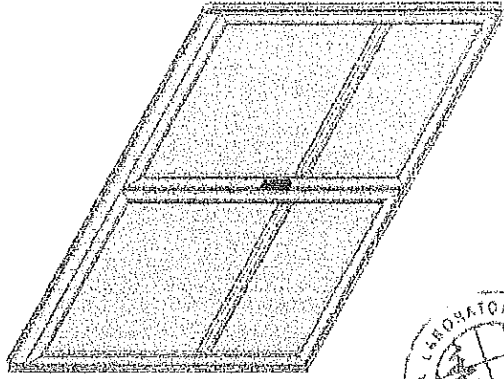
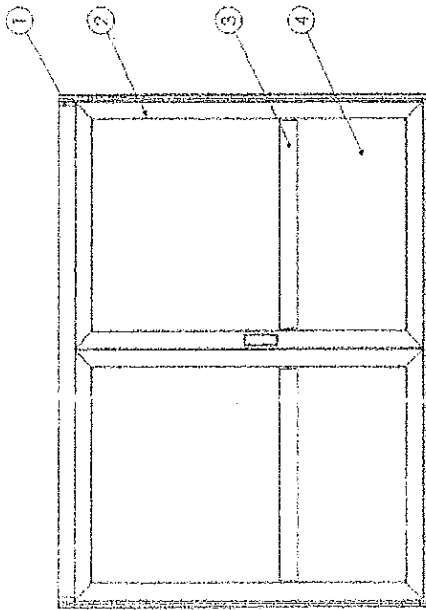


Handwritten mark



High Power Laboratory (HPL)
Date: Oct. 02. 2013



- 1. Frame
- 2. Outside opening doors/sash
- 3. Transom
- 4. Sandwich panel /alum. sheet + styrofoam + alum. sheet/

"PAVEL and SONS electric" Ltd.
Shumen city, Bulgaria

Scale: 1:50
Weight: 138,922
Number: 13002

Sheet: 1/14
CCTS 20/0.4KV 2x1000kVA

Doors - MV
switchboard



На основание чл. 2
от ЗЗЛД

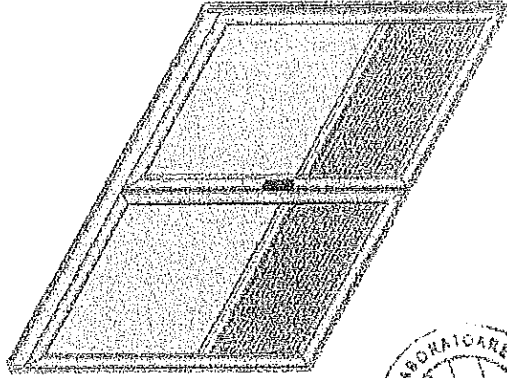
11
20
CH
SI

Handwritten signature

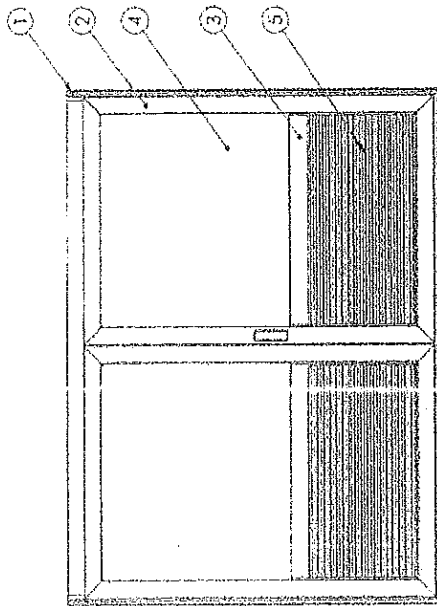


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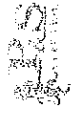


High Power Laboratory
Sofia, Bulgaria
Date: 07.05.2013



- 1. Frame opening doors/sash
- 2. Gaskets
- 3. Transom
- 4. Aluminium sheet
- 5. Ventilation grill

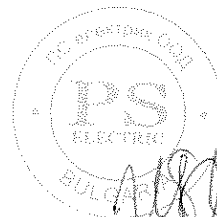
Scale: 1:50
 Weight: 102.524
 Number: 13002
 Sheet: 6/14
 "PAVEL and SONS electric" Ltd.
 Shumen city, Bulgaria
 CCTS 20/0.4KV 2X1000kVA
 Doors - LV
 switchboard



На основание чл. 2 от ЗЗЛД

...use
cont
Chit
Sign

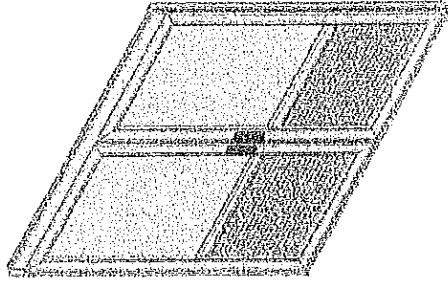
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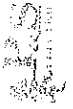


High Power Laboratory
Date: 08.02

scale 1:50 weight 80.342 number 13002
"PAVEL and SONS electric" Ltd.
Shumen city, Evlgaria

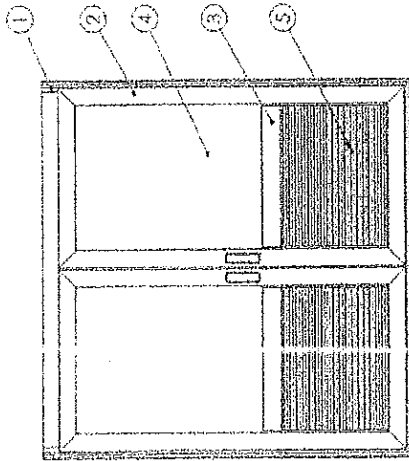
7/14 CCTS 20/0.4KV 2x1000KVA

Doors -
Transformers



На основание чл. 2
от ЗЗЛД

№ 1
com
City
Site

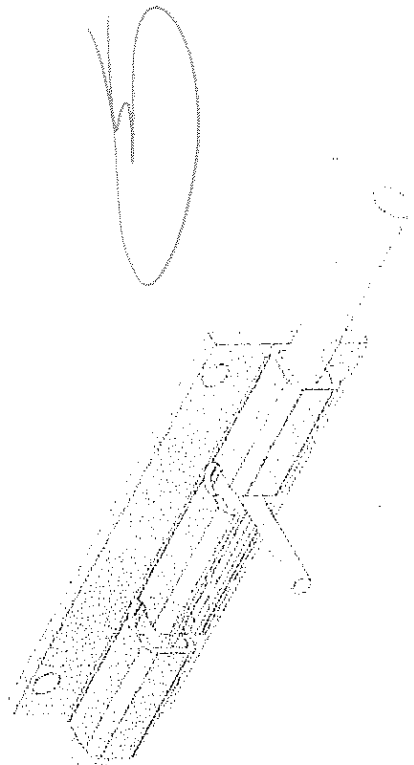


- 1. Frame
- 2. Outside opening doors/sash
- 3. Transom
- 4. Aluminium sheet
- 5. Ventilation grill

ВАРНО С
ОРИГИНАЛА



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scale 1:50 weight 0,261 number 13002 client "PAVEL and SONS electric" Ltd. Shumen city, Bulgaria
 sheet 8/14 CCTS 20/0.4KV 2X1000KVA

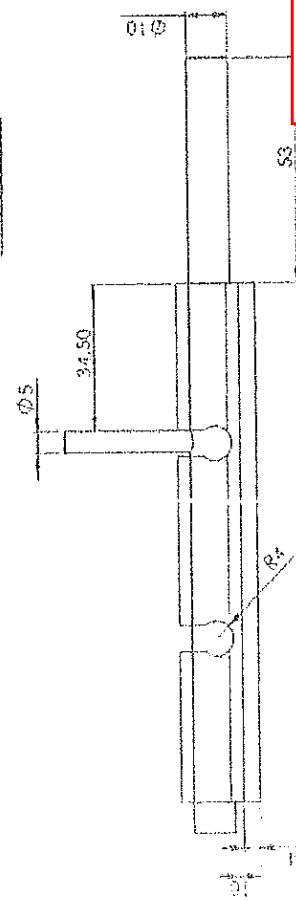
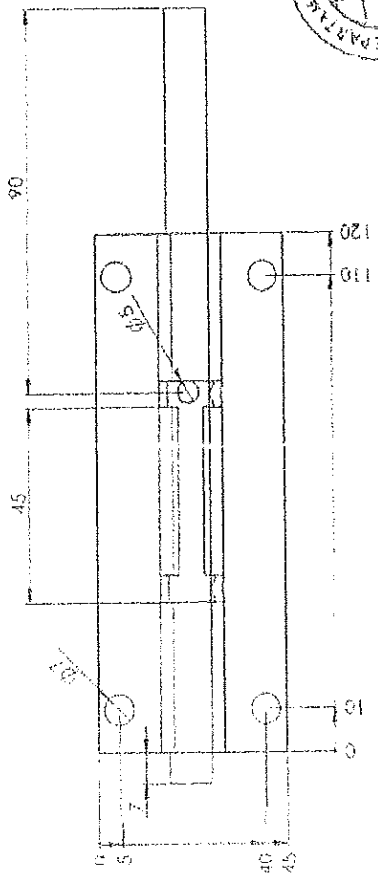
Latch



На основание чл. 2
от ЗЗЛД

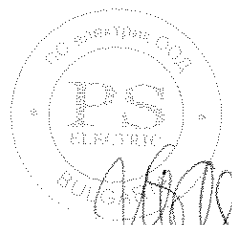


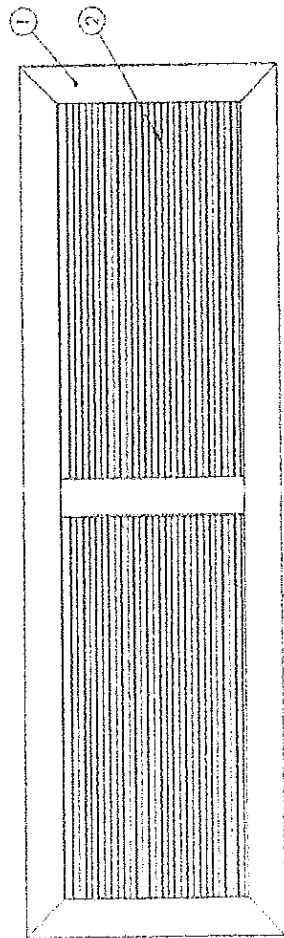
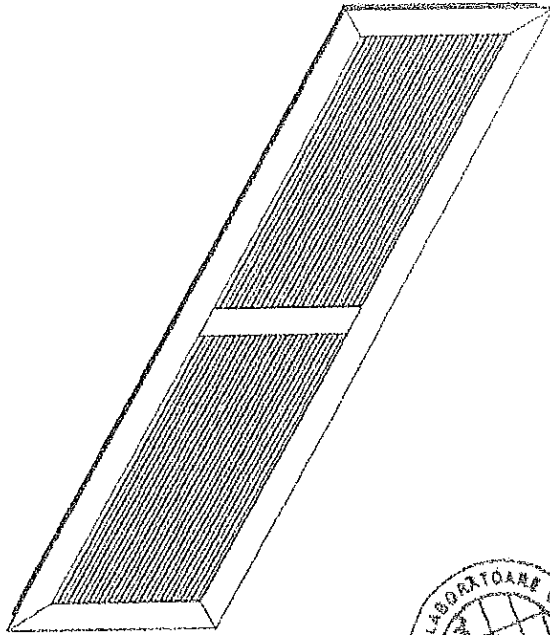
High Power Laboratory (HPL)
Date: 07-02-2017



abs. comp. Client Sign.

ВАРНО С
ОРИГИНАЛА





- 1. Frame
- 2. Ventilation grill



High Power Laboratory
Date: 08.02.2014

scale 1:50
weight 37.032
number 13002
sheet 9/14
"PAVEL and SONS electric" Ltd.
Shumen city, Bulgaria
CCTS 20/0.4KV 2x1000kVA

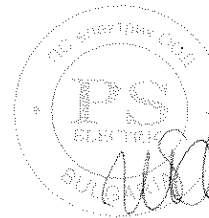
Ventilation grill



На основание чл. 2
от ЗЗЛД

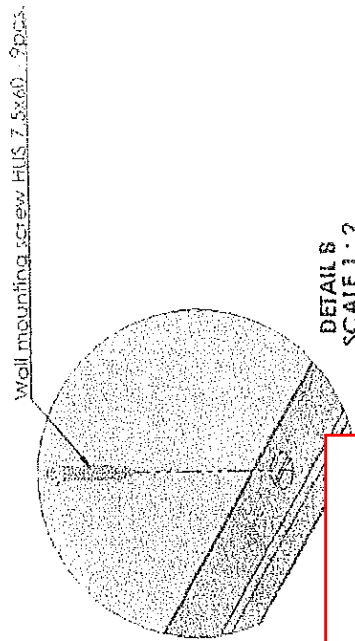
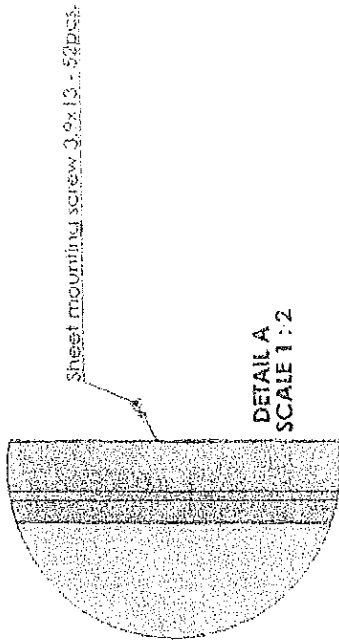
con
City
Sig

ВЯРНО С
ОРИГИНАЛА



Handwritten signature

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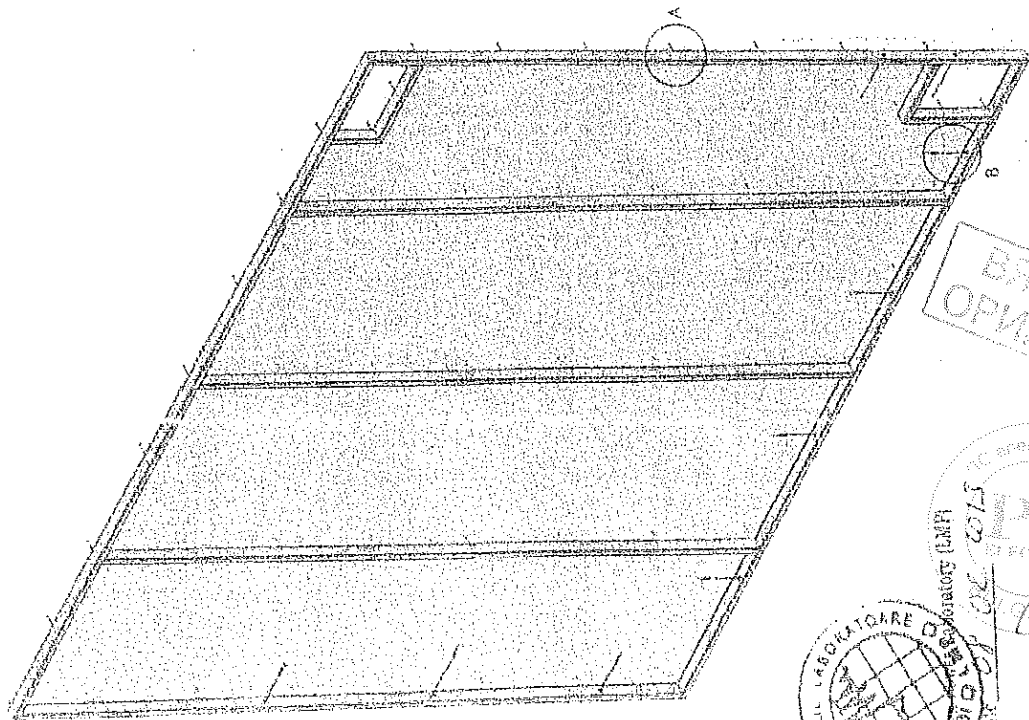


weight number "PAVEL and SONS electric" ttd. Shumen city, Bulgaria
56.291 13002

CCTS 20/0.4kV 2x1000kVA

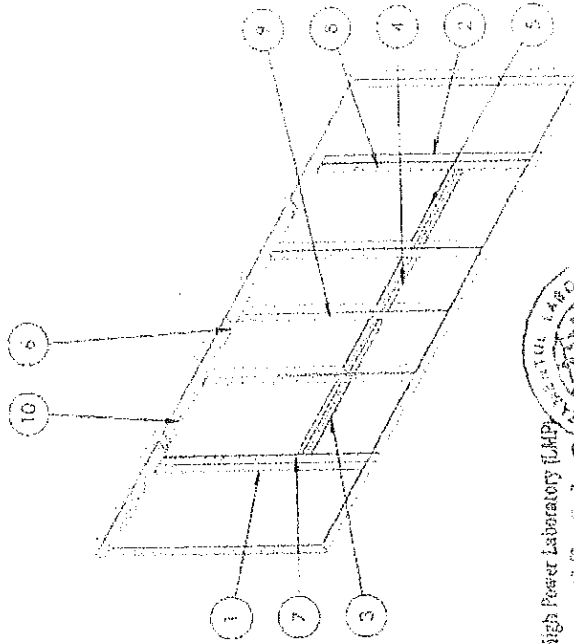
Metal barrier - mounting

На основание чл. 2 от ЗЗЛД



ВАРНО С ОРГИНИАЛА

ICMET
LABORATOIRE DE RECHERCHES
DEPARTMENT OF ELECTRICAL ENGINEERING
ICMET
LABORATORY (LMI)
2013
ICMET
LABORATORY (LMI)
DEPARTMENT OF ELECTRICAL ENGINEERING



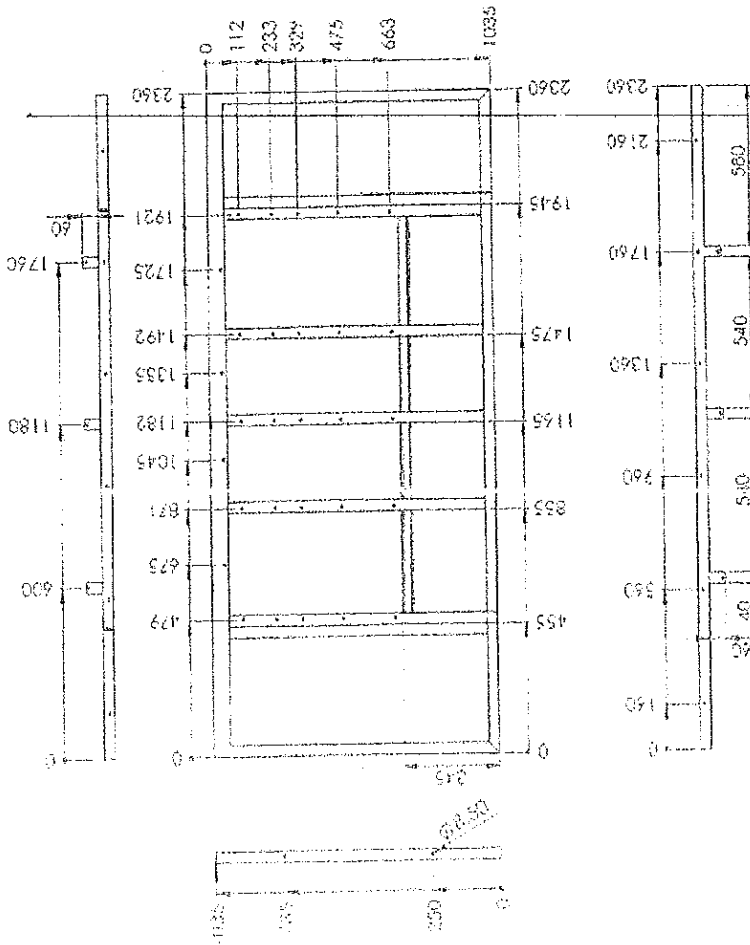
High Power Laboratory (HPL)
 Date: 08.02.2014

weight number "PAVEL and SONS electric" Ltd.
 39.637 13002 Shumen city, Bulgaria

CCTS 20/0.4kV 2x1000kVA

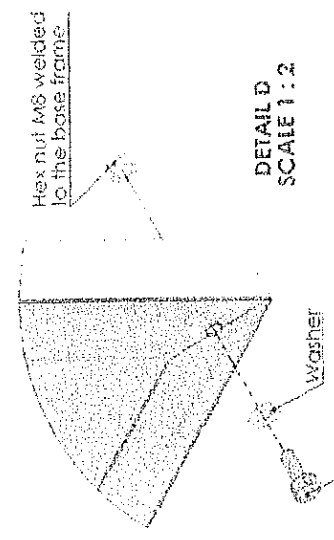
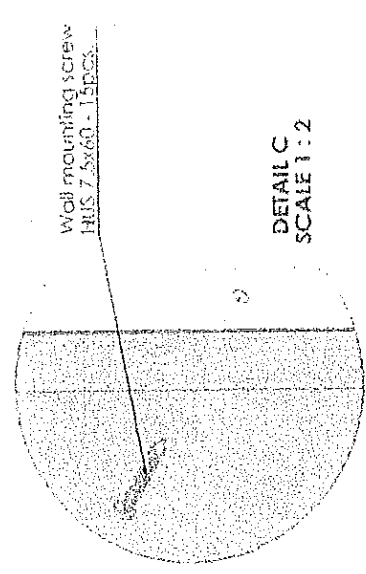
Base frame of RMU

На основание чл. 2 от ЗЗЛД



ITEM NO.	DESCRIPTION	LENGTH	QTY.
1	1 40 X 40 X 4	1033.34	1
2	1 40 X 40 X 4	1035	1
3	TUBE SQUARE 40 X 40 X 4	436.79	1
4	TUBE SQUARE 40 X 40 X 4	305.34	2
5	TUBE SQUARE 40 X 40 X 4	428.34	1
6	Sheet		
7	1 40 X 40 X 4	1035	1
8	1 40 X 40 X 4	1033.34	2
9	1 40 X 40 X 4	1033.34	2
10	1 60 X 40 X 4	670	1

10



Hex screw M8x20

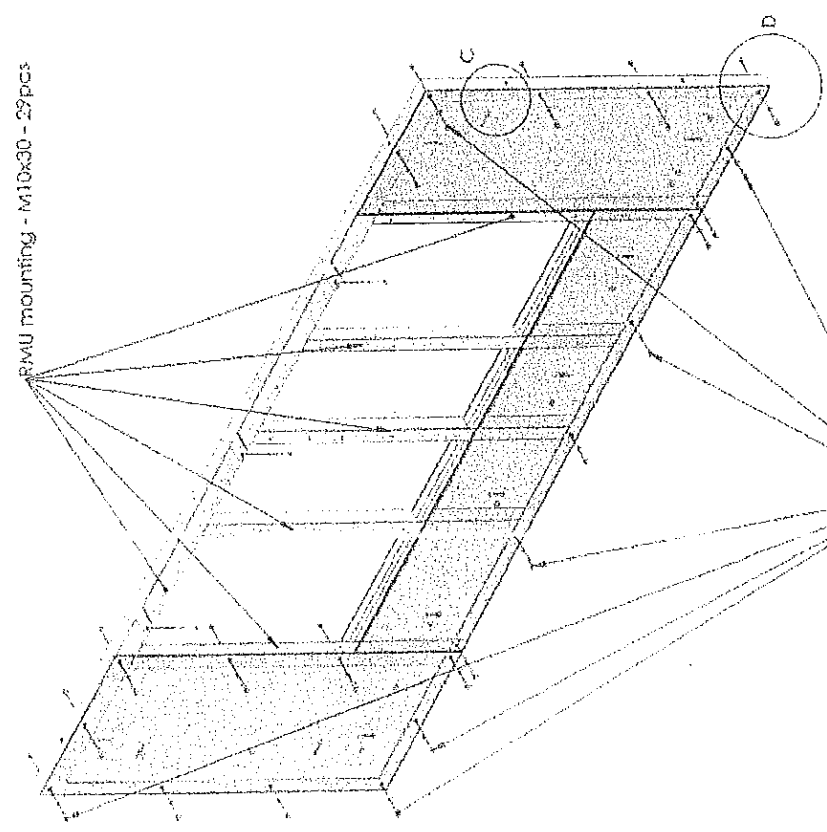
weight number "PAVEL and SONS electric" Ltd.
56.411 13002 Shumen city, Bulgaria

CCIS 20/0.4kV 2x1000kVA

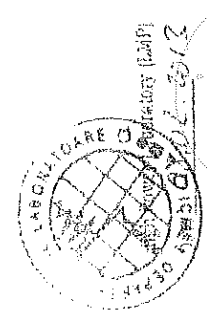
Base frame of RMU - mounting



На основание чл. 2
от ЗЗЛД

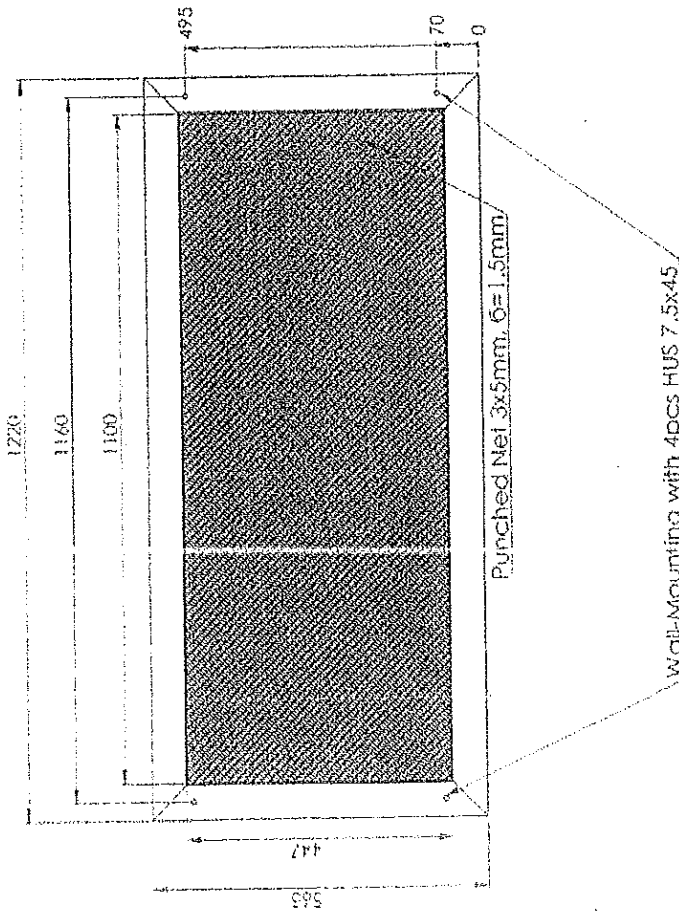
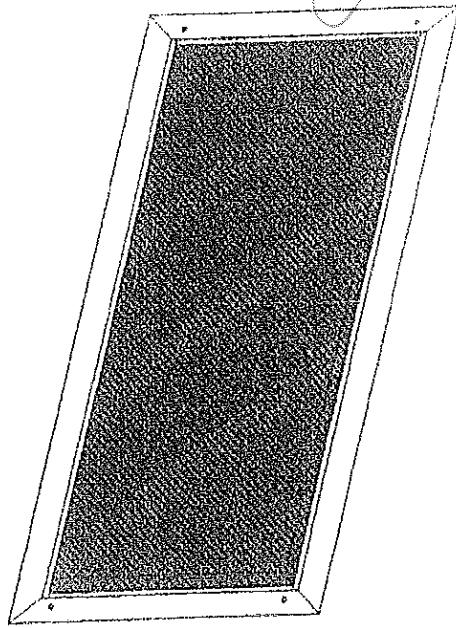


