offered)*
	The letters shall be in block capitals.	
6.3	Letters A, B, C denote fully insulated primary winding terminals and the lower-case letters a, b, c and n denote the corresponding secondary terminals. Letters da and dn denote the terminals of windings intended to supply a residual voltage	
6.4	Terminals having corresponding capital and lower-case markings shall have the same polarity at the same instant	
6.5	Each voltage transformer shall be packed in wooden crate firmly bound and closely together to avoid damage to the CVT including its porcelain insulator during transportation and storage	
7.1	List of documents submitted with tender for evaluation	
7.3	List of documents to be submitted by supplier to KPLC for approval before manufacture	
7.4	A set of three (3) original hard cover installation and technical manuals for the instrument transformers shall be supplied with the equipment during delivery	
Other details required with the tender	Weight of the complete capacitor voltage transformer, kg	
	Material of tank (to suit stated service conditions)	
	Weight of oil, kg	
	Weight of insulator, kg	
	Manufacturer's warranty and guarantee for the complete capacitor voltage transformer	
	Manufacturer's Letter of Authorization	
	Deviations from tender specifications (indicate supporting documents submitted)	

Manufacturer's Name, Signature, Stamp and Date

ANNEX B: Details for carrier-frequency accessories for power line carrier-frequency (PLC) application

Coupling Capacitors

Coupling capacitors using capacitor voltage transformers and lattice steel structures to be provided shall be suitable for mounting line traps on them. The capacitor shall have a rated capacitance of not less than12700pF, phase to phase, an impulse withstand voltage of 650Kv respectively and meet the insulation level and test voltage equivalents of IEC recommendation for the devices, (IEC 60358 coupling capacitors and capacitor dividers).

The coupling devices shall de designed for outdoor installation and shall provide impedance matching between terminal equipment and the transmission line for maximum PLC signal energy transfer. The coupling device shall comprise:

- Tuning device
- Line matching unit (transformer),
- Drain coil
- Protection device (lighting arrestor on primary and secondary sides),
- Grounding switch and all connecting accessories

The 'ON' (grounded) and 'OFF' position of the grounding switch shall be clearly visible from the outside of the device.

The coupling units shall be suitable for a carrier frequency range of 30 to 500 kHz.

The line side impedance of the device shall be matched in such a range that inter-modulation with the final amplifier is reliably prevented. The nominal equipment side impedance shall be 75 Ohms (unbalanced or 150 Ohms (balanced).

The coupling device shall be fitted with a rating plate according to IEC 60481. Additionally, thee type and capacity of the coupling capacitor for re-tuning and re-strapping, shall be indicated on a permanently attached plate.