ВЪРНО С
ОРИГИНАЛ



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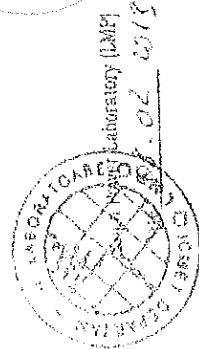
Scale: 1:50
 Weight: 2.398
 Number: 13002
 Manufacturer: "PAVEL and SONS electric" Ltd.
 Shumen city, Bulgaria

3/14 CCIS 20/0.4KV 2X1000KVA

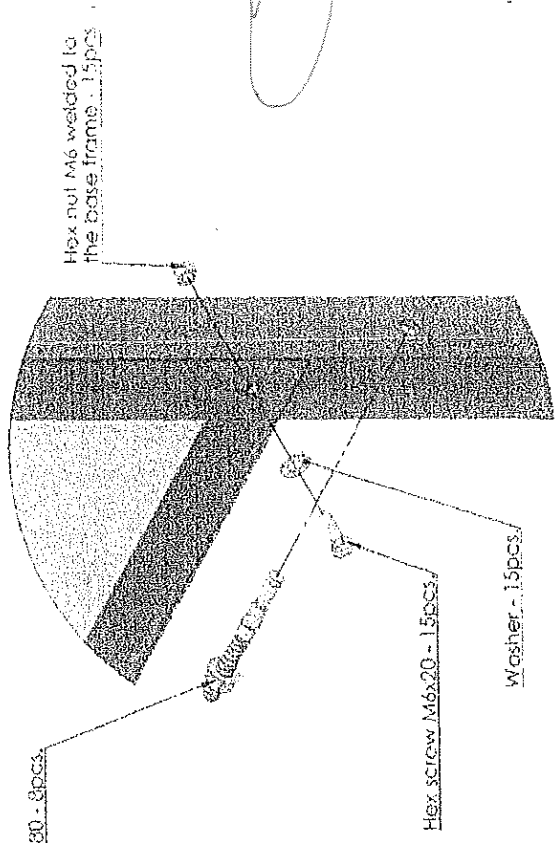
Ventilation grill
 for SF6

На основание чл. 2
 от ЗЗЛД

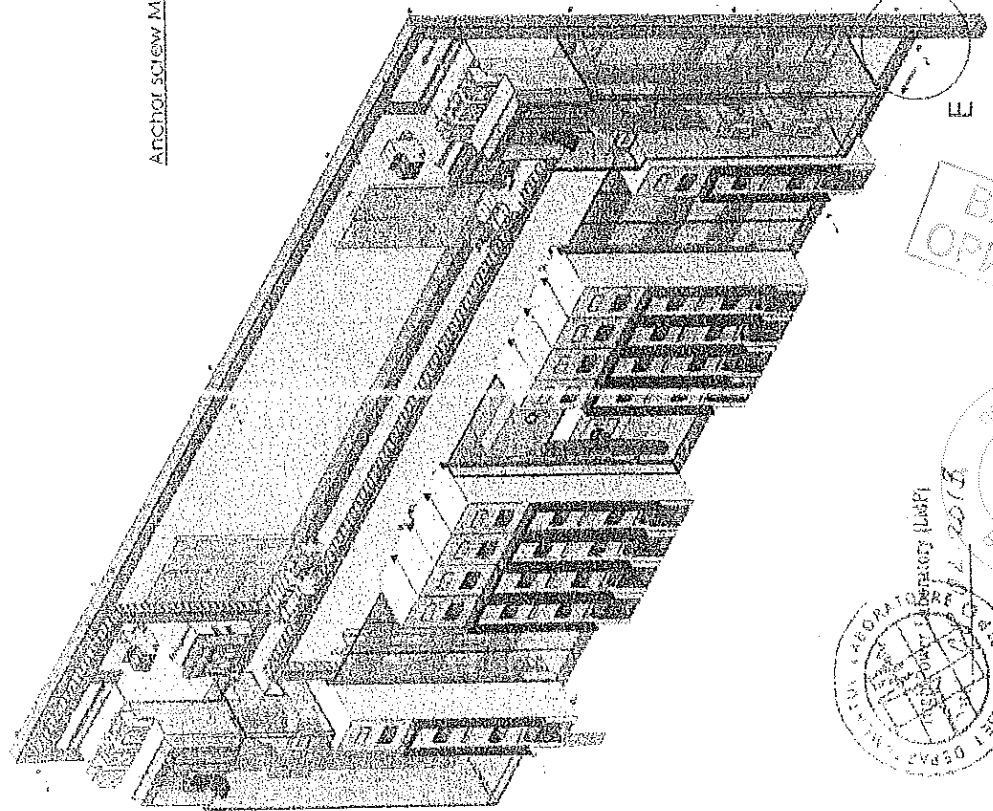
ВЯРНО С
 ОРИГИНАЛА



DETAIL E
SCALE 1 : 2



Anchor screw M8x80 - 8 pcs



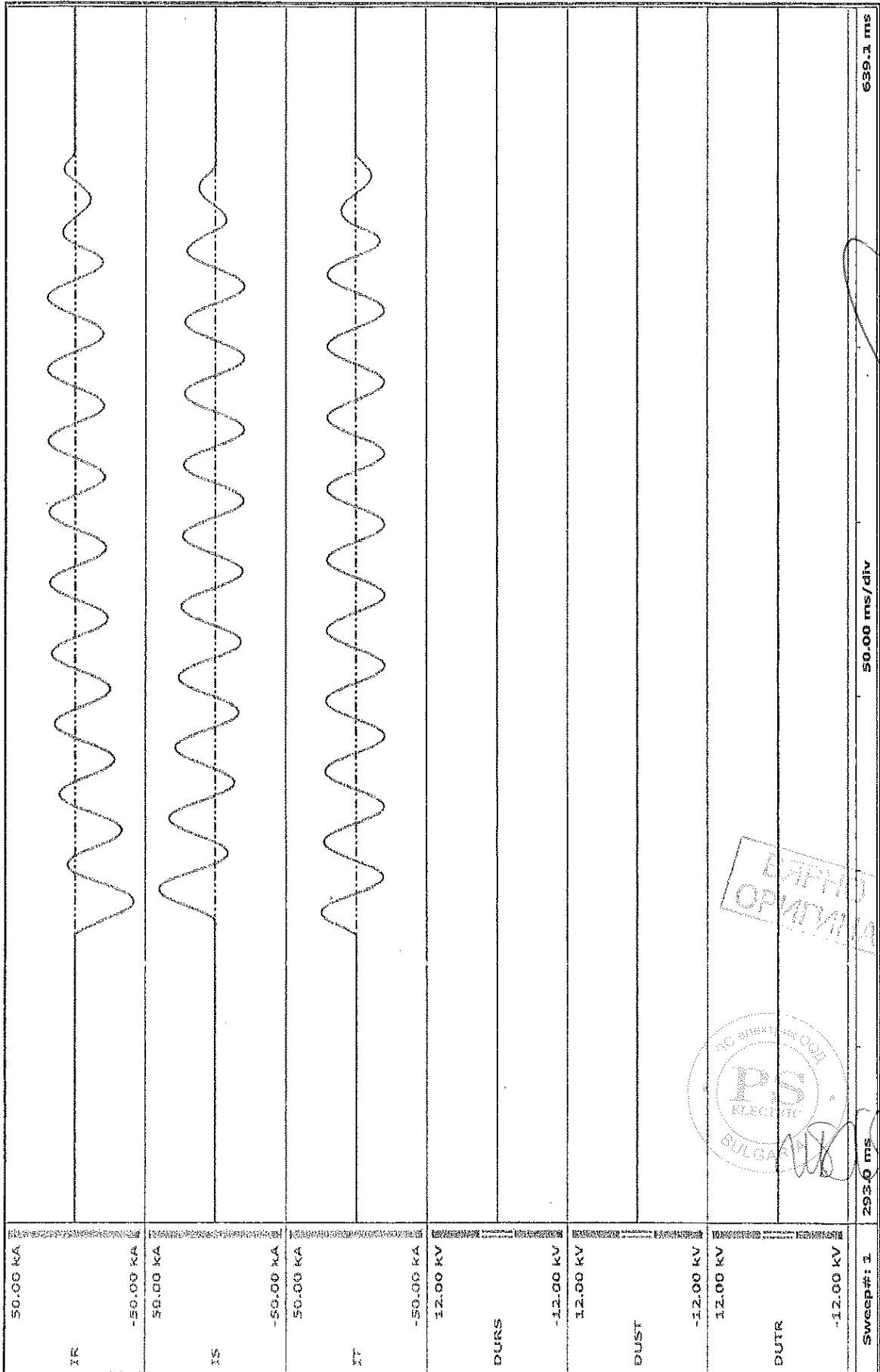
et has
 weight number
 13002
 "PAVEL and SONS electric" Ltd.
 Shumen city, Bulgaria
 1/14 CCTS 20/0.4KV 2x1000KVA

LV switchboard -
mounting

На основание чл. 2
 от ЗЗЛД

ВАРНО С
 ОПРИГАНАА

PS ELECTRIC
 BULGARIA
 DEPT. OF ELECTRICITY
 13002

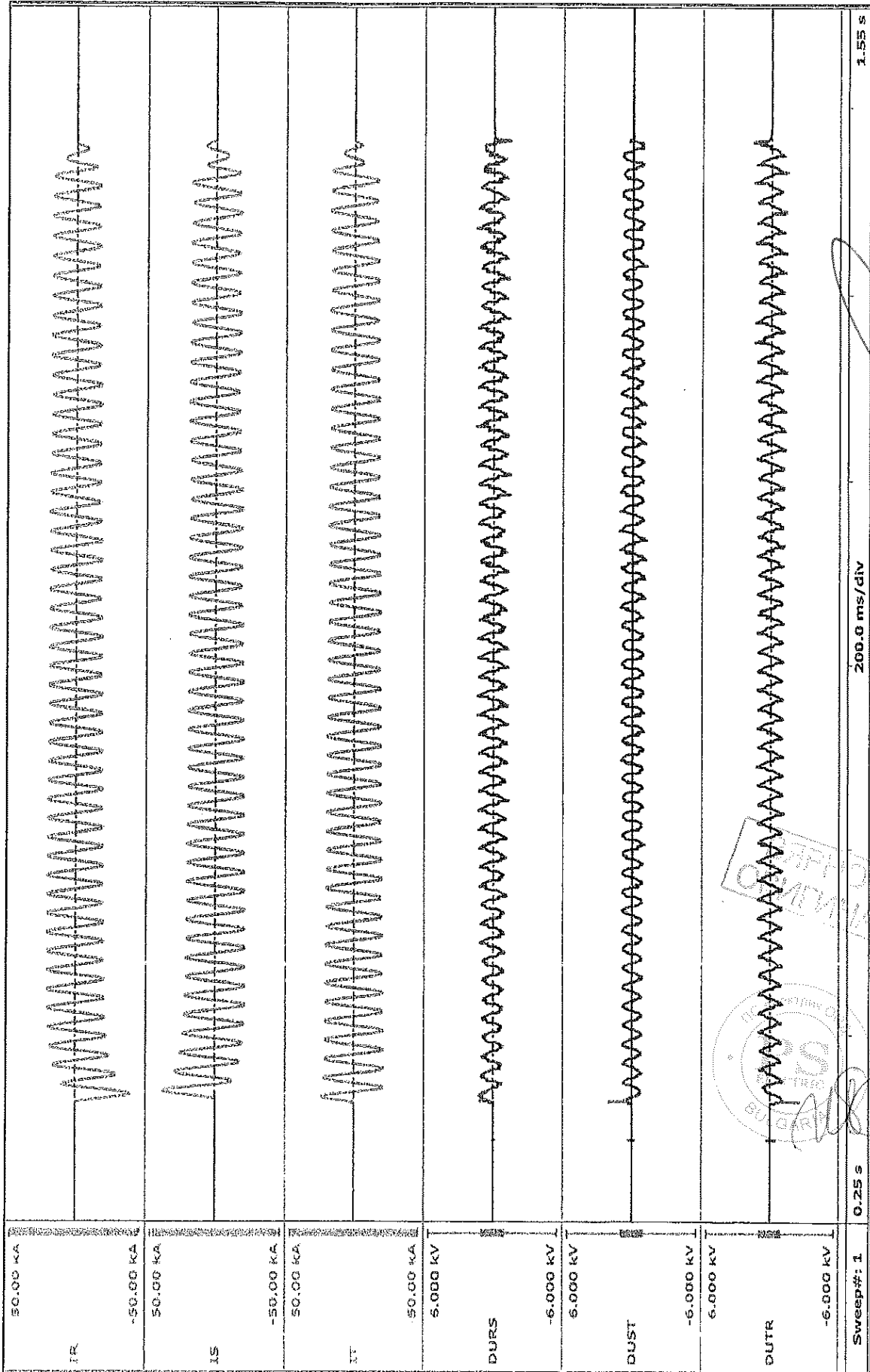


Oscillogram No. 84780 / 2013

БЪЛГАРСКО
ОПРИТЕЛСТВО

ПС
ELECTRIC
BULGARIA

6

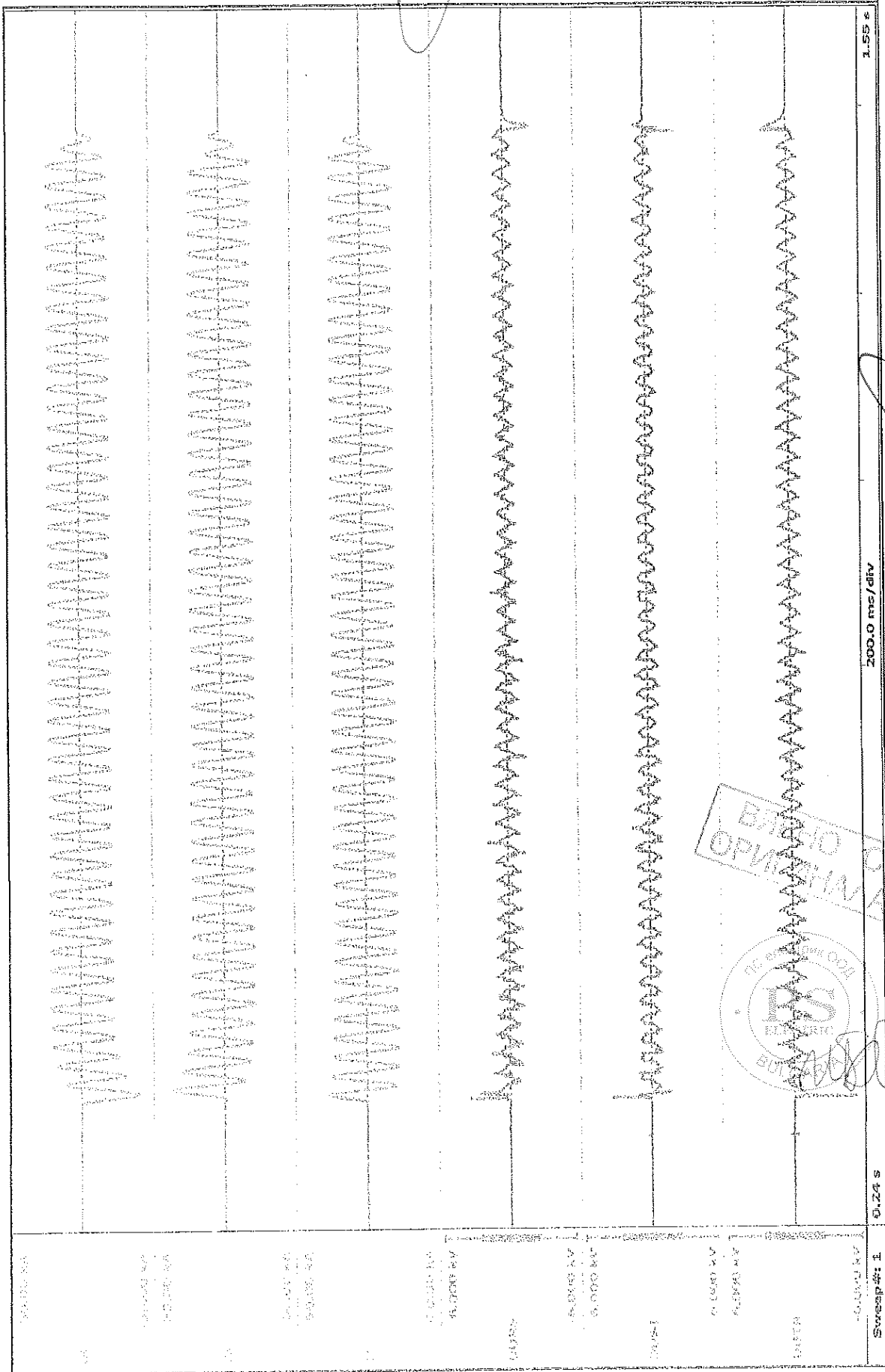


Oscillogram No. 84781 / 2013

Stamp: BUREAU NATIONAL DE METROLOGIE
Stamp: LABORATOIRE NATIONAL DE METROLOGIE
Stamp: C

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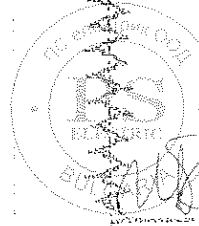
1.55 s

200.0 ns/div

0.24 s

Store #1

EMERGENCY OPERATIONS



Oscillogram No. 84782 / 2013



RESEARCH, DEVELOPMENT
AND TESTING NATIONAL
INSTITUTE FOR ELECTRICAL
ENGINEERING

INCERCARE



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Nr. 450 - L

ICMET CRAIOVA

HIGH VOLTAGE DIVISION – HVD

ELECTROMAGNETIC COMPATIBILITY LABORATORY – EMC Laboratory

Calea București Nr.144, 200515 Craiova, ROMANIA

Phone: + 40 351 402425, 404888, 404889; Fax: + 40 251 415482, 351 404890

www.icmet.ro, e-mail: market@icmet.ro

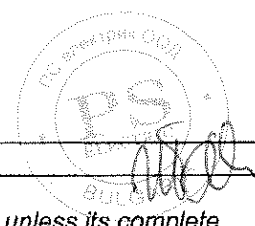
TEST REPORT

No. 41578 / 09.05.2008

1. **Customer:** Pavel & Sons Ltd.
2. **Customer's address:** Central office: 9700, Shumen - BULGARIA
3. **Manufacturer:** Pavel & Sons Ltd.
4. **Manufacturer's address:** Central office: 9700, Shumen - BULGARIA
5. **EUT:** Prefabricated Transformer Substation 20/04 kV, 2 x 800 kVA type BM 02, Serial no. 08126/2008
6. **Tests:**
 - Measurement of electric field
 - Measurement of magnetic field
7. **Test date:** 06.05.2008, 07.05.2008
8. **Test standard:** European Directive 2004/40/EC
9. **Test result:** The Results will be declared
10. **The Test Report contains 6 pages and was edited in 4 copies of which 3 copies for Customer.**

На основание чл. 2
от ЗЗЛД

О С
НАМ



CAUTIONS:

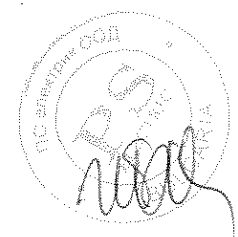
- a. The results refer to test product only.
- b. Publication or reproduction of the content of this report in any other form unless its complete photocopying is not allowed without the written approval of the division the laboratory belongs to.
- c. Accreditation of the Laboratory or any of its Test Reports issued in accreditation regime do not constitute or imply, themselves, an approval of the product by the accreditation body



Contents

1. General information about EUT	3
1.1. Description of the EUT	3
1.2. Technical data	3
1.3. Operating modes used for the test.....	3
1.4. Test Standard	3
2. Measuring results	3
2.1. Results of the electric field strength measurement	3
2.2. Results of the magnetic field strength measurement	4
3. Appendix	5

ВЯРНО С
ОРИГИНАЛА



**1. General information about EUT****1.1 Description of the EUT:**

Type of EUT: Prefabricated Transformer Substation 20/04 kV; 2 x 800 kVA
 Model: BM 02
 Serial number: 08126 / 2008

1.2 Technical data:

Rated voltage: 20 kV
 Rated power: 2 x 800 kVA
 Dimensions: 4400 x 2600 x 2830 mm

1.3 Operating modes used for the test:

- 1.3.1 During the electric field measurement the EUT was supplied at rated voltage.
 1.3.2 During the magnetic field measurement the EUT was supplied at rated current.

1.4 Test Standard

Directive 2004/40/EC of the European Parliament and of the Council of 29 April 2004, on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)

2. Measuring results**2.1 Results of the electric field strength measurement****General information about the test:**

Tested by:	Eng. Paul Nicolescu <i>PN</i>
Test date:	06.05.2008

Measuring instruments:

Description	Manufacturer	Type	Serial
EM Field analyzer	Narda Safety Test Solution GmbH, Germany	EFA-300	S-0007
E-Field Unit (EFA-300)	Narda Safety Test Solution GmbH, Germany	BN 2245/90.31	P-0003

Environmental conditions:

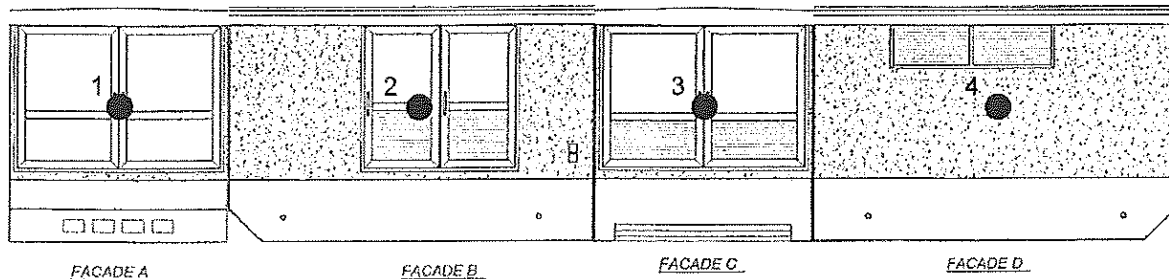
Parameter	Rated value	Measured value
Ambient temperature:	0 °C ÷ 50 °C	(14.8 ± 0.1) °C
Atmospheric pressure:	unspecified	1007 mbar
Relative humidity:	5 % ÷ 85 %	64 %

Test plan:

Test set-up:	E-Field unit of EFA 300 EM Field Analyzer was placed at 1 m height in central part of each side of the EUT. The maximum value over 6 minutes period was measured
Operating modes:	According 1.3.1
Distance between EUT and E-Field unit:	1 m

Test procedure:

It was measured the electric field strength using the EFA 300 EM field analyzer and E-Field unit.
 The measurement was performed on each side of the EUT.

**Measuring points:****Measuring results:**

Measuring point	1	2	3	4
Measured value E (V/m)	4.08	7.48	4.09	4.21
Percent of limit imposed by 2004/40/EC (%)	0.04	0.07	0.04	0.04

Result: The maximum value of electric field strength measured was 7.48 V/m and it was obtained in the point number 2 shown on the above drawing.

The measurement uncertainty is ± 3.4 dB. The reported uncertainty is an expanded uncertainty, based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a confidence level of approximately 95 %.

2.2 Results of the magnetic field measurement**General information about the test:**

Tested by:	Eng. Paul Nicolescu <i>PN</i>
Test date:	07.05.2008

Measuring instruments:

Description	Manufacturer	Type	Serial
EM Field analyzer	Narda Safety Test Solution GmbH, Germany	EFA-300	S-0007

Environmental conditions:

Parameter	Rated value	Measured value
Ambient temperature:	0 °C ÷ 50 °C	(18.5 ± 0.1) °C
Atmospheric pressure:	unspecified	1006 mbar
Relative humidity:	5 % ÷ 85 %	68 %

Test plan:

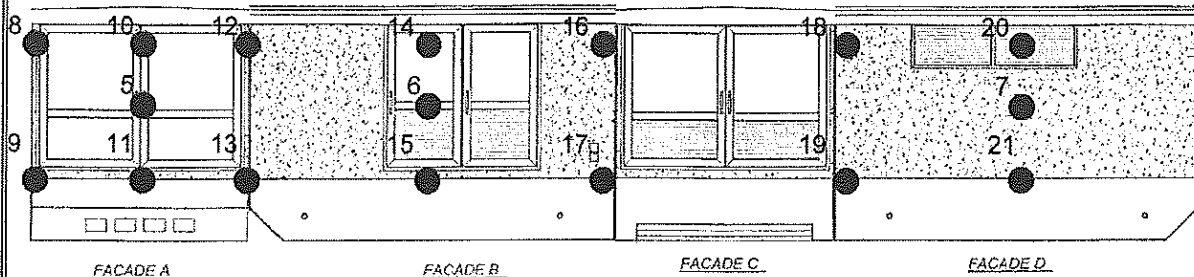
Test set-up:	EFA 300 EM Field Analyzer was placed at 1 m height from central part of three sides of the EUT (points 5 - 7); EFA 300 EM Field Analyzer was placed near the EUT (points 8 - 21); The maximum value over 6 minutes period was measured
Operating modes:	According 1.3.2
Distance between EUT and EM Field Analyzer:	1 m (points 5 - 7); 0,02 m (points 8 - 21)
Heights of points:	1 m (points 5 - 7) 2,7 m (points 8, 10, 12, 14, 16, 18, 20) 0,8 m (points 9, 11, 13, 15, 17, 19, 21)

Test procedure:

It was measured the magnetic induction using the EFA 300 EM field analyzer.
The measurement was performed on three sides of the EUT (the forth side was inaccessible).



Measuring points:



Measuring results:

Measuring point	5	6	7
Measured value B (μT)	6.88	21.67	22.99
Percent of limit imposed by 2004/40/EC (%)	1.37	4.33	4.59

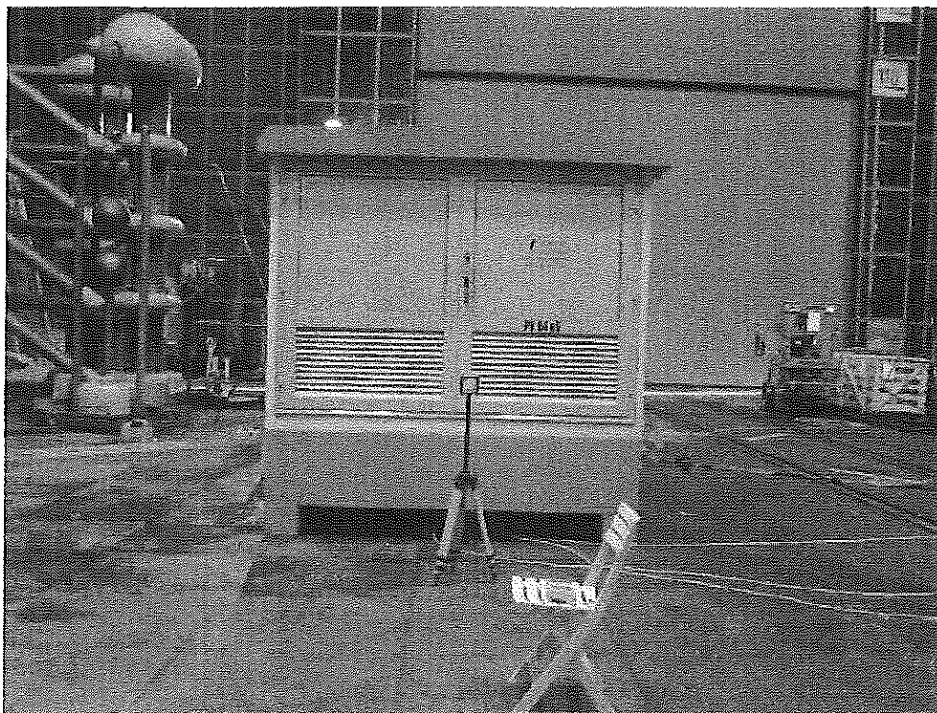
Measuring point	8	9	10	11	12	13	14
Measured value B (μT)	16.37	17.29	10.51	12.18	18.54	21.23	102.7
Percent of limit imposed by 2004/40/EC (%)	3.27	3.46	2.10	2.24	3.71	4.25	20.54

Measuring point	15	16	17	18	19	20	21
Measured value B (μT)	67.46	296.2	321.5	132.4	219.4	28.26	24.51
Percent of limit imposed by 2004/40/EC (%)	13.49	59.24	64.30	26.48	43.88	5.65	4.90

Result: The maximum value of magnetic induction measured was 321.5 μT and it was obtained in the point number 17 shown on the above drawing.

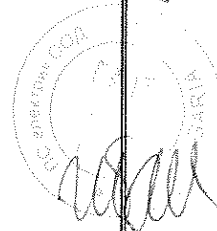
The measurement uncertainty is ± 3.3 dB. The reported uncertainty is an expanded uncertainty, based on a standard uncertainty multiplied by a coverage factor $k = 2$, providing a confidence level of approximately 95 %.

3. Appendix



Test set-up for measurement of electric field

ВЕРНО С
ВИТАНА



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Test set-up for measurement of magnetic field

ВЯРНО С
ОРИГИНАЛА

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RESEARCH-DEVELOPMENT AND TESTING NATIONAL
INSTITUTE FOR ELECTRICAL ENGINEERING

4.15

INCERCARE



ICMET CRAIOVA HIGH POWER DIVISION

SR EN ISO / CEI 17025: 2005
CERTIFICAT DE ACREDITARE
nr. LI 004 / 2007

HIGH POWER LABORATORY
"Ovidiu Rarinca"

200515-CRAIOVA Calea Bucuresti Nr. 144 ROMANIA
Phone: (351) 402 427; Fax: (251) 415482; (351) 404 890;
E-mail: lmp@icmet.ro

TEST REPORT No. 10179

CUSTOMER: PAVEL & SONS Ltd
Central office: 9700, Shumen BULGARIA

MANUFACTURER: PAVEL & SONS Ltd
Central office: 9700, Shumen BULGARIA

TESTED PRODUCT: 20/0.4 kV, 2x800kVA Prefabricated Transformer Substation made of reinforced concrete

REFERENCE STANDARD: IEC 62271-202/2006 clause 6.5

TEST PERFORMED: Functional tests

TEST DATE: 9.05.2008

TEST RESULT: Passed the tests

Report has 12 pages and it is edited in 4 copies from which 3 copies for customer.



HEAD OF HIGH POWER DIVISION:

HEAD OF LABORATORY:

На основание чл. 2
от ЗЗЛД

1. Results refer to test product only.
2. Publication or reproduction of the contents of this report in any other form unless its complete photocopying is not allowed without writing approval of division to which laboratory belong to.
3. Accreditation of the laboratory or any of its Test Reports issued under accreditation regime do not constitute or do not imply themselves an approval of the product by the accreditation body.

Content

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2.	Identification of the test product	3
2.1	Type	3
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2.3	Technical documentation/Drawing	3
2.4	Contract	3
2.5	Product receiving date	3
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3.	Technical characteristics checked by tests	3
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8.	Test results	4
9.	Annexes	5
9.1	Technical Specification	5
9.2	Drawings	7

ВЯРНО С
ОРИГИНАЛА



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1. PRESENT AT THE TESTS: Eng. Velimir Dimitrov and Eng. Dimitar Donchev from Pavel & Sons

2. IDENTIFICATION OF APPARATUS

	Substation	MV Cubicles	LV Switchboard
2.1 Type	BM 02	8DJ20 Sh.81	Compact
2.2 Serial number/year	08126/2008	CV 769630-000040/001/2008	-
2.3 Technical documentation / Drawing	See pages 5, 6 / 7-12		
2.4 Contract No.:	2167/09.03.2008		
2.5 Product receiving date:	05.05.2008		
2.6 Product condition at receiving:	New		

3. TECHNICAL CHARACTERISTICS CHECKED BY TESTS

	Substation	MV Switchboard	LV Switchboard
Rated power	2x800 kVA	-	-
Rated voltage	20/0.4 kV	24 kV	400 V
Rated current	-	630/200 A	2x1250 A
Rated frequency	50 Hz	50 Hz	50 Hz
Rated short - time withstand current:			
- peak value	40 kA	40 kA	84 kA
- r.m.s. value	16 kA	16 kA	40 kA
Rated duration of short-circuit (t_k)	1 s	1 s	1 s

4. TESTS PROGRAM

- 4.1 Operation of the switchgear and controlgear.
- 4.2 Mechanical operation of prefabricated substation doors.
- 4.3 Checking of the temperature and liquid level of the transformer.
- 4.4 Voltage indication check.
- 4.5 Fitting of earthing devices.
- 4.6 Replacement of fuses
- 4.7 Operation of the transformer tap-changer

Tests were performed according to own procedure PT 03-06.

5. RESPONSIBLE FOR TESTS: Eng. Dumitru Irimia

6. TEST REPORT DOCUMENTATION

Oscillograms	-;	Tables	-;
Photos	-;	Drawings	6

ВЯРНО С
ОРИГИНАЛА



B

7. FUNCTIONAL TESTS

7.1 Operation of the switchgear and controlgear

Manoeuvres were made with the medium and low voltage gear and were observed their correct operation.

7.2 Mechanical operation of prefabricated substation doors

Mechanical manoeuvres were performed with the substation doors and were observed their correct operation.

7.3 Checking of temperature and liquid level of the transformer

Oil level indicator and temperature indicators worked correctly.

7.4 Voltage indications check

The indications of medium voltage switchgear and controlgear voltage indicators were correct.

7.5 Fitting of earthing devices

Disconnectors of the medium voltage switchgear and controlgear worked correctly at close and clear operations.

7.6 Replacement of fuses

Fuses replacement has been easily made.

7.7 Operation of the transformer tap-changer

Tap-changer operation was correct on all five taps.

8. TEST RESULT: PASSED THE TEST

✓
PS

ВЯРНО С
ОРИГИНАЛА

PS
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Technical specification

Prefabricated transformer substation made of reinforced concrete

Type: BM02 20/0.4kV 2x800kVA
 Producer: "Pavel & sons" Ltd. , Shumen, Bulgaria
 Factory number: 08126

Casing: The casing of the Concrete Prefabricated Substation is made of water-tight reinforced concrete B45;

1.1 Measurements (roof included) :

L= 4600mm;B=2800mm;H=2830mm;

Weight with transformers: 20 800kg;

Equipment:

2.1.Equipment on the Middle Voltage side:

Complete distributing device - 8DJ20 Sh.81 2RK+2TR Siemens, which consists of cable "IN" 20kV,cable "OUT" and 2psc."Transformer protection".

2.2.Interconnections 20 kV from MV switchboard to transformers NA2X(F)2Y 3 x 1 x 50mm².

2.3.Transformer:

transformer 20/0.4kV 800 kVA

Dimensions:

L=1710mm.

W=1070mm.

H=1590mm.

2.4.Connecting cable from transformers to LV switchboard - NYY 3x(4x240mm²)+2x240mm².

2.5.Main circuit -breakers of LV switchboard - automatic circuit-breakers NS1250N Micrologic 2.0.

2.6.Terminals of LV switchboard - fuse-switch disconnecter MULTIVERT 630A-10 psc. "m.schneider Austria.

2.7. Sectional vertical switch disconnecter 1000A Jean Muller

2.7. Over-voltage protections 2psc., type: STH 3P Merlin Gerin:

I max.-65kA(20/8);

In-20kA(20/8);

Up=1.5kV;

Uc=275V;

2.8. Supply circuit-breaker of the overvoltage protection: MULTIBLOC 160A m.schneider Austria.

2.9. Copper bars' system:

Distributing rims - Copper bars 80/10mm.

Connection between main circuit - breaker and distributing rims - Copper bars 2x(50x10)mm.

Current transformer:

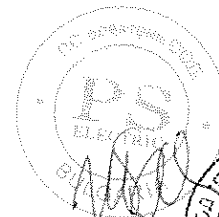
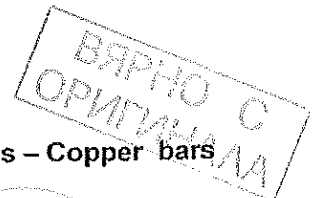
MAK 104/80 1250/5A

5VA grade of fit 0.5

Ith max 50kA.

3.Earthing instalation:

Internal connections- conductor H07V-k 1x50mm².



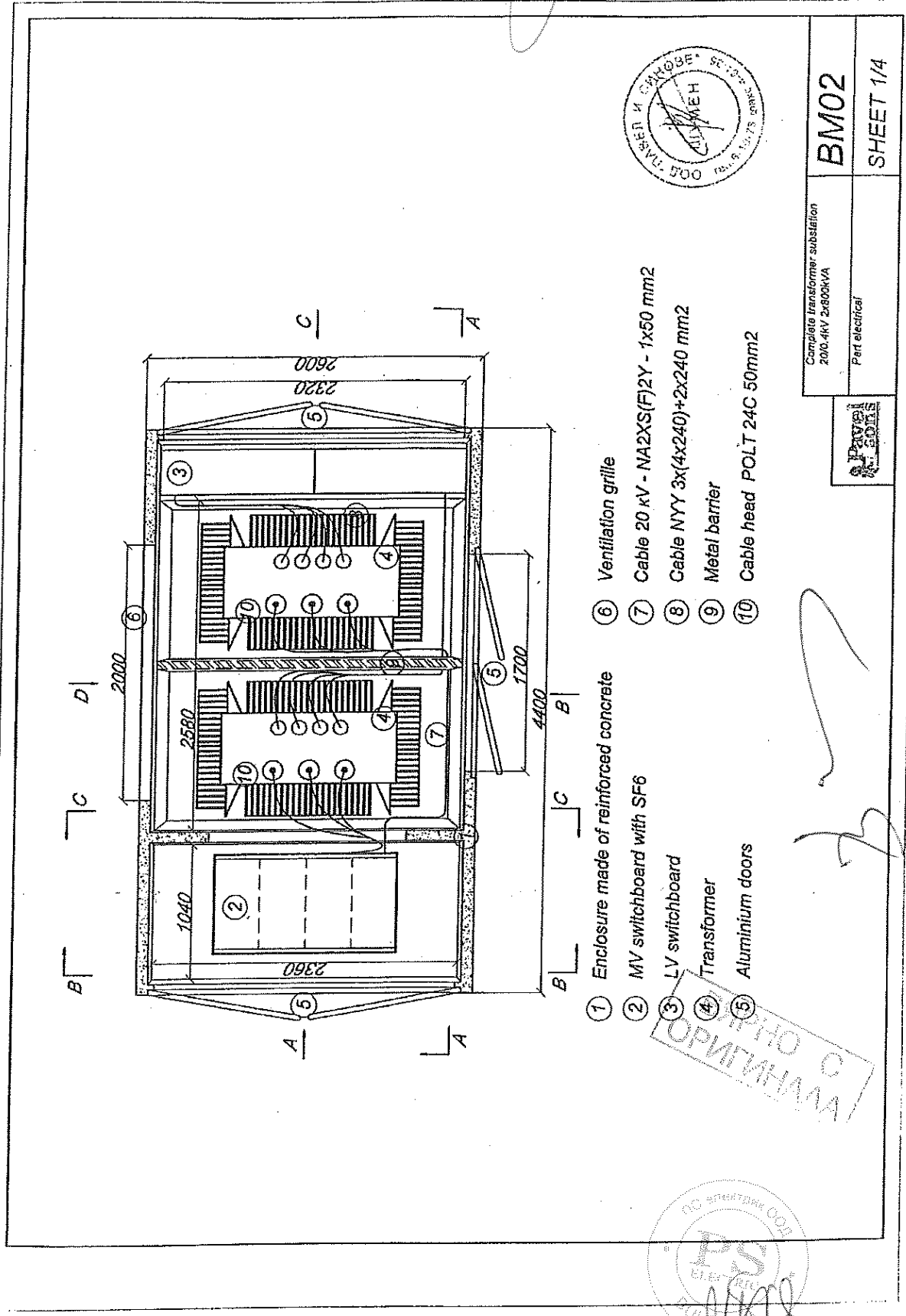
Connection between neutral copper bar and potential copper bar – conductor H07V-K 1x150mm².

Connection to external earthing contour –H07V-K 1x95mm²

Ratings of prefabricated substation:

- Rated voltage on MV side – 24kV;
- Operated voltage on MV side – 20kV;
- Rated insulation level on MV side -50kV;
- Rated lightning impulse withstand voltage on MV side-125kV;
- Rated voltage on LV side – 0.4kV;
- Rated insulation level on LV side -2,5kV;
- Rated normal current of MV busbar-630A;
- Rated lightning impulse withstand voltage on LV side- 5kV;
- Rated feeder current -630A;
- Rated feeder current for transformer panels – 200A;
- Main circuit breakers on LV switchboard-1250A;
- rated short time withstand current on MV side -16kA/1s;
- peak withstand rated current – on MV side-40kA;
- Short time withstand current on earthing circuit -16kA

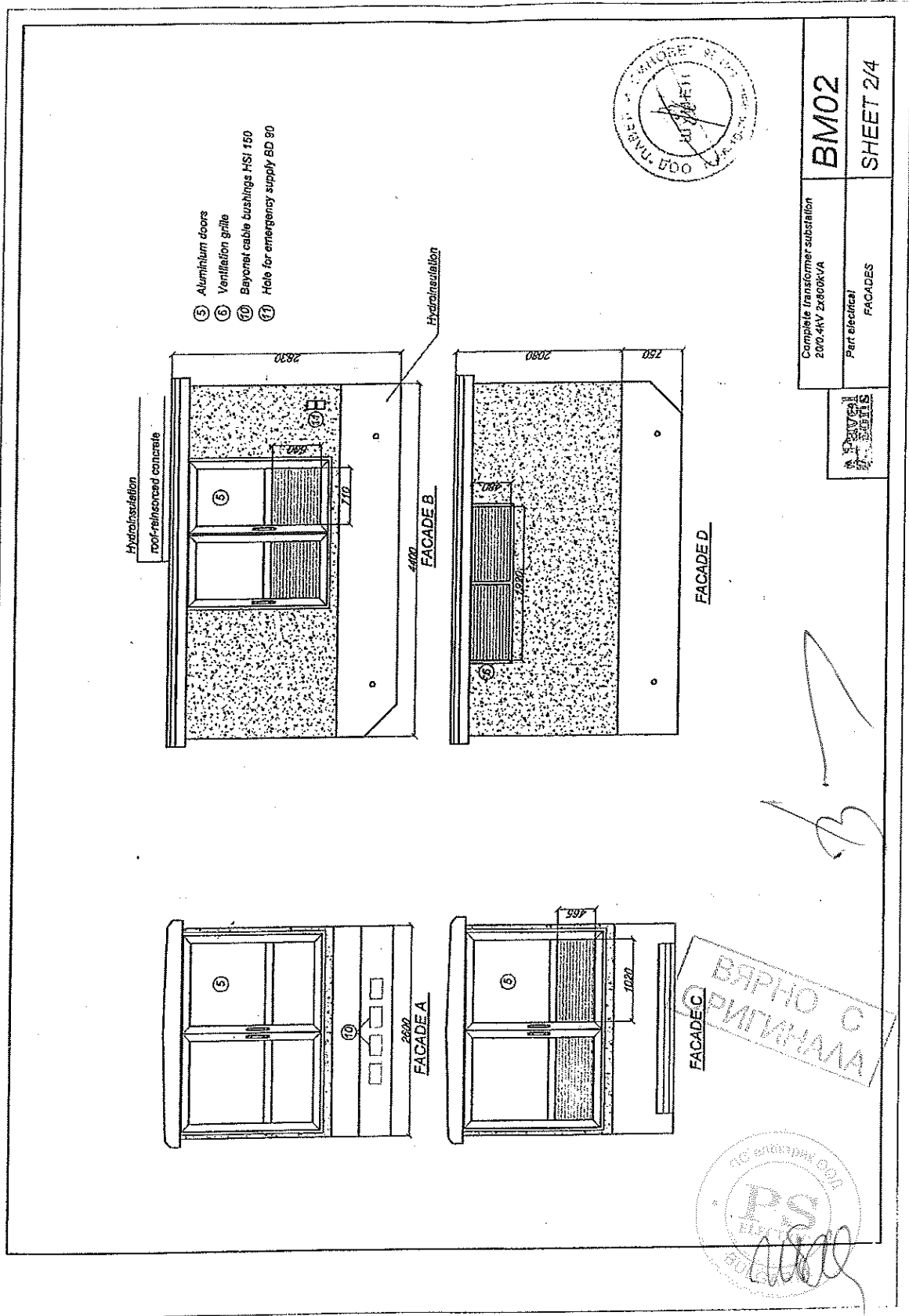


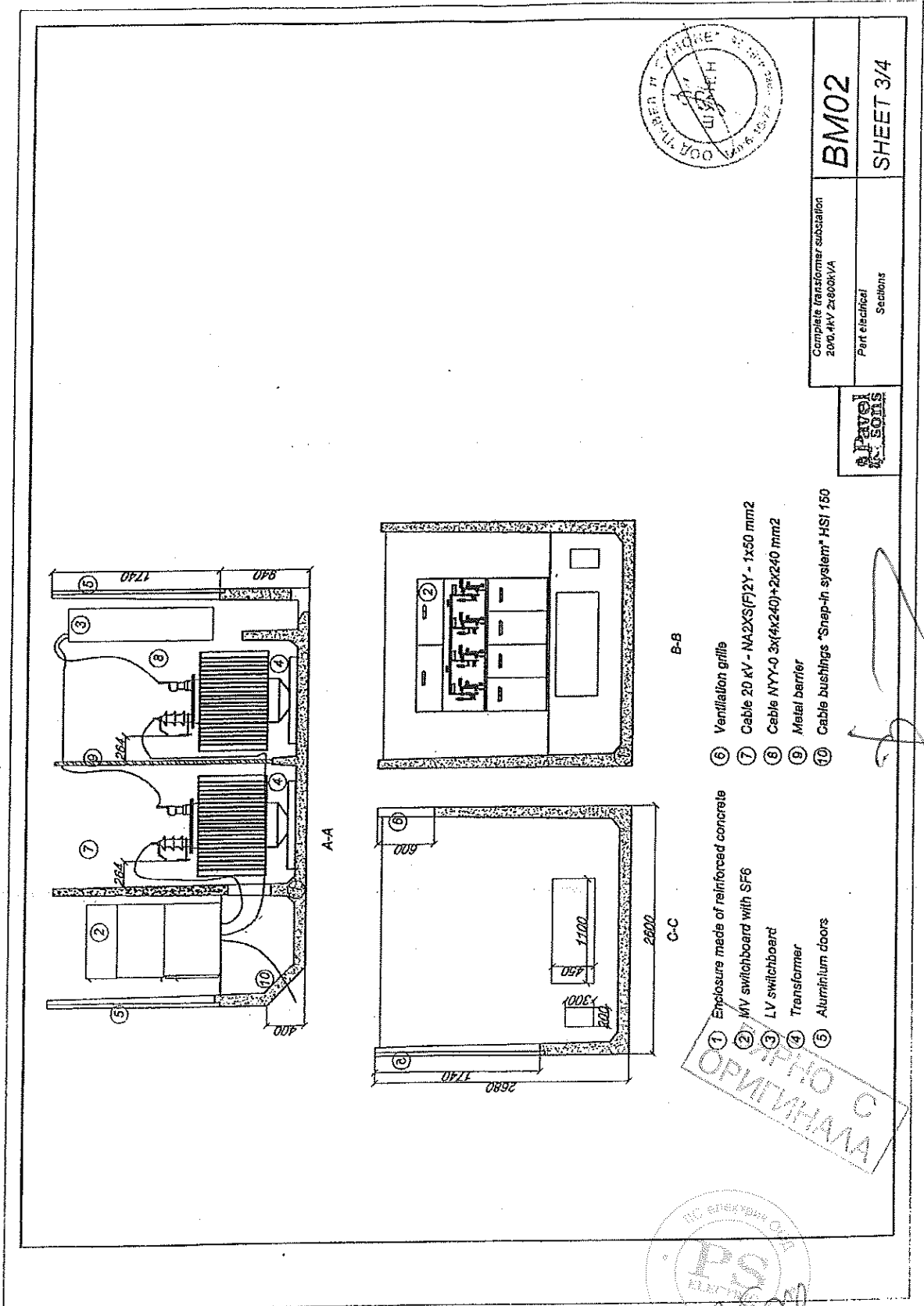


Complete transformer substation 200-4kV 2x600kVA	BM02
Part electrical	SHEET 1/4

ОРИГИНАЛ





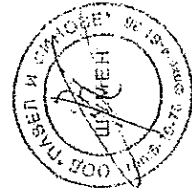
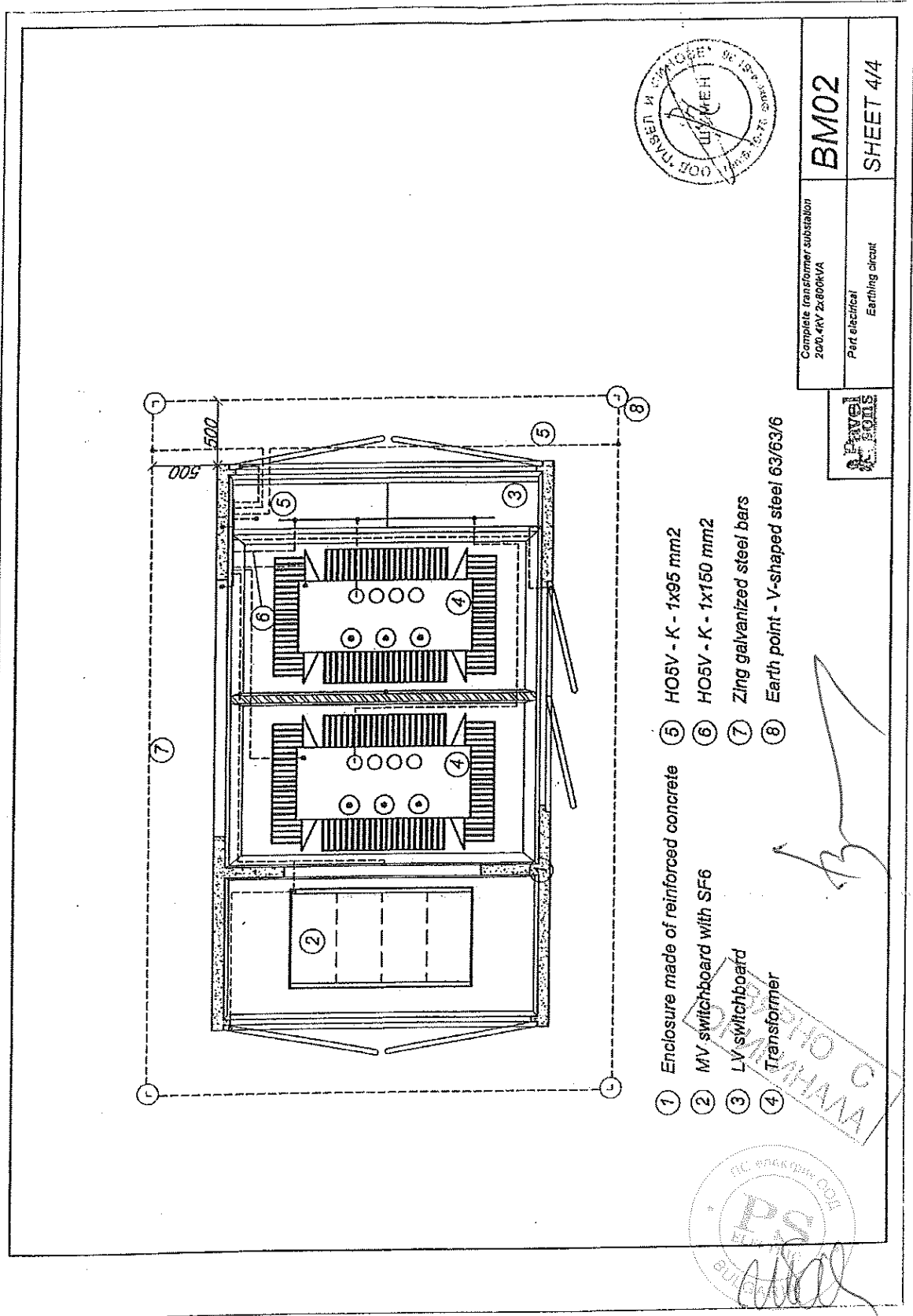


Complete transformer substation 2000 kV 24000kVA	BM02
Part electrical Sections	SHEET 3/4

OPREDELJENJE

- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ Aluminium doors
- ⑥ Ventilation grille
- ⑦ Cable 20 kV - NA2XS(F)2Y - 1x50 mm²
- ⑧ Cable NY-Y-0 3x(4x240)+2x240 mm²
- ⑨ Metal barrier
- ⑩ Cable bushings "Snap-in system" HSI 150

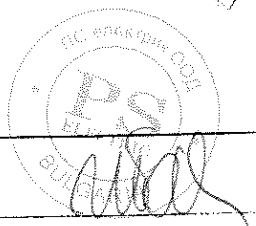
OPREDELJENJE
BULEVAR
100
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000

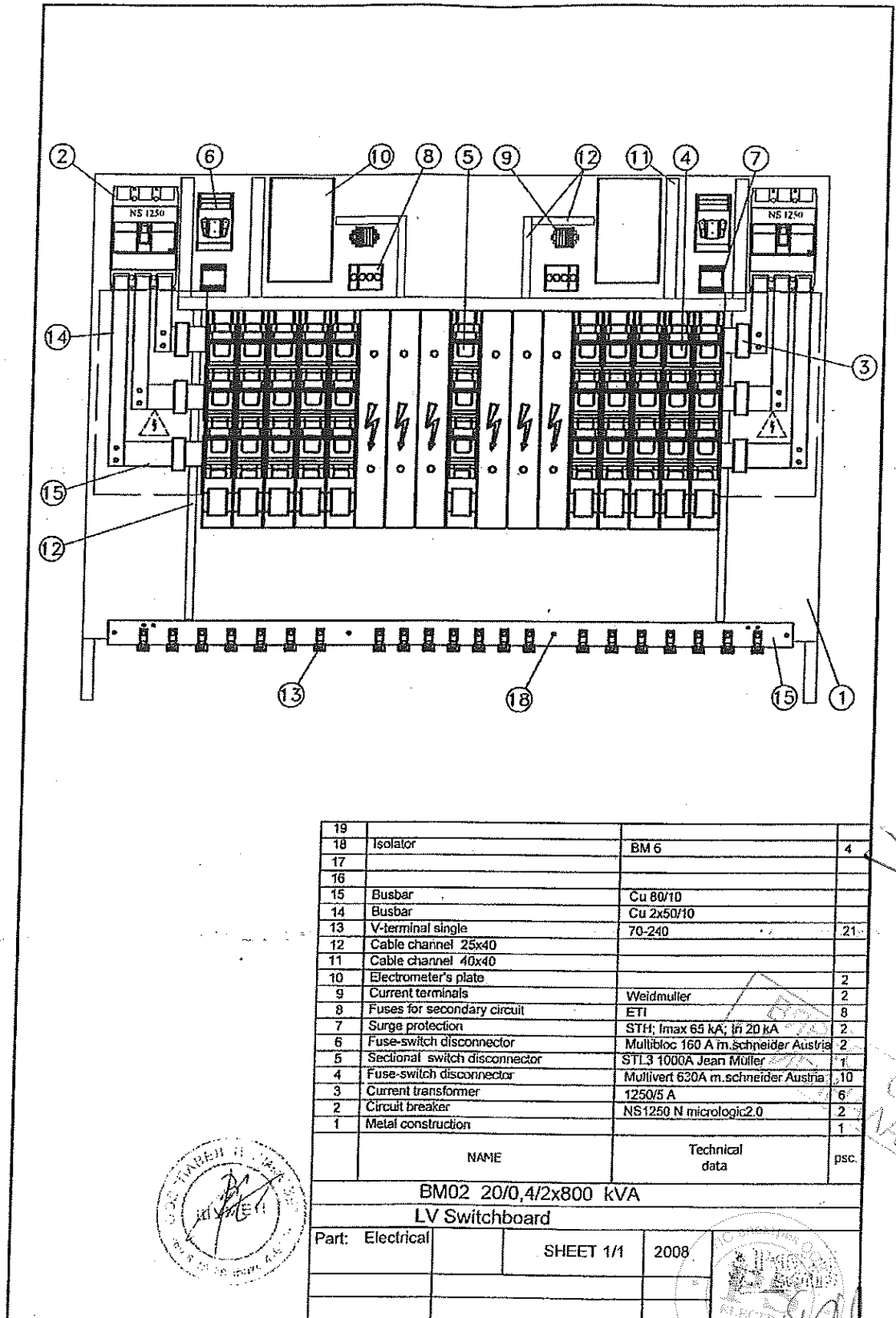


Complete transformer substation 200.4KV 2x600kVA	BM02
Part electrical Earthing circuit	SHEET 4/4



- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ HO5V - K - 1x95 mm2
- ⑥ HO5V - K - 1x150 mm2
- ⑦ Zing galvanized steel bars
- ⑧ Earth point - Y-shaped steel 63/63/6

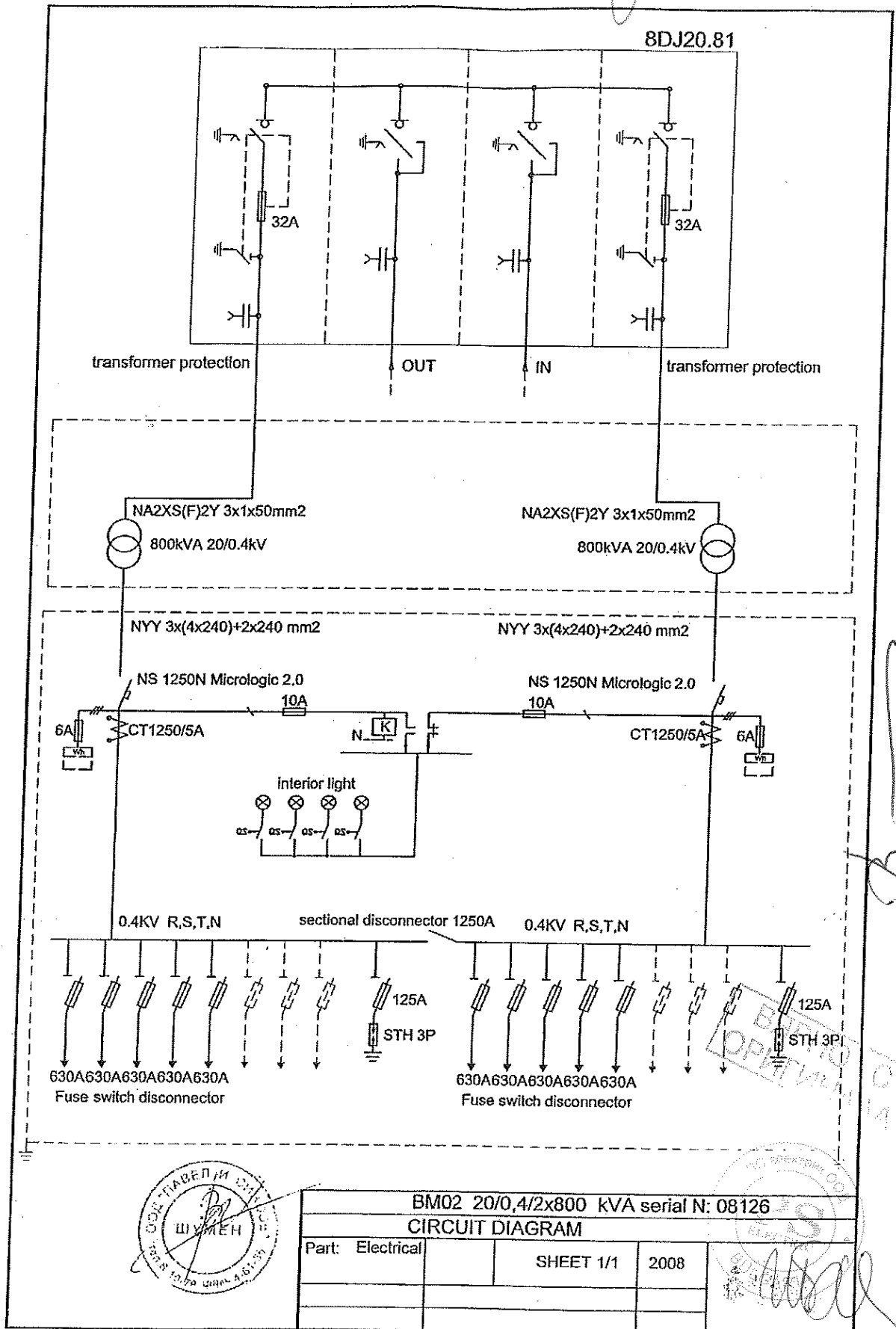


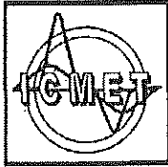


19			
18	Isolator	BM 6	4
17			
16			
15	Busbar	Cu 80/10	
14	Busbar	Cu 2x50/10	
13	V-terminal single	70-240	21
12	Cable channel 25x40		
11	Cable channel 40x40		
10	Electrometer's plate		2
9	Current terminals	Weidmuller	2
8	Fuses for secondary circuit	ETI	8
7	Surge protection	STH; I _{max} 65 kA; I _{ri} 20 kA	2
6	Fuse-switch disconnectors	Multibloc 160 A m. schneider Austria	2
5	Sectional switch disconnectors	STL3 1000A Jean Müller	1
4	Fuse-switch disconnectors	Multiver 630A m. schneider Austria	10
3	Current transformer	1250/5 A	6
2	Circuit breaker	NS1250 N micrologic2.0	2
1	Metal construction		1
	NAME	Technical data	psc.

BM02 20/0,4/2x800 kVA
LV Switchboard

Part: Electrical		SHEET 1/1	2008





RESEARCH, DEVELOPMENT AND TESTING NATIONAL INSTITUTE FOR ELECTRICAL ENGINEERING



LIT

ICMET CRAIOVA
ROMANIA
HIGH VOLTAGE LABORATORY - LIT

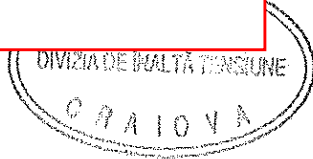
200515 Craiova, Calea Bucuresti 144
Phone : 0351 - 404888, 0351 - 404889, 0351 - 402425, Fax: 0251 - 415482; 0351 - 404890

TEST REPORT
No.41573 / 19.05.2008

1. Product: **Prefabricated Substation type BM 02; 20/0.4 kV; 2x800 kVA; 32 / 1250 A**
Serial no. 08126 / 08
2. Tests: – Tests to verify the degree of protection IP - 33
– Measurement of partial discharge
3. Test order: 20756 / 16.04.2008 (Contract no. 2167 / 19.03.2008)
4. Producer: Pavel & Sons
5. Customer: Pavel & Sons
6. Customer's address: Central office: 9700, Shumen - BULGARIA

На основание чл. 2
от ЗЗЛД

На основание чл. 2
от ЗЗЛД

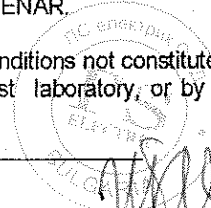


7. The test report contains 5 pages.
8. The test report was edited in 4 ex.; 1 ex to LIT and 3 ex to customer.

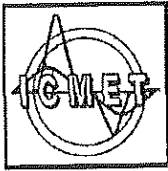
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CAUTION:

- a. The test result makes reference only to tested product.
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- d. Reports without original signatures are not valid.
- e. Laboratory accreditation or any of its test reports elaborated in accreditation conditions not constitute or imply, themselves, an approval of product by RENAR, which has accredited the test laboratory, or by any other organization.



my



LIT

1. Table of contents

	Page
Front sheet	1
1. Table of contents	2
2. Conclusions	2
3. Tests to verify the degree of protection	3
4. Measurement of partial discharge	4
5. Picture	5

2. CONCLUSIONS:

Prefabricated Substation type BM 02; 20/0.4 kV; 2x800 kVA passed the test



any



LIT

3. – VERIFICATION ON THE DEGREE PROTECTION IP – 33

3.1. Reception date of the product: 05.05.2008

3.2. Measurement date: 06.05.2008

3.3. Atmospheric conditions: $p = 1007$ mbar; $t = 14.8 \pm 0.1$ °C; $h = 64$ %

3.4. Test standard: CEI 60529 / 1999

a. Verification of the first characteristic numeral, "3"

a.1. Protection against access to hazardous parts

a.2. Protection against the penetration of solid foreign objects

For a.1 were used the access probe of 2.5 mm diameter and 100 mm length

For a.2. were used the object probe, sphere of 2.5 mm diameter.

They did not penetrate the test object.

b. Verification of the second characteristic numeral "3", against spraying water

b.1. Against spraying water at angle up to 60° on either side of the vertical.

It was used the spay nozzle compliant with Fig.5 of IEC 60529.

The spraying time was of 13 min 30 sec, because total area $A_T = 13.48$ m².

The debit was 10 l / min.

There was no ingress of water into the test object.

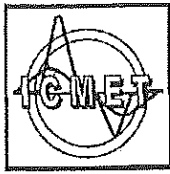
3.5. Conclusion: The product corresponding to the degree of protection IP – 33.

3.6. Test responsible: Te

На основание чл. 2

ВЯРНО С
ОРИГИНАЛА





LIT

4. Measurement of partial discharge

4.1. Reception date : 05.05.2008

4.2. Test date : 06.05.2008

4.3. Atmospheric conditions :

pressure p = 1007 mbar
 temperature t = 15 ± 0.1 °C
 absolute humidity h = 65 %

4.4. Test standard: IEC 60270, Specification ERP-15/01 / 11.01.2007; scl. 6.7.2.1;

4.5. Equipment used :

- Panel E12, 525V/85A of the LV installation of the HV Laboratory
- AC measuring system 350 kV consists of: high voltage compressed gas capacitor type MCF 75/350P, no.853889 and low voltage arm type H90, no.898939 + digital peak voltmeter type MU9, no.892204 for LV.
- Coupling capacitors no.3; 4; 5: 1 nF
- Charge for calibration: 25 pC
Calibrator type PET 2 -1, no.893534, Calibration Certificate DKD no.0085 / 20.03.2006.
- Measuring system: measuring impedances type LDM – 5/U (no.735 35 131; 736 35 131; 737 35 131) + Switching box type LDM – 5/M6 (734 35 131) wide band instrument type LDS – 6 (no.21543181) Calibration Certificate DKD no.0087/03.07.2006

4.6. Results:

Voltage [kV]	PD level (pC)		
	U	V	W
24	9	9	8

During the tests was determined also the PD inception and extinction voltages on each phase.

Phase	PD inception voltage [kV]	PD extinction voltage [kV]
U	18.3	16.7
V	17.8	15.5
W	18.7	16.9

Measuring uncertainty for the PD measurement is: $0.5 \text{ pC} + 0.04q \text{ (pC)}$
 The uncertainty stated is expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor $k = 2$ (coverage probability appr.95 %).

4.7. Conclusion: The product passed the test.

4.8. Test responsible

На основание чл. 2

ВЯРНО С
 ОРИГИНАЛА



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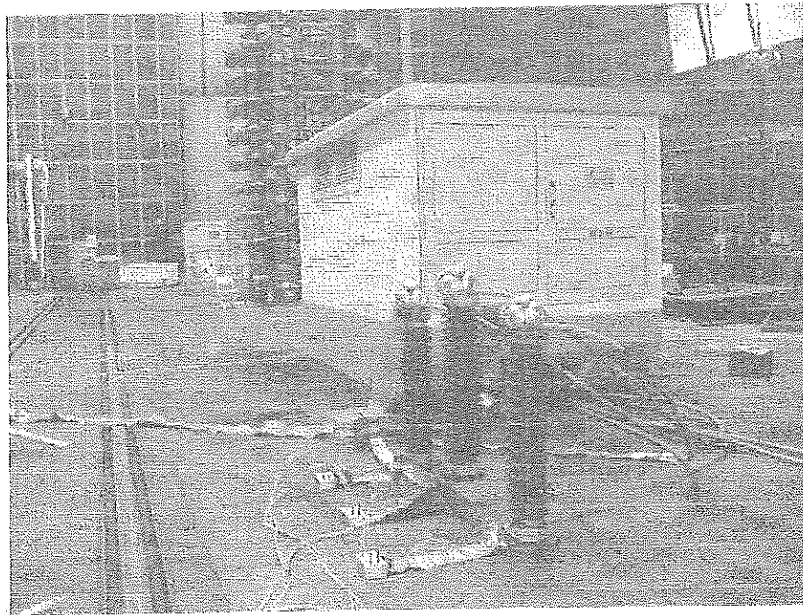
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TEST REPORT No. 41573

page 5

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ВЯРНО С
ОРИГИНАЛА



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RESEARCH-DEVELOPMENT AND TESTING NATIONAL
INSTITUTE FOR ELECTRICAL ENGINEERING

**ICMET CRAIOVA
HIGH POWER DIVISION**

**HIGH POWER LABORATORY
"Ovidiu Rarinca"**

200515-CRAIOVA Calea Bucuresti Nr. 144 ROMANIA
Phone: (351) 402 427; Fax: (251) 415482; (351) 404 890;
E-mail: lmp@icmet.ro

INCERCARE



SR EN ISO / CEI 17025: 2005
CERTIFICAT DE ACREDITARE
nr. LI 004 / 2007

**TEST REPORT
No. 10176**

CUSTOMER: PAVEL & SONS Ltd
Central office: 9700, Shumen BULGARIA

MANUFACTURER: PAVEL & SONS Ltd
Central office: 9700, Shumen BULGARIA

TESTED PRODUCT: 20/0.4 kV, 2x800kVA Prefabricated Transformer Substation made of reinforced concrete

REFERENCE STANDARD: IEC 62271-202/2006, clause 6.4

TEST PERFORMED: Short-time and peak withstand current tests on earthing conductor system

TEST DATE: 18.05.2008

TEST RESULT: Passed the tests

Report has 15 pages and it is edited in 4 copies from which 3 copies for customer.



HEAD OF HIGH POWER DIVISION

HEAD OF LABORATORY:

На основание чл. 2

DATE OF ISSUE: 05.06.2008

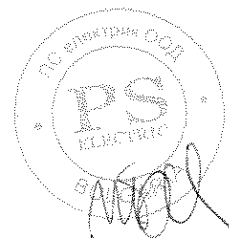


1. Results refer to test product only.
2. Publication or reproduction of the contents of this report in any other form unless its complete photocopying is not allowed without writing approval of division to which laboratory belong to.
3. Accreditation of the laboratory or any of its Test Reports issued under accreditation regime do not constitute or do not imply themselves an approval of the product by the accreditation body.

Content

1.	Present at the tests	3
2.	Identification of the test product	3
2.1	Type	3
2.2	Serial number/year	3
2.3	Technical specification/Drawing	3
2.4	Contract	3
2.5	Product receiving date	3
2.6	Product condition at receiving	3
3.	Technical characteristics checked by tests	3
4.	Tests program	3
5.	Responsible for tests	3
6.	Test report documentation	3
7.	Short-time and peak withstand current test	4
7.1	Data of testing and measuring circuit	4
7.2	Results obtained on test	5
7.2.1	Symbols used in tables and oscillograms	4
7.3	Remark	5
8.	Test results	5
9.	Annexes	6
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9.2	Technical specification	7
9.3	Drawings	9
9.4	Oscillograms	15

ВЯРНО С
ОРИГИНАЛА



1. PRESENT AT THE TESTS: Eng. Velimir Dimitrov and Eng. Dimitar Donchev from Pavel & Sons

2. IDENTIFICATION OF APPARATUS

	Substation	MV Cubicles	LV Switchboard
2.1 Type	BM02	8DJ20 Sh.81	Compact
2.2 Serial number/year	08126/2008	CV 769630-000040/001/2008 -	
2.3 Technical specification /Drawing	See pages 7, 8/9-14		
2.4 Contract No.:	2167/09.03.2008		
2.5 Product receiving date:	05.05.2008		
2.6 Product condition at receiving:	New		

3. TECHNICAL CHARACTERISTICS CHECKED BY TESTS

	Substation
Rated voltage	20/0.4 kV
Rated current	-
Rated frequency	50 Hz
Rated short - time withstand current:	
- peak value	40 kA
- r.m.s. value	16 kA
Rated duration of short-circuit (t_k)	1 s

4. TESTS PROGRAM

4.1 One single phase short-time and peak withstand current test on earthing conductor system at parameters: $I_p=40$ kA, $I_k=16$ kA, $t=1$ s. The supply was made between the earthing point provided of the MV Switchboard and the neutral bar from LV Switchboard by means of 2×95 mm² copper cables.

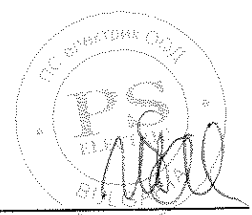
5. RESPONSIBLE FOR TESTS:

На основание чл. 2

6. TEST REPORT DOCUMENTATION

Oscillograms 1; Tables 2;
Photos 2; Drawings 6

ВЯРНО С
ОРИГИНАЛА



7. SHORT-TIME AND PEAK WITHSTAND CURRENT TEST

7.1 Data of testing and measuring circuit

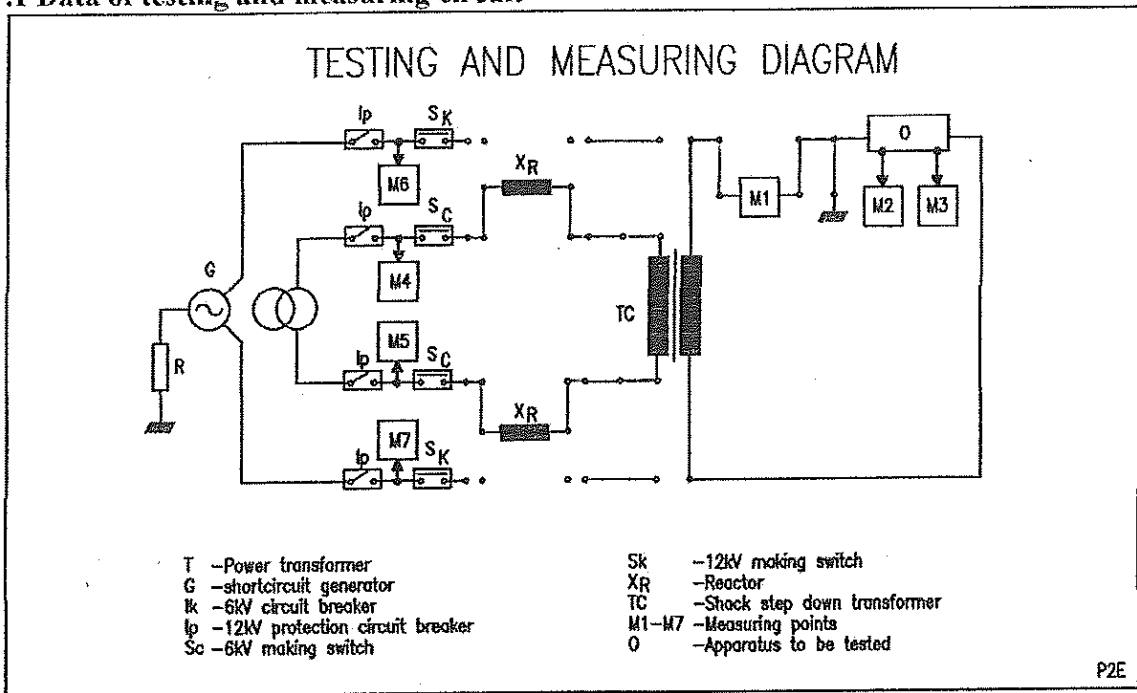


Table 1

Test	Short-time and peak withstand current	
Phases number	2	
Source / connection	Network + TF 15 MVA	
Transformer /Rate	TC 8 / 20	
Earthing	Source	600 Ω
	Apparatus	Net earthing connection
Reactor [Ω]	0	
Power factor	< 0.15	
M4 - Source voltage - Voltage transformer 15000/100V		
M1 - Apparatus current - Shunt 70 kA/1.75 V		
Data acquisition system SAPMD : 12 bit, 16 channels		

ВЯРНО С
 ОРИГИНАЛА



7.2 Results obtained on test

The supply was made between the earthing point provided of the MV Switchboard and the neutral bar from LV Switchboard (see photos from page 6).

The results are presented in table 2.

Table 2

Oscillogram No.	I_p [kA]	I_k [kA]	t_t [s]	$I_{k\text{equiv } t}$ [kA]	Remarks
71469/2007	40.5	18.1	0.82	16.39	Test on earthing circuit

Measurements were performed with uncertainty of: 1% for voltage; 1% for current; 0.5% for time and the confidence level $P = 95\%$.

7.2.1 Symbols used in tables and oscillograms

- I = Short-circuit current
 I_p = Peak of the short-circuit current
 I_k = R.m.s short-circuit current
 t_t = The duration of short - circuit
 $I_{k\text{equiv } t}$ = Equivalent value of short-time withstand current on $t = 1\text{ s}$,
 calculated as follows:

$$I_{k\text{equiv } t} = I_k \cdot \sqrt{\frac{t_t}{t}}$$

7.3 Remark:

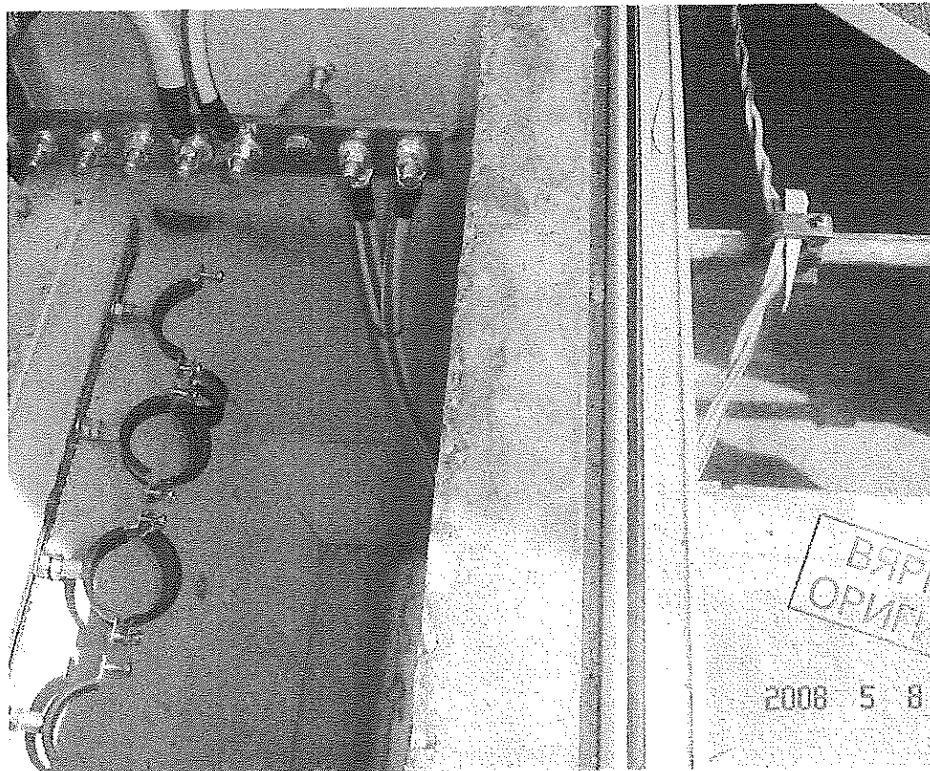
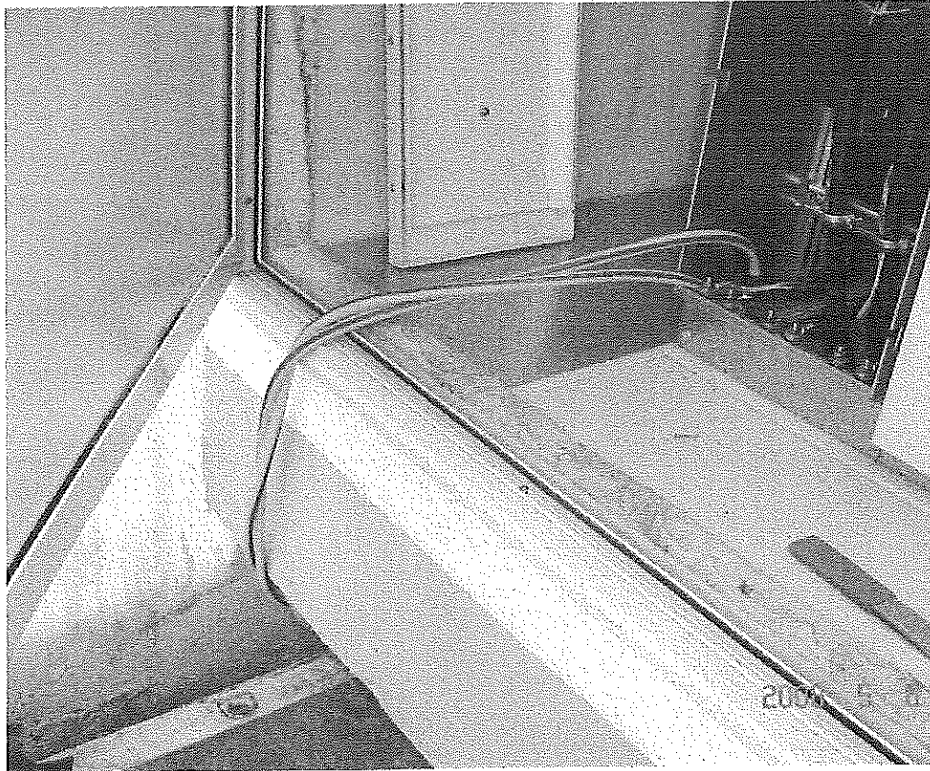
After the tests no significant deformations of the circuits were observed.

8. TEST RESULT: PASSED THE TEST

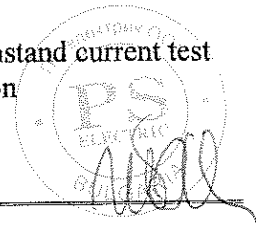
ВЯРНО С
ОРИГИНАЛА



9.1 Photos



Photos 1, 2 – Aspects of the supplying points for short-time and peak withstand current test on earthing circuit of Prefabricated Transformer Substation



Technical specification

Prefabricated transformer substation made of reinforced concrete

Type: BM02 20/0.4kV 2x800kVA
 Producer: "Pavel & sons" Ltd. , Shumen, Bulgaria
 Factory number: 08126

Casing: The casing of the Concrete Prefabricated Substation is made of water –tight reinforced concrete B45;

1.1 Measurements (roof included) :

L= 4600mm;B=2800mm;H=2830mm;

Weight with transformers: 20 800kg;

Equipment:

2.1.Equipment on the Middle Voltage side:

Complete distributing device - 8DJ20 Sh.81 2RK+2TR Siemens, which consists of cable "IN" 20kV,cable "OUT" and 2psc."Transformer protection".

2.2.Interconnections 20 kV from MV switchboard to transformers NA2X(F)2Y 3 x 1 x 50mm².

2.3.Transformer:

transformer 20/0.4kV 800 kVA

Dimensions:

L=1710mm.

W=1070mm.

H=1590mm.

2.4.Connecting cable from transformers to LV switchboard – NYY 3x(4x240mm²)+2x240mm².

2.5.Main circuit –breakers of LV switchboard – automatic circuit–breakers NS1250N Micrologic 2.0.

2.6.Terminals of LV switchboard – fuse-switch disconnecter MULTIVERT 630A-10 psc. "m.schneider Austria.

2.7. Sectional vertical switch disconnecter 1000A Jean Muller

2.7. Over-voltage protections 2psc., type: STH 3P Merlin Gerin:

I max.-65kA(20/8);

In-20kA(20/8);

Up=1.5kV;

Uc=275V;

2.8. Supply circuit-breaker of the overvoltage protection:

MULTIBLOC 160A m.schneider Austria.

2.9. Copper bars' system:

Distributing rims – Copper bars 80/10mm.

Connection between main circuit – breaker and distributing rims – Copper bars 2x(50x10)mm.

Current transformer:

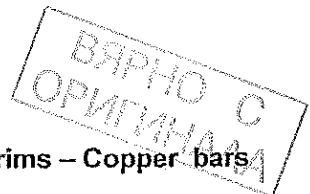
MAK 104/80 1250/5A

5VA grade of fit 0.5

Ith max 50kA.

3.Earthing instalation:

Internal connections- conductor H07V-k 1x50mm².

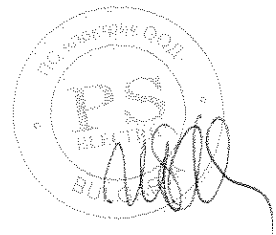


Connection between neutral copper bar and potential copper bar – conductor H07V-K 1x150mm².

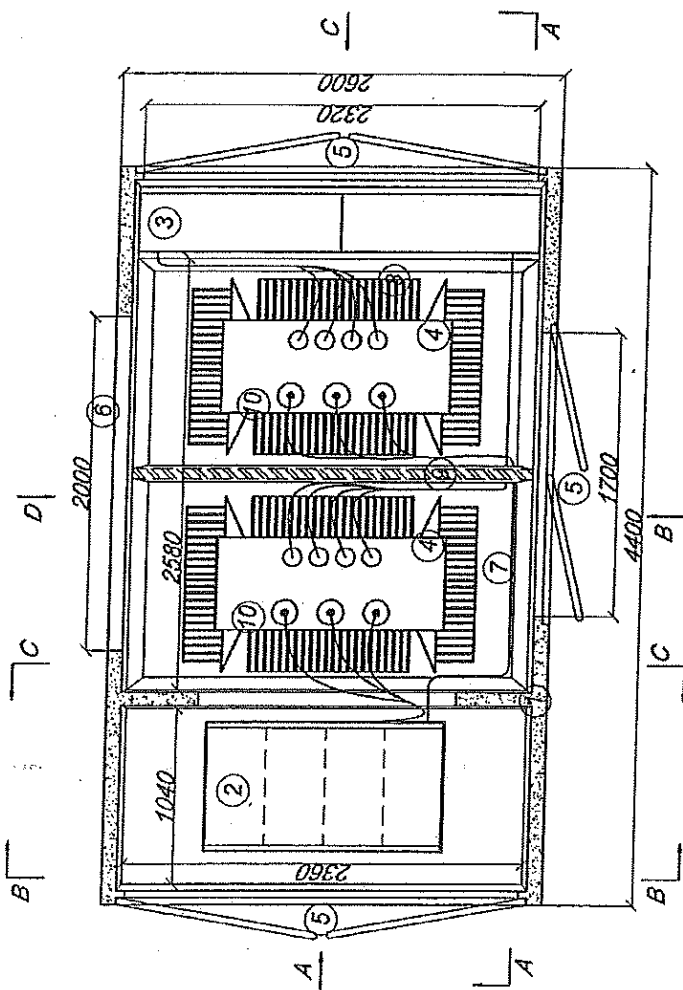
Connection to external earthing contour –H07V-K 1x95mm²

Ratings of prefabricated substation:

- Rated voltage on MV side – 24kV;
- Operated voltage on MV side – 20kV;
- Rated insulation level on MV side -50kV;
- Rated lightning impulse withstand voltage on MV side-125kV;
- Rated voltage on LV side – 0.4kV;
- Rated insulation level on LV side -2,5kV;
- Rated normal current of MV busbar-630A;
- Rated lightning impulse withstand voltage on LV side- 5kV;
- Rated feeder current -630A;
- Rated feeder current for transformer panels – 200A;
- Main circuit breakers on LV switchboard-1250A;
- rated short time withstand current on MV side -16kA/1s;
- peak withstand rated current – on MV side-40kA;
- Short time withstand current on earthing circuit -16kA



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- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ Aluminium doors
- ⑥ Ventilation grille
- ⑦ Cable 20 kV - NA2XS(F)2Y - 1x50 mm²
- ⑧ Cable NY 3x(4x240)+2x240 mm²
- ⑨ Metal barrier
- ⑩ Cable head POLT 24C 50mm²

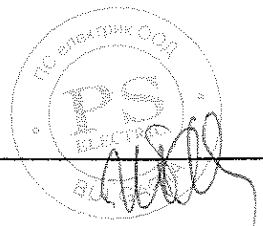


Complete transformer substation 200.4kV 21600kVA	BM02
Part electrical	SHEET 1/4



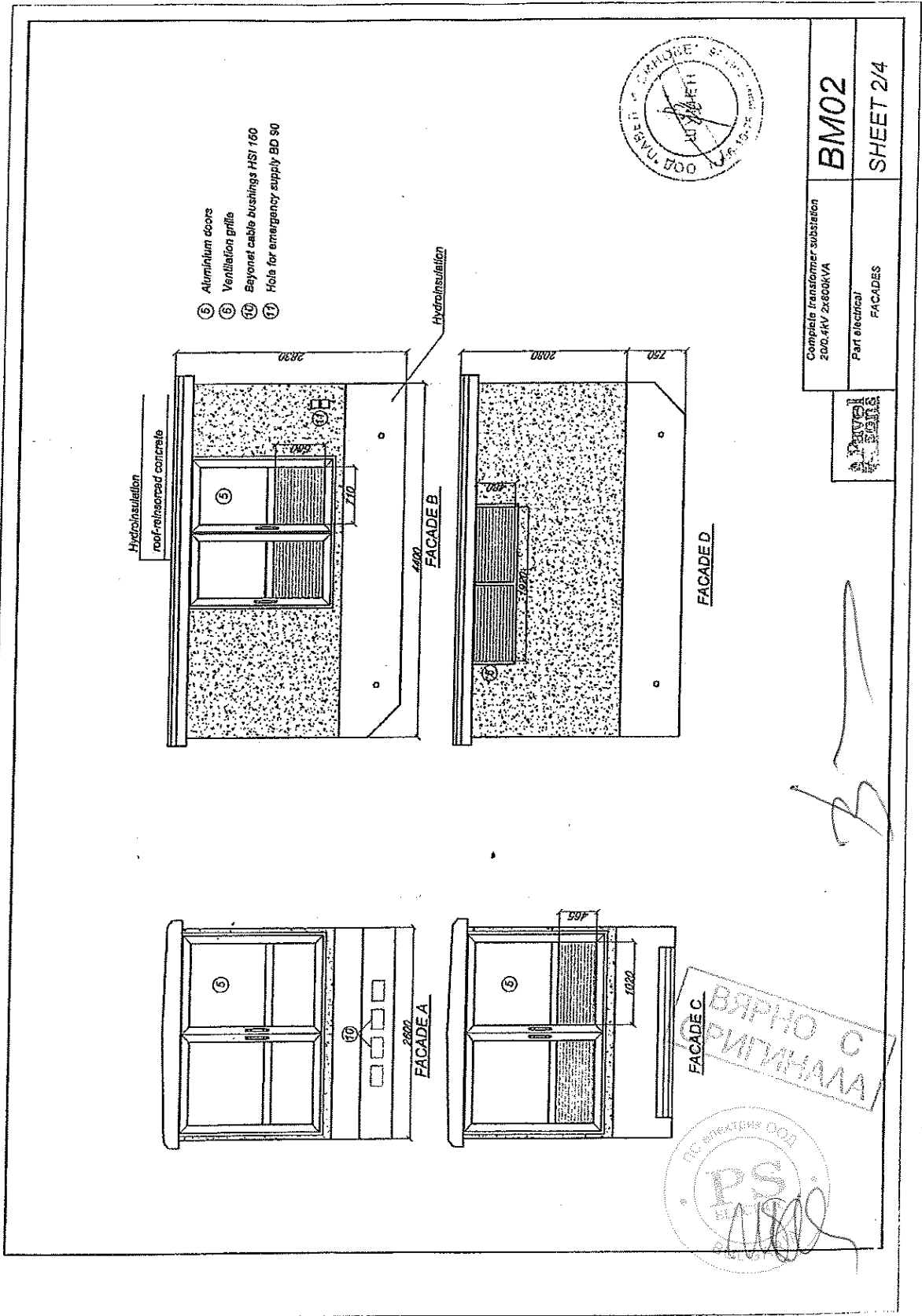
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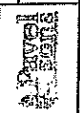
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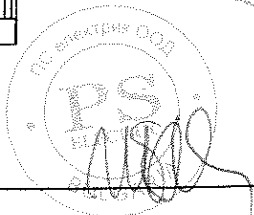
BM02
SHEET 2/4

Complete transformer substation
20/0.4KV 2x600KVA
Part electrical
FACADES



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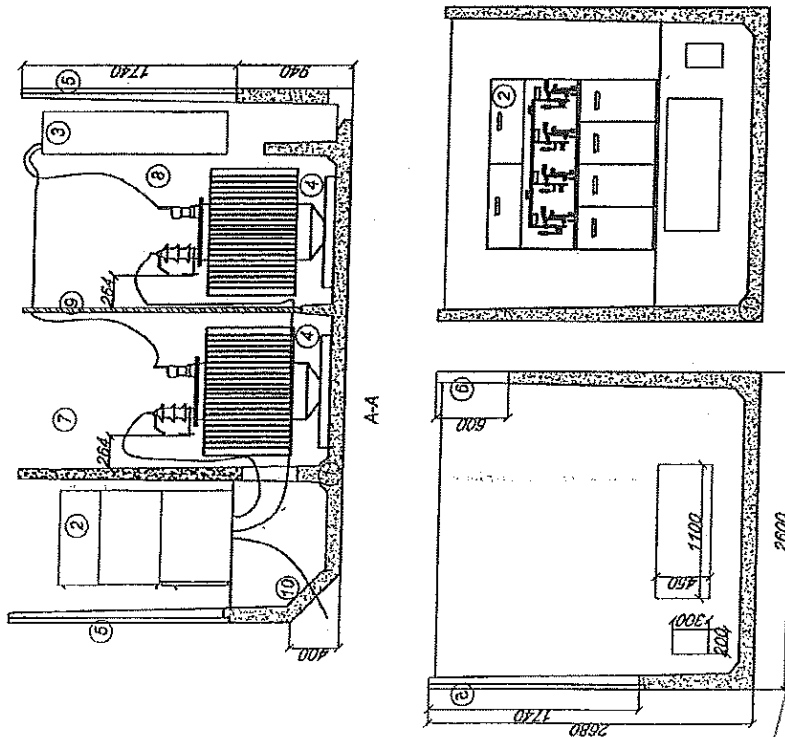
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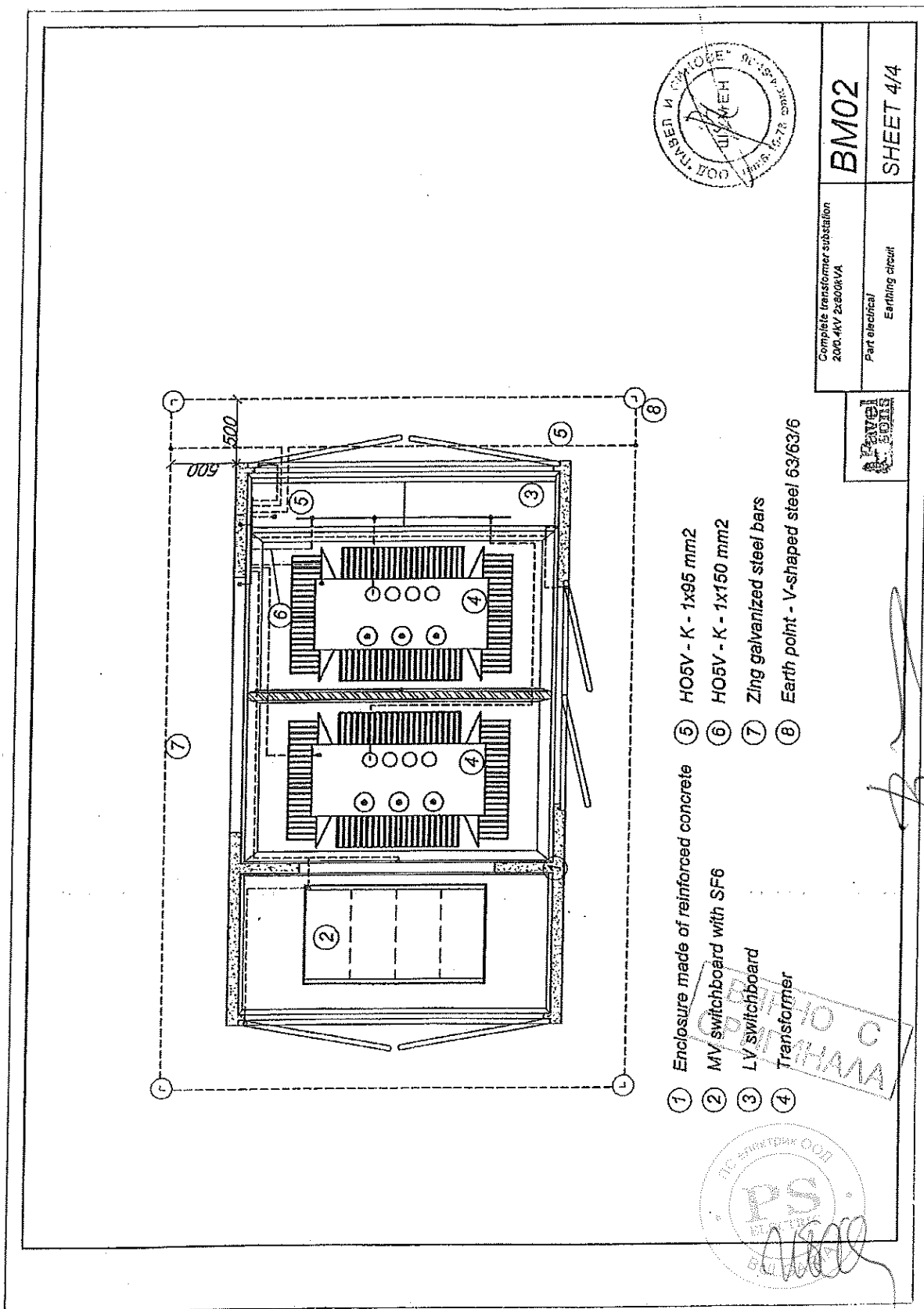
BM02	
Complete transformer substation 200.4KV 2x800KVA	
Part electrical	Sections



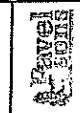
- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ Aluminium doors
- ⑥ Ventilation grills
- ⑦ Cable 20 kV - NA2XS(F)2Y - 1x50 mm²
- ⑧ Cable NYF-0 3x(4x240)+2x240 mm²
- ⑨ Metal barrier
- ⑩ Cable bushings "Snap-in system" HSI 150

ВАРНО С
ОРИГИНАЛА



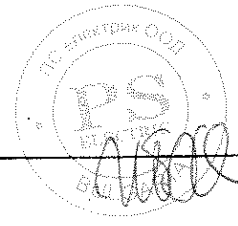


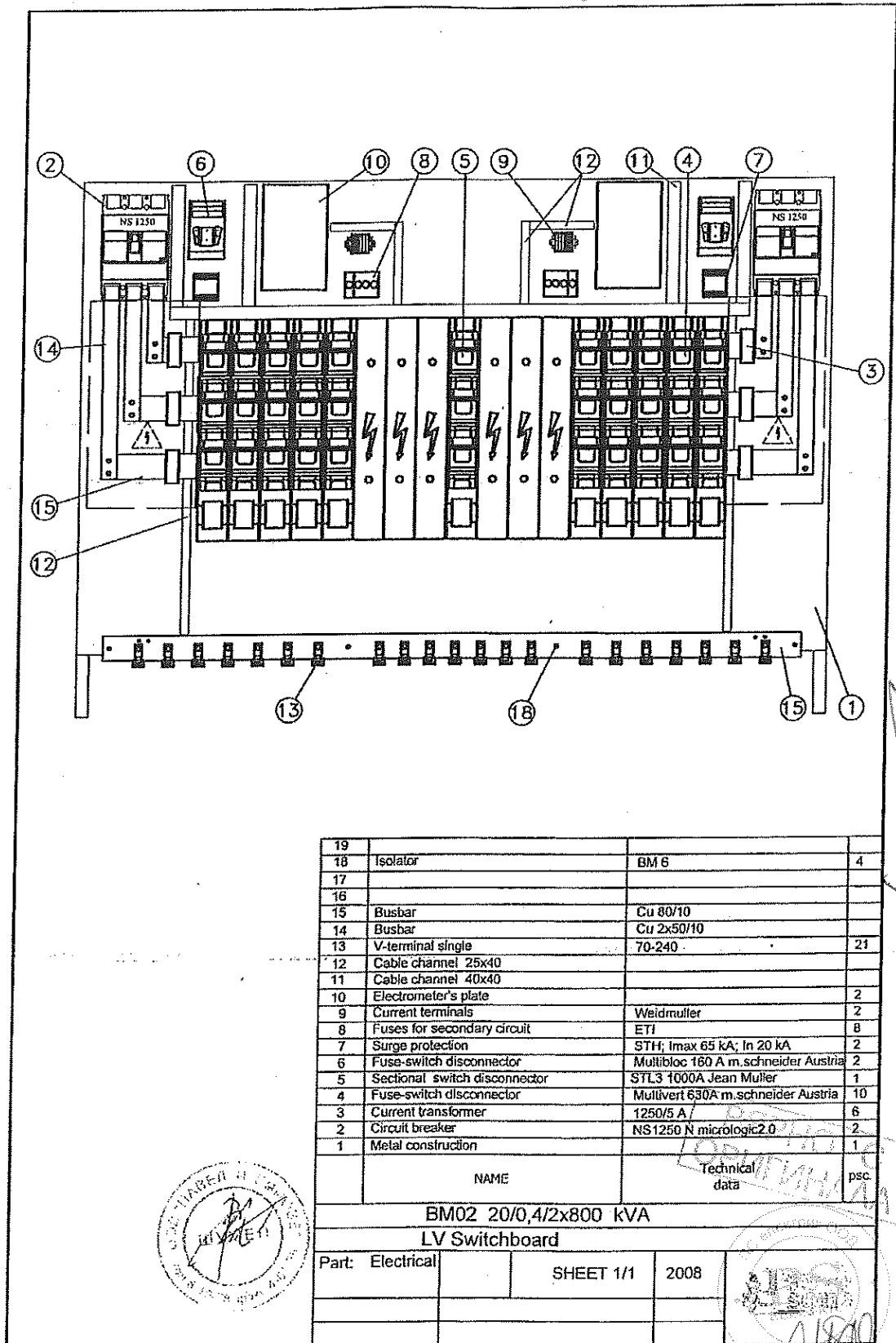
Complete transformer substation 200.4KV 2x300KVA	BM02
Part electrical Earthing circuit	SHEET 4/4



- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ HO5V - K - 1x95 mm2
- ⑥ HO5V - K - 1x150 mm2
- ⑦ Zing galvanized steel bars
- ⑧ Earth point - V-shaped steel 63/63/6

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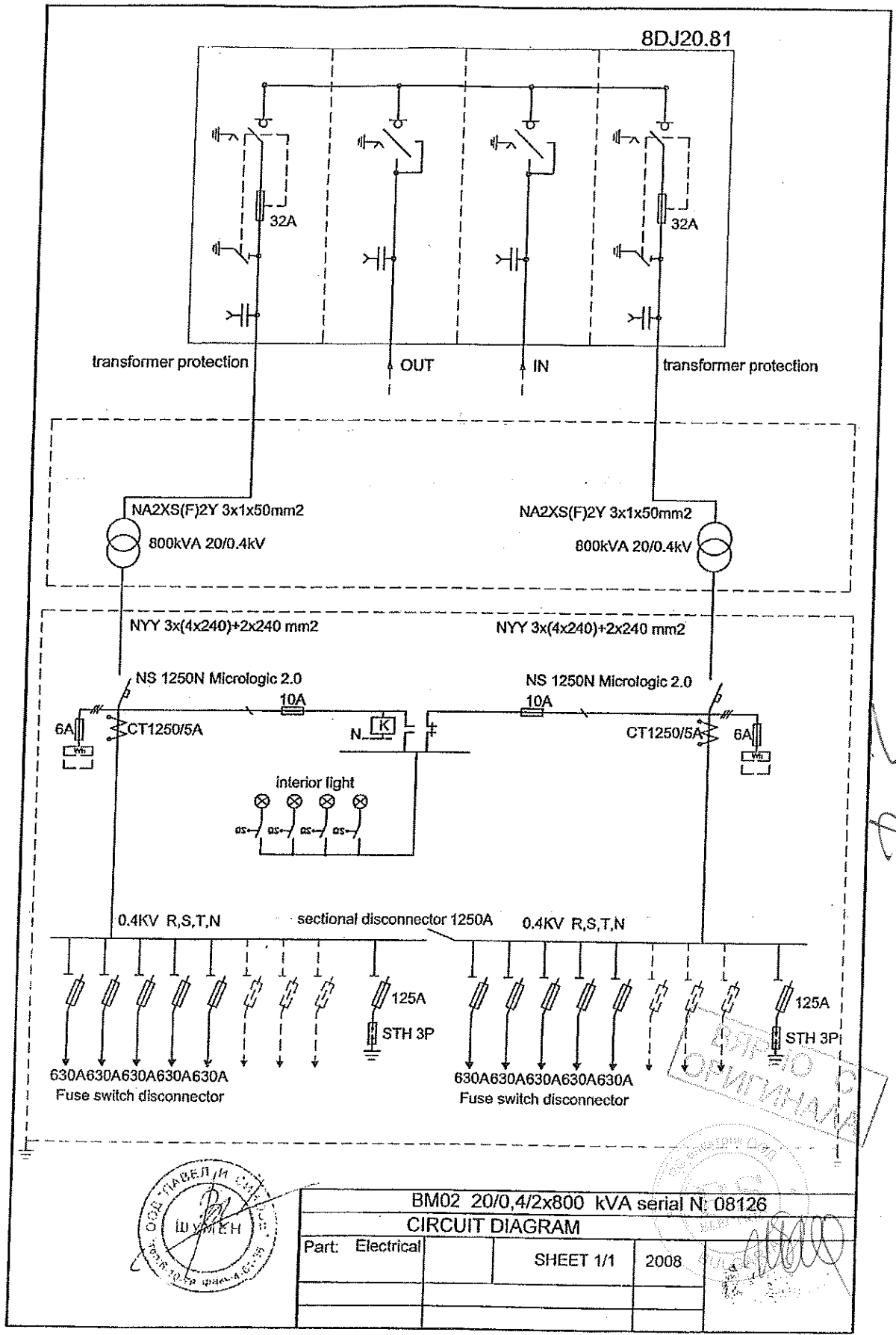




19			
18	Isolator	BM 6	4
17			
16			
15	Busbar	Cu 80/10	
14	Busbar	Cu 2x50/10	
13	V-terminal single	70-240	21
12	Cable channel 25x40		
11	Cable channel 40x40		
10	Electrometer's plate		2
9	Current terminals	Weidmuller	2
8	Fuses for secondary circuit	ETI	8
7	Surge protection	STH; I _{max} 65 kA; I _n 20 kA	2
6	Fuse-switch disconnector	Multibloc 160 A m.schneider Austria	2
5	Sectional switch disconnector	STL3 1000A Jean Muller	1
4	Fuse-switch disconnector	Multivert 630A m.schneider Austria	10
3	Current transformer	1250/5 A /	6
2	Circuit breaker	NS1250 N micrologic2.0	2
1	Metal construction		1
	NAME	Technical data	psc

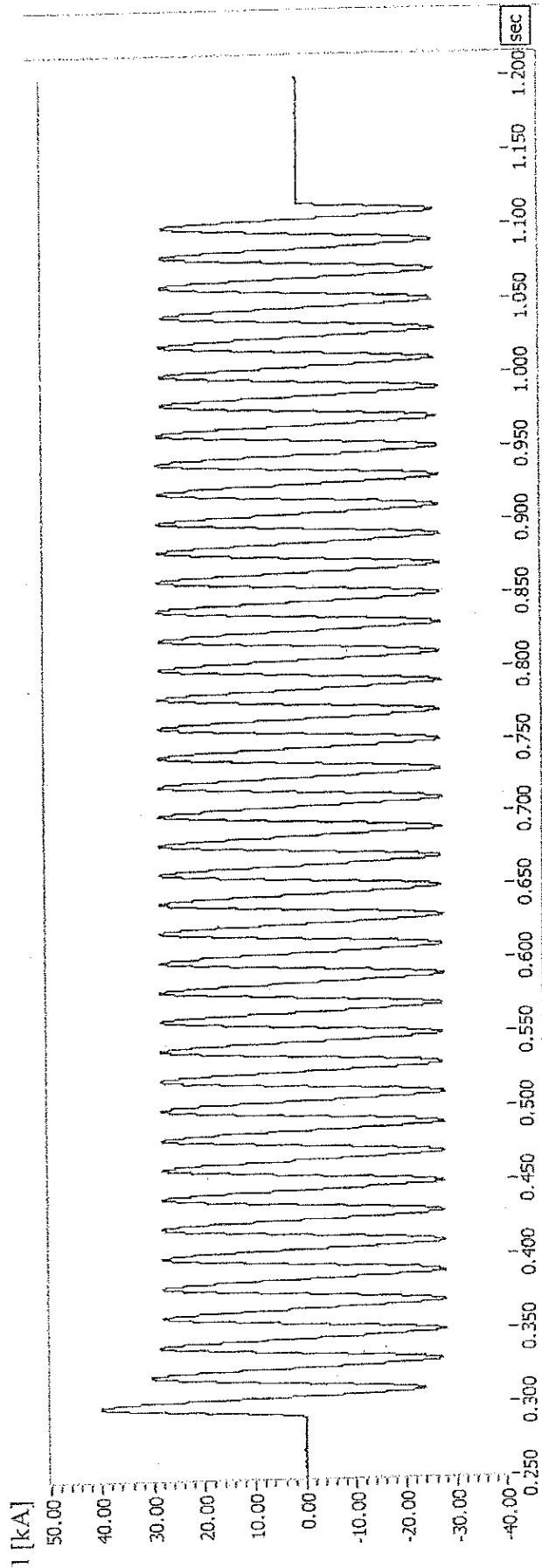
BM02 20/0,4/2x800 kVA
LV Switchboard

Part: Electrical		SHEET 1/1	2008



BM02 20/0,4/2x800 kVA serial N: 08126			
CIRCUIT DIAGRAM			
Part: Electrical		SHEET 1/1	2008

5



Oscillogram No. 71469 / 2008

ВЯРНО С
ОРИГИНАЛА





B

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Ex. 4/14

4.18

	<p>RESEARCH, DEVELOPMENT AND TESTING NATIONAL INSTITUTE FOR ELECTRICAL ENGINEERING ICMET CRAIOVA</p>	<p>acreditat pentru ÎNCERCARE</p>
<p>LABORATORIES DEPARTMENT HIGH VOLTAGE DIVISION - HVD Low Voltage Laboratory - LVL</p>		
		<p>SR EN ISO / CEI 17025: 2005 CERTIFICAT DE ACREDITARE nr. LI 529 / 2007</p>

Address: Calea Bucuresti 144, 200515 Craiova, ROMANIA
 Matriculation certificate: J 16/312/1999; Fiscal code RO3871599
 Phone: + 40 0351 402425, 404888; Fax: + 40 0251 415482, 0351 404890
 www.icmet.ro, e-mail: market@icmet.ro, ljt@icmet.ro

TEST REPORT Nr. 20008 / 09.05.2008

- | | |
|------------------------|---|
| 1. Test product: | Prefabricated Transformer Substation made of reinforced concrete, type BM02, 20/0.4 kV, 2x800 kVA, serial no. 08126 |
| 2. Tests: | I. Tests on low voltage interconnections and distribution circuits
I.a. Lightning impulse voltage tests
I.b. Verification of the creepage distances
II. Dielectric tests on auxiliary circuits
III. Tests to verify of the withstand of the enclosure against mechanical stress |
| 3. Test order: | 20756/16.04.2008, Contract nr.2167/19.03.2008 |
| 4. Customer: | PAVEL&SONS LTD. |
| 5. Customer's address: | Central Office 9700, Shumen, BULGARIA |
| 6. Manufacturer: | PAVEL&SONS LTD. |
| 7. Test standard | IEC 62271-202:2006 |
| 8. Test responsible: | Eng. Aurelia SCORNEA <i>AS</i> |

Head of Low Voltage Laboratory,

На основание чл. 2

Quality Manager,

На основание чл. 2

Head of High Voltage Division,

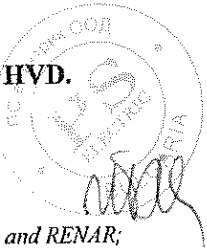
На основание чл. 2

ВЪРНО С
ОРИГИНАЛА

9. The report contains 5 pages.
 10. The report is edited in 4 copies: 3 copies for the client and 1 copy for HVD.

WARNINGS:

- Test results refer to the product under test mentioned at point 1, only;
- The integral reproduction of the present report is forbidden;
- Partial reproduction of the present report is only allowed with prior written consent of HVD and RENAR;
- All signatures of the present report are originals.
- The product was presented for the tests by the customer.



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I. TESTS ON LOW VOLTAGE INTERCONNECTIONS
AND DISTRIBUTION CIRCUITS
I.a. LIGHTNING IMPULSE VOLTAGE TESTS

1. Reception product date: 05.05.2008
2. Test date: 05.05.2008
3. Test standard: IEC 62271-202:2006
4. Atmospheric conditions: $t = 13,7^{\circ}\text{C}$, RH = 56 %
5. Equipments used:
 - Generator for lightning impulse voltage, negative polarity and power frequency voltage type SIP010, serial no. 620091, manufactured by RFT Germany, CE no. 0088/26.10.2006, expanded uncertainty $U=2,3\%$ for coverage factor $k=2$;
 - Generator for lightning impulse voltage, positive polarity, type SIP010, serial no. 620090, manufactured by RFT Germany, CE no. 0089/26.10.2006, expanded uncertainty $U=2,2\%$ for coverage factor $k=2$;
 - Thermohygrometer type HD 100, serial no. 06102404, manufactured by KIMO, France, CE no.4.8-11-06-025/13.11.2006, expanded uncertainty $U=0,3^{\circ}\text{C}$ for temperature measurement and $U=2\%$ for relative humidity for coverage factor $k=2$.

6. Procedure

The lightning impulse voltage tests on the low voltage interconnections between transformer and the low voltage circuit breaker and on distribution circuits was performed according to IEC 62271-202:2006, clause 6.2.2.2

The lightning impulse voltage with the waveform 1,2/50 μs and the peak value of 9,8 kV was applied three times for each polarity at intervals of 1s minimum.

During these tests, the devices used for overvoltage protection are disconnected, the fuses for the secondary circuits are taken out, the two low voltage circuit breakers are in close position and the fuse switch disconnectors 630A are also in close position. The secondary windings of the current transformers are short-circuited.

The lightning impulse voltage was applied between each active part and the others active parts of the low voltage circuit connected together to the accessible parts and to the earth.

7. Test result

The product withstood the test.

During the tests above, there were not disruptive discharges.



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**I. TESTS ON LOW VOLTAGE INTERCONNECTIONS
AND DISTRIBUTION CIRCUITS
I.b. VERIFICATION OF THE CREEPAGE DISTANCES**

1. Reception product date: 05.05.2008
2. Test date: 05.05.2008
3. Test standard: IEC 62271-202:2006
4. Atmospheric conditions: $t = 13,7^{\circ}\text{C}$, RH = 56 %
5. Equipments used:
 - Digital caliper serial no. G111089, manufactured by PROFIX Poland, CE no.06-1690993/06, expanded uncertainty $U=0,01\%$ for coverage factor $k=2$;
 - Thermohygrometer type HD 100, serial no. 06102404, manufactured by KIMO, France, CE no.4.8-11-06-025/13.11.2006, expanded uncertainty $U=0,3^{\circ}\text{C}$ for temperature measurement and $U=2\%$ for relative humidity for coverage factor $k=2$.

6. Procedure

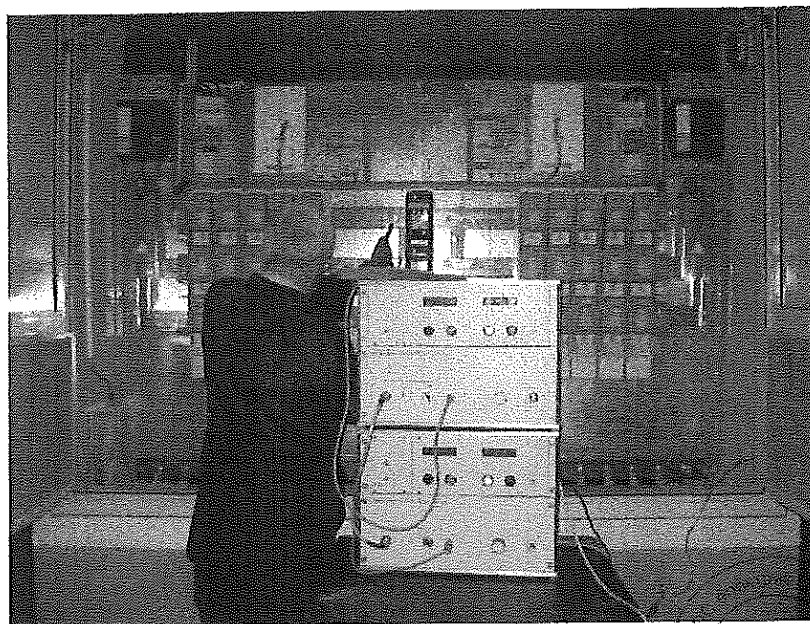
The verification of the creepage distances was performed according to IEC 62271-202:2006, clause 6.2.2.3.

There were measured the shortest creepage distances between the bars of the low voltage circuits and between the active parts and the accessible conductor parts.

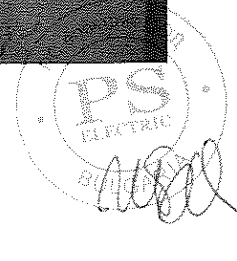
7. Test result

The product withstood the test.

The measured creepage distances were greater than 12,5mm, which is the minimum necessary creepage distance prescribed in the Table 4 of IEC 60664-1, for the working voltage of 400V and the most disadvantageous environmental conditions (pollution degree 4 and material group III).



ВЯРНО С
ОРИГИНАЛА



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**II. DIELECTRIC TESTS ON AUXILIARY CIRCUITS**

1. Reception product date: 05.05.2008
2. Test date: 05.05.2008
3. Test standard: IEC 62271-202:2006
4. Atmospheric conditions: $t = 13,7^{\circ}\text{C}$, RH = 56 %
5. Equipments used:
 - Generator for lightning impulse voltage, negative polarity and power frequency voltage type SIP010, serial no. 620091, manufactured by RFT Germany, CE no. 0088/26.10.2006, expanded uncertainty $U=2,3\%$ for coverage factor $k=2$;
 - Thermohygrometer type HD 100, serial no. 06102404, manufactured by KIMO, France, CE no.4.8-11-06-025/13.11.2006, expanded uncertainty $U=0,3^{\circ}\text{C}$ for temperature measurement and $U=2\%$ for relative humidity for coverage factor $k=2$.

6. Procedure

The dielectric tests auxiliary circuits were performed according to IEC 62271-202:2006, clause 6.2.3.

The power frequency test voltage was applied between the auxiliary circuits, connected together as a whole, and the frame and the actuator K is taken out from the circuit.

The power frequency test voltage applied to the auxiliary circuits was increased up to 2 kV and than it is maintained for 1 min.

7. Test result

The product withstood the test.

During the test above, there were not disruptive discharges.

ВЯРНО С
ОРИГИНАЛА



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**III. TESTS TO VERIFY OF THE WITHSTAND OF THE ENCLOSURE AGAINST MECHANICAL STRESS**

1. Reception product date: 05.05.2008
2. Test date: 05.05.2008
3. Test standard: IEC 62271-202:2006
4. Atmospheric conditions: $t = 13,7^{\circ}\text{C}$, RH = 56 %
5. Equipments:
 - Pendulum hammer, manufacturer ICMET according IEC 60068-2-75:1997, serial no.3, CE no.Dj 06-3061545/2006, expanded uncertainty $U=0,75\%$ for coverage factor $k=2$;
 - Thermohygrometer type HD 100, serial no. 06102404, manufactured by KIMO, France, CE no.4.8-11-06-025/13.11.2006, expanded uncertainty $U=0,3^{\circ}\text{C}$ for temperature measurement and $U=2\%$ for relative humidity for coverage factor $k=2$.

6. Procedure

The verification of the enclosure withstand to mechanical impacts was performed according to IEC 62271-202:2006, subclause 6.7.3.

The product was visually examined before the tests.

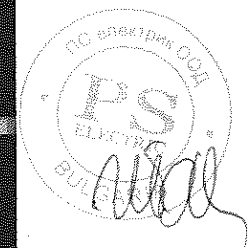
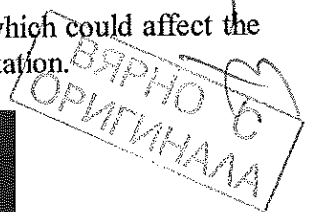
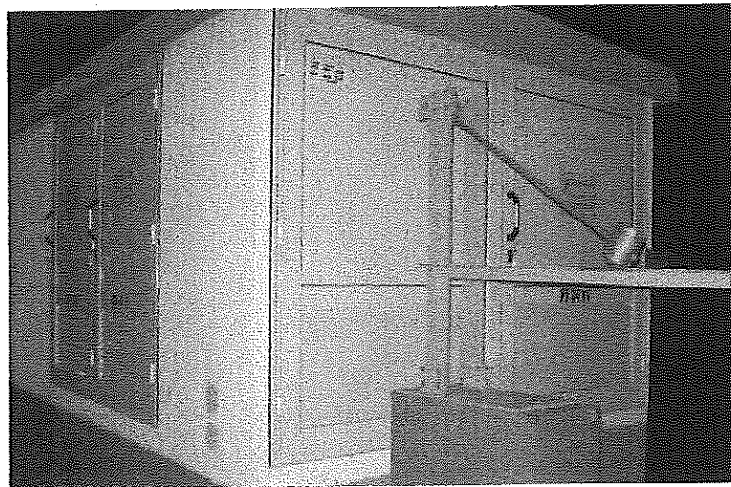
The impact energy must be 20 J, produced using a pendulum hammer with an equivalent mass of 5 kg $\pm 5\%$, with the height of fall 400mm $\pm 1\%$.

In order to check the enclosure withstand to mechanical impacts, there were applied blows with the pendulum hammer on each access door and ventilation openings, in the points assumed to be the weakest of the enclosure.

8. Test result

The product withstood to the mechanical impact test.

After the tests, the enclosure did not present any breaks or deformations which could affect the dielectric properties and the normal operation of the equipment inside the substation.



- End of the Test Report -

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RESEARCH-DEVELOPMENT AND TESTING NATIONAL
INSTITUTE FOR ELECTRICAL ENGINEERING

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ICMET CRAIOVA HIGH POWER DIVISION

SR EN ISO / CEI 17025: 2005
CERTIFICAT DE ACREDITARE
nr. LI 004 / 2007

HIGH POWER LABORATORY "Ovidiu Rarinca"

200515-CRAIOVA Calea Bucuresti Nr. 144 ROMANIA
Phone: (351) 402 427; Fax: (251) 415482; (351) 404 890;
E-mail: lmp@icmet.ro

TEST REPORT No. 10175

CUSTOMER: PAVEL&SONS Ltd.
Central Office:9700 Shumen Bulgaria
MANUFACTURER: PAVEL&SONS Ltd.
Central Office:9700 Shumen Bulgaria

TESTED PRODUCT 20/0.4kV, 2*800KVA Prefabricated transformer substation made of reinforced concrete

REFERENCE STANDARD: IEC 62271-202 / 2006 clause 6.3

TEST PERFORMED: Temperature-rise test and determination of thermal class

TEST DATE: 07.05.2008

TEST RESULT: Passed the tests

Report has 22 pages and it is edited in 4 copies from which 3 copies for customer.

HEAD OF HIGH POWER DIVISION: Dr. [Redacted]

LABORATORUL
"MARE PUTERE"
"VIDIU RARINCA"
CRAIOVA

На основание чл. 2

HEAD OF LABORATORY: [Redacted]

На основание чл. 2

DATE OF ISSUE: 25.05.2008

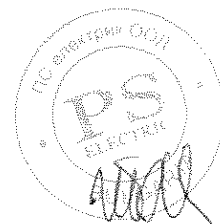


1. Results refer to test product only.
2. Publication or reproduction of the contents of this report in any other form unless its complete photocopying is not allowed without writing approval of division to which laboratory belong to.
3. Accreditation of the laboratory or any of its Test Reports issued under accreditation regime do not constitute or do not imply themselves an approval of the product by the accreditation body.

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2.2	Serial number/year	3
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ВЯРНО С
ОРИГИНАЛА



1. PRESENT AT THE TESTS: Eng. Velimir Dimitrov and Eng. Dimitar Donchev from Pavel & Sons

2. IDENTIFICATION OF APPARATUS

	Substation	MV Cubicles	LV Switch board	Transformer
2.1 Type	BM02	8DJ20 .81	Compact	TNOSN 800/20
2.2 Serial number/Year	08126/2008	C.V. 769630-000040/001	-	1610341013/ 1610341001
2.3 Technical documentation/ Drawing	See pages 11, 12 See pages 13 + 18			
2.4 Contract no.:	2167/ 09.03.2008			
2.5 Product receiving date:	05.05. 2008			
2.6 Product condition at receiving	New			

3. TECHNICAL CHARACTERISTICS CHECKED BY TESTS

	Substation	MV Cubicles	LV Switch board	Transformers
Rated power	2x800 kVA	-	-	2x800 kVA
Rated voltage	20/0.4 kV	20 kV	0.4 kV	10/0.4 kV
Rated current	-	630/200 A	2x1250 A	23.7/1154.7 A
Rated frequency	50Hz	50Hz	50Hz	50 Hz
Short-circuit voltage	-	-	-	5. %
Connection -	-	-	-	DYn5
Total losses	-	-	-	11856/11673W

4. TEST PROGRAM

4.1 One test to check the temperature-rise test of the transformer and the low voltage apparatuses from the substation.

The temperature rise test is performed at total losses of 11856W+11673 W up to the oil temperature stabilisation, followed by the heating at rated current $I_n = 2 \times 1154.7$ A for an hour.

Supply was made by copper flexible cables with $S = 240 \text{ mm}^2$ in low voltage panel at the output terminals of the fuses F1 to F3 (see drawing from page 13) of each TP-P1 and TP-P2 transformer.

4.21 One test to check the temperature-rise test of the transformer outside of the substation was performed on transformer serial no. 1610341013 at the total losses 11856W for TP-P1 respectively serial no. 1610341001 at total losses 11673W for TP-P2 by supply the low voltage windings with high voltage windings short-circuited.

4.3 Determination of thermal class of the substation.

5. RESPONSIBLE FOR TESTS: Eng. Ilie Sborn and Eng. Catalin Boltasu

6. TEST REPORT DOCUMENTATION:

Diagrams	4; Tables	11;
Photos	1; Drawings	6;

ВЯРНО С
ОРИГИНАЛА



7. TEMPERATURE-RISE TEST

7.1 Three-phase supply circuit for temperature rise test

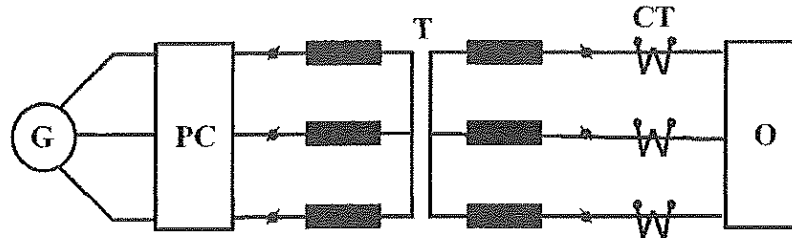


Fig. 1 – Test diagram for current paths temperature-rise test

- G - Generator type GSAM – 390 kVA, 400 V, 50 Hz
- PC - Connections panel
- T - Adapting transformer made of 3 single-phase transformers of 400 / 25V, 10 kA, 50 Hz
- CT - Current transformers type CIRSO- – 15000 / 5 A
- O - Object to be tested

7.2 Test conditions and calculation relations of temperature-rise

Table 1

Test stage	I	II
Load type	Loss (W)	Current / period (A / minutes)
	11856+11673	1154.6+1154.6 / 60.

Calculation relations (IEC 60076-2:1993, clause 5.4):

$$\theta_2 = (R_2 / R_1) * (235 + \theta_1) - 235 \text{ – for cooper winding}$$

$$\Delta\theta = \theta_2 - \theta_a$$

$$\Delta\theta_u = \theta_u - \theta_a$$

where:

- θ - windings average temperature
- R_1 - windings resistance measured in cold condition
- R_2 - windings resistance measured at shutdown
- θ_1 - environment temperature in cold condition
- θ_a - environment temperature at the end of temperature-rise test
- $\Delta\theta$ - windings temperature-rise
- θ_u - oil average temperature at the upper part
- $\Delta\theta_u$ - oil temperature-rise

ВЯРНО С
ОРИГИНАЛА



7.3 RESULTS OBTAINED AT TEST

7.3.1 Transformer's TP-P 1 temperature-rise test inside the substation

Table 2

Windings	Determined values					
	R ₁ (Ω)	θ ₁ (°C)	R ₂ (Ω)	θ _a (°C)	Δθ (°C)	Δθ _u (°C)
HV	5.80	18	7.44	21.3	68,24	65,95
LV	1.961x10 ⁻³		2.525x10 ⁻³		69,46	

Measurements were performed with uncertainty of: 3 % for voltages; 3% for currents; 2.5% for time and the confidence level P = 95%.

where:

HV - high voltage winding

LV - low voltage winding

7.3.2 Transformer's TP-P 2 temperature-rise test inside the substation

Table 3

Windings	Determined values					
	R ₁ (Ω)	θ ₁ (°C)	R ₂ (Ω)	θ _a (°C)	Δθ (°C)	Δθ _u (°C)
HV	5.68	18	7.255	21.3	66,85	64,63
LV	1.9486x10 ⁻³		2.500x10 ⁻³		68,29	

Measurements were performed with uncertainty of: 3 % for voltages; 3% for currents; 2.5% for time and the confidence level P = 95%.

where:

HV - high voltage winding

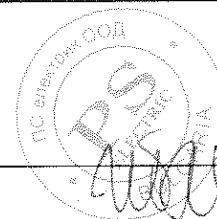
LV - low voltage winding

Remarks: Values of the measured resistances, calculated temperatures and temperature diagrams are presented in pages 5, 6, 7, 19, 20, 21, 22.

7.3.3 Measured values of currents, losses and temperatures for TP-P 1

Table 4

Time		Hour	13:15	14:15	15:15	16:15	17:15	18:15	19:15	19:16	20:16
Current on phases	I ₁	A	1288	1261	1240	1212	1199	1195	1191	1157	1158
	I ₂	A	1282	1256	1234	1207	1194	1185	1181	1155	1155
	I ₃	A	1273	1245	1225	1199	1176	1172	1169	1153	1152
Average current	I _m	A	1281	1254	1233	1206	1193	1184	1180	1155	1155
Measured loss	P ₁	W	3966	3968	3969	3966	3964	3963	3964	3602	3601
	P ₂	W	3975	3974	3976	3974	3973	3974	3975	3609	3608
	P ₃	W	3953	3951	3950	3951	3953	3953	3953	3592	3691
Total loss	P _m	W	11894	11893	11895	11891	11890	11890	11892	10803	10800
Environment temperature	θ _{a1}	°C	18.5	10.41	19.35	20.24	20.95	21.1	21.28	21.31	21.32
	θ _{a2}	°C	18.23	18.43	19.33	20.23	20.95	21.26	21.43	21.48	21.48
	θ _{a3}	°C	18.18	18.3	19.04	20.12	20.46	20.62	21.11	21.1	21.1
	θ _a	°C	18.15	18.38	19.24	20.20	20.79	20.99	21.29	21.3	21.3
Oil temperature	θ _u	°C	61.81	70.21	77.2	81.84	84.65	85.81	86.88	87.32	87.25
Oil temperature-rise	Δθ _u	°C	43.66	51.83	57.96	61.64	63.86	64.82	65.49	66.02	65.95



7.3.4 Measured values of currents, losses and temperatures for TP-P 2

Table 5

Time		Hour	13:15	14:15	15:15	16:15	17:15	18:15	19:15	19:16	20:16
Current on phases	I_1	A	1278	1254	1230	1207	1184	1179	1177	1158	1158
	I_2	A	1278	1250	1226	1202	1181	1175	1175	1154	1156
	I_3	A	1275	1248	1225	1200	1178	1173	1170	1153	1153
Average current	I_m	A	1277	1251	1227	1203	1181	1176	1174	1155	1155
Measured loss	P_1	W	3883	3885	3885	3884	3888	3890	3889	3522	3522
	P_2	W	3904	3903	3901	3903	3906	3906	3907	3522	3523
	P_3	W	3898	3900	3897	3903	3905	3905	3904	3521	3520
Total loss	P_m	W	11685	11688	11683	11690	11699	11701	11700	10566	10565
Environment temperature	θ_{a1}	°C	18.05	18.41	19.35	20.24	20.95	21.1	21.28	21.31	21.32
	θ_{a2}	°C	18.23	18.43	19.33	20.23	20.95	21.26	21.47	21.48	21.48
	θ_{a3}	°C	18.18	18.3	19.04	20.12	20.46	20.61	21.11	21.11	21.11
	θ_a	°C	18.15	18.38	19.24	20.20	20.79	20.99	21.29	21.3	21.3
Oil temperature	θ_u	°C	61.39	69.59	76.42	81.1	83.64	84.66	85.62	85.98	85.93
Oil temperature-rise	$\Delta\theta_u$	°C	43.24	51.21	57.18	60.90	62.85	63.67	64.33	64.68	64.63

Measurements were performed with uncertainty of: 5 % for powers; 3% for currents; 2.5% for time and the confidence level $P = 95\%$.

7.3.5 Symbols used in tables 4 and 5:

θ_{a1} ; θ_{a2} ; θ_{a3} - environment temperature in 3 measuring points

θ_a - environment average temperature: $\theta_a = (\theta_{a1} + \theta_{a2} + \theta_{a3})/3$

7.3.6 Values of the high and low voltage windings resistance measured after shutdown on TP-P1

The resistances of high and low voltage windings were measured in direct current for 10 minutes (one reading at each minute) using the ammeter-voltmeter method. The windings resistances determination at the time of shutdown (t_0) was made by extrapolation from the resistances diagrams (see pages 19 and 20).

Table 6

Time	High voltage winding			Low voltage winding		
	U_{HV} [V]	I_{HV} [A]	R_{HV} [Ω]	U_{LV} [mV]	I_{LV} [A]	R_{LV} [m Ω]
1	4.66	0.628	7.42	12.36	4.92	2.514
2	4.647	0.628	7.400	12.32	4.92	2.504
3	4.635	0.628	7.380	12.28	4.92	2.496
4	4.623	0.628	7.361	12.23	4.92	2.486
5	4.603	0.628	7.345	12.18	4.92	2.476
6	4.597	0.628	7.330	12.13	4.92	2.465
7	4.589	0.628	7.307	12.09	4.92	2.457
8	4.581	0.628	7.295	12.05	4.92	2.449
9	4.569	0.628	7.275	12.01	4.92	2.441
10	4.559	0.628	7.26	11.96	4.92	2.431

Measurements were performed with uncertainty of: 2.5 % for resistances and the confidence level $P = 95\%$.

Remark: Currents and loss values were measured using class 0.2 apparatus



7.3.7 Values of the high and low voltage windings resistance measured after shutdown on TP-P2
 The resistances of high and low voltage windings were measured in direct current for 10 minutes (one reading at each minute) using the ammeter-voltmeter method. The windings resistances determination at the time of shutdown (t_0) was made by extrapolation from the resistances diagrams (see pages 21 and 22). Table 7

Time t [min]	High voltage winding			Low voltage winding		
	U_{HV} [V]	I_{HV} [A]	R_{HV} [Ω]	U_{LV} [mV]	I_{LV} [A]	R_{LV} [m Ω]
1	4.627	0.64	7.23	12.33	4.97	2.48
2	4.611	0.64	7.205	12.23	4.97	2.46
3	4.595	0.64	7.18	12.13	4.97	2.44
4	4.584	0.64	7.163	12.03	4.97	2.42
5	4.573	0.64	7.145	11.95	4.97	2.404
6	4.56	0.64	7.125	11.88	4.97	2.39
7	4.48	0.64	7.106	11.78	4.97	2.370
8	4.38	0.64	7.09	11.70	4.97	2.355
9	4.525	0.64	7.07	11.63	4.97	2.34
10	4.512	0.64	7.05	11.56	4.97	2.326

Measurements were performed with uncertainty of: 2.5 % for resistances and the confidence level $P = 95\%$.

Remark: Currents and loss values were measured using class 0.2 apparatus.

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7.3.8 Temperature-rise of the low voltage equipment supplied by TP-P1

Table 8

No.	Elements and temperature measuring points denomination in fig. 1	Temperature-rise [°C]			Admitted
		Measured			
		U	V	W	
1	Supply (Output) Fuse 1	29.26	32.88	37.99	70
	Supply (Output) Fuse 2	32.94	42.09	30.3	
	Supply (Output) Fuse 3	32.31	42.21	41.2	
2	General bars (Output fuses)	54.43	42.69	43.35	
	3	Circuit breaker terminals			
		- Input	62.09	57.64	
	- Output	53.73	56.25	53.37	
4	Fuse handler	23.41			25
5	Circuit breaker manual operating lever	24.51			
6	Low voltage compartment environment	23.59			-
7	Power transformer compartment environment	44.92			
8	Environment temperature	21.29			

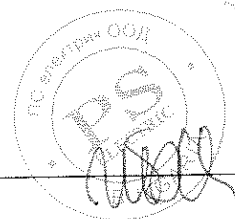
7.3.9 Temperature-rise of the low voltage equipment supplied by TP-P2

Table 9

No.	Elements and temperature measuring points denomination in fig. 1	Temperature-rise [°C]			Admitted
		Measured			
		U	V	W	
1	Supply (Output) Fuse 1	42.75	41.09	38.31	70
	Supply (Output) Fuse 2	33.63	34.97	39.66	
	Supply (Output) Fuse 3	36.32	38.64	38.11	
2	General bars (Output fuses)	55.43	53.72	46.4	
	3	Circuit breaker terminals			
		- Input	60.25	58.02	
	- Output	45.76	57.95	49.73	
4	Fuse handler	22.31			25
5	Circuit breaker manual operating lever	24.94			
6	Low voltage compartment environment	23.59			-
7	Power transformer compartment environment	32.36			
8	Environment temperature	21.29			

Measurements were performed with uncertainty of: 3 % for temperatures and the confidence level P = 95%.

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8 THERMAL CLASS DETERMINATION

To assess the thermal class the following relations (IEC 62271-202:2006, clause 6.3) will be applied:

$$\Delta t_1 = t_{11} - t_{a1},$$

$$\Delta t_2 = t_{12} - t_{a2},$$

$$\Delta t = \Delta t_2 - \Delta t_1$$

where:

t_{11} - temperature of the transformer windings outside the substation,

t_{a1} - environment temperature at the end of transformer temperature-rise test outside the substation,

Δt_1 - temperature-rise test of the transformer outside the substation,

t_{12} - temperature of the transformer windings inside the substation

t_{a2} - environment temperature at the end of transformer temperature-rise test inside the substation

Δt_2 - temperature-rise test of the transformer windings inside the substation.

8.1 Thermal class determination for TP-P1

Table 10

	Δt_1 [°C]	t_{11} [°C]	t_{a1} [°C]	Δt_2 [°C]	t_{12} [°C]	t_{a2} [°C]	Δt [°C]
HV winding	59.32	81.42	22.1	68.24	89.54	21.3	8.92
LV winding	60.57	82.67		69.59	90.89		9.02
Oil	56.79	78.89		65.95	87.25		9.15
Remarks:	These data are according to technical records made in the temperature-rise register			These data are according to table 2 of this Test Report			

Thermal class: because $5 \text{ K} < \Delta t < 10 \text{ K} \Rightarrow$ **Class 10**

8.2 Thermal class determination for TP-P2

Table 11

	Δt_1 [°C]	t_{11} [°C]	t_{a1} [°C]	Δt_2 [°C]	t_{12} [°C]	t_{a2} [°C]	Δt [°C]
HV winding	59.11	81.11	22	66.85	88.15	21.3	7.74
LV winding	60.38	82.38		68.29	89.59		7.91
Oil	56.6	78.6		64.63	85.93		8.03
Remarks:	These data are according to technical records made in the temperature-rise register			These data are according to table 2 of this Test Report			

Thermal class: because $5 \text{ K} < \Delta t < 10 \text{ K} \Rightarrow$ **Class 10**

9. REMARK

Aspect of the substation in the test circuit is presented in photo 1.

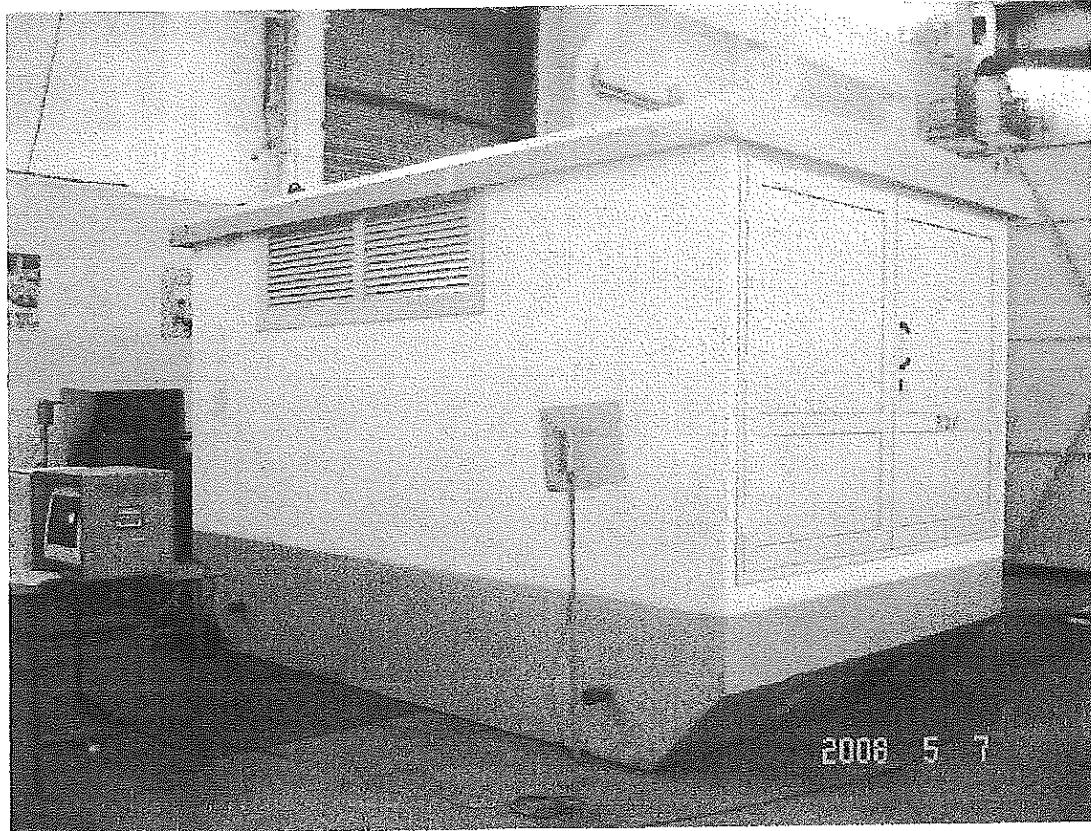
10. TEST RESULT: Temperature-rise of the low voltage equipment did not exceed the specified limits (see tables 8,9) and thermal class is 10 (see tables 10,11).

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ICMET Craiova

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10.1 Photo



Aspect of the Prefabricated transformer substation in the test circuit

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ИПС ЕЛЕКТРИКА ООД
ИПС
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Technical specification

Prefabricated transformer substation made of reinforced concrete

Type: BM02 20/0.4kV 2x800kVA
 Producer: "Pavel & sons" Ltd. , Shumen, Bulgaria
 Factory number: 08126

Casing: The casing of the Concrete Prefabricated Substation is made of water –tight reinforced concrete B45;

1.1 Measurements (roof included) :

L= 4600mm;B=2800mm;H=2830mm;

Weight with transformers: 20 800kg;

Equipment:

2.1.Equipment on the Middle Voltage side:

Complete distributing device - 8DJ20 Sh.81 2RK+2TR Siemens, which consists of cable "IN" 20kV,cable "OUT" and 2psc."Transformer protection".

2.2.Interconnections 20 kV from MV switchboard to transformers NA2X(F)2Y 3 x 1 x 50mm².

2.3.Transformer:

transformer 20/0.4kV 800 kVA

Dimensions:

L=1710mm.

W=1070mm.

H=1590mm.

2.4.Connecting cable from transformers to LV switchboard –
 NYY 3x(4x240mm²)+2x240mm².

2.5.Main circuit –breakers of LV switchboard – automatic circuit–breakers
 NS1250N Micrologic 2.0.

2.6.Terminals of LV switchboard – fuse-switch disconnecter MULTIVERT 630A-10
 psc. "m.schneider Austria.

2.7. Sectional vertical switch disconnecter 1000A Jean Muller

2.7. Over-voltage protections 2psc., type: STH 3P Merlin Gerin:

I max.-65kA(20/8);

I_n-20kA(20/8);

U_p=1.5kV;

U_c=275V;

2.8. Supply circuit-breaker of the overvoltage protection:

MULTIBLOC 160A m.schneider Austria.

2.9. Copper bars' system:

Distributing rims – Copper bars 80/10mm.

Connection between main circuit – breaker and distributing rims – Copper bars

2x(50x10)mm.

Current transformer:

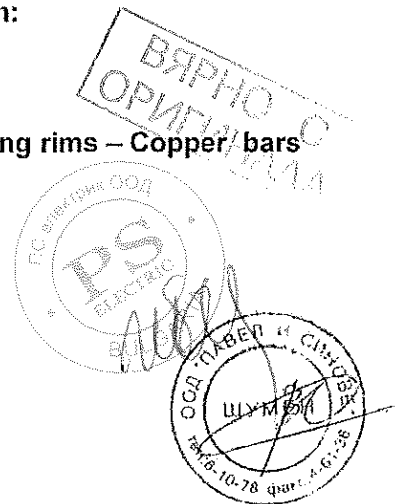
MAK 104/80 1250/5A

5VA grade of fit 0.5

I_{th} max 50kA.

3.Earthing instalation:

Internal connections- conductor H07V-k 1x50mm².



Connection between neutral copper bar and potential copper bar – conductor H07V-K 1x150mm².

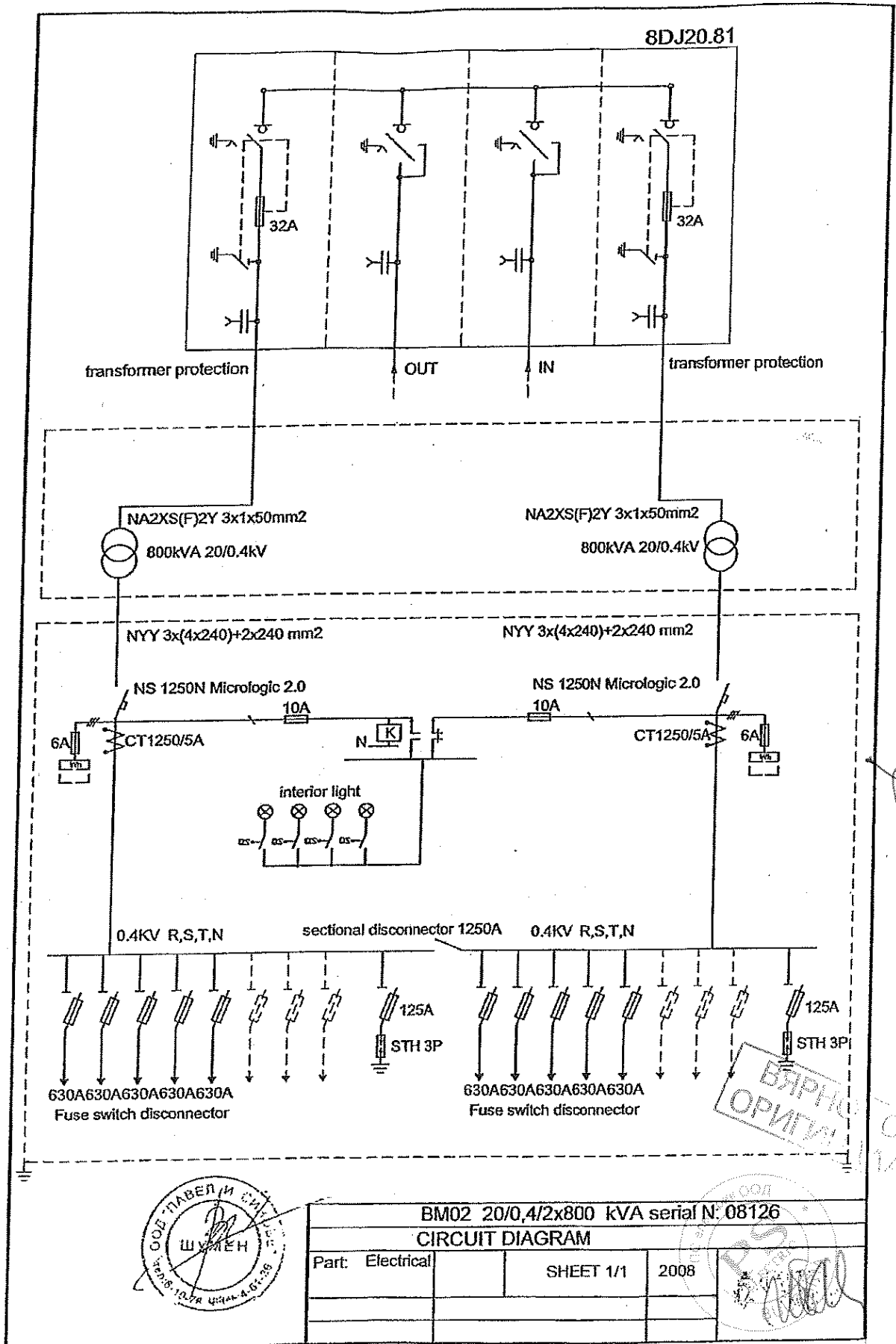
Connection to external earthing contour –H07V-K 1x95mm²

Ratings of prefabricated substation:

- Rated voltage on MV side – 24kV;
- Operated voltage on MV side – 20kV;
- Rated insulation level on MV side -50kV;
- Rated lightning impulse withstand voltage on MV side-125kV;
- Rated voltage on LV side – 0.4kV;
- Rated insulation level on LV side -2,5kV;
- Rated normal current of MV busbar-630A;
- Rated lightning impulse withstand voltage on LV side- 5kV;
- Rated feeder current -630A;
- Rated feeder current for transformer panels – 200A;
- Main circuit breakers on LV switchboard-1250A;
- rated short time withstand current on MV side -16kA/1s;
- peak withstand rated current – on MV side-40kA;
- Short time withstand current on earthing circuit -16kA

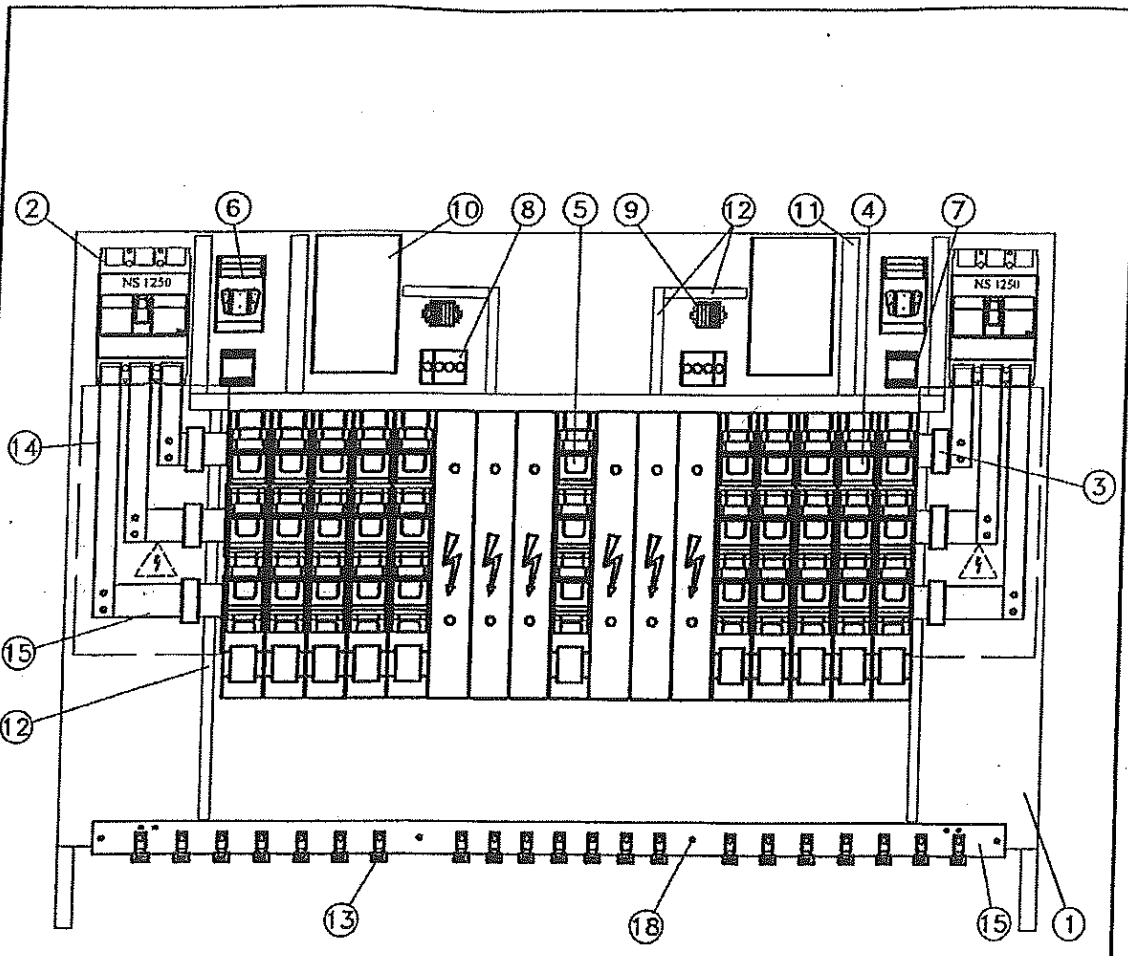


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BM02 20/0,4/2x800 kVA serial N: 08126			
CIRCUIT DIAGRAM			
Part: Electrical		SHEET 1/1	2008

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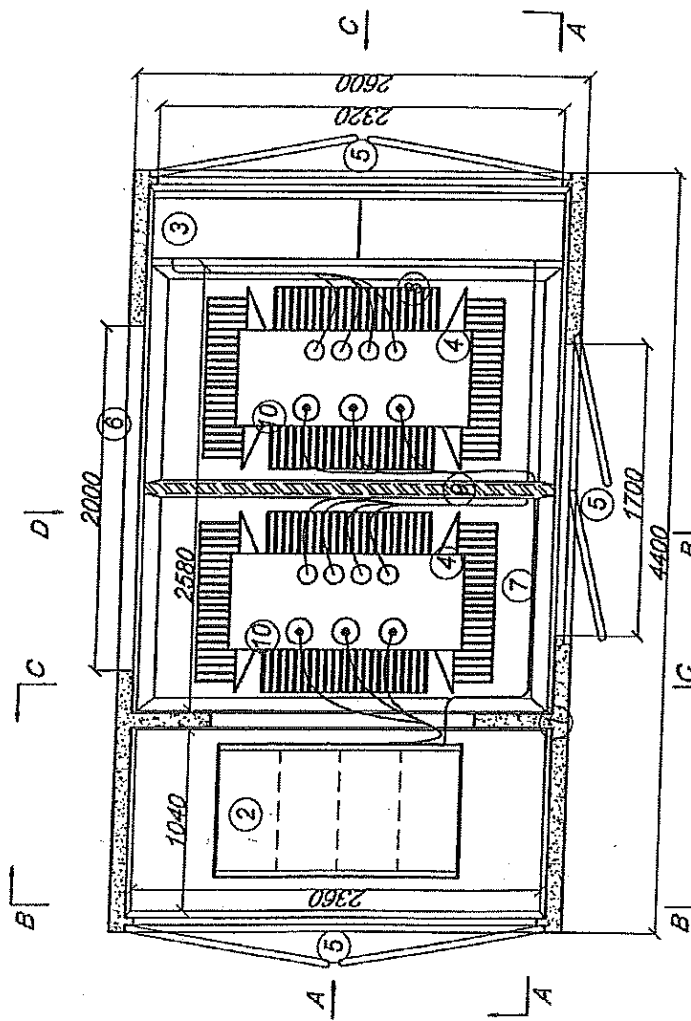


19	Isolator	BM 6	4
17			
16			
15	Busbar	Cu 80/10	
14	Busbar	Cu 2x50/10	
13	V-terminal single	70-240	21
12	Cable channel 25x40		
11	Cable channel 40x40		
10	Electrometer's plate		2
9	Current terminals	Weidmuller	2
8	Fuses for secondary circuit	ETI	8
7	Surge protection	STH; I _{max} 65 kA, I _n 20 kA	2
6	Fuse-switch disconnecter	Multibloc 180 A m.schneider Austria	2
5	Sectional switch disconnecter	STL3 1000A Jean Muller	1
4	Fuse-switch disconnecter	Multivert 630A m.schneider Austria	10
3	Current transformer	1250/5 A	6
2	Circuit breaker	NS1250 N micrologic2.0	2
1	Metal construction		1
	NAME	Technical data	psc.

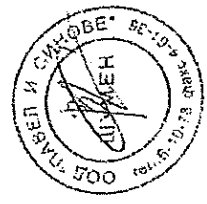


BM02 20/0,4/2x800 kVA
 LV Switchboard
 Part: Electrical SHEET 1/1 2008

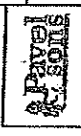
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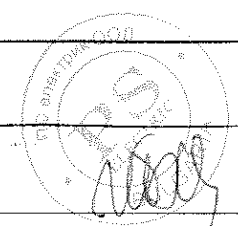
- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ Aluminium doors
- ⑥ Ventilation grille
- ⑦ Cable 20 kV - NA2XS(F)2Y - 1x50 mm²
- ⑧ Cable NY 3x(4x240)+2x240 mm²
- ⑨ Metal barrier
- ⑩ Cable head POLT 24C 50mm²



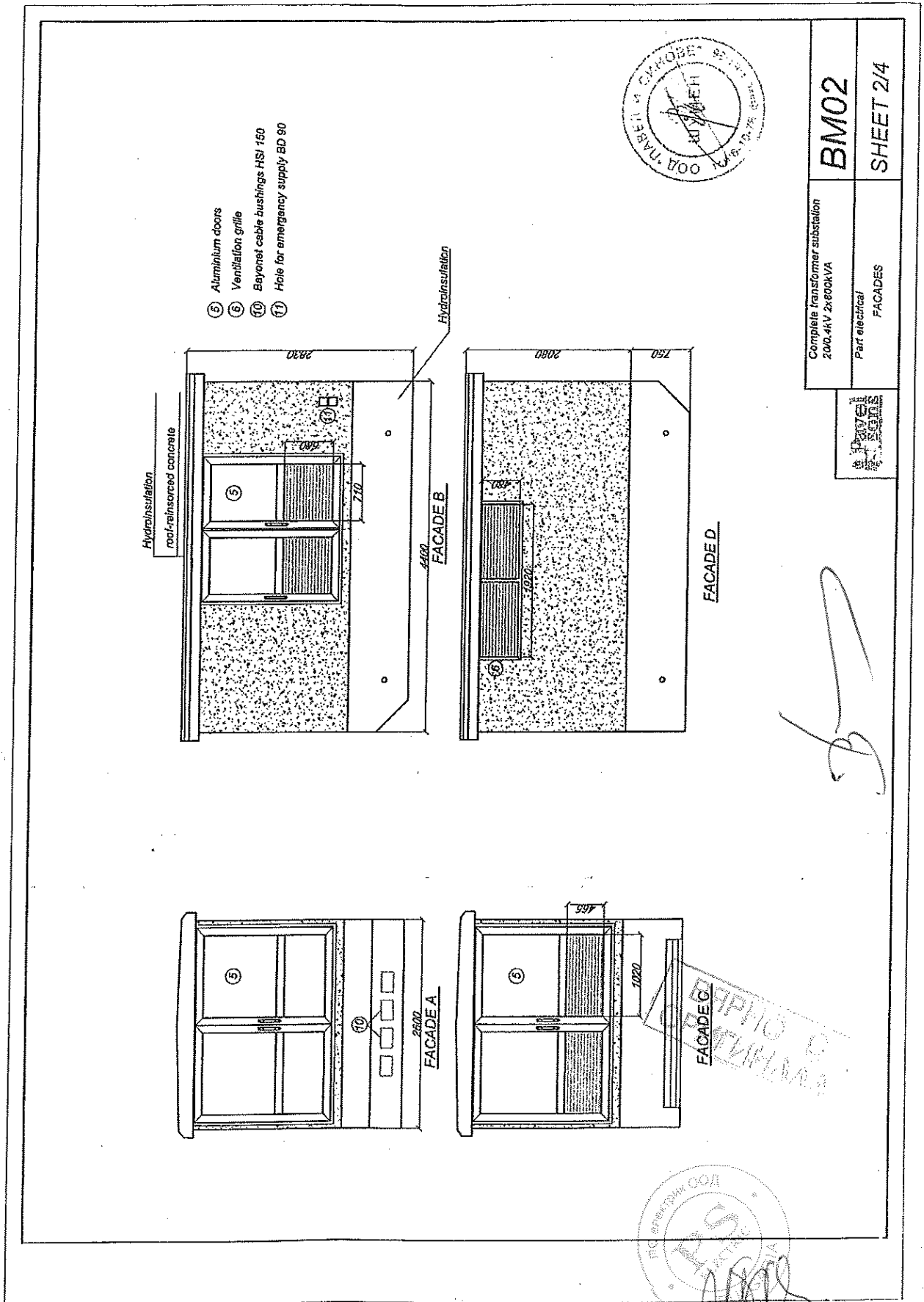
Complete transformer substation 200.4kV 2x800kVA	BM02
Part electrical	SHEET 1/4



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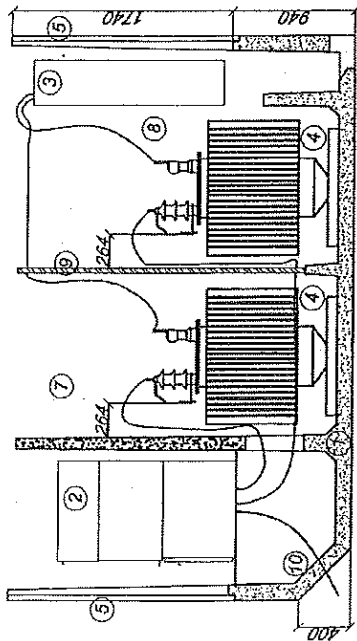


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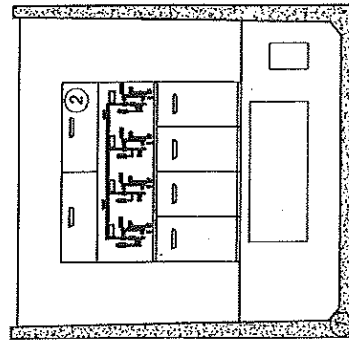
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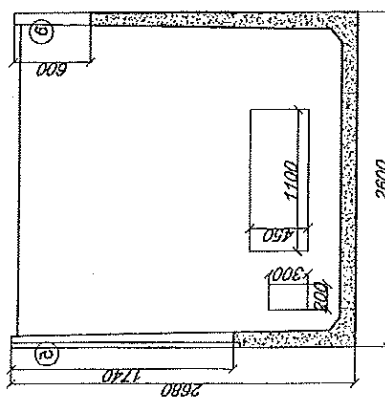
Complete transformer substation 200.4kV 2x800kVA	BM02
Part electrical Sections	SHEET 3/4



A-A



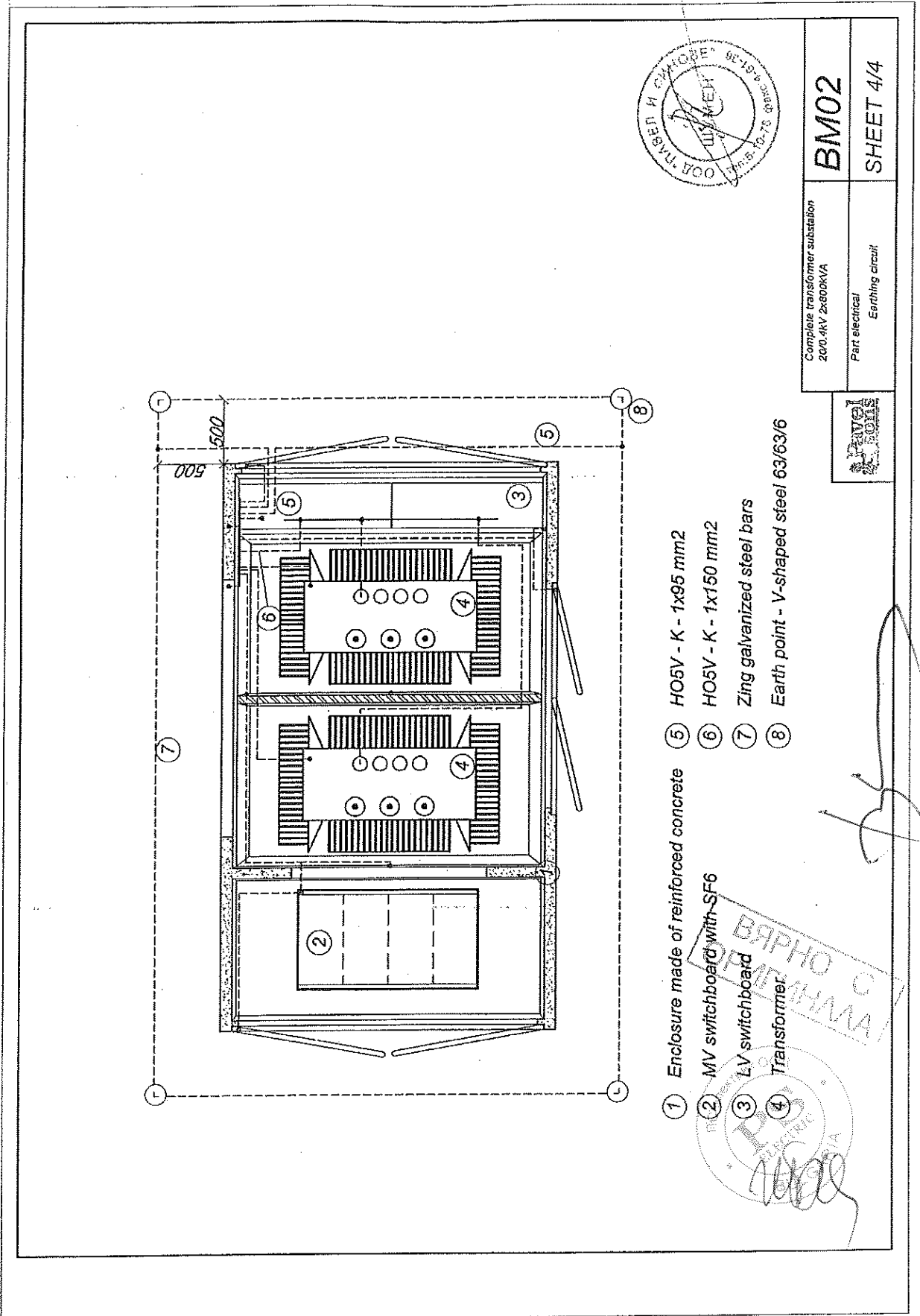
B-B



C-C

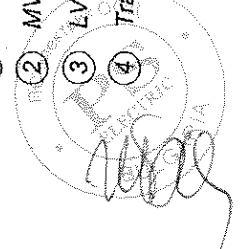
- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ Aluminium doors
- ⑥ Ventilation grille
- ⑦ Cable 20 kV - NA2XS(F)2Y - 1x50 mm²
- ⑧ Cable NY-Y-0 3x(4x240)+2x240 mm²
- ⑨ Metal barrier
- ⑩ Cable bushings "Snap-in system" HSI 150





- ① Enclosure made of reinforced concrete
- ② MV switchboard with SF6
- ③ LV switchboard
- ④ Transformer
- ⑤ HO5V - K - 1x95 mm²
- ⑥ HO5V - K - 1x150 mm²
- ⑦ Zing galvanized steel bars
- ⑧ Earth point - V-shaped steel 63/63/6

ВРНО С
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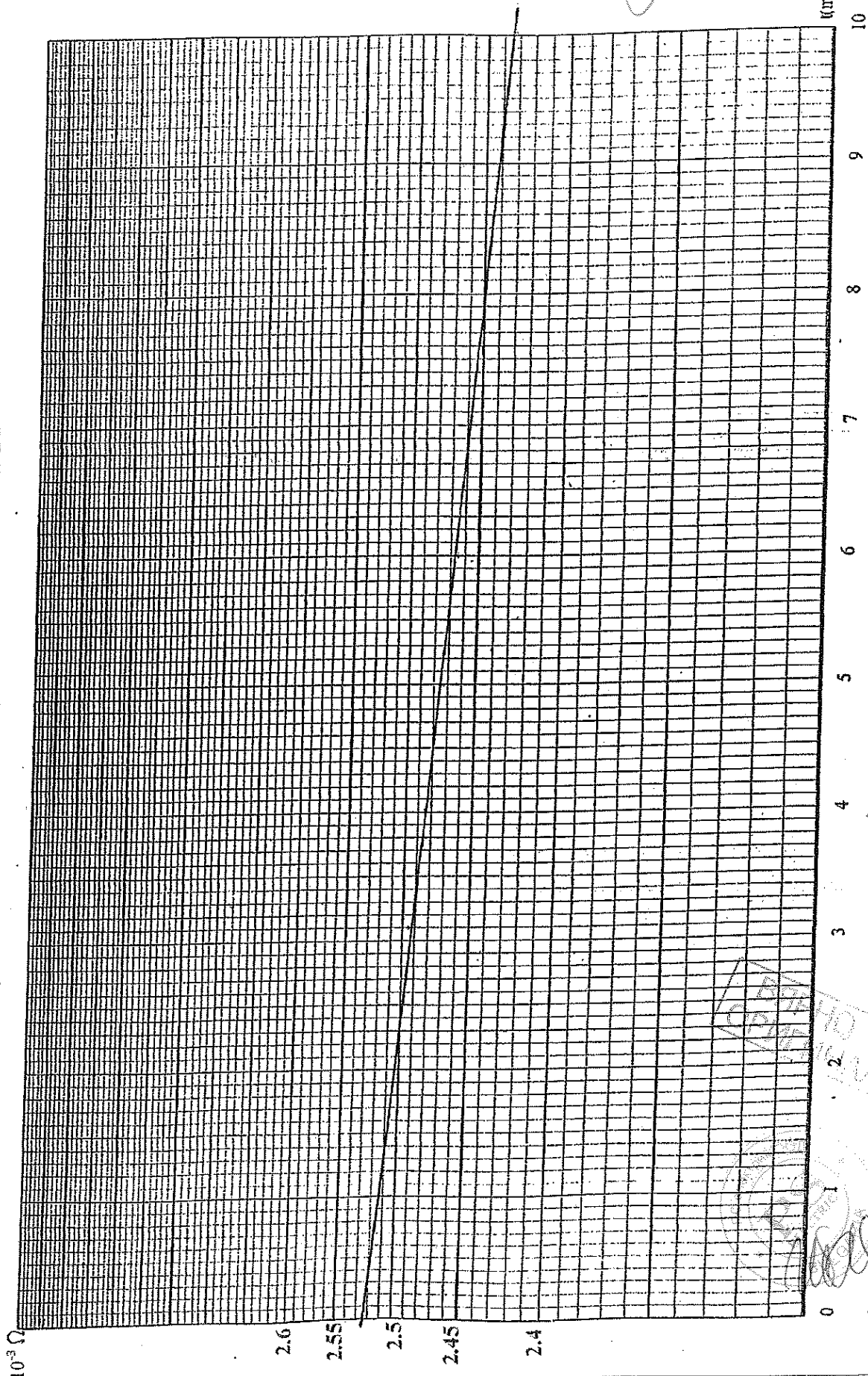


Complete transformer substation 20/0.4KV 2x800KVA	BM02
Part electrical Earthing circuit	SHEET 4/4



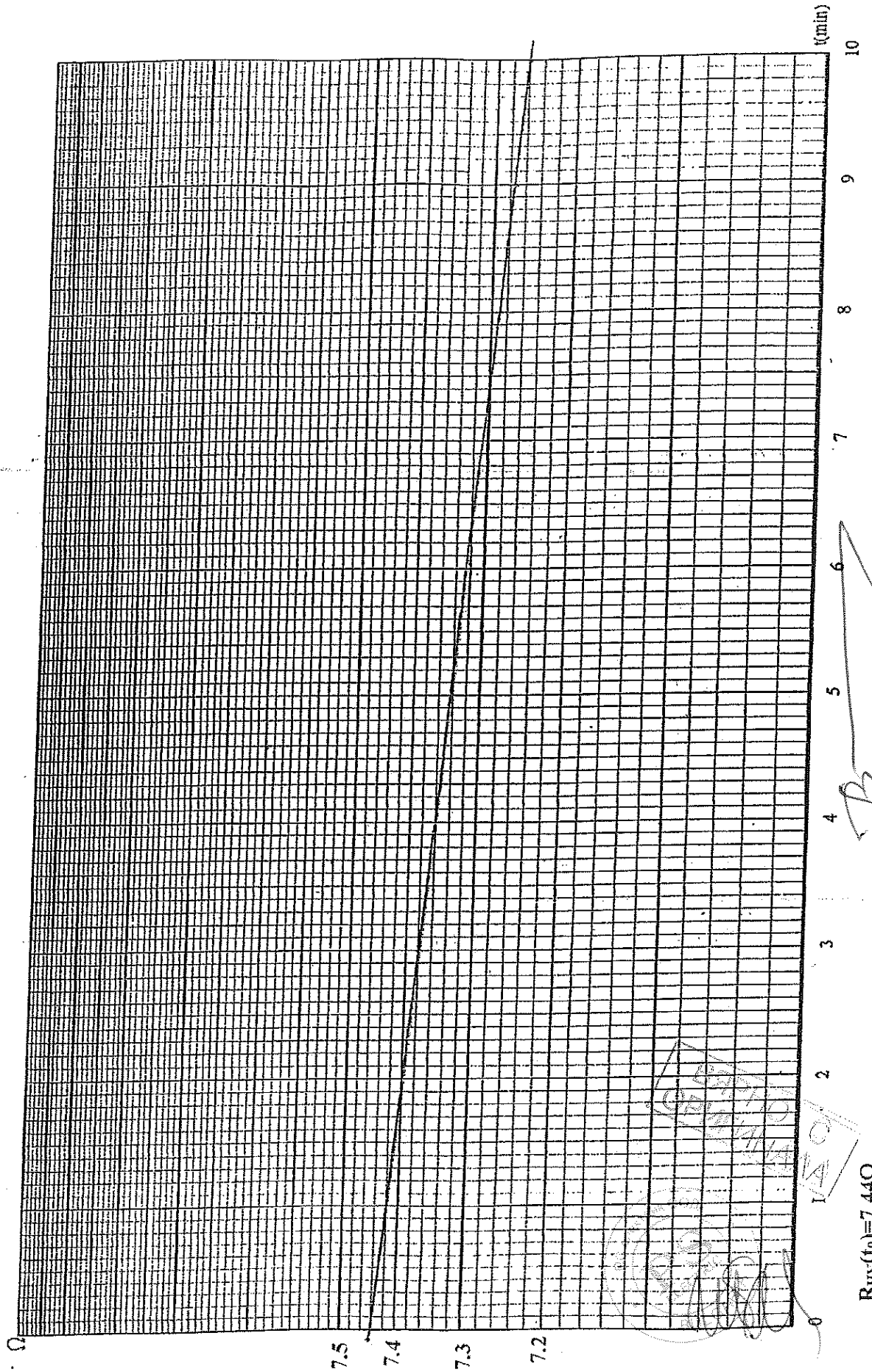
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Variation curve of $R_{LY}=f(t)$ after shut down for TP-P1



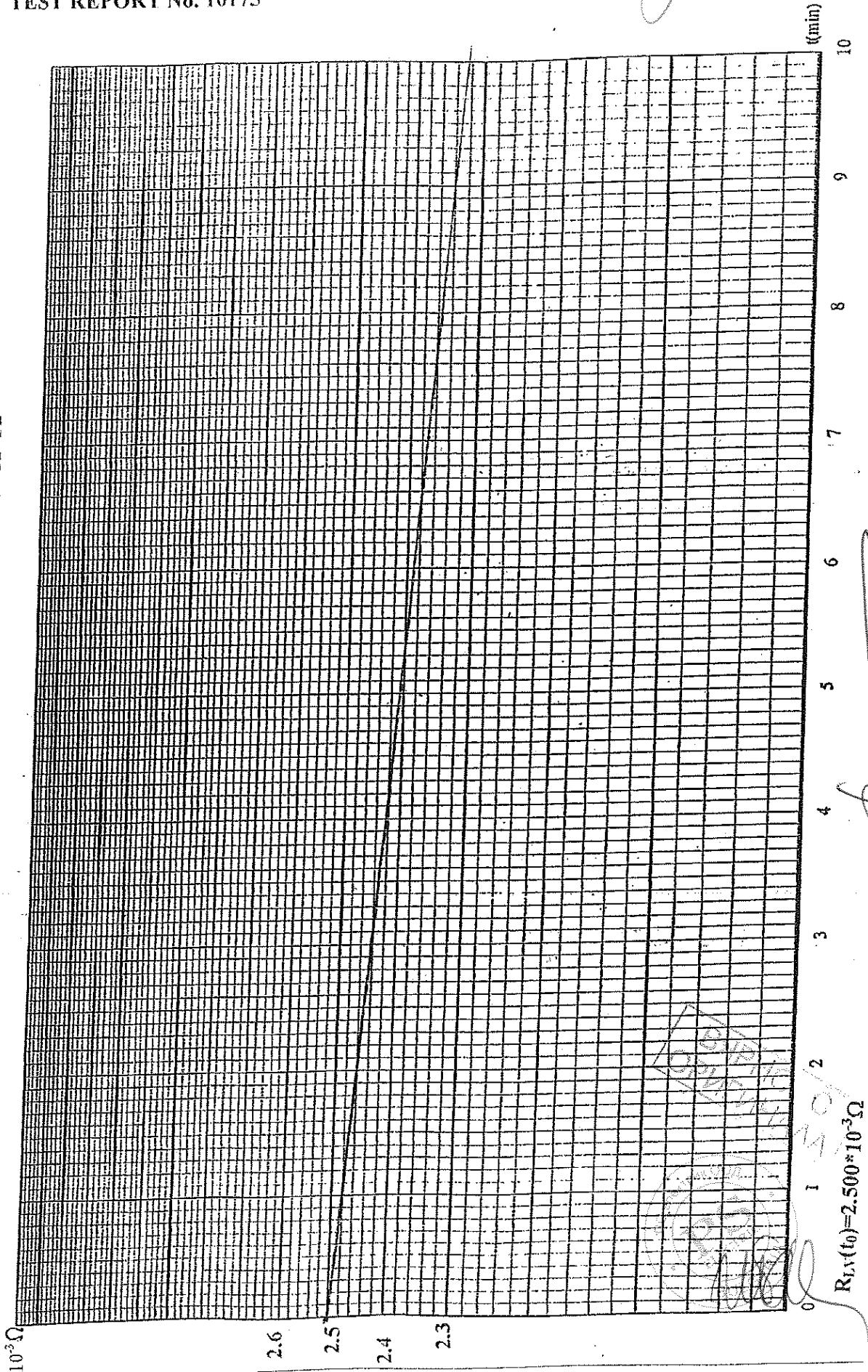
$R_{LY}(0) = 2.525 \cdot 10^{-3} \Omega$

Variation curve of $R_{riv}=f(t)$ after shut down for TP-P1

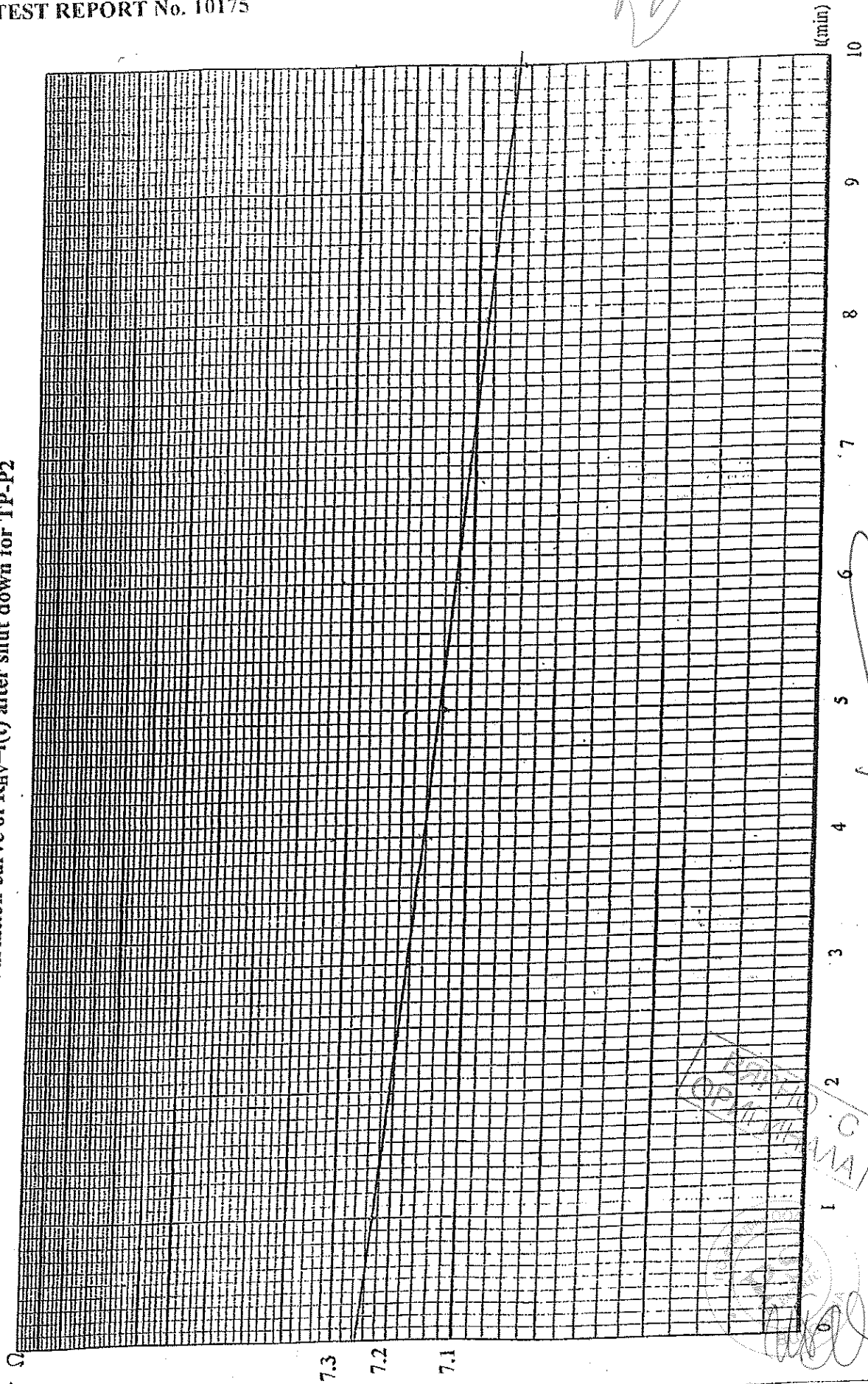


$R_{riv}(t_0)=7.44\Omega$

Variation curve of $R_{L,Y}=f(t)$ after shut down for TP-P2



Variation curve of $R_{HV}=f(t)$ after shut down for TP-P2



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R_{HV}(t₀) = 7.25Ω